Natural History Collections

Lothar A. Beck · Ulrich Joger *Editors*

Paleontological Collections of Germany, Austria and Switzerland

The History of Life of Fossil Organisms at Museums and Universities

Springer

Natural History Collections

Series Editors

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This book series is devoted to the subject of collecting, organizing and preserving specimens. Natural history collections are the libraries of life and a valuable resource for experts in biodiversity, as well as in evolutionary and environmental sciences. New techniques offer endless possibilities for reanalysing specimens, and natural history collections are an impressive source of undiscovered species. As long as they are properly cared for, even centuries-old specimens can lead to new discoveries. This series highlights the importance of our natural history collections around the globe and summarizes the knowledge, research, opportunities and challenges associated with them. This includes new techniques for sampling and preservation, as well as new exhibition concepts.

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Archives of Earth's History: An Introduction

This book is devoted to the knowledge of up to 250 years of collecting, organizing, and preserving paleontological collections by generations of scientists. Collections are a huge resource for modern paleontological research and should be available for national and international scientists and institutions, as well as prospective public and private customers. Moreover, these collections are an important part of the scientific enterprise, supporting scientific research, public education, and the documentation of past biodiversity. Knowledge gained in order to understand our world is mainly based on data we owe to the collection, preservation, and ongoing study of natural specimens. Properly preserved collections of fossil marine or terrestrial plants and animals are libraries of Earth's history and vital to our ability to learn about our place in it today and in future.

The approach employed by the editors not only involves an introduction to the topic but also pays attention to general aspects such as new approaches of sorting, preserving, and research in paleontological collections as well as new exhibition concepts. In addition, the book provides information about important public museums where research takes place, outstanding state museums and collections in regional, local, or private museums, and also collections at universities. This is a highly informative and carefully presented book, providing scientific insight for readers who have an interest in fossil record, biodiversity, taxonomy, or evolution, as well as natural history collections at large.

German, Austrian, and Swiss scientists have been playing an exceptional role in the development of paleontology as a science since the beginning of the nineteenth century. Fossil sites and collections such as Holzmaden (*Posidonia* shale), Solnhofen/Eichstätt (*Archaeopteryx*), and the Geiseltal and Messel pits (Eocene mammals with preserved soft body tissues) have gained worldwide fame. Researchers such as Blumenbach, Goldfuss, Kaup, Fraas, Stromer, von Huene, Hermann von Meyer, and von Zittel deserve important positions in the hall of fame of paleontology. They described numerous taxa (the type specimens of which are deposited in the respective collections) and contributed important information to the development of the stratigraphic system. German terms like "Lagerstätte" have been incorporated in the terminology of our discipline.

Therefore, after Springer issued the book series "Natural History Collections" and the first volume "Zoological Collections," we were happy that we received consent to compile an overview on the paleontological collections of the German-speaking countries. It was, nevertheless, planned in English as its main audience will be the international paleontological community. A compendium of 57 manuscripts is—naturally—dependent on a diversity of contributors. We are thankful to all those colleagues who reacted positively to our request and provided manuscripts on the collections under their care. Some restrictions were necessary to keep the special limits of the book: We could not consider the hundreds of small fossil collections (mostly communal or private-owned) although we admit that they fulfill important roles at a regional scale. We are sorry and ask your pardon if you were not considered. A small minority of collection curators did not respond to our request or did not deliver a manuscript, even after the deadline had been repeatedly prolonged. Those collections may be included in a future second edition. Finally, we are sure that we attained a representative overview on the important paleontological collections of Germany, Austria, and Switzerland.

As stated in our book on the zoological collections (Beck LA (ed.), Zoological Collections of Germany) museums can be categorized by their legal status: large research institutions (in Germany usually within the Leibniz community), state-owned, university-owned, or private. In the case of paleontological collections, some of the state-owned collections are not housed in a museum, but in a geological service institution (Landesamt für Geologie or Federal Institute for Geosciences). Some statistics may be worth mentioning: The "big seven" of paleontology (more than two million specimens each) are the collections at Basel, Berlin, Stuttgart, Vienna, Munich, the combined Senckenberg collections, and Göttingen. Together with two other "millionaires"— the collections of the Federal Institute for Geosciences at Hannover/Berlin, and the collection of Tübingen University—these nine "big tankers" constitute an amazing number of about 25 million paleontological specimens. The smaller and medium sized collections listed here amount only to about four million. But many of these have historically valuable collections, in case of the Zürich University collection dating back to Scheuchzer's times (beginning of the eighteenth century) or even earlier (collections of Gotha or Schleusingen). Therefore, the collections' history is an important part of each description. Many collections are closely linked to local sites, expeditions to foreign countries, or private collectors who donated their personal collections to an institution. Compiling such diverse information in a single volume is possibly a major virtue of this book.

Each chapter of the book gives the principal data of the respective collection (number of species and/or specimens, main focus of the collection, history), today's conditions of infrastructure of the paleontological collection (staff, rooms, laboratories, exhibitions, perspectives), examples of today's research, national and international networks, publications, or other media, and educational work.

Last but not least we would like to thank the team at Springer, especially Verena Penninger who initiated the book series on "Natural History Collections" and Martina Himberger (Heidelberg), Ms. Suganya Selvaraj and Mr. Dhanapal Palanisamy (Chennai, India) who were very helpful in coordinating and producing this volume.

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Contents

Chapter 1
Research and Open Questions—A Modern Concept Behind Berlins *T. rex* Presentation of Tristan Otto

Uwe Moldrzyk and Linda Gallé

1.1 General Information

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Year of foundation, and age of parts of the collection: Funded as part of the Humboldt-University in Berlin in 1810, current museum building opened 1889. Parts of the collection dating back to the late fifteenth century: one of the oldest objects are pieces of a meteorite found in 1492.

Number of species and/or specimens, focal points: Around 30 million objects. Collections combine geology, zoology, paleontology and botany (mainly fossil plants).

1.2 Introduction

In 1902, Barnum Brown found the remains of an unknown predatory dinosaur in the Hell Creek formation in Montana. Three years later his colleague Henry Fairfield Osborn gave it its scientific name "king of the terrifying lizards"–*Tyrannosaurus rex*. Right from the beginning the remains of this extinct dinosaur caught the public's imagination like no other animal before. The most illustrious dinosaur of all time conquered cinemas in 1933 when it fought King Kong, and ever since Michael

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Crichton and Stephen Spielberg's "Jurassic Park" the muscle-packed carnivore with teeth the size of steak knives has become part of popular culture. *T. rex* became a superstar.

The excitement reached a preliminary climax when a nearly complete skeleton named Sue was auctioned at Sotheby's for $7.6 million (Hoganson 1998). Approximately 50 specimens have been discovered so far, all in North America, none of them complete. Whether they are called Wankel, Sue, Stan or Black Beauty–all of them are only partially preserved, but every find is special. Each specimen is a piece in a scientific jigsaw puzzle that contributes to an ever clearer picture. And all of them are sure fire big sellers for any museum to show them.

1.3 Paleontological Objects in Exhibitions

Fossils in general belong to the classics amongst objects presented in natural history exhibitions. With roots dating back to the sixteenth century, when the famous Swiss naturalist Conrad Gessner (1516–1565) put his collection on display (eNotes 2017), it has always been a premise of natural history museums to communicate science and raise awareness about nature. Since it is the dose that makes the poison the suitable tools to reach this goal are as simple in theory as they are difficult to use: emotion and information. Too much of each might lead a good idea to failure. Excessive information depth might overtax a general audience while an overload of entertainment might interfere with the trustworthiness of the institution.

One could argue that curiosity is one of the characteristics of the human species. Either way it is the driver that leads people to become scientists or to visit museums. But while a researcher can get enthusiastic about any specimen in a natural history collection, not all of them are suited to draw the attention of an audience–even though that is also dependent on scenography and storytelling (Fig. 1.1). However, it is undisputed that eye catchers make a curator's work much easier (Fig. 1.2).

Paleontological collections seem to be the source for ideal objects to induce curiosity and to explain life on earth. Fossils are a screenshot of life that no human eye has seen in reality. They inspire a visitor's fantasy. They are proof of scientific theories–such as *Archaeopteryx* (Fig. 1.3) is an evidence for evolutionary processes as the critics of Darwin's big theory demanded at the time of its publication (Darwin 1859; Kritsky 1992; Wellnhofer 1990). And they are connected to various stories, be it the geological history of an object buried for millions of years under stone, be it the Holmesque approach to extract data and information of the remains or be it the adventurous circumstances of their discovery. Above that, they are proof of extinct species and the battle of life in environments that have undergone multiple dramatic changes over time–thus they can help us understand and explain the environmental situation and challenges we are facing nowadays. And they make darn good eye catchers.

Fig. 1.1 Storage of fossils in the museum collection: Paleo-Botanists might become immediately enthusiastic, a general audience might need some help here. **Copyright**: Carola Radke, MfN

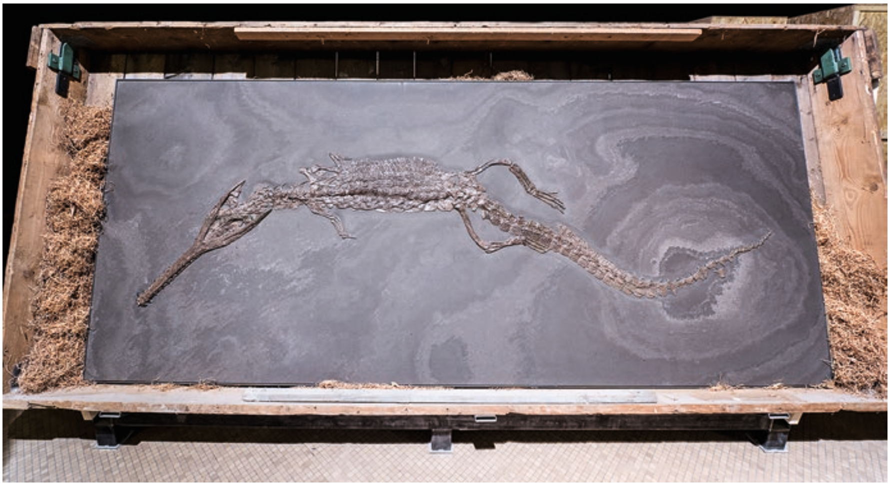

Fig. 1.2 Fossils of the Posidonia shales from the famous Holzmaden locations do make fantastic eye catchers for exhibitions. **Copyright**: Carola Radke, MfN

When the Museum für Naturkunde Berlin opened its renewed galleries in 2007 the wall of biodiversity was one of the eye catchers (Fig. 1.4), but the highlight ever since clearly has been its dino hall.

From the beginning the renewal project aimed on regaining international reputation (Moldrzyk 2015) as one of the important natural history museums in the world. With immediate success–the project got international press coverage over a period

Fig. 1.3 The famous Berlin specimen of *Archaeopteryx lithographica*. **Copyright**: Christoph Hellhake, München

Fig. 1.4 The wall of biodiversity works from the distance like a painting. The closer visitors get, the more the three dimensional character of the objects take over. **Copyright**: Carola Radke, MfN

Fig. 1.5 Sometimes mistaken as an installation: the wet collection actually is a research collection with the possibility for visitors to "have a look". **Copyright**: Carola Radke, MfN

of several months and only a couple of weeks after reopening funding was granted to restore the destroyed east wing and turn one of Berlin's last war ruins into the world's most modern wet collection (Fig. 1.5).

To recognize the museum's weaknesses over the past decades an analysis was run in the beginning of the renewal project. As a result, several premises were formed. First of all, the exhibitions (in an unguided visitor situation) should shift their function from educating the visitor to sparking interest. The general idea was to generate a space were visitors feel comfortable during their roughly 2-h stay and make them curious about nature. Concepts focused on scenography, the esthetics of objects and exhibition displays and a sensitivity not to overload with heavy contents–there should be no competition between objects and information on the visual level. Digital media should help understand objects and related stories but shouldn't compete with the exhibits. Objects should come from the own collection, original items should be preferred over casts, models or reconstructions, and contents should be focused on the research of its scientists or relate to the museum's history.

Regarding target groups the natural history museum in Berlin shifted its focus towards an adult audience. Not to be mistaken: school classes, children and families were still important to the museum, but they were already regular guests at that time. The group with the biggest growth potential was so called "single adults" that would rather be interested in art museums and galleries. Since Berlin is a tourist city, there was plenty of room to improve in that section as well. For the exhibition

Fig. 1.6 A crowded museum: the majority of the visitors in the dinosaur hall in this situation are adults. **Copyright**: Carola Radke, MfN

concepts that meant to reduce "school like" didactics and to avoid playful inter actives for kids, instead to put emphasis on scenography and to use texts written for a general public, not for children–who would hardly ever read themselves anyways, but that is another topic. The results were stunning, visitor numbers increased from around 200,000 to almost 500,000 per year ever since (Fig. 1.6). Visitor statistics prove the concept right: a disproportionately strong increase in single adults has been recorded.

1.4 Would You Like to Have a *T. rex*?

It might be the dream of museum directors that out of the blue someone offers a spectacular dinosaur for free but how about a real phone call from a real person offering a real *T. rex*. Who makes up these stories?

When in January 2015 the telephone rang at the Museum für Naturkunde, nobody knew that less than 12 months later, Berlin would have gained a spectacular crowd-puller: the first original *Tyrannosaurus rex* skeleton on display in Europe. Private collector Niels Nielsen was looking for a museum that would undertake scientific studies on his recently purchased *Tyrannosaurus rex* skeleton TRISTAN OTTO and make it accessible to the public (Ring 2015) (Fig. 1.7). The Berlin natural history museum was chosen not only because of its experience in displaying original

Fig. 1.7 Director General Johannes Vogel, Federal Minister of Education and Research Johanna Wanka and owner Niels Nielsen at the Tristan opening. **Copyright**: Carola Radke, MfN

dinosaur skeletons, but also because of its long tradition in paleontological research. Between 1909 and 1913, a dinosaur excavation took place at the Tendaguru hill in East Africa. Within 4 years, 230 tons of dinosaur fossils were recovered and taken to Berlin for further scientific research, which is still ongoing today. Due to the premises of the renewal project, the scientific results and the history of this important collection delivered the contents of the renewed dinosaur hall. This has the unusual effect that there are less dinosaurs today in the exhibition than there were before even though dinosaurs are crowd-pullers.

The offer was attached to the following conditions: to conduct research on the fossil and to make it accessible to the public by the end of the year. At the time of the phone call, the skeleton of the predatory dinosaur was still in a preparation workshop in Pennsylvania. Scientists from the museum in Berlin went to examine it there. The black bones were well preserved and had some special characteristics but the real sensation was the almost completely preserved skull. Their trip was the kickoff for studies that circle around the fields of anatomy, taphonomy, ecology, functional morphology and paleo-pathology (BMBF 2015). To put up the research program was the easy part.

Less than 11 months to develop and implement a complete exhibition from scratch, around an object that is not even ready to be presented is quite a challenge. But to keep to the own premises is even more so: the *T. rex* skeleton did not belong to the museum's collection, nor would the research program be able to provide results until the opening.

TRISTAN OTTO had been made available to the Museum für Naturkunde Berlin free of charge, for study as well as exhibition purposes. Although the skeleton remains in property of the private owners, it has been given an inventory number of the Berlin museum, a habit that is regular practice in art collections. MB.R.91216 makes the *Tyrannosaurus* find identifiable, and all generated data, including casts and scanning data, accessible for scientists.

Much more of a threat were two other issues related to the presentation of Tristan: How to use own research as the core to develop the exhibition contents, if there hasn't been any research conducted on the specimen so far? And–with adults as a new main target group–how can one seize the attraction of a dino-superstar, but not get overrun by publicity that jumps on the bandwagon of "Jurassic Park", Dino Adventures and other images which would ultimately throw one back in the corner of being a children's or family place only.

1.5 The Concept Behind the *T. rex* Show

Looking backwards the solution seems obvious and simple. As Tristan is the centerpiece of an active research program it should be nothing else in the exhibition. The same approach eases worries about potential risks regarding the image and reputation by being reduced to the Jurassic Park scenario through the media.

From the beginning, the project was brought into the public domain and accompanied by partnership. Both media coverage and the design of the exhibition itself demonstrated what can be achieved by an integrated research museum, bringing together current research in international networks, expertise in the handling of valuable exhibits, and expertise in the communication with the public at large. The arrival of the original skull in July 2015 was a first highlight, and at the press conference, the museum was teeming with journalists (Fig. 1.8). A few days later, a scientific dig began at the discovery site in Montana/USA to find further material for science study in the company of a camera team of the local TV station RBB (RBB 2015). They also reported live on the expedition. When the exhibition opened on 16 December 2015, Tristan grabbed the headlines of the daily newspapers, with a special supplement in the Berliner Zeitung. National Geographic and even the Financial Times reported not only about the exhibition, but also about research and collection.

The exhibition contents highlight the open questions that scientists will address in the coming years. Each of the five main research topics is presented in the exhibition by questions and a video installation in which each scientist explains in own words what is going to be investigated on the fossil and why this is relevant. As a result the exhibition contents evolve along the research program: any time new results are going to be published the exhibition will be able to give answers to some of the questions. In consequence information should be easy to change–a feat that digital media technologies offer with ease (Fig. 1.9).

The exhibition team developed new showcases that use a mix of projection and printed texts along with objects on display. The printed layers are easy to change,

Fig. 1.8 Media attention: the *T. rex* skull arrived in summer 2015. **Copyright**: Carola Radke, MfN

Fig. 1.9 The Tristan app provides additional information on the exhibits. Contents are easy to change if necessary. **Copyright**: Hwa Ja Götz, MfN

without the need of reproducing animations or rearranging the objects. Above all, the projectors enable the use of sensors in a way that only after the visitor's interaction the printed text becomes visible. The idea of "looking behind something", is also a metaphor for the second media installation where film clips are projected on transparent screens. Standing in front of it, visitors can either follow the films or look through them onto the skeleton of Tristan. This leads to an interesting effect that is supported by the position of the screens: visitors will always look at the part of Tristan's skeleton that is most important for the scientist's quest (Fig. 1.10).

However, the transparent screens serve a second purpose namely to regulate the visitor flow in the gallery. With Tristan being positioned in the center of the gallery and the expectation that most visitors would gather around the pedestal there was the need to create an additional incentive for people to back up from the central installation. In this situation, the transparency works its magic: while watching films usually is more or less an intimate situation, in the Tristan hall the audience does not feel locked out. They can still see the main attraction and everything going on in the exhibition hall (Fig. 1.11).

Next to Tristan its original skull is presented in a special showcase, while the cast of it completes the skeleton. Being the highlight of the fossil find the skull is mounted in a way that each of its single fragments can be taken and studied without the need of demounting it completely. Therefore the mount and the showcase have certain specifications to make it conveniently accessible for scientists and allow for studies to be conducted live in the exhibition during opening hours (Fig. 1.12).

The exhibition design is based on the fascination that transfers through probably every fossil find, be it scientist or visitor. Fossil finds are rarely complete, often scattered and twisted, buried and turned into stone from which they reappear in fragments after millions of years. Each has its own hidden story that has to be brought to light and adds to the bigger picture like a piece in a jigsaw puzzle.

The pedestal consists of a number of fragments that seem to be slightly detached–just as the fossil. The surface looks and feels like concrete (which would have been the material of choice be it not for the weight) creating a picture of the skeleton standing above the "stone" it was buried in for millions of years (Fig. 1.13). The illumination from above and underneath generate a playful mix of shadows from the skeleton all over the hall, meant as a metaphor for the remains that nowadays can be seen as the shadow of an animal that used to live in ancient times. These elements are also vivid parts of the overall communication design be it typo, graphics, key visual or the companion book (Fig. 1.14) of the exhibition.

So far the project is a tremendous success. Studies of the skull provided enough data for a thesis, scientific papers on paleo-pathology are about to be published and press- and media coverage (online and print) had a commercial equivalent of approximately 70 million €, Meltwater recorded 3750 online articles, there have been over 1000 printed reports, 481 radio and 152 television broadcasts and more than 1 million visitors have already seen the exhibition. Beyond that the concept of Tristan being the center piece of an ongoing research process transfers right in to the public: just prior to this publication a team of international scientists took samples from Tristan's teeth live in the exhibition with hundreds of visitors taking part (Museum für Naturkunde 2017).

The question of how to visualize the process of research in an authentic way is a hot topic in the field of science communication. There are plenty of projects worldwide dealing with the accessibility of research and collections as modern concepts. However, it is much harder to display real science in an exhibition than it is to give

Fig. 1.10 The magic of transparent screens: depending on the point of view projection and real objects can fuse. **Copyright**: Hwa Ja Götz, MfN

Fig. 1.11 Media installation and object presentation not only work together on a didactical level, they also optimize the distribution of visitors in the exhibition. **Copyright**: Carola Radke, MfN

Fig. 1.12 One of the world's most complete *Tyrannosaurus rex* skulls: 50 out of 54 bones are preserved. **Copyright**: Carola Radke, MfN

Fig. 1.13 The pedestal consists out of concrete-like fragments mixed with show cases and media installations. **Copyright**: Hwa Ja Götz, MfN

Fig. 1.14 Nice gimmick: a special edition of the companion book is covered in concrete. It has to be excavated like the fossil. **Copyright**: Carola Radke, MfN

an authentic view into collections. That is illustrated by numbers of live labs in natural history museums all over the world that can be observed unused or that are run by volunteers instead of scientists. As authenticity is the key word here the Tristan exhibition concept might work as an example for other projects. It at least works for Berlin (Fig. 1.15).

Fig. 1.15 How to measure success of exhibitions: visitor numbers can't be beaten. **Copyright**: Carola Radke, MfN

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Chapter 2
Scientific Methods of Geological and Paleontological Collections and Trends in Paleontological Investigation and Research

Cathrin Hühne

2.1 Introduction

In the last decades the methods of paleontological investigation have been significantly changed, from conventional mechanical and manual methods to technically advanced and computer based techniques. The new abundance of possibilities to investigate a paleontological object has, firstly, the advantage that the new methods can be used without destroying the very valuable and rare objects. A multitude of methods are easy and feasible with manageable costs. Disadvantages are the occasionally long waiting lists for investigation time on the special equipment or high initial costs. Other points to pay attention to are the large amount of required data storage space because of the high resolution scanning, the plethora of different file formats, and connected with these two points, a strategy for data protection and longtime data access.

2.2 Methods of Preparation and Preservation

One of the most important items for paleontological research and investigation is the nondestructive extraction of the fossils from their matrix. Conventional approaches for removing the matrix from the fossil specimen are to use mechanical, physical and chemical preparation methods. Mechanical tools include the use of needles, dentist drills, scalpels, and pneumatic air scibes. Physical methods include brushing, sand-blast units (resources are for example sand, metal

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powder, sodium hexametaphosphate (10%), backing powder or starch), ultrasound and laser beams. Common chemical processes exploit the chemical differences between the fossils and their host rock. According to the chemistry of the matrix and the chemistry of the fossil specimen, acids of different strength are used to dissolve the matrix and separate it from the fossils. For example, weak acetic acid can be used to remove limestone ($CaCO_3$) from phosphatic fossils (Jeppsson et al. 1999).

The general micro-paleontological preparation method is the enrichment of microfossils by dissolving or comminution of the host rocks and washing, sieving and picking out the samples. Furthermore, the fossil morphology can be recovered by filling the cavities of dissolved fossils with plaster, polyester resins, silicone or latex to make a cast. The production of thin sections and peelings, by etching the surface with acetone and transmitting the rock and fossil structures onto special synthetic films ("Triafol") are also common preparation techniques to identify structures of the investigated objects.

For several decades it was usual that rock plates, which enclose fossilized bones, were investigated by X-ray technology before the preparation takes place. For instance, in 2016 X-ray tomography was used by the State Museum of Natural History to investigate a plate of shale at the X-ray apparatus of a hospital in Braunschweig, Germany. On first sight, there were only small pieces of bones visible. However, by investigation with the imaging method of X-ray tomography some complete phalanges of *Dorygnathus*, an Early Jurassic pterosaur, could be identified (Figs. 2.1 and 2.2).

In spite of an extremely cautious approach throughout the preparation process, damage of particular features and delicate structures is possible. Furthermore, these techniques do not allow the study of internal anatomy. A solution to these problems is to take a tomographic approach, creating a 3D model of the fossil from series of 2D slices (Cunningham et al. 2014).

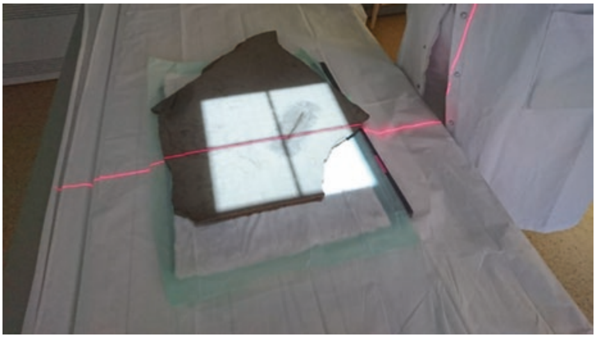

Fig. 2.1 Scanning process of a plate of shale with embedded phalanges of *Dorygnathus* by medical X-ray technology. Image: Sebastian Radecker, State Museum of Natural History in Braunschweig

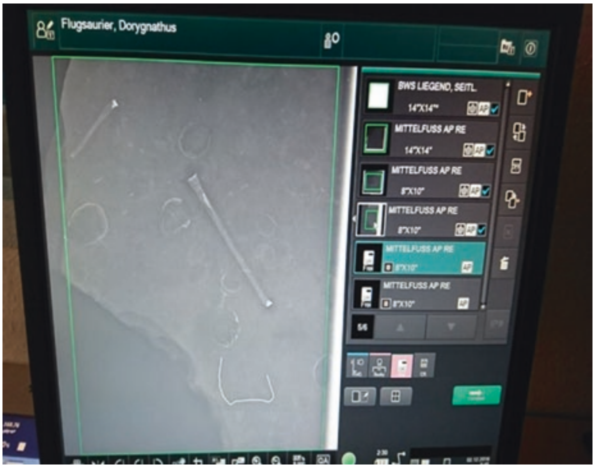

Fig. 2.2 2D visualization of the plate of shale and its fossil content on computer screen. Beside phalanges of *Dorygnathus,* several shells of bivalves can be seen. Image: Sebastian Radecker, State Museum of Natural History in Braunschweig

2.3 Spatial Visualization of Fossils

Computer tomography (CT), known as a very useful medical diagnostic procedure, has developed into a very powerful tool in modern paleontological research within the last three decades. In the 1970s, CT was introduced in material research while, in the 1990s, micro-CT (μCT) became an important nondestructive research technique (Cnudde et al. 2006). Computer tomography, or in full name "X-ray computed tomography", offers the nondestructive examination of valuable and irreplaceable fossils. With CT scans both the detailed analysis of internal structures and the visualization of surfaces in 3D are possible. Very small fossils of a size of less than a millimeter, like microfossils or teeth of small mammals, can be investigated as well as skulls or long bones from a centimeter to nearly a meter size, originating, for example, from dinosaurs or big mammals.

In contrast to the common X-ray, for computer tomography technology (*tomos* = slice, *graphos* = to write) a computer is connected to the X-ray apparatus. CT scanners take a great number of individual radiographs throughout the fossil at multiple angles. Each image is a single projection from only one angle. The CT software takes all these images and reconstructs the fossils, generating slices through the object and merges them into a 3D-graphic (Panciroli 2016).

CT scanning technology, which is used by paleontologists, is different from that of the medical profession. Micro-CT uses higher doses of X-rays than can be used on living organisms, allowing beams to penetrate denser materials like rock (Panciroli 2016). Furthermore, the medical CT scanners are restricted to relatively low-resolution imaging and thus are not able to visualize the fine anatomical details that are preserved in many important fossils, especially samples of sub-millimeter size (Cunningham et al. 2014). The development of the high-energy and high-resolution variants micro-CT and nano-CT were of advantage for paleontological research. Investigations by micro-CT technology have made it possible to differentiate fossils from their host rock entirely digitally. The technology is applicable to a wide range of sample sizes and compositions and is capable to visualize structures and internal anatomy in great details. However, the technology still has difficulties imaging chemically homogenous samples. If fossils and sediment are from the same material with similar properties, the fossils are hard to identify.

Fortunately, there are more powerful X-ray-based technologies, for example the X-ray synchrotron-radiation microtomography. X-ray beams used for X-ray synchrotron microtomography (SR-μCT) present three main properties that enhance significantly the data quality and the imaging possibilities: the monochromaticity, the high beam intensity and the partial coherence (Tafforeau et al. 2006).

A monochromatic synchrotron source, which emits only X-rays of a single energy, avoids the so-called "beam hardening" artefact, which is related to the conventional polychromatic sources and is mainly appearing as brightening of the samples' borders. The very high X-ray beam intensity of a synchrotron radiation source is orders of magnitude higher than that produced by X-ray tubes. High coherence and connected phase contrast leads to a higher image contrast and therefore allows studying fossils that cannot be investigated by conventional micro-CT due to a high degree of mineralization or low absorption contrast (Tafforeau et al. 2006).

The result is a rapidly scanning system at extraordinary spatial resolution, minimum of scanning artefacts, high quality and contrast, as well as, the capability to resolve minerals of similar density.

These properties make X-ray synchrotron-radiation microtomography an ideal investigation tool for paleontology (Tafforeau et al. 2006).

Another alternative technology for fossils with details which need a higher resolution than can be attained using X-ray tomography, even with a synchrotron source, is the focused ion beam (FIB).

Further investigative methods like neutron tomography and magnetic resonance imaging (MRI) have found their way into paleontology.

All the mentioned methods are non-destructive, but are restricted to specific preservation types or require special equipment. Therefore, their application in paleontology will be limited (Cunningham et al. 2014).

2.4 Laser 3D-Scans, 3D Prints and Their Applicability

Spatial visualization of internal structures of fossils is of paleontological interest. The high resolution nondestructive 3D-imaging of external surface features also finds its way in paleontological investigation and research. The surface scanning methods collect spatial and geometric digital information from the outer surface of the object during the scan process. The advantage of the surface scanning systems is that they are cheap, portable and useable for everyone under almost all conditions. Especially valuable collection objects could be protected by 3D-scanning and printing, because investigations of the object itself could be omitted, as well as eliminating the transport dangers.

Common surface scanning methods are laser scanning and photogrammetry.

At the State Museum of Natural History in Braunschweig the team used 3D-laser scanning technique in 2008 and 2009 to scan the bones of *Spinophorosaurus*, a dinosaur which was found in 2007 in Niger, West Africa.

During the scanning process the laser scanner has to be moved around the object or the object has to rotate on a rotation plate in front of a calibration board (Fig. 2.3). The object-data are transmitted in real-time to the connected computer-system (Fig. 2.4).

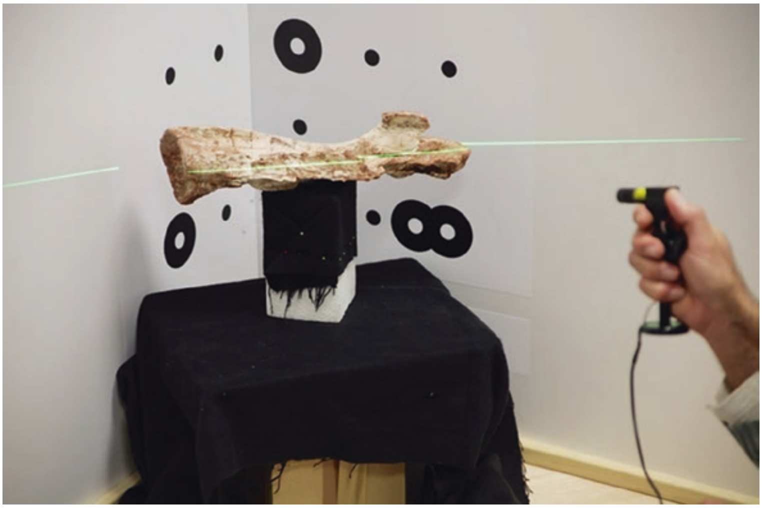

Fig. 2.3 Scanning process, the technician scans the object by moving the laser-scanner. Image: State Museum of Natural History in Braunschweig

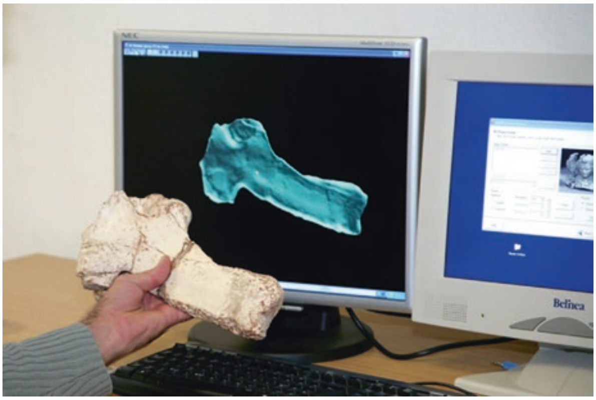

Fig. 2.4 The data are transferred in real-time into the computer system and the object appears immediately on the screen. Image: State Museum of Natural History in Braunschweig

With special software the scans of every single piece of bone were edited digitally. Subsequently, the scans were assembled together (Fig. 2.5).

The digital 3D-copies of the bones could now be adjusted, because the bones were deformed by overlaying sediments (Kosma and Ritter 2009) (Fig. 2.6).

After this, the images can be printed by a 3D printer. For the process of printing a special powder of calcium carbonate with a cover of epoxyd (laser sinter method) was used (Kosma and Ritter 2009). The 3D prints were stabilized with plastic hardener.

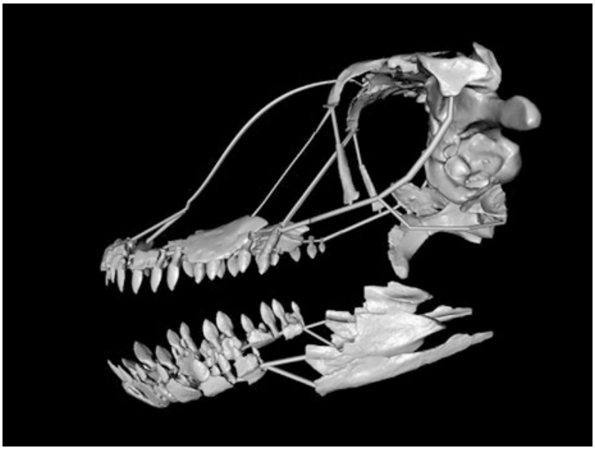

Fig. 2.5 3D images of cranial bones of a Sauropod are assembled together by computer software. Image: Achim Ritter, State Museum of Natural History in Braunschweig

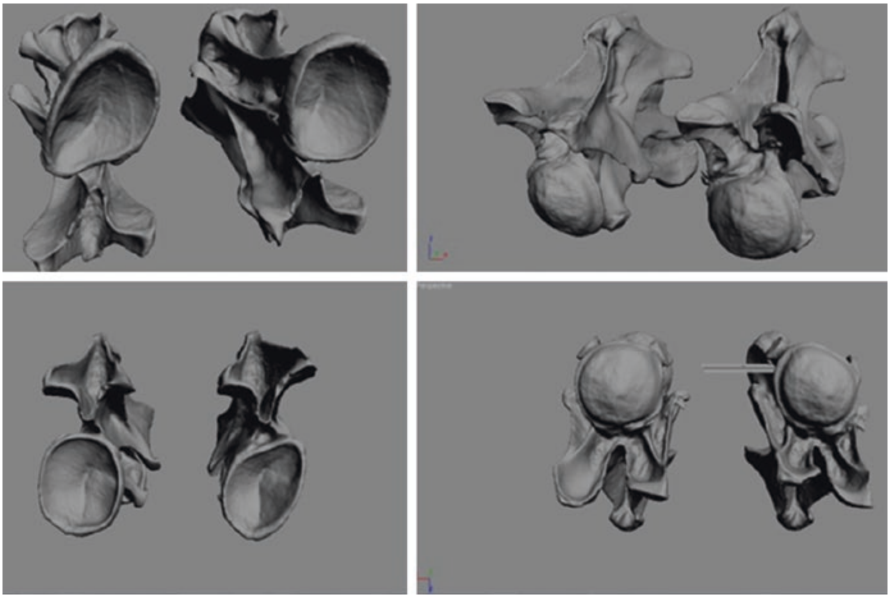

Fig. 2.6 Software-based adjusted vertebrae. Image: Achim Ritter, State Museum of Natural History in Braunschweig

Photogrammetry is an indirect method of 3D scanning. Computer software reconstructs the geometric proportions of an object from a series of overlapping images. The photographs from different angles and orientations of the object could be made by a common digital camera or smartphone of adequate resolution to determine all information of the shape. This method is very effective, easily accessible and cost efficient.

2.5 Processing of Data /Analysis

With advancing development of methods to visualize internal structures of fossils, and the detailed reconstruction of parts of it, analytical possibilities through computer modeling have developed too.

There are a number of functional analysis techniques, which can be used, depending on the focus of investigation.

Both finite element analysis (FEA) and computational fluid dynamics (CFD) are methods, which were adopted from engineering. FEA is a numerical method which allows to analyses the static and dynamic behavior of complex structures. FEA enables paleontologists to testify biomechanical hypotheses and to simulate different load cases, such as different conditions of strain and stress on a numerical model (Fastnacht et al. 2002). Whereas CFD can be used to test various hypotheses (Rahman 2017) relating to the functionality and ecology of fossil taxa, for example of the performance in aerial or aquatic environments.

Multibody dynamics analysis (MDA) is used to estimate the performance of vertebrate skeletal and soft tissues like muscles (Marcé-Nogué et al. 2015). MDA is a method to simulate systems consisting of bones, muscles, ligaments and tendons. The multibody system is used to model the dynamic behavior of interconnected bodies.

Generating accurate 3D images by CT and transforming them to Computer Aided Design (CAD) format, enables the possibility of conducting vertebrate simulation studies.

2.6 Data Storing

The establishment of the methods mentioned above, the falling costs and increasing availability of CT scanners has generated an increase in the amount of produced digital datasets, and because of the high resolution the datasets of CT scans can be very voluminous. This means that the memory capacity has to increase in the same way. On the one hand, own servers can be used for such data sets, in best case connected with the objects they belonged to in a collection database. On the other hand, the online sharing of datasets is more and more expected, led by the wish to make them available to the entire community, but this infers some problems. Researchers do not want to share datasets before they have published their findings. Second, the datasets exist in a very wide range of file formats, and a standard file format has not yet been agreed upon (Cunningham et al. 2014). Another point is that a repository for such datasets cannot be realized in place by every museum or research group.

With regard to data storing the development of a strategy for data protection and long time data access is mandatory. Frequent migration of datasets, and the use of data formats which are presumably enduring and long living are necessary as well as the application of a standardized vocabulary and specifications about originators and utilization rights.

For the use and data storing of the new large digital datasets and images it seems to be essential to quote the different parameters, which were used to create the data-set (Cunningham et al. 2014).

Current technical standards, especially with regard to backups and data protection, have to be taken into consideration.

To ensure a high quality of data and to make it easier for researchers to share data it could be useful to establish rules for the utilization of scans and 3D models by third parties. The utilization should take place in terms of knowledge enhancement because the link of different investigation methods with different focus on key areas could give a more extensive understanding of evolution, the way of life and the properties of former animals.

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Chapter 3
BAMBERG: The Paleontological Collection at the Museum of Natural History in Bamberg (NKMB)

Matthias Mäuser

3.1 History

The natural history collections of Bamberg's Museum of Natural History date back to the late eighteenth century. In 1791 the Prince Bishop to Bamberg and Würzburg, Franz Ludwig of Erthal, established a cabinet of natural history for his university in Bamberg (Mäuser 1995). Evidence of his efforts during the outgoing Age of Enlightenment can be found in the museum's Cabinet of Natural History, a museum within a museum, so to speak, and known today as the "Hall of Birds." While the design of the room has remained largely preserved in its original form, very few objects (among them fossils) remain from the original collections acquired by the prince regent.

In the nineteenth century, the special focus of the natural history collection efforts was the field of zoology. Nevertheless, a systematic fossil collection was also created, which, up until the beginning of the twentieth century, included about 7000 objects from all around the world. There is neither a specialization based on formations nor places of discovery. The main supplier of these purchased items was the famous mineral retailer *Mineralienhandlung Krantz*. Today, the museum's paleontological collection includes some 16,000 objects and thus remains one of the smaller collections in this field.

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3.2 The Collection Takes on a Regional Focus

In the twentieth century, the endemic Jurassic area became increasingly prominent. Theodor Schneid, curator at the museum from 1917–1945, accumulated (among many other native fossils) a special collection of some 1000 ammonites from the Late Jurassic of the Northern Franconian Jura. These include numerous specimens discussed in his publications (bibliography at Dettner 2015). A valuable addition is a collection of 700 plant fossils from the Early Jurassic from Großbellhofen/Middle Franconia, which was donated to the museum in 2001 by A. Müller/Erlangen. The museum collection is constantly being enriched by fossils of the Franconian Jurassic thanks to the collections of Thomas Bechmann, the museum's geoscientific fossil preparator.

3.3 Current Focus: The Wattendorf Plattenkalk

Since 2004, the museum has been performing an annual excavation in a quarry near the village of Wattendorf in Upper Franconia, with each dig lasting several weeks (Mäuser 2014). Within the quarry, bedded carbonates crop out in vertical and horizontal contact to massive dolomitized bioherm. These carbonates filled up the relief of the bioherm-basins. In the lower part of these accumulations fossil-rich plattenkalks occure, similar to the "Solnhofen Limestone" (Mäuser 2015). With an age dating back to the early Upper Kimmeridgian, however, they are slightly older than any other known laminated plattenkalks of the Late Jurassic period.

In the course of these excavations we have been able to retrieve some 4000 specimens. All fossils, together with their corresponding data, are entered into an excavation log on-site at the quarry. Later, the records are transferred to Excel files. Unless the specimens are put on display in the museum, they are kept in the museum stacks, which are equipped with a compacting unit.

In addition to terrestrial plants and marine algae, there are representatives of different strains of invertebrates, namely molluscs, brachiopods, cephalopods, echinoderms and a very diverse crustacean fauna. The fish fauna is likewise extremely diverse and reflects a variety of different habitats. Coelacanths and angelsharks have been found relatively frequently. Especially impressive are the numerous reptile discoveries, among which turtles are the most frequent. Crocodiles, various Rhynchocephalians, as well as a pterosaur were also among the specimens found. The latter, due to its uniqueness, has recently been included in the FRG list of nationally valuable cultural assets. As the previous treatment of the fossils shows, a large part of these species are new taxa (Figs. 3.1 and 3.2).

The ownership status of the discovered fossils is not without issue. All of the invertebrates as well as the smaller fish remain the property of the museum. The spectacular reptile specimens are divided between the museum and the quarry company. Since the technically-accessible Wattendorf plattenkalk deposits are to be removed in the long term by operational measures, the excavations will continue to

Fig. 3.1 Rhynchocephalian NKMB-P-Watt 15/56 from the Wattendorf Plattenkalk under ultraviolet light. Total length 54 cm. Foto: H. Tischlinger

Fig. 3.2 Coelecanth Undina penicillata NKMB-P-Watt 08/212 from the Wattendorf Plattenkalk. Total length 97 cm. Foto: NKMB

be the focal point of the museum's palaeontological work in the future with the express purpose of saving as many of the unique fossils as possible. Due to staffing constraints at the museum, the excavations are being carried out with the participation of trained volunteers and interns, as well as graduate students and colleagues at associated institutions. The systematic processing of the individual taxa is being carried out by scientists both here in Germany and abroad.

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Chapter 4
BASEL: The Natural History Museum Basel (NMB)

Walter Etter, Michael Knappertsbusch, and Loïc Costeur

4.1 Introduction: History Infrastructure Current Research Teaching and Didactic Outreach

The Natural History Museum Basel was founded in 1821 but its origins go back considerably further (see below Sect. 4.2.2). In 1849 it moved, together with the art collection, the collection of antiquities, the university library, the laboratories of physics and chemistry, into the new museum building at the Augustinergasse where it is still located today. The ever growing collections soon led to cramped conditions that were lessened with the moving out of the other institutions, the acquisition of additional neighboring buildings, and the construction of four large basement levels (Simon 2009; Huber et al. 2011). Yet the museum can no more house all of its collections, and since 2014 a large external storage accommodates the whole entomological collection as well as parts of the palaeontological collections. Currently, a new museum building at another location is in the planning. The museum is entirely funded by the government of Canton Basel-Stadt. Additional financial support for exhibits comes mostly from private sponsors, and research is in part financed through the Swiss National Science Foundation.

Today, the palaeontological collections are organized in two different subunits, each consisting of numerous individual collections (see Table 4.1).

Areas of active research based on the collections have varied over time. In the Geological collection taxonomic work on Neogene Mollusks from the Caribbean, taxonomic revisions of reference material, Jurassic ammonite stratigraphy, as well as the buildup of standardized stratigraphic correlation schemes (Gygi 2014) formed a focus until about 2000. In the Osteological collection, most research concerns the

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Table 4.1 Main features of the palaeontological collections at the Natural History Museum Basel (NMB)

Name	Geological collection	Osteological collection
Content	Fossil plants and invertebrates, microfossils (plus some rock samples)	Fossil vertebrates, skeletons of modern vertebrates
Permanent personnel	2 curators, 1 collection manager, 1 preparator	1 curator, 1 collection manager, 1 preparator
Number of specimens	3,500,000	600,000
Size	900 m^2	1200 m^2
Important subcollections	• Reference collections • Historical collections • Regional collections (e.g. Jura mountains, Caribbean, Indonesia, Middle East—Northern Africa) • Systematic collection • Special collections (e.g. collection Mayer-Eymar, Schaub)	• Fish collection • Amphibian collection • Reptile collection • Bird collection • Mammal collection • Bone alphabet
Collection and specimen inventories	• Hand- and machine written catalogues (up to 1990) • Database: MS Access, since 2012 BioOffice • Electronic archives (since about 2012)	• As for geological collection
Main exhibits	• Gallery of invertebrate fossils from northern Switzerland	• Dinosaur exhibit • Hall of extinct mammals

collection of mammals. A current focus of palaeontological research at the NMB is the phylogeny of Neogene Artiodactyla using micro-tomographic reconstructions of the middle and inner ear, and studies of evolutionary patterns in selected planktic foraminifera.

With interruptions, the palaeontology courses at the University of Basel were often taught by personnel of the NMB, more regularly, however, since about 1998. There are different kits with palaeontological material (e.g. dinosaurs, fossils, extinctions) for schools. Since 2016 the proceedings of the Basel Society of Natural Sciences also take place in the NMB. The Museum is furthermore on Facebook, and an electronic newsletter can be subscribed to.

4.2 The Collection of Microfossils, Fossil Plants and Invertebrates

These collections, traditionally labelled the “Geological collection” of the NMB, are stored in one large cellar at the museum itself (Fig. 4.1) and in one additional room in a large external storage facility. Together, these collections are estimated to

Fig. 4.1 Left: Storage cellar with mobile shelving facilities containing up to 200 drawers in one rack. Right top: Drawer with *Nummulites polygyratus* from the large reference collection to Schaub (1981). Right bottom: Detailed drawing and 3D-wax model of the large foraminifer *Orbitolina,* made by Manfred Reichel around 1955 but never published

total to about 3.5 million specimens (macrofossils, however with numbers of microfossil samples probably underestimated). The climate is artificially kept constant at 17–21 °C, and at a low relative humidity of 40–50%. This low humidity is instrumental in the inhibition of pyrite decay and formation of mold in paper documents and osteological collections. Different subcollections are curated and (digitally) catalogued to varying degrees and standard.

4.2.1 Reference Collections

The NMB curates approximatively 1600 collections of microfossils, fossil plants and invertebrates (Fig. 4.1) that contain published specimens (types, figured and listed specimens). On average between 5 and 15 new reference collections are established per year. A list of these is available at: http://www.nmbs.ch/home/museum/sammlungen/geowissenschaftlich/palaeontologie-wirbellose-und-pflanzen/typen-und-Belegsammlungen.html (→ Typen- und Belegsammlungen Details). For most of these we also preserve paper copies and pdf documents of the publications. For some studies we only house part of the material, the remainder being curated at other museums.

At present we do not have a definitive count of primary types and syntypes but they must number to over 2000. Almost all of the approx. 250,000 specimens/samples in the reference collections were given inventory numbers but only a small fraction of these are currently in our electronic database.

4.2.2 Historical Collections

These can be considered part of the reference collections, containing published material from the sixteenth through eighteenth century (Rutsch 1937). The highlights are specimens that were figured by Walch (1768–1773), Bruckner (1748–1763), and finally Gessner (1565; Fig. 4.2). The latter collection contains seven specimens/lots (parts of it kept in the Mineralogy collection: Felix Platter collection) and it is the oldest palaeontological reference collection worldwide (Etter 2016)!

Fig. 4.2 Two sample pages from Conrad Gessner's "De rerum fossilium … liber" (1565) and Gessner's original crab *Palaeocarpilius macrochelus* (Desmarest) that survived up to now in the NMB; length of the crab along the midline is 8.5 cm. Please note that the woodcut is inverted and that the draftsman complemented the broken parts

4.2.3 Systematic Collection

Probably more than one million specimens are kept in the systematic collection, ordered in their majority according to the (sometimes badly outdated) Treatise on Invertebrate Paleontology. Especially valuable is our material from the Jurassic from the Jura Mountains: sponges, corals, brachiopods, bivalves, gastropods, ammonites and echinoderms. Also important is the collection of Late Triassic plants from the Basel region. Pyritized fossils are kept separately to facilitate survey of possible decay.

4.2.4 Regional Collections

The regional collections are ordered according to geography and stratigraphy but not always in the same manner. Most important among them are:

- The collection of fossils from the Swiss Jura mountains (although much material was over the years transferred to the systematic collection); 1100 drawers with approx. 75,000 specimens.
- Fossils from the Swiss Alps, mostly from the Helvetic realm.

Many of the regional collections were established in the course of exploration for minerals or petroleum by members of the Basel University during the first half of the twentieth century who sent their material to the NMB, and therefore we also have important regional collections from other parts of the world:

- Rocks and fossils from south-east Asia, mainly today's Indonesia; important subcollections come from East and West Timor, the Moluccas, Java and the Lesser Sunda Islands, and Kalimantan (see also the review of Hottinger 2013).
- Rocks and fossiles from the Middle East and northern Africa; many samples with smaller and larger foraminifers.
- Caribbean collection; what started also as a regional-stratigraphic collection of geologists doing petroleum exploration mainly in Trinidad and Venezuela between 1920 and 1950 (Higgins 1986; Jung and Saunders 1987; Gisler 2014) turned, apart from 1960 and with international partners, into palaeontological research projects that investigated the Neogene fauna of the northern Dominican Republic (Saunders et al. 1986) and the Isthmus of Panama (Collins and Coates 1999; Jackson et al. 1996). With over 700,000 specimens of mollusks, corals and echinoderms we have one of the largest and best documented collections of Cenozoic fossils from that region. Especially to mention are the contributions of Hans G. Kugler (1893–1986) from Basel, who was a leading pioneer and expert in petroleum exploration in the Caribbean realm, and who was chief geologist of the oil company Trinidad Leaseholds Ltd (T.L.L.) until 1959. From his extensive field works in Trinidad and Venezuela he did not stop sending rocks and fossils

to the NMB, which now form the heart of many Caribbean collections in our hose. Notably—and less well known—is, that the NMB hosts probably an almost complete archive of T.L.L. documents, reports and maps about the geology of Trinidad and northeastern Venezuela—some of them confidential at those times—that later lead to Hans Kugler's famous "Treatise on the Geology of Trinidad" (Kugler 1959–2016).
- Fossils from the Mediterranean region, mostly Greece, collected by Carl Renz (1876–1951); 250 drawers with approx. 12,000 specimens.

4.2.5 Micropaleontological Collections

Micropaleontological collections at the NMB were put together for various reasons and motivations: Many of them were installed as type-collections to give reference to first descriptions of new species or genera. The majority of the micropaleontological collections, however, entered the museum as reference collections to particular research projects or publications of renowned Swiss and foreign micropaleontologists (see above Sect. 4.2.1), who have worked in academia or in oil industry. These collections have therefore a regional, stratigraphical, environmental or taxonomic character, depending on the specialist. The majority of these collections is quite well documented with publications, maps, unpublished reports, film negatives or printed photos, drawings, stratigraphic sections, field-books or correspondence, that either directly accompany the material or are deposited in the various geological archives and specialist hand-libraries of the NMB. Some of these collections are so extended in volume, that they are treated as "Special collections" (see below). Parts of these collections served also for teaching during university classes or specialist courses in symposia or industry. It is not known how many specimens, thin-sections, slides, sediment samples, preparations all micropalaeontological collections consist of, but they probably surpass the specimen numbers of the remaining geological collections.

The main curatorial activity concerning the micropaleontological collections focuses on documentation of these collections and associated archives, cross-reference collections where it is possible and reasonable, and indicate the physical locations where collection parts, archives, libraries or electronic media are scattered in the museum. This knowledge is laid down in an on-line inventory called "The Micropaleontological Collections held at the NMB in Basel" and is accessible under: https://micropal-basel.unibas.ch/Colls_NMB/MPCOLNMB.HTML

4.2.6 Special Collections

Several collections are kept separately, mainly for reasons of specialization of a researcher and size of the particular collection, e.g. (to name a few):

- Schaub collection: Hans Schaub (1913–1994) left us probably the largest and finest collection of nummulites in the world. This not only comprises a very large reference collection to Schaub (1981; Fig. 4.1) but also a systematic collection of *Nummulites* and *Assilina* plus many washed and raw samples.
- The collection of Lukas Hottinger (1933–2011) comprises an equally huge collection of benthic foraminifera that were raised during the long scientific life of this researcher. They comprise alveolines, nummulites and other larger foraminifera from the Paleogene of the Circum-Mediterranean Tethys, the Near-East and Far East, taxonomic studies of Mesozoic and Cenozoic benthic foraminifera from Morocco, materials from studies about environment, taxonomy and biology of recent benthic foraminifera in the Mediterranean Sea, Red Sea, Indian Ocean, Atlantic Ocean and the Pacific.
- The collections of Manfred Reichel (1896–1984): Manfred Reichel can be seen as one of the intellectual fathers for the "foraminiferal school in Basel". He was renowned for his excellence in drawing, reconstruction and 3D–modeling of foraminiferal structures from thin-sections (Fig. 4.1) far earlier than the invention of the modern method of computed X-Ray microtomography. He was very influencial in the development of the concept of functional morphology in microfossils, and that was further followed up so intensely by his student Lukas Hottinger.
- The collection of Hans M. Bolli (1917–2007), John B. Saunders, and Hans G. Kugler mainly with numerous taxonomic and stratigraphic studies to develop the worldwide tropical planktic standard foraminiferal zonations during the Mesozoic and Cenozoic.
- The MRC collection: The West European Micropaleontological Reference Center of the DSDP, ODP and IODP at Basel is one of worldwide 15 such centers to curate prime reference materials from DSDP and ODP campaigns (Knappertsbusch et al. 1998). These collections include preparations of Mesozoic through Cenozoic foraminifers, radiolarians, diatoms and calcareous nannofossils from all oceans; see also: https://iodp.tamu.edu/curation/mrc.html
- Gygi collection: Reinhart Gygi (1935–2014) measured and sampled between 1960 and 1995 more than 200 sections in the Oxfordian and Kimmeridgian of northern Switzerland. This material which includes more than 10,000 ammonites, rock samples and other fossils fills now around 800 drawers in the NMB. The published specimens, however, were transferred to the reference collections.
- Mayer-Eymar collection: Charles Mayer-Eymar (1826–1907), long-time employee and curator at the ETH Zürich, assembled in a life-long career several hundred thousand specimens of Tertiary mollusks from Europe and northern Africa. He described more than 1000 new species of gastropods and bivalves of which the types are within the collection and not always easily accessible. The Mayer-Eymar material belongs to the ETH but came in 1965 as a loan from Zürich to the NMB and is now kept here as a permanent loan. This collection is of paramount importance for those who work taxonomically on Palaeogene and Neogene mollusks.

- Raw-materials collection: Raw sediments were collected by a number of researchers working at the NMB during excursions and field trips to micropaleontological and stratigraphic symposia, mainly in the period from the 1960s to about 2000. The goal of such collections was to build up a kind of paleontological or micropaleontological "lithotheque" from well-known published standard stratigraphic sections, from where researchers may also sub-collect materials for their own research. Typically for the research focus at the NMB during that time, the raw material collections hold materials from the Caribbean Sea (West Indies, Trinidad, Dominican Republic), Central America (Panama), European Paleogene stratotype sections (Italy, Spain, France, Belgium, and England), Mesozoic standard sections from the Apennine, and from Switzerland.

4.3 The Collection of Fossil Vertebrates

This collection is, together with the collection of modern vertebrates, known as the "Osteological collection" and occupies also one large cellar at the NMB. Comparative anatomy became a particularly useful method in the nineteenth century and palaeontologists and university teachers built comparative collections made of extant and extinct animals. This tradition was followed over decades in Basel so that both the extant and extinct species are all stored next to one another, facilitating the work of today palaeontologists and palaeobiologists. The collection was established by Ludwig Rütimeyer (1825–1895) in the late nineteenth century and subsequently expanded by Hans Georg Stehlin (1870–1941), Samuel Schaub (1882–1962) and Johannes Hürzeler (1908–1995). The latter also established a much used register of fossiliferous localities in the Swiss Molasse basin (today more than 1000 localities) that forms an integral part of the collection. From 1968 until 1999, the collection was considerably enlarged by the efforts of Burkart Engesser who sampled around 30,000 teeth of small mammals.

Within the different vertebrate classes, all the specimens are ordered according to stratigraphy and locality. In contrast to the situation of the "Geological collection", types and published specimens are left within the main collection where they are specially marked.

4.3.1 The Collection of Fossil Fishes, Amphibians, Reptiles and Birds

The collection of fossil **fishes** comprises specimens mostly from European localities that are stored in approximately 250 drawers. Important are fishes from the Oligocene Engi slates (Matt Formation, Northern Helvetic Flysch) and freshwater fish remains from the Late Triassic dinosaur locality of Niederschönthal.

The collection of **amphibians** is rather small and comes mostly from localities in Europe that have also yielded other vertebrate remains.

Within the collection of **reptiles** (approximately 120 drawers), turtles are quite well represented with material mostly from the Late Jurassic of the Solothurn region and the Canton Jura. Also worth mentioning are the well preserved remains of the parareptile *Sclerosaurus* from the Early Triassic of the Basel region. Marine reptiles and crocodilians are not very well represented. Quite important are the dinosaur remains of *Plateosaurus* from the Late Triassic of Niederschönthal near Basel and of *Cetiosauriscus* from the Late Jurassic of Moutier, canton Bern. Also in the Basel collection is the holotype of the oldest azhdarchid pterosaur *Auroazhdarcho primordius* from the Late Jurassic Solnhofen limestone.

The collection of fossil **birds** (approximately 85 drawers) contains, except for a beautiful specimen of *Confuciusornis*, only material from the Cenozoic. The best represented localities are from the Miocene of the Allier basin in France, especially from Montaigu. All the material consists of isolated bones. An overview of material from the Swiss Molasse basin has recently been published (De Pietri et al. 2013).

4.3.2 The Collection of Fossil Mammals

This collection is one of the largest in Europe. It contains only Cenozoic material, mostly from the Swiss Molasse basin and the adjoining countries.

The European **Palaeocene** mammals are represented by a number of localities mostly from the French Paris Basin, in the area of the city of Reims. Worldwide known localities such as Cuis or Mont de Berru have been investigated in the past 150 years and have improved our understanding of the beginning of the Cenozoic mammalian radiation. The material stored in the NMB is significant albeit not extremely abundant. Highlights are beautifully preserved specimens from Mont de Berru including skulls and cranial remains of early ungulate-like mammals (e.g., *Arctocyon*, *Pleuraspidotherium*) or the famous primate-like Plesiadapiformes (*Plesiadapis*. *Platychoerops*, *Chiromyoides, Berruvius*).

Remains of **Eocene** mammals are stored in more than 700 drawers. The most important locality is Egerkingen where more than 50 mammal species, most of them new to science, were recovered from fissure fillings. Another notable locality well represented in the NMB is Bouxwiller (Bas-Rhin, eastern France). Parts of the finds from the Quercy phosphorites (see below) are also of Eocene age (Fig. 4.3). A catalogue of the holotypes of Eocene mammals in the collection of the NMB was recently published (Costeur and Schneider 2011).

Oligocene mammals are well represented in the collection of the NMB and were collected in many different localities in the Swiss Molasse basin (Lower Freshwater Molasse, Middle and Upper Oligocene). Also very important are the mammals from the Quercy phosphorites (southwestern France) and from St. André (southern France, near Marseilles). Bones from the latter locality contain quite often pyrite; its decay results in the destruction of the bone. Over the last years, a laborious removal of pyrite and conservation of the skeletal material was undertaken by the preparators and is now completed.

Fig. 4.3 Left: *Cercamonius brachyrhynchus* (Stehlin 1912)—NMB Q.V.619—Holotype of the Eocene primate from Prajoux (Quercy), originally published by Stehlin (1912). Right: Skull of the Eocene artiodactyl *Mixtotherium cuspidatum* Filhol, 1880—NMB Q.W.1749—Quercy

Several hundred localities in the Swiss Molasse basin (Upper Freshwater Molasse, Lower and Middle Miocene) and in the Swiss Jura Molasse (e.g. Charmoille) have yielded **Miocene** mammalian remains. Equally important are the contributions of localities in France (e.g. Paulhiac, Saulcet, Montaigu and Sansan) and Germany (Steinheim am Albuch). Remains from the famous Greek localities Pikermi and Samos are stored in the NMB, including primate partial skulls (*Mesopithecus*) or an exceptional hyrax skull (*Pliohyrax*). An important locality in Italy is the Baccinello region. In 1958, J. Hürzeler discovered in a coal mine an almost complete skeleton of the hominoid *Oreopithecus bambolii*, a primate that was apparently bipedal although its relationships to other hominoids are still disputed. Most finds are now in the Natural History Museum of Florence but Basel still keeps important material (including cranial and postcranial remains).

Fossiliferous **Pliocene** sediments are very rare in the Swiss Molasse basin and in the Jura Molasse. Mammals from the Pliocene in the NMB collection come mainly from French (Montpellier region, Vialette, Perrier, Etouaires) and Italian (Villafranca d'Asti, Valdarno basin) localities. Highlights are a fairly complete lynx skeleton from Perrier, beautifully preserved skulls of aardvarks, a tapir and a pig from French localities.

Various mammals from the **Pleistocene** were found in Ice Age sediments of the Basel region, some already in the early eighteenth century (described by Bruckner 1748–1763). Additional remains also come from neighbouring sites in Germany and France. Type localities of the middle and upper "Villafranchian" stage that were previously assigned to the Pliocene are according to the new timescale dated as Pleistocene: St. Vallier and Senèze in France representing more than 5000 fossils including several complete skeletons (a machaerodontine, rhinoceroses, antelopes, deer, horses, pigs, elephants), and parts of the Valdarno basin sediments. An important part of the Pleistocene collection is the material assembled by Charles Immanuel Forsyth Major (1843–1923). He started collecting Plio-Pleistocene mammals around 1870 in Tuscany, later Pleistocene mammals on the islands of Sardinia and Corsica (including several species showing insular dwarfism and island gigantism), and even later in Greece and Madagascar. Other museums housing parts of the Major collection are the Natural History Museum London and the Musée Cantonal de Géologie, Lausanne.

Few **Holocene** mammals are also in the NMB collection but this is material from archaeological sites. It is planned to transfer these remains to the Archaeological Survey of canton Basel-Stadt.

4.3.3 "Bone Alphabet"

As zoology professor, Ludwig Rütimeyer curated at the University of Basel a collection of vertebrate skeletons. Hans Georg Stehlin could transfer these skeletons into the museum's osteological collection, where these modern bones were used for comparative purposes and to aid in the identification of fossil bones.

Today this "bone alphabet" for the mammals contains diagnostic post-cranial bones such as those of the limbs and girdles. Skulls are stored separately but can also be accessed for comparative purposes. The "bone alphabet" for the birds contains mainly limb bones, sterna, wishbones and pelvic girdles as well as selected skulls. These "bone alphabets" are frequently consulted by visiting palaeontologists and archaeologists.

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Chapter 5
BERLIN: The Palaeontological Collections of the Museum für Naturkunde Berlin

Christian Neumann, Stephan Schultka, and Florian Witzmann

5.1 Introduction

The palaeontological collections of the *Stiftung Museum für Naturkunde Berlin* contain more than 2.5 million specimens used for research and display. Because of construction work at the museum building, the material is at the time of writing (2017) housed not only within the museum on Invalidenstrasse, but the main invertebrate palaeontology collection has been outhoused in the east wing of the museum building. They are currently stored in a former student canteen on the museum campus but will return to its original collection hall in autumn 2018. More extensive parts of the collection are also stored ca. 5 km away in a separate building in Berlin-Moabit at Reuchlinstrasse. The collections are generally systematically arranged, but important stratigraphic and regional suites do exist. Most specimens are kept in approximately 1400 wooden cabinets, shelves, and glass cases spread over 9 collection halls. The collections are divided into three main sections, the so-called *Hauptsammlungen* ("main collections"): fossil invertebrates, fossil vertebrates, and palaeobotany.

5.1.1 History of the Collections

The oldest parts of the palaeontological collections date back to the eighteenth century and have their origin in the foundation of the *Königliches Mineralienkabinett* (Royal Mineral Cabinet) in 1781, which was derived from the *Naturalienkabinett*

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der königlichen Kunstkammer (Natural History Cabinet of the Royal Art Chamber) of the Brandenburg-Prussian Royal family and the *Berliner Bergakademie* (Berlin Mining Academy) that was founded by Frederick the Great in 1770. In 1812, the *Königliches Mineralienkabinett* was transferred to the *Mineralogisches Museum der Universität* (Mineralogical Museum of the University) of the newly founded *Universität zu Berlin* (University of Berlin), the later Humboldt University. The museum was located in the *Prinz-Heinrich-Palais*, Unter den Linden 6, and its first director was Christian Samuel Weiss from 1810 until his death in 1856. He was also professor of "mineralogy", which included *Geognosie* and *Petrefaktenkunde* (the precursors of modern geology and palaeontology, respectively) at that time. The size of the collection was extended by means of new purchases and by personal collections undertaken by scientists and students of the university. Alexander von Humboldt had already donated remains of Pleistocene mammals from South America to the *Mineralienkabinett* in 1801. The geological collection of the *Gesellschaft Naturforschender Freunde zu Berlin* (founded in 1773) was gradually incorporated into the collection after 1827. In 1833, the *Mineralogisches Museum* acquired the palaeontological collections of Ernst Friedrich von Schlotheim (one of the founders of scientific palaeobotany). Among other acquisitions, the museum bought Pleistocene moas from New Zealand in 1850 from the Dutch dealer (*Naturalienhändler*) G. A. Frank and received the geological collection of the famous geologist Leopold von Buch. In 1857, the university purchased the important collection of Carboniferous fossil plants and Early Permian fossil fishes and amphibians from Lebach (Saarland) by Friedrich W. H. Jordan, and the fossil vertebrate collection of the eminent physiologist Johannes von Müller was transferred to the university in 1860. Between 1857 and 1889, the museum purchased four collections of Baltic amber, the collections Thomas, Berendt, Kühl, and Künow. Of significant importance was the acquisition of the second find of a skeleton of the Late Jurassic bird *Archaeopteryx lithographica* from Eichstädt (Bavaria), supported by a loan from the industrialist Werner von Siemens in 1880.

With the move of the rapidly growing collections into the newly constructed museum building under the new name *Museum für Naturkunde* at Invalidenstrasse 43 in 1888/1889, the collections were separated into a zoological, a mineralogical and a palaeontological part. In the late nineteenth and early twentieth century, the collections grew further through intense collecting activities in the field by palaeontologists like Hermann Karsten (1817–1908), Wilhelm Otto Dietrich (1881–1964) or Walter Gross (1903–1973). In the beginning of the twentieth century, two large-scale excavations were undertaken by scientists associated with the *Museum für Naturkunde* and yielded a wealth of fossil reptiles and other vertebrates which are now kept in the museum. In 1909–1912, Otto Jaekel (1863–1929), professor in Greifswald and former curator in Berlin, led the excavation at the Late Triassic locality of Halberstadt (Central Germany). Apart from a number of complete skeletons of the "prosauropod" dinosaur *Plateosaurus*, the Halberstadt locality yielded *Proganochelys*, one of the earliest known completely preserved turtles, phytosaurs, and giant amphibians. Between 1909 and 1913, excavations and extensive collections of dinosaurs at the Late Jurassic Tendaguru locality in today's Tanzania were made by the German Tendaguru Expedition led by Werner Janensch (1878–1969), Edwin Hennig (1882–1977), and Hans (1886–1937) and Ina Reck (1872–1942). The Tendaguru locality can be regarded as one of the world's most important dinosaur sites, and the almost complete skeletons of *Giraffatitan* [*Brachiosaurus*], *Elaphrosaurus*, *Dicraeosaurus*, *Kentrosaurus*, and *Dysalotosaurus* from Tendaguru are on display in the dinosaur hall and attract a large number of visitors. Further notable expeditions in the first half of the twentieth century were the Serengeti and Olduvai expedition of Hans Reck (1886–1937) in 1913 where he collected Pleistocene mammals, and the South Africa expeditions of Werner Janensch in 1929 and Hans Reck in 1932 and 1937, which yielded several remains of Permo-Triassic tetrapods.

During the Second World War, parts of the collections were evacuated, among them all types and originals (figured specimens), and were brought into the galleries of the limestone quarries in Rüdersdorf near Berlin. Although the war damage to the museum building was immense, a surprisingly small part of the fossil collection that remained in the museum was destroyed (e.g. parts of the dinosaur type material from Tendaguru and much of the fossil whale material). However, the most valuable objects like the *Archaeopteryx* skeleton and the skull of *Giraffatitan* were buried in the basement of the museum building and remained undamaged. After the war, the specimens evacuated to Rüdersdorf were brought to Leningrad by the Red Army, but were returned from the Soviet Union in 1958 in a very good curatorial condition.

In 1968, the huge collections of the *Arbeitsstelle für Paläobotanik und Kohlenkunde* (formerly belonging to the Geological Survey and since 1951 to the Academy of Sciences of the German Democratic Republic) were integrated into the museum's osteological collections. Additionally, the following important collections were acquired: the collection of Hugo Rühle von Lilienstern in 1969 (Triassic amphibians and reptiles, *Chirotherium*-tracks, Keuperian plants), the Felsberg collection in 1971 (especially fossil bivalves and gastropods), and the collections R. Völker and of the Landesmuseum Halle in 1984–1986 (cave bears and cave lions from Rübeland). In addition, many more local collections were purchased. Examples of important recent acquisitions of fossil material are a vast number of Devonian fish remains that resulted from field work in the Northwest Territories, Canada led by Hans-Peter Schultze in 1997, the purchase of the Ernst Edinger collection (consisting mainly of Palaeozoic amphibians and Palaeozoic and Mesozoic fishes) in 1998, and a large number of rock samples containing numerous microfossils and invertebrates as well as fusain samples from the Tendaguru locality collected by a Tanzanian-German expedition in 2000.

The *Museum für Naturkunde* was separated from the Humboldt-University in 2009 and transferred to the *Leibniz Gemeinschaft*, a foundation that is supported by the state of Berlin and the Federal Republic of Germany.

5.1.2 General Information

5.1.2.1 Acquisitions

The collections grow continuously through collecting activities during fieldwork, by purchase, by donation, and through bequests. Since 2014, a commission of experts (museum staff members) evaluates donations and applications of purchase with respect to their scientific value. Objects for acquisition have to fulfil one or more of the following criteria: (1) be the basis of a current research project of the museum scientists, (2) be of general scientific relevance, (3) fill existing gaps in our collections, (4) be of potential use in promoting the public understanding of science, which is one of the main missions of the museum or (5) be of historical significance. There are no constraints regarding the addition of new objects to the collections with respect to their geographical or temporal scope.

5.1.2.2 Access

All parts of the collections are accessible for research purposes with prior notice. Guided tours are offered to the public on special occasions like *Lange Nacht der Museen* (Long Night of Museums) and *Lange Nacht der Wissenschaften* (Long Night of Sciences). Digitalization of the collections including visualization (photographs and 3D-scans) is in progress; approximately 15% of the collection material is digitally recorded in a database, among them 100% of the type material. In the near future at least part of the collection should be accessible via the internet.

5.1.2.3 Loan

All specimens except for types and originals can be loaned to researchers and institutions for scientific investigation and also for external exhibitions.

5.1.2.4 Collection-Based Research

In accordance with the strategy of the *Museum für Naturkunde*, palaeontologists and zoologists of the museum focus their collection-based research on fundamental issues in earth and life sciences, especially on questions addressing evolution, biodiversity, palaeoclimate, and palaeoenvironment. Apart from thin sections of rocks, fossil bones, shells, and plants that can be produced in the preparation lab, non-invasive research methods like µCT-scanning play an increasingly important role. The museum has its own µCT-lab in which almost 2000 scans for internal and external partners in palaeontology and zoology are performed per year. The collections are open to national and international research, and numerous scientists from all over the world work with the collections every year. An overview on current collection-based research can be found in the annual reports of the Museum für Naturkunde which can be downloaded here:

https://www.naturkundemuseum.berlin/en/insights/about-us/publications-and-downloads

5.2 The Collections of Fossil Invertebrates

5.2.1 General Information

Curators: PD Dr. Martin Aberhan (Porifera, brachiopods, bivalves, gastropods), PD Dr. Dieter Korn (cephalopods, corals, Devonian regional collection), Dr. Christian Neumann (echinoderms, arthropods, bryozoans, Vermes, trace fossils), Dr. David Lazarus (Micropalaeontological collection).

Collections managers: Manuela Tilling, Andreas Abele

The fossil invertebrate collections comprise approximately 1.5 million macroinvertebrates, microfossils and trace fossils with an estimated number of more than 14,000 type and figured macroinvertebrate specimens. The geographical range is worldwide with German and European material predominant and well represented. These include excellent collections from famous *Lagerstätten* like the Devonian Hunsrück Slate, the Jurassic of Holzmaden and Solnhofen, the Cretaceous Crato Formation of Brazil, as well as Eocene Baltic amber. Foreign material stems from northern and eastern Africa, the Middle East and many other regions. Stratigraphic and regional suites comprise the Devonian of Germany (the former collection of the *Königlich Preußische Geologische Landesanstalt*), the Cretaceous of Germany and Spain, and glacial erratics, to name the most important. Some of the collections are historical, for example those from Gottfried Ehrenberg, Friedrich von Schlotheim, Heinrich Cotta, Leopold von Buch, Georg Schweinfurth and Georg Carl Berendt.

5.2.2 The Particular Fossil Invertebrate Collections

Fossil Porifera (5300 specimens). The fossil sponge collection contains mostly material from the Phanerozoic of Germany and neighbouring countries.

Fossil corals (8000 specimens). The fossil coral collection is rooted in the nineteenth century and contains specimens from the Schlotheim collection and others. Fossil corals from the Jurassic of the dinosaur locality Tendaguru hill (Tanzania) are currently a subject of research.

Fossil molluscs (380,000 specimens). The collection of fossil molluscs includes cephalopods (100,000 specimens), bivalves (115,000 specimens) and gastropods (165,000 specimens). Whereas the focus of the cephalopod collection is Palaeozoic and Mesozoic, containing the largest collection of Devonian ammonites world-wide, the bulk of the gastropods are from the Cenozoic era (e.g., collections of Bambach and Schweinfurth). Moreover, it includes collections from Schlotheim, von Buch, Beyrich, and Quenstedt and the Binkhorst collection from the type area of the Maastrichtian stage. Important regional suites are from the Middle East (e.g., Schweinfurth collection) and Morocco (Ebbighausen collection).

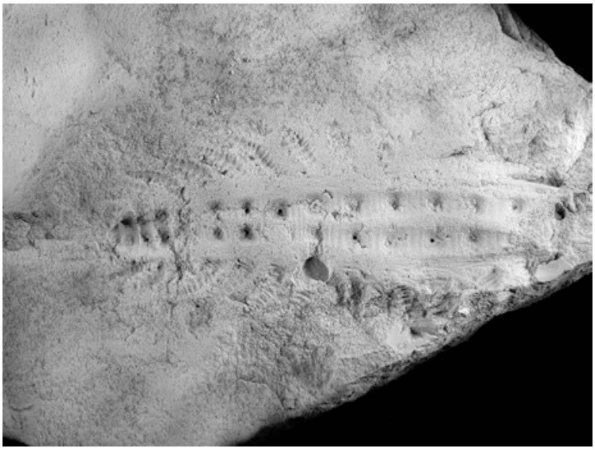

Fig. 5.1 The famous specimen of the Early Cambrian lobopod *Xenusion auerswaldae* Pompeckj, 1927 (length: 192 mm) from glacial erratics of Sewekow/Wittstock, N Germany. © Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science, photo: C. Neumann

Fossil arthropods. The fossil arthropod collection (about 150,000 specimens) contains fossil chelicerates, trilobites, crustaceans and insects. The amber collection (mostly Baltic amber) is also included. Unique characteristics of this arthropod collection are the holotype and only known complete specimen of the lobopod *Xenusion auerswaldae* from Cambrian glacial erratics of Brandenburg (Fig. 5.1), rich collections from famous *Konservat-Lagerstätten* (Hunsrück slate, Solnhofen lithographic limestone, Crato formation). The amber collection comprises 60,000 fossil inclusions preserved in Eocene Baltic amber (Figs. 5.2 and 5.3). Among these, about 1500 type specimens are included. Here, the historic collections of Berendt, Künow and Simon are to be emphasized. Whereas the larger part of the fossil arthropods is placed in the main invertebrate palaeontology collection, the amber and the trilobite collections are stored in separate rooms. Ostracods, although belonging to crustaceans, are stored and curated separately in the micropalaeontology collection.

Graptolites. The museum possesses a good systematic collection and a huge stratigraphic/regional collection of Silurian graptolites from Europe (Jäger collection).

Fossil bryozoans (15,000 specimens). Fossil bryozoans contain important collections from the Cretaceous of Europe, especially type material from Hagenow, Binkhorst, and Voigt.

Fossil brachiopods (55,000 specimens). Fossil brachiopods from the Devonian of the Rhenish Massif are of special importance.

Fossil echinoderms (36,000 specimens). Among the 900 type and figured specimens, types from Jaekel, Ubaghs, and Sieverts-Doreck, among others are included. Especially worth mentioning are Palaeozoic crinoids (Crawfordsville, Moscow, Bundenbach), asterozoans (Bundenbach slate), Jurassic crinoids (Holzmaden, Solnhofen, for instance large plates with *Seirocrinus*) and an exquisite collection of Mesozoic and Cenozoic echinoids from Europe, Africa, Middle East and North America. Recently acquired collections comprise the Ernst collection (10,000 echi-

Fig. 5.2 A view into the amber collection donated by Prof. Walter Simon, Königsberg (now Kaliningrad). © Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science, photo: C. Radke

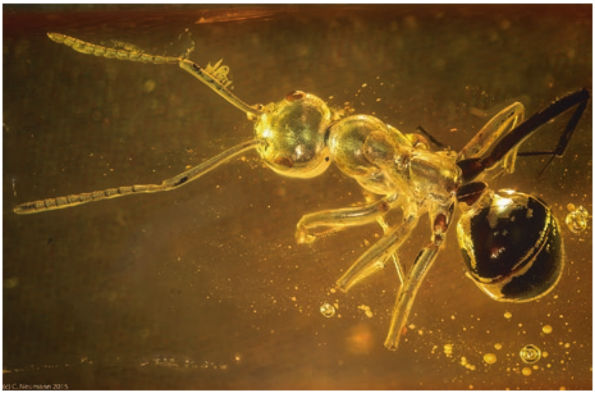

Fig. 5.3 The fossil ant *Yantaromyrmex (Hypoclinea) geinitzi* (Mayr, 1868) from Eocene Baltic amber (length: 2.1 mm). © Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science, photo: C. Neumann

noid specimen from the Upper Cretaceous of Europe) and the W. Maidorn collection (8000 specimens; mostly Mesozoic and Cenozoic echinoids from Western Europe and from the Arabic peninsula).

Micropalaeontological collection (100,000 samples). This collection includes mostly radiolarians and diatoms (Ehrenberg collection, 50,000 samples) and ostracods. The Ehrenberg collection from the early nineteenth century is the world's oldest micropalaeontological collection. Recent acquisitions comprise a collection of calcareous dinoflagellates (Keupp collection). The radiolarian collection was built up during the last 30 years as a part of the global deep-sea drilling program (DSDP, ODP, IODP).

Trace fossil collection (5000 specimens). The trace fossil collection consists of ichnofossils mostly from Europe and adjacent areas. With *Asteriacites* von Schlotheim, 1820, the collection contains the type to the oldest valid ichnogenus world-wide. A representative collection of bioerosional trace fossils is currently being erected.

5.3 The Collection of Fossil Vertebrates

5.3.1 General Information

Curators: PD Dr. Oliver Hampe (fossil mammals); Dr. Daniela Schwarz (fossil reptiles, birds, and tetrapod ichnofossils); PD Dr. Florian Witzmann (fossil fishes, amphibians, otoliths, and histological collection).

Collections manager: Thomas Schossleitner.

The collection of fossil vertebrates encompasses all major taxonomic groups of vertebrates and is subdivided into the collection of fossil fishes, amphibians, reptiles including tetrapod ichnofossils (i.e. tracks), birds, mammals, and hominids. Further parts of the collection of fossil vertebrates are the collection of histological slides and the collection of otoliths. The geographic range of the collection is world-wide with German and African material predominant. The collection is housed in five different collection rooms in two different buildings. The majority of specimens are stored in the main collection (*Hauptsammlung*) on the first floor of the museum building (Fig. 5.4). This room provides workspace for scientific visitors with a binocular microscope. Because of their size and weight, most of the massive bones of dinosaurs and large mammals are located in a cellar room of the museum building, informally named the "*Knochenkeller*" ("bone cellar") Pleistocene remains of bovids, cervids,

Fig. 5.4 The main collection of fossil vertebrates. © Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science, photo: C. Radke

and horses are stored in an adjacent room, the "bone cellar 2". Cave bears and a comparative anatomical skeletal collection are kept in a room on the third floor. The fifth collection room is located in a separate building at Reuchlinstrasse in Berlin-Moabit and contains ichnofossils (slabs with tetrapod tracks) and vertebrate material from the Cretaceous of Sudan (formerly belonging to the Technische Universität Berlin).

5.3.2 *The Particular Fossil Vertebrate Collections*

5.3.2.1 Fossil Fishes

This part of the collection comprises 20,000 inventoried specimens of jawless fish, placoderms, chondrichthyans, acanthodians, and osteichthyans, ranging from the Ordovician to the Holocene. The collection contains ca. 70 type specimens (among them the holotype of the Devonian near-tetrapod fish *Panderichthys* Gross, 1941) and more than 1200 originals. Famous Devonian material is derived from Bad Wildungen (collections of Jaekel and Stracke), the Rhenish Massif and the Baltic states (Gross collection), and the Canadian arctic (Schultze collection). The Edinger collection contains one of the most comprehensive collections of Devonian fishes from Scotland worldwide. Important specimens of Early Permian acanthodians come from Lebach, Saarland (Jordan collection). Numerous specimens of Mesozoic fishes are derived from the late Jurassic of Solnhofen (collections of Redenbacher and Kaufmann) and the Early Cretaceous of Lebanon (Blanckenhorn collection) and Brazil (Santana Formation). A large number of Cenozoic fishes come from the Eocene of Monte Bolca (Northern Italy; Meneguzzo collection) and the Oligocene of Glarus (Switzerland; Meyrath collection).

5.3.2.2 Fossil Amphibians

This collection encompasses 1547 specimens including 10 types and 254 originals. It contains Late Carboniferous temnospondyls and lepospondyls in exceptional preservation from Nýřany (old German version: Nürschan), Czech Republic, and from Linton, Ohio, USA (Jaekel collection). The comprehensive collection of early Permian temnospondyls from Döhlen (Saxony), Odernheim (Rhineland-Palatinate, Edinger collection), and Lebach (Saarland, Jordan collection) is famous for their extensive growth series from small larvae to adults. Mesozoic material contains the beautifully preserved holotype and only known skull of *Parotosuchus helgolandicus* (Fig. 5.5), numerous *Trematosaurus* and *Parotosuchus* specimens from Bernburg, Saxony-Anhalt (Burmeister collection), and the collection Rühle von Lilienstern (Bedheim, Thuringia) with vast material of *Mastodonsaurus* and other temnospondyls. Important Cenozoic amphibian fossils comprise frogs (including tadpoles) and salamanders with skin preservation from the Miocene of Libros, Teruel (Spain) and from the late Oligocene of Orsberg (Rhineland-Palatinate).

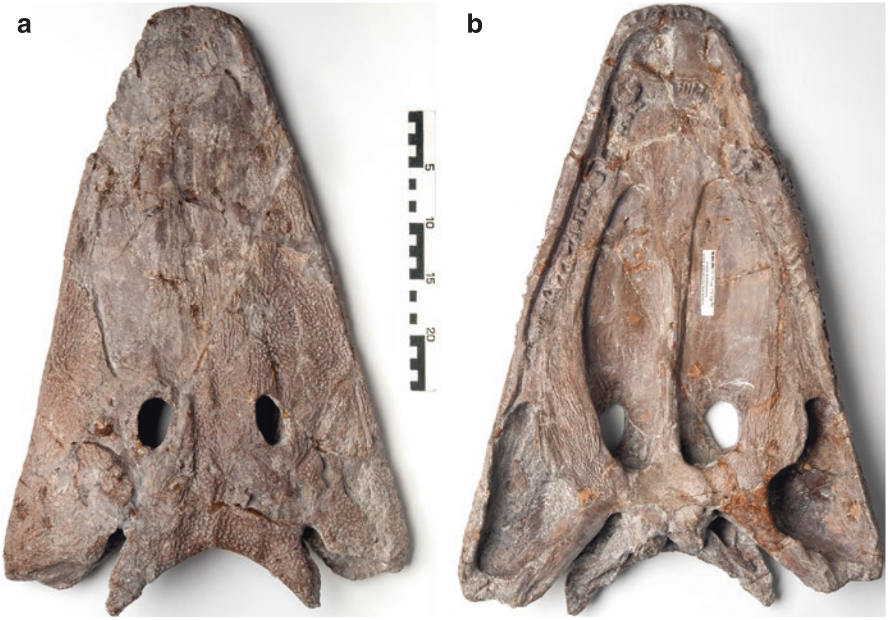

Fig. 5.5 The skull and holotype of *Parotosuchus helgolandicus* (MB.Am.841) from the Buntsandstein (Early Triassic) of Helgoland in (**a**) dorsal and (**b**) palatal view. © Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science, photo: H. Götz

5.3.2.3 Fossil Reptiles (Including Tetrapod Ichnofossils)

The reptile collection consists of about 18,000 specimens with more than 30 types and more than 600 originals. Basal reptiles (parareptiles) are represented by a complete skeleton of the pareiasaur *Bradysaurus* from the Permian of South Africa (Reck collection) and by the secondarily aquatic *Mesosaurus* from the Permian of Brazil. Important Triassic specimens from Halberstadt are the "prosauropod" *Plateosaurus* and the theropod *Halticosaurus*, the early turtle *Proganochelys*, and the enigmatic diapsid reptile *Elachistosuchus* (Jaekel collection). Further Triassic vertebrates are synapsids from the Triassic of the Karroo (South Africa; collections of Janensch and Reck), the dinosaurs *Liliensternus* and *Plateosaurus* from the Triassic of Thuringia (Rühle von Lilienstern collection), and *Nothosaurus* from the Muschelkalk of Rüdersdorf (Raab collection). World-renowned are the Late Jurassic dinosaurs from the Tendaguru locality in Tanzania, among them *Giraffatitan*, *Dicraeosaurus*, *Barosaurus*, *Tornieria*, *Kentrosaurus*, *Dysalotosaurus*, and *Elaphrosaurus*. Marine reptiles are represented by ichthyosaurs, plesiosaurs, and crocodilians from the Early Jurassic of Ohmden and Holzmaden (Bamberg collection). The von Fischer collection comprises pterosaurs from the Late Jurassic of Solnhofen, and the Selenka collection consists mainly of crocodile remains from the Plio- and Pleistocene of Java (Indonesia). The collection of tetrapod ichnofossils (tracks) contains about 400 specimens with ca. 5 types and ca. 10 originals, among them the famous *Chirotherium* and *Ichniotherium* trackways from the Triassic of Thuringia (Hessberg near Hildburghausen) and a large Triassic slab from the H. Rühle von Lilienstern collection that contains the oldest known turtle trackways.

5.3.2.4 Fossil Birds

About 3000 specimens are stored in the collection of fossil birds, including 11 types and ca. 250 originals. Iconic fossils are the beautifully preserved isolated feather of *Archaeopteryx lithographica* from the Late Jurassic limestone of Eichstätt (Bavaria; Fig. 5.6), and the to date best preserved skeleton of *Archaeopteryx*, the "Berlin specimen" which is probably the most famous fossil in the world. Another excellent

Fig. 5.6 The beautifully preserved single feather of *Archaeopteryx lithographica* (MB. Av.0100) from the Late Jurassic limestone of Eichstätt (Bavaria). The length of the feather measures 58 mm. © Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science, photo: C. Radke

bird fossil is a complete *Confuciusornis* from the Early Cretaceous of Liaoning (China). Further significant bird remains originate from the Palaeogene of Quercy (France; collection Rossignol), Pleistocene birds from Java (Indonesia; collection Selenka), as well as the skeletons of two subfossil giant moas from New Zealand (*Dinornis* and *Emeus*; collection Frank).

5.3.2.5 Fossil Mammals

With a total of 1,080,000 specimens, the fossil mammal collection is the largest part of the collection of fossil vertebrates, including more than 20 types and more than 1500 originals. The geologically oldest specimens of the mammal collection are the important *Brancatherulum*, *Tendagurodon*, and *Tendagurutherium* from the Late Jurassic of Tendaguru (Tanzania; collections of Janensch and Heinrich). Tertiary mammals comprise archaeocete whales (*Basilosaurus*, *Zygorhiza*, and *Pontogeneus*) from the Eocene of Alabama, USA (Koch collection), Palaeogene artiodactyls from the *Bohnerzspalten* of South Germany (Dietrich collection), remains of archaeocetes from the Palaeogene of Mottakam und Fayum (Egypt; Schweinfurth collection), Pliocene primates and horses from Pikermi and Samos (Greece; collections of Krüper and Dames), and beavers from the Pliocene of Tegelen (Netherlands; Krause collection). The collections of Reck and Kohl-Larsen comprise Plio-/Pleistocene mammals from the Serengeti and Olduvay. Pleistocene mammals are represented by marsupialians from Australia (Hartmann collection), the megafauna from Colombia and Venezuela (collection Karsten), giant sloths from South America (collections of Humboldt and Sellow), diverse faunas from Java (Indonesia; Selenka collection), cave bears from West and South Germany (Rosenmüller collection), cave bears and cave lions from Rübeland (Völker collection), and numerous taxa from the Rixdorfer Horizont of Berlin and Brandenburg, among them giant deer, woolly mammoth and woolly rhinos. Late Pleistocene/Early Holocene small vertebrates are derived from the fossil animal burrows at Pisede near Malchin in Mecklenburg (Heinrich collection).

5.3.2.6 Fossil Hominids

With 500 specimens, the hominid collection is the smallest part of the fossil vertebrate collection, but contains an original tooth of *Australopithecus afarensis* from the southern Serengeti (Tanzania; Kohl-Larsen collection). The collection contains more than 20 originals.

5.3.2.7 Otoliths

The collection of otoliths contains ca. 5000 specimens with ca. 60 types and ca. 130 originals and is based on the collections of Koken (Eocene of the USA and Oligocene–Pliocene of Germany) and Heinrich (late Miocene of Germany).

5.3.2.8 Histological Collection

The histological collection consists of more than 4000 slides (histological thin sections) including more than 270 originals of fossil bones and scales. Although the collection ranges taxonomically from agnathans to mammals and from the Silurian to the Holocene, its focus lies on fishes from the Late Silurian and Devonian of Germany and Latvia (Gross collection).

5.4 The Palaeobotanical Collections

5.4.1 General Information

Curators: N.N., acting responsible Mrs. Melanie Rühl.

Collections managers: Conny Hiller, Catrin Puffert, Lothar Maitas (herbarium).

Laboratory assistant and collection manager: Melanie Rühl (hydrofluoric acid laboratory).

The palaeobotanical collections are estimated to comprise 280,000 "collection units", organizationally divided into three areas (formerly "Custodies"), the Cenophytic, the Mesophytic, and the Palaeophytic. They include all groups of fossil plants with the focus on Carboniferous, Lower Cretaceous, and Neogene plants and an outstanding collection of Early Permian (Rotliegend) plants. The collection is completed by a very diverse, historical herbarium (*Schrader Herbar*—1830–1898) with about 45,000 leaves including 200 families and about 500 slides of recent wood. Important is the collection of fruits and seeds with approximately 25,000 collection units containing more than 400 families. Overall there are over 9300 types, isotypes (herbarium) and figured specimens. The geographical range is worldwide with a strong emphasis on Central European material, predominantly from Germany and neighbouring countries. A special slide collection of structurally preserved material contains around 2500 slides and peels mainly from German localities.

Most of the palaeobotanical collections are currently stored in two collection halls. An outstation at Berlin-Moabit (Reuchlinstrasse) is used for the storage of the Ceno- and Palaeophytic collections because of shortage of space in the main museum building. The main collections are housed in different types of wooden cabinets many of which are approximately 130 years old and come from the *Geologische Landesanstalt*. In addition many cabinets are from the 1960s to 1970s. All these cabinets contain approximately 8700 drawers in about 270 cabinet units and 60 glass cabinets.

The collections cover the entire taxonomic range of palaeobotany, comprising megafossils through the geologic history, microfossils, and Recent plants. Therefore the specimens range considerably in size and weight, from massive large blocks (for example, fossil tree trunks) requiring heavy-handling, to minute items that must be studied under the microscope. The number of items is estimated to be about 280,000 "collection units" (incl. herbarium), but many of these "units" include more than one specimen or individual. The absolute number of specimens is considerably higher, but to estimate the total sum does not appear meaningful because of the nature of the material—some blocks of matrix may contain several thousand individual specimens and yet, for practical reasons, are treated as one item. Holotypes and originals (figured specimens) count around 9300 specimens, mainly from Carboniferous and Tertiary strata.

The arrangement of the collections has its origin in the collection system of the *Königlich Preussische Geologische Landesanstalt* (Royal Prussian Geological Survey) that was a four level system: age—region—age—systematics. This presentation enables scientists to easily study floral assemblages and their palaeoecological context.

Of utmost interest are several historical collections that have been partly curated as integer entities. The so called *Kabinettsammlung* with its catalogue from 1836 (which is still in use today) shows more than 2000 specimens and includes the palaeobotanical part of the collection of Friedrich Ernst von Schlotheim.

5.4.2 The Particular Palaeobotanical Collections

Many important collections represent the progress of palaeontology/palaeobotany during the 19th and first part of the twentieth century, such as those of Manfred von Richthofen (material from China), Friedrich Nindel and Otto Gimm (mainly Rotliegend/Early Permian of Thuringia), and Hugo Rühle von Lilienstern (mainly Triassic of Thuringia). The geographical range is worldwide, with German material predominant and extraordinary well represented in Carboniferous and Tertiary material (due to the economic importance of coal mining). But there is also a representative collection of Lower Cretaceous plants from Brazil and of Upper Cretaceous specimens from the northern edge of the Harz Mountains (Central Germany). Also extensive are the collections of plants of Tertiary age from Austria, Poland, Greece and the Czech Republic.

5.4.2.1 Silicified Wood

An integral component with around 1400 specimens of fossil silificated wood is the collection of Heinrich Cotta. Although even Goethe already knew this collection, whose purchase was strongly supported by Alexander von Humboldt in the 1830s, there is still a great deal of research potential in this structurally preserved material.

5.4.2.2 Devonian-Collection

The approximately 5000 specimens containing collection (among others the Rebske-Collection) has been expanded considerably in the last decades. The focus of collecting was the Rheinisches Schiefergebirge with its highly diverse early landflora (Fig. 5.7). Parts of this collection have not yet been scientifically analysed.

Fig. 5.7 *Foozia minuta* (= *Koeppenia eifelensis*), an about 400 million years old, highly developed progymnosperm(?) from the Emsium of Waxweiler in the Eifel. © Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science, photo: St. Schultka

5.4.2.3 Carboniferous-Collection

Nearly 80,000 specimens are housed in the Carboniferous collection, mainly from coal deposits of former Prussian territories. The main focus lies on the Westphalian D with about 5000 specimens from Piesberg near Osnabrück (Stoßmeister-Collection), more than 2000 specimens from the Zwickau Basin, 1500 specimens from the Saar Basin and around 1300 specimens from Bulgaria (Tenchov-collection).

5.4.2.4 Rotliegend-Collection

Of particular importance are also the approximately 15,000 Lower Permian specimens (Fig. 5.8), enriched by the collection of Bergrat Johann Christian Mahr, who was one of Johann Wolfgang von Goethe's collectors.

5.4.2.5 Triassic-Collection

The about 2000 specimens of this collection prove a rich vegetation in a time segment which has generally produced only a small amount of fossil plant material. Particularly noteworthy is the collection of the Royal personal physician Johann Lucas Schönlein from the second half of the nineteenth century (Triassic of Bavaria).

Fig. 5.8 *Annularia spinulosa* (= *A. stellata*) (Mb.Pb.2007/0461), an about 296 million years old widespread articulate from the Rotliegend of the Döhlen Basin (Saxony). © Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science, photo: H. Götz

5.4.2.6 Cretaceous-Collection

An important time period of palaeobotanical research is the Cretaceous, in particular the development of early angiosperms, which is reflected in this part of the collection. The focus lies on the lower part of the Cretaceous with more than 7000 specimens (Fig. 5.9).

5.4.2.7 Tertiary-Collection

Originals of the publication of E.A. Rossmässler—by whom modern Tertiary palaeobotany was founded—can be found in the Cenophytic collections with their main focus on mid-German brown coal deposits. Based on this collection, H.D. May 1995 wrote his successful textbook *Tertiäre Vegetationsgeschichte Europas* (Tertiary vegetation history of Europe).

Fig. 5.9 *Pterophyllum* sp. (Mb.Pb.2010/0113), an about 135 million years old Cycadophyte from the Wealden of the clay pit Bock near Duingen (Lower Saxony). © Museum für Naturkunde—Leibniz Institute for Evolution and Biodiversity Science, photo: H. Götz

5.4.2.8 Pollen, Spores and Cuticules

The micro-palaeontological collections (cuticles, pollen and spores) are mainly focussed on Palaeogene and Neogene sediments, but also contain many boxes of Cretaceous material from southern high latitudes. They include some 27,500 slides arranged in geographical order. About 400 slides contain type or figured material. In addition, there are 3500 slides and 100 stubs ready for SEM research with ODP material and about 200 stubs of fusain mainly from the famous dinosaur *Lagerstätte* Tendaguru hill, Tanzania.

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Chapter 6
BERN: The Natural History Museum — An Institution of the Burgergemeinde of Bern

Ursula Menkveld-Gfeller

6.1 General Information

Number of staff, office space, etc.:The Natural History Museum Bern has in 2017 44 full-time positions distributed among 64 persons, half of them for science and/or exhibition/operation. There are ca. 35 offices, 1 lecture hall, 2 lecture rooms, laboratories (DNA laboratory, analytical laboratories, Earth science preparation lab, taxidermy lab), workshops (carpentry shop, etc.), 2200 m^2 collection rooms, and a library. The total exhibition area covers 5700 m^2.

Team Paleontology (Earth Sciences Department): Dr. Ursula Menkveld-Gfeller, Curator-in-Chief, Division of Paleontology (80%); Dr. Bernhard Hostettler, Assistant and Earth science preparations (65%); Gino Bernasconi, Earth science preparations (30%).

For more Information see: www.nmbe.ch, www.facebook.com/NMBern, https://twitter.com/NMBern

6.1.1 A Short History of the Museum

The Natural History Museum of the Burgergemeinde ("Citizen's Community") Bern (NMBE) has its roots in a small exhibition room with natural objects that Johann Rudolf Zeender established in the city library in 1694. In the eighteenth and early nineteenth centuries more collections were added to the initial assortment of minerals, rocks, coins, and other curiosities. These new additions comprised rocks and petrefacts (fossils), crystals confiscated by the state in 1721, herbaria, conchylia

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(mollusc shells), and the large bird collection made by Daniel Sprüngli. At that time, all these collections were under the aegis of the Library Commission.

It was not until 1832 that the NMBE acquired its own commission; making this year the official year of the Museum's foundation. Up to this time, the natural history objects were a part of the historical and ethnographical collection.

In 1852, the property of the old Bernese city-state was divided up between the state (Canton), the newly structural municipality, and the Burgergemeinde ("community of citizens", a corporation of citiziens without political power and without tax liability). The museum collections were placed under the property of the Burgergemeinde. Since then, the Burgergemeinde Bern has been responsible for the Museum's operation and financing.

In 1936, the NMBE moved into a new building on Bernastrasse (Fig. 6.1). This was necessary since it was continually expanding and had gained international reputation through its historical dioramas, especially the African big game exhibit created by Bernhard and Vivienne von Wattenwyl after an expedition in 1923–1924. The NMBE further enlarged in 1998 to meet the new demands of being not just an exhibition museum, but also a scientific research institute with the concomitant increase in staff. Aside from the Barry exhibition (the legendary St. Bernard Dog: www.barry.museum), the NMBE is also now famous for housing the giant Planggenstock crystals and for its outstanding temporary exhibitions.

6.1.2 Present Structure of the NMBE

The Museum has constantly changed and adapted itself to new requirements. Today, the public area is separated from the research area but the teams continue, of course, to work hand-in-hand. Moreover, the museum premises are used intensively for a number of activities. For instance, many public and private events also take place at the NMBE (more information on www.nmbe.ch).

Fig. 6.1 Natural History Museum Bern at Bernastrasse 15 (photo Lisa Schäublin, NMBE)

Fig. 6.2 The exhibition "Fins Feets Wings" — the Evolution of the Vertebrates" presents the evolution of the vertebrates using fossils and modern specimens (photo Lisa Schäublin, NMBE)

Only a small part of the paleontological collection is currently on display in the public area. There are two permanent exhibits: "Beetles & Co. — the Colourful World of Invertebrates," and "Fins Feets Wings - Evolution of the Vertebrates" (Fig. 6.2), along with some individual exhibits. From time to time, temporary paleontological exhibits focusing on special themes are presented.

6.1.3 Research at the NMBE

Today, the Museum comprises three scientific areas: (1) Earth sciences, focusing on mineralogy and paleontology, (2) invertebrates, and (3) vertebrates. The museum and the research areas are equipped with modern instruments. Close cooperation in all these areas with the University of Bern is an intrinsic part of our research program. This collaboration includes actively sharing infrastructure for the mutual benefit of both institutions and means that the Museum's scientific activity has been co-financed by the Canton of Bern since 1991.

Traditionally, the focus of research at natural history museums has been the study of diversity in nature, benefiting from their many and often large collections. This is also true for the NMBE and the collections of the Paleontology Division.

6.2 The Paleontological Collection

6.2.1 History of the Collection

The oldest fossil objects now at the NMBE were first acquired in 1803 with the gift of the collection of D. Sprüngli. The paleontology collection grew through the activities of the curator, B. Studer, and the donation of C. Brunner in the first half of the nineteenth century. An important addition was the extensive collection of the amateur scientist, W. A. Ooster, given to the NMBE in 1868. The Ooster collection consists mainly of fossils from the Swiss Alps, provided to Ooster by several paid fossil hunters. It contains some very rare specimens from famous localities such as Bern (Engehalde, Fig. 6.3), Bumbach, Châtel St-Denis (Veveyse), Moléson (Teysachaux), and many others. Other collections and important single objects were donated or directly provided by F.L. Koby, O. Hug, J. Uhlmann, F. Bürki-Marcuard, B. Hostettler, A. Klee, W. Bühler, H. Dreifuss, and J. Wegmüller.

Founded in 1928, the Association of the NMBE helps to acquire precious minerals, fossils, and animals to augment existing collections. The Association has also donated the Museum many valuable fossils for exhibitions (Fig. 6.4), and has financially supported exhibitions of paleontological objects (Fig. 6.5).

Two large collections were allocated to the NHMB in 2004 and 2005: the complete paleontological collection of the Geological Institute of the University of Bern and the paleontological collection of the Museum Schwab Biel (now known as the New Museum of Biel). Both collections are permanent loans.

In 2017, the paleontological collection from a private foundation, the Fondation Paléontologique Jurassienne (FPJ, Glovelier) was donated to the NMBE. The FPJ collection comprises over 40,000 fossils, mainly from the Jura mountains of Switzerland, all well documented with detailed locality information, lithostratigraphic affiliation, and date of finding. Many fossils were already prepared (for more information see www.fpju.ch). With the FPJ collection, the existing Jura mate-

Fig. 6.3 *Diaceratherium lemanense* (Pomel, 1853), a rhinoceros, Late Aquitanian, Engehalde, Canton Bern, Switzerland; skull and mandible; lateral view; width of object 55 cm (photo Peter Vollenweider, NMBE)

Fig. 6.4 Horsetail trunk overgrown with crinoids *Seirocrinus subangularis* (Miller, 1821) and bivalves *Pseudomytiloides* sp., Posidonia shale formation, Lower Toarcian, "Urweltsteinbruch Fischer," Holzmaden, Germany, Exhibition "Beetles & Co.," donated by the Museum Association 2012; width of the object 84 cm (photo Thomas Schüpbach, Ipsach)

Fig. 6.5 Reconstruction of *Plateosaurus engelhardti* Meyer, 1837 in its life environment in the Late Triassic in Frick Canton Aargau. Skeletal reconstruction and background illustration donated by the Museum Association (photo Lisa Schäublin, NMBE)

rial is far more than doubled. Highlights are: (1) one of the most important echinoderm collections from the Swiss Jura, and (2) the largest existing collection from the Renggeri member (early Oxfordian: containing pyritized ammonites and other invertebrates).

6.2.2 *Overview of the Present Paleontology Collection*

Today, the paleontology collection of the NMBE comprises over 400,000 objects included in the following sections.

6.2.2.1 Types and Figured Specimens Collection

This important regional collection contains typical material from the Alps, the Molasse Basin, and the Jura mountains. Ages of the type materials range from the Carboniferous to the Pleistocene. Meisner (1820) was the first to describe fossils that are deposited at the NMBE. Specimens described and figured in publications (see www.nmbe.ch), including Studer (1825), Ooster and Fischer-Ooster (1869, 1870–1871), Heer (1855), are stored at the NMBE.

6.2.2.2 The Molasse Basin Collection

Beginning with E. Kissling (1890), geologists took interest in fossils of the Bernese Molasse sediments and began collecting. R. Rutsch was also fascinated by fossils in the Molasse and published articles about them. E. Gerber furthered these efforts and carried out excavations in the years 1933–1938. A primary school teacher, H. Haas, accompanied him and donated his collection to the NMBE. In the 1980s, T. Pfister carried out several excavations at Belpberg, supported by U. and J. Wegmüller and B. Hostettler. The fauna of the Burdigalian Belpberg Beds was then studied, and published by Menkveld-Gfeller (2010) and Pfister et al. (2011). To compare this with other Molasse Basin collections, the Museum continually augments its comparative collection of fossils of the same age (Burdigalian, Oligocene) from other Swiss sites such as St. Gallen and Luzern.

6.2.2.3 The Jura Collection

About half of the fossils from the Jura Mountains now at the NMBE are from the territory of the Cantons of Bern and Jura. This includes part of the collection of F.L. Koby (1881–1894), with many fossils from the Rauracian Facies (Middle Oxfordian) exhibiting lagoon and reef environments. The current focus of the paleontological collection is being actively supplemented with excavations of Middle to Late Jurassic fossil-rich sediments in Hornussen (Canton of Aargau) and Anwil (Canton of Basel-Landschaft) and regular inspections at various other sites, as well as the acquisition of the large collection from the FPJ.

6.2.2.4 The Alpine Collection

Material from two collectors form the basis for this group: (1) the collection of C. Brunner that mainly covered Bernese Oberland (Bernese Highlands) and Central Switzerland came to the NMBE in 1850 and, (2) the fossil collection of W. A.

Ooster, who donated 7000 Jurassic to *Palaeogene* fossils from the Bernese, Vaud, and Fribourg Alps to the NMBE in 1868. Together with his brother-in-law, C. von Fischer-Ooster, he produced many publications on this material. Later came the collection of C. Mayer-Eymar and other smaller collections, especially from the Prealps and the Helvetic Alps. Today, this collection contains fossils from the entire Swiss Alpine mountain belt.

6.2.2.5 Stratigraphic Collection from Localities Outside Switzerland

This part of the palaeontological collection covers the Cambrian to Neogene periods and comprises many objects from well-known fossil sites such as Crailsheim, Priabona, Possagno, Daméry, Solnhofen, Holzmaden, and others. Nearly a quarter of this collection is made up of specimens from Palaeogene and Neogene of Europe to compare with specimens from the Molasse. In addition, fossils from type localities for the Bajocian (Middle Jurassic); Danian, Bartonian (*Palaeogene*); Aquitanian, Burdigalian and Tortonian (Neogene) are available. Remarkable is the collection from the estate of O. Hug that came to the NMBE in 1930. This contains a well-documented collection of ammonites from the Liassic and Middle Jurassic. With the FPJ collection, numerous well-preserved invertebrates from the Posidonia Shale Formation (Liassic, south-western Germany) have now come to the NMBE.

6.2.2.6 The Paleobotanic Collection

As early as 1857, the botanist R. J. Shuttleworth donated the NMBE a group of valuable fossilized plants of Carboniferous age from France, England, and Belgium. This collection was enlarged by fossils collected during the construction of the Lötschberg base tunnel (Brousmiche Delcambre and Menkveld-Gfeller 2007). The NMBE houses plant remains not only from many well-known sites in Switzerland but also from neighbouring regions, such as Oehningen (Miocene, southernmost Germany), among others. A considerable part of the paleobotanical collection is built of finds from the Miocene Molasse of the Cantons Bern (Ralligen on Lake Thun, Aarwangen, Eriz) and Neuchâtel (le Locle).

6.2.2.7 Fossil Vertebrates

A large part of this collection comprises discoveries from the Oligocene and Miocene Swiss freshwater Molasse. Among these are rare and valuable specimens from sites that are today no longer accessible, like Bumbach, Engehalde (Becker 2009). Similarly, in building up assemblages from outside Switzerland there is a focus on fossils of *Palaeogene* and Neogene age. Specimens in this group come from Ronzon and Bach (Oligocene, France), Cadibona (Miocene, Italy), and Samos (Miocene, Greece).

6.2.3 Present Collecting Activities and Research

Excavations and collecting activities by curators Ed. Gerber and Th. Pfister from 1907 to 1996, have furnished much well-documented material, mainly from the Upper Marine Molasse (Burdigalian) of Switzerland.

Since 2001 with Curator-in-Chief U. Menkveld, focus changed first to the *Palaeogene* of Helvetic Alps (lithostratigraphy and biostratigraphy with larger Foraminifera, Menkveld-Gfeller et al. 2016) and, due to on-going tunnel excavations, to Carboniferous plant remains from the Lötschberg base tunnel (Fig. 6.6, see also Brousmiche Delcambre and Menkveld-Gfeller 2007), and to Aquitanian vertebrate remains from the Neufeld tunnel (Menkveld-Gfeller and Becker 2008; Becker et al. 2010).

At present, U. Menkveld and B. Hostettler concentrate on ammonite biostratigraphy of Middle to Late Jurassic sediments and taxonomic revision of echinoids from Jurassic sediments from the Jura Mountains. In 2011 and 2014, two excavations in the Middle to Late Jurassic sediments were realized that provided very good fossil material (Fig. 6.7) and information about the sedimentology, taphonomy, and biostratigraphy (Dietze and Hostettler 2015; Menkveld-Gfeller et al. 2015).

For a number of years, the Paleontology team has been carrying out the excavations with several visits per year in a quarry presently being exploited by the cement industry. Many very special finds (from the Middle to Late Jurassic sequence) have

Fig. 6.6 *Pecopteris* (*Polymorphopteris*) (*Acithea*) polymorpha (Brogniart, 1834) Wagner, 1959, filicopsid plant, Stephanian, Carboniferous; collected at material dump of the Lötschberg Basistunnel at Mitholz, Canton Bern; width of the image 4 cm (photo Peter Vollenweider, NMBE)

Fig. 6.7 *Homeoplanulites* sp. and three specimen of *Macrocephalites verus* Buckmann, 1922 (in the middle a nearly complete microconch), ammonites, Early Callovian, Herveyi Zone, Kepplerei Subzone; Ifenthal Formation, Anwil Bank; Aechtelmatt, Anwil, Canton Baselland (Excavation 2014); width of the object 23 cm (photo Lisa Schäublin, NMBE)

thus been salvaged from the stone crusher and cement-making process. Detailed descriptions of some of these fossils have already been published (Hostettler and Menkveld-Gfeller 2015).

6.2.4 Research Activities

Focus for collecting and research is now, thanks to the collaboration with the FPJ and its collection material that is available for study, on projects in the Swiss Jura. Experts from Switzerland and abroad, and a Master's thesis, are dedicated to studying the fauna of the St-Ursanne Formation (Middle Oxfordian: echinids, gastropods, corals, etc.), using material from new finds and also older collections in the NMBE (Koby Collection, e.g. Gründel et al. 2016). For the revision of Jurassic Echinoids, the Cidarids of the Wildegg Formation (Middle Oxfordian, see Fig. 6.8 and Hostettler and Menkveld-Gfeller 2015) were studied. For various projects with partners like swisstopo (Federal Office of Topography, Mont Terri Consortium) and NAGRA (National Cooperative for the Disposal of Radioactive Waste), the Paleontological team carried out commissioned projects such as biostratigraphic studies on Early to Middle Jurassic sequences (Reisdorf et al. 2014; Reisdorf et al. 2016; Hostettler et al. 2017).

6.3 Public Outreach in Paleontology

Public outreach is an important task for the NMBE, here we focus on the efforts of the Paleontology Division to manage collections, further public relations, and support educational work.

Fig. 6.8 *Paracidaris* (*Anisocidaris*) *eluveitie* Hostettler and Menkveld-Gfeller, 2015 Holotype, an echinoid, Middle Oxfordian, Bifurcatus Zone, Stenocycloides Subzone, Effingen Member, Wildegg Formation, Jakobsberg quarry, Auenstein, Canton Aargau; height of the object 31 cm (photo Alain Georgy, Glovelier)

6.3.1 Training Young People

According to capacity, the Paleontology team continues to inspire young people for the subject of paleontology: Under our guidance, a diploma thesis, internships for students, and a Master's thesis have been and are presently being carried out. Thematic courses in the form of modules for high schools, universities, and technical colleges, and also for lay people, are offered and enjoy great popularity. In addition, staff from the Paleontology Division supervise stratigraphic field courses in conjunction with the University of Bern.

6.3.2 Other Tasks

One of the main tasks in collection managing is the digital cataloguing of collection materials and furthering public relations. Since 1995, the Paleontology team has been working intensively on the digital recording of all collection objects. Today, almost one fifth of the paleontological objects are recorded in the database. For our in-house exhibitions, the team supplies not only the objects, but also the thematic ideas and scientific input. Museum pedagogy with advice and activities is a strong focus; for instance, our lectures and courses inspire lay people for paleontology, and the team is always on call to answer questions from non-specialists as well as colleagues. Thus, every year we identify many newly found objects, many of which are sham fossils. Exceptionally, rare findings unexpectedly turn up that are then carefully scientifically evaluated.

6.3.3 Museum Education

A special division of the NMBE, “education and mediation”, covers educational activities such as training of teachers, providing didactic material (worksheets, thematic maps, animations, films, thematical trolleys), organising guided tours, thematic courses for children, and special corners in exploration exhibits, etc.

As an addition to the exhibition “Fins Feets Wings - The Evolution of the Vertebrate Animals”, a “moveable museum” in a revamped Swiss Post vehicle filled with experiments and interactive tasks related to the exhibit is ready to provide a clear picture of the development of life on our planet. For general geoscientific topics, our GeoLaboratory can be visited, which offers various experiments for all those interested to get hands-on experience in the geosciences.

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Chapter 7
BIELEFELD: Not Worth Mentioning? Paleontological Collections of Small Museums: The Example of Bielefeld (North Rhine Westphalia, Germany)

Mark Keiter and Sven Sachs

7.1 Many a Mickle Makes a Muckle

These days, small natural science museums face numerous challenges. They often have only little financial and personnel resources, but still need to manage such diverse tasks as administration, exhibitions, public relations, collections, and research. Due to their relatively small sphere of influence, smaller museums usually focus on their surrounding region. This gives them an air of provinciality that is often perceived as a weakness in a globalized world. However, provinciality can also be regarded as the biggest strength of small museums, because they provide a specific knowledge base for the geo- and biosphere of their region; a specialization that is usually reflected by their collections. The Naturkunde-Museum "namu" in Bielefeld (Fig. 7.1) is a prime example for this kind of museum: behind the scenes of a comparably small exhibition, a large geological/paleontological collection is maintained, catalogued and actively studied.

7.2 History of the Naturkunde-Museum and its Collection

The Naturkunde-Museum Bielefeld commenced as a sub-department of the Bielefeld Municipal Museum and was officially founded on October 3, 1906. In 1930, the historical and natural science collections were separated and for the first time, Bielefeld had an independent natural science museum. During World War 2, the collections were transported to several rural locations in order to

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Fig. 7.1 Since 1986 the home of the namu's exhibition: the "Spiegelshof" a nobleman's mansion built in the sixteenth century

protect them from Allied bombings. Separated, neglected and often stored inadequately until 1964 when the museum was re-established, large parts of the collection suffered heavily and an unknown, but significant number of specimens were lost.

Throughout its history, the museum has enjoyed a close partnership with the Naturwissenschaftlicher Verein für Bielefeld und Umgegend ("Natural science association of Bielefeld and its surroundings"), an organization of local citizens interested in natural sciences. The society was founded in 1908, shortly after the opening of the museum (Zickgraf 1909). Dr. August Oetker (founder and namesake of the famous Oetker company) significantly contributed to the emerging paleontological archive by donating a comprehensive and valuable fossil collection. Together with a number of fossils collected as early as the 1870s, the Oetker donation forms the core of what would, over the years, become a large and systematic paleontological collection. Other notable contributors were Wilhelm Althoff (collection manager 1910–1947) and Martin Büchner (director 1964–1997), as well as numerous autodidact private collectors, such as Hans Satzinger and Adolf Deppe. Mainly thanks to such dedicated museum managers, citizens and donators, the geological collection of the museum now comprises approximately 50,000+ items, among them more than 30,000 fossils.

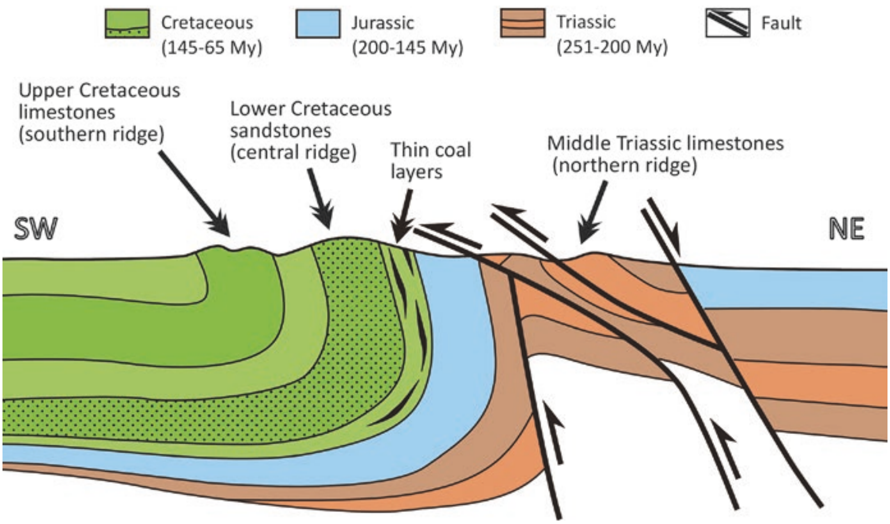

Fig. 7.2 Geological cross section through the ridge of the Teutoburger Wald (simplified after Geological Map of Nordrhein-Westfalen 1:100,000 (1986), Blatt C3914 Bielefeld). The Late Cretaceous Osning Thrust has tilted the strata, so that an almost complete Mesozoic succession crops out over a small area

7.3 Collection Highlights

Due to the special geological situation of the Teutoburger Wald (tectonically tilted rocks, Fig. 7.2), an almost complete Mesozoic succession has been exposed within the municipal area of Bielefeld. Over the years, these strata have yielded a fair number of invertebrate and vertebrate fossils, including several holotype specimens. Nowadays, however, most quarries and clay pits are abandoned and have been backfilled. Therefore, new material can only occasionally be collected. Citizen scientists actively document temporary outcrops (e.g. Schubert 2013; Keiter et al. 2016), but major discoveries such as those made when the quarries were still in operation, are rare. Hence, the 110-year-old collection of the Naturkunde-Museum is an extremely valuable archive.

7.3.1 Invertebrates

The largest number of invertebrate fossils (more than 12,000 items) derives from Jurassic strata of the Herford liassic syncline. Most of these specimens were recovered from the numerous clay pits in the area between Bielefeld and Herford (e.g. Althoff 1936), many of which were active until the second half of the twentieth century (Büchner et al. 1986). Some specimens, such as various ammonite findings, but especially bivalves (*Trigonia*, Fig. 7.3a) from “Bethel”, have found their way into various collections around the world (Büchner, pers. comm.).

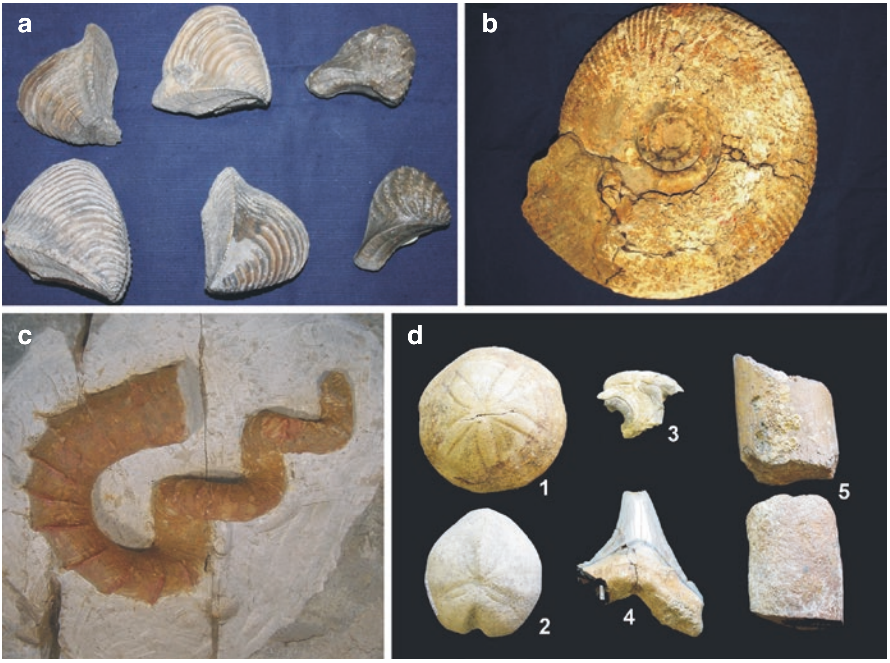

Fig. 7.3 Invertebrates and vertebrates from the collection of the namu Bielefeld. (**a**) Four specimens of *Trigonia subtriangularis* (left) and two specimens of *Clavotrigonia petasoides* (right) from "Bethel"(Bielefeld-Gadderbaum). Size of *Trigonia* specimens: ~7 cm. (**b**) *Prodichotomites sp.* from the Early Cretaceous Osning Sandstone, Bielefeld-Gadderbaum, diameter 34 cm. (**c**) *Hyphanthoceras reussianum* (Late Cretaceous) from Halle/Westfalen. (**d**) Assortment of fossils from the Oligocene Doberg locality (Bünde): (*1*) echinoid *Echinolampas kleinii,* (*2*) echinoid *Spatangus desmarestii,* (*3*) shell fragment of *Aturia aturi*, a rare Nautiloid, (*4*) shark tooth *Procarcharodon praemegalodon,* (*5*) bone fragments of the whale *Eosqualodon sp.* Diameter of *Echinolampas* specimen: 9.5 cm

The collection of Cretaceous invertebrates is notable for its rich fauna from the Early Cretaceous Osning Sandstone (Weerth 1884; Mutterlose 1995; Fig. 7.3b), a lithology that generally contains only few fossils. Quarrying of the Osning Sandstone has ceased decades ago and ever since the outcrop situation has detoriated significantly. There is not much potential to find any significant amount of new fossil material (Keiter 2015), making the archive of the Naturkunde-Museum Bielefeld very valuable. The invertebrate collection further includes numerous specimens of Late Cretaceous fossils from the wider region – among them spectacular heteromorphous ammonites (Fig. 7.3c).

Finally, approximately 3200 specimens from the Oligocene Doberg locality are part of our collection (Fig. 7.3d). Again, the core of this significant collection was donated to the museum by Dr. August Oetker more than 100 years ago (Pankoke and Ebel 2014).

7.3.2 Vertebrates

The majority of vertebrate fossils in the Bielefeld collection derives from the Mesozoic strata of the surroundings of the city. One of the most valuable specimens is the holotype of *Cyclotosaurus buechneri*: a Late Triassic temnospondyl skull (Fig. 7.4a), which was found in Bielefeld and has recently been described by Witzmann et al. (2016). However, the backbone of the vertebrate collection is formed by Early Jurassic fishes and tetrapods (Gliewe 1962; Hungerbühler and Sachs 1996; Sachs and Kear 2017). Most of these are historical findings which date back to the early twentieth century (e.g. Althoff 1922). Especially, fossils from Pliensbachian strata, which were once well exposed in the Bielefeld region and rarely yielded tetrapod fossils elsewhere in Germany, are present in the namu

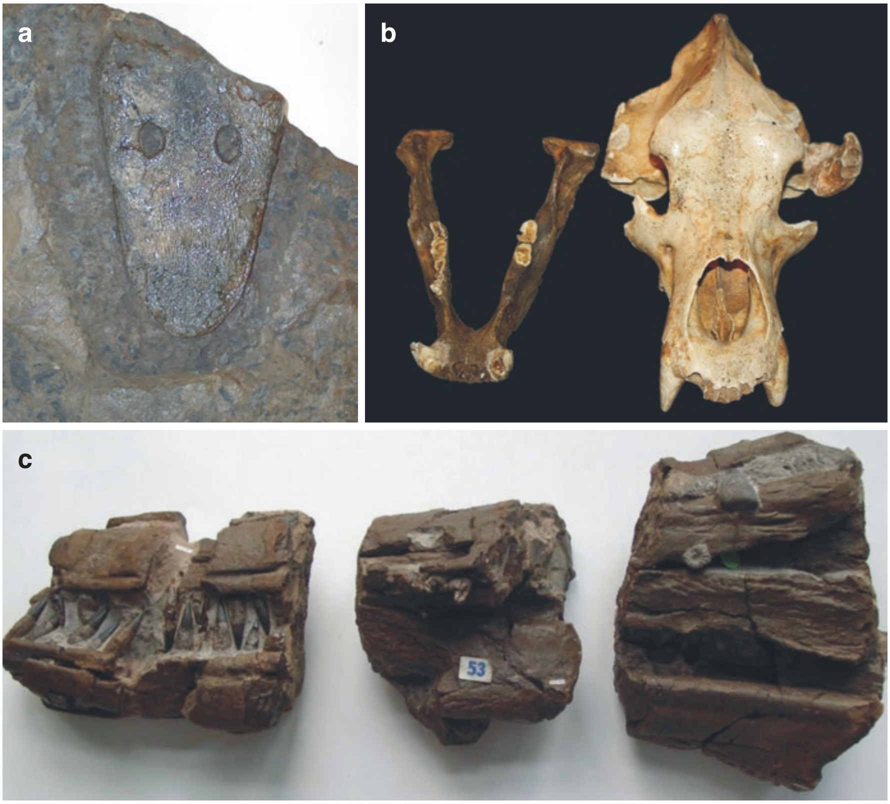

Fig. 7.4 Vertebrates from the collection of the namu Bielefeld. (**a**) Skull of *Cyclotosaurus buechneri* from the "Schilfsandstein"(Stuttgart-Formation, Late Triassic), Bielefeld-Sieker. Skull length: 30 cm. (**b**) Cave bear *Ursus spelaeus* (Goldfuss 1823), Upper Pleistocene, from the Heinrichshöhle (Sauerland). Skull and jaw belong to two different individuals, overall length of skull: 49 cm. Donated to the museum by August Oetker in 1906. (**c**) Jaw fragments of a ~10 m long ichthyosaur *Temnodontosaurus* sp., from the Pliensbachian (Lower Jurassic), Sudbrack clay pit in Bielefeld

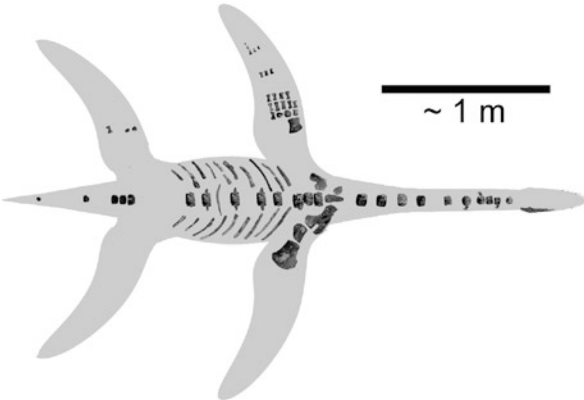

Fig. 7.5 Overview of the preserved elements of the plesiosaur *Arminisaurus schuberti* from the Pliensbachian (Lower Jurassic), Beukenhorst II clay pit in Bielefeld

collection. Certainly the most impressive specimen is a partial skull of a large ichthyosaur (Fig. 7.4b), identified as *Temnodontosaurus* by Hungerbühler and Sachs (1996). Additional Mesozoic vertebrate fossils include Middle Jurassic tetrapods from local outcrops (Sachs and Hornung 2015), fish remains from the Lower Cretaceous Osning Sandstone, footprints of ornithopod dinosaurs from the Berriasian of the nearby Bückenberge (Hornung 2015) and remnants of an elasmosaurid plesiosaurian from the Upper Cretaceous of Schleswig-Holstein (Sachs and Ladwig 2017). A fair amount of mammal specimens from the Pleistocene of Westphalia, such as a nearly complete skeleton of the Woolly Rhinoceros *Coelodonta antiquitatis* (Diedrich 2008) and cave bear remains (Fig. 7.4c), another Oetker donation, can be found in the collections at our museum.

Last but not least, the most important specimen in the namu collection is the holotype of *Arminisaurus schuberti*, a pliosaurid plesiosaurian that was found in Bielefeld and has recently been identified as a new genus and species (Sachs and Kear 2017, see Fig. 7.5).

7.4 Concluding Remarks: Diversity Matters

The Naturkunde-Museum Bielefeld considers itself primarily as a center for natural sciences of the city and its surroundings. This is reflected by its collections, which are specifically focussed on the wider Bielefeld region. It has always been the aim of the museum to work in close cooperation with the community and in fact, significant parts of the collections are donations from either active members of the local natural history society or citizens of the city or region. We always welcome and invite external researchers and interested laypersons to visit our collections and study our specimens, because only a collection that is actively maintained, preserved and worked on is a “living” one.

Small museums like the namu—and a large number of similar institutions—are an important asset in the German museal landscape, filling a niche of specialized local expertise that large centralized museums would struggle to provide. As such, they are doing the regional groundwork for larger-scale research and have huge potential as points of identification for the regional populace. With that comes the responsibility to raise awareness for the natural history of their respective region to the interested public, a task every regional nature museum is more than willing to fulfill.

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Chapter 8
BILZINGSLEBEN: The Bilzingsleben Collection

Clemens Pasda

The Steinrinne is a Pleistocene travertine deposit near Bilzingsleben (County Sömmerda, Federal State of Thuringia, Germany) known for its fossils by geologists since the late nineteenth century. From 1971 to 2002 Prof. Dr. Dietrich Mania excavated approximately 2000 m^2 of a sandy layer immediately below rock travertine. This fieldwork resulted in a collection with c. 150,000 flints, c. 25,000 rocks, c. 50,000 animal bones, many travertine rocks with well preserved plant imprints, few compacted wooden fragments as well as c. 30 human bones and teeth (Brasser 2017; Mai et al. 1983; Mania and Weber 1986; Vlçek et al. 2002). From 2004 to 2007 excavations on c. 30 m^2 by the University of Jena added c. 24,000 rocks, c. 6000 flints, c. 2600 animal bones (Fig. 8.1) as well as stratified samples of sediment, mollusks and ostracods (Daniel and Frenzel 2010; Müller and Pasda 2011; Pasda 2012; Vökler 2012). The whole documentary (field diary, plans, maps, find lists, profiles and slides) of the recent excavation are part of the collection too.

The collection is owned by the Federal States of Thuringia and Saxony-Anhalt. Since 2008 the whole collection is loaned by the University of Jena and stored on c. 350 m^2 on two floors in a building with space for future research (Fig. 8.2). The collection is not open to the public and is not used for educational work as preservation is not finished yet. Few rocks and bones are on display in permanent exhibitions in archaeological museums at Weimar and Halle/Saale. The human remains excavated between 1971 and 2002 are the most ancient human fossils in Central Germany (Street et al. 2006) but not part of the Bilzingsleben collection at Jena. These fossils are stored in the museum depots of Weimar and Halle/Saale.

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Fig. 8.1 Animals bones excavated at Bilzingsleben in 2004–2007 (photo by the author)

Fig. 8.2 Animal bones of the Bilzingsleben Collection at the University of Jena (photo by the author)

Palaeontological research on mammals and botanical remains indicate that the sandy, find-bearing layer as well as the rock travertine immediately above were deposited in a Late Middle Pleistocene interglacial, often correlated with the 'Holsteinian'. As animal remains of this time period are rarely preserved, the Bilzingsleben collection is a major biostratigraphic reference of palaeontological and palaeoecological research (e.g. Pint et al. 2012, 2015; van Asperen 2012; van Asperen and Kahlke 2015).

Beside the human and animal remains, Bilzingsleben became famous in archaeology as the site was interpreted to represent a Lower Palaeolithic camp-site with huts, hearths, a stone pavement, thousands of lithic artefacts and bone tools as well as material evidence of symbolism and large mammal hunting (Mania and Mania 2005). In contrast, due to the recent excavation and re-examination of the old collection the find-bearing layer is interpreted as being deposited by natural processes incorporating fluvial and limnic sediments as well as former parts of the Pleistocene landscape, among them few cut-marked animal bones and few lithic artefacts only (Brasser 2017; Liebermann and Pasda 2014).

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Chapter 9
The Paleontological Collection of the State Museum of Natural History (SNHM) in Braunschweig, Germany

Ralf Kosma

9.1 History of the Collection

The State Museum of Natural History (Staatliches Naturhistorisches Museum, SNHM) in Braunschweig houses some of the oldest collections of natural specimens in Europe. The history of the museum reaches back to 1728 when the traveler Johann Friedrich Armand von Uffenbach visited the Castle of Salzdahlum, which was formerly owned by Duke Anton Ulrich. Von Uffenbach mentioned fossils and ores which were on display in "Cabinet Number 3" of a total of 6 cabinets housed at the Castle of Salzdahlum. In 1753 Duke Charles the First of Braunschweig and Lüneburg made plans to open his collections of arts and natural curiosities to the public. In that year the residence of the Duke was moved from Wolfenbüttel/Salzdahlum to Braunschweig and this caused many changes. The medical doctor Daniel de Superville (1696–1773) was entrusted to build up this new cabinet. From the very beginning Charles the First and de Superville had a strong interest in displaying minerals and fossils, which mostly originated from the surrounding areas like the Harz Mountains. In 1773 the collection as well as the exhibitions of the specimens were located at the "Kleines Mosthaus" in Braunschweig. Most probably the cabinet was opened to the public in connection with the autumn fair of Braunschweig at 10th of October 1754. Unfortunately a written hint to confirm this date does not exist nowadays. The oldest inventory books can be tracked back until 1753 which makes the opening in 1754 very plausible.

At the 6th of September 1755 Duke Charles instructed the theologian, former courtmaster of the University Collegium Carolinum, and secretary of de Superville Johann Gottfried Hoefer (1719–1796) to "make a collection of all the natural his-

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tory specimens and curiosities of our countries”. Each and every information concerning the collectibles should be documented in an archive. The oldest visitors’ books from 1754 are still existing today and they document the names of all the important visitors at these times. Interestingly the British Museum in London also was founded in 1753, but it was opened to public in 1759.

The Duke’s collections also served as teaching material for lectures at the Collegium Carolinum (the precursor of today’s Technical University) during the second half of the eighteenth century. It included, aside from fossil specimens, botanical, zoological, and mineral specimens, some of which drew attention to several important scientists of that time, including Johann Wolfgang von Goethe.

In 1759 all State servants got the order to collect natural specimens and transfer these to the Dukes’ collection. But not many of the officials followed the ordinance. The principal Johann Arnold Ballenstedt (1705–1788) sent ceratites, fossil corals and rock samples from the Elm, a hilly area which is situated east of Braunschweig.

Duke Charles specificly ordered collectors to excavate specimens of the attractive fossil sea lily *Encrinus liliiformis* from outcrops in the vicinity of Braunschweig to use these as “exchange currency” for other collectibles (Fig. 9.1).

Three pieces of a petrified tree trunk from Erfurt were purchased for the collection in 1767.

In 1873 two collections, the “Maertens’sche Petrefactensammlung” and the collection “Michels”, consisting of fossils from the Eifel mts., were moved by the director Wilhelm Blasius from the museum to the Technical University of Braunschweig. The remaining parts of the Paleontological Collection of the museum were also shifted to the University 1 year later, in 1874, because Julius Ottmer, the new lecturer for mineralogy and geology at that time, had been hired and needed the material for his teachings.

The skeleton of an aurochs (*Bos primigenius*) was discovered in the Alvesse Moor west of Braunschweig in 1875 and presented to public for the first time in the museum in 1876. This specimen is one of the most complete specimens of aurochs ever found. It also was amazingly large. Since 2015, after an intensive process of

Fig. 9.1 Extremely rare sea lilies *Chelocrinus schlotheimi* (Quenstedt), 1835 from Wittmar/Asse in the SNHM Collection. The specimen originates from the Triassic (Upper Muschelkalk; mo1/Anisium; 235 million years) and was discovered by a private collector in 1979

restauration, this aurochs is on display again in the permanent exhibition of the State Museum of Natural History in Braunschweig (Fig. 9.2).

Bones from Woolly mammoths (*Mammuthus primigenius*) from Gittelde in the vicinity of Salzgitter were listed in the 1871 catalogue, and other specimens of Pleistocene mammals were already illustrated in 1817. These findings originated from Salzgitter-Thiede and were given to the museum in November 1892. They were discovered by the local physician Carl Bieling after a blowing in the gypsum quarry of Thiede in 1816. Among bones of mammoths there were also remains of other mammals like rhinoceros, bison, horse, and elk. Even as early as 1692 a mammoth molar from Thiede was pictured by Gottfried Wilhelm Leibniz in his “Protogaea” (Figs. 9.3 and 9.4) (Ahrens 2004).

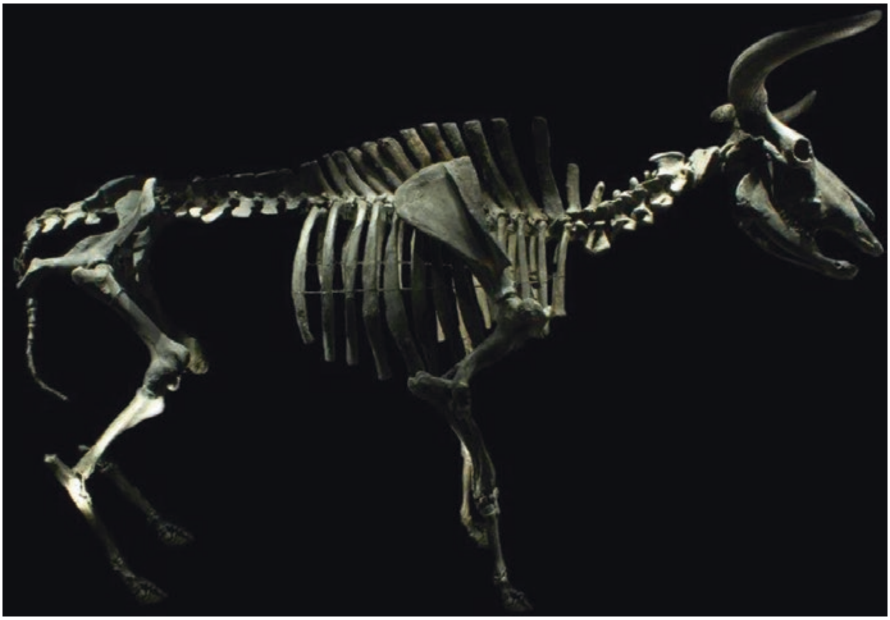

Fig. 9.2 Aurochs (*Bos primigenius*) in the permanent exhibition of the SNHM

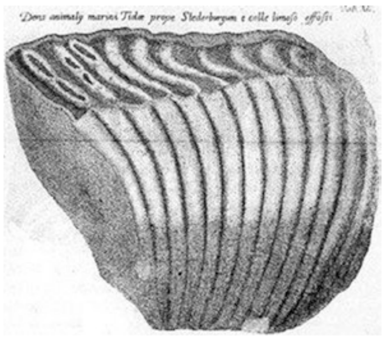

Fig. 9.3 Mammoth molar from Thiede depicted in Protogaea (Leibniz 1692, published posthumously in 1749)

Fig. 9.4 Collection of ammonites at the State Museum of Natural History

Fig. 9.5 Fragments of leopard mandibles from the Rübeland caves in lateral view

Between 1887 and 1897 several research campaigns by Blasius and his colleagues yielded large numbers of cave bear remains from the Pleistocene deposits of the Hermann's Cave and the Baumann's Cave (Rübeland, Harz Mountains). Among these bones and teeth an assemblage of remains from other taxa was found—including cave hyena, cave lion, leopard (Fig. 9.5), capricorn, fragmented antlers from reindeer, giant deer, bones from wolverine and wolf, and small mammals like rodents. Altogether there are 31 taxa represented, some are of characteristical glacial origin, and others of typical interglacial time periods. This large collection of mammal bones, mostly from the Weichsel Ice Age and its corresponding interstadials, is still housed at the museum today, and stands in the focus of actual research (Joger and Rosendahl 2012; Paijmans et al. 2018).

In 1879 a skeleton of a “saurian” was excavated in the vicinity of Salzgitter in an outcrop called “Goldsacksglück”. Blasius participated in that excavation. The recovered specimen, at that time designated as “*Belodon*”, “*Megalosaurus*” or “*Mystriosaurus*”, is now classified as *Angistorhinopsis* sp. and most of the specimen is housed at the Naturkundemuseum in Berlin after these bones were given to Berlin on loan for scientific research in 1889 and never returned to the museum in Braunschweig. Only some tiny fragments and osteoderms of this specimen are still present in the collection of the SNHM today. *Angistorhinopsis* is a genus of phytosaurs from the Late Triassic of Europe.

In 1871 most of the paleontological collections of the museum were moved to the Polytechnical School, the later University, where a new professorship for mineralogy and geology was invented in 1872 with Julius Ottmer as chairman. The geological department and its stockroom were located in close proximity of the Ducal Museum of Natural History, the later SNHM.

At the beginning of the twentieth century many important fossils found their way into the collections, including perfectly preserved ganoid fishes from the Lower Jurassic, cephalopods from the Triassic and a unique collection of belemnites. Until 1944 the gradually increasing collection belonged to the most important paleontological collections in Germany. Unfortunately the collection was almost completely destroyed by bombing on October 15th 1944.

After World War II the collections had to be rebuilt since only very few fossils (a partial skeleton of an ichthyosaur, some Jurassic fishes) could be uncovered from the ruins of the University building. Parts of the museum collections like the Pleistocene fossils from the Rübeland Caves (Fig. 9.6) had been outsourced during World War II and got through the rigors of the war without major damages. Preserved from the old collections are part of the amber collection, two specimens of the ganoid fish *Lepidotes osseus* and type specimens of the gastropods *Natica brunsvicensis* Müller, 1898 and *Brunonia grandis* Müller, 1898, which were both named after the city of Braunschweig and which originated from the Lower Campanian within the urban area of Braunschweig. During the following decades many fossils were given to the University by private collectors and within several years the collection grew again. Important specimens for instance were an ichthyosaur, *Stenopterygius* aff. *crassirostratus*, from the Posidonia shale of Schandelah, which was recovered by Curt Wunnenberg in 1934, as well as a marine crocodile, *Steneosaurus bollensis*, which was collected in 1956 by Josef Wincierz in the vicinity of Hondelage, a village some 10 km northeast of Braunschweig.

A comprehensive collection of ammonites and belemnites from the Jurassic and the Cretaceous was transferred into the collection in 1985 by Dr. Joachim Eikenberg (Fig. 9.4).

On 8th December of 1999 the new fossil hall, which was integrated in the permanent exhibition of the museum, was opened to public. From this time on, fossils on display became very important to the exhibitions of the State Museum of Natural History (Fig. 9.7).

Fig. 9.6 Pleistocene remains from different mammals at the paleontological collection of the SNHM

Fig. 9.7 Collection of mesozoic fishes

Fig. 9.8 Reconstructed skeleton of *Spinophorosaurus nigerensis* in the Dinosaur Hall of the SNHM

9.2 Research and New Acquisitions

In 2003 Ulrich Joger became the new director of the SNHM, and the main emphasis of the museum shifted into a more and more paleontological direction. The author of this article was hired as the curator of paleontology at the SNHM, a position that did not exist afore. New specimens revalued the paleontological collection of the museum. Many of these specimens were discovered and described as a result of own excavations, including the Cretaceous ichthyosaur *Acamptonectes densus* (Fischer et al. 2012) from Cremlingen in the vicinity of Braunschweig, and dinosaur bones from the Republic of Niger (*Spinophorosaurus nigerensis* Remes et al. 2009 (Fig. 9.8), *Jobaria tiguidensis* Sereno et al. 1999) or the theropod ichnotaxon *Paravipus didactyloides* Mudroch et al. (2011), whose holotype is housed at the SNHM (Fig. 9.9).

New collections where given to the museum, like the famous Collection Jablonka, which mainly comprises of perfectly preserved fossil fishes from the Wadi Haquel in Lebanon (Lower Cretaceous). Among those are a shark *Mesiteia* sp., a coelacanth and several stingrays. Apart from Haquel-fishes this collection contains a pterosaur

Fig. 9.9 Holotype of the dromaeosaur track *Paravipus didactyloides* from Niger. The specimen is housed at the collections of the SNHM

Fig. 9.10 Articulated specimen of *Stenopterygius* sp. from the Lower Jurassic of Schandelah in rare dorsal view. This specimen was discovered in the field during the digging campaign 2016

from Solnhofen, Bavaria (*Pterodactylus kochi* Wagner 1837) and some other fossil particularities.

Beginning in 2011 the museum initiated two major excavation projects in the Liassic Posidonia shale of the Braunschweig region. These excavations yielded several perfectly preserved ichthyosaur specimens (*Stenopterygius* sp., *Eurhinosaurus longirostris* Owen et Jaeger 1856). At least two of these are completely articulated (Fig. 9.10). Within 6 years of intensive investigation in the two quarries Hondelage and Schandelah several hundreds of Lower Jurassic fossils were retrieved for paleontological research and exhibits. Among these are bones of the pterosaur *Dorygnathus* cf. *banthensis* (Theodori 1830), which is extremely rare in Northern Germany, as well as bones and teeth from plesiosaurs, marine crocodiles and fishes like *Lepidotes gigas* Agassiz 1832, *Acidorhynchus brevirostris* (Woodward 1895), *Tetragonolepis semicincta* Bronn (1830), and a diversity of other taxa. A paleontological workshop is affiliated to the collection since 2006 so that preparation of the newly excavated fossils can be implemented immediately. As a result of these own excavations several special exhibitions were shown at the SNHM (Joger et al. 2009; Hauff et al. 2014, Englich et al. 2017).

To date (2017), the collection comprises roughly 50,000 specimens, but it is growing rapidly.

Fossil reptiles, especially from the Jurassic, became and will be the main focus of the paleontological collection of the SNHM. Despite this, fossils of different systematic positions and from different eras of earth history from the Braunschweig region will always be of major interest for our collection.

9.2.1 Public Outreach

Within the last years the public outreach of the SNHM increased on a regular basis. Different tutorials and educational activities were introduced, some of which were developed especially to support special exhibitions or excavations implemented by the museum. The members of the association "Gesellschaft für Naturkunde e.V." (www.gfn-bs.de), which supports the SNHM, donated fossils for the Fossil Hall in the second floor of the permanent exhibition. Among these are local fossils from the Mesozoic of the Braunschweig region like ammonites, bones of marine reptiles, trackways from *Chirotherium*, as well as paleozoic fossils from the Harz Mountains. Within the association many private collectors are connected to the museum.

For several years students of Geosciences and students of Biology got the chance to make a trainee at the Department of Paleontology. Each year within the last decade more than ten young people participated in the excavations of the SNHM or absolved an internship at the paleontological laboratory. These students originated from different universities. Bachelor's and Master's theses were carried out at the SNHM. But also scholars from higher grades of different grammar schools absolved trainees at the Department of Paleontology.

Throughout the year we organize a variety of special public events at our excavation sites and inside the museum. Among these are "The day of the fossil", "The day of the geotope" and monthly talks concerning paleontological topics (Fig. 9.11).

Different cooperations with other museums worldwide as well as cooperations with local institutions like the Geopark Harz. Braunschweiger Land. Ostfalen, the Palaeon (were the oldest wooden weapons, several well preserved spears carved by *Homo heidelbergensis* some 300.000 years ago, are on display), and the Dinosaurierpark Münchehagen led to a diversity of joint cooperations. Several conferences and special exhibitions during the last years were the result of these cooperations. The SNHM is an official branch of the Geopark.

Fig. 9.11 Public paleontological laboratory in 2017

Apart from special exhibitions dealing with zoological contents many special exhibitions with paleontological focus were presented to the public. Among these were "Saurier aus Russland und Asien" (Saurians from Russia and Asia) (2004/2005), "Mammut—Elefanten der Eiszeit (Mammoth—Elephants of the Ice Age)" (2005/2006), Fig. 9.12. "Fossile Schätze aus dem Jura- und Kreidemeer (Fossil treasures from the Jurassic and Cretaceous seas)" (2006), "Projekt Dino—Neu entdeckte Saurier aus Afrika (The Dino Projekt—recently discovered dinosaurs from Africa)" (2009/2010), "Wunderbare Wale (Wonderful whales)" (2011/2012), "Es begann am Heeseberg—Stromatolithe und der Ursprung des Lebens (It began at Heeseberg—Stromatolithes and the origin of life)" (2011/2012), "Welt im Verborgenen—Fossile Sammlungsschätze (The hidden world—fossil treasures in collections" (2012), "Elefantenreich—eine Fossilwelt in Europa (The Elephant Empire—a fossil world in Europe)" (2012/2013), "Jurameer—Niedersachsens versunkene Urwelt (Jurassic seas—the lost primeval world of Lower Saxonia)" (2014), "Planet 3.0—Klima.Leben. Zukunft. Eine Zeitreise durch den Klimawandel (Planet 3.0—Climate. Life. Future. A time trip through climatic changes)" (2015), "Zeitkapsel Bernstein—Lebewesen vergangener Welten (Time capsule amber—Creatures of the lost worlds)" (2015/2016), Jurassic Harz—Dinosaurier von Oker bis Wyoming (Jurassic Harz—Dinosaurs between Oker and Wyoming)" (2017, Fig. 9.13) (Englich et al. 2017), "Eiszeitsafari (Ice Age Safari)" (2017).

A new paleontological workshop with a team of taxidermists and volunteers is preserving delecate fossils, and since 2007 a quantity of 3-D Scans of fossil bones were made with the equipment owned by the museum. The mounted reconstruction of the skeleton of *Spinophorosaurus nigerensis* (see Fig. 9.8) was the first reconstruction of a sauropod reproduced by 3-D printing.

Fig. 9.12 Mammoth skeletons at the special exhibition "Mammut—Elefanten der Eiszeit" (2005/2006)

Fig. 9.13 Morrison-Dinosaurs and the contemporary dwarf sauropod *Europasaurus holgeri* (to the right) from the Harz Mountains, Lower Saxonia, at the special exhibition "Jurassic Harz" (2017)

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Chapter 10
BREMEN: The Paleontological Research Collection of the Geosciences Collection of the University of Bremen

Jens Lehmann

10.1 Introduction

The paleontological collection owned by Germany's smallest federal state Bremen, Germany, underwent a couple of complete relocations and one full rearrangement and a refurbishment of data over the past decades. Originally it was placed in the Übersee-Museum, an internationally highly recognized Natural History and Ethnographic museum in Bremen, integrating topics of nature, culture and distribution across the world in its exhibitions. On the other hand, the history of the Übersee-Museum dates back to the seventeenth century.

In the 1990s a relocation of geoscientific specimens of the same museum to the University of Bremen took place. They were unified as "Geosciences Collection of the University of Bremen". The main part is fossils, but this also included a comprising and scientifically valuable collections of modern gastropods, a fact in particularly the relocation of the latter was highly debated throughout the museums scene in the country. It took a while until the relocation got accepted as positive for the development of the collection, its accessibility and visibility on all fields (Lehmann 2016). Among others convincing arguments are the establishment of new collection rooms including an office and well-equipped laboratory facilities in 2004, when the collection moved into the newly built Marum building on the campus of the University of Bremen. This definitely triggered the evolution of the Geosciences Collection of the University of Bremen to a lively place of research and international academic exchange during the last decades on the field of paleontology. The combination of collection development and research projects is very intensive, particularly excavations in the early Cretaceous of North Germany coined

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this approach (Lehmann 2012). The latter is resulting in a series of research papers on both, micro- and macropaleontology (Schlak et al. 2016 and references therein) and is described below in Chap. 4. The collection is part of the Faculty of Geosciences, one of Germany's newly-founded universities, established in 1971 and according to an overview on all paleontology collections in Germany it belongs to Germany's mid-size academic collections (Jansen and Steininger 2002). General accounts on the collection are given by Kruckow (1954), Kuster-Wendenburg (1999), Lehmann (2017) and on specific aspects of the paleontological collection Lehmann and Menzel (2005; otoliths), Lehmann (2003a; Berriasian fossils from Obernkirchen).

The modern image of the main room of the collection is dominated by the skeleton of a giant deer and a cast of an iguanodontid dinosaur that were transferred from the former permanent exhibition of the Übersee-Museum in 2014 (Lehmann 2014; Fig. 10.1).

This paper aims to give an overview about the paleontological content to an international community, since the collection comprises scientifically significant material including types. The most valuable scientific assemblages are listed and the key papers are cited. After an historical overview this contribution is presenting essential information, including aspects of collection management and conditions. The focal points are presented and the state of the art of research is given, including

Fig. 10.1 Main hall of the Geosciences Collection of the University of Bremen, with a cast of *Iguanodon bernissartensis* of the type series in the foreground. The compact shelving unit housing the paleontological part of the collection can be seen in the center and left of the background. Photo: V. Diekamp

its potencies. The Geosciences Collection presents some specimens to the public, among others by touring exhibitions. In the final paragraphs of this paper the didactic conceptions are briefly discussed.

10.2 History of the Collection

In the fifteenth to seventeenth century the systematic collection of natural history specimens started, with the founding of rarity and curiosities compilations across Europe, initiated by peers or social societies. The specimens collected during this period later formed the base for newly founded Natural History Museums in the nineteenth century. Particularly in the Hanseatic City of Bremen a long tradition of trading triggered to collect natural history specimens from all over the world, but this is mainly true for the neontological part of the collection focused herein (Lehmann 2016). Nevertheless, systematic collection of fossils started in Bremen around the seventeenth century and this was also the beginning of the collection known as Geosciences Collection today. The historical development of the geoscientific collection was described by Kuster-Wendenburg (1999).

The early development of the natural history collections in general is less relevant for the assemblage of today's paleontological collection, for an outline Lehmann (2017) can be considered. Most of the material acquired after 1820 was presented and thus additions were less systematic, only in few cases individual geological specimens were purchased (Abel 1970). However, even the purchase of a comprising assemblage of fossils from the Triassic of the Alps from Prof. von Klippstein (city of Gießen) around 1850 was rather an exceptional coincidence than a systematic approach of increasing the paleontological collection. In the year 1911an extension of the museum's building made more space available (Abel 1970). Particularly the important malakozoological collections, but also the geological collections including fossils, were processed during the first world war, since the curator responsible at that time (F. Borchering), was too old to join the army (Abel 1970). However, the build-up of exhibits and probably also the processing of raw material were stopped in 1914 by recruiting the preparators to the military service.

After the World War I there was the intention to establish Bremen as "Stadt der Kolonien" (city of colonies; Abel 1970), and the reinforcement of the collections from the former colonies was in the focus during the period around world war II, material has been purchased mainly focusing on Africa (Abel 1970). Consequently, the name "Deutsches Kolonial- und Übersee-Museum" was established in 1935. This period was less important for the paleontological part of the collection. Among the prominent people influencing the build-up of Bremen natural history collections there is Franz Stapelfeldt (born 1877, deceased 1954). During the 1930s until the end of the second world he was a prominent person involved in the special circumstances of the third Reich history of modern Geosciences Collection of the Bremen university, but only few fossils present in the modern collection can be attributed to his activities according to extensive but unpublished provenance research by Bettina von Briskorn (Übersee-Museum Bremen; see Lehmann 2016).

The Bremen collection did not undergo much damage directly by destruction in World War II, but a significant loss of information has to be stated for parts of the material by various moving during times of war but also before and after.

A turning point and a significant reinforcement of the fossil collection at Bremen was the establishment of a full-time position for geology in 1953 (Abel 1970). Shortly before the museum was renamed to today's designation Übersee-Museum (established in 1951, see Abel 1970). Thorwald Kruckow was hired for this function and his expertise led to a distinguished curation until the end of the year 1981 when he retired, including a sophisticated labeling (Abel 1970; Kuster-Wendenburg 1999). In the 1950s a proper repository was build. From now on curation of paleontological specimens was almost continuous, since Elisabeth Kuster-Wendenburg took over the curatorial care in 1984 (Kuster-Wendenburg 1999). The number of fossils was rising mainly between the 1950s and 1970s. However, after further relocations the storage of the collections became poor again and was in urgent need of improvement.

Kuster-Wendenburg became vice director of the Übersee-Museum, but continuous personal arguments ended up in a relocation of all geoscientific material, including the paleontological specimens, as well as the malakozoological collections to the fairly newly established geosciences department of the University of Bremen (Kuster-Wendenburg 1999). This triggered the development of the collection significantly, new cupboards were purchased, among others with financial support by the ODP project (http://www.iodp.org/about-iodp/history; accessed 5th of January 2017). The collection was housed in the central area of the university first. The early years at the university were dominated by extensive labeling, the compilation of a database and a rearrangement of the collection. Almost no new fossil material was acquired. In the year 1999 E. Kuster-Wendenburg became retired and as new collection manager the present author was hired in 2000 (Willems 2001). Around the turn of the millenium several occasions of flowing water by accident disqualified the first site of housing on the campus. These disasters and no climate control reduced the number of pyritized fossils drastically, particularly the collections from the Lower Cretaceous (upper Valanginian) and Middle Jurassic (Callovian) of North Germany and there was an apparent need for further action. In 2001 a first laboratory for the preparation of fossils was established, including a special binocular microscope sponsored by special grants by the chancellor of the university. Nevertheless, the rooms did not match modern standards of safety and thus not only the collection housing was in need for a further change.

10.3 General Information

10.3.1 Official Label, Conditions and Contact

The Geosciences Collection of the University of Bremen, in German "Geowissenschaftliche Sammlung der Universität Bremen", is an administrative part of the "Fachbereich Geowissenschaften" (Faculty of Geosciences) with an independent annual budget available for collection affairs. The acronym is GSUB. All fossils are given a large letter (e.g. G = fossil gastropods). The main part of the collection is housed on the ground floor of the Marum building on the campus of the University of Bremen, Leobener Strasse, in 28357 Bremen, Germany. Specimens are housed in a total number of 144 individual units. These are either individual rows of drawers within a coherent cupboard system made of metal or rows in a manual mobile shelving system. The main hall of the collections also includes some workplaces for micropaleontological studies with binocular microscopes (Fig. 10.2).

One chemical laboratory and one workshop for technical preparation and cleaning that are separated from the collection room are exclusively associated to the collection. Additionally, there is an outpost in the "Verfahrenstechnik" building in the central area of the campus. The later is currently housing raw material and rock samples among minor parts of the main collection. Also there are a few large-size specimens, including a cave bear of unknown provenance, mounted in its nineteenth century display case, a bedding plane with an accumulation of *Ceratites* from the Middle Triassic of southern Germany (Schindgasse, Kraichgau, southern Germany, for locality details see Hölder 1960; Mayer 1961, 1967) and some raw material of Middle Jurassic rock slabs from northern France (Landaville) containing accumulations of regular echinoderms (for locality details see Richter 2003).

All enquiries to the collection should be made to PD Dr. Jens Lehmann, Faculty of Geosciences, University of Bremen, Klagenfurter Strasse 4, 28359 Bremen. e-mail: jens.lehmann@uni-bremen.de

Fig. 10.2 Workplaces for micropaleontological studies in the Geosciences Collection. Photo: M. Krogmann

10.3.2 Management Techniques Used

10.3.2.1 Registration

A part of the holdings was registered in a relational database based on Microsoft Access that was adapted to the specific needs (Kuster-Wendenburg 2008). About one third of the paleontological section of the collection has been fully inventorized (missing are vertebrates except for otoliths, crustaceans and fishes); only the recent marine gastropods are fully registered. Paper labels were printed-out directly from this computer program, limited by the fact that not all fields potentially included in the relational database fitted on the print-out and consequently a selection of database fields has been printed for space reasons. Avoiding these limits the registration of new entries to the collection today is realized in a Microsoft word file and the full set of information is printed on one, or in case of too many information, on subsequently numbered labels. All of these entries are continuously amended in Microsoft Access too. The language of registration changed from German to English at the beginning of the year 2005, generally for all specimens of the collection.

10.3.2.2 Techniques of Labeling

In earlier years labeling of specimens was very heterogeneous in general. Since 2010 on-specimen labeling is improved to enhance permanence by first applying a basic coat and secondly, after drying of the first, an India ink is used for the acronym-number labeling and at last a finish is coated, principally following the method described by Davidson et al. (2006). A couple of years before 2010 paper labeling was improved by laminating the hardcopies produced by a laser printer. After a short experimental stage with glossy laminating foils that are disadvantageous with respect to photography works, matt surface laminating foil is used today.

10.3.3 Focal Points

The most important main group of the paleontological compilation is mollusks. This fits well to the focal point of the neontological part of the collection. During the past 15 years the mollusk compilation has been systematically enlarged on the field of ammonites and particularly Cretaceous ammonites—due to the research focus of the head of the current head of the collection. Ammonites of the Cretaceous are particularly interesting because their evolution reveals a broad variety of morphotypes, including a large number of heteromorph ammonites (Lehmann 2015a). The research potential is high by evolutionary relationships still unexplained for many groups and a vague life style, anatomy and generally an uncertain biology (Klug and Lehmann 2015). There is important material housed in the collection that made significant scientific progress on the fields of anatomy and diet of ammonites (Wippich and Lehmann 2004; Klug et al. 2012; Klug and Lehmann 2015).

The collection comprises ammonite material from all over the world in the systematic part as well as in the collections related to publications (Table 10.1). Nevertheless, there is a focus on some regions, particularly North America, France, North Africa and Germany. In Germany the focus is on Cenomanian-Turonian ammonites from Westphalia and Lower Saxony as well as on those from the Aptian of Westphalia.

Table 10.1 Focal points of the "fossil assemblages related to publications" section of the Geosciences Collection

Field	Country	Main groups of fossils/specifics	Selected publications	Nb. of drawers	Stratigraphy
105	Sinai, Tunisia, Morocco, Jordan	Ammonites, bivalves	Bauer et al. (2001); Heldt et al. (2008, 2010); Lehmann and Herbig (2009); Lehmann et al. (2009); Wendler et al. (2010); Wiese and Schulze (2005); work in progress	1–15	Cretaceous: Aptian, Cenomanian, Turonian
100	England (Isle of Wight)	Ammonites, bivalves/mainly bed-by-bed collecting	Lehmann (2015b): work in progress	1–20	Cretaceous: Aptian
97	Germany (mainly Hohendorf, Mecklenburg and Lengerich, Westphalia)	Ammonites/soft tissues preservation (Lengerich)	Klug et al. (2012); Klug and Lehmann (2015); Lehmann et al. (2008, 2013, 2016a)	1–4	Cretaceous: Albian, Cenomanian/ Turonian
95–96	Germany (Alstätte, Westphalia)	Ammonites, belemnites, bivalves	Lehmann et al. (2012, 2016b); von Bargen and Lehmann (2014)	1–20 and 1–23	Cretaceous: Aptian
94	France (Rosans area)	Ammonites	Work in progress	1–10	Cretaceous: Albian
92	USA (South Dakota)	Ammonites	Work in progress	1–9	Cretaceous: mainly Turonian
91	USA (Texas)	Ammonites, bivalves, gastropods/ mainly bed-by-bed collecting	Reichelt 2005 and work in progress	1–6	Cretaceous: Albian

The column "Selected publications" refers to the particular publications dealing with the material listed

A further special collection is on statoliths—primarily otoliths of fish. This collection has been assembled by the honored amateur enthusiast Herbert Menzel (Litt 2003; Lehmann 2003b, 2010b). A former curator of the collection, T. Kruckow (see paragraph 2), encouraged him to do research on otoliths and he became a recognised specialist and presented his collection to the university in 2002. This collection is mainly including otoliths from Northern Germany, especially from the Oligocene and Miocene, with a significant part originating from the famous former Sunder clay pit in Twistringen, south of Bremen (locality details see e.g. Janssen 1983 and Hagemeister 1988; Menzel 1997). In co-operation with the institute for subsurface research of the state of Lower Saxony Menzel worked on many drilling holes in Lower Saxony. This work was based on fossil material for comparison from other parts of Germany as well as Belgium, Denmark, France, Italy, Austria and the Netherlands. A full summary of this statolith collection, including quite a few figures of specimens, can be found in Lehmann and Menzel (2005).

A minor focus of the collection is amber from different countries, but mainly Baltic amber. The scientifically most interesting inclusion is a fossil tick enclosed in amber (Fig. 10.3). It represents the only known adult tick in Baltic amber and is among the few records of this group of animals of the Paleogene and Cretaceous. It is the type of *Ixodes succineus*, a species described by Weidner (1964). The latter authors assumed a very close relationship to the recent and widely distributed European Castor Bean Tick, *Ixodes ricinus.* However, modern technology of X-ray tomography revealed that the closest living relative of the tick from the Baltic amber is the Asian tick *Ixodes ovatus* (Dunlop et al. 2016) and thus promoted this important find quite recently.

There are a few outstanding single specimens in the collection not embedded in one of the focal points of the collection that are scientifically important. Among these is a jawbone of a hitherto unknown reptile from the Middle Triassic from the famous Rüdersdorf quarry near Berlin that is a good example for the active research

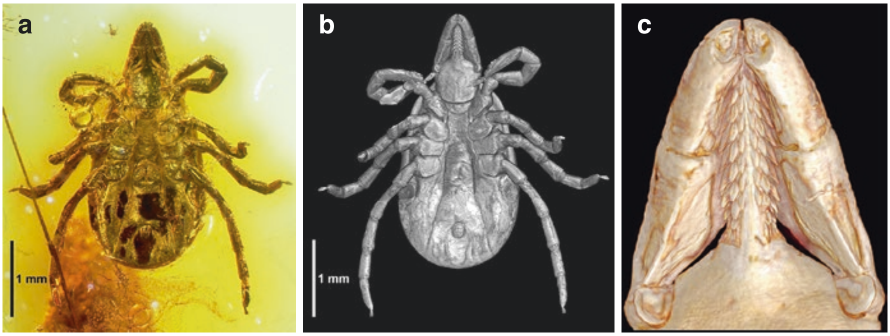

Fig. 10.3 Holotype of the Baltic amber tick *Ixodes succineus* Weidner, 1964; GSUB I21. (**a**) Binocular image, photo J. Dunlop. (**b**) Tomographic rendering. (**c**) Details of gnathosoma, tomographic rendering. Image (**b**) and (**c**) by F. Fusseis, M. Ehlke, S. Zachow, X. Xiao, R. Hoffmann. GSUB is the acronym of Geosciences Collection of the University of Bremen

Fig. 10.4 Hypotypoid of the very rare gar species *Obaichthys decoratus* Wenz and Brito, 1992 from the Santana Formation (Lower Cretaceous) of Brazil; GSUB V2251. (**a**) Specimen as a split fossil, the original condition after cracking the concretion with the fossil. (**b**) Specimen after acid preparation allowing the detailed anatomical studies used for the monograph of Grande (2010). Photos: M. Krogmann

policy of the collection. It was originally referred to as a new species of primitive ichthyosaur, *Omphalosaurus peyeri* by Maisch and Lehmann (2002), but modern X-ray tomography reveals a quite different phylogenetic alignment. This fossil probably belongs to an unknown placodontid (pers. commun. Tanja Wintrich, Bonn, 3rd of February 2015). Another example is a fossil garfish from the Lower Cretaceous of Brazil (Fig. 10.4), first misidentified as *Rhacolepis* sp. (Kuster-Wendenburg 1996), but later recognized as a belonging to *Obaichthys decoratus*, a rare gar species described by Wenz and Brito (1992). This drew the attention of a gar specialist of the Field Museum in Chicago to this fossil that has been borrowed and acid prepared in the United States after the turn of the millennium (Fig. 10.4). Later the fossil was enclosed into a comprehensive monograph about this group, adding some important anatomical details (Grande 2010).

The main hall of the collection is dominated by the cast of a dinosaur skeleton of *Iguanodon bernissartensis* from a skeleton of the collection of the Natural History Museum of Brussels (Fig. 10.1). This cast is widely known since it is used in the German and English version of the online encyclopedia Wikipedia (Lehmann 2014). Although the cast is not very detailed, it perfectly serves to indicate that the Geosciences Collection of the University of Bremen is mainly a paleontology collection and it illustrates the trace-maker of the *Iguanodontipus* ichnosp. Track on display in the same room (Lehmann 2003a). There are also some monetary valuable original specimens in the main hall of the collection on display (Fig. 10.5; Lehmann 2008a, 2014). One is a complete skeleton of a giant deer, *Megaloceros giganteus*, from the late Pleistocene of Ireland - a fossil typical for fossil trading in

Fig. 10.5 Giant deer *Megaloceros giganteus* Blumenbach, 1799, a very valuable fossil of the Geosciences Collection Bremen; late Pleistocene of Ireland, purchased for display in 1894. Photo: M. Krogmann

the nineteenth century (Aughey et al. 2016) and a demanded and pricy exhibit (Monaghan 1997). This specimen was purchased from the former director of the Breslau zoo, Mr. Stechmann, in 1894 (Kruckow 1964; Kruckow 1966b erroneously states 1896). This giant deer was on display in the Übersee-Museum until recently.

A very large rock slab from the Green River Formation (Eocene) of Wyoming, USA is on display at the entrance of the collection (Lehmann 2008a). It bears a palm leaf with a length of 165 cm and two completely preserved large fish (*Mioplosus labracoides,* maximum length 36 cm; *Diplomystus dentatus*, maximum length 50 cm). The specimen was originally purchased in 1993 for the "North America" exhibition of the Übersee-Museum (Lüderwaldt 1993) that was dismounted in 2007.

The largest part of the paleontological collection is arranged systematically in a compact shelving unit composed of nine individual rows. Each row consists of 10 fields, thus the whole shelving unit consists of 110 individual rows. Each row is filled with a maximum of 25 drawers, depending on the size of the specimens. In rows one to seven of the compact shelving unit an individual pragmatic systematic classification based on an arrangement depending on the individual holdings of the Bremen collection is used. The trace fossil collection (field 84–85 of row 7) is not arranged according to the systematic classification of organisms, but in an individual classification scheme for ichnofossils. Furthermore, a couple of topics are arranged separately, not following any systematic approach, namely the amber collection and the collection of curiosities and specific Bremen exhibits.

10.4 Research and Research Potencies

A large part of the collection, currently comprising several thousands of specimens, is summarized under "fossil assemblages related to publications" and is ordered after the individual countries the material originates from. Table 10.1 is summarizing the focal points of this part of the collection.

The research collections comprise type specimens of species critical for the evolution of certain groups of organisms (Fig. 10.6, Lehmann et al. 2017) as well as paleobiologically important finds, like the most spectacular soft tissue preservation found in the Cretaceous of Germany yet (Fig. 10.7, Klug et al. 2012; Klug and Lehmann 2015).

The list of individual compilations given above already illustrates that the research focus of the collection is currently on the Cretaceous and ammonoids. However, in earlier years the former head of the collection, E. Kuster-Wendenburg, worked on Neogene gastropods (e.g. Kuster-Wendenburg 1986) and underwent excavation to obtain material from the famous Miocene localities Miste in the Netherlands and Twistringen near Bremen in Germany (locality details see Chap. 10.3.3). Additionally there is material from the Pliocene of

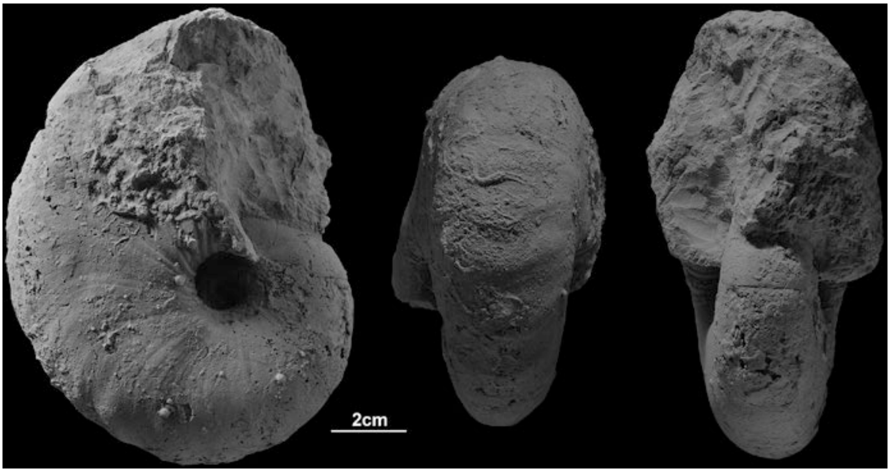

Fig. 10.6 Holotype of the nautiloid *Anglonautilus praeundulatus* Lehmann et al. 2017, the earliest representative of the *Anglonautilus* evolutionary lineage; Lower Cretaceous, Lower Aptian of Spain; GSUB C7505. Photos: M. Krogmann

Italy (Isle of Sicily, Rome area) collected at historical times by Förstner, Kemna and Klipstein (Kuster-Wendenburg 1999) that might have research potential. The same is true for Eocene gastropods and bivalves from classical localities of the Paris basin (Chauvey, Cuise, Damery, Grignon, Lizy, Chaumont) collected by Klipstein and obtained in 1896.

Scientific work in the collection was and is dominated for several years by the "*Alstätte project*." Alstätte is a town near Ahaus in Westphalia, directly on the border with the Netherlands. From August 2009 until June 2012, the collection carried out digging and probation campaigns in a clay pit near Alstätte that is now closed again. Many hundreds of macrofossils and microsamples were collected and documented: Their interpretation is still in progress (Fig. 10.8). Clay stones of the early Cretaceous period were quarried here in the 1960s before the companies were closed down, thus the recent excavation for the covering of a landfill in this period was a great chance. In contrast to earlier investigations at this site an exact documentation of the findings and the section itself has been carried out and therefore it became a scientific success with many unexpected results (see Schlak et al. 2016 and Lehmann et al. 2016b for further references). The project was supported by the local amateur geologist Thomas Hemker, who additionally collected hundreds of fossils bed-by-bed. Furthermore, a series of nine bachelor and master theses resulted from these activities, partly published in peer-review journals already, and one Ph.D. thesis (Schlak et al. 2016; von Bargen 2016; von Bargen et al. 2016). This project was also extensively used for educational work, namely public talks, journal articles (Lehmann 2012) and forthcoming exhibitions as outline in the following paragraph.

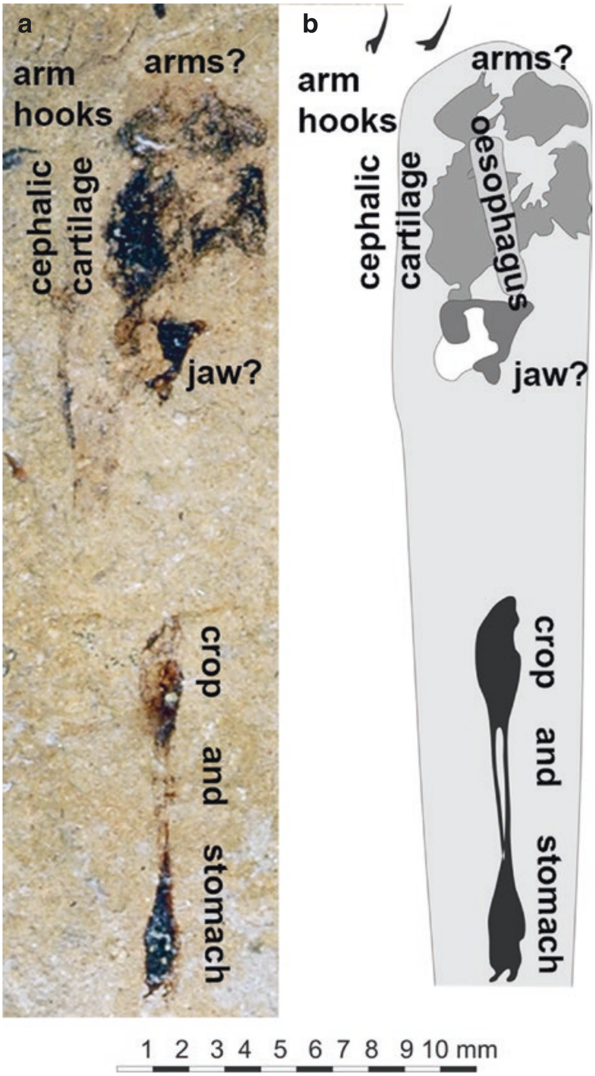

Fig. 10.7 Spectacular soft tissue preservation of a near-complete baculitid ammonite from the Cenomanian/Turonian black shales of North Germany. The specimen is showing remains of digestive tract, probably parts of buccal mass, cephalic cartilage and questionable arm crown; associated pair of coleoid arm hooks; GSUB C5836. Image: C. Klug

10.5 Educational Work

The images of rooms presented here (Figs. 10.1 and 10.5) indicate that the collection has exhibition qualities and owns a few display cases. Nevertheless, the rooms of the Geosciences Collection of the University of Bremen are generally designed as serving for research, thus the concept does not include opening hours for display cases and large fossils presented in the main hall on a regular base. The

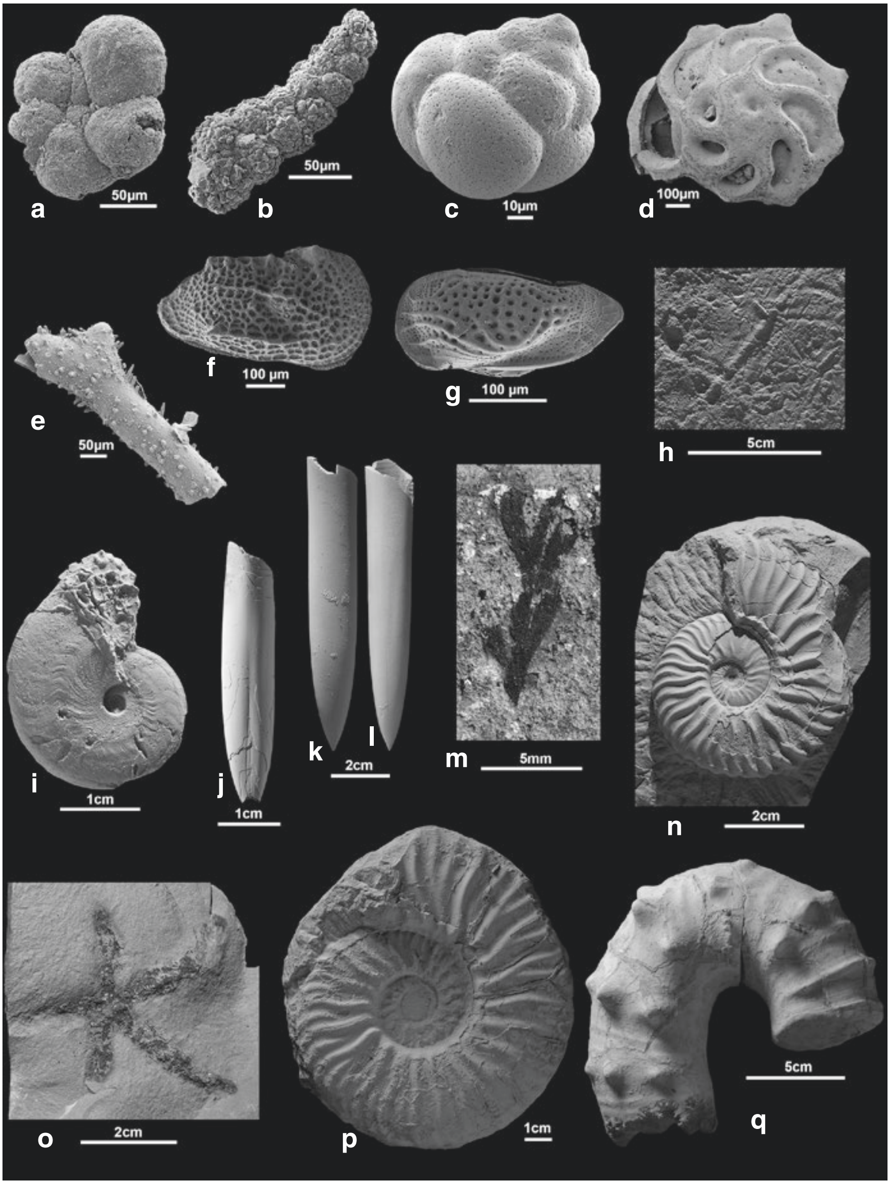

Fig. 10.8 Fossils obtained in the framework of the German Research Foundation (DFG) project of the Geosciences Collection Bremen on the Early Cretaceous (Aptian) of Alstätte, North Germany. (**a**) Benthic foraminifer *Falsogaudryinella* sp., GSUB M50. (**b**) Benthic foraminifer *Reophax* spp., GSUB M56. (**c**) Benthic foraminifer *Gubkinella graysonensis*, GSUB M38. (**d**) Benthic foraminifer *Epistomina ornata*, GSUB M61. (**e**) *Ramulina aculeata*, GSUB M63. (**f**) Ostracod gen. et sp. indet., GSUB M75. (**g**) Ostracod *Paranothacythere paraglobosa*, GSUB M71. (**h**) Trace fossils on a supposed firmground, GSUB I81. (**i**) Ammonite *Aconeceras nisoides,* GSUB C5818. (**j**) Belemnite *Duvalia grasiana,* GSUB C6173. (**k**, **l**) Belemnite *Oxyteuthis depressa*, GSUB C5668. (**m**) Plant fragment, GSUB P1402. (**n**) Ammonite *Deshayesites fissicostatus*, GSUB C5922. (**o**) Starfish, non det., GSUB E3195. (**p**) Ammonite *Deshayesites fissicostatus,* GSUB C5742. (**q**) Heteromorph ammonite, *Audouliceras urbani,* GSUB C5765. Photos: M. Krogmann

existing exhibit is presented for guided tours though, presenting topics like evolution of terrestrial and marine ecosystems. A recently invented booster club plans to expand offers to the public (Lehmann and Liebenberg 2015). Outside the campus some material is permanently on display in the Übersee-Museum. Following the conceptual framework of the museum geoscientific specimens are not concentrated at a certain site, but today are embedded in the individual topics presented by the museum (e.g. parts of the world like Oceania, Africa). This included some unique material occasionally on display, like a specimen of the largest ammonoid species recorded, *Parapuzosia seppenradensis*, from the late Cretaceous (Campanian) of Seppenrade in North Germany (Lehmann and Becker 2002). The latter represents a topotype and is of special interest since the locality is inaccessible today (Kennedy and Kaplan 1995) and has been formerly one of the central specimens in the exhibition "evolution" in the Übersee-Museum (Hohmann and Kuster-Wendenburg 1992).

In the field of public understanding of science material of the Bremen collection is on display in special exhibitions (e.g. Lehmann 2006b, 2017). A distinguished project was the special exhibition in the "Haus der Wissenschaft" (house of science) in Bremen in 2006 about dinosaurs (Lehmann 2006a), as it constitutes the most successful show in this institution yet. The special topic have been the local dinosaur track occurrence in the sandstones of the lowermost Cretaceous at Münchehagen and Obernkirchen in Lower Saxony, Germany, and the involvement of the Geosciences Collection in these findings (Lehmann et al. 2006). The conceptual framework used the local relation of Bremen to the quarrying of these sandstones centuries ago and the wide usage of this material in the Bremen city center (Kuster-Wendenburg 1999, 2002; Lehmann 2010a) to attract the audience. A comprising exhibition catalogue has been produced, documenting this event permanently (Lehmann 2006b).

The Geosciences Collection is also intensively cooperating with the Center of Marine Environmental Sciences at the University of Bremen (Marum) and this incorporates special exhibitions at exceptional places. An example is the "Geoschiff" (geoship) project realized in the "Year of Geosciences" in Germany in 2002. This was a 105 m long inland water vessel altered to contain a 600 square meter exhibition "Abenteuer Meeresforschung" (adventure marine science), visited by117,000 visitors in 62 cities across Germany during a period of almost 6 month (details see Lehmann 2016).

Another distinguished cooperation is "MeerErleben" ("Experience Ocean")—a traveling exhibition initialized by the Marum at the University of Bremen and financed by a shopping center project management company currently managing 199 centers in a total number of 14 countries (Fig. 10.9; Gerdes and Pätzold 2012, Lehmann 2017). These shopping centers attract around 4.6 million visitors, ideal places to predestine people over visual and acoustic stimuli for topics beyond consumption. Although the cooperation with the shopping centers came to an end this high quality exhibition is still occasionally on display, e.g. currently at the Deutsches Museum in Bonn in cooperation with the German Research Foundation (DFG; see Lehmann 2017). It should be mentioned that this cooperation of science with free economy has been also sponsoring the acquisition of new specimens as well as research activities.

Fig. 10.9 A display board showing the evolution of huge Cretaceous ammonites featured in the public exhibit “Experience the sea” (German title “MeerErleben”) on display in a shopping mall in Germany in 2016. Photo: J. Lehmann

The striking feature of exhibits drafted by the Geosciences Collection is the combination of paleontological and biological specimens, covering the key topics evolution, biodiversity and constructional morphology. Examples are the display “Evolution” during the geoship tour (Krogmann and Lehmann 2002) and that on diversity and evolution in the currently running presentation “Experience Ocean” (Lehmann 2017). In this general conception spectacular specimens, like giant ammonites (Fig. 10.9), are embedded in “display landscapes”, behind their natural occurrences. In the case figured the evolutionary sequence species from the Lower Cretaceous is arranged on the background of a cliff wall in southern England, showing individual beds. Captions to individual specimens are preferably very short, inconspicuously embedded and refer to daily subjects everybody is familiar with, a concept that is owed to the fact that some exhibits attract visitors at places untypical for displays. In other words people are getting involved that are usually not systematically visiting museums or public displays. These ideas are strongly influenced by the Tübingen paleontology school of the twentieth century (e.g. Seilacher and

Gishlick 2014). These didactical conceptions are also used for illustrating aspects of constructional morphology of organisms, including its analogies with daily life.

Regularly public talks are offered for a broad audience, including a series of lectures organized ten times a year by the Geosciences Collection and that is announced in the local press and on various websites. These talks often focus on research topics of the collection, but guest lecturers are also invited on a regular base.

Almost all of the outstanding single fossils of the collection and some of the focal points have been subject in popular books and public understanding of science journal articles. The popularization of paleontology is a declared aim of the collection and of the associated booster club. The following table (Table 10.2) lists the most prominent individual fossils:

Table 10.2 Examples of popularizing science in the Geosciences Collection and promotion of individual fossils in journals and books

Identification	Description of specimen (inventory number)	Popular references
Diplomystus dentatus (Cope 1877) *Mioplosus labracoides* (Cope 1877) *Sabalites* sp.	Large slab from the Eocene Green River Formation (GSUB V2431, V2432, P1288)	Lehmann (2008b)
Goniopholis simus (Owen 1878)	Crocodile skull from the earliest Cretaceous of North Germany, discovered in the debris of a natural building stone; building destroyed during world war II in the city of Bremen (GSUB V2297)	Kruckow (1966a); Kuster-Wendenburg (1999); Polenz and Spaeth (2004); Lehmann (2005, 2006b)
Iguanodontipus ichnosp.	Dinosaur trackway (large slab on display in collection; GSUB I1)	Lehmann (2006b); Polenz and Spaeth (2004)
Ixodes succineus (Weidner 1964)	Tick preserved in Baltic amber, holotype (GSUB I21)	Weitschat (2004); Wichard and Weitschat (2004); Lehmann (2007)
Obaichthys decoratus (Wenz and Brito 1992)	Lower Cretaceous gar fish (very rare) from the Santana Formation of Brazil (GSUB V2251)	Becker (2012); Lehmann (2013)
Pleurosternon bullockii (Owen 1842)*	Very well preserved imprint of a carapace of a very large turtle from the earliest Cretaceous of North Germany (GSUB V1434)	Lehmann (2006b)
indet.	Bird bones from the Miocene of North Germany, very rare (GSUB V2481)	Lehmann (2011)
Various species	Statolith collection of H. Menzel (various GSUB numbers)	Lehmann (2010c)

The column "Selected publications" refers to the particular publications dealing with the material listed. Asterisk: following the revision by Karl et al. (2007) of this specimen that is a historical original to Ludwig (1879) who referred to it as *Plesiochelys menki*

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Chapter 11
CHEMNITZ: Back to the Roots of Palaeobotany—Chemnitz and its Palaeontological Collection

Ronny Rößler and Thorid Zierold

11.1 General Information

The foundation of the museum can be traced back to 1859, when Chemnitz was a rapidly developing and increasing industrial centre in Saxony. However, contrary to its economic importance, science and culture were hardly represented in the city's public life. In Chemnitz, neither a patriarchal university nor scientific libraries as intellectual centres were present at that time. In 1859, 16 committed citizens founded a reader circle of technical literature—the precursor of the later Natural History Society, which not only invited for both lectures and excursions but also published its own scientific series. Speakers and authors were the members of this circle themselves, among them teachers, medical practitioners, scientists, traders and businessmen (Barthel 2001; Kogan 2016). Because of the rapidly growing collections, in 1864 the society felt impelled to offer them to the city. Only in 1868 the City of Chemnitz accepted the donation of the natural history collections and associated scientific library and, hence laid the cornerstone of today's Museum für Naturkunde. Conditions of the donation contract included on the one hand the continuation of scientific assistance by society members, on the other hand the request to make the collections accessible to the public. The latter was achieved not before 1875. Thanks to manifold activities of the society members and the considerable voluntary services provided by honorary custodians in particular, several collections were established. Among them was an outstanding collection of fossils. Depending

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on donations and the scientific work of society members, the main focus was directed at Permo-Carboniferous floras. Based on the petrified woods from Chemnitz (Fig. 11.1), an exchange developed even among other petrified forest sites in the world. The acquisition of new objects happened permanently per purchase, in former times, e.g., from the well reputed company Krantz in Bonn or with acceptable gifts from friendly local collectors.

Today the palaeontological collection consists of ca. 27,000 items and is focused primarily on fossil material that recorded the evolution and preservation of terrestrial ecosystems with special emphasis on volcanic environments and petrified wood (Rößler 2001; Rößler et al. 2006, 2014a). A further accent is being targeted on the local to regional Earth history or famous fossil sites in Germany. It is subdivided into several parts with different importance and linkage to active research.

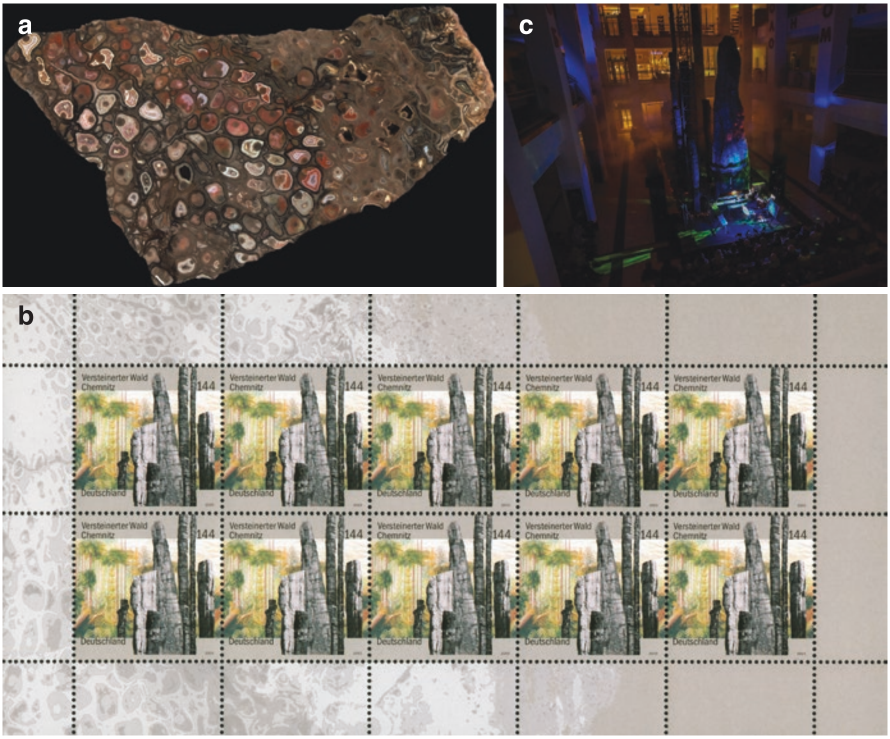

Fig. 11.1 The Petrified Forest of Chemnitz: (**a**) Roots of a *Psaronius* tree fern filled with colourful agate explaining that the original purpose of petrified wood from Chemnitz was to provide jewellery materials in the mid eighteenth century, 80 × 150 mm, K4984b. (**b**) Special issue stamp highlighting the Chemnitz Fossil Forest, design: Joachim Ries. (**c**) The world's only petrified forest with its own music. Release concert of the album 'Petrified Forest' created by Wellenvorm, Museum für Naturkunde Chemnitz, 2017, photo: Mike Flemming

11.2 Historical Development of Collecting and Conservation—Source and Result of Knowledge

The palaeontological collection of the Museum für Naturkunde Chemnitz comprises the petrified wood collection and the fossil collection. The following paragraphs give an overview of their genesis and consideration in recent research and educational programmes.

11.2.1 The Petrified Wood Collection

The Petrified wood collection comprises ca. 7000 catalogued specimens (labelled K or KH with serial number), from 20 gram to 12.5 tons weight, and represents an exceptional set of anatomically preserved plant fossils from different geological eras (Fig. 11.2). Most valuable objects are among the type material and published/figured specimens by Carl Bernhard von Cotta (1808–1879), Heinrich Robert Göppert (1800–1884), Karl Gustav Stenzel (1826–1905), Johann Traugott Sterzel (1841–1914), Hermann Count Solms-Laubach (1842–1915), August Schenk (1815–1891), Otto Weber (1858–1910), Birbal Sahni (1891–1949), Manfred Barthel (geb. 1934), and Ronny Rößler (geb. 1965). For any references to historical literature we refer to the bibliography provided in Rößler (2001).

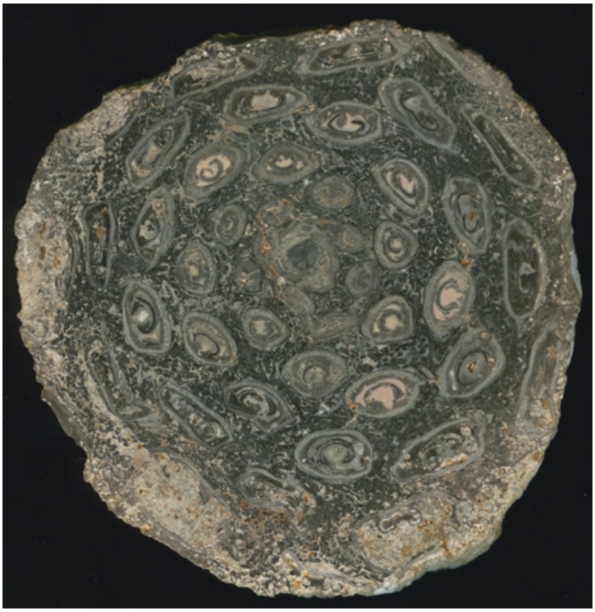

Fig. 11.2 *Tubicaulis solenites* (Sprengel 1828) Cotta 1832, transverse section of a unique tree fern, Bolsovian of the Flöha Basin, SE-Germany, diameter 116 mm, K4798

11.2.1.1 Chemnitz—The Permian Pompeii

The majority represents findings from the Chemnitz Fossil Forest, that have been collected since 1740 but further enlargement is continuing today from ongoing excavations. First mentioned by Georgius Agricola (1494–1555), mayor of Chemnitz, the term “fossil” was derived from the Latin “fossilis” that means “excavated from the soil”. The “forest of stone” moved into the centre of interest especially between 1740 and 1750 when larger specimens of petrified woods were being discovered. In the service of the Saxon elector, the mineralogist and gemstone inspector David Frenzel (1691–1772) had come across the occurrences of the “petrified forest” when prospecting for gemstones. Knowledge of the occurrence spread quickly, and collections such as the Cabinet of Naturalia at Waldenburg/Saxony still bear testimony to the collector’s diligence by means of the exhibits collected around the middle of the eighteenth century. Among the earliest finds are also specimens collected and labelled by the pharmacist Hermann Ottomar Leuckart (1818–1902). The large precious collection of the pastor Gottfried Hermann Schreckenbach (1807–1875) was acquired after his death in 1875. About 5000 objects, among them 480 petrified woods and rare palaeobotanical literature considerably enriched the museum’s collection (Barthel 2001).

What makes the Chemnitz Fossil Lagerstätte so special in comparison to other fossil forests with tree stumps preserved *in situ* is both its historical and geological importance. Collecting at this site dates back to the early eighteenth century and many collections worldwide house exhibition-quality specimens from the Chemnitz Fossil Forest (Urban 1980). Specimens from this site provided the basis for introduction of fossil plant names reaching back to the early days of palaeobotany. Several genera of common late Paleozoic plants were first described from Chemnitz, the type locality of *Psaronius, Calamitea*, and *Medullosa*. In Chemnitz, an early Permian landscape was buried instantaneously by volcanic ashes and flow deposits preserving outstanding fossil assemblages and many trees in their places of growth. Eruptions in the area of present-day Chemnitz resulted in the formation of a pyroclastic sequence referred to as the Zeisigwald Tuff of the upper Leukersdorf Formation. By the use of U-Pb measurements on zircons the age was constrained to 290.6 ± 1.8 Ma.

During residential building in the late nineteenth and early twentieth centuries the petrified wood collection grew again noticeably. During that time J.T. Sterzel was much supported by local people such as the private collector O. Weber, the builder Max Güldner and the land owner August Orth. Part of the collection are additionally ca. 300 thin sections privately ordered and paid by O. Weber concerning his studies on medullosans, containing many figured specimens of Weber and Sterzel (1896) and being still available for investigation (Fig. 11.3).

Fortunately during World War II only few objects of the palaeontological collection may have gone lost or were destroyed, even the valuable palaeobotanical library survived the tremendous fire following the Anglo-American air raid of 5th of February in 1945, which destroyed vast parts of the city.

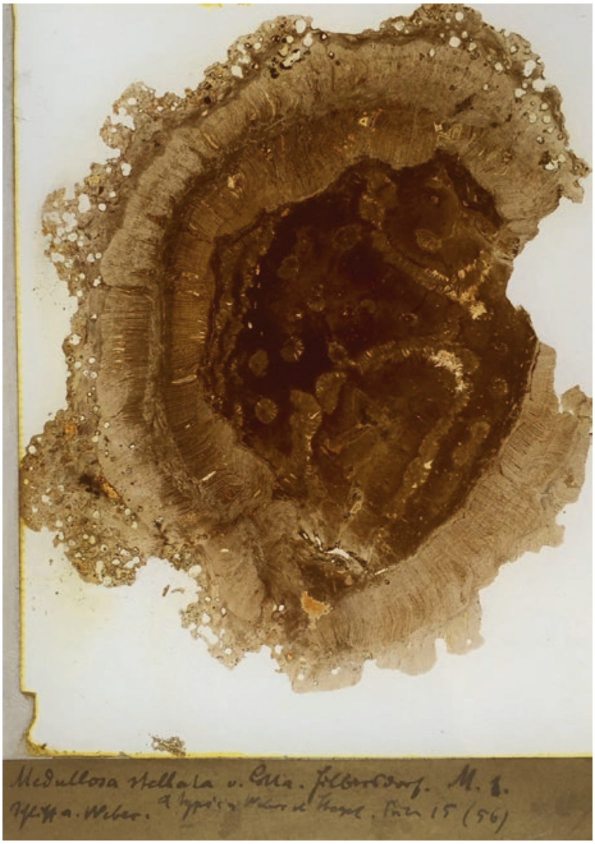

Fig. 11.3 *Medullosa stellata* (Cotta 1832) Weber et Sterzel 1896, historical transverse thin section from the holotype, Permian of Chemnitz, 80 × 110 mm, K3004-DS

Since the 1970s new specimens have been recovered during construction work, but all of them were unintentional, because most of the fossil forest has been developed into an urban area. Since collections are not ultimate items, their permanent enlargement is an essential process on the way to gain knowledge. Scientific excavations offer a wide field of activity, as the successful examples in Chemnitz show. Between 2008 and 2011, a scientific excavation at Chemnitz-Hilbersdorf delivered for the first time a more complete insight into a local taphocoenosis of this fossil forest (Fig. 11.4a). A huge amount of data was gathered offering potential for a detailed, albeit spatially confined, reconstruction of this ancient forest habitat (Rößler et al. 2012a, 2015). The fossil record comprises a comprehensive spectrum of plant and animal remains, more complete than ever documented before (Figs. 11.4b, c–11.6). Upright-standing petrified trees, still anchored in the original substrate, were discovered together with a variety of parautochthonously embedded stems and twigs (Luthardt and Rößler 2017). A countless number of leaf adpressions and moulds were found preserved in one single horizon next to various arthro-

Fig. 11.4 The first scientific excavation of the Museum für Naturkunde—the key to third-party funds and current research: (**a**) Excavation Chemnitz-Hilbersdorf (2008–2011). (**b**) *Ascendonanus nestleri* Spindler et al. 2018, first arboreal pelycosaur (Synapsida: Varanopidae) from the Chemnitz Fossil Lagerstätte, early Permian, length 174 mm, TA1045. (**c**) *Opsieobuthus tungeri* Dunlop et al. 2016, first scorpion find from the Permian, Chemnitz Fossil Lagerstätte, TA1126

pod remains or reptile and amphibian skeletons exhibiting even their former body outlines (Dunlop and Rößler 2013; Feng et al. 2014; Dunlop et al. 2016; Luthardt et al. 2016). Within a distance of approximately 2 km from the aforementioned locality, a second excavation site in Chemnitz-Sonnenberg was initiated in 2009 and finally set up in 2014 (Fig. 11.7). We aim to continue this excavation during the next years to verify the knowledge about the fossil forest ecosystem, especially regarding plant and animal diversity and spatial distribution, variation of site-specific environmental characteristics within a wider area and taphonomic differences correlated with different distances from the volcano.

Fig. 11.5 Ecological reconstruction of *O. tungeri* placed in its suggested original environment at the mouth of a burrow among woody roots on the forest floor. Drawing: Frederik Spindler

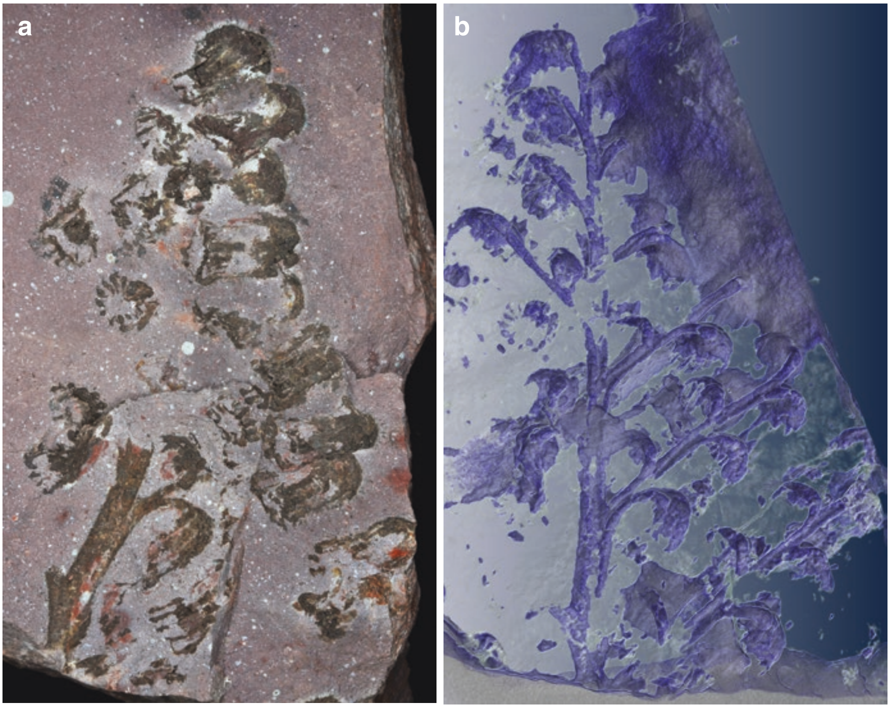

Fig. 11.6 *Sterzelitheca chemnitzensis* Feng et Roessler 2014: (**a**) Bipinnate pinna carrying seed fern pollen organs, Chemnitz-Hilbersdorf, length 72 mm, TA0201. (**b**) CT image illustrating detail of *Sterzelitheca chemnitzensis*

Fig. 11.7 Excavation Chemnitz-Sonnenberg—open air exhibition and privileged place for various educational programs, 2016, photo: Mike Flemming

11.2.1.2 Petrified Wood—Delicate Cell Preservation from Deep Time

The Petrified wood collection additionally comprises fossil woods from many meanwhile inaccessible sites from continents all over the world including Antarctica concerning geological systems from the Devonian up to the Quaternary. Among them are historical items, donations, purchased collections or single objects up to own finds from different geological sections and taphonomically diverse settings. Of particular interest are objects exhibiting different minerals involved in the petrifaction or permineralisation of wood (SiO_2, CaF_2, Carbonates, Fe-oxides, Fe-sulphides) or woods of different botanical affiliation (pteridophytes, gymnosperms, angiosperms).

In 1907, a collection of 127 thin sections of anatomically preserved coal ball plants from the Pennsylvanian of the British Coal Measures was bought from the geologist James Lomax, England. Since these excellent preparations recently offered the chance to recognise diverse forms of fungal microorganisms interacting with the plants tissues or recycling them, the thin sections will remain of future interest.

Collection material that has also been the basis of one decade of joint research, and therefore including several holotypes, originate from the Permian fossil forest of the Parnaíba Basin in NE Brazil (Rößler and Galtier 2002a, b, 2003; Dias-Brito et al. 2007; Kurzawe et al. 2013; Rößler 2014; Rößler et al. 2014b; Tavares et al.

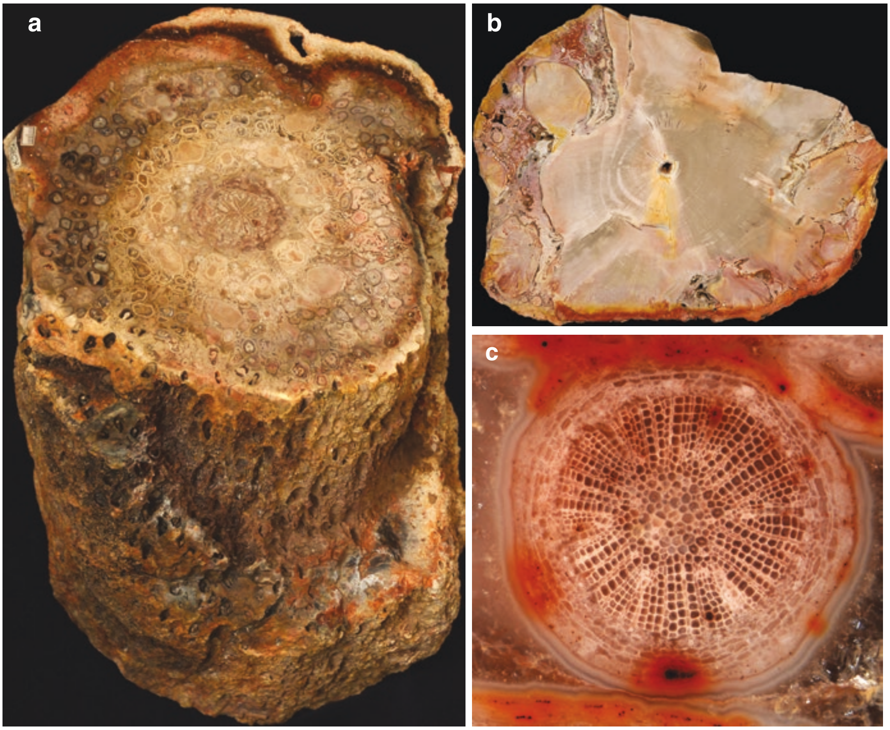

Fig. 11.8 Anatomically preserved plants: (**a**) *Dernbachia brasiliensis* Rößler et Galtier 2002, tree fern stem from the Permian of the Parnaíba Basin, NE Brazil, K5782. (**b**) Calamite stem of the *Arthropitys* type, transverse segment showing attached roots, Permian of the Parnaíba Basin, NE Brazil, 330 × 430 mm, K5258. (**c**) *Astromyelon*-type root with polyarch stele consisting of central pith, surrounding primary and secondary xylem and extraxylary (phloem?) tissue, Permian of the Parnaíba Basin, NE Brazil, diameter 1.6 mm, K5486

2014; Neregato et al. 2015, 2017). After professional preparation the citizen scientist Robert Noll provided the main part of this anatomically preserved fossil material (Fig. 11.8).

11.2.2 The Fossil Collection—Remains of Plants, Animals and Biosedimentary Structures

The fossil collection of the museum consists of ca. 20,000 catalogued specimens (labelled F or TA with serial number) arranged in geographic and stratigraphic order from the Precambrian up to the Quaternary. Emphases are classical fossil lagerstätten, such as Solnhofen, Holzmaden, Frankonian Jurassic, Copper Slate, Silurian of Thuringia, Cretaceous of Saxony and Rügen Island, Baltic Amber (Fig. 11.9a).

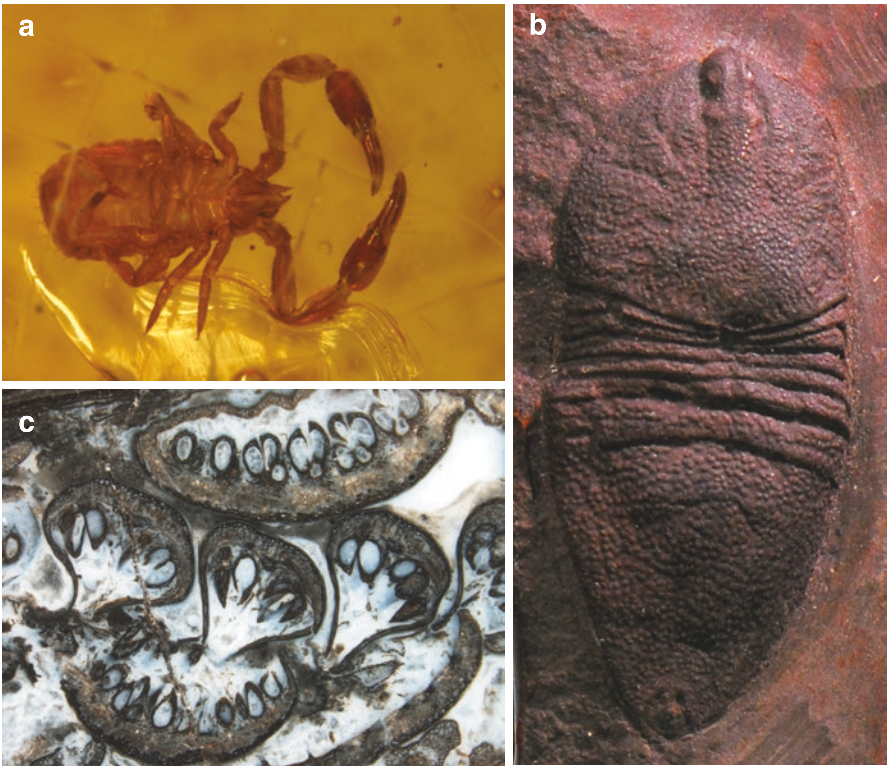

Fig. 11.9 Collection specimens in different preservational forms: (**a**) Pseudoscorpion in amber, Eocene of the Baltic, Russia, length of the animal 3.7 mm, F11933. (**b**) *Pycnotarbus verrucosus* Daber 1990, imprint of a phalangiotarbid arachnid, Asturian Coal Measures of Oelsnitz, SE Germany, 11 × 25.5 mm, F15184a. (**c**) Chert with anatomically preserved *Scolecopteris* pinnules, early Permian of Sardinia, Italy, 4.7 × 6.2 mm, F15368

Centrepiece of this collection is a number of local collections from Carboniferous and Permian sedimentary basins of Germany, Bohemia, Spain, USA and Russia including the largest collections of both the terrestrial Mississippian of Chemnitz and the Pennsylvanian of Zwickau-Lugau-Oelsnitz (Fig. 11.9b). Type material or figured specimens resulted from publications of Hanns Bruno Geinitz, J.T. Sterzel, Walter Gothan, Wolfgang Hartung, Georg Mayas, Friedrich Nindel, Rudolf Daber, Manfred Barthel, Jürgen Meyer, and R. Rößler.

Further part is the collection of fossiliferous cherts (except from Chemnitz-Altendorf that are traditionally included in the petrified wood collection), mainly from the Pennsylvanian and Permian of Germany (Freital, Zwickau, Donnersberg, NW Saxony), but also from other sites and times worldwide, such as Rhynie, Sardinia and Brazil (Fig. 11.9c).

Sizeable stromatolites of different ages from the Precambrian up to the Neogene add to this collection (Fig. 11.10). Among them are classical sites, such as

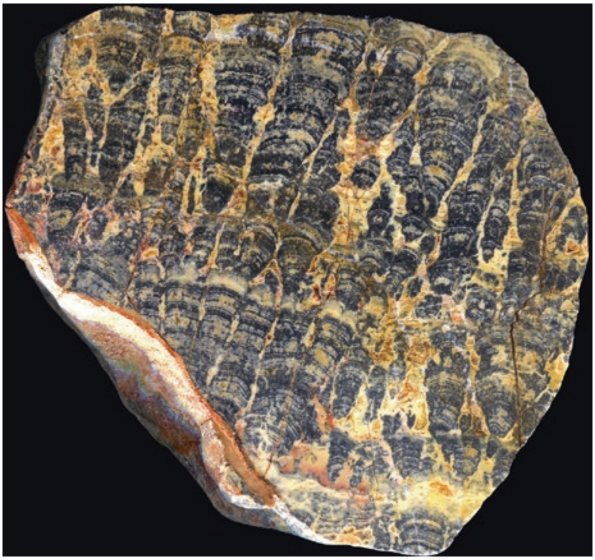

Fig. 11.10 Stromatolite representing the oldest known biota on Earth, Precambrian of Warrawoona, W-Australia, 165 × 178 mm, F13904

Warrawoona/Australia, Minnesota/USA, or Hebei Province/China (Precambrian), but also occurrences in Germany, such as the Saar Nahe and Thuringian Forest basins (Permian) or the Mainz Basin (Neogene).

11.2.3 Staff, Edificial Infrastructure and Perspectives

The staff concerned with geoscientific projects consists of: one curator (geoecologist/biologist), one geologist/palaeontologist and one geotechnician both from funded projects, one scientific volunteer (geologist/palaeontologist), one geological preparator, and the museum director (geologist/palaeontologist).

The infrastructure comprises study rooms, collections, offices, the natural science museum library and laboratories (several are external) for sectioning/grinding/polishing, thin sectioning, transmitted/reflected light-microscopy, macro- and microphotography (Figs. 11.11 and 11.12).

Besides temporary exhibition the museum is providing the following permanent exhibitions: (1) petrified forest, (2) Sterzeleanum, (3) Insektarium, (4) excavation “window to the past”.

Financial support for the work in and with the collection, basic educational programmes and for exhibitions is provided by the City of Chemnitz and the Free State of Saxony. Research activities and special educational programmes as well as acquisition are based on the contribution by third-party funds such as Deutsche Forschungsgemeinschaft, Volkswagen Foundation, and the registered association “Freundeskreis des Museums für Naturkunde Chemnitz e. V.” (founded in 1996). In

Fig. 11.11 Laboratory facilities at the Palaeobotanical Research Centre (PRC) of the Museum für Naturkunde Chemnitz, 2017

Fig. 11.12 View into the Palaeontological Collection of the Museum für Naturkunde Chemnitz, 2017

addition to that the museum's research activities rely heavily on the collaboration with other research institutions and companies providing special analytical facilities.

Future activities focus first on collection-oriented research and their translation into a new contemporary and modern permanent exhibition that complies with the growing demand for science communication and second on the consequent development of the permanent excavation area "window to the past".

11.3 Research—Key to the Past and Future

11.3.1 Development of Research Items

The development of the collections has been closely related to research and associated international cooperation (Fig. 11.13). Already in the nineteenth century scientists from several universities and museums had come to study fossil woods from Chemnitz. Among them were the botanists Franz Unger from Graz, August Corda from Prague and several decades H.R. Göppert from Breslau with his scholar Carl Gustav Stenzel working on gymnosperms and tree ferns. August Schenk, working at Leipzig University, was particularly interested in medullosans. H. Count Solms-Laubach from Strasbourg was working on tree ferns and medullosans. At the beginning of the twentieth century, Paul Bertrand from Lille was interested in the rare ferns from both Chemnitz and Flöha, as the palaeobotanist Birbal Sahni from Lucknow/India did. Finally, Rudolf Florin from Stockholm was working on the plant fossils from the Altendorf Chert, which already attracted H.B. Geinitz from Dresden from 1872 onward. End of the nineteenth century J.T. Sterzel got diverse petrified woods from Domenico Lovisato (1842–1916) geologist at Cagliari, Sardinia, Italy, for research (Fig. 11.14) and published on Oligocene palms (Sterzel 1900).

In the second half of the twentieth century research based on the palaeontological collection of Chemnitz was exclusively done by visiting scientists from other institutions working on floral monographs (Manfred Barthel), fossil-rich sites (Klaus-Ulrich Leistikow, Jörg W. Schneider,) or new finds (Ralf Werneburg).

Present-day research focuses on the museum vision and pervading the other keystones of a museum, such as conservation, collection, exhibition and education. Based on the historically evolved collections and related activities, since 1995 the museums' collection and research conceptions address traditional fields again, such as the occurrence, formation, fossil record, and palaeoecology of petrified forests, particularly those from Carboniferous and Permian times, and systematics, taphonomy and evolution of Paleozoic arthropods as well (Dietrich et al. 2013; Rößler et al. 2003; Dunlop et al. 2016).

Thus studying historical and recent exhibits to provide any additional insights for the understanding and maintaining of life on our planet makes up our mission. Therefore we are certain that historical collections are not ultimate but anxious for consequent enhancement and new scientific interpretation. Our recent excavations

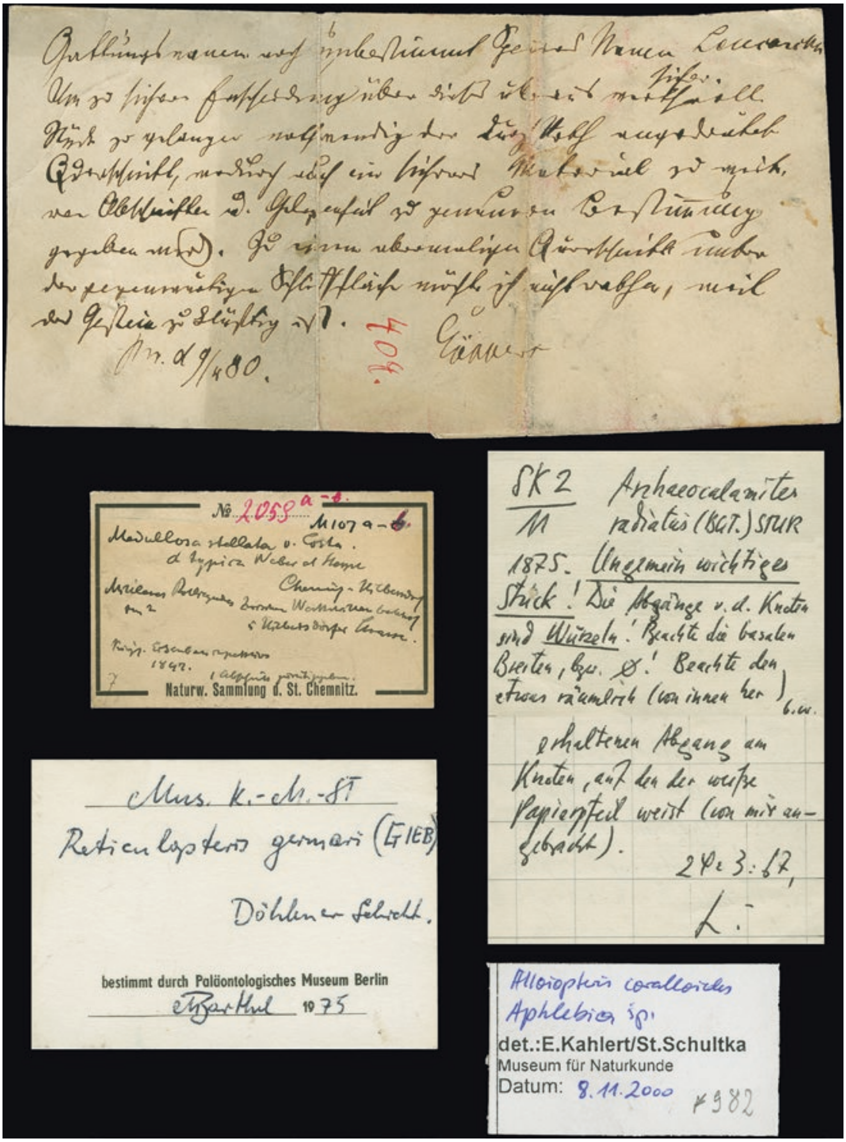

Fig. 11.13 Collection labels documenting three centuries of research by curators or visiting scientists (Heinrich Robert Göppert: 1880, Johann Traugott Sterzel: 1897, Klaus-Ulrich Leistikow: 1967, Manfred Barthel: 1975, Eberhard Kahlert und Stephan Schultka: 2000)

within the area of the city provide an excellent connection between historical collections and pioneering research. As expected for a museum, the professionals are faced with the public in their daily work. In talks, events and guided tours they present first-hand knowledge and have the opportunity to answer the visitors' questions experiencing their advice, suggestions and perspectives (Rößler and Zierold 2016).

Fig. 11.14 *Palmoxylon lovisatoi* Sterzel 1900, anatomically preserved palm stem named in honour of Domenico Lovisato, Oligocene of Sardinia, Italy, 94 × 112 mm, F7556a

11.3.2 Present-Day Research: From Front-Door to International Networking

Interdisciplinary networking is required to address the issues of the complex Chemnitz Fossil Lagerstätte. On this account we are highly interested to maintain and strengthen our research communication. Thus we are able to solicit third-party funds by means of our research outcomes. However, the Museum für Naturkunde not only collaborates with international scientists but also emphasises the cooperation with universities and other educational institutions to work along in "Jugend forscht" projects or academic qualification studies.

Research networks enable us to communicate irrespective of borders, to accelerate the achievements via divided responsibilities and to increase the impact of publications in peer-reviewed journals.

With the initiative of the Volkswagen Foundation "Forschung in Museen" we obtained the opportunity for our research project "The Petrified Forest of Chemnitz—Snapshot picture of a Permian ecosystem preserved by explosive volcanism". The prosperous outcome enabled us to allocate state of the art palaeontological research at the museum which was highly appreciated by the scientific community. In addition to that they provide the fundament for educational programmes and the scheduled revision of the permanent exhibition.

Derived from the collection resources and the scientific experience of our staff we are focusing on the following research topics:

- Systematics, morphology, anatomy, and ecology of late Paleozoic plants (Rößler 2000; Rößler and Noll 2006, 2007; Rößler et al. 2012b)
- Systematics, evolution, ecology and taphonomy of late Paleozoic arthropods (Rößler and Schneider 1997; Dunlop and Rößler 2013; Dunlop et al. 2016)
- Volcanic influenced palaeoecosystems and their role in the evolution of organisms (Rößler et al. 2012a)
- Volcanic taphonomy and *in situ* preservation of plants and animals (T^0 assemblages) (Werneburg 1993; Rößler et al. 2012a; Löcse et al. 2013)
- Pathways of silicification and anatomical preservation of plants, formation of cherts (Nestler et al. 2003; Witke et al. 2004; Matysova et al. 2010; Dietrich et al. 2013)
- Environmental analysis of Permocarboniferous fossil forests (Rößler 2006)
- Palaeoclimatology of late Paleozoic terrestrial ecosystems (Luthardt et al. 2016)
- The significance of natural data archives (Luthardt and Rößler 2017)
- Geological development and stratigraphy of the Chemnitz Region (Rößler et al. 2015)

The following research and citizen science projects contribute to the scientific output of the museum:

- Analysis of an early Permian forest ecosystem preserved in situ by volcanism (Chemnitz Basin, SE Germany)
- Dynamics of Pennsylvanian basin margin to upland environments—a case study from Stephanian fluvial deposits of the Kyffhäuser Mountains (Saale Basin, Central Germany)
- Investigating a volcano-sedimentary complex of the mid-European Variscids (Pennsylvanian, Flöha Basin, SE Germany)
- Palaeoecological and palaeogeographic significance of low latitude palaeofloras of Gondwana (Permian, Parnaíba Basin, NE Brazil)
- A Permian key occurrence offering new perspectives to understand/reconstruct the interaction of climate, environment, ecology and taphonomy (Manebach Formation, Thuringia, East Germany)

Both the research grant by the Deutsche Forschungsgemeinschaft as well as the integration into academic teaching at the TU Bergakademie Freiberg promotes the ongoing research at the museum. Volunteers, students and doctoral students enhance the museum's work, imply innovations and regain experience from their hosts. As universities welcome contributions of external lecturers at no charge, cooperation with museums provides various opportunities to achieve research funds, collaborate in projects or to unlock treasures in collections.

Together with Lutz Kunzmann, Senckenberg Dresden, Ronny Rößler has continuously offered the lecture Palaeobotany as a visiting Professor at the Geological Institute of TU Bergakademie Freiberg since 1995. As part of the module "Evolution of organisms" the lectures, seminars and excursions are mandatory for M.Sc. students in geology/palaeontology but additionally open to international master programmes and studium generale (http://tu-freiberg.de/geo/palaeo/lehre).

The Museum für Naturkunde Chemnitz plays an integral role in developing the field of volcanic taphonomy by participating and hosting the year's International Workshop on Plant Taphonomy. Processes responsible for the integration of any plant or plant part into the fossil record are picked out by various talks and discussions. Deciphering taphonomic processes helps to understand how and what biological and geological information have been lost, as well as how a fossil plant assemblage differs from the plant community in the original environment.

In difference to universities one important task of museums is to communicate science with the public. This is realised not only by exhibitions and educational programmes but also in publications for broader audience's understanding. Therefore the museum publishes its own scientific series "Veröffentlichungen des Museums für Naturkunde Chemnitz" that appears annually. With that medium we encourage both professionals and amateur scientists to present their studies to a broad public. The museum tasks are closely related to collaborations with citizen scientists and amateur palaeontologists. They are incorporated in the work process of the museum, have access to research facilities and appreciate the scientific discussion, thus providing a win-win-situation for both. Often partnerships result in dedication to the scientific excavation, in sponsorship or even the donation of private collections.

Communication and outreach activities incorporate also workshops and conferences. Between 2002 and 2015, the museum housed an annual workshop enlightening fossiliferous cherts and their formation (www.kieseltorf.de). Despite the sometimes excellent preservation of cellular detail, cherts do not always get the attention they deserve because they are most often found as displaced fragments, pebbles, and boulders. The workshop developed into a discussion platform of both professional and amateur palaeontologists from Germany and bordering countries.

11.4 Didactic Conceptions, Public Engagement and Educational Work

The Museum für Naturkunde is located in the city centre of Chemnitz in the cultural centre, Tietz. Originally opened in 1913 as one of the most distinguished shopping centres, nowadays the building houses the adult education centre, the Museum für

Naturkunde, the city library, an art gallery as well as little shops. Visitors of the building are welcomed by the Petrified Forest exhibition which is open to the public. Entering the exhibition area of the "Sterzeleanum" our visitor will gain insights into the thrilling history of the area of todays Chemnitz. Animations of a volcano, immense touchable exhibits, podcasts and bilingual panels (German and English) ensure an entertaining as well as educational stay.

The exhibition, Insektarium is anything but dead. Visitors can watch living leafcutter ants at their diligent work, observe the busy honey bees in their crystalline hive and enjoy the opportunity to get a close look at living tarantulas, scorpions, millipeds and crabs, which—together with the insects—make up the arthropods, the largest animal group on Earth. The beauty of the shiny butterflies and the many different kinds of well hidden ghost insects will mesmerise the viewer. Beside this the exhibition explains the evolutionary backgrounds of arthropods.

Our special exhibitions provide a platform for current issues and virulent topics and are both challenge and opportunity. They request the ability to take the broader view beyond once subject of research and communicate science to a broad public. The connecting element between each of the special exhibitions is our urge to unhide the precious fossils of the collection, to interpret new scientific research outcomes and to engage young people. Within the last 10 years the museum can look back to projects with kids, students and contemporary artists such as:

- Im Extremen zu Hause (Zierold 2014)
- News from the Permian—international contemporary jewellery and the Petrified Forest Chemnitz (Museum für Naturkunde 2013)

Temporary exhibitions also based on the collaboration with citizen scientists. The following selections of exhibitions illustrate a remarkable documented evidence:

- Vulkanische Pflanzen vom Donnersberg (2014)
- Vom Zufallsfund zur Rarität—die Rätsel eines 310 Millionen Jahre alten Mosaiksteins aus der Evolution der Farne (Löcse et al. 2015)
- Rock Fossils—Ja, es ist Liebe (2016/17)

Work study associations are an instrument for ensuring a reservoir of young skilled labour (Kutloch and Zierold 2012). Instructed by museum specialists the kids are involved in collection related work, trained in systematics and thus inhale the atmosphere behind the curtain. Often the youth stay connected with the museum. The federal volunteer service and the voluntary ecological year are great opportunities in gathering first work experience and to prepare for university studies.

The outreach of the museum includes not only public preparations of vertebrates, social media and website activities, Radio and TV presentations but also the participation in Science Slams. Within the last few years three museum specialists talking about their research won this competition.

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Chapter 12
COBURG: Naturkunde-Museum Coburg—Paleontological Collections

Eckhard Mönnig

www.naturkunde-museum-coburg.de

Opening times: 9am to 5pm daily
Year of foundation: 1844, but parts of the collection are from the 18th century
Number of specimens: 300.000
Staff: one scientist (also responsible for mineralogy and archaeology)

12.1 The Museum

The Naturkunde-Museum Coburg is located in the Hofgarten, a landscape park of the nineteenth century in the English style, between the castle of Veste Coburg and Ehrenburg Palace. The museum was founded in 1844 by Duke Ernst II. of Sachsen-Coburg and Gotha and Prince Consort Albert as 'Herzogliches Naturaliencabinet'. But the collections date back to the eighteenth century. The present museum building has 4800 m^2 of usable floor space, with 2200 m^2 for exhibitions, including 13 halls with the following fields: mineralogy, rocks, earth history (250 m^2), animals of Central Europe and North America, invertebrates, birds, prehistoric and protohistoric archaeology, ethnology, and museum's history. The collections comprise more than one million specimens. The legal owner of the collections is the Coburger Landesstiftung, which has been supported by the Free State of Bavaria since 1920. Before that they were the property of the Coburg dukes. (Fig. 12.1)

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Fig. 12.1 Fossil plants in the exhibition room 'Earth History'

The paleontological collections comprise about 30,000 boxes with hundreds of thousands of fossils. There is one depot with 150 m^2 and one laboratory for the geological preparator. The scientist is responsible not only for paleontology, but also for all other museum collections (Figs. 12.2 and 12.3).

12.1.1 History of the Paleontological Collections

The collection of fossils and their scientific interpretation has a long tradition in Coburg and goes back to Johann Konrad Schwarz (1677–1747), a teacher at the Coburg Gymnasium. The collection was extensively expanded by Hermann Gottlieb Hornschuch (1745–1795), who described it in 12 reports (1783–1794). Hornschuch also designed a kind of stratigraphic profile of the cuesta landscape of Coburg. He was the first to use the term 'Keuper'.

Then came the Ducal Councillor Friedrich Adolf von Roepert, who assembled a small fossil collection. He sold the Jurassic ammonites to the Gymnasium Casimirianum, where they were scientifically studied by the then-director and polymath Johann Christoph Matthias Reinecke (1770–1818). In addition to the system-

Fig. 12.2 Naturkunde-Museum Coburg, geological depot

Fig. 12.3 Ammonite collection (*Macrocephalites*) in the geological depot

atic examination of the ammonites, Reinecke also realized the basic intentions of stratigraphy and developed an early theory of evolution (Reinecke 1818).

The natural history museum of Coburg has its origin in the collecting activity of Duke Franz Friedrich Anton of Sachsen-Coburg-Saalfeld (1757–1806). Besides books and coins, his collection of copperplate engravings is of international importance. Various references indicate that he was already involved in building up the natural history collection in his youth. This included a sandstone plate with numerous fish from the Keuper (later originals of *Semionotus bergeri* Ag.) and a large trunk of silicified wood from the upper Sandsteinkeuper Formation (later original to *Dadoxylon keuperianum* (Unger) emend. Endlicher). Shortly before his death (1806), the Duke gave his Naturaliencabinet to the Gymnasium.

The dramatic political events at the beginning of the nineteenth century did not pass the Duchy of Coburg, and so there is little to report on the ducal collections. Their revival took place through the sons of Ernst I., Prince Ernst (1818–1893) and Prince Albert (1819–1861). Albert, in particular, showed a preference for natural sciences and serious studies. In a short time both had collected a considerable collection of stuffed birds, fossils and minerals, which bore from 1838 the name 'Herzogliches Naturaliencabinet'.

The inventory is evident from the lists from 1838 to 1844. In 1840, Prince Albert married his cousin Queen Victoria, and moved to England. He continued to support his Naturaliencabinet with money and the sending of fossils and minerals from the Empire. On his initiative, the collections were exhibited in the Palais at the Ketschentor, and two directors were commissioned with the support of the latter, whereby the Herzogliches Naturaliencabinet was officially founded as a museum in 1844. The first visitors were Albert himself and Queen Victoria on their first trip to Coburg (1845) (Fig. 12.4).

The first director was the geologist Carl Friedrich Freiherr von Schauroth (1818–1893). The scientific activities of Schauroth fall into the years 1850–1865, with an

Fig. 12.4 *Dapedium*, a fossil fish from the upper Lias of England. Collection of Prince Consort Albert (1845)

emphasis on the Triassic deposits of the Duchy of Coburg. With the steady growth of the collections, the Palais Ketschentor became too cramped, so Ernst II. had to look for a new location. A building on the Veste Coburg proved to be suitable and was adapted accordingly and opened to the public in 1864. At the request of the deceased Albert, the inventory books were to be published, and so the paleontological collections are documented in detail in the 'Verzeichnis der Versteinerungen im Herzoglichen Naturaliencabinet zu Coburg No. 1-4328' (Schauroth 1865). On 30 tables, Schauroth pictured many specimens and also described 275 new species, the validity of which has yet to be examined in one particular case. The most famous Schauroth species is the conifer *Voltzia coburgensis* from the Coburger Sandstein (Upper Triasssic).

After the death of Duke Ernst II. (1893), the Herzogliche Naturaliencabinet was designated the 'Naturwissenschaftliche Sammlungen'. A new revival of the paleontology collection was initiated by the physician Rudolf Fischer, director of the museum from 1895 to 1914. He gathered together a geological collection with unique findings from the Keuper of Coburg. In 1910, the collections had to give way to the reconstruction of Veste Coburg, and finally Duke Carl Edward had to build a new museum in the Hofgarten (1912–1914). After the First World War, the collections were transferred to the Coburger Landesstiftung, a foundation maintained by the Free State of Bavaria since then.

At that time the Geological Association of Coburg played an important role (Brückner 1929). At times there were over 250 very active members. The purpose of the association was to spread and promote knowledge of the geology and paleontology of Coburg and neighbouring surroundings, and the enrichment of the geological collections. Valuable fossils such as *Koiloskiosaurus coburgense* von Huene or *Cleistrolepis brückneri* Oertle thus came into the museum. Under National Socialism, the Geological Association was forced to dissolve, but it continued to pursue its activities unofficially. During the last years of the war a few important collections were added to the museum, such as those of Albert Krug, who lived in Breslau and saved his collection from the approaching Russian army by sending it to the Coburg Museum.

After the war, both the collecting of fossils and the association practically came to a standstill, and with the construction of the zonal border the contacts with Thuringia were lost. It was not until the mid-50s that a new interest in geology emerged, and the work of the community resumed. In the years up to 1990, valuable fossil collections accrued, some of which were acquired by the Natural History Museum (Coll. Vollmann, Lager, Götz, Steiner).

In addition to these external acquisitions, the museum has always been able to supplement its inventory with its own excavations, especially in the last few years in outcrops at new motorways and railway lines. Since the 1960s, the museum has been provided sufficient money for new acquisitions. For the most part, large decorative exhibits have been acquired, but also collections for scientific purposes.

12.2 Constituents and Classification System

The paleontological collection comprises about 30,000 boxes, but the number of individual specimens is much higher. For example, there are boxes with over 100 brachiopods, so the absolute number of macrofossils goes into the hundreds of thousands, not taking micropaleontology into account.

The paleontological collection is organized according to the following hierarchy: system (e.g. Trias) > group (e.g. Keuper) or stage (e.g. Rhät) > formation (e.g. Rhätsandstein) > location (e.g. Kipfendorf near Coburg). For this the basis is the Stratigraphical Table of Germany (Menning ed 2016). Some special collections are stored separately, e.g. specimens of the Schauroth catalog nos. 1-4328 (Schauroth 1865), or pieces and collections of historical value (fossils from dugouts of the First World War) (Mönnig 2015). An electronic database is lacking, because there is no staff to enter the relevant data. For scientific inquiries, the Custos seeks out the desired pieces or a scientist can take a look at himself.

About a third of the fossils are from the Jurassic, most of them from the Franconian and Swabian Albs. This is followed by the Triassic (a quarter) with specimens from the wider surroundings of Coburg. The Palaeozoic as well as Cretaceous and Cenozoic are only minor collection parts with 10% each. In the following, some important collections are listed and briefly described:

- coll. Franz Friedrich Anton (1750–1806): Origin of the 'Herzogliches Naturaliencabinet', including Triassic fish (*Semionotus*), and petrified wood (*Dadoxylon*) from the Keuper Group of Coburg, and a collection of Jurassic fossils from Solnhofen.
- coll. Nivard Rather: Jurassic ammonites from the northern Franconian Alb; former collection of the gymnasium, including the types of Reinecke 1818 (Mönnig 2006a, b): e.g. *Leioceras opalinum, Leioceras comptum, Reineckeia anceps, Hecticoceras hecticum, Macrocephalites tumidus, Kosmoceras jason, Sutneria platynota* oder *Ataxioceras polyplocum* (Fig. 12.5).
- coll. Prince Consort Albert of Sachsen-Coburg and Gotha (1819–1861): fossils from the Lower Jurassic of England, mainly Lyme Regis, probably former coll. Mary Anning (Mönnig 2007). A collection of fossil copal includes many types of Giebel (1862).
- coll. Carl von Schauroth (1818–1883): Zechstein und Triassic from southern Thuringia and fossils from the Vicenza Alps, including a good collection of fish from Monte Bolca (Schauroth 1865).
- First World War (1914–1916): ca. 200 boxes with Jurassic, Cretateous and Cenozoic fossils, collected by 20 soldiers from Coburg in dugouts of the First World War in France, Belgium, Serbia and Galicia.
- (unknown collector): ca. 3000 boxes, whole Phanerocoic, but mainly glacial drift from the Gdansk area.
- coll. Rudolf Fischer (−1914): ca. 1500 boxes of invertebrates, mainly Triassic and Jurassic of Coburg and surroundings and from the Staffelberg (most northern part of the Franconian Alb).

Fig. 12.5 Holotype of *Leioceras opalinum* (Reinecke 1818) and original figure

- coll. Otto Greif (1905–1937): ca. 2000 boxes with Jurassic fossils of Franconia, important documentation of the locality Ützing.
- Albert Krug (1879–1950): ca. 1300 boxes, mainly Jurassic from the Swabian Alb and Paleozoic of Silesia.
- coll. Gustav Köhler (1884–1962): Excellent collection of vertebrates from Holzmaden (Posidonia Shale), with 40 plates, including a perfectly preserved marine crocodile and a very good scull of *Suevoleviatan integer*.
- coll. Karl Götz (1920–1997): ca. 1000 boxes with Jurassic fossils in excellent preservation, mainly ammonites (Fig. 12.6).
- coll. Robert Lager (*1936): ca. 1000 ammonites form the Ornatenton Formation of Oberlangheim bei Lichtenfels (Callovium, Middle Jurassic), so-called ‘Goldschnecken’ (pyritic ammonites).
- coll. Peter Beginski (*1940): 400 ammonites from the Macrocephalenoolite (Middle Jurassic) of Porta-Westfalica (Callovian, Middle Jurassic), many rare species of *Macrocephalites, Kepplerites, Cadoceras, Hecticoceras.*

12.2.1 Library

The geoscientific library of the Naturkunde-Museum Coburg has been compiled according to the daily needs of museum work. For exhibitions and for museum offices of education, more than 1000 current textbooks are available, as well as some popular scientific journals. Scientific activity is concentrated on the stratigraphy and paleontology of the Jurassic and Triasssic, in accordance with the collection concept. For this topic, 300 subject books and about 2500 special prints are available. In addition, 16 scientific journals are drawn up, partly in exchange with the Jahrbuch der Coburger Landesstiftung. Often, the museum provides expert geological information to public authorities and private individuals. For this purpose, the library has more than 200 geological maps, including all 1: 25,000 sheets of southern Thuringia and Northern Bavaria, with the corresponding topographic maps, as well as all possible geological maps. Older literature and historical maps

Fig. 12.6 Ammonites of genus *Dactylioceras* from Schlaifhausen, Lower Jurassic. Coll. Götz

are kept in the Coburg state library. A lithograph of the famous Ichthyosaurian skull of Banz is noteworthy. This sheet, over 2 m^2 in size, was made by Carl Theodori and is probably the largest scientific lithograph ever. The library of the Natural History Museum can be used during the service hours, lending is possible by arrangement.

12.2.2 Research and Educational Work

Scientific work is limited in smaller museums because the curators are mainly concerned with administration, exhibition management and public relations. In Coburg this is not different, especially since the geologist was also responsible for education and communication until 2012. Since then, there is a separate position, which has been filled with a biologist, so that geological topics are moving into the background. But there is now more time for geological research. In the tradition of Reinecke (1818), the focus lies on the Jurassic System, especially ammonites. Through the International Commission on Stratigraphy (ICS) and the German Stratigraphic Commission (DSK), the museum is integrated into national and international networks. In 2008 the museum participated in the International Year of Planet Earth (IYPE). Over 40 groups with 200 participants, mostly pupils, participated in the event. The project was later presented at scientific conferences, which showed that research and educational Work are difficult to reconcile (Mönnig 2008). The paleontological exhibition covers 15% of the museums area with the following topics: fossils, crises of evolution, the conquest of the continents and earth history of Coburg.

Admission of access

Collections can be visited by appointment during office hours. Curator: Dipl.-Geol. Dr. Eckhard Mönnig, Naturkunde-Museum Coburg, Park 6, D-96450 Coburg, Tel.: +49-9561-8081-13e.moennig@naturkunde-museum-coburg.de

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Schauroth CFV (1865) Verzeichnis der Versteinerungen im Herzoglichen Naturaliencabinet zu Coburg, 327 pp.; Coburg (Dietzsche Hofdruckerei)

Chapter 13
COTTBUS: Museum of Natural History and Environment in Cottbus

Rolf Striegler and Ursula Striegler

Geological/palaeontological collecting has had tradition in Cottbus, at least since 1905, when the Association for Local History was established. Over the Second World War nothing of these older collections has survived—except for an attractive 2.14 m long skeleton of a fish saurian *Stenopterygius quadriscissus* from the Jurassic of Holzmaden.

When after the Second World War in 1946 a municipal museum was founded in the castle of Prince Pückler, it took until 1961, before a department of natural science was established, which was expanded by two geologists—the authors—in 1974. Since the Municipal Museum became a District Museum for the district of Cottbus, the new Department of Geology was then responsible for the entire district of Cottbus, which approximately corresponds to the landscape of Lower Lusatia (Niederlausitz), the center of which was the city of Cottbus, which at that time had up to 130,000 inhabitants.

After the political change of the year 1989 the independent Museum of Nature and the Environment was developed from the Department of Natural History in 1995, but the exhibition was closed in 2005, and collections and personnel were added to the Municipal Museum, which is caring only for the urban area. The staff was also reduced for financial reasons. The authors did not receive any successors after their retirement. Although the Cottbus Nature Museum was the only one in Brandenburg in which geological work was being carried out, neither the city nor the regional government had any interest in preserving the nature museum as an institution. In contrast to modern art, which is generously financially supported, the Brandenburg Minister of Science, Research and Culture considers a natural history museum in Cottbus to be superfluous in spite of intensive mining in the region. That is why today the Department of Natural History of the Municipal Museum has only one staff member for the biological and geological collections, which has only the task of supervising the collections (Striegler 2010).

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A geological collection was built up especially between 1974 and the political change in 1989/1990, which today comprises 60,000 objects, the biological collection has even 400,000 samples.

For the Department of Geology, the most important area for geological collecting was the entire Lower Lusatia in the south of the present state of Brandenburg. This area is predominantly lowland, which during the Pleistocene was characterized by several glacier advances of the inland ice with a striking end moraine, the Lusatian Dividing Hills (Lausitzer Grenzwall) from the Saalian II glacial. The glacial sediments are covering the Tertiary deposits in the north-east of the territory, paleozoic to pre-Cambrian rocks in the south-west of the Lusatian Main Fault (Lausitzer Hauptabbruch). The higher tertiary layers (mainly Middle and Upper Miocene) were accessible through up to 15 brown coal opencast mines. Thus the geological collection activities were aligned with tertiary and quaternary sediments (Fig. 13.1).

Three quarters of the geological collection of the museum are concerning fossils, half the fossil samples are from the Lower Lusatia. Most fossils of the Lower Lusatia were collected in three geological excavations of the museum: one in upper Miocene layers and two in Eemian interglacial lake basins.

Out of a leaf-bearing clay from Wischgrund near Lauchhammer (Tortonium), there are more than 11,000 clay plates in the museum, containing mainly leaves (Fig. 13.2) and conifer needles in 78 species of trees and shrubs, as well as coniferous cones, besides seeds and fruits of deciduous and coniferous plants and seeds of herbaceous plants (predominantly aquatic plants) in 33 species (Striegler 2017). These objects are the basis for the reconstruction of a landscape of the primeval Elbe river on an area of 1.5 hectare by means of recent related trees (Fig. 13.3) under the name “Niederlausitzer Tertiärwald” (Striegler and Striegler 2002).

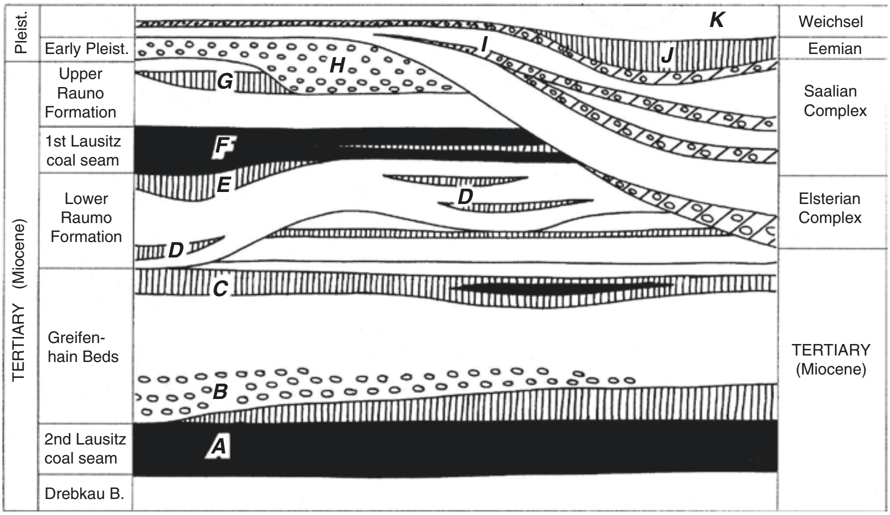

Fig. 13.1 Synopsis of fossil-bearing beds in the opencast mines of Lower Lusatia B—Seese gravel association, G—Leaf-bearing clay of Wischgrund

Fig. 13.2 Fossil leaf of *Liquidambar triloba* from the leaf-bearing clay of Wischgrund (Upper Miocene)

Fig. 13.3 Autumnal aspect of the *Taxodium* swamp in the Niederlausitzer Tertiärwald in Cottbus

The excavation Schönfeld on the edge of the opencast mine Seese-West has brought over 5000 finds out of the lake deposits of the Eemian warm period (Striegler and Striegler 1991, 1996). Most of these are karpological remains, but also leaves of trees, freshwater molluscs, bones of fishes, amphibians, reptiles, birds and mammals. A special feature is the detection of a population of pond turtle (*Emys orbicularis*) with more than 50 individuals (Fig. 13.4).

Also from lake deposits of the Eemian interglacial are about 4000 finds from the geological excavation located on the edge of the opencast mine Jänschwalde near Cottbus. This occurrence of interglacial sediments and fossils was already known by mammalian bones as early as 1892. The former investigator A. Nehring compared the foundations of the occurrence with the Cromer Forest Beds in England because of presence of *Brasenia* and the still unknown seeds of *Stratiotes aloides* (Fig. 13.5). However, further extensive studies have shown the Eemian age of the layers (Striegler et al. 2007, 2008). From this place comes an originally complete mammoth skeleton from the Early Weichsel, which is now located in the Natural History Museum Berlin.

The material of the three large excavations is mostly researched and published or is still to be edited. The two excavations Schönfeld and Klinge were an excursion destination for the International Quaternary Congress in Berlin 1995.

The largest exhibit is a 3.20 m thick giant tree trunk (*Sequoioxylon gypsaceum*, Fig. 13.6) with a weight of more than 22 tons from the first Lusatian coal seam in

Fig. 13.4 Carapace and plastron of the pond turtle (*Emys orbicularis*) from the Eemian of Schönfeld (shell length 153 mm)

Fig. 13.5 Fruits of *Stratiotes aloides* from the Eemian of Klinge

Fig. 13.6 Fossil mammoth tree trunks (diameter 3.20 m) from the 1.Lusatian coal seam (Middle Miocene)

the Klettwitz opencast mine. It has nearly 1100 annual rings. For almost 12 years it was standing in front of the Marstall of Branitz Castle and since 1994 has found a more suitable domicile in the Spreeauenpark on the edge of the Tertiary Forest. Among the most remarkable exhibits are several latex profiles, which are particularly interesting because they show the storage relationships of layers and thus directly reflect geological history.

Further fossil finds from the Lower Lusatia and the surrounding areas to document the geological development of the investigation area in our collection are:

- Holocene bone remains from the bottom of the Lake Schwielochsee (beaver, bear, pond turtle, etc.)
- Interglacial animal and plant remains from further Eem occurrences of the Lower Lusatia
- Some cold-time mammalian bones from layers of the Baruth glacial stream channel (mammoth, rhinoceros, horse, reindeer, red deer)
- Predominantly Ordovician, Silurian and Cretaceous fossils in boulders from the ground moraine of the Saalian glacial period
- Pebbles of Permian silicified wood from different fossil river sediments of the primeval Elbe
- Miocene plant finds from the second Lusatian brown coal seam, which is still mined today in four open-cast mines, as well as its covering sediments
- Fossils of the tertiary Seese gravel association (Fig. 13.7) originated in the Baltic area (silicified fossils mainly from Ordovician and Silurian, similar to the Pliocene of Sylt)

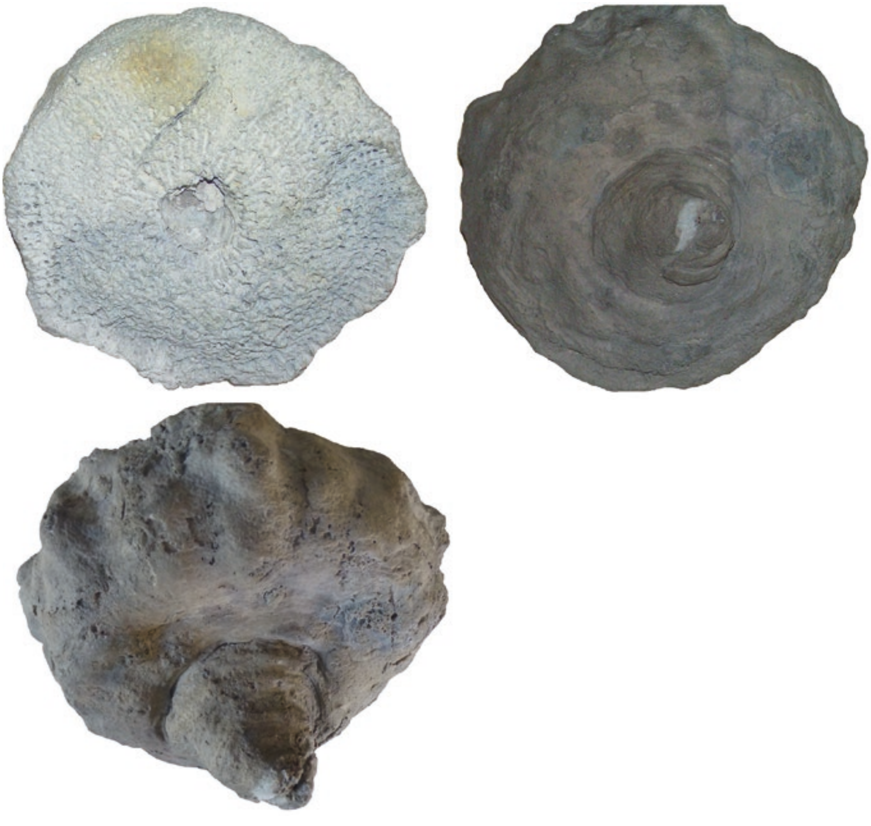

Fig. 13.7 Silicified sponge *Aulocopium* from the Seese gravel association

- Amber from the tertiary layers above the second Lusatian coal seam, partly with inclusions
- Oligocene plant remains from Seifhennersdorf/Upper Lusatia
- Oligocene seeds and fruits from Wiesa near Kamenz/Upper Lusatia
- Drill cores of pre-tertiary, tertiary and quaternary layers, partly with fossils (volume: approx. 650 specimens)
- Marine fossils from the Upper Cretaceous of the Elbtalzone near Dresden
- Marine fossils from the Muschelkalk of Rüdersdorf near Berlin
- Carboniferous plant remains from the Viséan of the synclinal zone Torgau—Doberlug
- Graptolites from the Silurian of the Eichberg near Weißig/Upper Lusatia
- Trilobites from the Lower Cambrian of Niederludwigsdorf near Görlitz/Upper Lusatia

In order to compare the tertiary development of the Lower Lusatia with other regions of Europe, the following collected complexes were acquired, partly by our own collection activities:

Molluscs

Pleistocene	North Italy: river Stirone
	USA: Florida
Pliocene	Czech Republic: Hodonín
	Bulgaria: Kavarna, Balčik
	North Italy: Salsomaggiore, Poggibonsi, Baldichieri, Orvieto
	Hungary: Tihany
	USA: Florida
Miocene	Niedersachsen: Groß Pampau
	Russia: Island Sachalin
Oligocene	Mecklenburg-Vorpommern: Malliß
	Hungary: Eger, Mariahalom
Eocene	Sachsen-Anhalt: Nachterstedt
	France: Paris Basin
	Hungary: Gant, Tatabanya
	Bulgaria: Beloslav

Other Groups of Animals

Miocene	Bavaria: Micromammals from Southern German caves
	Bavaria: Mammals from the Freshwater Molasse
Oligocene	Bavaria: Micromammals from Southern German caves
Middle Miocene to Middle Eocene	Inclusions in Dominican Amber
Lower Oligocene to Middle Eocene	Inclusions in Baltic Amber
Eocene	Hessen: Messel (Fig. 13.8)

Fig. 13.8 Skeleton of the running bird *Palaeotis* from the Eocene location Messel

Plants

Pliocene	North Italy: Meleto (leaves)
Miocene	Nordrhein-Westfalen: Opencast mine Hambach (Karpofossils)
	Czech Republic, North Bohemia: Bilina, Želenky (leaves)
Oligocene	Czech Republic, North Bohemia: Kundratice (leaves)
Eocene	Czech Republic, North Bohemia: Staré Sedlo (leaves)

In order to present the general development of organisms in exhibitions, the museum also acquired material from other areas:

- Marine fossils from the Maastrichtian (Cretaceous) of Rügen (Mecklenburg-Vorpommern)
- Fishes, insects and plant remains from Cretaceous of Santana Formation/Brazil (Fig. 13.9)
- Solnhofen limestone (Upper Jurassic of Bavaria)
- Shells of bivalves and ammonites from the Jurassic of Eisenach/Thuringia
- Plant fossils and molluscs from the Jurassic of Pecs (Mecsek Mountains/Hungary)
- Plant fossils from the Carboniferous/Permian of Thuringia
- Bundenbach Slates (Devonian of the Rhenish Slate Mountains)
- Ordovician and Middle Cambrian of the Barrandium (Czech Republic)

Fig. 13.9 Conifere branch of *Brachyphyllum* from the Santana Formation (Lower Cretaceous) of Brazil

Attractive single objects are the above mentioned fish saurian from Holzmaden as well as two *Mesosaurus* skeletons from the Permian of Brazil.

Last but not least, the Cottbus Museum preserves the memory of the Australian explorer Ludwig Leichhardt (1813 – about 1848), who was born in Brandenburg, attended the Gymnasium in Cottbus for 7 years, and was missing in 1848, as he tried to cross Australia from East to West. That is why the museum has endeavored to obtain finds from the outcrops which he had investigated on his journeys through S-England, France, Italy, Switzerland, and Australia, for example from the Permian of Newcastle, Australia.

Unfortunately, the Natural History Museum in Cottbus is currently not able to show its geological treasures to the public.

If you are looking for information about the petrographic and the mineralogical collections of the museum, please refer to the publication of Striegler 2010.

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Chapter 14
DARMSTADT: The Paleontological Collections of Hessisches Landesmuseum Darmstadt

Gabriele Gruber, Oliver Sandrock, and Torsten Wappler

14.1 History

Hessisches Landesmuseum Darmstadt was opened in 1906 and houses collections of art and cultural history as well as natural history. Natural history consists of two departments, zoology and earth and life history.

The origins of the collections of earth and life history date back to Johann Heinrich Merck (1741–1791) to the 1780s. Landgrave Ludwig X acquired Merck's estate in 1792 for his natural history collection. Johann Jakob Kaup (1803–1875), Inspector of the natural history collection since 1837, enlarged the collection by working in the ca. 10 Ma old "Dinotheriensande" of the proto-Rhine river and in sediments of the last Ice Age in the Upper Rhine Valley. The proboscidean *Deinotherium giganteum*, the hornless rhino *Aceratherium incisivum* or the tapir *Tapirus priscus* are famous fossils that were described by Kaup. "Peale's Mastodon", an American proboscidean (*Mammut americanum*), was acquired by Kaup in London in 1854. This historic elephantid was the first mounted skeleton in North America, was exhibited in Philadelphia in 1801 and is standing in the entrance of the permanent exhibition of earth- and life history since 1906. In 1876, Richard Lepsius was appointed inspector of the department of geology and mineralogy. Under his long-term aegis the fossil stock increased considerably especially with stratigraphic collections of the Devonian of the "Rheinisches Schiefergebirge" and the "Mainzer Becken". The sea cow *Halitherium schintzi* was discovered at Alzey and exhibited for the first time in 1906.

The museum was heavily damaged on 11 September 1944. It reopened in 1955, after its collections were gradually returned. Heinz Tobien (1911–1993) rebuilt the

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new permanent exhibition and enlarged the paleontological collection extensively through his international research projects. Between 2007 and 2014 the whole museum was closed due to a general renovation.

14.2 Collections

The Messel collection consists of ca. 10,500 objects, the collections of geology, mineralogy and paleontology consist of ca. 185,000 objects. The major paleontological collections, sorted by locality, are as follows:

The "Messel Pit" was included in the UNESCO World Natural Heritage list in 1995. The bituminous claystone, which was mined as an oil slate until 1971, represents a unique archive of a tropical-subtropical ecosystem about 47 Ma ago. Recorded is a very diverse and well-preserved fauna and flora, which has become world-famous especially through the mammalian fossils. Hessisches Landesmuseum Darmstadt houses the oldest and one of the most extensive Messel collections in the world.

The "Rupelton" of the Unterfeld clay pit and the "Meeressande" of the "Mainzer Becken" give fascinating insights into the animal and plant world during an advancement of the sea reaching the Upper Rhine Valley about 32–30 Ma ago. These include two major sea cow skeletons.

The "Dinotheriensande" (Eppelsheim Formation) have an age of ca. 10 Ma and are known for their abundance of fossil large mammals from proboscideans to apes. The river deposits are located on the line Westhofen—Eppelsheim—Alzey—Bingen.

The "Hoewenegg" locality has an age of ca. 10 Ma and is part of the Hegau volcanic field on the southern edge of the Swabian Alb. The most common fossils belong to the ungulates. Nearly complete skeletons of horse and antelope relatives are known.

Fossils from Samos and Pikermi formed a characteristic organism community of different animals and plants. The so-called "Pikermi Biome" stretched far beyond the Middle East to China and consisted of Eurasian and African animals living in a woodland mosaic. The fauna has an age of 7–8 Ma.

The "Mauer Sands" originate from a former bend of the Neckar river near Heidelberg. The "Mosbach Sands" represent deposits of the Rhine and Main rivers in the vicinity of Wiesbaden-Biebrich. Both localities can be categorized into the Cromer warm period between approximately 621,000 and 475,000 years.

The "Rhine river deposits" of the northern Upper Rhine Valley unite the sediments of the Last Interglacial (Eemian) and the Last Glacial (Weichselian) periods. The fauna is diverse and among others consists of woolly mammoth and woolly rhino, straight-tusked elephant and forest rhino, hippo, water buffalo, bison and Irish Elk.

Upper Cretaceous rudists from Central Oman are a highlight of the invertebrate collection. Emphasized should be the generalized systematic and stratigraphic collection, the “Maurer” collection of Devonian age and the “Gruhl” collection especially with Mesozoic corals from Nattheim. The collection of plants is sorted by stratigraphy and, beside lignites from the federal state of Hesse, comprises fossils of important European localities.

The exhibition on human evolution is famous due to its hominin reconstructions. The most important types of pre-humans—*Sahelanthropus tchadensis, Australopithecus anamensis, Australopithecus afarensis, Kenyanthropus platyops, Australopithecus africanus, Paranthropus boisei*—, and early humans—*Homo rudolfensis, Homo habilis, Homo erectus*, Neandertal—, are displayed as realistic busts.

14.3 Research

The curators of vertebrate paleontology had different research topics. H. Tobien had a focus on the “Hoewenegg” locality and Darmstadt, beside the Staatliches Museum für Naturkunde Karlsruhe, enlarged its collection of primarily horse and antelope fossils. W.v. Koenigswald (von Koenigswald 2016) had an emphasis on fossils of the “Rhine river deposits” and the glacial–interglacial cycles. F. Schrenk and his American colleague T. Bromage founded the Hominid Corridor Research Project (HCRP) with Hessisches Landesmuseum Darmstadt as a long-term partner. This project is running in the Chiwondo Beds of Northern Malawi and focuses on the Plio-Pleistocene fauna and the paleobiogeography between the Eastern and Southern African hominid sites (Lüdecke et al. 2016). Hominid fossils of *Homo rudolfensis* and *Paranthropus boisei* were discovered.

Curator N. Micklich mainly worked on the Messel fish and their skeletal variability. Hosting one of the largest museum collections, the potential for major research activities at the famous Messel site are structured around combining both the geological and biological aspects of paleontology to gain a complete picture of ancient environments.

In the current era of global climate change this allows insights into how faunas were shaped and affected and how global climate pattern shifts can provide critical insights into ecosystems and their global functioning. The paleontological and ecological implications of these interactions are also of interest for insect-plant evolution in terms of ecology, behavior, speciation, macroevolution and systematics (Wappler et al. 2015).

The department of natural history edits “KAUPIA” once a year. In this journal, monographs, papers of ongoing research or workshop volumes are published since 1992. G. Gruber (Gruber 2012) is member of the “National GeoPark-Expertengruppe der GeoUnion Alfred-Wegener-Stiftung”.

14.4 Infrastructure

Three curators are working in the department of earth and life history, for the Messel, vertebrate and invertebrate collections respectively. A laboratory with two fossil preparators and one technician belongs to the department, where, among other things, the complex synthetic resin objects of the Messel fossils are produced. Due to lack of space, the laboratories of natural history were kept outside the museum after its renovation—on the same compound, where the entire museum was outsourced between 2007 and 2014. The hope is a new building for depots and laboratories adjacent to the museum, which is planned for the future.

One large hall on the main museum floor is dedicated to special exhibitions of art and natural history. The permanent paleontological exhibition is situated on the first floor.

The department of museum education cares for special exhibitions, museum events or central museum objects. It is cooperating with schools in and around Darmstadt on a project-related basis.
Facebook, YouTube and Instagram are used in combination with the museum's website. Highlight objects of the exhibitions are emphasized by videos that can be accessed by mobile devices via QR codes. These are constantly expanded by more objects and will be replaced by VR solutions.

Fig. 14.1 Messel anteater, *Eurotamandua joresi,* HLMD-Me 17000 ©Wolfgang Fuhrmannek, HLMD

Fig. 14.2 Messel tapir, *Hyrachyus minimus,* HLMD-Me 16000 ©Wolfgang Fuhrmannek, HLMD

Fig. 14.3 Messel horse, *Propalaeotherium hassiacum,* HLMD-Be 136 ©Wolfgang Fuhrmannek, HLMD

Fig. 14.4 Straight-tusked elephant, Crumstadt, *Elephas antiquus*, HLMD-WT 3003-77 ©Wolfgang Fuhrmannek, HLMD

Fig. 14.5 Proboscidean, Dinotheriensande, *Deinotherium giganteum,* HLMD-Din 467a ©Wolfgang Fuhrmannek, HLMD

Fig. 14.6 Hominin reconstructions ©Wolfgang Fuhrmannek, HLMD

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Chapter 15
DESSAU-ROSSLAU: Museum of Natural History and Prehistory—Paleontological Collection

Angelika Hesse

15.1 Introduction

In 1864 the Anhaltische Geologische Landessammlung was founded. It formed the basis of the geological collection. The museum MNVD was opened on 29th of October 1927 in the former Leopold-Dank-Stift, a building dating from 1750. After two world wars, severe destruction and several relocations and rearrangements, the museum MNVD looks back on a changeful history. In World War II, the MNVD museum burned down almost completely on 7th March 1945, the whole permanent exhibition was destroyed. Some parts of the collection were evacuated to the Zerbst Castle, which was destroyed by bombs on 16 April 1945, thus mainly the objects collected before the war that had been stored in the museum's archives have survived. In 1948 the first exhibition was reopened in the MNVD museum, and by 1958 all exhibitions rooms had been restored. An important basis of the paleontological collection of the MNVD museum is the tireless and thorough collection of fossils by private people, whose collections have been donated to the MNVD museum or purchased. The Bitterfeld amber collection of the MNVD museum was mainly made possible by generous donations from the friends of the museum MNVD. In the 1990s, early Tertiary clay layers in the surroundings of Stassfurt and also in and around Magdeburg were exposed for a short time, where an abundant fauna could be extracted (Hesse 2002).

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15.2 Partial Collections

15.2.1 Anhaltinische Geologische Landessammlung

Throughout his life, Bergrat Carl Andreas Bischof (1812–1884) was an enthusiastic fossil collector, above all in the Harz Mountains. Because of health problems caused by his work in the Mägdesprung Ironworks, where he inhaled poisonous vapours during his experiments with gases, Bischof was forced to retire in 1863, and moved to Dessau. Commissioned by Duke Leopold IV Friedrich of Anhalt (1794–1871), he started in 1864 to establish the Anhalt. Geol. Landessammlung. It was set up in a building dating from 1750 (Bischof et al. 1864 eds., 1865, 1867), where today's museum can be found. In 1869 he extended the collection by selling his private fossils to the State Ministry of the Dukedom of Anhalt. After Bischof had moved to Halle, the Anhalt. Geol. Landessammlung was continued until 1944, mainly by acquiring till objects from the former Anhalt area. Of the approx. 4000 fossils in the present surviving collection, almost 1700 fossils are from Carl Andreas Bischof; most of them bear hand-written labels. A peculiarity of Bischof's collection are 760 early Tertiary molluscs from Latdorf, the type locality for the Latdorfium.

15.2.2 General Fossil Collection

The tradition of the Anhalt. Geol. Landessammlung was continued after 1945 by excavations and collections in an area of approximately 100 km around Dessau. Important components in the General Fossil Collection of 46,500 fossils in total are 2500 fossils from the former Anhalt area, mainly till fossils, 500 hard coal plants from the historical hard coal deposits near Plötz and Wettin, 1400 Tertiary plants and woods from lignite deposits in Central Germany, 700 Jurassic and Cretaceous fossils from the northern foothills of the Harz Mountains, and 470 Baltic chalk fossils.

Numerous private collectors have contributed to the whole collection. The largest collection of Georg Heinze from Rosslau, which came to the museum MNVD in 1966, consists of approximately 5100 fossils. It is only known that Georg Heinze was born around 1900 and studied geology in Halle together with Ehrhard Voigt (1905–2004), for a while under Johannes Weigelt (1890–1948) (Ehrhard Voigt, personal communication). 1936 he lived in Munich (unpublished letter).

Georg Heinze concentrated on the early Tertiary Age in the surroundings of Dessau and Rosslau, with 2000 molluscs, and on the late Tertiary Age of Northern Italy, with 1400 molluscs. Special features of his collection are 210 till fossils from Rosslau, a local collection from the High Elbe Banks, and about 160 Malm fossils from Nattheim.

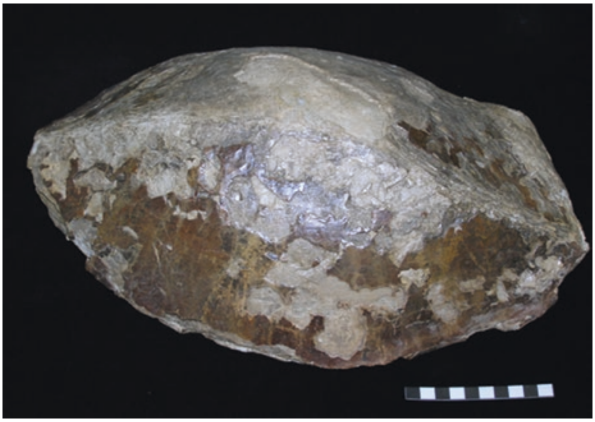

Fig. 15.1 Soft-shell turtle *Allaeochelys parayrei* Noulet 1867 MNVD-G 15310, Tertiary, Oligocene, Chattian, Steutz/Elbe

Friedrich Winter from Dessau was a shopkeeper who collected fossils in his sparetime all over Germany. Born around 1900, he sold in 1976 the most beautiful 200 objects to the museum MNVD, including ten very rare crinoid calyxes from Devon, of Gerolstein. Furthermore very well preserved Carboniferous plants came from Stefan C of Wettin.

In 2012, the geologist Daniel Krause from Teutschenthal donated more than 2100 fossils to the MNVD, mainly till fossils and Tertiary and Pleistocene plants from the meanwhile flooded former opencast lignite mine Gröbern near Gräfenhainichen.

Additional private collections were donated to the museum MNVD, for example 750 ammonites by Gerd Müller, from Oldenburg in 2001, from the Jurassic period in France. 1060 fossils were donated mainly from Rügen chalk by Klaus Körner, from Wolfen in 2005. Lastly 750 till fossils were given to the museum from gravel pits between Bitterfeld and Leipzig by Paul Müller from Löbnitz in 2015. The paleontological collection of the museum MNVD continues to expand due to the donations received from private collectors.

From the beginning to the middle of the 1990s, an abundant micro-fauna could be obtained in Oligocene clay layers, found in temporary explorations near Stassfurt, in Magdeburg, in Mammendorf to the west of Magdeburg, near Gardelegen and in Steutz to the west of Dessau-Rosslau. The micro-fauna forms the basis for Bachelor and Master theses at the Freiberg University.

Currently the fragment of an Eemian interglacial juvenile forest rhinoceros from the Sewecken Mountains near Quedlinburg is being scientifically investigated and described at the Leiden University, the Netherlands. It belongs to the few known remains of a new species of Pleistocene forest rhinoceroses in the world. (Prof. M. van Kolfschoten, personal communication).

The soft-shell turtle *Allaeochelys parayrei* (Fig. 15.1) was found by a private collector in Steutz to the west of Dessau-Rosslau at the banks of the river Elbe in 2005. It is by far the largest and stratigraphically youngest individual of the genus

Fig. 15.2 *Podocarpoxylon radiciforme* Süss & Müller 2015, holotype MNVD-G 26707, root wood with root intergrowth of *Taxodioxylon gypsaceum* (Goeppert) Kräusel 1949; Tertiary, Oligocene, opencast lignite mine Espenhain

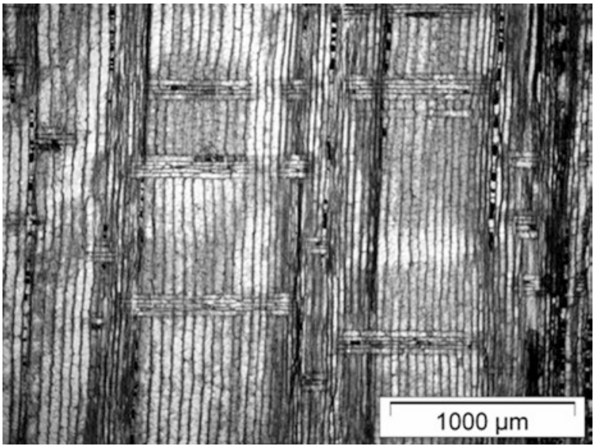

Fig. 15.3 *Ginkgoxylpropinquus saxonicum* Süss & Müller 2015 holotype MNVD-G 27275, thin section, stem wood, radial view with early and late wood zones showing the arrangement of the tracheids and the wood parenchymas as well as the course of the wood radiation. Tertiary, Oligocene, opencast lignite mine Espenhain

Allaeochelys, which by now has only been known from the early to late Eocene period in France, Spain, England, Belgium and Germany (Karl et al. 2006).

The root wood *Podocarpoxylon radiciforme* Süss and Müller 2015a (Fig. 15.2) and the ginkgo plant *Ginkgoxylpropinquus saxonicum* Süss and Müller 2015b (Fig. 15.3) are new species in the Tertiary of the Central German lignite. *Ginkgoxylpropinquus saxonicum* is the first evidence of a wood fossil of ginkgo plants in the Tertiary of the Central German lignite (Süss and Müller 2015a, 2015b).

Other important research objects are the so-called “Bernburg Saurians”, amphibians from the Buntsandstein at Bernburg, and molars of Cenozoic mammals.

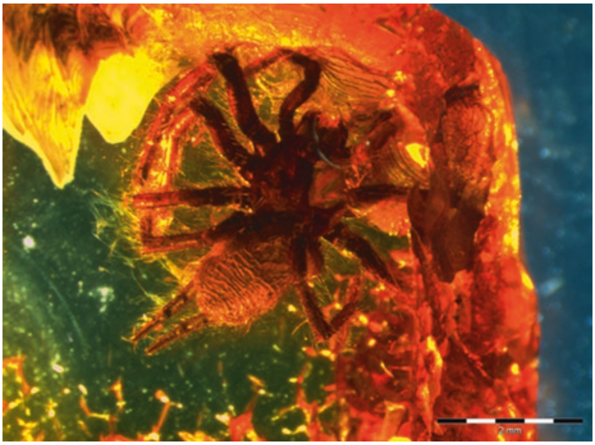

Fig. 15.4 An extremely rare piece among the amber inclusions is this curtain-web spider *Clostes priscus* Menge 1869 MNVD-G 22600 (Dr. Jason Dunlop, Berlin, personal communication). Photo and Copyright: Dr. Anne Janovsky, Dessau-Rosslau

15.2.3 Bitterfeld Amber Collection

The amber deposit in the former opencast lignite mine Goitzsche near Bitterfeld was mined until 1993. Thanks to several donations by the friends of the museum MNVD, the Bitterfeld amber collection has grown to 3400 amber inclusions (Fig. 15.4) and 120 kg of Bitterfeld amber, presumably containing further inclusions. The flora and fauna in the Bitterfeld amber deposit is of scientific interest for current research activities. At the moment, the lepidoptera are investigated and scientifically described at the Smithsonian Institution in Washington.

15.2.4 Working with the Collection

The paleontological collection is the basis of the permanent paleontological exhibition and of special museum MNVD exhibitions on paleontological topics. In the permanent exhibition, the visitors get acquainted with the development of the history of life in the Dessau-Rosslau region, by means of life-size dioramas from the Carboniferous period to the Pleistocene period, based on drill cores taken from the ground in the Dessau-Rosslau region. The evolution of the terrestrial vertebrates is presented in the six-floor museum tower. In museum-pedagogical actions, children and young people are taught the history of life on earth, alongside associated museum MNVD exhibitions. Guided tours through the evolution exhibition in the museum tower are especially attractive for school classes and other interested people.

The paleontological exhibition is currently supervised by a curator and a museologist. A variety of people support the work in the collection under the umbrella of, for example, the Federal Voluntary Service, student internships, taxidermists and pupils.

The collection is open to scientists, students and people interested in paleontology for research activities and visits of the collection. The collection is available in digital form. Guided tours through the exhibition are possible on request at any time.

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Chapter 16
DORTMUND: Museum für Naturkunde der Stadt Dortmund

Jan-Michael Ilger and Oliver Adrian

16.1 General Information

The Museum was first opened to the public in 1912. Palaeontological collections date back to 1887 when the Naturwissenschaftlicher Verein Dortmund was founded and have incorporated earlier private collections of society members.

There are approximately 70,000 specimens in the entire geological collection. It contains samples of rocks, coal types, fossils, minerals (e.g. 1500 agates), and meteorites.

Additionally, the museum maintains a biological collection of extant species: 150,000 insects, 3000 other invertebrates (mainly molluscs, echinoderms, and corals), 2200 vertebrates, and a herbarium with 20,000 plants.

About 30,000 objects are of palaeontological interest. The focal point is on the local strata found in Dortmund and surrounding Westphalia. Mentionable are e.g. giant ammonites from the Cretaceous (*Lewesiceras mantelli* and *Mesopuzoia mobergi*) which weigh up to 280 kg each. Due to the historical and local context of the extraction of coal from the Ruhr area seams the museum has an extensive palaeobotanical collection of Carboniferous and Devonian plant remains.

About 800 fossils from the Messel pit (Eocene) are an extraordinary part of the collection, including one specimen of the equid *Propalaeotherium hassiacum* (Fig. 16.1). Furthermore, a number of specimens comes from the Hunsrück slate (Lower Devonian).

Additionally, there are systematic and stratigraphical sub-collections with specimens from the Precambrian to Quaternary and subfossil species. A synoptic overview with the approximate number of specimens in each category can be found in Jansen & Steininger (2002, p. 29).

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Fig. 16.1 *Propalaeotherium hassiacum* from a palaeontological excavation campaign of the museum in the Messel pit near Darmstadt, unearthed in 1978

The collection is supervised by one geoscientific curator and maintained by two geological preparators.

The collection itself is stored in three depots with a total space of 165 m^2. Preparation and exhibition arrangements are mainly carried out in two rooms with less than 95 m^2 in total.

The Museum für Naturkunde is a municipal museum and part of the Kulturbetriebe, an owner-operator of the municipality of Dortmund. Due to this, it has a limited financial budget. Nevertheless, an extensive modernisation is in progress at the deadline of this chapter. This includes not only a building restoration but also the renewal of the permanent exhibition.

16.2 History

In the nineteenth century, Dortmund was a hotspot of industrial development in Germany. The social structure was agriculturally shaped but rapidly changed into a big city community with a high rate of immigrants from all over Europe. The heavy industry with its factory fumes, noise and space requirements had also direct consequences for the environment, just as for the fauna and flora. The progressive loss of homeland, forests, and countryside motivated some citizens of Dortmund to campaign for natural history. On April 2nd 1887 a small number of people met in an inn called "Kaiserhalle" to found the Naturwissenschaftlicher Tauschverein. The founding members contributed their own private collections of fossils, rocks, minerals, plants, insects etc.—so the basis of the present-day museum collections was provided. Initially, the centrepiece consisted of extant insects and minerals. Members frequently met in the "Kaiserhalle" to discuss and exchange specimens. In 1888, this kind of casual club became the character of an official society and was renamed to Naturwissenschaftlicher Verein in Dortmund. In the next twenty years, the society grew and became more and more active in nature protection. Additionally, from the very beginning on there was a strong interest in education, too. According to this, the society lent collection exemplars to schools and gave public talks.

In the beginning of the twentieth century, the teacher Edgar Weinert took care of the natural history collection of his school and was in close interaction with the society. His fund grew so extensively that Weinert proposed the foundation of a municipal museum to the city of Dortmund in collaboration with the Naturwissenschaftlicher Verein. Finally, in 1912 the urban administration bought an adequate house in the Viktoriastraße to realize Weinert's vision. He became the first director of the institution. From now on, the history of the museum's palaeontological collection is part of the history of the museum itself.

The museum was very popular and wealthy citizens who were interested in natural history bought exhibits and donated them to the institution. A skeleton of *Ursus spelaeus* was composed from bones of different adult individuals from a cave near Trieste (Italy) and was a highlight of the exhibition (Fig. 16.2).

22 years later, in 1934, the house in the Viktoriastraße was eventually too small, and the museum moved into a bigger building in the Balkenstraße.

World War II was completely fatal for the entire city of Dortmund. As it was a major place of industrial production, it became a target of several British and

Fig. 16.2 Historic photograph of the former exhibition rooms in the Viktoriastraße (1912) with the mounted skeleton of *Ursus spelaeus*. The martial posture of the bear was typical for museum presentations in these days

Fig. 16.3 Examples for typical WWII damages in the collection: two fritted specimens of *Dactylioceras* sp. (*below*) from the Upper Jurassic of Eichstätt (registration no. 3508 and 3510). All further information and the original labels got lost. For comparison an unaffected specimen of *Perisphinctes* sp. (*above*) from the same area (no. 9181) that shows the characteristic colours of the rocks coming from this Lagerstätte

American air raids. The museum was struck also, and up to 90% of the collection got lost. Today, there are still some samples in the palaeontological collection that show distinct fire damages (Fig. 16.3). Furthermore, many information on the specimens, both destroyed and extant, got lost together with inventory registers and corresponding files. Thanks to the zealous contribution of the citizens, the municipal administration and the society, the re-opening was possible soon after the war.

In 1953, the building in the Balkenstraße became too small again. At this time, several alternatives were in discussion. However, it took over two decades until a new concept was finally concluded: a brand new building should be erected in the north of the city.

From 1974 to 1979, a number of giant ammonites (*Lewesiceras mantelli* and *Mesopuzoia mobergi* from Turonian strata) with weights up to 280 kg were found during the building of a metropolitan railway (partially underground). They came to the museum and are among the most spectacular objects for the visitors until today.

In the late 1970s, the museum organized palaeontological excavations in the Messel pit near Darmstadt. Several Eocene specimens (mainly fish and plant remains) were recovered and prepared. One highlight of the collection is a complete individual of *Propalaeotherium hassiacum* (Fig. 16.1) discovered in 1978.

For arrangement of the permanent exhibition in the new building the collection was extended by several objects. The main focus was on display quality and uniqueness, not on the scientific importance – a point of view that originates from the very first days of the collection in 1887 when education and public presentation were the motor to the foundation of the society.

On May 24th 1980, the building at the Fredenbaumpark in the north of Dortmund opened its doors to the public. The geological and palaeontological exhibition was located on the upper floor, whereas the biological exhibition and the aquarium were on the ground floor. The ground plot of the building shows an interlocking of different octagonal figures that resemble mineral structures.

According to the didactic concept, which was status quo until 2014, visitors could pass through Earth's history from the Precambrian to the Quaternary. They could learn something about the evolution of life based on fossils, dioramas, and life scenes. In a central atrium, there were original-sized reconstructions of *Iguanodon* and *Styracosaurus*—in the way their habitus was supposed to have looked like in the 1980s. An overview of the history of the museum until 2012 can be found in Museum für Naturkunde (1987, 2012).

During the production of this book chapter, the museum is once again in an intensive stage of re-construction. After 35 years the building technology, electricity and the didactic concept had become outmoded. Consequently, the house has been closed in September 2014 for visitors. The new concept focuses on accessibility for all people, regardless if disabled or not. The scientific focus will be on the local geological situation. Following the working title "lift to the past", the exhibition concentrates on those stratigraphic units that can be found below ground under the museum: Quaternary, Cretaceous, and Carboniferous. The geology will be complemented with excursuses to space (evolution of the solar system) and mineralogy.

Most of the palaeontological specimens that will be visible in the new exhibition come from the existing collection and the former exhibition. An example are the Fossil tree discs from the Petrified Forest in Arizona (Araucaria; Triassic) and other locations (Fig. 16.4).

Some outstanding new acquisitions were made. For example a private collection of plants and invertebrates from Hagen-Vorhalle (Upper Carboniferous) could be purchased in 2016, including one insect (Palaeodictyoptera) and one arachnid (Trigonotarbida). Furthermore, one of the six known Carboniferous Eurypterids from the Ruhr area came to the museum in 2017. The most prominent object in the new exhibition will be the mounted skeleton of a female *Mammuthus primigenius* from the North Sea area.

Fig. 16.4 Twelve disks of petrified wood in the atrium of the museum. Most of them come from the Petrified Forest in Arizona. In 2017, they were the first objects built-in for the new permanent exhibition

16.3 Research

From the beginning, the palaeontological collection in Dortmund was an instrument for didactics and educational work. Several specimens were acquired for exhibition, both permanent and special shows. Until some years ago, the museum's staff was very small in number and research nearly impossible. An exception to this worth mentioning are the studies of a former museum's director on gold deposits of the Rhenish Slate Mountains.

The "new generation" of scientists at the museum endeavours to establish a sound basis for more research to be done in the near future. This includes the setup of a digital database and consequent inventory of numberless specimens.

Close co-operations are promoted with local nature conservation societies and citizen scientists. Since 1967, a scientific journal ("Dortmunder Beiträge zur

Landeskunde") is published by the museum. This journal includes articles from professional as well as from citizen scientists on regional flora, fauna, geology and palaeontology.

16.4 Educational Work

Educational work plays a prominent role since the foundation of the museum. Some years before the current renovation, educational programmes had been modernised and new programmes established. Lastly, more than 500 courses, workshops and guided tours have been performed each year. After the re-opening of the museum, these programmes will be up-dated and adapted to the new permanent exhibition again.

In the course "nature experience", pre-school children visit the museum for ten subsequent weeks and learn about birds, insects, dinosaurs, minerals and coal mining, among others. Groups of children and teenagers of all ages can choose among a wide variety of courses and guided tours on such diverse topics as human evolution, freshwater ecology, biology, ecology and evolution of specific animal taxa such as bats or dinosaurs, the formation of stone coal or life during the Pleistocene. Very popular is also the possibility for children to celebrate one's birthday in the museum. During public holidays, special programmes for children lasting several days are offered.

A group of private mineral and fossil collectors meets regularly in the museum and organises public talks on geological, palaeontological and mineralogical topics.

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Museum für Naturkunde (2012) 100 Jahre Museum für Naturkunde Dortmund. 1912–2012. Museum für Naturkunde, Dortmund

Chapter 17
DOTTERNHAUSEN: The Jurassic World of the Swabian Alb Region (South Germany): The Fossil Collection of the Werkforum and Fossil Museum of Dotternhausen

Annette Schmid-Röhl

17.1 Introduction

The Lower Jurassic oil shale or Posidonia Shale is world famous for its excellently preserved fossils. Besides the famous Holzmaden area spectacular finds of vertebrate fossils were also made at localities like Balingen, Schömberg, Dormettingen and Dotternhausen. The 180 m.y. old dark gray organic-rich sediments were deposited under mainly oxygen-deficient conditions.

17.2 The Museum

The fossil museum at Dotternhausen is part of an extraordinary cement plant which uses the organic-rich Posidonia Shale to produce oil shale cement with about 20% less CO_2 emissions compared to traditional cement (since 1939 Rohrbach Zement, since 2005 Holcim (Süddeutschland) GmbH). The museum was founded in 1989 by Rudolf Rohrbach. The systematic recovery of fossils from own quarries started already in 1973, when two preparators were employed. The focal point of the collection is on the Lower Jurassic (Lower Toarcian) Posidonia Shale and on the Upper Jurassic finds of the Plettenberg quarry. Additional exhibits were added to give an overview on the complete Jurassic stratigraphy of the South German Cuesta Landscape.

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Fig. 17.1 A sensational find: a 3D preserved scull of a 180 m.y. old ichthyosaur (*Temnodontosaurus trigonodon*)

In an aesthetic architecture e.g. ammonites, belemnites, sea lilies, bivalves but also vertebrates like ganoid fish, ichthyosaurs, crocodiles and pterosaurs are displayed. The permanent exhibition shows around 1000 exhibits (mainly fossils but also reconstructions, rocks, thin sections, polished slabs) of the Jurassic (Figs. 17.1, 17.2 and 17.3).

Since its opening in 1989, the fossil museum is directed by a palaeontologist. Additionally there is staff at the reception desk and the museums shop and still one preparator. A preparation laboratory and a kids research laboratory belong to the Werkforum. The museum is financed by the Holcim group.

17.3 Research Aspects

A lot of research has been done since the last centuries and the Posidonia Shale is known as a famous Fossillagerstätte. There is a significant potential not only for fossils but also for interdisciplinary research due to the high organic carbon content of these black shales. Within the Posidonia Shale plenty of information is preserved over millions of years which allows sedimentological, geochemical, geophysical, palaeontological, ecological and climate research. Elsewhere, it is one of the most important source rocks for petroleum production. Therefore it is far more than an interesting raw material for cement production.

Fig. 17.2 The fossil museum of Holcim in Dotternhausen gives an overview of the Jurassic fauna 200–145 m.y. ago

Fig. 17.3 The fossil museum of Holcim at Dotternhausen gives an overview of the Jurassic fauna 200–145 m.y. ago

Students and scientists all over the world come to visit the collection which is open for research purposes. The collection includes around 2000 specimens. In the active quarries of the Posidonia Shale of Dormettingen, the Upper Jurassic Plettenberg and the Middle Jurassic Opalinum Clay quarry near Schömberg sampling for scientific research is possible. There are several scientific research projects on the Posidonia Shale as well as on the Plettenberg fauna and sedimentology.

17.4 Activities

The museum provides a 150 page tour guide including colored figures and photos. In the entrance area a landscape model introduces the public into the southwest German geology. Additionally movies give information about the Jurassic life. The museums tours is a stroll through the early, middle and late Jurassic time. A ramp of Earth History demonstrates incredibly long time spans of geology in terms of length.

Two special exhibitions are displayed every year. One aims to honor regional fossil collectors and to give them the possibility to show their finds to the public.

The museum has about 20,000 visitors every year, 6000 of them are children and students. There is a museums quiz for different age groups. Tours and special programs for kids, e.g. the summer holiday program are part of the museums didactic concept. A cooperation with the Hector foundation includes museum tours for particularly interested kids.

Outside the Werkforum a “rummage site” of oil shale invites visitors to hunting for fossils. Hammers, safety goggles and chisels can be borrowed at the Werkforum reception desk.

The museum is one of more than 20 Geopark infopoints of the UNESCO Geopark Schwäbische Alb.

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Chapter 18
EICHSTÄTT: The Jura-Museum Eichstätt

Martina Kölbl-Ebert

18.1 General Information

The present collection was founded in 1844 as a teaching and research collection of the Bishop's Seminary in Eichstätt (Heiler 2014, Kölbl-Ebert 2016). Since 1970, it is curated by staff of The Bavarian Natural History Collections (*Staatliche Naturwissenschaftliche Sammlungen Bayerns*, SNSB). It is constantly enriched by palaeontological excavations in the Solnhofen limestone region of Bavaria (Germany; see Viohl & Zapp 2006, Ebert et al. 2015). The collection encompasses some 100,000 objects (zoological, entomological, botanical, mineralogical and palaeontological specimens as well as historical teaching aids). Its main focus, however, are the fossils of the Solnhofen limestone, for which it is the worldwide largest research collection with some 20,000 specimens. The collection is especially rich in fossil fishes (ca. 6500 specimens) (Fig. 18.1). There has been no damage through World Wars I and II.

Curatorship by personnel of the SNSB ensures professional standards for housing, ordering, documentation and accessibility (Kölbl-Ebert 2014). The collection personnel also includes a preparator. Financial grants by the *Volkswagenstiftung* (I/84 636) and the *Deutsche Forschungsgemeinschaft* (Ko 1682/5-1) have enabled the collection to increase staff at least temporarily and for specific tasks, and to purchase necessary equipment including a modern microscope and camera, which is available to guest-scientists. Most recently, the collection is promoted via specialist internet portals to increase visibility for the scientific community (e.g. http://www.gbif.org/dataset/44c26867-9738-4ac5-9213-f612b0ef3197; see also Ebert et al. 2017).

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Fig. 18.1 *Macrosemimimus fegerti*, JME-ETT3956, from Ettling (MarktPförring, Bavaria) (© Jura-Museum Eichstätt)

Fig. 18.2 The Eichstätt specimen of *Archaeopteryx lithographica*, JME-SOS3570a (© Jura-Museum Eichstätt)

18.2 Research

The collection is available as a research tool and many international guest scientists work regularly in the collections of the Bishop's Seminary Eichstätt—on the Eichstätt specimen of *Archaeopteryx lithographica* (Fig. 18.2), the dinosaur *Juravenator starki* Göhlich & Chiappe 2006, pterosaurs, lizards, sphenodontids and turtles, fish diversity, fossil crustaceans, insects or squids—all from the Upper Jurassic time period. During the last decade, more than a hundred geoscientific publications by guest scientists and collection personnel appeared using material of the Eichstätt collection (see the annual reports of the museum included in the SNSB reports at http://www.snsb.mwn.de/index.php/de/jahresbericht. The list of publications is fully given in the annual reports in Archaeopteryx, i.e. the house journal of the Jura-Museum Eichstätt.)

Currently, the collection houses 73 holotypes and seven neotypes, several more are in print or in preparation. Historical hand catalogues exist for part of the fossils and for the zoological specimens. Some 15,000 fossils of the Solnhofen limestone have been documented in an electronic inventory, 6500 of them—all fossil fishes—

being fully digitized. (For detailed information see: http://ides.snsb.info/; Ebert et al. 2017, Triebel et al. 2014.)

The collection is also frequently used as locus for various conferences and workshops, Eichstätt being rather attractive as a conference venue due to the beautiful location, the comparatively cheap accommodation and the logistic aid, which the Bishop's Seminary has to offer. The conferences include the Archaeopteryx Conference "The Beginning of Birds" (1984), The fourth International Symposium on Lithographic Limestone and Plattenkalk (2005), the annual meeting of the International Commission on the History of Geological Sciences (INHIGEO) "Geology and Religion" (2007; see Kölbl-Ebert 2009), The fourth Symposium on Mesozoic and Cenozoic Decapod Crustaceans (2010) and The first Workshop on Fossil Fishes of the Solnhofen Archipelago (2012). Specialist groups interested in the collection are welcome to organize their meetings in Eichstätt.

18.3 Educational Work

The Jura-Museum Eichstätt (Fig. 18.3) is the public window of the Eichstätt Natural History Collection. The museum currently welcomes around 50,000 visitors per year (ca. 19,000 of them school children). It was founded in 1976 as a taxonomically arranged permanent exhibition (700 m^2). In the 1990s, special exhibitions (90 m^2) once or twice a year were added as well as a few computer installations.

Fig. 18.3 The main hall of the Jura-Museum Eichstätt (© Jura-Museum Eichstätt)

Since 2006, refurbishments of the permanent exhibition have brought ecological, evolutionary and biomechanical topics into the museum (Kölbl-Ebert 2007, 2010, 2011). The exhibitions thus currently address the evolution of birds and comparison with other flying animals (pterosaurs, bats, insects), the ecology of the Upper Jurassic Solnhofen Archipelago, biomechanics of fossil fishes, convergent evolution of fishes, squids and ichthyosaurs, the Ettling excavation as an example for research at the Eichstätt collection, reefs in the Jurassic and comparison with reefs throughout Earth's history, "living fossils" (gars, horseshoe crabs, nautilus) and modern coral reefs in the aquarium. Models, interactive elements and media stations help to understand the fossils. Museum texts are bilingual (German and English).

Around 550–600 guided tours per year, dedicated to specific topics, where visitors are engaged in dialogue and are allowed to touch selected objects, are run by about a dozen freelance museum guides, who have been trained by the museum personnel. The museum offers various activities and fieldtrips, lectures and workshops (see http://www.jura-museum.de).

Thanks to two EU-funded museum education projects (Natural Europe (ICT PSP programme); Geovillages (Grundtvig Adult Educational European Project)), the museum also provides innovative educational features such as e-learning pathways for teachers (http://www.natural-europe.eu/educational/), electronic media in the exhibition and a free-download audio drama on its website featuring cutting edge palaeontology wrapped in a thrilling time travel story (Kölbl-Ebert & Matterstock 2013).

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Chapter 19
ERLANGEN: The Erlangen Paleobiology Collections

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19.1 History

The palaeontological collection of the Friedrich-Alexander University (FAU) of Erlangen-Nuremberg has its seeds in the "Naturalienkabinett" of Margrave Friedrich of Brandenburg-Bayreuth. After the death of the margrave in 1763 the material was moved to the new Erlangen University (Wittern-Strezel 2007). Due to acquisitions and donations the "Erlanger Kabinett" grew massively and had to be moved repeatedly into larger premises. In the course of progressive specialization in science, the "Kabinett" was split into a mineralogical and a zoological part in 1833. Fossils stayed with the mineral collection. The ever increasing amount of material finally required the construction (from 1896 onwards) of a separate building, the future "Geologisch-Mineralogisches Institut" in the Schlossgarten of Erlangen. In the 1930s a museum was established in several rooms of this new building. The palaeontological collections on display were Franconian Mesozoic fossils and Pleistocene vertebrates from caves.

During Word Wars I and II, the collection was largely unaffected, even though it had to be removed for two years whilst the building was used as an American school in 1946–1947. An own Palaeontological Institute was founded in 1972 and established in a separate facility but the geological, mineralogical and palaeontological collections remained in the Schlossgarten until the closure of the museum in 1990 (Höfling et al. 2007). Due to space constraints large parts of the collections were then transferred to the "Naturhistorische Gesellschaft" in Nuremberg as a permanent loan.

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Fig. 19.1 Skull of a cave hyena (*Crocuta crocuta spelaea*) from the Zoolithenhöhle in the Erlangen Paleobiology Collection (Inv. 103/203)

19.2 Situation at present

The total number of objects in the palaeontological collections is currently > 50,000 specimens. A few thousand specimens, predominantly invertebrate fossils, are kept in the Schlossgarten for teaching. The remaining parts of the palaeontological collection are temporarily stored in several university buildings in Erlangen. Among those are the Pleistocene vertebrates from Franconia. A small part, mainly the material of recent scientific work, is housed in the basement of the Palaeontological Institute.

The research focus on carbonate microfacies analysis since 1972 has added numerous carbonate thin sections to the collections, which form the basis for student education as well as for the annual, international "Flügel microfacies course". Active research on older collection material focuses on Pleistocene vertebrate fossils from Franconian caves (e.g., Stiller et al. 2014). The biggest part of this collection is from the Zoolithenhöhle near Burggaillenreuth (Fig. 19.1). Another big part of the vertebrate collections derives from Hunas, near Pommelsbrunn (Rosendahl et al. 2011). The Hunas excavation commenced in 1956 and continued with interruptions until 2016. The third focal point of the Erlangen Paleobiology Collection is Mesozoic invertebrate fossils collected in the nineteenth and twentieth century. This part of the collection is intensively used for teaching (Fig. 19.2).

19.3 The future

With the employment of a permanent database administrator (C. Krause), the institute has started to catalogue and digitize its collections. The majority of Pleistocene vertebrates and more than 3000 invertebrate fossils are currently available in a MySQL database. The database has two levels of access: the public version allows

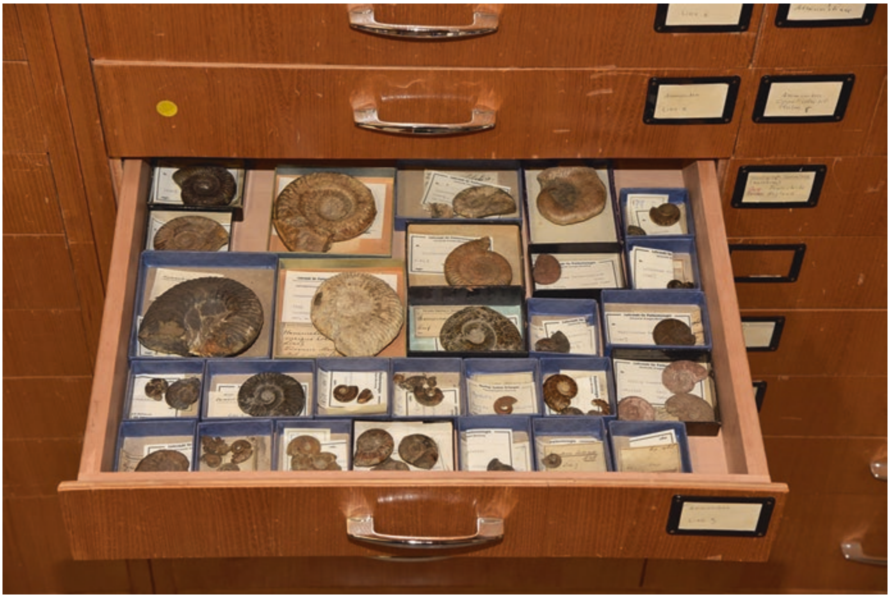

Fig. 19.2 Drawer with Early Jurassic ammonites in the study collection

data query and displays basic information, whereas the password-protected versions give access to all data and have a download function. Importantly, the digitized collection data are also available through the Global Biodiversity Information System (http://www.gbif.org/dataset/11a9393f-2fe9-4404-ad1d-3f2f6c1a6376). The current database has information on taxonomy, geography and stratigraphy. Photographs of the most important fossils are currently being linked with the data and will be mobilized as soon as possible.

Lack of space and staff for curation remain issues at Erlangen. New fossils collected during field campaigns are usually transferred to museums with curatorial staff after study. Precious material from Erlangen is already housed at the Bayerische Staatssammlung für Paläontologie und Geologie in Munich and the Senckenberg Museum in Frankfurt. The fate of the vertebrate collections is currently uncertain.

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Chapter 20
ESSEN: Ruhr Museum—Geological Collection

Ulrike Stottrop, Udo Scheer, and Esther Guderley

20.1 Introduction, History

The Ruhr Museum is located in the largest building of the UNESCO Zollverein World Heritage Site, the former coal washing plant of Zollverein colliery, shaft XII. As a unique type of regional museum it showcases the entire natural and cultural history of the traditional coal-mining Ruhr Area as its permanent exhibition. It makes visible the myths, phenomena and structures of the Ruhr Area, the immense dimensions of its geological history, the pre-industrial memory of the region, the long history of industrialization including its consequences and perspectives for the future. The Ruhr Museum possesses extensive collections of the geology, archeology, history and photography of the Ruhr Area, mainly based on the collections of the former municipal Ruhrlandmuseum.

The Ruhr Museum began in 1901 with the formation of a museum society, initiated by the Historical Society and Krupp Educational Society. The City of Essen Museum, which opened in 1904, was one of the first museums in the entire Ruhr area and focused on natural history, local history, ethnology and the fine arts. In 1934 the museum was named the Ruhrlandmuseum (Stottrop, & Scheer 1994).

After a changing history at different locations the museum developed a completely new structure in 2008. In 2010, when the city of Essen and the Ruhr area itself became "European Capital of Culture", more than 500,000 people visited the newly opened Ruhr Museum and its brand new permanent exhibition (Fig. 20.1a,b).

From its early beginnings the geological collection was continuously upgraded. Today the whole geological collection contains approximately 400,000 objects

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from the fields of general geology, palaeontology/stratigraphy and mineralogy. As a result of in-house fieldwork, acquisitions and cooperation with the Department for Palaeontological Preservation of Archaeological Monuments of the Rhineland Regional Council (Landschaftsverband Rheinland; LVR), it has been possible to steadily increase the number of items in the collection. In the last twenty years especially, major donations have enlarged the collection. In 2015, the geo-scientific collections of the Fuhlrott-Museum Wuppertal were transferred into the ownership of the Ruhr Museum Foundation.

Fossils and rocks dating from the Devonian, Carboniferous, Cretaceous and Quaternary periods of the Ruhr area itself and surrounding regions form the main part of the Ruhr Museum collection. Besides these traditional topics, over recent years the focus has been on raw materials from all over the world, those used in iron and steel as well as the non-ferrous industry of the Ruhr area.

In addition, from the beginning, the Ruhr Museum was intended to be an educational institution for the general public. For this reason the collection includes fos-

Fig. 20.1 (**a**, **b**) Showcase in the permanent exhibition with fern-like Upper Carboniferous fossils from the Ruhr basin and Piesberg-locality (south of Osnabrück); height 1.3 m. Copyright: Foundation Ruhr Museum/Rainer Rothenberg

Fig. 20.1 (continued)

sils from many classic German and European locations and spectacular objects from many countries in- and outside Europe.

20.2 Staff, Infrastructure, Research

Since 1986 a geologist (head of Geological Department and additionally deputy director of the Ruhrlandmuseum/Ruhr Museum) and from 1990 till today a palaeontologist as curator constitute the Geological Department, jointly responsible for exhibitions and collecting and research strategies. Support is provided by a geoscientific preparator and, half a day per week, 8–10 volunteers.

Today the collection is housed in three depots, one of which is climate controlled. This one is equipped with movable closets. 2020 a new central depot will open at Zollverein which will be accessible to visitors. Until then, the Fuhlrott-collection will be stored separately.

The registration of the objects follows a system developed in the 1950s, probably by the Rhenish Museums Organization. Each object is classified with nine numbers, with the prefix RE for Ruhrlandmuseum Essen/Ruhr Museum Essen. The first three numbers represent the categories: 549. (Mineralogy), 551. (Common Geology and Stratigraphy), 552 (Petrography), 553 (Deposits). 560 (Palaeontology). The museum adopted the registration system and started to apply it to the collection. The decision was made to categorize almost all palaeontological specimens by their stratigraphy. RE 551.763.310 for example represents 551 Stratigraphy, 763 Cretaceous, 310 Cenomanian age. Within this base number, every specimen possesses its own access number, separated by an "A" from the base number. For practical reasons all specimens are stored according to this system. When there are a lot of samples from one locality within a lithostratigraphical unit, these items are concentrated in one or more drawers.

In 1986 the collections began to be registered electronically. After some experiments with different commercial programs, the American DOS-based program Question & Answer (Q&A) was selected (in its German version F&A, Frage & Antwort). Since current versions of Windows require 64-bit hardware (limit of F&A are 32 bits), in 2016 all data were converted to the FAUST database system, which was already used by the other departments. Priority is given to objects that have been selected for exhibitions, loans and to new incoming objects. IT-registration is seen as a tool for daily work, but not as the sole mode of registration. Index cards are still printed as basal documents for each new specimen in parallel to electronic registration. Currently 128,000 items are IT-registered, about 90,000 within the stratigraphic collection.

In spite of the huge number of objects and restricted staff with many duties, scientific research on the collection is taken seriously. For larger groups of specimens which need to be given nomenclature specialists with the required experience are contracted. Also the museums staff watches the scientific "market" to draw the attention of colleagues at universities and the bigger research museums to that material, which could be of interest to them. National and international experts from various institutions and private researchers rely on the collection for their work. Between 1500 and 2000 objects are regularly on loan just for research purposes. Currently on loan to various individuals and working groups are Cretaceous crabs (R. Fraaije, Boxtel), Miocene/Pliocene conifers (R. Goßmann, Bonn), Cenomanian algae (O. Dragastan, Bucharest), Triassic and Cenomanian reptile-bones (B. Kear, Uppsala) to mention only a few projects which will result in publications.

20.3 Collections

20.3.1 Main Focus: Regional Geology

Situated at the juncture of the Münster Cretaceous Basin and the western part of the Paleozoic Rhenish Slate Mountains and close to the Palaeogen/Neogene Lower Rhine Embayment, the local geology determines the program of the Ruhr Museum as a regional museum for the entire Ruhr Basin.

From the reports it is clear that intensive field work was done during the first decades of the museum's history. The loss of many of the original documents and index cards means that it is almost impossible to identify which specimens entered the collection before World War II, and the quantity and quality of the losses remains unclear. Only parts of the Carboniferous and Cretaceous fossil collection can be correlated to these activities, – for example numerous samples from the Cenomanian and Turonian of Mülheim/Ruhr (Kassenberg locality), which still is a "hot spot" for current activity (see Scheer & Stottrop (1995) with an extensive list of references).

It is worth mentioning the acquisition of the Paul collection from the Upper Devonian to Lower Carboniferous from the Rhenish Slate Mountains; the Bernhardt collection with plant fossils from the Namurian of Hagen-Vorhalle; the Falk collection with numerous invertebrates from Upper Cretaceous strata (Santonian/Campanian), as well as numerous samples from the Neogene/Palaeogene, Cretaceous and even Triassic and Permian strata from 31 mining shafts from the western part of the Ruhr Basin. These were all acquired before World War II.

In 1964 the pharmacist Giers from Hamm (Westphalia) donated his collection of Campanian fossils from the cement producing region around Beckum at the eastern margin of the Ruhr Basin. It was the first of the larger collections of regional importance to come into our collections after World War II.

From 1967 until his death in 1983, the palaeobotanist Karl Kilpper was a curator at the Ruhrlandmuseum. Here he completed his work on Neogene conifers from the soft coal mining area of the Lower Rhine Embayment, which he had begun at the University of Cologne. Later on his scientific interest moved to Upper Triassic/Middle Jurassic plants from the Zagros Mountains (Iran). Unfortunately he neither registered a huge number of samples from different stratigraphical horizons in many Rhenish open cast mines from this time, nor his Iranian material (Figs. 20.2 and 20.3).

In 1998 the museum was fortunately able to buy the huge Hilpert collection with more than 22,000 well documented items, which greatly increased the quality of the entire collection. It fills many gaps, especially as regards the Upper Cretaceous (Campanian) of the Münster Cretaceous Basin. The hundreds of sponges, crabs and large ammonites are not only attractive for exhibitions but possess a high scientific value (Fig. 20.4).

Close collaboration with the Department of Preservation of Palaeontological and Archaeological Monuments (Amt für Bodendenkmalpflege) of the Rhineland Regional Council (Landschaftsverband Rheinland) started in 2002. By arrangement, all fossils found during official activities are handed over to the Ruhr Museum. Since then not only some 3000 bones of Pleistocene mammals have enlarged the collection, hundreds of Lower Carboniferous marine invertebrates (Viséan) have been recovered during the construction of a new gas-pipeline. In the near future a remarkable collection from the Upper Devonian Knoppenbissen Formation from Bergisch Gladbach, which is famous because of its well preserved invertebrate and vertebrate remains, will also enter the collection.

Over the last twenty years a large number of private donations and acquired collections have enhanced the quality of the collection as a whole.

Fig. 20.2 A standard drawer, size 0.4–0.6 m, here filled with tiny gastropods from the Upper Oligocene Grafenberg Formation; found drilling a well in Osterath (Lower Rhine Embayment); ex Neumann collection. Copyright: Foundation Ruhr Museum/Rainer Rothenberg

- The Hackenbeck collection (1993): Palaeogene fossils from the sinking of shaft Rheinberg (Rheinland colliery); Campanian fauna from the construction site of highway A 31 near Dorsten
- The Baschin collection (1994/1995): Cretaceous fossils from North-Rhine Westphalia (mainly cephalopods and echinids)
- The Boche collection (1995/2012): Fossiliferous gravels from the River Rhine
- The Lehmann collection (1998): Cenomanian/Turonian fauna from the northern Münster Cretaceous Basin
- The Schapfeld collection (1999): Neogene Fauna, Lower Rhine Embayment
- The Martens collection (2005): Devonian corals from the Eifel-mountains

Fig. 20.3 Publication by Kilpper (1971) on Jurassic Ginkgophyts from Iran and specimen *Czekanowskia setaceae* HEER, figured on pl. 26, Fig. 20.3. Copyright: Foundation Ruhr Museum/Rainer Rothenberg

Fig. 20.4 *Janassa bituminosa* (Schlotheim, 1820), a ray-like fish from the Upper Permian from Ibbenbüren, Northwestern-most edge of North-Rhine Westphalia; span 0.28 m. Copyright: Foundation Ruhr Museum/Rainer Rothenberg

- The Linke collection (2006): Cenomanian fossils from Mülheim/Ruhr (Kassenberg locality) and Bochum with a huge amount of micro- and mesofossils like foraminifera, bryozoans and roveacrinid crinoids.
- The Janzen collection (2007): Upper Carboniferous plant-fossils from Piesberg-locality, south of Osnabrück (Lower Saxony)
- The Rochow collection (2013): Middle Devonian plants from Lindlar (western Rhenish Slate Mountains)
- The Rohde collection (2014): Middle Devonian invertebrates with many nautilid cephalopods and upper Devonian fishes from Bergisch Gladbach

- The Latzel collection (2014): Upper Carboniferous plants from Essen, Neogene plants from the Lower Rhine Embayment
- The Neumann collection (2015): Palaeogene mesofossils from several well drillings (Lower Rhine Embayment) and Devonian trilobites from Eifel Mountains
- The Collection of the Historical Society of Mülheim/R (ex-Klaumann collection) (2015): Cenomanian-Turonian fauna from Mülheim/R. (Kassenberg-locality)
- The Franz collection (2016): Lower Namurian plants from Arnsberg (Rhenish Slate Mountains) and Cretaceous to Palaeogene macrofossils from the sinking of the Rheinberg shaft (Rheinland colliery); Campanian fauna from the construction of highway A 31 near Dorsten
- The Wientjens collection (2017): Cenomanian fauna from Essen; Campanian fauna from the construction of highway A 31 near Dorsten
- The Schafsteck collection (2017): Cenomanian macro- to microfossils from Mülheim/Ruhr (Kassenberg locality) and Essen

Around 2010 the administration of the city of Wuppertal (North-Rhine Westphalia) decided to close the traditional Fuhlrott Museum of Natural History. The Ruhr Museum was able to obtain all parts of the geo-scientific collection as well as large sections of the malacological collection, initially as a long term loan. On January 1st 2015 the Ruhr Museum became the owner of these collections.

Whereas the mineralogical collection with around 20,000 items is well documented, registration of the collections of general geology and palaeontology is very poor. Nevertheless the regional collections from the western part of the Rhenish Slate Mountains in particular possess high scientific potential. Unfortunately (the circumstances are unclear) the reference collection was already missing in Wuppertal.

20.3.2 The Historical Krupp Collection

The collecting history of the Ruhr Museum began with the donation of numerous duplicates from the private collection of the Krupp family. Friedrich Alfred Krupp (1854–1902) showed great interest in geology, mineralogy and later on in zoology. He started his own geological collection by purchasing the collection of his deceased financial director Nusser, a student of Quenstedt's, who collected fossils mainly from the Swabian Jurassic, from the well-known southern German localities of Öhningen (Miocene), Engelswies (Miocene) and Kressenberg (Eocene), from the Devonian of Gerolstein in the Eifel mountains and, during his time at the Krupp Company, the Cenomanian of Essen.

In 1884 Krupp employed the subsequently famous palaeontologist Eberhard Fraas (1862–1915) to sort and classify the collection. Fraas reduced the huge amount of 100,000 items in order to form a broadly based palaeontological collection. We can assume Fraas obtained several fossils from the Middle Triassic of Gogolin (Silesia), Liassic of Holzmaden with one Ichthyosaur signed by B. Hauff, 1886, Eocene crabs and other invertebrates from Egypt, Oligocene mammals from Dakota, Pliocene mammals from Samos and even one dinosaur humerus from Tendaguru (Tanzania). In the first years after World War II the Krupp collection, which had been seriously damaged by Allied soldiers, was reconditioned by the staff of the Ruhrlandmuseum and in 1948 passed to that museum. In 1962 the Ruhrlandmuseum finally became the owner of this important collection which supplies the museum with attractive fossils for permanent and special exhibitions.

20.3.3 Classic Localities

In addition to fossils from the above mentioned sites, the Krupp collection brought into stock good samples from the classical Lower Devonian region around Bundenbach and Gemünden (Hunsrück/Rhenish Slate Mountains). In the decades after World War II many specimens were bought from private collections and commercial traders for exhibition purposes to enlarge the "classical localities aspect" from Germany, Europe and even overseas countries. In parts they derive from the Hilpert collection (Fig. 20.5). To mention only some examples:

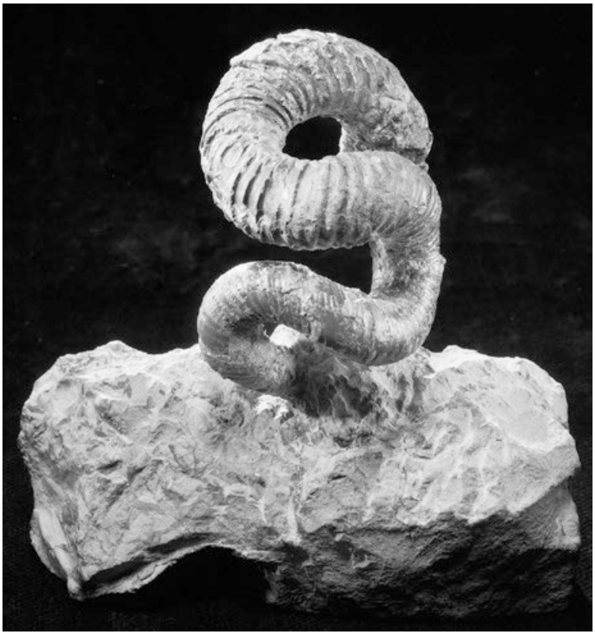

Fig. 20.5 Heteromorph ammonite *Nipponites bacchus* (Matsumoto & Matsumoto, 1967) from the Middle Turonian from Hokkaido, Japan; height 0.11 m. Copyright: Foundation Ruhr Museum/ Rainer Rothenberg

- Silurian invertebrates from Gotland (Sweden),
- Silurian/Devonian arthropods and fishes from Scotland,
- Lower Carboniferous fishes from the Bear Gulch Formation (USA/Montana)
- Lower Carboniferous echinoderms (USA/Illinois, Indiana, Alabama)
- Lower Permian fishes, amphibians and plants from Rhineland-Palatinate,
- Lower Callovian ammonites, from a former iron ore mine in Bad Oeynhausen-Dehme (North-Rhine Westphalia)
- Tithonian from Solnhofen/Eichstätt (Bavaria)
- Berriasian reptiles and sediments from Obernkirchen (Lower Saxony)
- Valanginian crustaceans and ammonites from Sachsenhagen (Lower Saxony)
- Albian ammonites from Troyes (France)
- Campanian/Maastrichtian ammonites with mother of pearl (USA/Dakota and adjacent Canada)
- Eocene vertebrates from Messel (Hessonia),
- Eocene molluscs from the Paris Basin (France),
- Oligocene insects and fishes from Cereste (France)
- Pliocene plant fossils and insects from Willershausen (Lower Saxony)

20.3.4 Reference Collections

Up until now looking at the entire history of the museum we have found around 160 publications dealing with specimens from our collection. A list of publications is available on the Ruhr Museum website. To mention just a few examples from the last 25 years: R. Haude (Göttingen) worked on Devonian crinoids, J. Frank (Prague) on Cretaceous nautilids, S. Kiel and K. Bandel (Hamburg) on Cenomanian gastropods, U. Kaplan (Gütersloh) and W.J. Kennedy (Oxford) with various co-authors on Cretaceous ammonites and stratigraphy, D. Korn (Berlin) on Carboniferous goniatids, H. Löser (Hermosillo/Mexico) on Cenomanian corals, H.M. Weber (Bergisch Gladbach) and G. Becker (Frankfurt/M.) on ostracods. Their results have been presented in 65 publications. Altogether about 200 specimens have been defined as holotypes. Unfortunately diverse samples from publications before World War II have not yet been identified (for example from Keller, 1934) or are definitively lost in part or completely (for instance from Edinger, 1931, Fiege, 1930 and Keller, 1938).

The reference collections are separated from the main collection in a movable closet close to the entrance of the depot in order to evacuate them first in case of emergency.

We regard the potential for future work as notable, especially on Devonian, Carboniferous and Cretaceous fossil taxa and stratigraphy.

20.4 Educational Work

The museum's staff creates almost all of the special exhibitions at the Ruhr Museum. Parallel to the making of the exhibition, didactic concepts are developed by the relevant museum educator. The programmes target all visitors: adults, children, young people and people with disabilities as well as people with dementia. Formats include guided tours, discussions, children's birthday parties, workshops, classes, excursions and programmes for special events.

The principal tasks of a museum, collecting, preserving, researching, displaying and mediating, are also a part of educational work to make museum work more transparent. The complexity of the museum as an institution can be experienced in dialogue with the visitors. One of the most popular events is the "Fossil hunt at Lake Baldeney", where children and young people search for rocks and fossils from the Carboniferous on top of a stockpile and investigate them with the help of experts. Aspects of fossilisation and the preservation of fossils are taught via impression techniques, the reconstruction of living beings via modelling, to name just a few. A fully equipped workshop is available for supervised visitors to use in preparing fossils for research and display. Moreover, the Ruhr Museum has been participating in the "Day of the Geotope" for years. Geotopes from the Carboniferous, the Cretaceous, the Tertiary and Quaternary periods as well as their fossil environment are the focus of excursions and tours to the collection storage facility (Fig. 20.6).

Fig. 20.6 Fossil hunt. Copyright: Foundation Ruhr Museum/Esther Guderley

20.4.1 Cooperation with Schools

The educational programme is aimed at school classes from lower to upper secondary level as well as primary-schools. As a modern regional museum concerned with the Ruhr Area, it is a multifaceted extracurricular place of learning. Just as its permanent exhibition presents nature, culture and history of the Ruhr Area from Carboniferous, the Pre-Historical and Pre-Industrial Eras up to the period of structural change, the Ruhr Museum offers interdisciplinary educational programmes and tours. “Echt tierisch! Das Tier im Revier von der Urzeit bis heute”, a tour for schools, concentrates on palaeontological, zoological, cultural and historical aspects of the animal-human relationship.

A wide range of different events within the educational programme enables school classes to become acquainted with prehistoric animals and changes to the environment in the course of the history of the earth. In the “Fossil Workshop” the participants learn about fossils from the Carboniferous, Cretaceous and Quaternary periods, and make their own plaster copies from original ammonites, belemnites and inoceramids (Fig. 20.7a–c). The guided tour on “Tracking the Dinosaurs” uses original bones and teeth as well as plaster skeletons and skulls, petrified foot prints, fossilised dinosaur droppings and eggs to present interesting information about the “dreadful lizards”. By providing hands-on samples, the “Carbon Workshop ‘The Formation of Black Gold’” explains the carbonisation of plant matter, peat and lignite into black coal. In front of a carbon diorama students experience the formation of coal through role play and create frottages of carbon fossils.

Fig. 20.7 (**a–c**) Fossil workshop. Copyright: Foundation Zollverein/Jochen Tack

Fig. 20.8 Permanent exhibition: guided tour. Copyright: Foundation Zollverein/Jochen Tack

The Ruhr Museum cooperates in the long term with several schools in terms of education partnerships, which are specific and individually framed in written contracts. In regular meetings with partner schools the experiences are evaluated and further cooperation is planned. Regular training for teachers and trainee teachers keeps them informed about new programmes and topics at the museum. Moreover, continuing educational programmes are made in cooperation with universities in the Ruhr Area.

Common goals are the optimal and continuous usage of themes and objects as well as promoting competences, knowledge and creativity in the special learning environment of a museum. The direct encounter with original museum objects and the authentic Zollverein site with its industrial nature, engaging with different museum educational media and forms of work, in which pupils actively participate, contribute to developing media and culture skills in children and young people (Fig. 20.8).

20.5 Social Media

Since 2010:
https://twitter.com/ruhrmuseum 865 tweets, 3,190 followers (19.2.2017).
https://www.instagram.com/ruhrmuseum/, 48 posts, 322 followers (19.2.2017).

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Chapter 21
FRANKFURT/DRESDEN/GÖRLITZ: Palaeontological collections of the Senckenberg Gesellschaft für Naturforschung

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21.1 Introduction

The Senckenberg Gesellschaft für Naturforschung (cf. Senckenberg Homepage) consists of seven institutes with stations at eleven localities (Fig. 21.1). Three out of these institutes have special palaeontological collections:

- Senckenberg Research Institute and Natural History Museum Frankfurt
- Senckenberg Natural History Collections Dresden
- Senckenberg Museum of Natural History Görlitz

Additionally Senckenberg scientists are curating the palaeontological collections of Tübingen University at the Senckenberg Center for Human Evolution and Palaeoenvironment at Tübingen University (cf. Werneburg and Böhme, this volume).

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Fig. 21.1 Map of Germany highlighting the different Senckenberg localities with palaeontological collections (names written in blue)

There is huge diversity of different palaeontological collections, each with its own character and traditions, due to the long, independent history of these institutes. Nevertheless, today all collections are curated following common standards, although they are distributed over six departments at five localities. The present chapter provides an overview on the particular features of the individual institutes and departments. In the Frankfurt Institute, the palaeontological collections are the largest compared to zoological and botanical collections. The same is true for Dresden. In Görlitz, the palaeontological collections are comparatively small. Other institutes also have palaeontological objects in their collections, but here they are included in zoological collections based on taxonomic/systematic aspects (e.g. insects in amber at Müncheberg). The significant collections of Devonian fossils, fossils from the Messel pit, as well as the abundant collections of Quaternary fossils in Weimar are distinctive features of the institute in Frankfurt, while in Dresden there is a special focus on the Cretaceous and Tertiary of Central Germany, i.e. Saxony.

Additionally, the chapter provides information about the overall scientific concepts and research questions that integrate the diverse research topics of more than 20 palaeontologists from these institutes.

21.2 Senckenberg Forschungsinstitut und Naturmuseum Frankfurt

The palaeontological collections of Senckenberg in Frankfurt are as old as the Senckenberg Gesellschaft für Naturforschung, which was founded in 1817. Following critical comments by J. W. von Goethe on the situation of natural history studies in Frankfurt (von Goethe 1816) one of the most important motives for establishing a natural history society was the construction of a museum as an appropriate place to house the already existing natural history collections in the city (Türkay et al. 2018) (Fig. 21.2). Many wealthy citizens possessed private collections of animals, plants, fossils and minerals, which formed the base of the abundant collections of Senckenberg in Frankfurt. Only four years after the foundation of the society the first Natural History Museum in Frankfurt was opened in 1821.

During the last 200 years this museum and its collections had a history full of ups and downs. Detailed and vivid reports on the history of the Senckenberg Forschungsinstitut und Naturmuseum Frankfurt have repeatedly been published during the last decades (e.g. Struve 1967; Türkay and Ziegler 1992; Mollenhauer and Ziegler 1992; Ziegler, 1992, 1996; Jansen and Steininger 2002; Jansen and Türkay 2010; Kahlke et al. 2009, 2014; Fiedler 2012; Keiler 2017; Schaal et al. in press; Smith et al. in press). As the Senckenberg Naturmuseum in Frankfurt has a large exhibition of iconic dinosaur skeletons (Figs. 21.3 and 21.4) and fossils from the Messel pit (Fig. 21.5) it is intricately connected to palaeontology in the minds of the majority of its visitors (ca. 350,000 per year).

Fig. 21.2 View of the main building of the Senckenberg Forschungsinstitut und Naturmuseum Frankfurt (photo: S. Tränkner)

Fig. 21.3 Dinosaur exhibition in the Senckenberg Forschungsinstitut und Naturmuseum Frankfurt (photo: S. Tränkner)

Fig. 21.4 Mummified specimen of the hadrosaur *Edmontosaurus annecdens* from the Cretaceous of Canada, on exhibit in the Senckenberg Forschungsinstitut und Naturmuseum Frankfurt (photo: S. Tränkner)

Today (2017) the Frankfurt Institute has four Departments with large palaeontological collections: the Department of Palaeontology and Historical Geology (head: Prof. Dr. Dieter Uhl), the Department of Messel Research and Mammalogy (head: Dr. Stephan Schaal), the Department of Palaeoanthropology (head: PD Dr. Ottmar

Fig. 21.5 Messel exhibition in the Senckenberg Forschungsinstitut und Naturmuseum Frankfurt (photo: S. Tränkner)

Kullmer) and the Department of Quaternary Palaeontology in Weimar (head: Prof. Dr. Ralf-D. Kahlke). Additionally, there are smaller palaeontological collections, like Cenozoic molluscs, which are curated in the zoological departments in Frankfurt. Information about these parts of the palaeontological collections has recently been provided by Türkay et al. (in press).

All in all, the palaeontological collections in Frankfurt and Weimar comprise a total number of more than 1.7 million specimens and series from all periods of Earth's history, although focal points exist on the Devonian of the Rhenish Slate mountains, the Eocene of the Messel pit, a UNESCO world heritage since 1995, as well as the Quaternary of Thuringia.

21.2.1 Department of Palaeontology and Historical Geology (Frankfurt)

At the beginning of 2017 a total of seven scientists and eight technicians work in the palaeontological sections of this department. Additionally, a number of honorary researchers (mostly retired palaeontologists) are active in doing research.

The collections of the department, which comprise a total of more than 1.5 million specimens and series, are quite diverse but historically some stratigraphic and regional focal points developed. Due to such a traditional focus on the Palaeozoic, especially the Devonian, unique special collections of brachiopods (>900,000 specimens), trilobites (>120,000 specimens) and conodonts (>20,000 specimens and series), mostly from this period, are curated by scientists from the department.

A large number of other collections, comprising from only a few specimens up to several thousands of specimens of various organism groups (e.g. cephalopods, coprolites, receptaculites, stromatolites, scaphopodes, tentaculites) from all periods of Earth's history are also curated within the department.

Due to the long history of research on the Devonian of the Rhenish Slate Mountains there are large stratigraphic and regional collections, like a collection of material from the "Wetteldorfer Richtschnitt" (the GSSP for the Emsian-Eifelian boundary with approximately 100,000 specimens) and large collections of material from the Early and Middle Devonian. Additionally, there is a considerable collection of fossils from the Hunsrück slate (Fig. 21.6), which also includes the X-ray archive of W. Stürmer consisting of 8964 photographic negatives. This particular collection has been digitized in the last few years (Jansen and Türkay 2010) and is now available online through the Senckenberg database AQUiLA (https://search.senckenberg.de/aquila-public-search/search).

The department also houses large and historically important collections of fossil vertebrates, i.e. agnathans and fishes (>9700 specimens and series), amphibians (>600 specimens and series), reptiles (>5000 specimens and series), birds (>500

Fig. 21.6 Devonian arthropod *Weinbergina opitzi* from the Hunsrückschiefer collection (coll. no. HS 704), a fossil rarer than the famous *Archaeopteryx* (photo: S. Tränkner)

specimens and series) and mammals (>8000 specimens; not counting small mammals and mammals from Messel which are housed in the Department of Messel Research and Mammalogy).

Another historically important part of the department's collections are the micropalaeontological collections. Besides a unique collection of conodonts (Fig. 21.7), there are also large collections of ostracods (>21,000 specimens and series), foraminifera (>15,000 specimens and series) and otoliths (>10,000 specimens and series) from the Devonian up to the Quaternary, as well as modern material for comparison (Franz and Lord 2011; Franz et al. 2011).

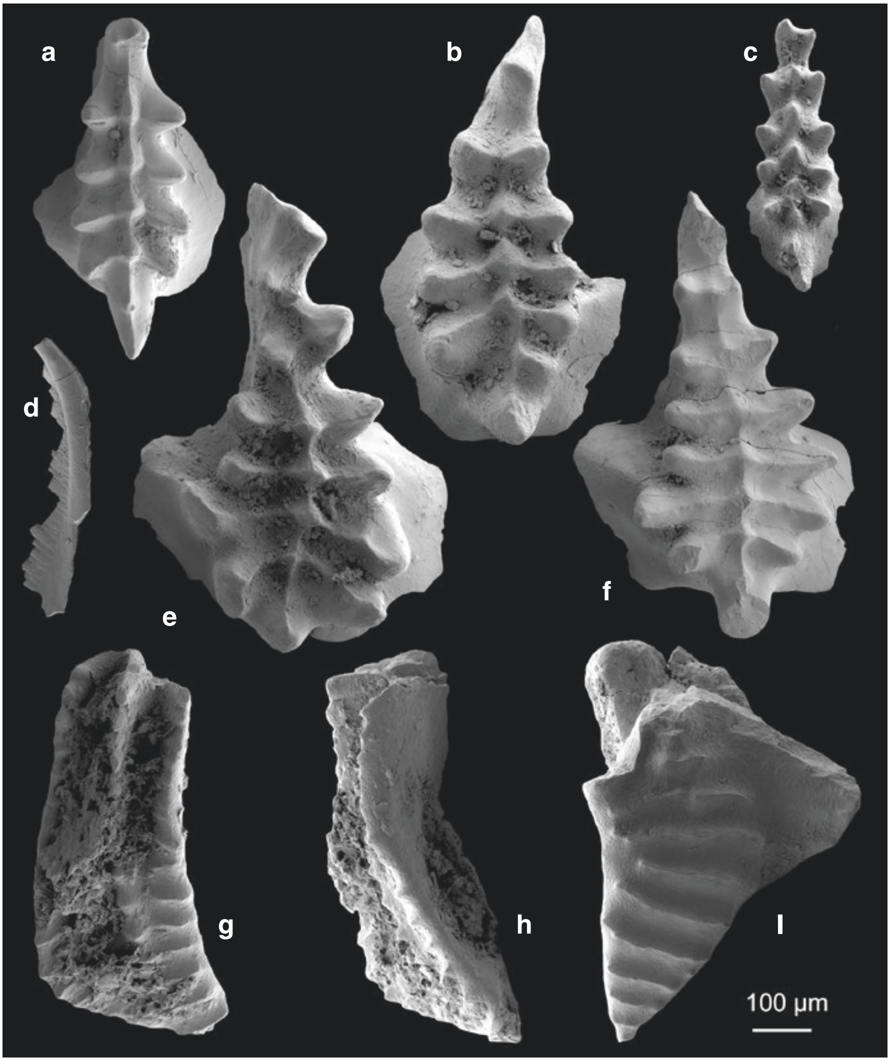

Fig. 21.7 Microfossils, like these conodonts from the Devonian of the Eifel, represent important tools for Palaeozoic biostratigraphy **(a)** *Icriodus struvei* Weddige, 1977; (**b**) *Icriodus werneri* Weddige,1977; (**c**) *Icriodus regularicrescens* Bultynck, 1970; (**d**) *Belodella* sp.; (**e**) *Icriodus retrodepressus* Bultynck, 1970; (**f**) *Icriodus arkonensis* Hinde, 1938; (**g**) & (**h**) *Polygnathus linguiformis linguiformis* Hinde, 1879; (**i**) *Polygnathus linguiformis linguiformis* Hinde, 1879 (photo: P. Königshof)

Together with the SNSD the Senckenberg Forschungsinstitut und Naturmuseum Frankfurt is one of the few institutions in Germany that houses large palaeobotanical collections which are curated by palaeobotanists. Together with the collections of the Museum für Naturkunde in Berlin these collections represent the largest palaeobotanical collections in Germany. Besides large palynological collections with focal points on the Palaeozoic and Palaeogene, as well as one of the largest collections of nannoplankton slides worldwide, there are extensive macro-palaeobotanical collections. A large part of these collections comes from regional localities of Tertiary age, including more than 30,000 specimens from the Eocene of the Messel fossil pit. Plant remains from the Devonian of the Rhenish Slate mountains are another focal point of these collections. The latter had already been a focal point before WW II, but many of the Devonian specimens collected before 1945 was lost during the last days of the war due to military actions (Dilcher and Schaarschmidt 1992). A third, but considerably smaller, focal point of these collections, are plants from the Mesozoic, including important collections gathered by R. Kräusel in Brasil, S-Africa and India (Dilcher and Schaarschmidt 1992). Besides these focal points, the palaeobotanical collections include also material from numerous localities distributed all over the world and from all periods.

Scientists from the department also take care of a considerable collection of amber, copal and modern resin (more than 10,500 specimens with a total of more than 100,000 inclusions; Fig. 21.8) from localities distributed all over the world (e.g. Baltic Sea, Dominican Republic, Mexico, Myanmar, Austria, China, Madagascar, Columbia and Kenya) (Girard et al. 2011, 2012).

The largest recent addition to the palaeontological collections of Senckenberg in Frankfurt is the GeoArchive Marburg, consisting of the collections of the former Faculty of Geosciences at the Philipps University in Marburg (Oppl et al. 2014). After closing down the Faculty of Geosciences at Marburg University by the Hessian State Government, the collections have been transferred to the Naturkundemuseum Kassel (Quaternary material) and the Senckenberg Research Institute and Natural History Museum Frankfurt (the larger part of the collections). The part of the collection kept in Frankfurt consists of about 142,000 specimens and series, from all stratigraphic periods and localities all over the world. However, a focus of the collections is on the Palaeozoic and the Rhenish Slate mountains. Due to its historic significance, the GeoArchive Marburg is treated in more detail in a separate contribution (Amler et al., this volume).

Scientists from the department are actively enlarging the collections during field work in Germany (e.g. Devonian of the Rhenish slate mountains, Palaeogene of Schöningen) as well as international scientific expeditions (e.g. Jordan, Madagascar,

Fig. 21.8 Baltic amber (~42 my) with abundant inclusions, including a woodlouse (Isopoda), a centipede (Chilopoda) and different wasps (Hymenoptera), flies and mosquitoes (Diptera) (photo: S. Tränkner)

New Caledonia, Thailand, Turkey, Vietnam). Additionally, the collection is enlarged by donations from private collectors, abandoned university and museum collections and occasionally by buying significant specimens.

21.2.2 Department of Messel Research and Mammalogy (Frankfurt and Messel)

The Department of Messel Research, later of Messel Research and Mammalogy, was founded in 1992. The collection exists since 1975, the beginning of Senckenberg's scientific excavations in the Messel Pit (Fig. 21.9).

The Messel collection contains hundreds of well-known and undescribed species of animals. The collection comprises 48 million-year-old fossils from the oil shales in the Messel Pit, a UNESCO-listed world heritage site renowned for its exquisite fossils. Focal points are insects and vertebrates (Fig. 21.10). Plant fossils found in the Eocene of Messel are deposited in a separate collection in the palaeobotany section of the Department of Palaeontology and Historical Geology.

16,000 fossil insects discovered and prepared over the last 42 years are deposited in the Senckenberg Research Station in Messel. They are curated by a palaeoentomologist and a technical assistant. 7000 vertebrate fossils are inventoried and deposited in the collection rooms in Frankfurt.

Fig. 21.9 Oil-shale excavation in the Messel Pit Fossil Site, a UNESCO World Heritage Site. The extracted oil-shale plates are split by a Senckenberg excavation team and examined for fossils. Once the excavation data are recorded, the discoveries are carefully packed for transport to the preparation laboratory

Fig. 21.10 The primeval horse *Eurohippus messelensis*. By means of a special preparation method developed specifically for Messel fossils, the 48 million-year-old skeleton was transfered onto an epoxy plate. The animal, roughly the size of a fox terrier, serves as a mascot for the Messel locality

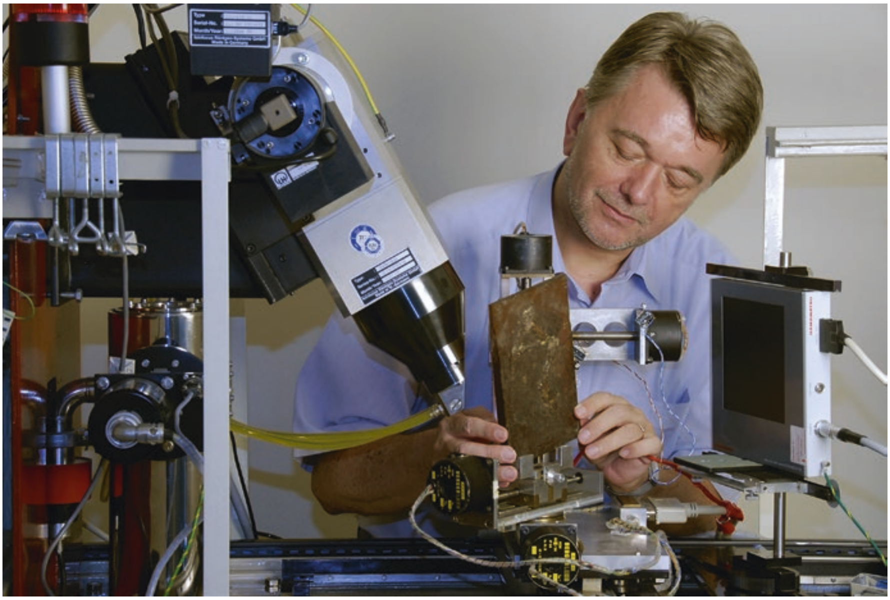

Fig. 21.11 Micro-computed tomography for the non-destructive study of valuable fossils. The object is rotated through a full circle in thousands of tiny steps, an X-ray image made at every step. Processing of the images reveals the tiniest structures of the fossil in 2D or 3D. The photo shows J. Habersetzer mounting a fossil primate limb from Messel

The department also has a collection of some 100,000 mostly Cenozoic-aged small mammal fossils.

At present seven salaried scientists conduct projects about Messel and other sites of the same age. They are supported by 8.5 technical positions (technical assistants or preparators) who supervise the excavation sites, prepare the fossil finds and take care of the collections, laboratory and office work. The preparation laboratory is located at the Messel Research Station.

The department operates a 2D radiography laboratory (with two X-ray machines; Fig. 21.11) as well as two micro-CT machines with associated high-end workstations in Frankfurt. Department staff has actively contributed to the development of new or alternative techniques like tomosynthesis (Habersetzer et al. 2012). Two of the three working groups dedicated to CT applications at Senckenberg are based in the department.

The department will move into another building within the next three years. A new large central laboratory for radiography and scanning electron microscopy is included in Senckenberg's development program. The Messel exhibition in Frankfurt is being newly conceived.

For 25 years Senckenberg has been responsible for operating the Messel Pit. To ensure continued support for scientific excavations and public tourism, the state of Hesse is responsible for financial support of activities in the pit. The scientific activities have been highly successful since systematic excavations began 40 years ago. Scientists and politicians who promote research on Messel believe that Messel has a bright future. Perspectives for this research field are positive and dependent on continued financial support.

21.2.3 Department of Palaeoanthropology (Frankfurt)

The Collection "Gustav Heinrich Ralph von Koenigswald" (GHRvK) is housed in the Palaeoanthropology department at the Senckenberg Research Institute and Natural History Museum in Frankfurt since 1968, and it has been subsequently grown by Gustav Heinrich Ralph von Koenigswald until he passed away in 1982. The original GHRvK collection was owned by the Werner Reimers-Foundation in 1967, which amongst others provided financial support to the Senckenberg Gesellschaft für Naturforschung to establish palaeoanthropological research in Frankfurt, integrating the GHRvK collection into the Senckenberg Institute in Frankfurt. The successor of GHRvK at the Palaeoanthropology Department, Jens Lorenz Franzen enlarged the departments' collection by adding collections from his own field research in particular from excavations in upper Miocene deposits in Rheinhessen. The initial body of (and major portion of the) specimens in the departments´ care has been collected by GHRvK since the 1930s, after he had entered the Dutch Geological Survey in Bandung, Indonesia (Koenigswald 1935, 1939). The specimens, achieved during his fieldworks and excursions on Java island and other places in Southeast Asia, were transported by him to the American Museum of Natural History, New York, USA, in 1946, when GHRvK decided to leave Indonesia due to civil unrest in the frame of independence.

He was nominated for the chair for palaeontology at the University of Utrecht in the Netherlands in 1947, which he held until his retirement in 1967. The collection was moved to Utrecht. GHRvK expanded his collection in Utrecht when he visited L.S.B. Leakey in Kenya and when he organized a student's excursion to Pakistan. Upon his retirement GHRvK finally transported his collection to the Senckenberg Research Institute and Natural History Museum in Frankfurt, where he continued working in the field of human evolution.

The collection GHRvK includes large fossil mammal specimens, including hominid remains today mostly attributed to *Homo erectus* from Sangiran, in particular three important cranial fossils which are worldwide known as Sangiran 2 (Fig. 21.12), Sangiran 3, and Sangiran 4, and five maxillary and mandibular fragments, Sangiran 1, Sangiran 5 (holotype *Pithecanthropus dubius*) and Sangiran 6 (holotype *Meganthropus palaeojavanicus*) as well as a collection of 52 mostly isolated teeth (subsumed as Sangiran 7; Fig. 21.13). In particular the hominin status of Sangiran 5 and Sangiran 6 and also of some isolated molars in the Sangiran 7 assemblage is highly debated since then.

The entire GHRvK collection comprises of a total of 9003 collection numbers, mostly single specimens, but several serial numbers are included. For the most part the collection consists of fossil faunal remains, but also a large number of stone artifacts and tectites belong to the GHRvK collection. Von Koenigswald's initial collection includes 7129 specimens from Indonesia, the majority mammal remains from Sangiran (n = 6046, early and/or middle Pleistocene), Pacitan (n = 903, late Pleistocene), Punung (n = 36, late Pleistocene), and Guo Lowo (n = 36, late Pleistocene).

Another sizeable part of the collection has been obtained by GHRvK from Chinese drugstores all across East and Southeast Asia and even in the United States. The specimens (n = 325) are believed to stem from Pleistocene cave sites in Southern China, no matter where they have been bought. Because the precise locality is unknown, the stratigraphic context is a subject of debate. Nevertheless, the collection includes the holotype specimens of *Hemanthropus pei* and *Sinanthropus officinalis*. 591 specimens from China stem from Zhoukoudian and/or unknown localities. The GHRvK drugstore collection also contains isolated teeth including the holotype of *Gigantopithecus blacki* (Koenigswald 1952, 1957).

Material other than hominids has rarely been studied. The reason for that is that GHRvK used specific biostratigraphic assignments, in particular for his collection

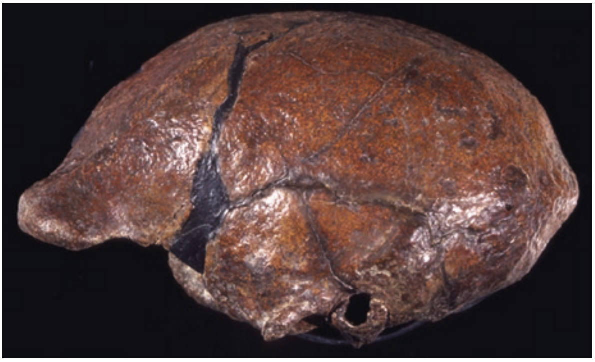

Fig. 21.12 Lateral view of the famous skull Sangiran 2 found in 1937 on the island of Java in Indonesia. The fossil was attributed by Gustav Heinrich Ralph von Koenigswald to *Pithecanthropus erectus*, today *Homo erectus*, after its reconstruction from 33 fragments found by a local assistant about 1 km southeast of the town Bapang in fossil-rich river deposits of the Sangiran dome

Fig. 21.13 Important hominid specimens in the Gustav Heinrich Ralph von Koenigswald collection housed in the Paleoanthropology department in the Senckenberg Reserach Institute and Natural History Museum Frankfurt. The collection comprises far more than hundred original fossils of Early Pleistocene homininds, including great apes, among famous Sangiran fossils of *Pithecanthropus*, and the type-specimen of *Giganthopithecus blacki*

from Sangiran. These biostratigraphic units are considered invalid at present. Because the vertebrate bearing deposits in Sangiran cover a time span of approx. 1 million years, it is not possible to conclude on the lithostratigraphic context and/or to infer the co-occurrence of particular taxa without further clues. Recent studies mainly focused on the non-hominin part of the GHRvK collection.

Additional collections housed in the Department of Palaeoanthropology consist mostly of mammal remains from the earliest river and lake deposits in the vicinity of the proto Rhine system in the Alzey-Worms district in Rheinland-Pfalz from the localities close to the towns of Dorn-Dürkheim and Eppelsheim. The fossil specimens from Eppelsheim belong to the famous ca. 10.5 Ma old Dinothere sand deposits with the type locality of 34 Upper Miocene mammalian taxa. Specimens stemming from Senckenberg excavations in Dorn-Dürkheim since 1989 and from Eppelsheim since 1996 are on permanent loan in the Senckenberg Research Institute and Natural History Museum Frankfurt. They are inventoried and belong to the collections of the Landessammlung für Naturkunde Rheinland-Pfalz.

In the meantime, the collections in the Department of Palaeoanthropology have further grown with the adoption of 120 chimpanzee (*Pan troglodytes verus*) skull specimens from the former Anthropology Department of the Justus-Liebig-University in Gießen in 2007 and the comparative collection of the former Anthropology Department from the Goethe University in Frankfurt in 2010. Besides a high number of hominid replica specimens, the collections from the Goethe University include 286 modern chimpanzee (*Pan troglodytes verus*) skulls in various ontogenetic stages from Liberia. The collections from the Justus-Liebig-University and Goethe University are on permanent loan housed and inventoried in the Senckenberg Research Institute and Natural History Museum Frankfurt.

In addition, the Department of Palaeoanthropology services an extensive cast collection of hominid specimens and a number of virtual 3-D data for comparative studies (Kullmer et al. 2002).

21.2.4 Research Station of Quaternary Palaeontology (Weimar)

The Quaternary palaeontological research and collection activities in Thuringia are associated with the names of many well-known scientists, including J. W. von Goethe (1749–1832), F. Klopfleisch (1831–1896), W. G. von Fritsch (1838–1906), A. Nehring (1845–1904), H. Virchow (1852–1940), H. Pohlig (1855–1937), A. Weiss (1871–1940), L. Siegert (1872–1917), F. Weidenreich (1873–1948), F. Wiegers (1875–1955), E. Wüst (1875–1934) and W. Soergel (1887–1946). After the end of the Second World War and during the following period when Germany was split into two separate states, it was predominantly the work of H.-D. Kahlke that advanced Ice Age palaeontology in Thuringia. With the founding of the Institute for Quaternary Palaeontology in Weimar in 1962, the collection and research activities could function on an independent basis for the first time. In the year 2000, integration into the Senckenberg Research Institute took place and new institute buildings with modern collection storerooms were swiftly finished and moved into in 2005 (Fig. 21.14). Nineteen collections of Ice Age fossils of different origins and ages, as well as recent comparative materials, now form the basis of the research infrastructure of Quaternary Palaeontology in Weimar. At present, the collections are comprised of 83,992 finds, specimens or series (as of January 2018), which are housed in eleven storerooms equipped with a total of approximately 270 collection cabinets. Supervision and care of the collection falls into four distinct scientific sections of different specializations (Quaternary large mammals, Quaternary small mammals, Quaternary macroflorae, Quaternary microflorae).

Continuous collection activity and decades of planned and rescue excavations have made the Senckenberg collections of Pleistocene large mammals in Weimar one of the world's most complete archives of fossil finds of the past 2.6 million years of earth history (Fig. 21.15). Twelve collections (Untermassfeld, Voigtstedt, Süßenborn, Weimar-Ehringsdorf, Taubach, Weimar, Burgtonna I and II, Thuringian Basin, Southern Thuringia, Foreign collection and Type collection) are comprised of nearly 32,500 large mammal remains from approximately 310 sites of different ages. Original publications are available for more than 70% of the items in these collections. Since 1982, systematic collection and research activity on Quaternary microvertebrates has also been carried out in Weimar. The present collection con-

Fig. 21.14 Senckenberg Research Station of Quaternary Palaeontology: Storage room with large mammal preparations from Voigtstedt, one of the most important early Middle Pleistocene excavation sites in Europe. (photo: T. Korn)

Fig. 21.15 The world's largest cheetah: Skull of *Acinonyx pardinensis pleistocaenicus* from 1.05 million years old fluviatile sediments near Untermassfeld in Southern Thuringia, length 21.6 cm (Inventory number IQW 1980/16,350 (Mei. 15,861). (photo: T. Korn)

tains about 16,000 Pleistocene specimens/series, mainly fossil remains from Quaternary sites in Thuringia (Untermassfeld, Voigtstedt, Süßenborn, Weimar-Ehringsdorf, Taubach, Burgtonna and others), along with modern reference samples. In addition to small mammal fossils, remains of birds, reptiles, amphibians and fish are also well-represented.

One of the available collections currently not integrated into any section is that of Pleistocene and recent mollusks. This collection is based on research activities which took place during the early twentieth century. From the 1950s to the 1970s the collection was increased, largely through the work of H. Zeissler, from research conducted predominantly in Central Germany. The collection also contains extensive reference material of Holocene snail successions from Southern Ontario deriving from Senckenberg research projects on the fauna and environmental development of North America. More recently, both reference and type material from external projects in Kazakhstan and Tajikistan have been added to the collection. Currently, 13,850 items have been catalogued.

The palaeobotanical collection is comprised of approximately 10,500 fossils, mainly plant encrustations in travertines from Weimar-Ehringsdorf, Burgtonna and Weimar (Belvederer Allee), as well as those in tephra from the Laacher See eruption near Sinzig (Rheinland-Pfalz) (Fig. 21.16). The collection also contains approximately 500 series of fossil plant macro remains, mostly seeds, fruits and leaf fragments from lake deposits in Central Europe, as well as from permafrost sequences from the Arctic. A herbarium and its associated carpological collection with a geographical focus on Europe, Siberia, East Asia and Alaska is used as a reference for determining fossil plant remains and is continuously being expanded (it currently contains approximately 4,400 records). The palynological collection currently contains 2,900 fossil pollen samples from various study areas, including Thuringia, France, the Czech Republic, China, Kyrgyzstan and India. In addition, the modern palynological reference collection includes approximately 1500 plant species from Europe and Asia.

Fig. 21.16 Fruits in travertine: European crab apple *Malus sylvestris* from Weimar-Ehringsdorf, scale bar 5 cm (Inventory number IQW 1968/10,712 (Ehr. 12,183). (photo: T. Korn)

21.3 Senckenberg Naturhistorische Sammlungen Dresden

The palaeontological collections at Dresden are part of one of the oldest geoscientific institutions worldwide, the Museum für Mineralogie und Geologie. The foundation of an Art Chamber that yielded also geoscientific objects such as rocks, minerals and fossils at the court in Dresden by the Saxon Elector August in 1560 is in force as date of formation of the natural history collections (Thalheim 2007). Knowing that those fossils were pieces of petrified wood none of these specimens stand the test of times. The current oldest palaeontological objects in the collections are accessions of the early eighteenth century (Fischer 1939) partly mentioned and illustrated in oldest palaeontological catalogues such as a palaeobotanical inventory of 1757 (Eilenburg 1757).

Due to immense diversity of objects and the huge number of specimens in the Art Chamber Saxon's Elector Friedrich August I ("August the Strong") decided in 1728 its complete breakup and the establishment of several independent public museums, one of which is the Gallery of Natural History (Lange and Kühne 2006). A guide to the public natural history museum referring also to the most famous palaeontological objects of the exhibition was issued by Eilenburg (1755), then inspector of the museum. Absence of a palaeontologist in the museum during the 18th and early nineteenth century prevented a strategic development of the respective collection and scientific issues. Moreover, large parts of the palaeontological collection were damaged and/or destroyed during the civil war in central Germany in 1849 (Geinitz 1849a).

By the appointment of Hanns Bruno Geinitz in 1837 as inspector, later director of the Königliches Mineralogisch-Geologisches Museum (Lange and Kühne 2006), the first palaeontologist worked in the museum both developing the palaeontological collections enormously and conducting broad-ranging palaeontological research. As one of the last universal palaeontologists in the nineteenth century, Geinitz investigated fossil fauna and flora focusing on the Permian and Cretaceous systems (Geinitz 1855, 1871–75). His successors were specialized either in palaeozoology or palaeobotany, simultaneously setting the focus to Quaternary vertebrates in the early twentieth century and to Tertiary vegetation from the 1960s onwards (Lange and Kühne 2006). The Museum für Mineralogie und Geologie was integrated as a department into the Senckenberg Gesellschaft für Naturforschung in 2009, the two palaeontological collections are curated by a palaeobotanist and a palaeozoologist, respectively, both actively carrying on research in their palaeontological disciplines.

21.3.1 Department Museum für Mineralogie und Geologie (Dresden)

The department consists of five scientific sections, each of which headed by a scientist who is permanently supported by two technical assistants for collection management and scientific support. Research is also carried out by young scientists, i.e. third-party funded PhD students and research employees getting a two-years training to be qualified as scientific curators for natural history museums. The research groups are completed by free-lance scientific and technical staff.

The collections are stored in up-to-date mobile shelf systems in air-conditioned storage rooms within a 1999 newly built research and collection building (Figs. 21.17 and 21.18). The department's equipment encompasses high-end optical microscopes, thin-sectioning machines, XRF, LA ICP-MS and a scanning electron microscope. The well-stocked geoscientific library is an inherent part of the department.

Among the five scientific sections, two sections keep and manage palaeontological collections, i.e. the section of palaeobotany and the section of palaeozoology.

21.3.1.1 Section of Palaeobotany (Dresden)

The section currently keeps about 79,800 catalog numbers and/or series of scientific objects in their collection (effective 2016; see Table 21.1). The whole material including raw samples encompasses approximately 500,000 objects. Scientific objects are (1) single plant fossils such as leaves, wood (Fig. 21.19), fruits and

Fig. 21.17 View onto institute building Senckenberg Naturhistorische Sammlungen Dresden, A.-B.-Meyer-Bau in Dresden-Klotzsche, built in 1999 (photo: F. Höhler)

Fig. 21.18 View into a storage room of the Museum of Mineralogie und Geologie, institute building A.-B.-Meyer-Bau in Dresden-Klotzsche, Sachsen, built in 1999 (photo: F. Höhler)

Table 21.1 Palaeobotanical collection Dresden (effective December 2016)

Collection part	Specification	Catalogue no. of specimens/series
Plant fossils	Inventoried total	52,200
	Thereof Paleogene and Neogene	40,800
	Thereof from central Germany	33,500
	"Raw" materials	~45,000
Scientific preparations	All types of preparations and slides	18,100
Herbarium	Single-leaf herbarium and herbarium sheets	~8,500
Type specimens	From all collection parts	124
Published specimens (originals)	From all collection parts	~15,500

Fig. 21.19 Petrified trunk of the extinct bennetittalean seed plant *Cycadeoidea* ("*Raumeria*") *reichenbachiana* (Göppert) Wieland, holotype, Early Cretaceous, found near Wieliczka (Poland) in 1751, donated to the Dresden collection in 1753, Senckenberg Naturhistorische Sammlungen Dresden, collection palaeobotany, coll. no. MMG PB PnK 1 (photo: F. Höhler)

seeds and series of them, (2) scientific preparations such as glass slides of leaf cuticles, cleared leaves, thin sections, polished wood sections, samples for scanning electron microscopy, and (3) special extant plant material for comparison studies. Currently, ca. 15% of the inventoried specimens are implemented in the collection database.

Stratigraphically, about 78% of the numbered specimens and series come from Paleogene and Neogene fossil localities in central Europe. About 33.000 catalogue numbers were collected by the section members from central German lignite open-

Fig. 21.20 Fossil leaf (part and counterpart) of extinct Fagaceae *Eotrigonobalanus furcinervis* (Roßmäßler) Walther et Kvaček, Paleogene, late Eocene, from a lignite seam in the Vereinigtes Schleenhain opencast mine near Borna, Sachsen, collected 1997, Senckenberg Naturhistorische Sammlungen Dresden, collection palaeobotany, coll. no. MMG PB SchleOE:1, 2 (photo: F. Höhler)

cast mines during field work over the last decades (Walther and Kunzmann 2008; Fig. 21.20). This fact nicely demonstrates the focal research topic, namely evolution of Paleogene and Neogene vegetation in Europe, of the section since 40 years. Scientifically the fossil leaf collection is most important, whereby the type and number of preparation slides, e.g. of leaf cuticles (Fig. 21.21), is explained. For preparation purposes the section is equipped with a HF laboratory beyond above mentioned equipping of the department.

Regularly, visiting scientists from different countries study specific parts of the palaeobotanical collections. Although the collection is all-in-all a scientific infrastructure, appropriate specimens of various stratigraphic ages and of various origin are shown in public exhibitions (Kunzmann 2005).

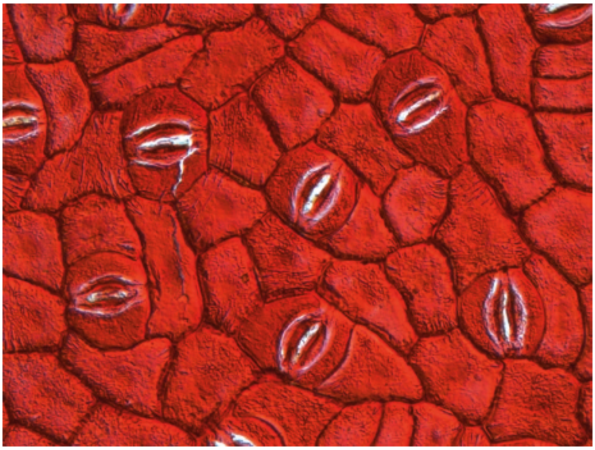

Fig. 21.21 Leaf cuticle of the fossil mistletoe *Viscum morlotii* (Unger) Knobloch et Kvaček, Neogene, early Miocene, from fluviatile sediments exposed in the clay pit Wiesa near Kamenz, Sachsen, Senckenberg Naturhistorische Sammlungen Dresden, collection palaeobotany, coll. no. MMG PB W 672 (photo: L. Kunzmann)

21.3.1.2 Section of Palaeozoology (Dresden)

The palaeozoological collection currently keeps about 85,000 specimens and/or series of scientific objects (as of 2017). The total number of individual items including raw samples certainly amounts to >100,000, and the collection includes a large number of often historical primary types (>150) and originals (Fig. 21.22). Currently, ca. 50% of the inventoried specimens are implemented in the collection database. Historically, the collection has always been structured into two basic sub-collections (national and international) with numerous regionally and chronostratigraphically organized collection parts. The national repository contains 16 regional or topical collection parts with numerous stratigraphic subunits while the international repository features 36 geographic collection parts (plus stratigraphic subunits).

The oldest fossils in the collection date back into the early eighteenth century, for example several specimens of the brachiopod *Coenothyris vulgaris* from the Muschelkalk, collected as *Conchites* "*on the way from Jena to Weimar*"in 1718 (Fig. 21.23), as well as the types of the Cretaceous starfish *Comptoniaster michaelisi*, found in Saxony in 1727, and the Early Jurassic marine crocodile *Steneosaurus bollensis*, acquired around 1730. The geographical focus has (historically) been central Germany, with large and significant collections parts stemming from the upper Palaeozoic to Mesozoic of Sachsen, Thüringen and Bayern. The collection is thus an important regional reference archive. The Cretaceous collection part with >30,000 items is the most important stratigraphical subunit, well complementing the research focus of the section on late Mesozoic marine ecosystems. In the course of this ongoing research, numerous Cretaceous fossils from different places in Asia, northern Africa and Europe have recently been integrated into the collection.

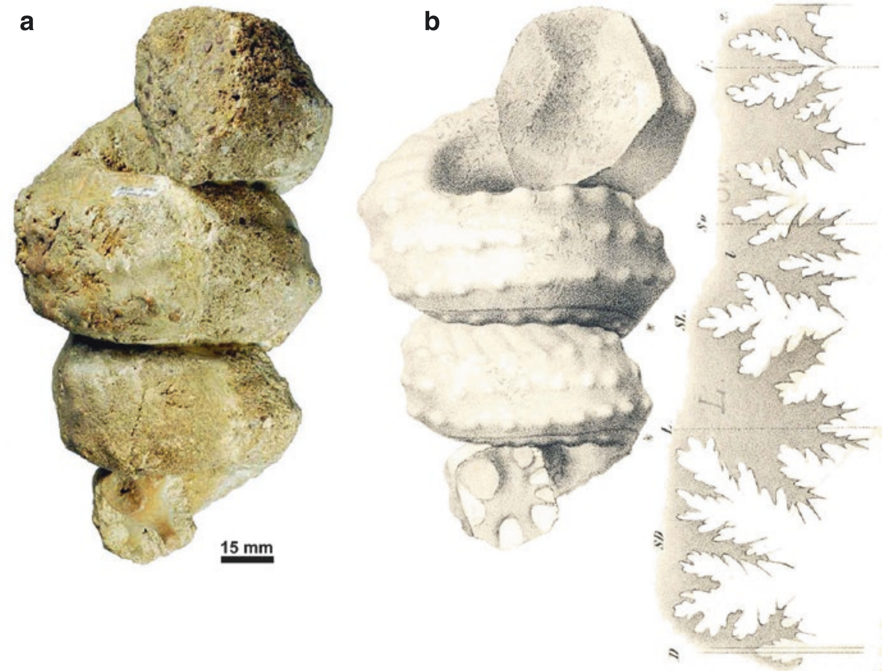

Fig. 21.22 (**a**) Holotype of the heteromorph ammonite *Mariella essenensis* (Geinitz 1849b) from the Lower Cenomanian Essen Grünsand Formation of the Ruhrgebiet (Senckenberg Naturhistorische Sammlungen Dresden, palaeozoology collection, MMG: NwK 1). (**b**) Original illustrations of *Turrilites essensis* Geinitz (1849b, pl. 6, Figs. 1 and 2)

Fig. 21.23 Sample with several specimens of *Coenothyris vulgaris* (Schlotheim) from the Lower Muschelkalk (Jena Formation) of the Jena area, Thuringia (Senckenberg Naturhistorische Sammlungen Dresden, palaeozoology collection, MMG: ThTr 338 collected in 1718)

The palaeozoological collection forms an important basis for research by members of the section (e.g., Engelke et al. 2016; Wilmsen 2017), including monographic revisions of important sub-collections (e.g., Cretaceous fossils of Saxony: Niebuhr and Wilmsen 2014, 2016; Fig. 21.24). Furthermore, guest scientists from

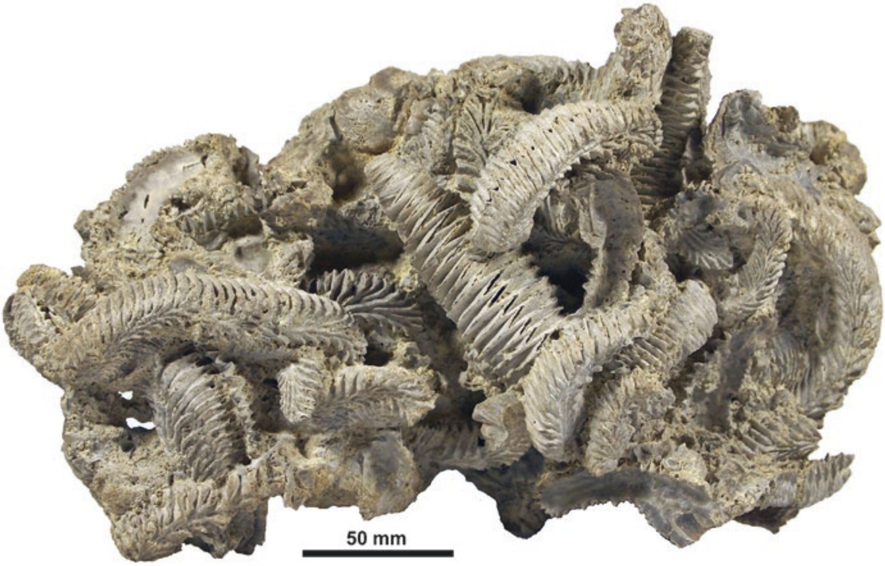

Fig. 21.24 Small oyster reef with numerous *Rastellum carinatum* (Lamarck) from the lower Dölzschen Formation at Hoher Stein in Dresden-Plauen (Senckenberg Naturhistorische Sammlungen Dresden, palaeozoology collection, MMG: SaK 7379). This is one of the most famous fossil specimens in the palaeozoological collection, obtained in 1867

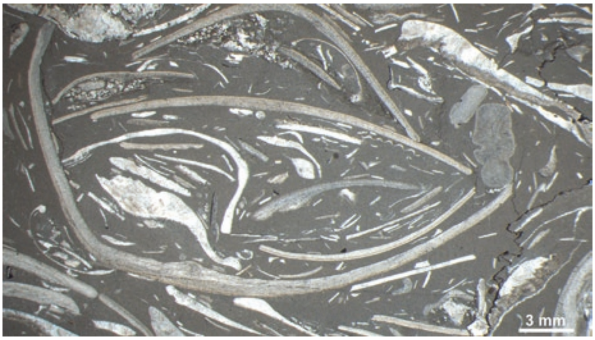

Fig. 21.25 Thin-section view of the upper Terebratelbank, Lower Muschelkalk (Jena Formation) of Bayern, showing numerous shells of brachiopods and bivalves as well as debris of crinoids (Senckenberg Naturhistorische Sammlungen Dresden, palaeozoology collection, MMG: D_BaTr_Gr-7)

Germany and other countries often visit the palaeozoological collection in order to study specific parts or specimens (ca. 150 man-days in 2010–2016), benefitting from the scientific service and showing its importance as a scientific infrastructure.

Carbonate rocks are mainly of biological origin and their microscopical study is largely "palaeontology in thin-sections" (Fig. 21.25). Thus, additionally to the palaeozoological standard preparation techniques, a large-scale thin-sectioning facility for carbonate rocks has been established in 2013, strengthening microfacies analysis as one of the main pillars of research within the section (e.g., Wilmsen et al. 2014). The large collection of >1000 thin-sections kept within the section is currently registered in a database system in order to develop a reference micro-biofacies collection for marine carbonate systems.

21.4 Senckenberg Museum für Naturkunde Görlitz

The Senckenberg Museum für Naturkunde Görlitz has its roots in the year 1811, when the "Ornithological Society of Görlitz" was founded. Later the society changed its name to "Naturforschende Gesellschaft zu Görlitz" in 1823. After the end of the 2nd World War the society was liquidated by the new administration and in 1953 it became a national research institute in the GDR. Following the reunification of Germany, the museum received in February 1991 the status of a State Museum of the Free State of Saxony and since 1 January 2009, it is an institute of the Senckenberg Gesellschaft für Naturforschung, and thus a member of the Leibniz Society. The Museum has extensive scientific collections with a total of over 6.5 million objects from soil zoology, zoology, botany, geology and palaeontology.

The Geology and Palaeontology Section of the Senckenberg Museum für Naturkunde in Görlitz manages palaentological collections as part of its geosciences collection. Two main parts contain palaeontological objects. These are objects of the historical collection from 1811 to 1945 and the scientific collection of Miocene plant fossils, mainly collected in the 1990s and 2000s.

The historical palaeontology collection is stored in original historical cabinets together with historical labels and boxes and in the historical systematic and structure from the end of the nineteenth century (Tietz and Berner 1996). The collection has never been inventoried and the number of objects is estimated at 4000 (or about 5000 specimens). Apart from the missing inventory, the collection has been in good conservative condition since 1998.

Within the framework of a research project on the palaeobotanical fossil remains of the Berzdorf lignite mine (upper and middle Miocene), a large fossil plant collection was developed from 1995 to 2002. This collection included 1195 carpological object numbers (with approximately 20,000 specimens; Fig. 21.26) and 1360 differently sized sediment slabs with leaves (approx. 4000 specimens), as well as 600 physically preserved leaves (Figs. 21.27 and 21.28) from two different stratigraphical levels, 300 brown coal xylites and 350 palynological samples with 120 microscopical (palynomorpha) preparation slides. Additionally, 530 microscopic (cuticula) preparation slides from leaf fossils exist. All sampling sites of these objects are documented, e.g. with geographical xyz-coordinates and the lithostratigraphical information. Many of the objects are scientifically processed; Tietz and Czaja (2004) provide an overview of the key results. The majority of the palaeobotanical Berzdorf collection is inventoried by record card, only the carpological collection by electronic database.

Besides these two collections about 550 palaeontological objects exit in the Lausitz collection, with a focus on Pleistocene vertebrates and Tertiary plant and animal fossils from different outcrops such as Seifhennersdorf or Tetta-Buchholz (Tietz and Düker 2009).

Fig. 21.26 Composite sample of carpological remains, i.e. fossil fruits and seeds, Neogene, Miocene, abandoned lignite opencast mine Berzdorf near Görlitz, Sachsen, Senckenberg Museum für Naturkunde Görlitz, geoscience collection. Image width = 11.5 cm (photo: O. Tietz)

Fig. 21.27 Fossil laurel leaf *Laurophyllum pseudoprinceps* Weyland et Kilpper, leaf removed from sediment and bleached and mounted on glass slide, Neogene, lower Miocene, abandoned lignite opencast mine Berzdorf near Görlitz, Sachsen, Senckenberg Museum für Naturkunde Görlitz, geoscience collection. Leaf is 11 cm long (photo: O. Tietz)

Fig. 21.28 Fossil oak leaf *Quercus kubinyii* (Kováts ex Ettingshausen) Czeczott, leaf removed from sediment and bleached and mounted on glass slide, Neogene, middle Miocene, abandoned lignite opencast mine Berzdorf near Görlitz, Sachsen, Senckenberg Museum für Naturkunde Görlitz, geoscience collection. Leaf is 10 cm long (photo: O. Tietz)

21.5 Research

Research at Senckenberg is divided in 4 Research Fields following a holistic Geobiodiversity approach:

- RF I: Biodiversity and Systematics
- RF II: Biodiversity and Ecosystems
- RF III: Biodiversity and Climate
- RF IV: Biodiversity and Earth System Dynamics

Senckenberg scientists working on palaeontological collections contribute mainly to RF I, III and IV, whilst RF II is mostly focused on long-term ecosystem monitoring. By the very nature of taxonomic studies, these contribute to RF I. Examples are careful studies of fossil insects from amber and clastic sediments, fossil plants as well as fossil brachiopods. Focuses of palaeontological studies contributing to RF III are Quaternary organisms and ecosystems and the climatic feedbacks on them. RF IV with its focus on Earth System Dynamics is the natural home of most studies dealing with the palaeontological collections at Senckenberg. Contributions range from analyses of biosedimentary systems, biostratigraphic studies, palaeobiogeographic, palaeoclimatic and palaeoenvironmental reconstructions to the biological and cultural evolution of humans. Most research activities use the palaeontological collections with their regional and stratigraphic focal points as the base of research projects which contribute to the Geobiodiversity approach pursued by Senckenberg.

21.5.1 National and International Network and Cooperation

Senckenberg palaeontologists have numerous cooperations with universities, museums and research institutes from Germany as well as a large number of countries worldwide.

Results from research on the palaeontological collections are primarily published in international peer-reviewed journals as well as in scientific monographs but some publications also appear in regional journals. Knowledge generated from the collections is also regularly disseminated by lectures presented during national and international congresses, in newspapers, radio and TV, in books published for the general public, as well as numerous public lectures, e.g. at large venues like the Munich Show and at small venues like schools or clubs.

Each year the so-called Messel Workshop is organized at Senckenberg's Messel Research Station. About 25 scientists from different institutions (mostly in Germany) participate, and the geological and paleontological topics cover Messel and related sites (Wedmann and Schaal 2016). Additionally, a large international conference on "The World at the Time of Messel" was held at Senckenberg in 2011 (Lehmann and Schaal 2011).

21.5.2 Educational Work

In Frankfurt, the palaeontological collections have a clear focus on research and curation of collections, while a separate department is dealing with museum issues like exhibitions and public outreach to schools. The use of social media to disseminate scientific results is centrally run by Senckenberg's communications department.

Scientists working with palaeontological collections are involved in a number of Bachelor-, Master- and PhD-Thesis at various universities (e.g. Frankfurt, Dresden, Freiberg, Tübingen, Darmstadt, Jena). In Frankfurt scientists curating palaeontological collections are also involved in the Senckenberg School for Technical Assistants for natural history museums.

In 2015, the first Senckenberg International Taxonomy School was established for experienced young scientists from all biological and palaeontological disciplines. The two-weeks workshop was held at SNSD in Dresden and included also practical collection-based research work.

Beside various teaching activities of Senckenberg's palaeontologists at universities SMNG collaborates with the Technische Universität Dresden and established the Master of Science program *Biodiversity and Collection Management* at the university branch Internationales Hochschulinstitut Zittau at Zittau (Sachsen). The MSc program incorporates also internships in Senckenberg's palaeontological collections.

21.5.3 Losses During WW II

In Frankfurt, there were only a few loses during WW II. These mostly affected parts of the palaeobotanical collections, which were evacuated to a small museum in the Wetterau north of Frankfurt. This museum was occupied by a unit of the SS shortly before the end of the war. During military actions to displace these troops the museum was heavily shelled and all material stored there was destroyed. This included not only important types and originals of Devonian plants but also the larger parts of the famous Pliocene "Klärbeckenflora" from Frankfurt/Niederrad (Dilcher and Schaarschmidt 1992).

Shortly before the city centre of Dresden was heavily destroyed including the Zwinger Palais as museum building, the mineralogical, geological and palaeontological collections were packed and moved to several places mostly outside Dresden that were thought to be secure. Most appropriate locations were used for the collections of Sachsen which almost completely overcame the war as well as the turmoil after the war. Unfortunately, a huge part of fossil specimens from outside of Sachsen got lost by various causes (Lange and Kühne 2006).

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Chapter 22
FRICK: Late Triassic Basal Sauropodomorph and Theropod Dinosaurs at the Sauriermuseum Frick, Switzerland

Andrea B. Oettl-Rieser and Marion Zahner

22.1 Introduction

In the 1970s and 1980s, several spectacular plateosaur individuals were excavated from late Norian sediments (Klettgau Formation, Jordan et al. 2016) of the local Gruhalde clay pit of the Tonwerke Keller AG (TWK) in Frick, Kanton Aargau, Switzerland. These discoveries triggered an initiative for a local dinosaur museum, which was opened in 1991 after several years of planning and fund raising. The small museum is situated in the basement of a school (Schulhaus 1912) in Frick. On an area of 400 m^2, fossils of Late Triassic dinosaurs, other reptiles and fishes from the first up to very recent excavations are permanently on display. Hence, the vertebrate specimens shown in the main hall of the museum date from 1976 to 2017 (Fig. 22.1). A huge amount of largely unprepared dinosaur material is stored in the museum's local storage and in an additional storage room nearby. On the museum's gallery, Early Jurassic marine invertebrate and vertebrate remains are presented. A small extra-room allows for temporary exhibitions on special topics related to dinosaurs, other fossils or minerals.

The first dinosaur bones were already discovered in 1961 by Ernst Wälchli, the former head of laboratory at TWK. In 1976, the first scientific excavation was carried out on private initiative. In the course of this, a foot of a large individual of *Plateosaurus* (Fig. 22.2) was unearthed. Further field campaigns were undertaken during the eighties and provided the first complete *Plateosaurus* skeleton. Since 2004, palaeontological excavations precede phases of clay mining in a systematic

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Fig. 22.1 Main hall of the Sauriermuseum Frick with Late Triassic dinosaur and other vertebrate material and gallery with Jurassic marine fossils

Fig. 22.2 Foot of *Plateosaurus* unearthed in 1976 during the first excavation. Length 50 cm

manner. In 2009, it became clear that the fossil bearing Late Triassic layers are not limited to the Gruhalde clay pit when the same fossil-bearing sediments where detected in construction sites of the Frickberg area, 1.5 km north of the pit. Besides the specimens in the exhibition of the SMF, additional material is on display in several other natural history and dinosaur museums in Switzerland, the Netherlands (Leiden) and Belgium (Brussels).

The dinosaur fossils are owned by the Kanton Aargau. The SMF is run by the village of Frick and regularly opened on Sunday afternoons. Appointed group tours are possible during the week. The museum staff comprises eight people. Six persons work on Sunday, while the two others are responsible for the guided tours. There are neither scientists employed nor is there a lab at the museum. A permanent commission of the municipality of Frick (Saurierkommission), consisting of representatives of the community, the canton, the University of Zurich, and the SMF, ensures the scientific standard of the field campaigns, the scientific projects, and the development of the museum. Financial support for excavations is currently provided by the Swisslos Fund—a cantonal institution—whereas funding for research projects must be organized by the scientists themselves. On occasion private donations allow the preparation of new material for display.

22.2 Research

The clay pit and the fossils of Frick are of great scientific interest and offer many possibilities for research projects on geological, stratigraphical, paleoenvironmental, palaeontological and evolutionary aspects, both on microscopic and macroscopic scales. While the University of Bonn mainly works on questions concerning the life history and general biology of basal sauropodomorphs, a team from the University of Zurich focuses on morphological differences, phylogenetic relationships, and distribution patterns of the Frick dinosaurs.

22.2.1 Geologic Setting

The Gruhalde clay pit exposes a sedimentary sequence reaching from the Late Triassic Klettgau Formation to the Early Jurassic Staffelegg Formation. The terrestrial deposits of the Triassic have recently been described in detail by Jordan et al. (2016), while Reisdorf et al. (2011) gave a detailed description of the marine sediments of the Jurassic. Within the Late Triassic “Obere Bunte Mergel” (Gruhalde Member of the Klettgau Formation) that consist of reddish, greenish and greyish marls, there are at least three distinct layers containing articulated dinosaur material. These sediments were likely deposited on a semiarid floodplain with little vegetation and heavy seasonal precipitations (Brinkmann and Stössel 2010).

22.2.2 Plateosaurus

According to Galton (1986), most of the vertebrate material at SMF can be assigned to *Plateosaurus engelhardti*. The plateosaurids were the most abundant basal sauropodomorphs in the Late Triassic of Europe, 210 mya (Hofmann and Sander 2014).

Until 2016, bones of more than 80 individuals have been excavated in Frick. The elements are often articulated but displaced material is also frequently found. The

Fig. 22.3 First complete skeleton of *Plateosaurus* found in Frick in 1985. The skeleton is mounted in its original position as it has been detected and measures ca. 5 m

main attraction of the Frick museum is a complete plateosaur skeleton in its dying position that was discovered in 1985 (Fig. 22.3). Currently, this specimen is under study by a PhD-student from Bonn University. The deep position of its articulated hind legs is interpreted as the result of miring in a mud pit acting as a trap (Hofmann and Sander 2014).

Before 2010, only animals larger than five meters had been known and it was supposed that smaller ones were too light to get trapped in the mud (Sander 1992). But surprisingly, skeletal material of a juvenile *Plateosaurus* was found in 2010 and 2011.

In 2015, the so far largest plateosaur individual from Frick was recovered in the lowermost and thus oldest dinosaur layer of the clay pit. Its skeleton is nearly complete and indicates a total length of about eight meters. Only one year later, a likewise sensational find could be made in the middle fossil layer: the smallest specimen of *Plateosaurus* ever found (femur length: 23 cm). Parts of the largest and the smallest individuals are already prepared and displayed at the SMF.

As the fossil bones of several examined plateosaur specimens show, there is little correlation between size and age in adult specimens of the taxon. This developmental plasticity was probably driven by environmental factors (Sander and Klein 2005; Hofmann and Sander 2014).

22.2.3 The First Swiss Theropod Skeleton

The theropod material that was collected from the uppermost dinosaur layer of the clay pit Gruhalde in 2006 and 2009, belongs to a ~2.6 m long juvenile to subadult individual. It is impressively complete and represents the by far best preserved theropod skeleton from the Late Triassic of Europe. Amongst others, it comprises a skull, two perfectly articulated forelimbs (Fig. 22.4), and stomach contents, whereof

Fig. 22.4 Forelimbs and scapula of the Frick theropod. Total length ca. 50 cm

remains of the rhynchocephalian *Clevosaurus* could be identified. The Frick theropod is a basal neotheropod with affinities to *Zupaysaurus rougieri* and displays an interesting mixture of characters typically found either in coelophysids or in "dilophosaurids". The museum shows the original postcranium, a cast of the skull and a 3D-reconstruction of the whole animal with its prey (Hugi 2008; Unterrassner 2009; Zahner 2014).

22.2.4 Proganochelys

In 2009, the remains of an extinct turtle were recovered at the Frickberg site, together with dinosaur bones of the genus *Plateosaurus*. After preparation of the bones, it was apparent that they likely represented a new specimen of *Proganochelys quenstedti*. This species is also documented by several individuals found in German localities (Gaffney 1985), so that the osteology (skeletal anatomy) of those specimens will now be compared with the new finding. Characteristics of *Proganochelys* are a flat and broad shell with a row of 24 additional keratinous shield impressions (so-called supramarginals), dermal armour plates covering the neck and tail, as well as stout extremities with short and strong hands and feet. Only few scattered remains of the skull of the Frickberg specimen are known, but they fit in shape with those skull remains from Germany.

22.2.5 Other Triassic Vertebrate Fossils of the Gruhalde Clay Pit

During various field campaigns, e.g. that of 2013, material of several individuals of a basal sauropodomorph was unearthed in the uppermost dinosaur layer of the clay pit (Fig. 22.5). This material is currently examined in the framework of a PhD thesis at the University of Zurich.

Fig. 22.5 Skull of the basal sauropodomorph excavated 2013 in the uppermost dinosaur layer. Skull length 30 cm

Isolated teeth of carnivorous saurians are found occasionally together with plateosaur bones. These teeth are often larger than those from the theropod described in Sect. 2.3, but could nonetheless belong to an adult representative of the same species.

The non-dinosaur material comprises remains of rhynchocephalians, aetosaurs, bony and cartilaginous fishes (Foelix et al. 2011).

22.2.6 Ichthyosaur Skull

1999 an incomplete skull attributed to *Ichthyosaurus communis* was discovered in the fossiliferous Lower Sinemurian calcarenites (Beggingen Member, Arietenkalk) that crop out in the upper part of the clay pit. Maisch et al. (2008) gave a detailed description and discussion of the large skull fragment, which is imbedded in a slab of ca. 700 × 500 mm. The fossil is not only the first record of the genus *Ichthyosaurus* in Switzerland but also one of the few diagnostic ichthyosaur specimens from the Sinemurian (Lower Jurassic) of Central Europe. Additionally, disarticulated ichthyosaur bones (vertebrae, ribs) have been unearthed from the same unit.

22.3 Educational Work

The SMF hosts ca. 10,000 visitors every year. Thereof about 5000 persons visit the museum on Sunday afternoons when it is regularly open to the public. A movie of 15 min duration summarizes background details and answers the most frequently asked questions concerning the field work in the Gruhalde clay pit and the Frick dinosaurs.

Especially school groups, company staff and university students attend the 200 tours conducted every year. During summer holidays special events are arranged for pupils.

On five Sundays from June to October, a group of amateur palaeontologists and fossil hunters (Geologisch-Paläontologischer Arbeitskreis Frick) offers guidance in fossil collecting at the "Klopfplatz", a public fossil search site next to the Gruhalde clay pit, where fossil bearing limestone of the Early Jurassic of this site is deposited (Fig. 22.6). The access to the clay pit itself is forbidden except for during occasional guided tours.

Since 2005 a geo-trail consisting of eight columns that display information on different topics of dinosaurs and earth history guides visitors from the SMF to the "Klopfplatz". The trail is marked by orange dinosaur-footprints on the street and side walks.

Fig. 22.6 "Klopfplatz" next to the Gruhalde clay pit: place with fossiliferous early Jurassic limestone (Arietenkalk) for the public, where it is allowed to search for fossils

22.4 Conclusions

The dinosaur sites of Frick (Gruhalde clay pit, Frickberg) belong to the most productive localities in Europe, providing excellently preserved, articulated Late Triassic theropod and sauropodomorph material. Although most specimens can be attributed to *Plateosaurus*, recent findings such as the first theropod skeleton from Switzerland, several complete dinosaur skulls, the tiniest plateosaur specimen of the world and the turtle *Proganochelys* have shown that further impressive discoveries can be expected in the future.

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Chapter 23
GOTHA: Museum der Natur, Stiftung Schloss Friedenstein Gotha

Oliver Wings and Carsten Eckert

23.1 Collections

The roots of the paleontological collections in Gotha date back to the mid-seventeenth century. Ernst I, called the Pious (1601–1675), founder of the Ernestine dukedom of Saxony-Gotha-Altenburg, established a ducal "Kunstkammer" (cabinet of arts and curiosities), which included a department of "Naturalia" (natural objects). The first inventory dates from the year 1656, shortly after completion of the newly constructed Friedenstein Castle (Martens 2002). It already includes paleontological objects in a present-day meaning, listing "ten different pieces of Mansfeld slate on which have grown fish" (fossil fish from the Lower Permian copper shale of Mansfeld). The Kunstkammer subsequently included more fossils, which were contemporarily understood as sculptured stones or rather animals and plants that had grown directly in rocks. An important first scientific study dealing with the origin of these so called "work or play of nature" fell in the period of the Early Enlightenment: A "huge carcass of unusual size" was found in a sand pit near the village Burgtonna, north of Gotha, at the end of the year 1695 (Lindner 1995). The skeletal remains were transported to Friedenstein Castle and a Collegium Medicum was commissioned to examine the bones. This group of scholarly physicians concluded in their report that the bones had a mineral origin. However, Wilhelm Ernst Tentzel (1659–1707), at that time the inspector of the ducal coin cabinet in Gotha, examined the

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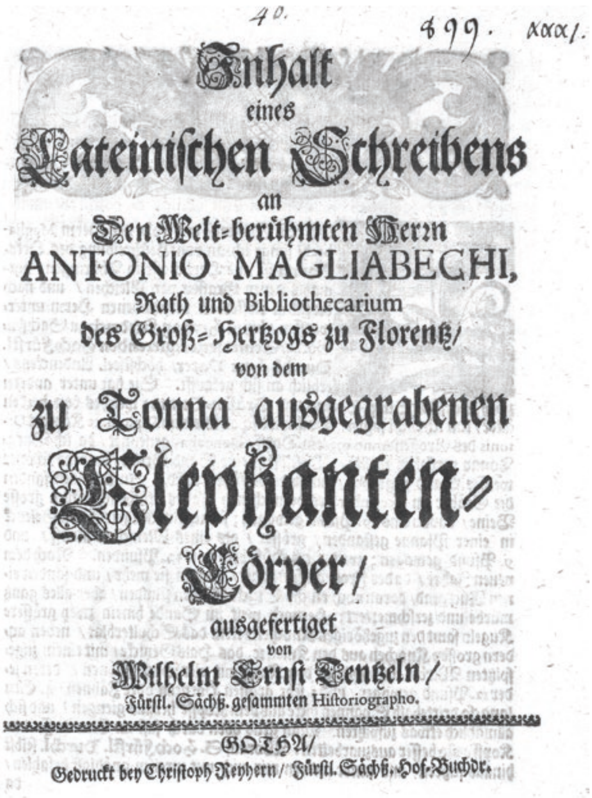
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Cörper/
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von
Wilhelm Ernst Tentzeln/
Fürstl. Sächß. gesammten Historiographo.
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Fig. 23.1 Cover of the original description of the skeletal remains of the Burgtonna elephant described by Ernst Wilhelm Tentzel in Tentzel 1696. (Copyright: Stiftung Schloss Friedenstein Gotha)

find closely. His close correspondence with the Hanoverian polymath Gottfried Wilhelm Leibniz (1646–1716) led to a completely new view of the fossil remains: Tentzel interpreted the fossil tusks and bones as belonging to an elephant carried by the Deluge to Europe (Fig. 23.1) and Leibniz considered that "… changes have taken place in the elephants, that is, that elephants have once existed, which were better adapted to cold regions than those still living today, and that they were inhabitants of our continent." (Bungies and Heinekamp 1990). This view was one of the first steps to the conception of deep time history of living organisms.

One hundred years later, during the regency of the enlightened sovereign Ernest II, Duke of Saxe-Gotha-Altenburg (1745–1804) and a promoter of natural sciences, two distinguished geologists worked at the court of Gotha: Karl Ernst Adolf von Hoff (1771–1837), one of the founders of actualism or uniformitarianism in geosciences, and Ernst Friedrich von Schlotheim (1764–1832), who implemented the Linnean binomial nomenclature in paleobotany (Schlotheim 1820). Both were state servants and temporary trustees of the ducal collections. Hoff's own geological collections remained in Gotha (including some fossils), but Schlotheim's huge private collection was split after his death. His invaluable paleobotanical collection was purchased in 1833 by the Prussian government for the collections of the Royal University in Berlin and is today kept in the Museum für Naturkunde Berlin.

Another foundation of the paleontological collections in Gotha was laid in 1834, when von Hoff purchased hundreds of fossils from Heinrich Georg Bronn (1800–1862) in Heidelberg. August Hellmann (1816–1881), who was trustee between 1852 and 1880, published the first—but unfortunately incomplete—catalog of the paleontological collection (Hellmann 1866). In 1878, at the end of his service in Gotha, the Naturalienkabinett moved from Friedenstein Castle to the nearby newly constructed Ducal Museum [Herzogliches Museum]. During the nineteenth century, the collections were substantially enlarged by purchases of fossils of important Central European sites: Among them are specimens from the Devonian of the Eifel, Germany, the Permian copper shale from Mansfeld, Germany, the Jurassic of Southern Germany (including many ammonites and other invertebrates, several ichthyosaurs from Holzmaden; but relatively few Solnhofen fossils), and the Tertiary of the Parisian and Viennese basins and the Rhön. Substantial numbers of Thuringian fossils come from the Silurian of Eastern Thuringia, the Early and Late Permian of the Thuringian Forest (Fig. 23.2), the complete Triassic (Buntsandstein, Muschelkalk, and Keuper; Fig. 23.3), the Liassic around Gotha, as well as from various Quaternary sites.

Today, more than 60,000 fossils, 15,000 minerals and 5,000 rock samples are kept and scientifically curated in the Museum of Nature Gotha. The most significant material among the paleontological objects are the Early Permian body and trace fossils. Of special importance is the fossil trackway collection of the ichnologist Wilhelm Pabst (1856–1908; Fig. 23.4), originated between 1890 and 1908, as well as the track collections of Bernhard Jacobi, acquired in 1971, and by Sebastian Voigt, acquired in 2004. Many slabs show interesting features such as trackways crossing each other, several ichnotaxa on the same slab, differential depth impressions, claw marks, and pad impressions. Skin impressions are known from well-preserved footprints and from body resting traces. Among the countless scientifically important slabs are for example the hololectotype (MNG 1351) and the paralectotype (MNG 1515) of *Ichniotherium sphaerodactylum*; one of the best examples of *Ichniotherium cottae* (MNG 1352); two "pelycosaurian-grade" synapsid trackways on one slab (MNG 1828): a rare *Tambachichnium schmidti* together with trackways of *Dimetropus leisnerianus*; the holotype of *Varanopus microdactylus* (MNG 1785) and one of the best trackways of this taxon (MNG 2052).

In 1965, an extensive collection of fossil fish, branchiosaurs, and plants of Early Permian strata of the Gottlob Quarry near Friedrichroda was acquired by the museum. This specialization in fossils of the Lower Permian in Thuringia has been continued by curator Thomas Martens since the end of the 1970s. His special research collection of Lower Permian and Triassic conchostracans (clam shrimps) holds about 10,000 individuals. Lower Permian fossil collections of invertebrates, trace fossils and plants were established from over 30 locations in the Thuringian Forest between Gehren in the southeast and Eisenach in the northwest.

With the discovery of the first tetrapod bones in 1974, another area came into the renewed focus of collection and research: the fossillagerstätte "Bromacker" in the Lower Permian Tambach Formation. During the next 35 years, Martens and colleagues were able to build up one of the most important scientific collections of early amphibians, sauropsids, and synapsids outside the USA (Fig. 23.5). Especially since 1993, excavation, preparation and research has been significantly promoted by

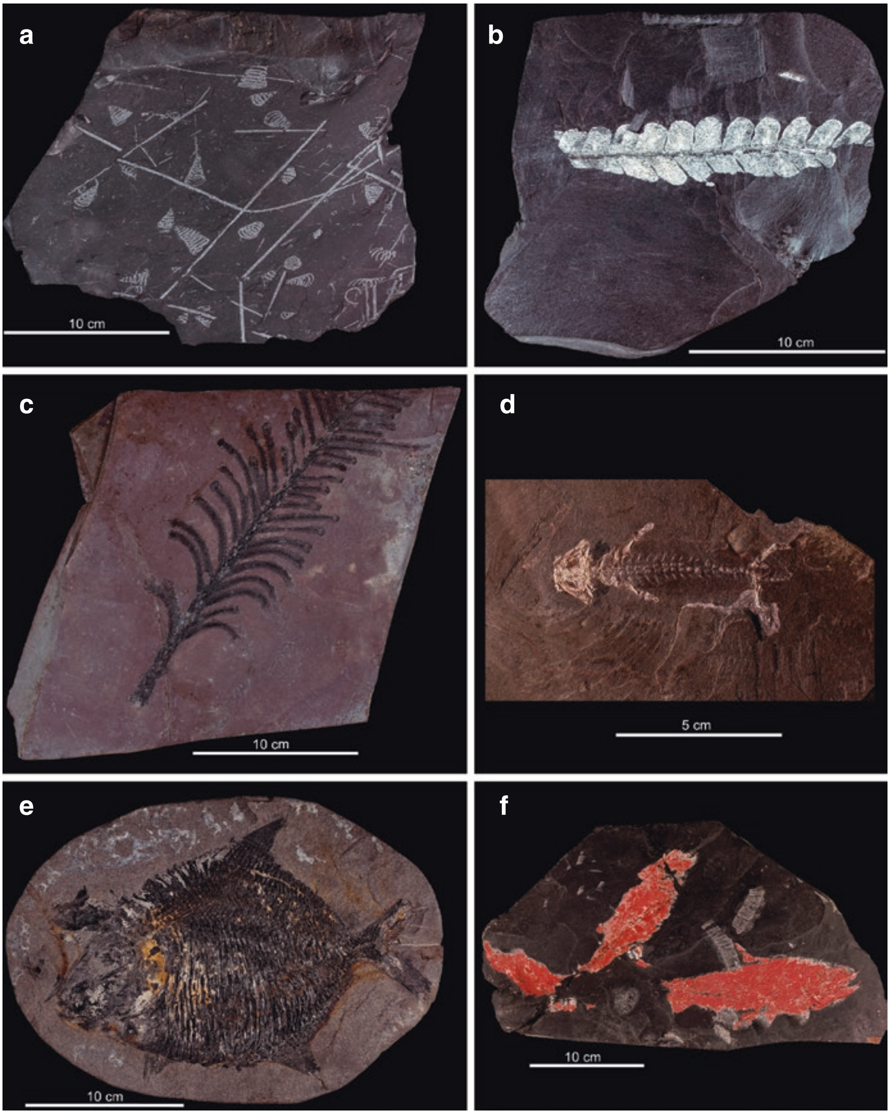

Fig. 23.2 Typical Paleozoic fossils in the MNG collections. (**a**): Graptolites (*Monograptus* & *Diplograptus*) from Hohenleuben. MNG 2336–49. (**b**): Seed fern *Neuropteris* from the Early Carboniferous shales at Lehesten. MNG 3210. (**c**): Conifer branch from the Lower Permian of the Thuringian Forest. MNG 3240. (**d**): Branchiosaurs are small temnospondyls which are very common in Lower Permian shale deposits in the Thuringian Forest. MNG 2335. (**e**): This fossil fish from the Early Permian copper shale of Mansfeld was one of the first specimens in the Gotha collections. MNG 3262. (**f**): Typical red-colored fossil fishes from the Early Permian shale of Gottlob Steinbruch near Friedrichroda. MNG 11526

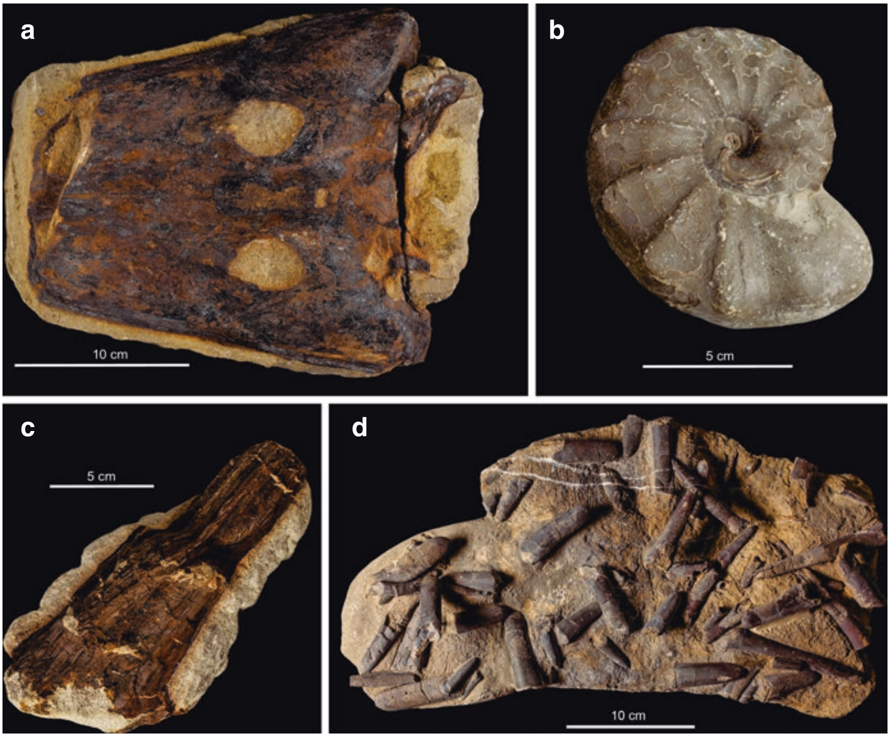

Fig. 23.3 Typical Mesozoic fossils in the MNG collections. (**a**): This skull of the temnospondyl *Trematosaurus*, Middle Buntsandstein, Fuhn et al near Bernburg was received around 1850. MNG 3273b. (**b**): The iconic ammonoid *Ceratites nodosus* is a common index fossil of the Late Triassic Upper Muschelkalk, this specimen was found at the Seeberg bei Gotha. MNG 2109. (**c**): Coaly conifer remains from the Late Triassic Keuper sandstones of the former Toller Hund Quarry in Gotha. MNG 8530. (**d**): Belemnites from the Liassic (very rare in Thuringia) of Röhnberg near Wandersleben. MNG 8783-1

an international team of vertebrate paleontologists from the USA, Canada, Slovakia, and Germany. About 40 skeletons of 13 different early terrestrial tetrapods were discovered in the Tambach Formation until now and allow unique insights into a rare Permian terrestrial upland ecosystem.

Microsaurs, small lepospondyls, are represented by at least the ostodolepid *Tambaroter carrolli* (holotype: MNG 14708; it is the only taxon that has been found outside the Bromacker Quarry at a building pit in nearby Tambach-Dietharz) and a yet undescribed new taxon. Two taxa of dissorophoid temnospondyls belonging to the family Trematopidae, *Tambachia trogallas* (holotype: MNG 7722) and *Rotaryus gothae* (holotype: MNG 10182) are known. Another dissorophoid, *Georgenthalia clavinasica*, (holotype: MNG 11135), belongs to the Amphibamidae. The tetrapod *Seymouria sanjuanensis* (Seymouriamorpha) was formerly known

Fig. 23.4 This photograph was taken in fall 1903 in the southern "stone hall" of the Ducal Museum Gotha. It depicts Wilhelm Pabst with his amanuensis D. Spiegler in front of a large selection of showcases and slabs with Lower Permian tetrapod tracks (Copyright: Stiftung Schloss Friedenstein Gotha)

only from North America. In 1997, ten years after the initial discovery of *Seymouria* at Bromacker, the possibly most iconic and well-known find in the MNG collections was made: the "Tambach Lovers", two complete articulated skeletons embedded in close proximity (MNG 10553 and 10554) which allowed a redescription of the taxon (Berman et al. 2000). Isolated bone and articulated skeletons of diadectids were found regularly at the Bromacker. Two new taxa have been established until now: *Diadectes* ("*Silvadectes*") *absitus* (holotype: MNG 8853) and *Orobates pabsti* (holotype: MNG 10181). Several amniote taxa have been found at the Bromacker as well. Among them are the basal reptile *Thuringothyris mahlendorffae* (holotype: MNG 7729) and the earliest representative of the bolosaurids, *Eudibamus cursoris* (holotype: MNG 8852). *Eudibamus* is also by far the most complete specimen of the bolosaurids world-wide. Its anatomy provided profound evidence for the earliest cursorial bipedal locomotion (Berman et al. 2000). Synapsids ("mammal-like reptiles") are represented by *Dimetrodon teutonis* (Sphenacodontidae; holotype: MNG 10598) and *Tambacarnifex unguifalcatus* (Varanopidae; holotype: MNG 10596). Furthermore, four specimens of a new caseid taxon have been discovered between 1994 and 2006. Their description is currently in preparation.

Since 1992, all fossils with scientific importance excavated in Thuringia fall under the Monument Protection Act and become the property of the Free State of Thuringia.

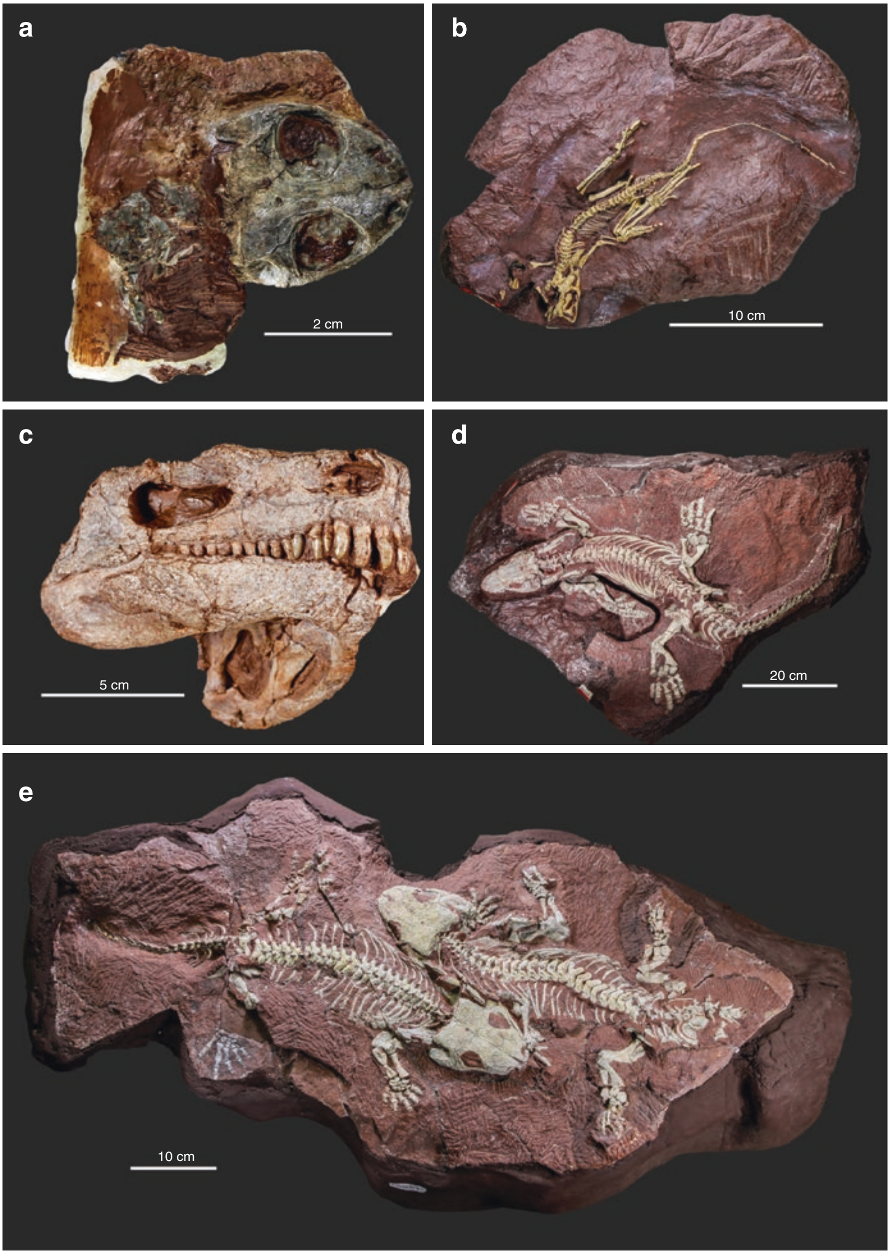

Fig. 23.5 Important tetrapod fossils from the Bromacker locality. (**a**): Skull of the holotype of the amphibamid dissorophoid, *Georgenthalia clavinasica*. MNG 11135. (**b**): Cast of the holotype of *Eudibamus cursoris*, the first bipedal tetrapod in the fossil record. MNG 8852. (**c**): Excellently preserved skull of an diadectid tetrapod. MNG 8760. (**d**): Holotype of the diadectid *Orobates pabsti*. MNG 10181. (**e**): Probably the best-known specimen in the collections of the Museum der Natur Gotha: the “Tambach Lovers”, two fully articulated specimens of *Seymouria sanjuanensis*. MNG 10553 and 10554

This includes most of the Bromacker vertebrates, which are currently curated at the Museum der Natur. It is theoretically possible that these specimens and their curation may be transferred to another institution in Thuringia which affects future fieldwork under the statutes of the Stiftung Schloss Friedenstein. Future priority for expanding the collections lies in fossils and rocks of regional and supraregional importance from the surroundings of Gotha and Thuringia. In agreement with all other Thuringian natural history museums, the collection effort of the Museum of Nature is primarily focused on the Thuringian Forest and West Thuringia. We expect the main future paleontological collecting activities in Lower Permian strata of the Tambach Formation.

A challenge for most museums is to meet modern international standards for accessibility of collections via the registration of the specimens in digital databases. All departments of the Stiftung Schloss Friedenstein use the database IMDAS Pro which is curated by the Bibliotheksservice-Zentrum Baden Württemberg. While the digital IMDAS Pro catalog of the paleontological collections is just aborning, available digital data already include state-of-the-art three-dimensional models of important specimens (Fig. 23.6). Digital spread sheet lists of important parts of the collections were in use for several years until now. Online access to catalogs is planned for the future.

Fig. 23.6 Left: Photograph of track slab MNG 1823 with *Dimetropus leisnerianus* (including tail drag marks). Wilhelm Pabst for scale. Photograph taken in 1903. Right: Computer screen-shot of the photogrammetric three-dimensional model of the slab

23.2 Exhibitions

It is plausible that paleontological objects were already included in the displays of the baroque Kunstkammer of Friedenstein Castle. In the nineteenth century, after the opening of the Ducal Museum on April 17, 1879, this new home for the collections presented collections of both art and natural sciences to the public. However, it was not until the discovery of Permian vertebrate trackways at Tambach-Dietharz and their subsequent systematic collection by Wilhelm Pabst that paleontological objects played an important role in the collections and exhibitions (Fig. 23.4).

Following WWII, after the removal of many art objects by the occupying powers, only the natural sciences collections remained in the museum building. It became the "Zentralmuseum für Biologie" (central museum of biology) with an exclusive focus on collection and exhibition of biological, geological, and paleontological objects. The ducal collection was amended by the collections of the previously independent local Natural History Museum in 1953. In August 1954, soon after the exhibition "Earth History of Germany" was finished, the Zentralmuseum was opened. Development and construction of the exhibition "Thuringian Forest—Nature and Natural History of a Landscape" begun in 1960 and extended over a period of 14 years. In 1979, fundamental reworking of the earth history section took place and the new exhibition was titled "Petrified Witnesses from Millions of Years". In 1997, after the spectacular tetrapod fossils finds at the Bromacker, the exhibition "Early Saurians between the Thuringian Forest and the Rocky Mountains" was opened. At the center of this presentation were the unique findings of early amphibians, sauropsids and synapsids combined with a 12 m wide diorama created by the Canadian artist Jan Sovák.

In December 2010, all natural history exhibitions in the Ducal Museum had to close to the public due to ongoing restoration work, the restructuring of the museal landscape in Gotha, and the implementation of the masterplan "Baroque Universe Gotha" (Samietz et al. 2014). Plans for the future include that the "Kunstkammer" and the "Naturalienkabinett" (historical natural history collections) will once again be brought together under one roof—the castle—in order to display and communicate baroque and enlightening thinking to the visitors. Several other permanent exhibitions of the Museum of Nature, including the paleontological collections with a special focus on the Lower Permian Bromacker fossils, will subsequently move into Schloss Friedenstein once the west wing of the castle is completely restored. Until then, temporary exhibits and travel exhibitions will highlight some aspects of Gotha's rich paleontological treasures.

23.3 Repositories and Rooms

The basement of the Ducal Museum housed art objects as well as the geological collections between 1879 and 2010. It also housed the offices of the employees until 2010. Nowadays, the main offices of the scientists of the Museum of Nature are situated in Friedenstein Castle. Since 2015, the collections are hold in two state-of-the-art repositories in the Perthes-Forum in Gotha, situated some 500 m from the castle. The first of two dedicated, air-conditioned, and safety-monitored rooms holds all large specimens including Pleistocene material and large fossil track slabs, most other ichnofossils and the Lower Permian fossil material, except from Bromacker. The second room yields not only the latter, but also all other paleontological objects together with the rock and mineral collections. During the move of the collections to the Perthes-Forum, plans were realized for a new paleontological preparation lab. The rooms are available, but still await most technical equipment necessary for an efficient and productive preparation of fossils.

23.4 Staff

One permanent position with the main responsibility of curating the geoscientific collections is designated in the staff appointment scheme of the foundation Stiftung Schloss Friedenstein. From 2017 to 2022, a temporary position funded by the Thuringian Ministry of Science is complementing the research on the historical parts of the geoscientific collections around 1800. Unfortunately, there is currently no permanent geoscientific preparator position available in Gotha. It is feasible, however, that temporary preparator positions will open up with upcoming research projects.

23.5 Research

Research in the paleontological collections in Gotha has a long and successful tradition. As mentioned earlier, geologists and paleontologists in Gotha have contributed significantly to the development of modern geosciences. Today's research in the Museum der Natur is focused on two areas: The first topic concerns the historical collections and history of geosciences in Gotha. Virtually all collection catalogs have survived the centuries and are available for historical research. Together with a substantial number of surviving original specimens, a wealth of written correspondence, and other documents archived in the Gotha Research Library, the catalogs provide excellent conditions to clarify the relationships and scientific views around the year 1800.

The second topic is largely based on the vertebrate fossils and the trace fossils from the fossillagerstätte Bromacker. Initiated by Thomas Martens, the responsible curator at that time, a very productive cooperation between the Carnegie Museum of Natural History and the Museum of Nature Gotha was established in 1993. The outcome of this cooperation regarding the Bromacker locality manifests not only in many superbly prepared tetrapod fossils, but also in a large number for scientific publications and popular reports. Bromacker research still relies on cooperation with visiting specialists from other institutions. For example, a large research project is currently established with vertebrate paleontologists at the Museum für Naturkunde Berlin.

Another strong topic of research remains the Lower Permian vertebrate tracks (predominately the collections of Wilhelm Pabst and Sebastian Voigt). Trackway studies were conducted early beginning with Arno Hermann Müller (University of Freiberg) in the 1950s and Hartmut Haubold (University of Halle-Wittenberg) in the late 1960s and early 1970s. This work continues up to today. For example, the Bromacker locality is unique in preserving highly detailed vertebrate trackways and exquisitely preserved skeletons in one stratigraphic section. This allows matching trackways with their makers, as has been shown for the ichnotaxa *Ichniotherium cottae* and *Ichniotherium sphaerodactylum*, which match the body fossils of the diadectids *Diadectes absitus* and *Orobates pabsti*, respectively (Voigt et al. 2007). The Bromacker material still has high potential for research in many aspects, such as taxonomy (the majority of the finds has not yet been prepared), taphonomy, paleobiology, and paleoecology. Other comprehensive parts of the collections, such as the Permian fish and plant fossils from the Thuringian Forest, have not been studied at all.

23.6 Public Outreach

With the current lack of a permanent paleontological exhibition, the public outreach is limited to museum educational service for school classes, smaller temporary exhibitions about special topics, and occasional documentaries by TV and radio stations. Use of social media will be intensified in the near future in order to exhibit the curational work to the public.

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Chapter 24
GÖTTINGEN: The Palaeontological Collections of the Geoscience Museum at the Georg-August University in Göttingen

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As starting point of the palaeontological collections at the Georg-August University of Göttingen (known informally also as Georgia Augusta), the founding of the Royal Academic Museum in 1773 can be considered. However, due to the accession of whole collections from various sources after this date as well as from the acquisition of objects from early academic teachers of the University (founded in 1737) a considerable number of items dates back as far as to the late seventeenth century (Reich 2012a). A good example for this may be one of the collection's oldest objects, a large slab of Early Jurassic Posidonia Shale from southern Germany (Fig. 24.1), excavated around the year 1700 and first mentioned and figured by Hiemer (1724). It was acquired together with the collection of Georg August Ebell (1745–1824) in 1827 (Reich 2010, 2014). Another example are skeletal remains of the woolly rhinoceros (*Coelodonta antiquitatis*) from

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Fig. 24.1 Sea-lily (*Seirocrinus subangularis*) from the Early Jurassic Posidonia Shale of southern Germany, also known as the "swabian caput medusae", first illustrated by Hiemer (1724) [Inv.-no. GZG. HST.04999]. Size of the slab approx. 1 m^2. Photo: GZG Museum/G. Hundertmark

the southwestern margin of the Harz mountains, sent to the Göttingen professor Samuel Christian Hollmann (1696–1787) in 1750 and 1751 (Hollmann 1753a, b) that were later incorporated into the museum collections and served, together with material from Russia, as a basis for the scientific description of the species by Johann Friedrich Blumenbach (1752–1840) in 1799 (Blumenbach 1799).

The collection attained a first significant growth, already in its founding year with the purchase of the coin and natural history cabinet of Christian Wilhelm Büttner (1716–1801) that contained besides coins, objects of art and archaeology as well as zoological specimens, minerals, rocks and gemstones, also a considerable amount of fossils. In 1777 the large geoscientific collection of Christoph Andreas Schlüter (1668–1743), previously stored at the Royal library in Hannover, was obtained, together with objects with provenance from Gottfried Wilhelm Leibniz (1646–1716) (Fig. 24.2) that have been kept there too (Walliser and Alberti 1987; Reitner et al. 2001; Reich 2012b; Reich et al. 2014, 2015a; Reich and Gehler 2014).

Starting from 1776, J. F. Blumenbach steered the fortunes of the royal academic museum for several decades, first as the curator of the collections under the direction of Christian Gottlob Heyne (1729–1812), from 1812 onwards as its director.

A first comprehensive catalogue of the Academic Museum collections was finished by J. F. Blumenbach in 1778 that lists more than 1500 positions with palaeontological objects.

In the same year an alumnus of the Georgia Augusta, Georg Thomas von Asch (1729–1807), started his substantial donations (mainly books, coins, objects of nat-

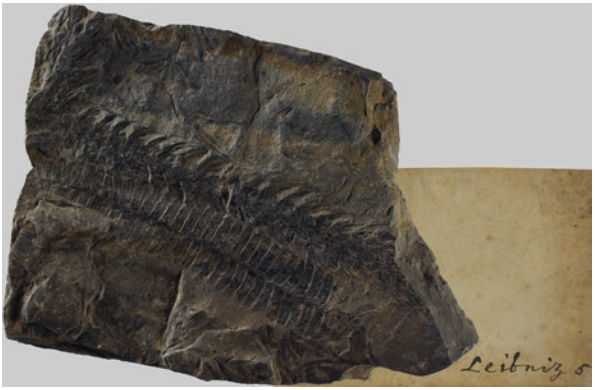

Fig. 24.2 Tree-like horsetail (*Annularia sphenophylloides*), from the Late Carboniferous of Planitz near Zwickau; Saxony from the collection of G. W. Leibniz together with a handwritten label of J. F. Blumenbach [Inv.-no. GZG.HST.00916]. Size ca 10 × 7.5 cm. Photo: GZG Museum/G. Hundertmark

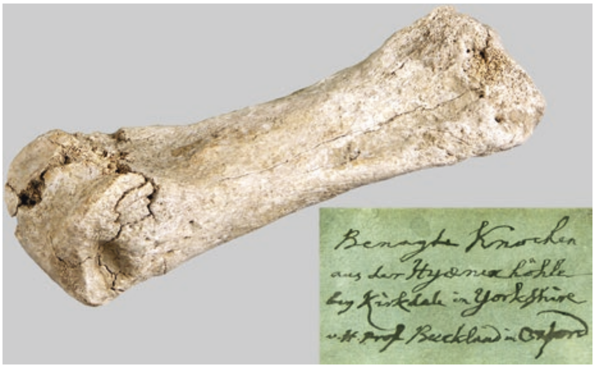

Fig. 24.3 Metacarpal bone of a woolly rhinoceros (*Coelodonta antiquitatis*) from the Pleistocene of the hyaena cave in Kirkdale, England with cave hyaena (*Crocuta crocuta spelaea*) gnaw-marks. A donation of W. Buckland with a handwritten label of J. F. Blumenbach [Inv.-no. GZG.HST.00169]. Length ca 16 cm. Photo: GZG Museum/G. Hundertmark

ural history and ethnography) from all over the vast Russian Empire, including a considerable number of fossils. His continuous endowments lasted for nearly three decades, until 1806 (Reich et al. 2014).

In 1793 the (Royal) Academic Museum moved with all its collections (excluding the herbaria, which were placed in the botanical gardens now) due to reasons of space from the eastern wing of the university library to another building nearby that formerly served as residence for professors.

The palaeontological collections of the Academic Museum (as well as his private collection) were growing continuously under Blumenbach's care. His colleagues and correspondants, like Joseph Banks (1743–1820), William Buckland (1784–1856), Petrus Camper (1722–1789), Jean-André Deluc (1727–1817), Georges Cuvier (1769–1832), Georg Forster (1754–1794), Johann Reinhold Forster (1729–1798), Carl Ludwig Giesecke (1761–1833), Johann Wolfgang von Goethe (1749–1832), Adolf von Hüpsch (1730–1805), Martin Hinrich Carl Lichtenstein (1780–1857), Martinus van Marum (1750–1837), Johann Heinrich Merck (1741–1791) and Samuel Thomas von Soemmerring (1755–1830) supported him with considerable numbers of natural history objects (Fig. 24.3).

Fig. 24.4 Trilobites (*Ellipsocephalus hoffi*) from the Middle Cambrian of Jince, Czech Republic. A gift of E. F. von Schlotheim (who named the species after another pupil of Blumenbach, K. E. A. von Hoff) with a handwritten label of J. F. Blumenbach [Inv.-no. GZG.HST.00873]. Size ca 6.5 × 4.5 cm. Photo: GZG Museum/G. Hundertmark

A growing number of current and former students, among them Christian Leopold von Buch (1774–1853), Christian VIII. of Denmark and Norway (1786–1848), Karl Ernst Adolf von Hoff (1771–1837), Alexander von Humboldt (1769–1859), Georg Heinrich von Langsdorff (1774–1852), Ludwig I. von Bayern (1786–1868), Ernst Friedrich von Schlotheim (1764–1832), Vasilij Michajlovič Severgin (1765–1826) and Maximilian zu Wied-Neuwied (1782–1867), followed this practice (Fig. 24.4).

After the death of J. F. Blumenbach in 1840, Johann Friedrich Ludwig Hausmann (1782–1859) took over the direction of the Academic Museum, who already held the first geoscientific chair (mineralogy and technology) at Göttingen University and was involved in the curation of the mineralogical collection since 1815. Blumenbachs private natural history collections that complemented the still existing inventory in an excellent way were purchased by the University a few months after his death (Reich and Gehler 2012).

A large contribution of more than 2,500 palaeontological objects was made by Wolfgang Sartorius von Waltershausen (1809–1876) in 1847 that were part of a donation of overall more than 13,000 geoscientific specimens (Anonymus 1862), in 1848, von Waltershausen got an extraordinary professorship for mineralogy and geology in Göttingen. After rejecting several sale offers of fossil collections in former years, e.g. in 1838 that of Friedrich Adolph Roemer (1809–1869) and in 1845 that of Georg Graf zu Münster (1776–1844), the university in 1856 bought the collection of Friedrich Ludwig Christian Jugler (1792–1871) with a large regional focus. After the death of J. F. L. Hausmann in 1859, W. S. v. Waltershausen followed him as ordinary professor of mineralogy and geology and director of the mineralogical collections (that at this time included palaeontology as well) in 1860. In 1862 these collections were moved, again due to reasons of space, to the university's Aula at the Wilhelmsplatz. A second geoscientific professorship (geology-palaeontology) was installed and filled with Karl von Seebach (1839–1880) in 1863. In the same year, the collection of Heinrich Anton Karl Berger (1796–1861) was bought, already one year before that of Friedrich Armbrust (1830–1861) and K. v. Seebach donated his personal collection in 1866, the year the collections were moved again to a former hospital building in the Mühlenstraße (Seebach 1867) (Fig. 24.5). Subsequently

Fig. 24.5 Skeleton of an European badger (*Meles meles*) from the Pleistocene travertines of the area of Weimar, Thuringia, originating from the collection of K. v. Seebach and published by Hermann von Meyer in 1859 [Inv.-no. GZG.V.21237]. Size ca 25 × 20 cm. Photo: GZG Museum/G. Hundertmark

a lot more (smaller) acquisitions were made (Seebach 1869, 1870, 1871). Two larger collections containing palaeontological objects were acquired from Georg Landgrebe (1802–1873) and Wilhelm Waagen (1841–1900) in 1869 and 1870 respectively (von Seebach 1870, 1871). Two more large collections were accessed, one from Friedrich Ernst Witte (1803–1872) as a donation in 1873 the other from Friedrich Ludolf Hausmann (1810–1880), oldest son of J. F. L. Hausmann, which in part also contained fossils, as a purchase in 1875 (Reich et al. 2014).

A milestone was reached in 1877 with the reunification of all collections of natural sciences in the newly built Natural History Museum nearby the railway station, where the palaeontological collections should be housed for nearly the next 100 years.

After K. v. Seebachs early death, Adolf von Koenen (1837–1915) was set on his position in 1881, his private collection was purchased one year later. In 1884 an own institute for geology and palaeontology was founded.

Further partial collections were purchased, e.g. those of Johann Georg Bornemann (1831–1896) in 1897 and Heinrich Ludolf Wissmann (1815–1892) in 1899 as well as a large collection of fossil ostracods from Ernst Lienenklaus (1849–1905) in 1905.

As successor of A. v. Koenen, Josef Felix Pompeckj (1867–1930) was appointed in 1907 as professor for geology and palaeontology.

After J. Pompeckj moved to a professorship in Tübingen, Hans Stille (1876–1966) got his position in 1913. Also in 1913, another important purchase was made with a large part of the collection of Anton Schrammen (1869–1953) and Hugo Wegele (1886–1914) received his doctorate with a work on Tertiary sediments in the area of Willershausen, Lower Saxony, that laid the foundation for the still ongoing exploration of the Pliocene fossil lagerstaette Willershausen (e.g. Reich 2008; Reich and Gehler 2011) and the huge respective collection with today more than 40,000 specimens.

In the first year of World War I, H. Stille was drafted to military service and was substituted first by the emeritus A. v. Koenen until his death in 1915 and later by Rudolf Wedekind (1883–1961), who also donated his fossil collection in 1915 to the University of Göttingen. He moved in 1917 to the University of Marburg. However, additionally to his Marburg position, he realised his tasks in Göttingen still until November 1918, when H. Stille returned to Göttingen.

In 1922, Hermann Schmidt (1892–1978) was employed as a curator for the geological-palaeontological collections. As in 1932 H. Stille moved to Berlin, the search for a successor could not be completed until 1934. Finally in 1935, Othenio Abel (1875–1946) was appointed as chair. During the yearly conference of the Paläontologische Gesellschaft in 1937, a new permanent exhibition, initiated by O. Abel, was inaugurated that contained besides reconstructions of fossil vertebrates on large paintings and as sculptures from Franz Roubal (1889–1967) also a special part dedicated to history of palaeontology, particular with regard to the historical collections of Göttingen University. Also in 1937, a second (extraordinary) professorship (geology) was established in the Geological-palaeontological institute and was filled with Walter Schriel (1892–1959), who took over the chair professorship after O. Abel became Emeritus in 1940 (Walliser and Alberti 1987; Reitner et al. 2001; Reich et al. 2014).

The losses due to World War II occurred mainly in 1945. Although moderate, they were deeply distressing, as besides important type material, also original specimens illustrated by Leibniz (1749) in his "Protogaea" as well as some Blumenbachiana were among them. Early in 1945, 25 boxes with exceptionally valuable material from the Geological-palaeontological institute were removed to the potash mine Volpriehausen near Göttingen to ensure a safe storage, to which already parts of the famous collection of Baltic Amber from the Albertus University in Königsberg (at that time a partner university) were had been evacuated. They survived there safely the end of the war, however, in September an underground explosion destroyed large parts of the books and objects from Göttingen University and other places stored there. Already in the last war weeks, on 7th April 1945, a blockbuster bomb hit the museum building and parts of the permanent exhibition were destroyed (Schmidt 1964; Reich et al. 2014, 2015b).

After the suspension of W. Schriel in 1945 by the British occupation authorities, Erich Bederke (1895–1978) became ordinarius for geology and palaeontology in Göttingen in 1946. Following World War II also some scientists who formerly worked in Königsberg found a new home in Göttingen, among them Karl Erich Andrée (1880–1959), once scholar of A. v. Koenen in Göttingen and later professor at the Albertus University as well as director of the formerly world's largest amber collection. From the latter, luckily the most important part in two wooden boxes was recovered from the Volpriehausen potash mine before the explosion took place (more material was retrieved still from the rubble after the explosion), in all the

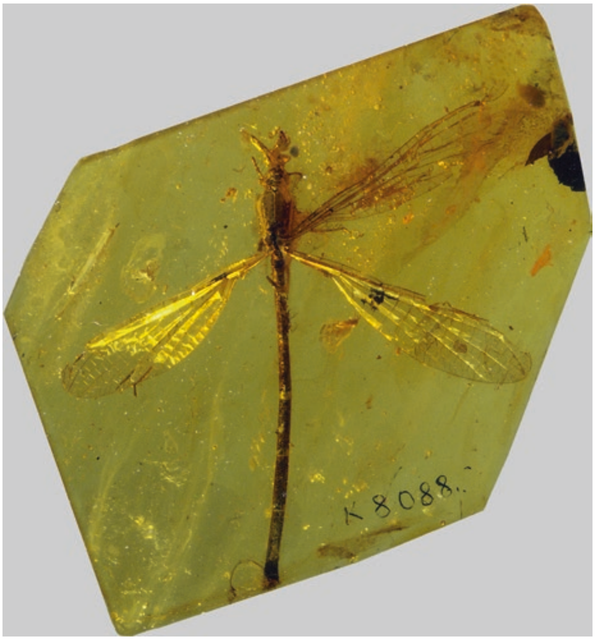

Fig. 24.6 Damselfly (Odonata: Zygoptera) in Eocene Baltic amber, originating from the former Königsberg Amber Collection [Inv.-no. GZG. BST.05506]. Size ca 5 × 4.5 cm. Photo: GZG Museum/G. Hundertmark

saved part comprised about 20,000 samples. Until 1958 this supply was kept in the central storage for cultural heritage of the British occupation zone in Celle, thereafter it was placed under trusteeship of the University of Göttingen in the palaeontological collections, where it is kept until today (Fig. 24.6). In 1961 H. Schmidt (who had become adjunct professor in 1927 and extraordinary professor in 1954) retired. A second chair professorship (palaeontology) was erected in the Geological-palaeontological institute in 1963 and filled with Adolf Seilacher (1925–2014). As he moved to Tübingen in 1965, his position was replaced by Otto Heinrich Walliser (1928–2010). In the same year E. Bederke's chair was reoccupied (now solely geology) after his retirement in 1965 with Henno Martin (1910–1998).

In 1966, Siegfried Ritzkowski (born 1933) became curator of the geological and palaeontological collections. An eminent acquisition was made in 1968, when a special collection of the Pliocene fossil lagerstaette Willershausen with more than 17,000 specimens was purchased from Adolf Straus (1904–1986). A. Straus did already his doctorate in 1929 on palaeobotanical aspects of this famous locality with H. Schmidt as his supervisor. Despite he pursued a professional career away from geosciences, his interest in investigating this special fossil site (including the accumulation of extensive collections) lasted life long (Fig. 24.7).

From 1974 to 1976 the palaeontological collections were moved to their contemporary location on the northern campus of Göttingen University.

Hans Jahnke (born 1941) was employed as a second curator in 1976, in the same year the geological collection of the Adolfinum secondary school in Bückeburg, Lower Saxony was committed to Göttingen as a long-term loan. This collection, consisting of about 1,500 specimens, focuses mainly on vertebrate remains (e.g.

Fig. 24.7 Eurasian field mouse (*Apodemus atavus*) from the Pliocene fossil lagerstätte Willershausen, Lower Saxony [Inv.-no. GZG.W.20027]. Picture width ca. 12 cm. Photo: GZG Museum/G. Hundertmark

Fig. 24.8 Small ornithischian dinosaur (*Stenopelix valdensis*) from the Early Cretaceous, found in 1855 on the Harrl heights near Bückeburg, Lower Saxony and described by Hermann von Meyer in 1857. It belongs to the geological collection of the Adolfinum secondary school in Bückeburg [Inv.-no. GZG.BA.00048]. Size ca 60 × 35 cm. Photo: GZG Museum/G. Hundertmark

crocodiles, turles and dinosaurs) from Lower Cretaceous (Berriasian) strata of the Bückeburg area (Fig. 24.8) (Reich et al. 2014; Reich et al. 2015).

The retirement of O. H. Walliser took place in 1993, he was followed by Joachim Reitner (born 1952), who holds this position since 1994. After the retirement of S. Ritzkowski in 1998 (without restoring his position) and H. Jahnke in 2004, Mike Reich (born 1973) became curator of the collections (including the entire mineralogical collections as a result of the retirement of Günter Schnorrer (1941–2015) with end of year 2003).

In 2008 an important acquisition was made with the collections of Manfred Kutscher (born 1943) that focus mainly on Bitterfeld Amber and invertebrates from Cretaceous strata of northern Germany. When, in 2014, M. Reich switched to the Bavarian State Collections of Palaeontology and Geology in Munich, Alexander Gehler (born 1978) became curator of the Göttingen geoscience collections.

Overall, the palaeontological collections today incorporate about 2.5 million objects, which are dispersed on micropalaeontology (ca 2,000,000), invertebrate palaeontology (ca 250,000), vertebrate palaeontology (ca 100,000), palaeobotany (ca 40,000), Willershausen collection (ca 40,000), amber collections (ca 30,000), fossil lagerstaetten (excluding Willershausen ca 15,000), ichnofossils (ca 12,000), Adolfinum collection (ca 1,500).

In addition to the persons mentioned above, in the course of their studentical education, doctorate or postdoctoral work, a large number of other well-known palaeontologically working geoscientists of the nineteenth and twentieth century spent time at the Georgia Augusta, to mention only a small selection, this included Hermann Credner (1841–1913), Franz Eugen Geinitz (1854–1925), Louis Beushausen (1863–1904), James Perrin Smith (1864–1931), Alexander Tornquist (1868–1944), Arnold Bode (1876–1961), Wilhelm Freudenberg (1881–1960), Hans Salfeld (1882–19??), Anselm Windhausen (1882–1932), Rudolf Wedekind (1883–1961), Fritz Dahlgrün (1894–1954), Hans Gallwitz (1896–1958), Otto Heinrich Schindewolf (1896–1971), Kurt Friedrich Daniel Fiege (1897–1983), Roland Brinkmann (1898–1995), Otto Sickenberg (1901–1974), Johannes Wolburg (1905–1976), Martin Schwarzbach (1907–2003), Ulrich Lehmann (1916–2003), Arno Hermann Müller (1916–2004) and Jürgen Remane (1934–2004).

This explains once more the highly diversified research that was performed in Göttingen within the last nearly three centuries in all fields of palaeontology. Today, the palaeontological research areas focus mainly on invertebrates, early life on earth (geobiology) and geomicrobiology, as well as on palaeobotany and amber research.

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Chapter 25
HALLE: The Geiseltal Collection of Martin Luther University, Halle-Wittenberg

Frank D. Steinheimer and Alexander K. Hastings

25.1 Introduction

For the former coal excavation site of the Geiseltal near Merseburg in Saxony-Anhalt, Germany, the first Eocene fossils were formally recognized in 1908, but their scientific significance was not appreciated before Ben Barnes' (1903–1969) studies in the 1920s (Barnes 1927). With extensive coal excavation and extraordinary cooperation with the coal digging company, systematic studies on the fossils were conducted from the 1930s onwards by Prof. Dr. Johannes Walther (1860–1937) and Prof. Dr. Johannes Weigelt (1890–1948). Weigelt wrote many of the early scientific papers on Geiseltal, including the description of a nearly complete skeleton of an ancestral horse (Weigelt 1934). Careful documentation and stratigraphic studies accompanied the fossil excavation. Much of Weigelt's research later focused on biostratinomy, the study of what happens to a deceased organism from the time of death to its final burial. By 1934, a dedicated museum for the Geiseltal fossils was founded and housed in the historic Renaissance building, the so-called New Residence of Cardinal Albrecht of Brandenburg (Hellmund 2002). This Geiseltalmuseum gave an overview of the scope of fossils found at the site as well as explaining phylogeny and diversification of vertebrates of the Eocene, in comparison to skeletons of recent species. In the 1950s the mounted skeletons of recent species were exchanged for large wall paintings illustrating the ancient environments of the Geiseltal. Prof. Dr. Hans Gallwitz (1896–1958) and Prof. Dr. Horst Werner Matthes (born 1911, retired 1976) restarted excavations after World War II. During the 1950s and 1960s the largest amount of fossils were rescued for the collection. In 1993 the coal pit was closed, subsequently flooded and

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fossil excavation came to an end by 2003. The Geiseltal Museum has limited the public access to one afternoon per week due to curatorial and climatic problems in the historic Renaissance building. These problems, however, have been addressed and in the near future, the entire collection will be moved to a specially adapted collection space nearby. Except for most of the plant fossils, all other fossils from the Geiseltal site came to the Geiseltal Collection of the university at Halle (Saale); plant fossils were mainly forwarded to Berlin's natural history museum where in the 1970s an expert team headed by Dr. Ludwig Rüffle (b. 1931) worked on the pollen, seeds, leaves and other plant remains. The Geiseltal Collection has been nominated as part of the important national heritage of Germany.

25.2 Preservation of Geiseltal Fossils

During the Eocene, Geiseltal was covered by dense jungles and open plains with sinkhole lakes, creeks, and peat bogs. The warm and wet habitats supported abundant vegetation, building up in swamps and the surrounding areas of sinkholes. Along with the water and plant material (biomass), bodies of the animals that lived in the area gathered and were gradually buried underneath more and more vegetation. This lush environment persisted for more than five million years. Compression from the overlying organic material and resulting acidic chemical processes turned the vegetation into peat millions of years later. Further chemical degradation (called diagenesis) led to further change of the peat into a loose rock known as lignite, or brown coal. Most of the fossils of Geiseltal are incredibly preserved. Normally the aggressive acids associated with peat bog formation destroy the bodies and even the bones of ancient animals during the long coal formation processes. However, at Geiseltal there was an important feature nearby that ultimately led to rare and phenomenal fossil preservation. Uphill, to the west and southwest of the peat-forming area, was a limestone plateau that was being slowly weathered by small waterways or riverlets. These riverlets brought water that contained calcium-carbonate that counteracted the acids built up from the decaying plant matter. As a result, instead of being fully decomposed, animal carcasses at Geiseltal could often be fossilized in three dimensions within the forming coal. In many cases the fossilization process was so complete that skeletons were preserved in complete articulation. Even soft tissue was sometimes preserved, including the stomach contents of a fossil horse. Furthermore, microstructures such as stomata of leaves, the iridescent colours of jewel beetles or even the chlorophyll of plants are conserved. Studies were even able to determine whether these Eocene plants accumulated carbonate as C4 or C3 pathways.

The collection is unique for the understanding of life conditions of vertebrates from the Eocene. The Geiseltal researchers have therefore become leading experts in the understanding of the proportions and ecology of enigmatic species such as the giant flightless bird *Gastornis* or the land-living (and land-hunting) crocodile *Boverisuchus*. The Geiseltal site is also special in the way it accumulated the bodies of deceased animals (Krumbiegel et al. 1983). All fossilized animals also lived in the place where their bodies accumulated, dying and fossilizing in the same place, without or with hardly any water-driven movement, explaining the large number of articulated skeleton remains. This preservation of even larger mammals on the spot diminished the bias towards smaller specimens of other sites such as Messel and supported a large scope of all living vertebrates (125 species recorded so far, Hellmund 2007). Important for the Geiseltal site is that most animal bodies were immediately imbedded within the bog, not allowing for substantial decay or transport before fossilization. All deposits accumulated within an oxygen-poor environment, inhibiting bacterial activity, and improving preservation quality during the fossilization process.

The differences of accumulated calcium carbonate in the ancient Geiseltal site are problematic because of clinal variation in preservation of fossils. Those specimens found closer to the limestone plateau have fossilized more completely than those further away. Thus from Southwest to Northeast the quality of fossils changes considerably, leaving very fragile fossils in the most distant pits.

25.3 The Palaeo-Environment and the Long-Geological Time Sequence of Geiseltal

Studies of fossil plants at Geiseltal backed the first estimates of past temperature at around 22.9–25 °C mean annual temperature (Mosbrugger et al. 2005). Likewise, the coldest month mean temperature for the site was estimated at 16.9–23.0 °C. Thus, the palaeo-climate of the Eocene at Geiseltal was comparable to the subtropics of modern-day Florida (USA). The geographical position of modern Geiseltal is centred in the mainland of Europe, but 45 million years ago it was situated in a network of subtropical islands in a shallow sea covering most of northern Germany and northern France. Ancient Geiseltal itself was definitely an inland habitat, but much closer to the coastline than today (Storch 1986).

Geological dating of the Geiseltal deposit proved difficult—there is no method available to determine the absolute age of coal from this time. However, by the help of the Mammal Paleogene Zones (MP Zones), a division of time based on rapid mammalian evolution, one can use direct comparisons to other fossil sites and their dating to estimate the geological age of the Geiseltal site (Franzen & Haubold 1987). The mammal fossils at Geiseltal were so abundant and representative of their time that the unit of time they represent was named the "Geiseltalian" (European Land Mammal Age, or ELMA). Based on the fossils found at Geiseltal, other fossil sites were found to match with this time and therefore also assigned a Geiseltalian age. These include the well-known Messel fossil site near Darmstadt, Germany, dated by the rock underneath to 47.8 ± 0.2 million years ago (Mertz & Renne 2005), temporally equivalent with the geologically older layers at Geiseltal, and the Eckfeld fossil site in southwestern Eifel, Germany, dated 44.3 ± 0.4 million years ago (Mertz et al. 2000), equivalent with the younger Geiseltal layers. Interestingly, the youngest fossil deposits of the Geiseltal site actually extend even beyond the Geiseltalian into the next ELMA, the Robiacian. All in all, the geological time of the Eocene fossil record at Geiseltal is thus dated to about 47.5–42.5 million years old, representing roughly a five million year time sequence, far more than can be found at any other Eocene site in Germany (Hastings & Hellmund 2015b). This includes the Mammal Palaeogene Zones (MP) 11–14.

25.4 Scope of the Geiseltal Collection

Considering the fact that the fossil record at any location is always a small proportion of what used to live in the area, and still preserving a substantial fossil record, one can postulate that the ancient ecosystem of Geiseltal was highly diverse, supporting a wide array of animals, especially vertebrates. Thus far, 125 different vertebrate species have been identified at the Geiseltal fossil site (Hellmund 2007). Generally, diversity increased across the Geiseltalian, reaching its peak in the later layers of the lignite deposits. Fossils range from incredibly common species, with hundreds of individuals, to ones identified from just one partial bone. Altogether, about 50,000 fossils are now archived in the Geiseltal Collection.

Plants. Plant fossils at Geiseltal have included a species of horsetail (*Equisetum*), five different kinds of fern, one cycad species, five different conifers, and 37 different species of flowering plants. Both, the three dimensional preservation, for instance, of pine cones as well as the high quality preservation of microstructures in leaves and pollen on cell level make these remains a unique source for the study of Eocene floras (Teodoridis et al. 2012). A large amount of the Geiseltal plant material is illustrated by Schmidt (1976).

Invertebrates. By 1935, eight different fossil gastropods were described, five land snails and three fresh water snails, followed by additional species found later. Just three specimens of crustaceans have been recorded, all belonging to the ostracods. The insect diversity is rather strong, with a pronounced species record of jewel

Fig. 25.1 Fossil jewel beetle *Lampetis weigelti* (Pongrácz, 1935) from the Geiseltal Collection (GMH Ce VIII-1756-1935), showing the fantastic preservation of 45 Million year old iridescent colours. Photo/©: Markus Scholz

beetles (Fig. 25.1), darkling beetles and click beetles, as well as cockroaches. Altogether, specimens of at least eight different insect orders have been described (Bettenstaedt et al. 1935).

Fish. The fossil fish fauna of Geiseltal is small, due to the lack of substantial water bodies in the region. In total, five species of fish have been recognized so far, including bowfin-relatives (today's Amiidae), gars (Lepisosteidae), very distant relatives of the salmon (Thaumaturidae), and perches (Percidae).

Amphibians. Amphibians are relatively uncommon and have only been recovered from younger layers at Geiseltal. The frog fauna includes six recorded species mostly from the MP 13 zone. Several fossil salamanders have been found at Geiseltal belonging to at least two different species.

Reptiles. Five different kinds of turtles have been recognized at Geiseltal. The aquatic species belong mostly to *Chrysemys* and *Geoemyda*. The soft-shelled turtle, *Trionyx* sp. represents an important warm, aquatic habitat and bears a shell pattern very different from other species of freshwater turtles. Nearly all turtle fossils come from later deposits at Geiseltal, but *Geochelone eocaenica* is found in MP 11. All lizards at Geiseltal have come from later deposits and include 11 different species, among them are the distant relatives of monitor lizards, *Eolacerta robusta*, the legless lizard *Ophisauriscus* (also called *Ophisaurus*) *quadrupes* and the iguana-relative *Geiseltaliellus maarius*. Two kinds of boas and one species related to modern pipesnakes (Aniliidae) have been identified from Geiseltal. Five kinds of crocodiles, with at least four species living sympatrically are found at Geiseltal, *Diplocynodon darwini* (Fig. 25.2), a distant relative of the alligator (Hastings & Hellmund 2017),

Fig. 25.2 Partial skeleton of the crocodylian *Diplocynodon darwini* Ludwig, 1877, from the Geiseltal fossil site (GMH XXII-700-1965). Photo/©: Alexander Hastings

being most abundant. Of *Bergisuchus* two fossil remains were discovered. The largest predator at Geiseltal was the crocodylian *Asiatosuchus*, with an average length of 2.5 m, and shares a lineage with the modern Nile Crocodile. One particularly bizarre species of crocodylian is well represented at Geiseltal, the land-crocodile *Boverisuchus magnifrons*. This species was uniquely suited to hunting on land, with a tall snout filled with serrated teeth, modified feet for running, longer legs held closer to the body, and a shorter and lighter tail. Even maternal care by Eocene crocodylian was recorded in the fossil record at Geiseltal (Hastings & Hellmund 2015a).

Birds. A wealth of work has been conducted on the avifauna of Messel (e.g. Mayr 2000, 2006), but comparatively less focus has been drawn to the Geiseltal avifauna so far, with 12 identified types of bird (Mayr 2002). Fossils have been found from the giant land bird *Gastornis geiselensis* (Hellmund 2013b). This bird has been frequently debated as to its role within the larger ecosystem but calcium isotope analysis now proves its herbivorous way of life. It thus was not a dangerous predator but was large to avoid being prey. Other birds found include the ostrich-like *Palaeotis weigelti*, the mousebird-like *Selmes absurdipes* and the relative of modern mousebirds, *Eoglaucidium*, the extinct relative of the hoopoe *Messelirrisor*, the extinct relative of the cuckoo roller, *Plesiocatharthes geiselensis*, the extinct swift-like *Aegialornis broweri*, the enigmatic *Coturnipes* of unknown origin, the extinct parrot-relative *Pseudasturides* and the chicken-sized flightless bird *Strigogyps robustus* (Mayr 2002). New studies of the Geiseltal bird fossils will likely result in even more species.

Mammals. The mammalian taxa have been studied in detail, resulting in fairly well-established taxa. In total, 76 different mammals have been identified at Geiseltal (Hellmund 2007). These mammals include the marsupial *Amphiperatherium*, eight different forms of primate, including *Europolemur*, eight forms of early carnivorous mammals (Creodonta), two species of early insectivorous mammals, early bats belonging to two different groups, the European pangolin *Eurotamandua joresi* and four different forms of rodents. A tillodontian mammal was also recovered from Geiseltal that represents a bizarre offshoot of mammalian evolution with no living descendent. Furthermore, Geiseltal supported many hoofed mammals (ungulates), representing 14 forms not found at the other important Eocene site of Messel. Among these hoofed mammals are ancient horses (at least four species: *Europhippus parvulus*, *Propalaeotherium hassiacum*, *P. isselanum*, *Hallensia matthesi*) and the largest of all recovered mammals, the tapir-like *Lophiodon* and its smaller relative *Hyrachyus*. Particularly well-represented at Geiseltal are three complete individuals of *Lophiodon* found together in three-dimensional articulation.

25.5 Excavation Challenges of Fragile Geiseltal Fossils

Although the Geiseltal fossils are of high quality and three-dimensional preservation, their excavation was remarkably difficult. The fragile nature of the bones meant they could not be simply lifted out of the ground. Fossil bone from Geiseltal tends to disintegrate as it dries unless treated. Prof. Dr. Ehrhard Voigt (1905–2004) developed two new excavation methods to remove the fossils safely, the paraffin-method and the lackfilm-method—both transferring substrate onto a carrier medium (Voigt 1933). Both methods involved adding a bonding agent to the fossil and its surrounding brown coal matrix. For excavating larger fossils such as *Lophiodon* remains, a wall of clay around the fossil was filled with melted paraffin wax over the exposed fossil surface. Once cooled, the diggers would cover the paraffin surface with a hard plaster (called a plaster jacket) then dig it out of the ground. The plaster jacket would then be flipped over and prepared from the side that was facing the ground. As a result, fossils prepared in this way show the opposite side from what was originally exposed at the surface. For smaller fossils, paleontologists would use the lackfilm-method. A pliant lacquer would be painted over the exposed surface of a fossil with a brush and allowed to harden. Analogous to the paraffin-method, the fossil was lifted and removed from the brown coal substrate and then carefully prepared in the fossil preparation laboratory in Halle (Saale). When coal production moved further away from the calcium carbonate-rich layers fossil excavation efforts also dwindled significantly around the 1980s. The final fossil excavation ended in the summer of 1993, which was also the final year of brown coal production at Geiseltal. The last vertebrate fossil discovery included a jaw fragment with teeth of a crocodilian. In the year 2000, the last studies focussed on fossil pollen content, stratigraphy, and geochemistry. Today, the Geiseltal mining area is filled with water creating a large lake.

25.6 Collection Use

The collection benefits from a permanent research position. In the past, this position was filled by Dr. Günter Krumbiegel (1926–2014) and Dr. Meinolf Hellmund (1960–2016). While Krumbiegel is well known for the general aspects of the Geiseltal site (e.g. Krumbiegel et al. 1983), the latter worked extensively on the ancient horse species, their teeth development and stomach content as well as, lately, on ecological aspects of *Gastornis* (i.e. Hellmund 2013a, 2013b, Wilde & Hellmund 2010). However, the Geiseltal Collection is also highly sought by Eocene specialists world-wide. It serves international research, recently supported by new methods such as 3D-imaging (Geiseltal Collection holds a 3D-scanner and 3D carving machine) and isotope analysis. With funding from the German Federal Cultural Foundation (KSB) the Geiseltal Collection was able to secure a postdoctoral fellowship position filled by Dr. Alexander Hastings, researching niche partitioning of crododylian species at Geiseltal. Further funding from the KSB included an outreach project which produced a special exhibition shown in two different cities, a bilingual catalogue and its own webpage (see www.geiseltal-ausstellung.de). For the first time since the presentation of the former Geiseltal Museum in the design of the 1950s, modern research and new design opened the collection to a greater audience. Recently the Volkswagen Foundation financed a postdoctoral position for Dr.

Márton Rabi, studying ecological aspects of cold-blooded vertebrates during the climate optimum in the Middle Eocene. Numerous new proposals of collection studies have recently been submitted and we expect thriving research in the next decades, showing the high potential of the Geiseltal Collection for modern studies. The Geiseltal Collection also serves the teaching of palaeontology, albeit Martin Luther University Halle-Wittenberg itself hardly runs any course in palaeontology in recent times—most student visitors come from other universities. This might change in the future, however. The Geiseltal Collection also serves as a venue for conferences such as the excursion of the Society of Vertebrate Paleontology or the Workshop of the Society of German Preparators. Since 2016, the Center for Natural Science Collections of Martin Luther University Halle-Wittenberg employs its own communication officer giving guided tours, organizing children workshops and supporting a core team of young scientists. The Geiseltal Collection is featured several times a year in the media/press and has been part of different film and art projects.

25.7 General Information

Postal address:	Geiseltal Collection Zentralmagazin Naturwissenschaftlicher Sammlungen (ZNS) Martin Luther University Halle-Wittenberg Domplatz 4, 06108 Halle (Saale), Germany
Homepage:	http://www.naturkundemuseum.uni-halle.de http://www.geiseltal-ausstellung.de

Contact:	Oliver Wings, Tel. *49-55-26073, oliver.wings@zns.uni-halle.de
Year of foundation:	1934 (with oldest fossils from 1908)
No. of specimens:	50,000
Staff:	One scientist, one technical staff, several research associates
Infrastructure:	Preparation workshop, 3D-Scanner/3D cutting machine, photogrammetry equipment, archival documentation, relevant literature, complete collection data-base, all acquisition records scanned
Perspectives:	New laboratories by 2022, adapted storage building by 2022
Exhibition:	Exhibition room for temporary shows

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Chapter 26
HALLE: The Palaeontological Collection of the Martin Luther University Halle-Wittenberg in Halle (Saale)

Norbert Hauschke

26.1 Introduction

The Palaeontological Collection in the Department of Geosciences and Geography at Halle (Saale) is one of numerous academic collections, which are preserved and scientifically overseen at the Martin Luther University Halle-Wittenberg. Still today, in the digital age, the Palaeontological Collection is broadly used in the context of lectures for students. This collection also constitutes an important archive for palaeontologists. The vital importance of the Palaeontological Collection is based on its scientific value, particularly of a large number of fossils, which are type specimens, some of them are even of the rank of holotypes. Thus, national and international scientists regularly use this material for their scientific research. For special exhibitions in or outside of Halle specimens are requested and loaned.

26.2 Historical Aspects

The Palaeontological Collection and other natural scientific collections of Martin Luther University (e.g. Berg et al. 2002, Lehmann and Ruprecht 2017) owe its origins to the Cabinets of Natural and Artificial Curiosities of the seventeenth and eighteenth Century (e.g. Schwab 2003). One of these cabinets in Halle (Saale) can be visited at the Francke Foundation, were the original cabinets are still exhibited (Müller-Bahlke 1998), allowing an authentic view on these baroque collections and their original presentation. The Palaeontological Collection and other geoscientific

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collections of Martin Luther University can be traced back to the Natural Cabinet of Friedrich Hoffmann (1660–1742), who was a professor of medicine. His collection was completely absorbed in the collection of Johann Friedrich Gottlieb Goldhagen (1742–1788), who was the first professor of natural history at Halle University. Goldhagen used specimens from his own collection for demonstrations in his lectures. In this context, it must be mentioned that Johann Reinhold Forster (1729–1798), who was a member of the circumnavigator James Cook's second voyage of exploration, for a short time (1788–1789; Schwab 2006) also supervised the Natural History and Mineralogical Collections at Halle.

With the foundation of the Mineralogical Cabinet in 1805, the Mineralogical Museum in 1851 and the Mineralogical Department (Mineralogisches Institut) in 1873 earth sciences gradually emancipated itself as an independent specific field within the university. The first professor of mineralogy was Henryk Steffens (1773–1845). Further professors in mineralogy, which were in most cases also supervisors of the Mineralogical Collection, were famous scientists such as Ernst Friedrich Germar (1786–1853), Karl Freiherr von Fritsch (1838–1906) and Johannes Walther (1860–1937; Fig. 26.1). Germar is well-known for his systematic collecting of fossil plants and invertebrates in the fossiliferous strata of Carboniferous and Permian age north of Halle, and particularly for his palaeobotanical research (Germar 1844–1853). Von Fritsch (1901) considered Germar as the real founder of the Geoscientific

Fig. 26.1 Left: Johannes Walther (1860–1937), portrait from about 1900. Archives of the Palaeontological Collection. Right: Fossil algae nodule (rhodolith) from the Neogene of Sicily with thin section, and original label, which was handwritten by Johannes Walther. The Walther collection is part of the Palaeontological Collection. Scale 1 cm. Photos and © Norbert Hauschke, 2010

Collections of Martin Luther University. Under the direction of von Fritsch as professor in ordinary for mineralogy, the Mineralogical Cabinet was raised to the rank of a Mineralogical Department (Mineralogisches Institut). With respect to the extension and presentation of the geoscientific collections, a first period of prosperity took place. Large galleries came into existence to present fossils, which were collected in the former Province of Saxony (Sachsen) and bordering regions. In a systematic arrangement, plant and animal fossils as well as minerals could be studied. The stock was systematically expanded by acquisition and donation (von Fritsch 1901; Reichstein 1998). It must be emphasized that for Germar as well as for von Fritsch palaeontological research was strongly in focus.

A complete reorganization took place with the inauguration of Johannes Walther (1860–1937), who was the professor in ordinary for mineralogy from 1906 to 1914, and professor in ordinary for geology and palaeontology from 1914 to 1928. Walther already in 1907 renamed the Mineralogical Department as the "Geological and Mineralogical Department" (Geologisches und Mineralogisches Institut), and gave geosciences at the Halle university a new direction for the future. Thus, in 1914, on the initiative of Johannes Walther the mineralogist Ferdinand von Wolff was appointed as professor in ordinary for mineralogy and petrography. Consequently, this step led to the functional and also spatial separation into two independent departments, and made clear the advancing specialization of scientific disciplines at the beginning of the twentieth century. Under the direction of Johannes Walther, the areas for exhibitions were remarkably enlarged, and a modern exhibition concept was realized, which can be retraced by means of a museum guide, Walther's "Führer durch die Lehr- und Schausammlungen des Geologisch-Paläontologischen Instituts der Universität Halle" (Walther 1928). Johannes Walther was an interdisciplinary explorer, who studied the deserts and reefs of the present and past all over the world, and brought huge collections of geological, palaeontological and zoological objects back to Halle, which are still today part of the university collections (Hauschke et al. 2011; Fig. 26.1). It was also Johannes Walther, who initiated fossil excavation in the Eocene of the Geiseltal mining area near Halle. The exploitation of this important fossil Lagerstätte was continued under the leadership of Johannes Weigelt (1890–1948), who held the chair in geology and palaeontology as the successor of Johannes Walther. The world-renowned Geiseltal collection with mostly vertebrate fossils like the small primitive horse *Propalaeotherium*, was presented since 1934 in the Geiseltal Museum (Haubold and Hellmund 1994), that unfortunately has been closed to the public since a few years. In 1935 a sponsoring association, the "Verein zur Förderung des Museums für Mitteldeutsche Erdgeschichte in Halle a. S.", was established to introduce people into the earth history of Central Germany ("Mitteldeutschland"). For that reason, a presentation in eight exhibition spaces, the so-called Museum of Earth History in Central Germany (Museum für mitteldeutsche Erdgeschichte), was realized by Hans Gallwitz (1896–1958), who succeeded Johannes Weigelt. The conception of a walk through earth history in Central Germany allowed the integration of the Geiseltal Museum into the new and more comprehensive exhibition. During World War II, in the years 1944/45, parts of the collection were removed from stock for protection. In May 1945, the Department of

Geology and Palaeontology and also the Geiseltal Museum was closed, but its reopening took place as early as 1946 (Schwab 2006).

In 1967 the Geological and Palaeontological Department was closed for political reasons. Geological sciences from now on were subordinated to two sections within the Martin Luther University: geology became part of the section geography (Sektion Geographie) and palaeontology of the section biology (Sektion Biologie). After the collapse of the GDR and the subsequent reunification of Germany in 1990, the former sections were liquidated, and the Department of Geological Sciences and Geiseltal Museum (Institut für Geologische Wissenschaften und Geiseltalmuseum) was established. But already in 2004, a relocation of the geographical and geological departments, which were formerly spread across different locations in the city of Halle, took place. These two departments were united to a new department (today: Institut für Geowissenschaften und Geographie), including also the Palaeontological Collection (Hauschke 2007), but no longer the Geiseltal Museum. For the Palaeontological Collection, special areas were scheduled. But areas for expositions, as were realized on a large scale in the old and traditional department in the center of Halle, in the so-called New Residence (Neue Residenz)—a Renaissance building from Cardinal Albert of Brandenburg (in German: Albrecht; 1490–1545), who was the Archbishop of Mainz and Magdeburg—were no longer part of the department at the new location. The Geiseltal Museum, which always possessed a special status, was not relocated, and went down its own path. Today, the Geiseltal Collection is part of the ZNS (Zentralmagazin Naturwissenschaftlicher Sammlungen der Martin-Luther-Universität).

26.3 Important Collections and Outstanding Specimens

University collections have their distinctive history, illustrate ideas of the particular collectors, and are documents, which reflect the history of natural sciences. All these aspects make University collections unique. This particularly applies to the Palaeontological Collection of Martin Luther University, which steadily increased since the early twentieth Century. This and other traditionally rich university collections are regarded as part of the cultural heritage, and deserve special protection.

The Palaeontological Collection can be subdivided into several parts. A first distinction is drawn between collections with plant, invertebrate and vertebrate fossils. On the other hand, fossils are arranged in stratigraphical and regional contexts. Larger complexes of the Palaeontological Collection frequently refer to fossiliferous strata in the range of Central Germany, like the Upper Carboniferous (Stefanian) of the Saale Basin, the Upper Permian Copper Shale (Kupferschiefer) of the Mansfeld and Sangerhausen synclines (Fig. 26.2), the Lower Triassic Buntsandstein and the Middle Triassic Lower Muschelkalk near Halle or in the Thuringian syncline (Fig. 26.3), the Cretaceous north of the Harz Mountains, particular strata of the Palaeogene and Neogene, and of the Pleistocene in different parts of Sachsen-Anhalt (Saxony Anhalt) (Hauschke and Mertmann 2015). The comprehensive stock from the Upper Carboniferous consists of invertebrate fossils like insects, but mostly of plant fossils. Useful for comparative studies are large collections of plant material from other coal

Fig. 26.2 *Menaspis armata*, a ratfish, which is nearly completely preserved. Copper shale of Eisleben, Sachsen-Anhalt. The specimen first was described by Johannes Weigelt (1930). Scale 1 cm. Photo and © Norbert Hauschke, 2017

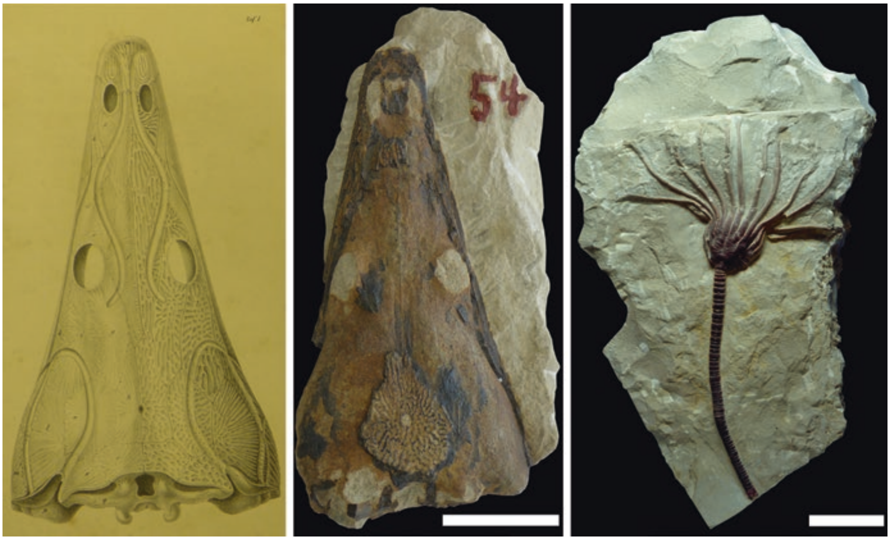

Fig. 26.3 *Trematosaurus brauni*, skull of a temnospondyl amphibian from the Buntsandstein of Bernburg, Sachsen-Anhalt. The genus and species was first named by Hermann Burmeister (1849). Left: Plate from the monograph of Burmeister. Middle: One of numerous skulls from the Braun collection, which was the basis for Burmeister's investigations, and which is today part of the Palaeontological Collection. Scale: 5 cm. Right: *Carnallicrinus carnalli*, the red color originates from the preservation of hypericin and related pigments in this stalked crinoids from the Muschelkalk of Freyburg, Sachsen-Anhalt. Scale: 5 cm. Photo and © Norbert Hauschke, 2017

bearing regions like Lower Silesia (Niederschlesien, Polonia), Zwickau, the Ruhr district (Ruhrgebiet) or the Saar basin (Saargebiet). During a long lasting period of mining of the Copper Shale, which can be traced back to the end of the twelfth century, a huge stock of fossils found its way into the Palaeontological Collection. Among plants and invertebrates, numerous well preserved taxa of vertebrates, mostly fishes, are remarkable. In addition to actinopterygians, like the most frequent species *Palaeoniscum freieslebeni*, also crossopterygians and chondrichthyes, like the ratfish species *Menaspis armata* (Fig. 26.2), could be demonstrated. Finds of anapsid and diapsid reptiles, like the genus *Coelurosauravus*, which was able to glide because of specialized wing-like structures, belong to the very rare finds. The Lower Buntsandstein of Bernburg/Saale is well-known for numerous finds of the lycopod species *Pleuromeia sternbergii*, for skulls of the temnospondyl amphibian genera *Parotosuchus* and *Trematosaurus*, of which the latter was investigated in Halle by Burmeister (1849); beyond that the single find of the reptile *Trachelosaurus* should be mentioned. The Lower Muschelkalk of Freyburg/Unstrut is characterized by finds of marine sauropterygian reptiles and by cephalopods like the genera *Judicarites* or *Discoptychites*, which immigrated from the Tethyan Ocean into the Middle European Basin. Remarkable are red to purple stalked crinoids (Fig. 26.3); it could be demonstrated with the help of material from the Palaeontological Collection that the dye of these fossils consists of hypericine, as could also be proved in extant deep sea crinoids. Among fossils from the Cretaceous of Sachsen-Anhalt, well preserved plants, like the early plantanoid leaves of *Credneria* from an area north of the Harz Mountains, are of special interest. Spectacular is a vast collection from the Palaeocene of Walbeck, with numerous finds of amphibians, birds, small carnivores, which were still hooved, and many other animal groups. The Eocene of Teuchern in southern Sachsen-Anhalt is unique for the only finds of xiphosurans ever found in the Tertiary worldwide (Fig. 26.4).

Fig. 26.4 *Limulus decheni*, adult female of a xiphosuran (horseshoe crab) from the Eocene of Teuchern, Sachsen-Anhalt. A considerably smaller adult male specimen, which is the holotype (Giebel 1863) of this species, also belongs to the Palaeontological Collection. Scale: 5 cm. Photo and © Norbert Hauschke, 2017

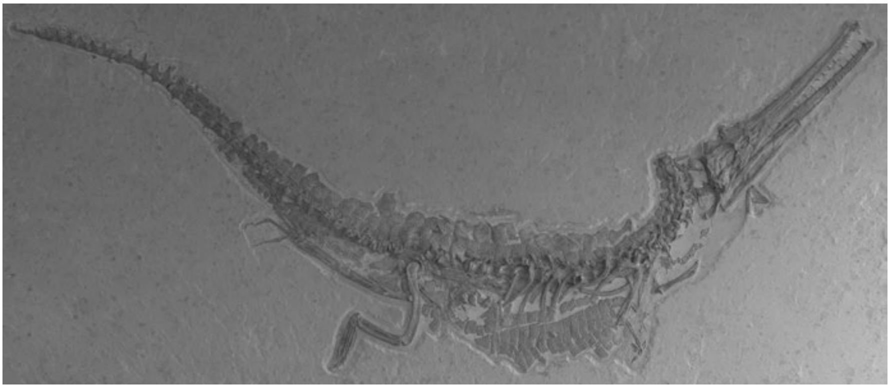

Fig. 26.5 *Steneosaurus bollensis*, a marine teleosaurid crocodyliform from the Early Jurassic (Toarcian, Posidonia Shale) of Bad Boll, Baden Württemberg. This and other specimens, which are today part of the Palaeontological Collection, were described by D'Alton & Burmeister (1854). Width of the slab with the fossil: 310 cm. Photo and © Norbert Hauschke, 2017

From other parts of Germany the collections from the Lower Jurassic of Bad Boll and Holzmaden (Fig. 26.5) and from the Upper Jurassic of Solnhofen, Eichstätt and other localities are remarkable (Hauschke and Mertmann 2016). One of the most valuable specimens in the Palaeontological Collections is the second specimen of *Xenusion auerswaldae* ever to be discovered from the Lower Cambrian of south-eastern Sweden, which is supposed to be an early animal in the transitional field between polychaete worms and arthropods (Fig. 26.6). The specimen is embedded in an erratic boulder, which was discovered on Hiddensee island in the Baltic Sea. From outside Germany, the Palaeontological Collection possesses fossils from important localities like the Burgess Shale in the Canadian Rocky Mountains, with animals from the Middle Cambrian, which show extraordinary detail of soft and hard tissues, like the common arthropod species *Marella splendens*. Lots of other special collections with fossils from localities abroad exist. Here, only two further localities shall be mentioned, Maragha in the Iran e. g. with the proboscidean *Gomphotherium* and Quercy in France, with a remarkable mammal fauna.

Many special collections, which are now incorporated in the Palaeontological Collection, are documented in scientific publications, mostly dealing with selected groups of fossils. The respective scientists deposited their valuable material in the Palaeontological Collection of Halle University. But also private collectors of fossils gave their collections over to the university. Some of them also published the results of their studies, frequently at a high scientific level. Two prominent examples, Johann Georg Bornemann (1831–1896) and Adolf Franke (1860–1942), will be mentioned here. Bornemann, who was a successful entrepreneur and a creative and broad minded scientist of the nineteenth century, paved the way towards new scientific and also technical developments. When he was 25 years old, in 1856, he already established a new method, which is called "bulk maceration". Bornemann extracted fossil cuticles from Keuper beds, that

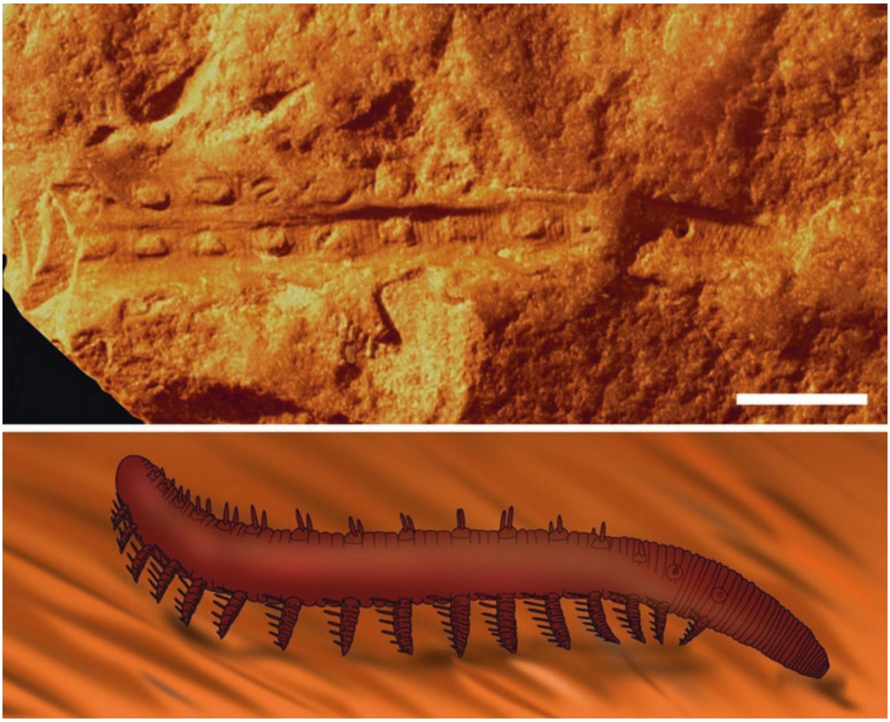

Fig. 26.6 *Xenusion auerswaldae*, a marine lobopodian from the Lower Cambrian, which is embedded in an erratic boulder that was transported by inland ice from southeastern Sweden to Hiddensee Island, Mecklenburg-Vorpommern, where it was discovered. Above: The specimen is preserved with its frontal part (proximal end on the right). The vermiform trunk on both side bears lobopod limbs with backwards oriented spines (best visible in the middle part). Scale: 2 cm. Photo and © Danilo Wolf, 2015. Below: Reconstruction. © Sophie Kretschmer, 2015

he embedded in Canada balsam to analyze the structures on microscope slides (Fig. 26.7). The value of cuticles for taxonomy is widely recognized, and Bornemann is considered to be the first who systematically studied fossil gymnosperm cuticules. His mining activities in southwestern Sardinia led Bornemann to collect and investigate fossils from the Cambrian, like archaeocyathans and trilobites, to an exceptionally high level. Bornemann's scientific collection, which also includes handmade drawings and handwritten explanations, is housed in Halle University (e.g. Hauschke and Kretschmer 2015). Franke, who was a teacher and, like Bornemann, was born in Thuringia (Thüringen), is regarded as a pioneer of micropaleontology and the inventor of the "Franke cell", which is used to preserve microfossils, like ostracods or foraminiferans, for scientific investigations. The largest part of Franke's collection, some thousands of micro cells, belongs to the Palaeontological Collection of Martin Luther University (Hauschke et al. 2017).

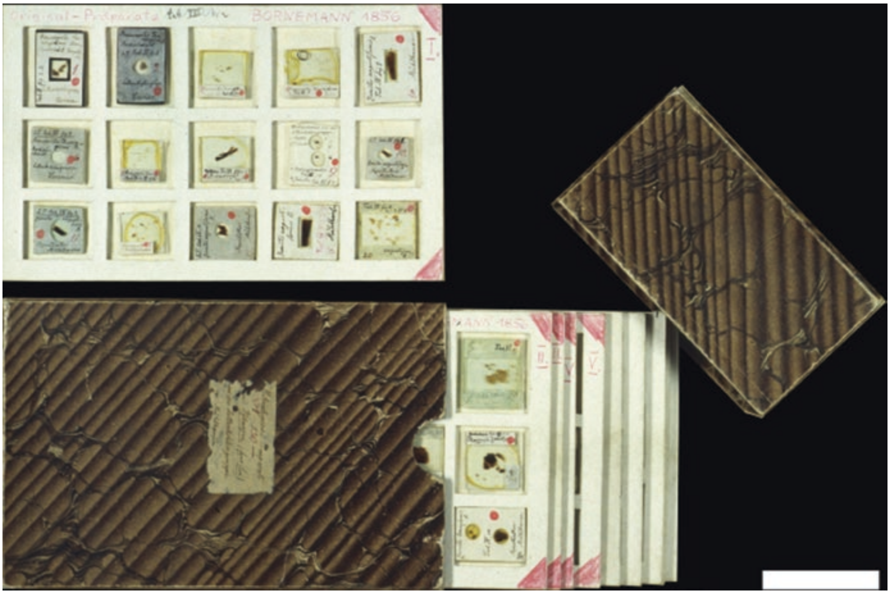

Fig. 26.7 Fossil plant cuticles from Keuper beds (Upper Triassic) in Thuringia, which were extracted from dispersed leaf fragments, and embedded in hot and liquid Canada balsam between two lantern slides for light microscope analysis by Johann Georg Bornemann (1856). Arrangement of a box with several trays that keep lantern slides with macerated cuticles. Width of the tray top left: 18.5 cm. Photo and © Norbert Hauschke, 2015

26.4 Current Use of the Collection

The Palaeontological Collection has been preferentially used for teaching and for scientific purposes since the beginning. In palaeontological lectures, specimens are essential for a better understanding of fossils. Therefore, students are allowed to take specimens into their own hands to be able to distinguish different taxa from one other, to assess the respective state of preservation and to get a feeling for the respective unique specimen.

Scientists who want to study palaeontological material in the Palaeontological Collection of Martin Luther University find good conditions to study the fossils of interest, to compare specimens with each other and to document them by taking photographs. If necessary, specimens will be loaned for a certain time. But fossils will no longer be sent by post or delivery services because of the risk of damage.

Lately, revisions of fossil material touched on, e.g., the following parts of the Palaeontological Collection: archaeocythids and trilobites (Bornemann collection), bivalves (Giebel and Gründel collections), bryozoans (Korn collection), corals (Frech and Volz collections), cephalopods (e.g. von Fritsch and Philippi collections), insects (Germar collection), plants (Germar and Mägdefrau collections) and tetrapod footprints from the Permian and Triassic (Haubold collection). Other scientists dealt with collection complexes like the Kupferschiefer collection (e.g. plants and fishes; Weigelt collection), the Solnhofen collection (e. g. crustaceans, xiphosurans) and the Walbeck collection (amphibians, birds, and mammals; Weigelt collection) and the xiphosurans from Teuchern. But also at the present time, palaeontological material is incorporated into the Palaeontological Collection. In the course of scientific investigations at outcrops near Halle, e.g. in the Triassic, diverse arthropods like insects, notostracans (tadpole shrimps) and xiphosurans (horseshoe crabs), and a broad spectrum of ichnofossils could be incorporated into the collection. Thus, also in the present time new finds are important to complete the Palaeontological Collections and to keep specimens ready for investigations in the future.

A good opportunity to present collection treasures to the public is to organize special exhibitions. Within the scope of these exhibitions many visitors get an idea of what fascinating objects are slumbering in university collections. An example for a special exhibition, in which all university collections were invited to participate, was the exhibition EMPORIUM, that was organized on the occasion of the anniversary of 500 years of Martin Luther University in 2002; the Palaeontological Collection took place within the focal topic "life sciences" (Berg et al. 2002). Together with the Zoological Collections and the Geiseltal Museum a special exhibition in honor of Hermann Burmeister was organized in 2007 (Schneider et al. 2007). One of several other special exhibitions, which were organized by the Palaeontological Collection, was dedicated to Johannes Walther on the occasion of his 150th birthday (Hauschke et al. 2011). In cooperation with the Senckenberg Museum an exhibition on the Triassic was prepared and presented in 1998 in Halle and in 1999 in Frankfurt/Main (Hauschke and Wilde 1999). Requests from museums for loaning specimens from the Palaeontological Collection of Martin Luther University for special exhibitions are normal.

Currently, the curator that is responsible for the Palaeontological Collection, is fully involved in teaching and administrative tasks. Furthermore, the curator is unassisted and without regular financial support for the collection. So, progress in the registration of the stock and scientific work on the collection is lower than expected. Hence, the problem remains that only parts of the vast stock of fossils could be inventoried until now. Traditionally, samples were registered on index cards or in a database, which is available only for the use within the department. To bring forward the collection and to make it available for scientists, an initiative has been started some years ago. In the context of bachelor and master theses, selected specimens or particular parts of the Palaeontological Collection, were digitalized using laser scanning and photogrammetric techniques. The resulting 3D scans can be used as 3D PDF's for helping scientists to obtain the appropriate scientific background information about the chosen samples and to enable them to obtain their own measurements and interactive visualization of 3D scans of the chosen specimens (e.g. Schimpf et al. 2017).

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Chapter 27
HAMBURG: Palaeontological Collections of the Center of Natural History, Universität Hamburg

Ulrich Kotthoff and Jochen Schlüter

27.1 Historical Background

The geological-palaeontological collections of the Center of Natural History have their origin in the former "Naturhistorisches Museum Hamburg", which had been founded in 1843. In 1891, the museum moved into a new building at the Steintorwall close to the main train station in Hamburg (Brandt et al. 2010). In 1907, the geoscientific collections of the museum were moved into the "Mineralogisch-Geologisches Staatsinstitut". The geological-palaeontological collections nowadays still contain a few objects from that time interval (e.g. specimens from the Hunsrück Schiefer, Fig. 27.1), but most of the old palaeontological collections were destroyed in 1943 (Brandt et al. 2010; Hillmer and Weitschat 1983) when the old building of the Staatsinstitut was ruined during a bombing attack on Hamburg.

After World War II, the geological-palaeontological collections moved into the so-called "Kommode", a building in the center of Hamburg close to the Alster river, where the mineralogical collections had already been moved to in 1928. New collections for teaching and research were built up under the aegis of Prof Dr. Eberhard Voigt. In 1960, the geological-palaeontological and the mineralogical collections moved into new adjacent buildings which included rooms for public exhibitions, much acclaimed by the public community in Hamburg (Hillmer and Weitschat 1983). In 1969, the former "Staatsinstitut", including its collections, was transferred into the University of Hamburg.

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Fig. 27.1 Arthropod (*Mimetaster hexagonalis*, GPIH00002, described by Gürich 1931) and an asteroid from the Hunsrück Schiefer (length of plate ~9.5 cm). This specimen was saved from the ruins of the "Geologisches Staatsinstitut" in 1943. Photo: Ulrich Kotthoff

Fig. 27.2 Ammonite (*Eleganticeras elegantulum*, Lias epsilon, size ~4.9 cm) and fragments of further Jurassic ammonoids from glacial drift deposits from Ahrensburg. Photo: Ulrich Kotthoff

When moving into the Geomatikum in 1975, a section of ~900 m^2 was used to exhibit objects from the collections which had been built up during the past three decades. Among these collections, the "Geschiebesammlung" (containing glacial drift deposits; Fig. 27.2) and the amber collection were built up with significant support of private collectors. Eberhard Voigt, among other collections, founded and expanded an impressive collection of Bryozoa, which is now stored in the Senckenberg Institute, and a huge collection of "Lackfilme" (i.e., sedimentary peels, see e.g. Voigt and Gittins 1977). In 1980, the institute and the related exhibition area were renamed to “Geologisch-Paläontologisches Institut and Museum”. The collections were still enlarged in the following years, particularly the amber collection supervised by Dr. Wolfgang Weitschat. In 2014, the geological and palaeontological collections, as well as the rooms used for the museum, officially became part of the new “Center of Natural History”, together with the zoological and the mineralogical collections, while the Geological-Palaeontological Institute merged with the Institute of Biogeochemistry to form the new Institute for Geology.

27.2 Recent Collections

The total number of specimens housed in the palaeontological collections has not yet been determined. They contain probably more than 100,000 macrofossil specimens, but in many cases, several specimens are part of the same object (e.g. insects included in one piece of amber, or several cephalopod shales being part of the same piece of sediment). The focus of the collections is on glacial deposits, Cretaceous fossils, Baltic and Bitterfeld Amber, and fossil cephalopods. The collection of glacial deposits contains fossil material from the past 600 million years, including Palaeozoic corals, fragments of Jurassic vertebrates, and Mesozoic ammonoids. The amber collection with more than 6000 pieces with inclusions (mainly insects) is among the biggest amber collections in Germany. The collection of sedimentary peels contains more than 1000 “Lackfilme” in total. The recording status of the collections is very inhomogeneous: The amber collection, e.g., is completely digitalized, including detail photographs for each amber piece, while most of the Cretaceous fossils are only roughly catalogued. Presently, 10% of the collection material are documented in detail. The collection of glacial drift deposits shall be catalogued in a next step.

27.3 Structure

The Geological-Palaeontological Museum is part of the Center of Natural History (CeNak) at the University of Hamburg, together with the Mineralogical and the Zoological Museum. One curator is in charge of the palaeontological collections and of the Palaeontology section of the CeNak. Public relations and museum pedagogy are centrally organized for all three museums combined in the CeNak. The palaeontological collections are also used for research by other sections (e.g. Arachnology and Entomology) of the CeNak. At present, laboratories for palaeontological research are provided by the Institute of Geology, with which the CeNak closely collaborates. A basic financial support is granted by the university, and research and special projects related to the collection are financed via third-party funding (e.g. DFG-grants). The Museum can be visited during the opening times of the Geomatikum (see “Educational work”), and access to the collections is organized by the curator.

27.4 Research

Mollusks played an important role for research at the former "Geologisch-Paläontologisches Institut und Museum". Studies dealt with, e.g., Triassic ammonoids and their application for biostratigraphy (e.g. Dagys and Weitschat 1993; Hounslow et al. 2008) and Gastropods (e.g. Bandel 2007). This research resulted in the gathering of several mollusk-related collections. Research related to the amber collection of the Geological-Palaeontological Museum was another important aspect during the past years. On the one hand, the huge collection has been used by numerous scientist from other institutions, particularly for palaeoentomological and -arachnological studies. Among the insect groups analyzed in this framework are wasps (Olmi and Bechly 2001), bugs (Popov and Herczek 2006), weevils (Riedel 2010) and ants (Dlussky 2009), to refer only to a few of numerous studies. Own amber-based research at the Geological-Palaeontological Institute and Museum lead to the publication of several new species and generally to a better understanding of the ecosystems reflected in European amber deposits. One of the most interesting findings published is probably that of an ostracod in Baltic Amber (Weitschat et al. 2002). Recent palaeoentomological studies have focused on Hymenopterans, e.g. the evolution of eusocial insects (Kotthoff et al. 2013). Currently, mantids and pseudoscorpions in the amber collections (Figs. 27.3 and 27.4) are revisited and to be analyzed and 3-d-visualized in collaboration with the DESY in Hamburg (Jason et al. 2018).

There have also been studies related to cretaceous outcrops in Northern Germany, e.g. on asteroids (Schulz and Weitschat 1971), corals (Kommritz and Hillmer 2004), and an elasmosaur (Maisch and Spaeth 2004). Furthermore, palaeontological and palaeoanthropological studies are executed by the Mammalogy group at CeNak, for example concerning the feeding strategies of ungulates (Tütken et al. 2013).

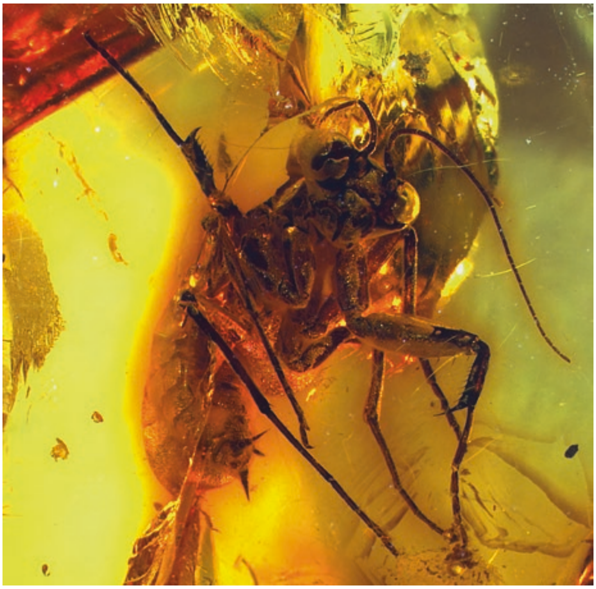

Fig. 27.3 Mantid (probably Chaeteessidae, GPIH04846/SEBS01549, body length ~4.5 mm) from the amber collection. Photo: Eva Vinx/Alexander Bratek

Fig. 27.4 Pseudoscorpion (*Neobisium*, GPIH00262/ SEBS1240, body length ~3 mm) from Baltic Amber, first described by Beier (1955). Photo: Eva Vinx

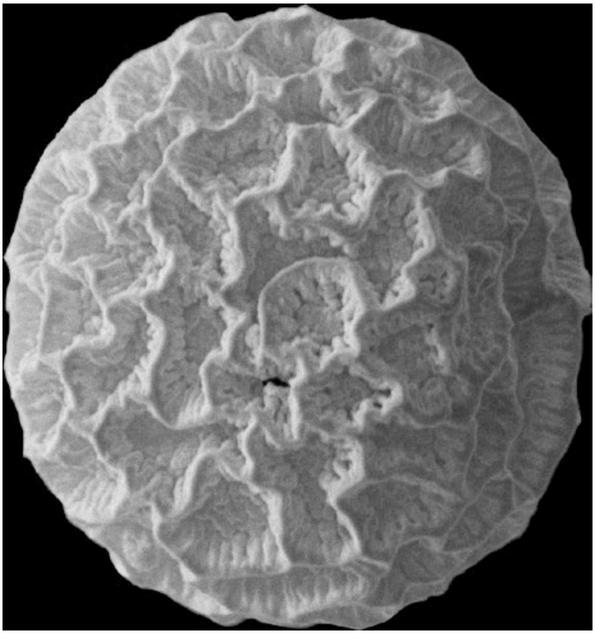

Fig. 27.5 Pollen grain of *Persicaria* (palynological collection, diameter ~50 µm). Photo: Sabine Prader

During the past years, the palaeontological research at the Geological-Palaeontological Institute and Museum was focused on micropalaeontology-based studies. Micropalaeontology-related research projects at the CeNak are currently mainly related to expeditions in the framework of the International Ocean Discovery Programm (IODP), dealing with palynological analyses of sediments from the Baltic Sea (IODP Expedition 347; e.g. Andrén et al. 2015) and the New Jersey Shelf (IODP Expedition 313; e.g. Kotthoff et al. 2014; Fig. 27.5). In the framework of the latter project, a third-party-funded PhD student is examining the ecosystem and climate development in the New Jersey region during the Miocene. In addition, there are ongoing research projects focusing at the Quaternary in the Mediterranean region and Central Europe (e.g. Kotthoff et al. 2011; Pross et al. 2015) and, in collaboration with the Institute of Geology, at the Holocene in the North Sea region. In several of these projects, BSc and MSc students are involved.

27.5 Educational Work

The exhibition of the Geological-Palaeontological Museum consists of two levels which are situated in the Geomatikum Building at Universität Hamburg. The upper level grants an overview on the history of Life on Earth in ten display cases. These show, for example, fossils reflecting Precambrian life, the groups which developed during the Cambrian Explosion, plant fossils from the Carboniferous, specimens from Jurassic and the development of Earth during the Cenozoic. The general overview given upstairs allows the visitors to better asses the exhibition parts displayed in the lower level.

The lower level shows fossils from German fossillagerstätten (e.g., Solnhofen, Messel, Lägerdorf), fossils and rocks from glacial erratics, and examples from the amber collection. Furthermore, a few Pleistocene fossils are shown, including a cave bear. Every year, a small special exhibition reflects on topics presented in the framework of the Long Nights of the Museums in Hamburg. Some objects in the museum can be touched by the visitors in order to gain a haptic feeling. Additionally, special objects are shown in the framework of guided tours. The public exhibitions can be visited every day from Monday to Friday between 9:00 and 18:00 and Saturday between 9:00 and 12:00 during lecture intervals at University of Hamburg.

The Long Nights of the Museums in Hamburg are particularly important events for the Geological-Palaeontological Museum, during which between 700 and 1000 visitors are attracted each year. The programs are co-organized with the Institute of Geology at Universität Hamburg and comprise public talks, guided tours, fossil identification for hobby collectors, and special actions for children. Topics treated during the past Long Nights included “How tasted honey 40 million years ago?”, “Whales in Hamburg”, “Trace fossils in Earth’s history”. The museum also regularly contributes to the “Night of Knowledge” in Hamburg in collaboration with the center for earth system research and sustainability at University of Hamburg.

Pedagogics is generally centrally organized for all three Museums combined in the CeNak. There are several guided tour programs focusing on the Geological-Palaeontological Museum with topics like: “On the tracks of dinosaurs”, “Fossil Fascination”, and “Foraminifera—great little microorganisms”. Cooperation with schools is an important aspect for these programs. They can be booked via the Museumsdienst Hamburg (http://www.museumsdienst-hamburg.de/de/home). Furthermore, the museum supports projects related to “Jugend forscht”.

The CeNak has an own website where the collections, exhibitions and ongoing scientific projects are introduced (https://www.cenak.uni-hamburg.de/en.html).

Additionally, Twitter and Facebook are used to inform about news from the center regarding scientific projects, exhibitions, and special events. The Geological-Palaeontological Museum has been described in detail by Hillmer and Weitschat (1983), but has been changed in several aspects since then. More information on the CeNak can be found in Brandt et al. (2010).

The palaeontological collections also play an important role for the geoscience-related teaching at the Institute of Geology at University of Hamburg. Particularly the micropalaeontological collections are used for courses in applied palaeontology. In the framework of one course, also trace and vertebrate fossils are analyzed by the students. The geological and palaeontological collections at the University of Hamburg (including the teaching collection of the Institute of Geology) are also used to support lectures dealing with general palaeontology and earth history.

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Chapter 28
HANNOVER/BERLIN: The Geoscientific Collections of the Federal Institute for Geosciences and Natural Resources and the State Authority for Mining, Energy and Geology in Hannover and Berlin

Angela Ehling and Carmen Heunisch

28.1 The Palaeontological Collection at the 'Geocenter Hannover' (BGR and LBEG)

The focus of this collection lies on specimens from northern Germany, related to the geological survey of Lower Saxony. Many fossils, however, derive from other parts of Germany or elsewhere, and have been contributed by BGR scientists working all over the world.

In total about 800,000 specimens are stored in the so-called stratigraphic collection. They are stratigraphically distributed as follows (Jansen and Steininger 2002):

- Proterozoic: 20
- Palaeozoic: 99,250
- Mesozoic: 634,000
- Cenozoic: 41,500

The systemic distribution of the fossils is:

- Plants (microfossils) 85,500
- Higher plants: 40,000
- Porifera: 1000
- Coelenterata: 4000
- Mollusca: 540,000

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- Annelida: 1000
- Arthropoda: 15,800
- Bryozoa: 20,000

Together with further parts (e.g. minerals, raw materials and core samples), the collection is stored in an about 850 m^2 room located in the basement of the 'Geocenter Hannover' (Fig. 28.1). The presentation of the palaeontological content follows the stratigraphical systematic. The micropaleontological samples are stored separately in a compact unit (Fig. 28.2). It contains certainly more than one million of mostly calcareous microfossils, currently from more than 112,000 samples. The residues (about 80,000) of the palynological investigations are stored in separate cabinets.

Besides the valuable collection of scientific originals with 30,000 specimens of macro- and microfossils (Wiese et al. 2015), one of the interesting parts in Hannover is the so-called Hemmoor collection. Hemmoor is a village situated in northern Germany. The collection comprises samples from a former quarry in the vicinity of this village. In 1976, before this huge chalk quarry was flooded, scientists from the LBEG sampled the quarry bed by bed and saved pretty large sample volumes from each bed of the succession for future research. The microfossil content of these samples was investigated in detail. Furthermore, cherts and macrofossils of each bed were sampled. This alone resulted in 1015 sea urchins (Fig. 28.3), many brachiopods and a lot of specimens of other fossil groups. The Hemmoor collection is considered one of the best collections of boreal Maastrichtian sediments worldwide.

Fig. 28.1 Entrance area of the Hannover collection

Fig. 28.2 The compact unit of the micropalaeontological collection at Hannover

Fig. 28.3 Sea urchins of the Hemmoor collection at Hannover

28.2 The Palaeontological Collection in Berlin-Spandau (BGR)

The Berlin branch has a long and changeful history, described in detail at our website. After the foundation in 1770, the establishment of the Königlich-Preußische Geologische Landesanstalt (PGLA) in 1873 was an important benchmark. From 1878 to 1996 the collection was mainly stored in down-town Berlin, Invalidenstraße 44.

During World War II some valuable parts of the collection (mostly fossils and minerals) had been transferred to the limestone quarry in Rüdersdorf near Berlin to protect them from barrage. From there they were transported as loot to Moscow in 1945 and returned in 1957. Some of the remained objects had been destroyed by bombs, though. Big parts of the collection (many vertebrates, Rhenish Devonian fossils, spores, pollen and others) were moved to the neighboring Museum for Natural History in Berlin. Some parts and objects were displaced uncontrolled and got lost, respectively.

Between 1945 and 1990 the collection belonged to Zentrales Geologisches Institut (ZGI) of the German Democratic Republic (GDR), which became the branch office of the BGR in Berlin. 1996 the branch office – including the collection – moved to its present site in Berlin-Spandau. The collection and its historical wooden cabinets found a beautiful new home in perfectly renovated former horse stables of a Prussian barrack from the dawn of the nineteenth century (Fig. 28.4).

According to the historical classification system the main part of the fossils – the **macrofossils** – is integrated into the **stratigraphic collection**. It reflects the strong connection with the geological mapping of the Prussian territory, accompanied by intensive palaeontological investigation. Besides the objects, which are evidences for the historical mapping, drilling and research at the territory of Prussia and later of the GDR, it contains several collections of private researchers. The fossils are not ordered by taxa but by stratigraphy and location (Fig. 28.5). Even the glacial erratics are integrated in this collection by their geological age.

In total about 370,000 specimens are stored in the so-called stratigraphic collection. They are stratigraphically distributed as follows (Jansen and Steininger 2002):

- Proterozoic: 500
- Palaeozoic: 178,000
- Mesozoic: 153,000
- Cenozoic: 42,000

The following special collections as parts of the stratigraphical collection are noteworthy:

- Corals – worldwide – O.H. Schindewolf (2200)
- Brachiopoda – Devonian, Carboniferous, mainly Germany – W. Paeckelmann (1400)
- Shells – Devonian-Permian – H. Paul (2800)

Fig. 28.4 The stratigraphical collection at Berlin-Spandau

Fig. 28.5 Drawers with Jurassic fossils from the stratigraphical collection, Berlin-Spandau

- Devonian Brachiopoda and Mollusca – Rheinland, Harz – G. Dahmer (3500)
- Carboniferous Flora – Plötz-Löbejün – W. Remy & A. Kampe (2800)
- Muschelkalk Rüdersdorf – O. Raab (ca. 1500)
- Upper Silesian Muschelkalk – P. Assmann and others (ca. 3000)

Palaeontological originals – after Prussian definition: each fossil which had been published by figure – are concentrated in a separate collection. This collection contains 12,600 types from 900 publications between 1841 and 2016; divided into 11,000 palaeozoological and 1600 palaeobotanical objects, complimented by 2200 palynological originals (Tertiary – coll. Krutzsch) (Wiese et al. 2015).

Unfortunately a considerable number of the originals got lost during World War II.

The **micropalaeobotanical collection** comprising spores and pollen is directly connected with the research work of Robert Potonié and his colleagues at the PGLA. Most of this important and historic collection is now stored at the Museum for Natural History in Berlin. Nevertheless the BGR still houses a big palynological collection with 175,185 preparations and samples, mainly documenting the work of scientists after 1950. Worth mentioning are the following parts:

- W. Krutzsch – Upper Cretaceous + Tertiary (80,000 preparations and samples)
- E. Schulz – Lower Palaeozoic + Lower Mesozoic (35,000 preparations and samples)
- H. Döring – Upper Palaeozoic + Upper Mesozoic (43,000 preparations and samples)
- W. Erd and J. Strahl – Quarternary (7000 preparations and samples)
- Recent spores and pollen (8600 preparations and samples)
- W. Schwarzenholz – Pleistocene Diatomea (ca. 11,800 preparations)
- G. Burmann – Palaeozoic Acritarcha (23,000 preparations)
- G. Alberti – Upper Cretaceous + Tertiary Dinoflagellates (860)

The **micropalaeozoological collection** contains all kinds of zoological microfossils. The amount is estimated at about 400,000 objects. Worth mentioning is the collection N. Brügge – microfossils from the Lower Carboniferous of Rügen Island (8300) and the collection of Devonian ostracods (H. Blumenstengel).

28.3 Further Informations for Both Sites

The digital documentation of the collection is one of the main tasks since many years. The aim is to document the available information of each of the objects including photography. The resulting database GewiS will soon be available for the public via web access. Up to now, about 20% of the stratigraphic collections in Hannover and Berlin are documented digitally.

Currently, each of the palaeontological collections is led by a scientific curator, who at the Berlin site is responsible for the whole geoscientific collection. Both of them have technical support by a technical curator and other staff members. The collections are part of BGR and LBEG. Accordingly, the financial budget of them is part of the annual budgets of these two institutions.

The collection is open to the scientific community, resulting in an intensive national and international loan system, but is not open to the public. Only at special occasions, e.g. open house presentations, guided tours are offered. Since 14 years a webpage presents the “collection’s object of the quarter”. This science, history as well as interest of this object is also part of the monthly electronic newsletter of BGR. Furthermore, in Hannover changing exhibitions in two display cabinets are shown in the entrance hall of the ‘Geocenter Hannover’. In Berlin-Spandau there is an exhibition hall, where different topics are presented, too.

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Chapter 29
HANNOVER: Niedersächsisches Landesmuseum Hannover—Lower Saxony State Museum Hannover

Annette Richter and Annina Böhme

29.1 Foundation, History and a Brief View Upon the Chronology of the Main Collection Parts

Today's Natural History Department at the Landesmuseum Hannover (Lower Saxony State Museum), a compound museum with four branches (natural history, classical art & numismatics, ethnology, archaeology), roots back to December 1797, when the "Naturhistorische Gesellschaft Hannover (NGH)" was founded by ambitious Hannover citizens, being the second-oldest natural history society of Germany, continuously active until today. The NGH-founders decided to promote the knowledge about nature *sensu lato*, in a first step especially by buying natural history books—which were rare and expensive at that time. Thus, they first formed a so called "Lesegesellschaft" (reading society) to purchase expensive books together and practise share-reading—accompanied by occasional physical and chemical experiments. Around 1800, the NGH began to collect objects, among others starting with some mammoth teeth—possibly belonging to Blumenbach's famous mammoth remains found in 1799 (see Reich & Gehler, this volume). They continued erratical collecting in the three fields of mineralogical, geological and palaeontological objects. In spite of increasing specimen numbers especially in the biology section, public interest decreased massively until 1850, though. Only a few remaining active people cared for the society, which led to some losses within the young collections. Not much material is recorded from that time, unfortunately (Gersemann 2000; Gersemann and Küster 2007; Ude 1897; Valentin 1997).

After a dynamic relaunch phase, the NGH began to publish annual reports regularly from 1850/1851 on, and this time, the Royal Court of Hannover supported the natural history activities of the society by donating a small building in 1852, which

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can be regarded as a first “proto-museum”. As this place was naturally much too small, the leading NGH-people formed a linkage mainly together with the “Verein für die öffentliche Kunstsammlung” (an Art Society) and the “Historischer Verein” (Historical Society), collected money and 1856 moved solemnly into the new “Museum für Kunst und Wissenschaft” (Museum for Art and Sciences), situated in the Sophienstraße. The Royal Family as well as many influential citizens donated large amounts of interesting natural history objects around the opening of the new museum, one of the most precious being 2500 minerals from Carl Freiherr Grote. It soon became necessary to have voluntary custodians for the material housed in the museum building. One of them was Carl Eberhard Friedrich Struckmann, who cared especially for the palaeontology, 1874–1885 and 1890–1898 (see below).

In 1887, the museum formally went into possession of the province of Hannover and was named “Provinzialmuseum”.

Geosciences weren’t a major collecting focus until 1870, when the government decided to support the natural history department by an annual acquisition budget. Thus, it was possible to buy some large suites of *Petrefacta* both from big companies like Krantz/Bonn and prominent private collectors of the region to complete the existing collection profile.

Soon, even the new building proved too small for the growing collections. Thus, the museum as a whole moved to a representative and large new building in 1902, exclusively planned for museum purposes and in usage until today (then: Rudolf-von-Bennigsen-Straße, later: Am Maschpark, since 1995 until now: Willy-Brandt-Allee). The NGH decided in 1906 to continue only their own scientifical (and publishing) work and to sell its collections to the museum as a basis for the newly founded natural history department and its exhibitions. Sophisticated citizens with pronounced geo-interests donated large collections from around 1900, again, e.g. Prof. Dr. Wilhelm Hoyer (see below). Collecting excursions were conducted not only regionally, but also to Iceland and other foreign countries; on the long-term, they turned out to be too costy, though.

Already from 1890 on, stable positions were established to take care of biology as well as geology collections (the most prolific custodian was Fritz Hamm in the 1940/50s), but there was a marked emphasis on zoology and palaeozoology. Botany and palaeobotany were never in the main focus of the later museum, in contrary to the founding society NGH.

During WW I, all activities of the NGH were rather dormant; publishing stopped completely.

Shortly before WW II—in 1933—the museum was re-named “Landesmuseum”. During WW II, the museum transferred parts of the collections to external depots. Indeed, a firebomb caused a major fire-damage to the building in 1943, which completely lost its dome. Due to this and the chaotic early post-war years, some collection material got lost.

In 1946, the new (and artificial) German federal state “Niedersachsen” (Lower Saxony) was founded by the Allies, and Hannover was established as its new capital, today often called “Leibniz-town” due to its most prolific former inhabitant, Gottfried Wilhelm Leibniz (1646–1716). The museum was soon after renamed once more into "Niedersächsisches Landesmuseum", keeping its four branches, beginning with first steps to establish an additional aquarium (and some terraristic parts) for the natural history and, naturally, further increasing its collections by donations as well as by acquisitions. The biggest one surely was the collection of Otto Klages (bought in 1984, see below), and the most specialized one Kurt Wiedenroth's collection (mainly ammonites, bought in 1990). Accumulation of new collection material continued until additional dependencies were necessary besides the main exhibition building. After phases with altogether three separate buildings, one large, major long-term building finally resulted, which is situated in Hannover-Linden and houses all natural history and most of the other branches'collections together with the preparation laboratories, libraries and offices since 1997 and until today. In 2014, further external storage rooms had to be rented for the extensively growing archaeology.

Since the mid-2000s, an additional collection focus was laid upon the terrestrial Lower Cretaceous within the geo-section (see below).

The most recent steps within the development of the main (= exhibitions & administration) building was an allover building refurbishment from 1995 to 1999 and the complete exhibitions rebuilding phase, starting in 2013. Then, the natural history left the traditional 1st floor to be united with the "living" parts of its exhibitions (aquariums etc.) on the ground floor, altogether successfully building up the new combined, interdisciplinary permanent exhibition "NaturWelten" (NatureWorlds) since summer 2014 (Summaries can be found at Boenigk 1990; Broschinski 2002; Gmelin 1985; Grape-Albers 2002; Richter and Böhme 2013; Rohde and Gervais 1986).

29.2 Focal Points of Main Collection Parts

Carl Eberhard Friedrich Struckmann (life data: 1833–1898; app. 6000 specimens and series; in the museum since 1906).

On one hand, this collection comprises mostly disarticulated and mainly marine Upper Jurassic invertebrate and vertebrate fossils (Fig. 29.1), with a marked focus

Fig. 29.1 Struckmann-collection; complete skeleton of the fossil rhynchocephalian *Kallimodon pulchellus*, Upper Jurassic (Kimmeridgian); Ahlem. Ahlem is a borough of Hannover, today. Measurements of limestone slab: 37 × 19 × 9 cm. Copyright: Landesmuseum Hannover

on Oxfordian and Kimmeridgian specimens from the Western Hannover underground now urbanized. Locality names like "Lindener Berg" or "Ahlem" stem from times when these areas had own limestone quarries, where Struckmann collected; nowadays, they belong to Hannover proper.

On the other hand, Struckmann actively led digging campaigns in the famous Pleistocene "Einhornhöhle" (unicorn cave) in the vicinity of Scharzfeld, southern Harz Mountains; besides general osteological material from there, especially the beautifully preserved (but disarticulated) cave bear material deserves being mentioned here. Also, Struckmann surely was the first North German palaeontologist to collect and correctly identify Lower Cretaceous "Wealden" tracks in the local sandstone from the "Rehburger Berge" (Rehburg mountains) as belonging to the freshly erected clade Dinosauria. The historical labels of his collection can be identified by graphological comparisons and show an ancient German handwriting of the 19. Century (not "Sütterlin", but with some similarities to "Deutsche Kurrentschrift" see Fig. 29.2), often containing many details about locality, stratum, date, characters of specimen, etc.

Wilhelm Hoyer (1854–1932, collected around 1900; app. 5000 specimens and series; in museum since 1951).

Shortly after the main collecting activities of Struckmann, the construction engineer and geologist Prof. Hoyer meticulously collected large numbers of fossils W'of Hannover, around Hildesheim and between the Weser and Leine rivers. His collection comprises mainly large numbers of ammonites (Mönnig 1989) and belemnites and marine invertebrates typical of the whole series of regional Lower Saxony Jurassic strata; some ichthyosaur and other vertebrate remains are also recorded.

Otto Klages (1903–1982, app. 3000 specimens and series; in museum since 1984).

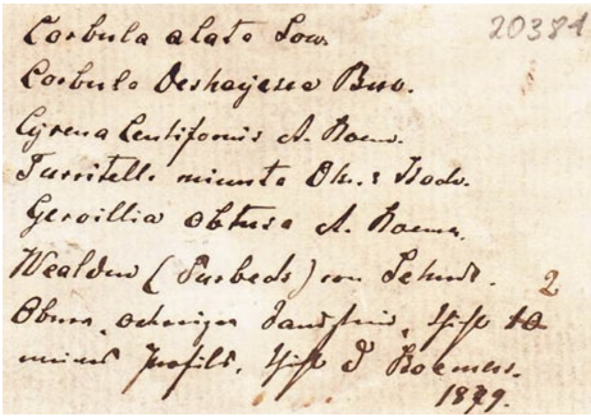

Fig. 29.2 Example of a handwritten label from the Struckmann-collection (1879) with many systematical notes about the fossil content of a small Lower Cretaceous handpiece E'of Hannover. Note the difference between the first six taxonomic/locality and the last two stratigraphical lines, the latter containing "sch" and "ch"-combinations of this "fossil" handwriting. Pencil in corner is the inventory number (1970s?). Original size: 5.5 × 8.7 cm. Copyright: Landesmuseum Hannover

Having been an allround collector, Klages put his focus not merely on fossils, but also on minerals and rocks. His huge threefold collection was bought by the Ministry of Science and Culture and comprises different focal points. The most important fossils derive from the regional Muschelkalk (Middle Triassic)/Elm (= his home) region near Königslutter, Eastern Lower Saxony. During post-war times, Klages had the opportunity to collect in a series of then still active Muschelkalk quarries, which are all shut down by now. At these times, they yielded well preserved and abundant crinoids (Fig. 29.3), and Klages used the large amounts of his crinoid surplus material like an exchange currency for his quite international fossil collectors' circles. The ceratites from his Elm Muschelkalk collections also deserve some extra mentioning. Also, Klages had started an Upper Cretaceous focus upon the Campanian Misburg/Höver-fossils (E' of Hannover, often called "Hannover-Anderten"), but unfortunately most of them with ambiguous stratigraphic information. The same holds true for his Upper Jurassic "Plattenkalk collection" from the Bavarian Altmühltal.

Fig. 29.3 Klages-collection: Rather complete fossil crinoids (*Encrinus liliiformis*) from Erkerode, Elm Hills, near Königslutter, one of the most prominent occurrences of Lower Saxony's "Unterer Muschelkalk" (Lower Muschelkalk, Middle Triassic). Measurements of the limestone slab: 85 × 55 × 11 cm. Copyright: Landesmuseum Hannover

Fig. 29.4 Wiedenroth-collection: *Androgynoceras* cf. *capricornus* and *Liparoceras* cf. *gallicum, Passaloteuthis* sp.; Jurassic, Liassic, *lataecostatum*-zone, nearby Wolfsburg, county Helmstedt, Lower Saxony. This impressive large cephalopod limestone slab weighs 35 kg. It is part of the new permanent exhibition "NaturWelten". Copyright: Landesmuseum Hannover

Kurt Wiedenroth (born 1938, app. 1500 specimens and series; in the museum since 1990).

An active collector until today, Wiedenroth sold one of his sub-collections to the Landesmuseum Hannover. During that time he had specialized in the Jurassic ammonites of the region (Fig. 29.4); he changed focal points later on. The collection comprises mainly beautifully preserved and highly diverse ammonites, skillfully prepared by himself.

Additionally to that collection, Wiedenroth had donated material before (i.g., disarticulated, but well-preserved remains of a Lyme Regis pliosaur (Jurassic), a rhomaleosaurid, which will be named after him; see below).

Werner Pockrandt et al. (**1905–1988;** domestically called "(Leibniz) University Collection" (ca. 1200 specimens and series; added by miscellaneous other privat collectors'material; in the museum since 2007).

The former head of the Hannover fossil collectors' circle ("Arbeitskreis Paläontologie Hannover, APH"), Pockrandt collected quite intensively in the region of Hannover and especially throughout the Cretaceous, there having not only the Campanian focus, but also marine Lower Cretaceous (Sachsenhagen etc.). He donated his collection to the Institute of Geology and Palaeontology, now Institut of Geology, at the Leibniz University. When the Institute needed one of the collection rooms for new laboratories, a large part of his collection and of material he had acquisitioned from APH-fellows was given to the Landesmuseum. It's a matter of geologically levelled, precisely labelled and mainly small-sized fossils of diverse marine taxa.

Wolfgang Weidehaus (**born 1954,** app. 3000 specimens and additional material; in the museum since 1996).

Still on focus for research and not yet completely inventoried, a large Pleistocene to Medieval mammal bone collection was gathered by Weidehaus at the gravel pits of Hemmingen and Koldingen, S'of Hannover. This material was pre-sorted in a comparative anatomical way. This grand collection accompanies the 50 or so single, large Pleistocene objects from underground train construction work in Hannover (mostly 1960s; mammoth tusks, woolly rhinoceros skulls, musk ox etc.). Also, Weidehaus donated material from the Upper Cretaceous (Campanian) of the Misburg-Höver-area E'of Hannover.

29.2.1 Miscellanea

From ca. 2000 on, terrestrial fossil material from the sandy Berriasian of both the Münchehagen Quarry (**Family Ferdinand Wesling**) and the Obernkirchen Quarry (**Klaus Köster**) has been donated/acquired/dug up, comprising ichnofossils like theropod and ornithopod dinosaur tracks, but also tree logs, smaller plants (e.g., Ginkgo leafs) and clams as well as further vertebrate remains like crocodile skulls and jaws and turtle shells in the typical hollow preservational mode. Much of this material is now part of the new exhibition (see above).

In 2013, the museum could purchase a very well and three-dimensionally preserved, rather complete ichthyosaur from the Lowermost Jurassic of Great Britain (Liassic, Donniford Bay). This specimen is also on display and currently under study by ichthyhosaur specialists from Germany and Great Britain.

The *Europasaurus*-project (2013–2016)—funded by the VolkswagenStiftung—yielded the first record of (north) German Mesozoic mammal teeth, which were found slightly below the so-called "dinosaur-bank" from the Langenberg quarry (see below) within the Kimmeridgian, focal research point of the museum's cooperational partner "Dinosaurierpark und Freilichtmuseum Münchehagen". To date, it is known that at least two of these teeth belonged to Multituberculates.

During this project, historical dinosaur (theropod) teeth from the Struckmann-collection were involved in the study of theropod teeth from all over Northwest Germany.

Long-term loans: As heritage from the last decades, a certain amount of long-term loans from the "Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)" can be identified within the collections, among those containing both elasmosaurid material (see below) and Pleistocene vertebrates.

29.3 Infrastructure

Today's Natural History Department has a staff of ten. In a mode of staff-union, the actual head of the department is also the Earth Sciences senior custodian. The Bio-Sciences are represented by a Biology curator. A scientifical trainee belongs to the regular junior staff (2-year-terms). For both subbranches, a collection manager takes care of new and old material and their data, all objects stored within the generally air-conditioned collection rooms. Geosciences are housed in two areas, one major and large double-room for general geosciences (dehumidified) and a smaller one for Pleistocene bones (humidified). A zoological preparator as well as a fossil preparator—both with large and well-equipped laboratories—belong to the department. A specialized and experienced pedagogue joins the team for all purposes of scientifical promotion or general knowledge mediation as well as a librarian, who is also responsible for the books from the other branches. A newly hired registrar cares for the loan affairs of all branches.

For the living parts of the department, two professional animal keepers and usually one trainee (3-year-terms) round up the staff, those three being situated at the main building at the animal exhibition zones, the rest of the staff in the dependance "Fössestraße". Financial perspectives are a bit tautly since 2015, and regular larger acquisitions cannot be made any more since 1995 (regular acquisition budget was cancelled), but there is always solid ground for continuous work at the collections, research and the exhibitions. The Landesmuseum Hannover is a subordinate authority of the Lower Saxony "Ministerium für Wissenschaft und Kultur" (Ministry of Science and Culture) and receives its financial support from there.

29.4 Research/Network/Thesis Supervisions/Publications

Due to the focus on the typically marine Lower Saxony Mesozoic strata, especially the large ammonite collections (Hoyer, Wiedenroth, Klages) were topics of research until the 1990s (under supervision of K. Friese and H. Rohde). From the mid-2000s on, the emphasis was put on terrestrial sediments ("Wealden"-sandstones) from the local Berriasian at the last two active quarries, Münchehagen and Obernkirchen. Volunteer-based fieldwork was conducted under the project management of A. Richter and A. Böhme (as well as partially O. Wings) together with the staff from the Dinopark Münchehagen at Münchehagen from 2004 until 2008 and at the Obernkirchen Sandstone Quarries from 2007 until recently (2016; collection impact see above). The enormous amount of well-preserved dinosaur tracks (Fig. 29.5) in long trackways, containing unexpected new ichnotaxa, led to ongoing national and international research contacts, an international symposium (2011) and an internationally published major book (2016). Due to the necessities of this kind of large-scale field research on enormous layer surfaces, photogrammetry was introduced in the natural history department und constitutes the youngest branch of the palaeowork. An efficient photogrammetry computer station was installed to be more independent from university cooperations.

The Landesmuseum dinotrack research is internationally acquainted by a series of publications and well-established by a group of national (A. Richter, A. Böhme, J. Hornung, O. Wings, B. Englich, N. Knötschke) and international (J. Farlow, P. Falkingham, D. Marty, and many others) co-workers; an additional axis to Spanish colleagues with comparable "Wealden" sediments and ichnofauna has been established in 2016 (D. Castanera & colleagues).

Fig. 29.5 Current research in the Lower Cretaceous (Berriasian) sandstones in southwest Lower Saxony: Tridactyl dinosaur (theropod) track in the Obernkirchen Sandstone Quarries, Bückeberg, County of Schaumburg. Casts and original slabs from Obernkirchen and Münchehagen (Rehburger Berge, county of Nienburg) are housed in the Landesmuseum Hannover due to this focal research point. Copyright: A. Richter

A 4-year-research-project funded by the VolkswagenStiftung joined the Landesmuseum with the Dinopark Münchehagen again, as the palaeontologists there had been conducting regular and very successful fieldwork at the Upper Jurassic Langenberg Quarry (Oker, vicinity of Goslar, northern Harz Mountains) since 1999/2000, markedly increasing the dinosaur research within Lower Saxony. O. Wings led the coop-project (2013–2016); during that time, the very first Mesozoic Mammal teeth were discovered and integrated into the Landesmuseum's collections (see above). Dozens of publications had their origin within this project.

A series of bachelor theses from students focussing on fossils from the aforementioned collections (especially Struckmann and the Kimmeridgian, but also Pleistocene material like mammoth and musk ox) were supervised by A. Richter during the last 12 years and mostly published in the more regional journal of the founding society NGH ("Naturhistorica"). A newly donated, disarticulated, but extremely well-documented ichthyosaur from the nearby town of Garbsen will be the next fossil complex to be studied within this series. Hopefully, it can be compared to the fragmentary material in the Hoyer collection (work in progress; see above).

For the future, the scientific value of at least the two main historical collections with Jurassic fossils, Struckmann and Hoyer, will surely rise in spite of the partially lacking stratigraphic details, as urban settlement still increases in the Western part of Hannover and leaves no access to the characteristic Jurassic sediments any more.

The same holds true for the Elm Muschelkalk quarries from the Klages collection and many local clay pits from the Wiedenroth collection.

To date, the external research focus is set on founding new cooperations with competent international specialists for outstanding (mainly marine) fossils from all over the Hannover palaeo-collections, like the Wiedenroth-pliosaur (see above;

already in press), an elasmosaurid from the Lower Cretaceous of Sarstedt (oldest elasmosaur, BGR-loan, see above; also in press), the large new British ichthyosaur (see above; in progress), a large and fully articulated *Enchodus*-species from the Upper Cretaceous (donated by the former TEUTONIA Cement Company; in negotiation), and many more.

29.5 Exhibitions

According to actual alignments from the Ministry of Science and Culture, the concept for the newly erected permanent exhibition of the natural history department—the "NaturWelten" from 2013/14—represents a series of multidisciplinary connections. At first, as mentioned above, living animals (mostly fishes, but also amphibians and reptiles) were combined with the exhibition *sensu stricto*—thus, with objects (Fig. 29.6). Second, biology and palaeontology objects were combined with each other. Third, all three object classes form an interdigitating connex within a narrative structure following the *panta rei*-principle of natural sciences.

One suitable example here is the South America zone, where the visitor can see that today's jungle—horizontally far away—has been here in Lower Saxony, too, but in a vertical aspect, say: time. During the Carboniferous, the Piesberg region (near Osnabrück) also was a tropical jungle with large woods formed by the typical Carboniferous palaeoflora.

Fig. 29.6 View into the "waterworld" of the new permanent exhibition "NaturWelten" in well-planned ambiental atmosphere with interdisciplinary approach; aside the fish tanks, for example osteological material is on display. Note a skull from Steller's sea cow (*Hydrodamalis gigas*: subfossil/subrecent) in the middle of the picture. Copyright: Landesmuseum Hannover

Fig. 29.7 The large ammonites *Patagiosites* (*Pachydiscus*) *stobaei* (75 cm Ø) from the Campanian East of Hannover (Misburg and Höver) are almost as famous as the world's largest ones from the Münster Cretaceous basin. They are rarely ever found in such complete and undamaged condition as the shown specimen

In contrast to the 1990s, when a high percentage of models and casts were favoured for exhibitions, many authentic original fossils are presented again, which vividly changed the appearance of the natural history department.

Together with modern equipment like digital infoscreens, also rare and precious authentic exhibits are on display (Fig. 29.7) partly with reduced information and altogether within perfect ambiance. This new exhibition received and receives much positive resonance.

29.6 Cooperation with Schools

Large-scale cooperation with schools is a major feature of the museum education at the Landesmuseum Hannover. During the last three decades, especially the natural history department has evolved into an important off-campus learning place for environmental and geo-bio-sciences, with programs developed for all school grades and types.

Teaching units and workshops are offered in accordance with German/Lower Saxony school curricula and on the basis of a concise mediation claim concept. Special cooperations are established with some partner-schools, allowing for intensive long-term projects even within intercultural context.

Additionally, the facilities of the Landesmuseum Hannover are frequently used to enhance university teaching by high-level guided tours to the exhibitions and anatomical study afternoons in collection rooms. This brings the authentic original object into the focus of students and a practical aspect to theoretical lectures (G. W. Leibniz: *Theoria cum praxi*).

Cooperation projects with New Media specialists from the University of Applied Sciences are already traditionally used to enhance the quality of digital hands-on offers within the exhibition.

29.7 Media/Social Media

Multimedia Guides are available free of charge both for large parts of the permanent exhibitions as well as the special ones. For professional guidance tours, a Tour-Guide-System has been established.

Social media like Facebook, Instagram, a Museum-Blog or Twitter are currently applied by the Public Relation Department of the Landesmuseum Hannover; Breaking News about current research results, exhibitions and other new information are routed there and made known to the public, regularly. Intensified YouTube application is planned for the nearby future.

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Chapter 30
HILDESHEIM: Roemer- and Pelizaeus-Museum

Jürgen Vespermann

The Roemer- and Pelizaeus-Museum is composed of the two separate institutions: the Roemer-Museum and the Pelizaeus-Museum. Whereas the Pelizaeus-Museum is well-known for its collections of ancient Egyptian art, the Roemer-Museum houses all partitions of natural history and human history. The depot is in the vicinity of the main station.

The paleontological collection of the Roemer- und Pelizaeus-Museum comprises about 120,000 specimens of all systems, series and periods. Nearly all systematical units are well presented. Even though the focus is on the systems of the mesozoian ages Triassic, Jurassic and Cretaceous, which form the surroundings of Hildesheim.

The roots of our house can be traced back to the early fourties of the nineteenth century when Hermann Roemer (1816–1894), his brother Friedrich Adolph Roemer (1809–1869) and a couple of well-known citizens of Hildesheim founded the "Verein für Kunde der Natur und der Kunst im Fürstenthume Hildesheim und in der Stadt Goslar" (Society of Nature and Art). In the second half of the nineteenth century mainly Hermann Roemer and later his successor Prof. Dr. Achilles Andreae compiled a large collection of fossils from all over the world. Both of them made important donations of fossils and amounts of money for the museum.

The most valuable part is the Original material of the early works of Friedrich Adolph Roemer's monographs on the Jurassic system (Oolithengebirge (1836 and 1839) and on the Cretaceous system (Kreidegebirge 1841). Moreover there is a lot of material of the works of Anton Schrammen on Cretaceous Porifera.

An overview of the varieties of important material:

Friedrich Adolph Roemer (1836 and 1839) Oolithengebirge e.g. the Jurassic system of northern Germany.

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Friedrich Adolph Roemer (1841) Kreidegebirge e.g. The Cretaceous System of Northern Germany.

Alcide d'Orbigny (1846): The fossil Foraminifers of the tertiary Vienna basin.

Material to the following works is in the collection:

Andreae (1893), (1904), Beyrich (1854), Bode, A. (1953), Bölsche (1867), Dames (1888), Dunker (1851), Eck (1885), Hoffmann (1913), Huf (1968), Janssen (1978) (1979), Koenen (1902), Koken (1883), Krause (1891), Lipps (1923), Menzel (1902), Meyer (1841), Mönnig (1989), (1992), Neumayr & Uhlig (1881), Orbigny (1846), Philippi (1843), Roemer, F. (1876), Roemer, F.A. (1836, 1839), (1838), (1841), (1862–1864), (1864–1866), Roemer, H. (1874), Rust (1998), Salfeld (1909), Schlönbach (1863), Schrammen (1899–1912), Struckmann (1880), Thies (1988), Volz (1895), Wollemann (1900).

Fig. 30.1 The giant egg of *Aepyornis maximus* with a volume of 7.67 L was purchased in 1885 for an amount of 850 Reichmarks. It is nearly complete and was found in Pleistocenian deposits in Madagascar

Fig. 30.2 *Pholidosaurus schaumburgensis* H. v. Meyer. Lower Cretaceous, Berriasian, Bückeburg Quarries, Lower Saxony, Germany. A mold of the lower jaw of a Gharial-like reptile, detected in the Wealden-deposits during the nineteenth century. I was published by the famous Hermann von Meyer in 1841, and again by Koken 1883. The overall length is about 120 cm

Fig. 30.3 Tooth of *Liopleurodon cf. ferox* Sauvage. Middle Jurassic, Callovium, Hildesheim, Temme clay-pit. Fragment with 89 mm length. Originally the length was more than 20 cm of a banana-like-shaped fang. There are some more isolated bones (vertebrae, femur-bones etc.) of these giant reptiles in the collection of the museum

Fig. 30.4 *Stenopterygius sp*. One of the famous specimens with complete preserved shape of the skin ("Hautschattenerhaltung") from the Holzmaden-Lagerstätte. Lower Jurassic, Lower-Toarcian of the Holzmaden-Ohmden area. It was purchased in 1935 by the former director of the Roemer-Museum Prof. Dr. Friederich Schöndorf. Dimensions of the specimen: 135 × 51 cm. Only some few Ichthyosaurs are known with this extraordinary preservation of organic material

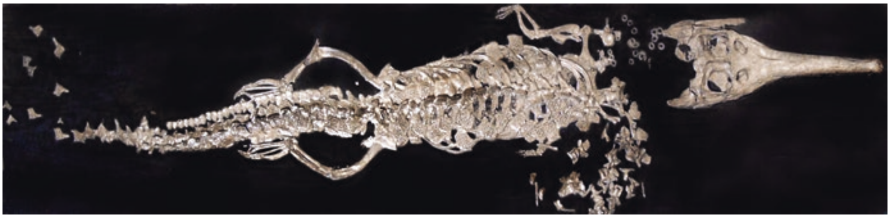

Fig. 30.5 *Steneosaurus bollensis* Jaeger. A nearly complete specimen of a Gharial-like crocodile also from the Holzmaden-Ohmden area. It was purchased by Hermann Roemer in about 1890. The specimen was prepared and signed by the well-known Bernhard Hauff (1866–1950) in 1890. Dimensions: 314 × 77 cm

Chapter 31
HOLZMADEN: Prehistoric Museum Hauff—A Fossil Museum Since 4 Generations—(Urweltmuseum Hauff)

Rolf Bernhard Hauff and Ulrich Joger

The Prehistoric Museum Hauff is situated within the world-wide known Jurassic (Lias epsilon) fossil site Holzmaden/Ohmden and displays the most impressing and most beautiful fossils found at this place during the last 150 years.

The foundation of the museum was laid by Bernhard Hauff senior (1866–1950) with his private collection. He prepared his first fossils already at the end of the nineteenth century.

His father Alwin Hauff had studied chemistry at Tübingen University and had come to Holzmaden to follow his idea to gain mineral oil out of the local shale. Competition from abroad forced him later to produce alternative industrial goods such as popular bricks made from burned limestone and grinded shale. The Holzmaden shale was processed into stove bases, wall panels, table-tops and window-sills. This was the beginning of the Holzmaden shale industry, which still exists today.

Bernhard Hauff was, however, more interested in the fossils. He found them during his everyday work in his father's shale quarry and prepared them himself—often in the early morning. For this purpose, he developed specific tools which he constantly improved. Finally he managed to work out under a microscope fossil soft tissue of an ichthyosaur. For the scientists of those days it was sensational when in 1892 he prepared a complete ichthyosaur with its surrounding skin.

In 1921 the University of Tübingen bestowed on Bernard Hauff the title of an honorary doctor.

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Fig. 31.1 The crocodile *Steneosaurus bollensis* Jaeger, the museum's symbol

In the years 1936/37 the private collection of Bernhard Hauff was transferred into the first museum. Thousands of motorists remember the famous signposts with the museum symbol on the motorway A8 Stuttgart-Ulm, exit Aichelberg, pointing the way since decades ago. It shows a Jurassic marine crocodile (*Steneosaurus*, Fig. 31.1).

In the years 1967–1971 the museum was rebuilt by Bernhard Hauff jun (1912–1990), the son of its founder. Today that building is still the main building of the museum complex.

Without any compromise, the main focus of the visitors is concentrated on the perfectly prepared fossils. The collection includes spectacular fossils of the locality Holzmaden/Ohmden. The most interesting exhibits are: one of the best preserved ichthyosaurs with fossilized skin and muscles, a pregnant ichthyosaur with five embryos (Fig. 31.2), moreover one of the largest complete ichthyosaur skeletons of 8 m length, two extremely rare plesiosaurs, a complete pterosaur, diverse Jurassic marine crocodiles (Fig. 31.3), a collection of numerous, very rare and exceptionally

Fig. 31.2 *Stenopterygius quadriscissus* (Quenstedt) Ichthyosaur with body shape shadow

Fig. 31.3 *Stenopterygius crassicostatus* mut *antecedens* (Huene) Ichthyosaur female with 5 embryos and a juvenile embedded besides the mother

well preserved fishes (Fig. 31.4), a great variety of ammonites, belemnites, crustaceans and other invertebrates and, last but not least, crinoids as relatives of sea urchins and starfishes. The World's largest colony of fossil crinoids covers a surface

Fig. 31.4 *Dapedium stollorum* (Thies Hauff)

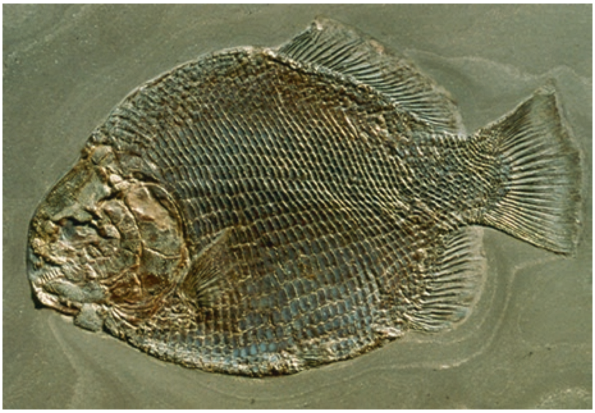

Fig. 31.5 *Seirocrinus subangularis* (Miller). The world's largest colony of fossil crinoids with more than 100 individuals

of 18 by 6 m. Several hundred crinoids crowns on long stems surround a 12 m long piece of driftwood. This big colony represents one of the museum's main highlights (Fig. 31.5).

In the years 1989–1993 the grandson of the founder (who presides the museum today) erected a large extension building. Here the typical stratigraphy of the Holzmaden shale—deposited 180 million years ago—is on display. If a mean sedimentation rate of 3 mm shale per 1000 years is considered, the 6 meter thick profile shows the visitors two million years of marine history, presented step-like in a 1: 1 scale. In addition, the typical fossils of each layer are presented.

In four dioramas the post-mortem destiny of ichthyosaurs is shown—their embedding, fossilization and preparation, leading to a lively reconstructed model.

In a cinema, visitors can watch a 25 min. movie and compare the rich marine fauna of Jurassic times with that of today.

In the external area a dinosaur park was installed in the year 2000. At the bank of a lake, live-size models of mainly Jurassic dinosaurs can be seen among plants like *Equisetum*, *Gingko* and *Metasequoia*.

During the last 10 years, the museum received an improved light conception with LEDs. The exhibition of pterosaurs has been enlarged and equipped with very detailed models. The department of invertebrates has been redone with respect to ecological motives. In a new media station, the Jurassic period is shown in the context of a geological clock that represents the complete history of the earth. The cinema was equipped with a modern screen on which movies or powerpoint presentations can be shown. In 2016, a panorama of the Jurassic sea, measuring 4 by 2 m, was installed. A couple of lively models of reptiles and fishes improve the exhibition and make the phantastic submarine world of the Jurassic come alive.

In the workshop of the museum, two specialists are preparing new and old finds every day. During workdays and weekends, 10 staff members are taking care for the 35,000 visitors per year. From May to July, about 400 school classes visit the museum.

Doctoral students and scientists from all over the world utilize the scientific collection of the museum for scientific research and publications on fossils of the *Posidonia* shale. Approximate numbers of available specimens: 15 complete ichthyosaurs, 4 *Steneosaurus*, 7 pterosaurs, 200 fish, several hundred belemnites and ammonites, 20 crustaceans and 20 plants in the scientific collection, about 90 complete vertebrate skeletons and 560 invertebrates or plants in the public exhibition.

Still today the museum is being lead by the Hauff family in its fourth generation without any public funds. In 1989 it has been transformed into a non-profit foundation. In 2013, a supporting society was founded.

The Holzmaden locality was declared a protected fossil site in 1979. In 2006, the Academy of Geological Sciences at Hannover admitted Holzmaden into its List of National Geotopes, and proposed it as a UNESCO World Heritage site.

Only at few sites on earth, geological history can be experienced as authentically as in Holzmaden. Here, where 180 million years ago, reptiles, fishes, crinoids and ammonites used to live, they are now shown in the museum, and in the nearby quarry visitors can look for fossils on their own.

Chapter 32
INGELFINGEN: Muschelkalkmuseum Hagdorn Stadt Ingelfingen

Hans Hagdorn

32.1 From Private Collection to Public Museum: Development of the Collection

The Muschelkalkmuseum Ingelfingen holds a specialized collection of fossils from the Triassic Period with a focus on the Muschelkalk and Lower Keuper, the Middle Triassic in Central Europe, and Triassic echinoderms worldwide. The Museum originated from the private fossil collection of the museum founder, Hans Hagdorn (K. Hagdorn 1997). In the early 1960s he started collecting in natural and artificial outcrops exposing Muschelkalk rocks around Schwäbisch Hall and Crailsheim (Baden-Württemberg). Collecting was then most successful in the countless active stone quarries exploiting Upper Muschelkalk for production of gravel and building stones. Since the mid 1970s he expanded his collecting area to Central and North Germany and Eastern France, and after the fall of the Iron Curtain also to East Germany and Southern Poland. By the end of the 1980s, many small quarries were shut down due to gradual technical and economic concentration and locational disadvantage or inefficient organization. Moreover, access to the surviving big quarries became increasingly difficult for safety and operational reasons. Nevertheless, the collection is still growing with newly found specimens and by acquisition or donation of other collections. Eventually, joint research projects made it possible to include Triassic fossils from other countries and continents. Hence, one of the largest and most representative specific collections could be accumulated (Figs. 32.1, 32.2, 32.3, 32.4, 32.5, and 32.6).

A first public exhibition was opened in 1986 in two rooms of Hagdorns' eighteenth century private house in Schlossstraße 11. The scientific collection was stored in the basement in historical museum cabinets discarded by other institutions.

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Fig. 32.1 The Muschelkalkmuseum in the historical "Innere Kelter" in the Ingelfingen town center

However, the growing collection required more space for public display and for storing the scientific material. In 1996 the Ingelfingen town council and administration made new rooms available in the restored "Innere Kelter" in Schlossstraße 3, a large historical wine press building in the center of the town. On approx. 350 m^2 it was now possible to display all major groups of Muschelkalk and Lower Keuper invertebrates and vertebrates in glass cases (H. Hagdorn 2004). Installations displaying the 1865 Ingelfingen deep drillhole and the morphology of the deeply incised Kocher valley, as well as a separate cabinet for fossil echinoids were added.

In 1997 regional companies producing Muschelkalk gravel and building stones established the "Friedrich von Alberti-Stiftung der Hohenloher Muschelkalkwerke" (Alberti Foundation). The mission of this foundation is to promote scientific research on the Muschelkalk in North Baden-Württemberg and to honor professional and private paleontologists with the Alberti Prize which is endowed with € 10,000.00. Starting in 1998, the ownership of the collection was transferred in annual tranches to the Alberti Foundation. It was an inspiring idea

Fig. 32.2 The Muschelkalk crinoid *Encrinus liliiformis*—object of research since almost 500 years. Length of crown 7.5 cm

to return the fossil treasures collected from their quarries and pits to the foundation members.

In 2003 the Ingelfingen town administration provided a nearby dry and technically suitable 90 m^2 room to house the journal library and the scientific collections. This room became prerequisite for adequate and secure storage of the much increased collection and for inclusion of several private collections acquired by or donated to the Alberti Foundation. Most notable were the donations of an excellent Muschelkalk collection by Werner Kunz (Würzburg) in 2011, and the Lower Keuper and Muschelkalk collection of Werner Kugler (Crailsheim) since 2010. The latter comprised the largest private collection of Middle Triassic vertebrates in Europe and made the Muschelkalkmuseum a considerable address for specific research.

Public display of the Kugler collection highlights required additional space. Hence, a complete floor under the roof of the "Innere Kelter" was fitted out as a

Fig. 32.3 The pseudoplanktonic crinoid *Traumatocrinus* from early Late Triassic black shales of South China has been a major object of Muschelkalkmuseum research

Fig. 32.4 Skull and lower jaw of *Mastodonsaurus giganteus*, the biggest amphibian of earth history. Length of skull 60 cm

gallery for the Lower Keuper fossil and environment exhibition (H. Hagdorn 2009). At present the Muschelkalkmuseum displays its paleontological and geological objects on approx. 650 m^2 in the staircase area and on two floors of the "Innere Kelter". A third floor is waiting for a possible future extension of the exhibition.

Fig. 32.5 Werner Kugler Gallery with Lower Keuper exhibition in the truss of the "Innere Kelter"

Fig. 32.6 Scientific collection and journal library

32.2 The Collection

In its present state, the Muschelkalkmuseum collections comprise more than 25,000 specimens and series of fossils, minerals, and rock samples from the Germanic Muschelkalk and Lower Keuper, the Tethyan Triassic of Europe, Asia and North America with focuses on Triassic echinoderms worldwide, Muschelkalk and Lower Keuper vertebrates, and Muschelkalk invertebrates in general. Among these are several hundred specimens described and displayed in scientific publications since 1982, some type specimens (Echinodermata, Mollusca, Vertebrata, trace fossils) included. Numbers of specimens (exhibition and collection) were roughly counted drawer by drawer.

Stromatolites and onkolites (45 specimens); Dasycladales (20 specimens); Muschelkalk and Lower Keuper higher plants (220 specimens); Middle Keuper silicified wood (40 specimens); Porifera (30 specimens); Anthozoa (150 specimens); Hydrozoa (35 specimens); Microconchida (60 specimens); Bryozoa (20 specimens); Brachiopoda (2400 specimens and series); Arthropoda: Ostracoda and Spinicaudata (50 samples); Hexapoda (3 specimens); Decapoda (130 specimens); Mollusca: Scaphopoda (40 specimens); Gastropoda (230 specimens); Bivalvia (3500 specimens and series); Cephalopoda (4600 specimens and series); Echinodermata: Crinoidea (2250 specimens and series); Echinoidea (180 specimens and series); Holothuroidea (5 specimens); Ophiuroidea (320 specimens and series); Asteroidea (70 specimens); locality based Muschelkalk and Upper Buntsandstein faunas (mostly Mollusca) – (2700 specimens); Vertebrata: Chondrichthyes, Actinopterygia, Sarcopterygia (750 specimens and series); Temnospondyla (860 specimens incl. 30 skulls); Reptilia (1200 specimens incl. 7 skulls); trace fossils (290); bonebed samples (100); mineral and rock samples (460 specimens); Germanotype Triassic: South France, Spain, Hungary, Israel, Saudi Arabia (250 specimens and series); Tethyan and Boreal Triassic: Alps, Hungary, Greece, Bosnia, Timor, China, North America, Russia (2400 specimens); Echinoidea, systematic collection (1600 specimens); Crinoidea excl. Triassic: 250 specimens and series); echinoderms and other fossils, Cretaceous of Mön (300 specimens); 1 mammoth tusk.

Detailed documentation of localities, stratigraphic data, date of finding or acquisition, provenance etc. have been added to each specimen on paper labels and/or by immediate inscription in Indian ink. Published specimens are registered by inventory numbers in current sequence on labels and on extra index cards. These numbers with the acronym MHI (Muschelkalkmuseum Hagdorn Ingelfingen) occur also in Indian ink on the respective specimens. A printed catalogue of types and published specimens or an electronic databank is not available but highly desirable.

32.3 Research

The scientific output of the Muschelkalkmuseum comprises more than 200 scientific and popular publications in regional and peer reviewed international journals, chapters in books and in a museum guide book (H. Hagdorn 2004). Again the focus is on

Muschelkalk stratigraphy and paleoecology, taxonomy and functional morphology of Triassic echinoderms, and also on history of paleontology. Many of these publications resulted from cooperation with the Tübingen "Sonderforschungsbereich 53", with the Staatliches Museum für Naturkunde Stuttgart, the German Subcommission of Permian and Triassic Stratigraphy, the Goldfuss Museum Bonn, the Field Museum Chicago, the Yichang Institute of Geology and Mineral Resources, and other paleontological institutes in several countries. Research on Muschelkalkmuseum material by other scientists has been published in many journal articles.

32.4 Infrastructure and Didactic Conception

Technically and financially, the Muschelkalkmuseum is run by the municipality of Ingelfingen, with occasional financial support by local companies or private persons. Collection and exhibition management, preparation, research, events, meetings, workshops, field trips etc. are done on an honorary basis by the director. The museum has no staff at its disposal, however Ingelfingen seniors organize additional opening hours and a fossil collector assists with museum didactics and guided tours. Nevertheless, the Muschelkalkmuseum specimens are available for scientific research. Loans to other scientific institutions are possible. On average, 3–5 loans are made per year. The museum facilities are available for foreign researchers.

The Muschelkalkmuseum holds a well-sorted library covering regional and some major international paleontological journals, geological maps, several thousand reprints and books with a focus on Triassic paleontology and stratigraphy. The photo archive comprises a collection of black-and-white negatives, color slides, and electronic image files of Triassic fossils and outcrops many of which do not exist anymore. Facilities for fossil preparation and technical procession of micropaleontological or sedimentological samples are poor and not noteworthy.

The didactic conception of the Muschelkalkmuseum is to introduce visitors to the Triassic world by means of original fossils, additional replicas and models of invertebrates and vertebrates, graphic and photographic artwork and by introductory texts. Other topics are the Muschelkalk as mineral resource (rock salt, gypsum, limestone) and the development of the present landscape. The conception is targeted at any visitors interested in earth and life history with student and school classes in special. Fossil collectors can determine their finds and learn about their meaning.

32.5 Deficiencies and Perspectives

As a small institution run by a town of 5500 inhabitants and managed on an honorary basis, the Muschelkalkmuseum is unable to employ salaried staff. Hence, some museum functions cannot be done sufficiently. This concerns fossil preparation and database documentation, organization and financing of temporary exhibitions, internet and social media presence, and developing and executing modern didactic concepts. As it is nearly impossible to find a suitable volunteer successor for museum management, close cooperation of the funding bodies with one of the big natural history museums will be necessary to ensure the future of the Muschelkalkmuseum.

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Chapter 33
JENA: The Palaeontological Collections at the Phyletisches Museum in Jena

Dietrich von Knorre and Rolf G. Beutel

The Phyletisches Museum close to the city center of Jena (Vor dem Neutor 1, 07743 Jena) belongs to the Institut für Spezielle Zoologie und Evolutionsbiologie of the Friedrich-Schiller-Universität Jena (FSU). Its foundation in 1908 can be considered as a culminating point in the life and scientific career of the famous German zoologist Ernst Haeckel (1834–1919). His intention was to create an educational institution combining art and science, to present the concept of biological development and evolution in a vivid and accessible way to the educated public (Haeckel 1907; Uschmann 1959). The strictly symmetric Art Nouveau building clearly reflects his vision and concept. However, the design of the exhibition was exclusively in the hands of Haeckel's successors after his retirement ("Emeritierung") in 1909 (Fischer et al. 2008).

The history of the palaeontological collections is much older than the Phyletisches Museum itself. Today the two collections are stored separately based on their separate history. The origin is indicated by the acronyms of the inventory numbers to facilitate the search for voucher specimens, type material and other specimens. All specimens integrated into the collection of the Phyletisches Museum after the closure of the geoscientific institutes of the FSU in 1968 are designated with the acronym PJM **P** …., and are therefore easily recognizable as a historical unit. All other fossils bear the acronym PMJ **Pa** …. This part of the collection includes specimens purchased since the foundation of the Phyletisches Museums for the exhibition, donated material, and also more recent acquisitions.

In 1700 Wilhelm Ernst Duke of Sachsen-Weimar (1662–1728) initiated the installation of a "Naturalien- and Kunstkammer" (cabinet for natural objects and art) at his castle in Weimar (Maaz 2003). An early example for the acquisition of

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"petrefacts" is an ammonite from Altdorf, *Phylloceras heterophyllum* [Inv.-Nr. PMJ P 109], which was purchased from J. J. Baier (1677–1735) in 1728. This fossil is still part of the fossil collection of the Phyletisches Museum today (Kursawe 1995, 2000). In 1779 Duke Carl August of Sachsen-Weimar-Eisenach (1757–1828) purchased the "Naturalienkabinett" (cabinet of natural objects) of Johann Ernst Immanuel Walch (1725–1778), an important extension of the collection of "petrefacts" in Weimar. He combined this material with objects from the ducal "Naturalienkabinett", which were by that time already stored at the town castle of Jena, forming what was then called the "Herzogliches Museum" (Ducal Museum). Aside from material acquired from Baier (see above) it contained numerous specimens of the Walch collection used by this scholar for his work "Die Naturgeschichte der Versteinungen" (The natural history of petrefacts) (Walch 1773). Unfortunately, these specific fossils were not labelled by Walch, which makes it impossible to identify them in the collection today.

On the request of Johann Wolfgang von Goethe (1749–1832) Johann Georg Lenz (1748–1832) prepared a short overview of the natural history objects kept in the Jena city castle by that time, with special emphasis on fossil material (Lenz 1783). According to this account the "petrefacts" were stored in 11 large chests of drawers ("elf großen Commoden") in a room of the Ducal Museum. The presence of a body fossil of a *Palaeoniscus* cf. *freislebeni* in a slate kidney ("Schieferniere") from Ilmenau [Inv.-Nr. PMJ P 1124] was emphasized, and it was pointed out that the Ducal Museum is in the possession of some original pieces depicted by Bayer in his Orictographia norica (Table X, Figs. 33.1 and 33.2, Table XI …) (Lenz 1783).

In the following years the ducal collection of petrefacts ("Herzogliche Petrefacten-Sammlung", since 1815 "Großherzogliche Petrefacten-Sammlung") remained closely linked with the development of the Mineralogical Museum ("Mineralogisches Museum") until the building housing this institution was destroyed on March 19 1945 (Zenker 1836; Knorre and Beutel 2006; Kreher-Hartmann 2006).

With the installation of the "Haeckel-professorship for palaeontology and historical geology" ("Haeckel-Professur für Paläontologie und historische Geologie") from resources of the Ritter-foundation ("Ritter-Stiftung") (Uschmann 1959), well-known palaeontologists were active in Jena between 1894 and 1922 (Knorre 2010). However, apparently they did not greatly contribute to the enrichment and inventory of the palaeontological collection. In contrast to the mineralogical collection the palaeontological collection of the Mineralogical Institute was not kept in protected storage facilities during the Second World War. It suffered serious losses during the bombardment of Jena at March 19 1945 (Knorre 1983). The reconstruction of the geological study collection ("geologische Lehrsammlung"), which also comprised palaeontological voucher specimens, began already in the fall 1945 under the supervision of Fritz Deubel (1898–1966). The installation of an explicitly palaeontological collection was accomplished by Arno Hermann Müller (1916–2004) from 1952 until 1958, the year of his appointment as full professor ("Ordinarius") for palaeontology at the Montane Academy ("Bergakademie") of Freiberg in Saxony (Schneider et al. 2005). The material comprised borrowed old specimens and fossils acquired through his own fieldwork. An inventory remained

Fig. 33.1 Holotype of *Bos primigenius taurus* Bojanus (aurochs), from reedy marshes of Hassleben, western Thuringia. Foto: Frank Müller

very incomplete (about 330 specimens), but the collection contained valuable vouchers and original pieces used for his three-volume palaeontological textbook "Lehrbuch der Paläozoologie" (Müller 1957–1994). When it was taken over by the Phyletisches Museum in 1969 the collection comprised three parts, used either in the exhibition or for teaching purposes, or kept in the magazine, respectively. They were later combined as a single complex (4937 inventory numbers PMJ P 1–PMJ P 4937) and stored and inventoried under the designation "Sammlung des ehemaligen geologisch-palaeontologischen Institutes".

Aside from donations an important source for the formation of the palaeontological collection at the Phyletisches Museum were targeted purchases, like for instance from Bernhard Hauff (1866–1950) from Holzmaden (Baden Württemberg) in the 1920s, or the scientifc legacy of Arthur Weiss (1871–1940) with extensive series of "conchylia" from the Pleistozene of Thuringia, and casts of fossils from Solnhofen (Bavaria) and Holzmaden from the holdings of the anatomical institute of the FSU. A highlight is the skeleton of an Aurochs (*Bos primigenius*) from the

Fig. 33.2 Holotype of *Kinzelbachilla ellenbergeri* Pohl & Beutel (Strepsiptera), holotype, embedded in Burmese amber (ca. 100 my), scale bar 500 µm. Foto courtesy of PD Dr. H. Pohl

reedy marshes of Hassleben (Thurinigia), dated as approximately 10.000 years old. This specimen (PMJ Pa 4749) was used by Ludwig Heinrich von Bojanus (1776–1827) for the formal description of the extinct species (Bojanus 1827). In the years 1817–1822 Goethe (s. Goethe's works 1893, 1906) investigated this specimen and further findings of the aurochs in Thuringia (Burkhard 1974, Gersch 1974). The skeleton is depicted on table 24 (Taf. 24) of the publication of Bojanus (1827), whereby the facial part of the skull was complemented with parts from a different specimen. Goethe later commissioned a precise drawing of the skull fragments of the exemplar from Hassleben for Bojanus and sent it to him (see table in Nees von Esenbeck 1831). Mertens (1906) remarked: "Wesentlich auf dieses Exemplar hat Bojanus the Art *Bos primigenius* begründet" (Bojanus essentially based his description of the species *Bos primigenius* on this specimen). As the aurochs is the ancestral form of the domestic cattle named as *Bos taurus* by Linnaeus (1758), the name *Bos taurus* should be used following the priority rule. However, the International Commission on Zoological Nomenclature (ICZN, Opinion 2027) decreed an exceptional rule in 2003 for 17 domesticated species. It was determined that *Bos primigenius* should be used for the aurochs and *Bos primigenius taurus* for domesticated cattle.

Presently the palaeontological main collection comprises 6081 inventoried specimens, mainly pieces from Central Europe, with a certain focus on Triassic fossils (Tables 33.1 and 33.2). Recognized types belong to the following groups: trace fossils (5), Mollusca (3), Arthropoda (4), Echinodermata (1), Reptilia (1) and Mammalia (1). The two curators in charge of the zoological collection (ca. 600.000 specimens) are also responsible for the palaeontological material.

Table 33.1 Collection material in taxonomical order (count of inventory numbers—single specimens of series)

Taxonomic group	Collection former Geolog./ Palaeontol. Institut Jena **PMJ P…**	Main collection Phyletisches Museum Jena **PMJ Pa…**	Total
Undet. pieces	216	149	365
Life traces	178	50	228
Diverse small groups of plants	5	31	36
Pteridophyta	84	118	202
Spermatophyta	221	211	432
Protozoa	73	15	88
Porifera	129	39	168
Coelenterata	264	133	397
Diverse small groups of animals	25	10	34
Mollusca	1788	3046	4834
Arthropoda	254	169	423
Bryozoa	21	20	41
Brachiopoda	377	342	719
Echinodermata	375	166	541
Graptolithina	202	112	314
Vertebrata	725	1471	2196
Total	**4937**	**6082**	**11,018**

Recently the collection of amber fossils could be enriched by the purchase of the holotype of a new family of the controversial parasitic insect order Strepsiptera (Pohl and Beutel 2016; see also Pohl et al. 2005). This was made possible by financial support from the "Förderverein des Phyletischen Museums". Intensive research is also carried out with other amber fossils using innovative techniques, especially micro-computed tomography. The anatomy of a specimen of *Menge tertiara* (Baltic amber) could be reconstructed almost completely (Pohl et al. 2010; Hünefeld et al. 2011). Research on amber fossils is also carried out with material from other institutions, mainly in cooperation with the Institute of Zoology of the Chinese Academy of Science (Bai et al. 2013; Beutel et al. 2016). A new insect order was described based on a specimen embedded in Burmese amber (Bai et al. 2016). Presently, a postdoctoral fellow (Alexander von Humboldt Foundation) from the Palaeontological Institute of the Russian Academy of Sciences (Moscow), Dr. Evgeny V. Yan, is investigating impression fossils of beetles from the Permian-Triassic zone (Yan et al. 2017). The material is mainly from the collection of the Palaeontological Institute in Moscow. Palaeontological material from the collection of the Phyletisches Museum is occasionally used in the teaching program of the Institut für Spezielle Zoologie und Evolutionsbiologie, for instance in a course on the morphology and phylogeny of Arthropoda. The exhibition has about 18.000 visitors per year, including many school classes. Palaeontology is not in the main focus, but several palae-

Table 33.2 Stratigraphic overview of the collection material (count based on inventory numbers—single specimens of series)

System	Collection former Geolog./Palaeontol. Institut Jena **PMJ P…**	Main collection Phyletisches Museum Jena **PMJ Pa…**	Total
Undetermined	998	563	1561
Palaeozoic total	**1164**	**690**	**1854**
Cambrium	46	9	55
Ordovicium	107	1	108
Silurian	312	170	482
Devonian	368	288	656
Carboniferous	39	124	163
Permian	292	98	390
Mesozoic total	**2204**	**1502**	**3706**
Triassic	1064	766	1830
Jurassic	640	499	1139
Createceous	500	237	737
Caenozoic total	**571**	**3327**	**3898**
"Tertiary"	41	206	247
Eocene	32	262	294
Oligocene	80	312	392
Miocene	50	660	710
Pliocene	7	259	266
"Quarternary"	233	24	257
Pleistocene	118	1482	1600
Holocene	10	122	132
Total	**4937**	**6082**	**11,019**

ontological items are displayed in an evolutionary context, with the aurochs as a very prominent exhibit in the evolution hall on the ground floor. Temporary exhibitions were dedicated to traces of saurians (1994, "Saurierfährten", in cooperation with the Naturhistorisches Museum Gotha), traces of Precambrian fossils (1995, "Fossile Kunst - Spuren präkambrischer Organismen", cooperation with Prof. Dr. D. Seilacher), amber fossils (2000, cooperation with M. Kobbert), and *Archaeopteryx* (2008, cooperation with Senckenberg Institution) (Fischer et al. 2008).

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Chapter 34
MAUER: The Locality of Mauer and its Virtual Collection of Middle Pleistocene Mammal Fossils

H. Dieter Schreiber, Kristina Eck, and Volker Liebig

34.1 Introduction

The main issue concerning the fossil assemblage from the locality of Mauer is, that the objects are stored in collections at several institutions and museums of natural history. The fossils of the 'Mauer collection' have been sampled from sand pits around the villages of Mauer and Bammental (16 km southeast of Heidelberg, southwestern Germany) over the last 200 years by different persons with different intentions. While extracting the sand for economical purposes the majority of fossils were found by chance and donated or sold to institutions, private dealers or private collectors.

A project initiated in 2004 by the association "*Homo heidelbergensis* von Mauer e.V." (VHHM) started an inventory and documentation of the fossils from the locality of Mauer that were available at institutions at the time (Schreiber 2006, 2007), resulting in a 'virtual' catalogue and database of the collections: the '**F**ossilien **D**aten **S**ammlung **M**auer' (FDSM). The project was supported by the State Museum of Natural History Karlsruhe (SMNK) and the Institute of Earth Sciences of the Heidelberg University (GEOW), and financially supported by the 'Klaus-Tschira-Stiftung, gemeinnützige GmbH' in Heidelberg (KTS). It ended in 2006, but the catalogue FDSM has been continually revised and expanded to the present day by H. D. Schreiber with regard to osteological, taxonomical, taphonomical and stratigraphical aspects of the specimen. The catalogue reached a status of 5,769 datasets representing 13,004 fossil specimens stored at 12 different institutions in Germany (as of March 1, 2015).

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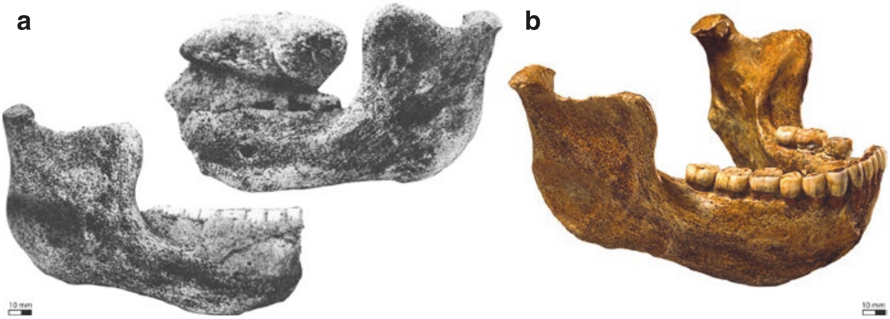

Fig. 34.1 The mandible of *Homo heidelbergensis* Schoetensack, 1908 ("Mauer 1", M.1 [MS 0001]): (**a**) condition before any preparation (Schoetensack 1908), (**b**) present condition (photo: K. Schacherl, GEOW)

With the find of a hominid mandible in 1907 (Fig. 34.1, see also below) the Middle Pleistocene locality of Mauer, esp. the 'Grafenrain' sand pit, became famous world-wide for containing the historical first evidence for the early presence of humans in Europe before the Neanderthals. Almost one year later Otto Schoetensack (1850–1912) argued that the new hominid species, *Homo heidelbergensis*, was ancestral to the Neanderthals and modern humans (Schoetensack 1908). Beside the human fossil the locality of Mauer was already well known in the palaeontological community for its rich and varied mammalian faunal assemblage dating to a warm period before the three holarctic glaciations. Especially the molluscs were the focus of early investigations (see Andreae 1884; Sauer 1898), giving a climatic signal of warm temperatures, similar to the locality of Mosbach (near Wiesbaden). It was also Andreae (1884) who gave a first mammalian faunal list for Mauer, containing the straight-tusked elephant and a 'forest' rhinoceros, supporting the warm climatic signal. Several scientists drew comparisons with Mauer in their revisions of similar localities or fossils (esp. Schroeder 1898, 1903; Wüst 1901; Toula 1906; Reichenau 1910). With his major revision of the faunal list Soergel (1914) confirmed the warm age character of the assemblage from the Grafenrain sand pit. Beside numerous special investigations of the taxa, later revisions corroborated Soergel's list while also updating it on the basis of new discoveries, nomenclature, and taxonomy (Rüger 1927; Koenigswald 1997; Koenigswald and Heinrich 1999; Schreiber 2007; Wagner et al. 2011; Maul et al. 2015; Löscher and Schreiber 2015).

34.2 The Hominid Mandible from Mauer

During his work on 21st October 1907 in the Grafenrain sand pit north of the village of Mauer, the sand worker Daniel Hartmann (1854–1952) unearthed the mandible of a prehistoric man (Fig. 34.1). He reported his discovery to Josef Rösch (1838–1925), the tenant of the pit, who wrote a letter to the head of the

Zoological Institute at Heidelberg University Otto Büschli (1848–1929) and Otto Schoetensack: "You struggled for 20 years to prove that prehistoric men and mammoths lived at the same time in our region, based on remains from my sand pit. Yesterday we produced proof of this assumption. We found a mandible of a prehistoric man 20 m under the arable land on the stope of my sand pit. The fossil is in very good condition and with complete dentition. The left side of the lower jaw is covered by a conglomerate, but the right side is completely visible" (Schoetensack 1908: p. 22). Because of a fracture at the symphysis the mandible was broken into two parts.

34.3 History of its Research

Just one year later in 1908 Otto Schoetensack published his monograph on the new hominid species *Homo heidelbergensis* (Schoetensack 1908), based on the mandible "Mauer 1" (M.1, [MS 0001]) from Mauer. His anatomical study relied mainly on the work of the anatomist Hermann Klaatsch (1863–1916). Gottlieb Port (1867–1918) did X-ray photographs of both parts of the mandible at the Dental Institute of Heidelberg University. It was the first time that a human fossil was investigated with radiography (Kontny et al. 2007). In the following decades it became rather quiet about the mandible. The next investigations only commenced in 1994, when the former Institute of Anthropology and Human Genetics, University of Frankfurt, analysed the mastication of Heidelberg Man (Haidle 1996). Ten years later, in 2004, the Division of Neuroradiology of Heidelberg University Hospital took computed tomography images of the mandible. The images showed flawless teeth without caries sitting on a strong alveolar ridge without any indication of bone atrophy. Additionally a healed fracture in the left ramus of the mandible was recognized (Kontny et al. 2007). The Max Planck Institute for Evolutionary Anthropology in Leipzig (MPI Leipzig) performed digital measurements of the mandible in 2006 under the direction of J.-J. Hublin and K. Harvati-Papatheodorou. This investigation delivered detailed scans of all teeth with a resolution of 25 μm and a new casting form (Kontny et al. 2007). Mounier et al. (2009) investigated the validity of the species *Homo heidelbergensis* based on a careful anatomical description. Since that study the definition of *Homo heidelbergensis* has been more precise and mainly supports the theory of an Afro-European taxon that is the last common ancestor of *Homo neanderthalensis* and *Homo sapiens*. G. A. Wagner from the Geographical Institute of Heidelberg University presented a new radiometric dating of the type site Grafenrain (Wagner et al. (2010). The mandible's age was for the first time determined as to be 609 ka (± 40). Meanwhile the MPI Leipzig developed methods for the retrieval of DNA sequences from archaeological and paleontological remains. Unfortunately it is not possible to extract the DNA of any fossil from the Mauer sands (pers. com. M. Meyer, MPI Leipzig, 2014).

34.4 History of Preparation

Otto Büschli undertook the first preparation in 1907. During removal of the concretion from the left side of the mandible four teeth broke off (p3, p4, m1, m2). After a complete cleaning and assembly of both parts of the mandible, the whole fossil was coated with shellac. Because of missing parts of the enamel of the four broken teeth, they were not fixed again (Wegner 2007). The second preparation was carried out in 1937 for the 30th anniversary. The head of the 'Geologisch-Paläontologisches Institut der Universität Heidelberg' (GPIH, today GEOW), Ludwig Wilser (1888–1949), arranged a completion of the dentition to be done by Peter Welz (1884–1962). After this preparation the dentition of the mandible was complete for the first time since its discovery (Kontny et al. 2007). During the Second World War the Mauer mandible was stored in a box in the salt mine Kochendorf (Baden-Württemberg, Germany). After the war the box was found opened and the mandible lost, but the specimen was re-discovered on a garbage heap in the salt mine. It was broken into two pieces again at the symphysis and two of the four broken teeth were lost for good. These circumstances required a third preparation in 1947. Again Peter Welz fixed the mandible and after his repairs the distance between the two condyles was found to have decreased by 10 mm (Kontny et al. 2007). Many years later in 1994 the former Institute of Anthropology and Human Genetics, University of Frankfurt, submitted a proposal to prepare the fossil again. The head of the GPIH, T. Bechstädt, and the curator at the time, H. Bahlburg, supported this idea. The mandible was disjointed again at the symphysis to remove the residual glue of the previous preparations and to construct a new junction of both parts. After one year in Frankfurt, the mandible returned to the institute in Heidelberg (Kontny et al. 2007), where it is now stored in a safe again.

34.5 History of the 'Mauer Collections'

The first collections were established in the 1830s at the museums of natural history in Karlsruhe and Stuttgart by the donation of the private collectors and priests Johann Jakob Rutz (1800–1851) from Mauer (Figs. 34.2 and 34.3), Johann Balthasar Ullmann (1764–1846) from Epfenbach, and Johann David Karl Wilhelmi (1786–1857) from Sinsheim (Fig. 34.4). But the main collecting activities were established by Heidelberg University over the decades in the 19th and twentieth century, starting at the Zoological Institute with Heinrich Georg Bronn (1800–1862) professor of zoology, who first introduced the locality of Mauer into the scientific literature in 1830 (Bronn 1830), followed by Otto Schoetensack and Wilhelm Salomon-Calvi (1868–1941) at the Geological Institute.

Fig. 34.2 Fragmented bone from the collection of the priest Johann Jakob Rutz. (**a**) tibia, sinistral, distal fragment, plantar view. Mauer, 'Karlsruhe collection', SMNK [MS 3790]. *Cervus elaphus* (red deer). (**b**) label, mentioning the locality of Mauer, the year 1838, assigned to the priest Rutz

34.6 'Karlsruhe Collection' (SMNK)

As mentioned above the collection of fossils from the locality of Mauer started in Karlsruhe in the 1830s by donations of the priest Johann Jakob Rutz. He had been in contact with Alexander Braun (1805–1877), director of the museum in Karlsruhe (the "Naturalienkabinett zu Karlsruhe", today SMNK). Again in 1849 Rutz donated material to the museum in Karlsruhe and even offered support for systematic excavations, but the authorities of the museum rejected the offer (Mayer 1971). By the 1920s only little material from private collectors had become part of the collection. Unfortunately a complete account of the collection up to 1945 is impossible as a result of heavy damage to the museum buildings caused by air strikes during the Second World War in 1942 and 1944. The newest specimens in the 'Karlsruhe collection', like two isolated teeth of macaque (Fig. 34.5, Schreiber and Löscher 2011, Schreiber 2012), a pelvis of a rhinoceros and a micromammal assemblage, are owed to the dedicated work of the private collector M. Löscher (teacher and member of the VHHM, see below). Thus far the 'Karlsruhe collection' amounts to 728 specimens, of which 14 are thought to come from Rutz.

Beside its own collection from Mauer, the SMNK took over three collections, containing material from Mauer, which have become part of its own Quaternary collection. First, the 'Freiburg collection' (with 38 specimens from Mauer), which was removed from the Geological Institute at the University of Freiburg in the 1980s. Second, the 'Mannheim collection' (with 19 specimens), which belonged to the former 'Zeughaus Museum' in Mannheim, was transferred to Karlsruhe in 1977. Finally, there is the collection of the palaeontologist Wilhelm Freudenberg (1881–1960), who assembled a huge private collection of Pleistocene fossils during his career, parts of

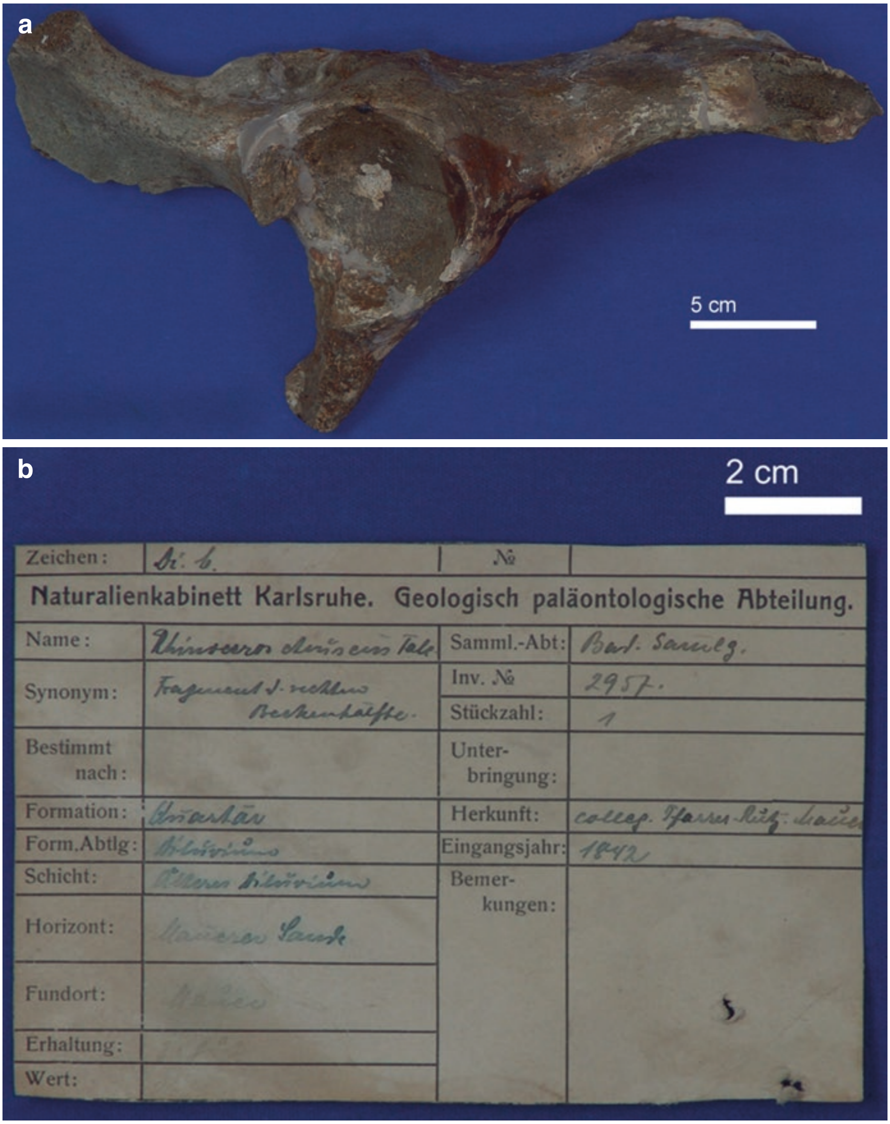

Fig. 34.3 Inventoried at the museum in Karlsruhe: (**a**) pelvis, coxa (acetabulum with fragment of ilium, ischium and pubis), dextral, lateral view. Mauer, Mauer sands, 'Karlsruhe collection', SMNK Inv. 2957 [MS 4994]. *Stephanorhinus* cf. *hundsheimensis* (Hundsheim rhinoceros). (**b**) label of the 'Naturalienkabinett', mentioning the specimen as part of a donation to the collection in Karlsruhe in 1842 by the priest Rutz

which were sold to the museum in 1926 (Mayer 1971). In the following decades, further parts of Freudenberg's collection came to Karlsruhe from different sources. Unfortunately there is a lack of documentation. The 'Freudenberg collection' counts 133 specimens relatable to Mauer.

Fig. 34.4 Fragmented bone from the collection of the priest Johann David Karl Wilhelmi at the Museum in Stuttgart. Mandible, rostral symphysis, dextral and sinistral, ventral view. Mauer, 'Stuttgart collection', SMNS 33926 [MS 4035]. *Equus mosbachensis* (Mosbach horse). The label fixed on the specimen mentions a taxon, the locality of Mauer, and the year 1835; signed by the priest Wilhelmi

Fig. 34.5 The evidence of macaques in the locality of Mauer: two isolated teeth of *Macaca sylvanus* were found in 2008, resp. 2010 (Schreiber and Löscher 2011, Schreiber 2012). Lower molars, m2 and m3, dextral, occlusal view. Mauer, Grafenrain sand pit, lower Mauer sands, 'Löscher collection' (SMNK), m2: SMNK-PAL 6602 [MS 5136], m3: SMNK-PAL 6630 [MS 5149]

34.7 'Stuttgart Collection' (SMNS)

The greater part of the 271 specimens from Mauer at the State Museum of Natural History Stuttgart (SMNS) goes back to acquisitions from private collectors, esp. Wilhelm Freudenberg in the 1940s. Some 62 specimens from the locality of Mauer remain in the hands of the family Freudenberg. Other private collectors, like the priest Wilhelmi (in 1835, Fig. 34.4), Otto Schoetensack (in 1893), G. Stettner (member of an excursion in 1936) or R. Wild (SMNS, in the 1960s) donated smaller numbers of Mauer specimens to the museum.

34.8 'Heidelberg Collection' (GEOW, SMNK)

Two remains of a rhinoceros are historically the first recognisable fossil objects from Mauer in the collection of Heidelberg, donated by Professor Kilian (?1812–1846, probably from Mannheim) in 1856. Including an almost complete skull of the straight-tusked elephant (*Elephas antiquus*) found in 1887 (Fig. 34.6), the number of fossils grew to 4,625 by 1962, when the Grafenrain sand pit was closed. The elephant skull from 1887 inspired Otto Schoetensack to start as a professor at Heidelberg University in 1888. Based on the fossil record of Taubach near Weimar (Portis 1878) he defended the hypothesis, that where *Elephas* can be found, human fossils might be present too (Schoetensack 1908, Adam 1997). In the following two decades Schoetensack continuously visited the fossil site of Mauer and maintained contact with the tenant of the pit Josef Rösch, instructed the sand workers about fossils (Schoetensack and Schoetensack 1997), and became the first contact person concerning the hominid find on 21st October 1907. After this important find, and boosted by Wilhelm Salomon-Calvi, the engagement of Heidelberg University reached a new level with the exclusive right of purchase of fossil objects from the Grafenrain sand pit. Until the 1930s and again in the 1950s, fossil acquisitions were greatest at the GPIH (today GEOW). In the 1980s the material was newly conserved and catalogued. Since 1992 most of the 'Heidelberg collection' is stored at the SMNK (Fig. 34.7), but some original material and well-preserved material remained at the

Fig. 34.6 Cranium, nearly complete, found in 1887 in the Grafenrain sand pit. Mauer, 'Heidelberg collection' (GEOW), M.303, M.304, M.305, M.306 [MS 0189]. *Elephas antiquus* (straight-tusked elephant). On exhibit since 1992 at the Reiss-Engelhorn-Museen in Mannheim (REM)

Fig. 34.7 Inspecting fossil material of Mauer in the collection of the SMNK for the new catalogue FDSM. The purpose was to observe osteological, taxonomical and taphonomical features on the material

Fig. 34.8 The exhibition at the GEOW (former GPIH) with well-preserved specimens of the ‘Heidelberg collection’

institute in Heidelberg (Fig. 34.8), and a smaller amount was provided for the exhibition in the 'Urgeschichtliches Museum' (UMRM) in the town hall of Mauer.

34.9 'Darmstadt Collection' (HLMD)

The fossil material at the Hesse State Museum Darmstadt (HLMD) dates back to an acquisition from private sellers (D. Blatz, Heidelberg, and Krantz, Bonn) between 1896 and 1940 probably in order to establish a reference collection from the locality of Mauer. The collection at HLMD contains 565 specimens.

34.10 'Löscher Collection'

The motivation of M. Löscher for screening samples from the Grafenrain sand pit in order to gain micromammal fossils was to establish a biostratigraphic basis for dating Mauer, and to teach school kids about methods in the earth sciences. Since 1995 Löscher takes frequently samples from the Mauer sands in the Grafenrain sand pit (Löscher and Löscher 2012; Maul et al. 2015; Löscher and Schreiber 2015), publishing first results with the evidence of the *Pliomys episcopalis* und *P. coronensis* in the fossil record of Mauer (Löscher and Unkel 1997). By 2015 the collection contained 6,512 specimens. Besides the remains of small mammals and numerous mollusc shell fragments, Löscher occasionally found larger fossils, such as specimens of *Cervus elaphus* (mandibula, calcaneus), *Bison* sp. (axis), a pelvis of *Stephanorhinus* sp. (Fig. 34.9), two isolated teeth of *Macaca* (see above), and well-rounded isolated teeth of *Capreolus* and *Cervus* (Löscher and Schreiber 2015).

34.11 Smaller Collections

In the case of some smaller collections the fossil remains were collected under very different circumstances, like scientific field campaigns (6 specimens at the Steinmann-Institut für Geologie, Mineralogie und Paläontologie, Bonn), and fieldtrips to the Grafenrain sand pit (10 specimens at the Bayerischen Staatssammlungen für Paläontologie und Geologie, München), or private collectings by chance (14 specimens at the Forschungsinstitut Senckenberg Frankfurt). In other cases the material dates back to historic collections of scientists (3 at the Museum für Naturkunde Berlin, 7 at the Naturhistorisches Museum Basel).

At the Reiss-Engelhorn-Museen Mannheim (REM) are stored 11 specimens donated by Karl F. Hormuth (1904–1992), an enthusiastic private collector of artefacts, who frequently visited the sand pits in Mauer and Bammental in the late 1920s.

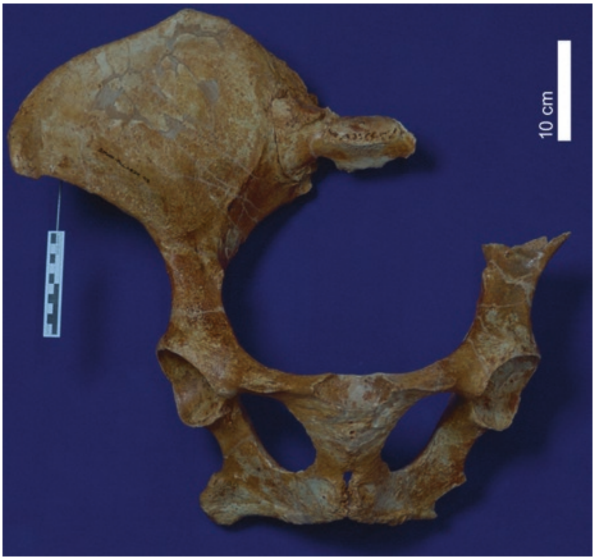

Fig. 34.9 Pelvis, nearly complete, illium sinistral missed, cranial view. Mauer, Grafenrain sand pit, lower Mauer sands, 'Löscher collection' (SMNK), SMNK-PAL 2630 [MS 3784]. *Stephanorhinus* sp., found in 2005, while sampling for micromammals

The amount of specimens in the collection of the company 'Dr. F. Krantz Rheinisches Mineralien-Kontor' (Company Krantz, Bonn) is unknown, but some material collected by Friedrich Krantz (1888–1926) in the early twentieth century remains with the company (pers. comm. U. Müller-Krantz, 2006). In the first half of the twentieth century Krantz was a reputable seller of fossils in Europe, and he had the license to sell casts of the hominid mandible.

34.12 The Virtual Catalogue FDSM (Fossilien Daten Sammlung Mauer)

Usually institutions develop their own system of inventory, which are not necessarily comparable. The experience of dealing with the collections of numerous museums from the same locality suggested the establishment of a new catalogue with unique numbering and consistent metadata for the fossil remains from the locality of Mauer. An additional aim was to achieve the best possible overview and create an instrument for future investigations on the faunal assemblages from the fossil sites. It covers the requirements of inventories, and the scientific approach to the palaeontological objects, stored in different museums and institutes. The specimens are characterized as far as possible with regard to their osteological, taphonomical, and taxonomical features, the circumstances of their discovery, and collections history. The FDSM introduces a new numbering in the format "MS …. [four digit number]", like MS 0001 for the mandible of *Homo heidelbergensis*. At the same time, the inventory numbers of the several collections retain their validity. The FDSM catalogue is available for scientific purposes from H. D. Schreiber.

34.13 Geological Background and Faunal Assemblages

The majority of fossils from the locality of Mauer are isolated and fragmentary finds from the fluvial sequences of the Quaternary deposits along a former meander of the Neckar river. The sands and gravels have been extracted from 13 sand pits in the valley between Mauer and Bammental, but just a few outcrops preserved fossil remains. The Grafenrain sand pit yielded the largest amount (around 77 % of the specimens), followed by the Hollmut sand pit northern to Bammental (5 %). Other 11 % come from different horizons and outcrops, and for 7 % a specific site is unknown.

The Quaternary deposits at Mauer represent several cyclic phases of erosion and deposition in the valley of the Neckar river. It started with gravels, preserved at higher altitudes (187 to 165 m above sea level) near Wiesenbach (2 km north of Mauer), followed by the Mauer sands with a thickness of around 50 m in the lowest reached altitude (119 m above sea level), after a longer phase of erosion in the Neckar valley.

The Mauer sands sequence stopped with a cut-off of the Neckar river meander near Bammental (2 km northwest of Mauer), but continued soon with sediments known from the Hollmut sand pit. After a next meander cut-off near Neckargemünd (6 km north of Mauer) the sequence of the Mauer sands terminated.

Subsequently the Elsenz river ran through the former western Neckar valley, and started to cut into the Mauer sands. This process has been interrupted few times, but it continues even today. The origin of the so called ‘Rostrote Sande’ dates back to the early phase of erosion. The Rostrote Sande is a localised deposit of red-brown, well-sorted sands, probably laid down on the riverbank of the Elsenz river in the area of the later Grafenrain sand pit. During the cold ages of the Middle and Upper Pleistocene the landscape was covered by loess, reaching 10 m thickness in places.

Based on the geological structures of the deposits, and their corresponding faunal (and floral) content, it is necessary to distinguish five faunal and one floral assemblages at the locality of Mauer (in addition to Schreiber et al. 2007):

– The ‘Fauna Mauerer Sande’ [FM]. Fossil record from the fluvial sediments of the Mauer sands (main fossil record), from base to top, early Middle Pleistocene, MIS 15 (to 13?), 627 to 420 ka (Wagner et al. 2010), warm climate, forest to open land (Koenigswald and Heinrich 1999; Schreiber et al. 2007).
– The ‘Fauna Hollmut’ [FH]. Fossil record from the fluvial sediments of the Mauer sands south of the Hollmut hillside, exposed in the Hollmut sand pit, early Middle Pleistocene (MIS 13?), warm climate, forest to open land, with tendency to a temperate climate.
– The ‘Fauna Rostrote Sande’ [FR]. Fossil record from red-brown sands, extracted from the area of the Grafenrain sand pit, top of the Mauer sands, underlying the loess (Wurm 1913; Förster 1913a, b), late Middle Pleistocene (MIS 12-6?) or Upper Pleistocene (Weichselian), cold climate, open land (cold steppe).

– The ‘Fauna Löss’ [FL]. Fossil record from the loess in the area of the Grafenrain sand pit and the outcrop ‘Ziegelei’, representing the glacials of the Middle and Upper Pleistocene (probable just the Weichselian), cold climate, open land, cold steppe (Koenigswald 1992, 1997).
– The ‘Flora Mauerer Sande’ [Fa]. Fossil plant record (pollen, wood imprints) from the fluvial sediments of the Mauer sands, early Middle Pleistocene (see Urban 1992, 1997; Koenigswald 1997).
– the ‘Fauna Wiesenbach’ [FW]. Fossil record from ‘Wiesenbacher gravels’ north of Wiesenbach, Lower to Middle Pleistocene (?).

34.14 Exhibitions and Public Activities

“Urgeschichtliches Museum” (UMRM): The museum was established in the town hall of Mauer in 1982. Here, open to the public, the museum presents the largest exhibition of fossils from the Mauer sands (Fig. 34.10). The exhibition focus on *Homo heidelbergensis* and its ‘large hominid family’. Numerous original fossils illustrate the accompanying fauna. In 2007, after 25 years, on the occasion of the 100th anniversary of the discovery of the Mauer mandible, the museum was renovated and the exhibition revised (www.gemeinde-mauer.de).

Fig. 34.10 The exhibition at the “Urgeschichtliches Museum” (UMRM) in the town hall of Mauer, revised in 2007

Fig. 34.11 Mauer sands exposed at the Grafenrain sand pit

Grafenrain sand pit: After the end of the sand mining in the 1960s the numerous sand pits in the former meander of the Neckar river near Mauer were abandoned or refilled. Only at the Grafenrain sand pit, which is situated directly on the outskirts north of Mauer, small remnants of the originally gigantic pit walls remained (Fig. 34.11). This is where Heidelberg Man and most fossils of the Mauer collections were discovered. Today the sand pit is under nature protection and equipped with displays. It can be visited at all times.

“Heid’sches Haus”: A half-timbered house in Mauer hosts an information centre, which is also the seat of the association VHHM. Here, in the so-called “Heid’sches Haus”, the history of the discovery and the research on *Homo heidelbergensis* of Mauer is presented in a small exhibition.

Time path: The three parts of the exhibition about *Homo heidelbergensis*, UMRM, “Heid’sches Haus” and the Grafenrain sand pit, are connected by a time path, which runs through the village for a length of about 1.1 km. Displays along the path illustrate events of the last 600,000 years of human history.

Association “*Homo heidelbergensis* von Mauer e.V.” (VHHM): The VHHM was founded in 2001. It coordinates all activities concerning *Homo heidelbergensis* in the village of Mauer. For example, all-year-round guided tours with the topic “Human ancestors” can be booked by anyone. From April to October there are free public guided tours every Sunday. A vaulted cellar in the “Heid’sches Haus” hosts a “stone age studio”. Here, courses in experimental archaeology are offered, especially for children. In addition, the association offers free evening lectures once a month from September to March (www.homoheidelbergensis.de).

34.15 Exhibitions outside of Mauer

Museum of Geosciences at the GEOW in Heidelberg: At the beginning of the 1960s the current GEOW (former GPIH) was moved to the Campus "Im Neuenheimer Feld". There is a permanent geological and palaeontological exhibition, which also presents fossils from the Mauer sands (Fig. 34.8). They belong to the 'Heidelberg collection'. Among these are remarkable objects like several partially articulated bones probably belonging to one young red deer. The mandible of *Homo heidelbergensis* is usually displayed as a cast in the permanent exhibition. The original is securely locked away in a safe of the institute. It can be visited on request (www.geow.uni-heidelberg.de).

Reiss-Engelhorn-Museen Mannheim (REM): In the permanent exhibition "MenschenZeit", Heidelberg Man plays a special role. Also the accompanying animal world from the Mauer sands is presented to the visitor in a vivid manner. For example, the visitor may encounter the largest contemporary of *Homo heidelbergensis*, a straight-tusked elephant. In the form of a life-size reconstruction, the elephant is placed nearby the nearly complete skull found in the Grafenrain sand pit (Fig. 34.6). In the entrance hall of the museum, a drill core from a research drilling project gives an insight into the geology of the site (www.rem-mannheim.de).

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Chapter 35
KÖLN: Geological Collections of the University of Cologne (GCC) (Geological and Palaeontological Collections of the Institute of Geology and Mineralogy, University of Cologne)

Michael R. W. Amler and Hans-Georg Herbig

35.1 Introduction

The geological and palaeontological collections of Cologne University are one of the minor collections of German institutes of geosciences. Due to the history of the institute, it houses fossils and rock samples mostly from 1949 onwards, primarily collected by the former and current scientists. Although united with the former Institute of Geology in 2004, the collections of the former Institute of Mineralogy are still separated and stored in the 'GeoMuseum Cologne'. The number of rock and fossil samples is unknown, as only a small part of the collections is catalogued and many samples are microfossil bulk samples. Important parts of the collections include reference material and type specimens of scientific papers dating back until 1950, the famous Weyland collection, consisting of fossil plants collected since the twenties of the last century, as well as rocks and fossils from some localities today no longer accessible. Today, the geological collections of the Institute of Geology and Mineralogy are stored in about 50 cabinets, containing up to 40 drawers each, and a compactus storage system containing about 1000 drawers. About two thirds are palaeontological objects and one third samples of sedimentary rocks.

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35.2 History

The collections of the Cologne institute include the material of two former collections. First, a collection of minerals and rocks, dating back into the 1920s and presented to the public from 1938 onwards in the 'Rundbau', a former Prussian fortress close to the railway station Cologne South ('Südbahnhof'), where today the Institute of Geography is located. Second, the collections of the former Museum of Natural Sciences of the City of Cologne, housed in the Severinstorburg building between 1881 and 1902 and in the Stapelhaus from 1902 until 1945.

Both collections were mostly destroyed during World War II, but already in the 1950s and 1960s the directors of the Mineralogical Institute (Georg Kalb and Karl Jasmund) and the Geological Institute (Martin Schwarzbach) restored and expanded the collections from relict samples, purchase, collecting and exchange. In 1962, the Mineralogical Institute received all the minerals and rocks rescued from the destroyed Stapelhaus, the former Museum of Natural Sciences. Contemporaneously, the Geological Institute received some of the fossils; other specimens as well as recent molluscs were given to the Zoological Institute.

In 1967, two new separate buildings were opened for the Institute of Mineralogy and for the Institute of Geology, both equipped with separate museums.

In the 1990s, the Geological Museum was closed due to space requirements for the new library for geosciences ('GeoBibliothek') and partly merged with the Mineralogical Museum. Re-named and re-opened in 2000, the 'GeoMuseum Cologne' today mostly presents minerals; palaeontological objects are presented in a small exhibition on earth history including a few impressive vertebrate fossils.

35.3 Collections

The Geological Collections Cologne are divided into different parts. The most important section is the collection of types and reference material. It includes more than 2000 specimens and series, i.e., several specimens or thin-sections under the same collection number or several specimens of the same species. This collection houses the type material of species and genera and also many of the figured reference specimens of more than 100 publications since 1950, indicated by the acronym GIK, i.e. 'Geologisches Institut Köln' (Geological Institute Cologne), and a four-digit number. Many of the specimens correspond to papers published in 'Sonderveröffentlichungen des Geologischen Institutes der Universität zu Köln', published by the institute between 1956 and 1997 and replaced 1998 by the journal 'Kölner Forum für Geologie und Paläontologie'.

Well known among palaeobotanists is the Weyland Collection (Fig. 35.1). It includes about 6000 specimens of fossil flora from the Early Palaeophytic until Recent. Hermann Weyland (1888–1974), a chemist and botanist, collected fossil plants since 1922, which served as a basis for many publications between 1923 and

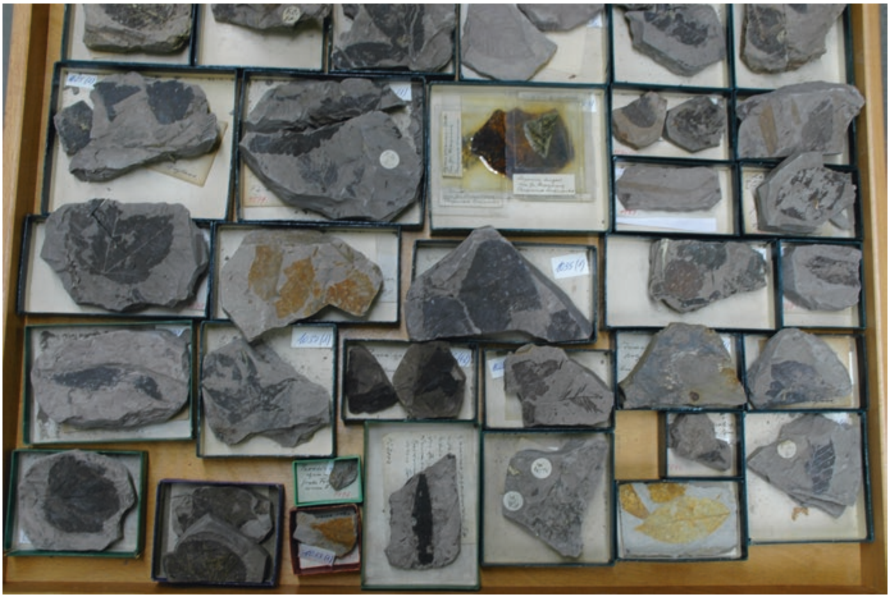

Fig. 35.1 View into a drawer with fossil plants from the Weyland collection—Fischbach Shale, Miocene, from the mine pit Fischbach near Horrem. Locality recultivated and no longer accessible (photo: M. Amler)

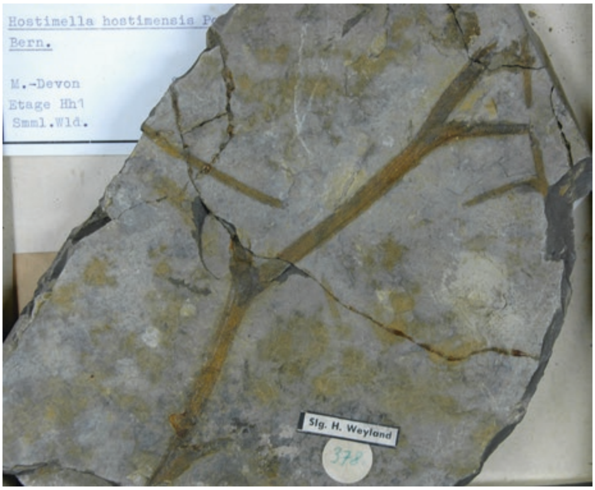

Fig. 35.2 *Hostimella hostimensis* Potonié and Bernard, an early plant from the Middle Devonian of Srbsko, Bohemia, in the Weyland collection (photo: M. Amler)

1970. This collection is famous for its Devonian flora (Fig. 35.2), especially from the Rheinisches Schiefergebirge (Rhenish Mountains). A separate collection of Recent seed and Weyland's herbarium were transferred to the Goldfuß Museum at the Steinmann Institute of Palaeontology, University of Bonn, in 2017 (Fig. 35.3).

Fig. 35.3 *Palmoxylon* sp. silicified stem of a Neogene palm from a fossil river, lower Miocene, Moghra Formation, Bait Owian Member, SW of Wadi Natrun, Egypt; height 1.2 m; collected by U. Jux in 1976 (photo: M. Amler)

The main part of the institute's collection are uncatalogued samples of former and current scientists, e.g. Martin Schwarzbach (1907–2003), Ulrich Jux (1929–2017), Eugen K. Kempf (1932–2017) [fossil spores and ostracodes], Helmut Wopfner (*1924), Michael Grigo (*1957) and Hans-Georg Herbig (*1955). Devonian fossils from the Bergisches Land (western Rheinisches Schiefergebirge) collected by U. Jux are currently transferred to the Natural History Museum of Bergisch Gladbach, Germany. Further material from various localities in Nordrhein-Westfalen and Rheinland-Pfalz has been moved to the Ruhr Museum Essen, the Geologischer Dienst Nordrhein-Westfalen, Krefeld, and the Senckenberg Research Institute and Natural History Museum Frankfurt for long-term archiving. This includes among others Lower Devonian brachiopods from the Eifel Hills, Upper Carboniferous

(Pennsylvanian) coals, sedimentary rocks and fossils from no longer accessible shafts of the Ruhr mining district, Zechstein salts from mines in the Lower Rhine Embayment, as well as cores and core cuttings from wells penetrating the Tertiary of the Lower Rhine Embayment. Reference material of diploma and PhD theses is generally no longer stored, if not published and registered.

Apart from research material of the geologists and palaeontologists mentioned above and those currently working at the Cologne institute, a standard collection of systematic palaeontology (12 cabinets) and a collection of the regional geology of Europe (15 cabinets) is kept. A small exhibition on earth history is open to the public in the 'GeoMuseum Cologne' (Figs. 35.4 and 35.5). Most spectacular are a three-dimensionally preserved skeleton of the amphibian *Eryops* from the lower Permian of Texas, an ichthyosaur skeleton of *Stenopterygius quadriscissus* with remains of an unborn embryo and a *Steneosaurus bollensis* containing gastrolites

Fig. 35.4 *Pleuronoceras nodosum* (von Schlotheim), a nautiloid cephalopod from the Middle Devonian of the Eifel Hills, western Germany, diameter ca. 24 cm; on display in the GeoMuseum Cologne (photo: M. Amler)

Fig. 35.5 *Heliobatis radians* Marsh, a stingray, with *Knightia eocaena* Jordan, a bony fish, from the Eocene Green River Formation, Wyoming, U.S.A., length about 35 cm; on display in the GeoMuseum Cologne (photo: M. Amler)

and faint food remains in the stomach region, both from the Lower Jurassic Posidonia Shale of Holzmaden (Southern Germany). Also on display is an almost 2000 years old, polished giant redwood slab, 2.7 m in diameter accompanied by a huge *Sequoia* stump from the Miocene brown coal of the Niederrhein Embayment. The most precious object of the collections is a single original ‘Würzburger Lügenstein’ (Lying Stone) from the world-famous fossil falsifications described by J. Beringer in 1726 in the ‘Lithographiae Wirceburgensis’. It is even more curious as the limestone is partially reddened due to fire damage suffered from the bombing of Cologne during World War II.

35.4 Access

All parts of the collections are accessible for research after prior notice.

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Chapter 36
KREFELD: Palaeobotanical and Palynological Collection at the Geological Survey North Rhine-Westphalia

Christoph Hartkopf-Fröder

36.1 History, Infrastructure and Research

The Geological Survey North Rhine-Westphalia (hereinafter Survey) was founded in 1957. The most important missions were: (1) to conduct geological research in North Rhine-Westphalia with special reference to economic geology, hydrogeology, engineering geology, soil science and geophysics; (2) to undertake geological surveys state-wide and produce earth-science maps; (3) to provide comprehensive advisory service and geoscience information to the government, industry and citizens; (4) set up archives, especially of borehole records; and (5) to publish results. The very first organizational plan included nine departments of which two were devoted to lignite and hard coal geology, respectively, one to micropalaeontology, coal petrology and palaeobotany and one to applied palynology. Hence, from the outset of the Survey, coal geology and palaeontology maintained a crucial role in state-wide geoscience investigations. During the first 12 years the Survey was provisionally located in up to nine buildings in Krefeld. In 1969 the Survey moved to a new, seven-storey building on the outskirts of Krefeld which then offered adequate space for laboratories and the various subunits of the collection. Adjacent buildings have since been added, especially a core and cuttings library.

The permanent palaeontological staff includes two palynologists, a micropalaeontologist (specialized on Mesozoic and Cenozoic foraminifers and ostracodes) and a conodont researcher. However, the latter two are also occupied with additional duties and one of the palynologists is head of the laboratory department and hence involved in management functions. The palaeontologists' main task is to

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provide biostratigraphic and palaeoenvironmental information in order to support the geologists in mapping programmes and the investigation of boreholes. The results are presented in thousands of internal reports, dozens of explanatory memoirs accompanying geological maps and numerous peer-reviewed and in-house publications (e.g. Fortschritte in der Geologie von Rheinland und Westfalen, Scriptum).

Palaeontology at the Survey is very attractive for geoscience students from universities nearby to fulfil practical training which is stipulated by the examination regulations. National and international cooperations are maintained with numerous universities and research institutions. This includes the loan of specimens, supply of raw materials (e.g. cores, washed samples) and preparation of pure concentrates of macerals and organically preserved fossils such as palynomorphs for isotope and organic-geochemical analyses.

Occasionally, palaeontological exhibitions are organized in the foyer of the Survey which is open to the public during working hours. The collection, however, is usually reserved for experts and students. As it also contains confidential material, the collection is accessible by appointment only and detailed requests must be directed to the Survey prior to visitation.

36.2 Collections

It must be emphasized that the purpose of all collections of the Survey is to serve its mission. Hence, the goal is not to acquire spectacular specimens but to collect samples from all over North Rhine-Westphalia which e.g. are needed in geological mapping programmes or to support the local exploration and raw material industry. The fossil collections are therefore to be regarded as archives to assist applied palaeontological research.

The collections of the Survey are organized into various subcollections. The majority of the material was collected in North Rhine-Westphalia. Samples from other areas in Germany or from abroad constitute a very minor part. The subcollections are curated and registered in databases to varying degree and quality. At present the following subcollections are installed:

36.2.1 Core and Cuttings Library

At present approx. 30 km of cores of different quality and origin are housed in a modern high-bay warehouse adjacent to the main building. Many boreholes were drilled and funded by the Survey for routine geological and engineering geological mapping projects and to provide data for exploration companies. In addition, over the years numerous research boreholes were drilled and either financed by the

Survey itself or by raising funds from exploration industry and research organizations.

36.2.2 Regional and Stratigraphic Collection

This collection includes rock samples (also pieces of cores and cuttings) and various fossils. Most of the material was gathered during geological mapping programmes.

36.2.3 Mineralogical Collection

Besides numerous permanent slides for heavy mineral analysis it includes mineral and ore specimens.

36.2.4 Organic Petrology Collection

This is now becoming exceptionally valuable following a decision taken by the EU Commission to close down all hard coal mines in Germany by 2018. This collection comprises lignite and hard coal samples, organic-rich sediments for thermal maturity analyses and polished blocks for microscopical studies (e.g. maceral analysis, vitrinite reflectance, fluorescence microscopy). The collection was set up by Erich Stach and Marlies and Rolf Teichmüller, internationally renowned and leading experts in coal petrology between the thirties and eighties of the past century. In addition to thousands of lignite and hard coal samples from North Rhine-Westphalia, the collection also includes foreign material which was studied during research projects or consulting contracts.

36.2.5 Micropalaeontological Collection

The main emphasis is on Mesozoic to Cenozoic foraminifers and ostracodes and Devonian to Carboniferous conodonts. The collection also comprises material studied by Willi Ziegler, nestor of German conodont taxonomy and biostratigraphy. Most of the samples are collected by mapping geologists, processed in the micropalaeontological laboratory and studied by the micropalaeontologists of the Survey. The processed concentrates are kept in glass vials and selected microfossils in plastic microslides.

36.2.6 Palaeobotanical Collection

The collection comprises approximately 40,000 specimens, predominantly from the Pennsylvanian of the Aachen and Ruhr district. A very minor part comes from donations of private collectors while most specimens were sampled from cores drilled during hard coal exploration (Fig. 36.1a, b). Additional material was gathered from shafts and underground galleries in hard coal mines (Fig. 36.1c, d). Some material which is still confidential derives from hydrocarbon exploration boreholes located in North Rhine-Westphalia, Lower Saxony and the German sector of the North Sea. The comprehensive monographs on the Pennsylvanian macroflora of northwest Germany (e.g. Josten 1991) are based on this collection. It also serves as basis for the macrofloral biozonation of the late Namurian to early Stephanian of northwest Germany (e.g. Josten 2005). Hence, the collection is well curated and digitally catalogued in a database. Since special emphasis is given to material from North Rhine-Westphalia, specimens which were collected during congress field trips in non-European countries and which were regarded as superfluous were occasionally transferred to large museums and research institutions.

36.2.7 Palynological Collection

The palynological collection comprises residues of more than 100,000 samples and several tens of thousands of slides and sediment raw samples. As for the micropalaeontological collection, most of the samples originate from extensive field work during geological mapping programmes. A minor part was provided during consulting contracts and by universities who asked for permanent storage of materials studied during master and PhD thesises. The majority of this collection is quite well documented as all samples are given inventory numbers accompanied by paper documents but only those which entered the collection during the last decade are registered in an electronic database (a laboratory information management system). With the foundation of the Survey, palynological research played a vital role in supporting lignite and hard coal exploration. Paul W. Thomson, Gerhard Kremp and particularly Robert Potonié who was one of the most outstanding and influential palynologists between the thirties and sixties of the past century, laid the basis for this collection.

Throughout the years main emphasis has been given to the

- Devonian of the Rhenish Massif
- Pennsylvanian of the Ruhr and Saar districts (includes material published by e.g. Potonié and Kremp 1955, 1956a, b; Bhardwaj 1957; Grebe 1972)
- Zechstein of the Lower Rhine Embayment (includes material published by Grebe 1957; Grebe and Schweitzer 1964)
- Cretaceous karst infillings in the Rhenish Massif (includes material published by e.g. Grebe 1979, 1982)
- Neogene lignite deposits of the Lower Rhine Embayment (includes material published by e.g. von der Brelie and Rein 1958; von der Brelie 1968)
- Quaternary of North Rhine-Westphalia.

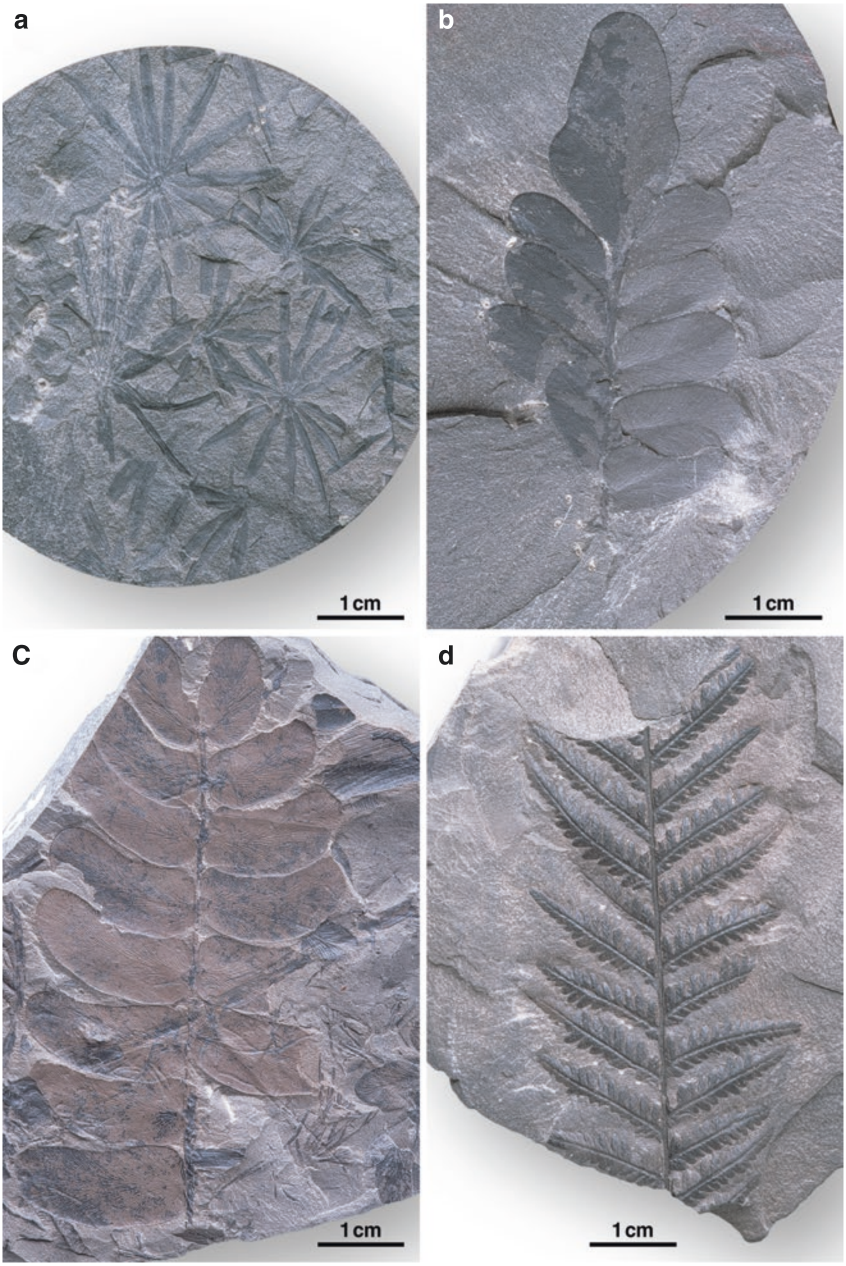

Fig. 36.1 Plant remains from the Pennsylvanian of the Ruhr district collected from boreholes (**a**, **b**) and coal shafts (**c**, **d**). (**a**) *Annularia jongmansi* Walton 1936. Borehole Südkirchen 1, 1000.5–1001.0 m. Near Ernestine seam, Middle Bochum Formation, Langsettian. (**b**) *Neuropteris chalardi* Laveine 1967. Borehole Specking 1, 1438.0–1438.5 m. Iduna seam group, Upper Dorsten Formation, Bolsovian. (**c**) *Paripteris gigantea* (Sternberg 1821) Gothan 1953. Coal shaft Schlägel-Eisen, 705.0–712.0 m. Upper Bochum Formation, Langsettian. (**d**) *Pecopteris* (*Senftenbergia*) *plumosa* (Artis 1825) Brongniart 1828. Coal shaft General Blumenthal 8, 910.0–918.0 m. Plaßhofsbank Horizon, Lower Bochum Formation, Langsettian

Special requirements are needed for the conservation of palynological samples, residues/kerogen concentrates and permanent strew mounts. The main issues are to avoid fungal growth on the organic residues resulting from palynological processing and to prevent drying of the embedding medium in the slides.

10 g of a moderately productive sample is generally sufficient for a single palynological maceration. The processing of highly productive coals or siltstones may even require less than 5 g. However, the Survey usually saves 20–50 g of sediment. Prior to storage all samples are air-dried at room temperature to avoid microbial growth which can alter the palynomorph association. Wet and organic rich samples which are put aside for a few weeks constitute ideal conditions to encourage infestation by microorganisms which even attack sporopollenin, one of the most resistant and chemically inert biopolymers.

Most palynological samples are kept in labelled plastic bags. However, it became apparent that after decades some plastic bags decomposed due to the evaporation of plasticisers and further additives, even though the samples were stored in a cellar under a constant temperature and with no exposure to sunlight. Durable cloth bags are more suitable for storage. If the samples are intended to be used in subsequent organic-geochemical studies, precleaned glass vials or metal cans are particularly recommended as they have the advantage that the sediment is not contaminated by phthalates which interfere in gas chromatography-mass spectrometry analyses as artefacts. At the Survey rare samples are wrapped in aluminium foil and saved in amber glass vials with screw caps and PTFE liner to avoid any contaminants.

After processing of the samples, all residues are permanently stored in glass vials. Samples dating from Paleogene to Quaternary are kept in glycerine. As a rule, no permanent strew mounts are prepared from such samples. The identification of Cenozoic pollen grains is easier if specimens of special interest can be rotated in a liquid mounting medium (e.g. glycerine or silicone oil). Hence, after quantitative pollen analysis the slides are disposed and only the residue is preserved. Devonian to Cretaceous residues are stored in ethanol-filled vials which allows to produce permanent strew mounts using glycerine jelly or synthetic polymers. Glycerine jelly is excellent with regard to the refractive index but desiccation is a constant risk. Hence, at the Survey, glycerine jelly has been replaced by polyvinyl alcohol as a mounting medium and Elvacite 2044™ epoxy resin as an embedding medium since approximately 30 years. These slides seem to be durable and the residue is permanently glued to the cover slip.

Slides prepared with glycerine jelly must be kept in a horizontal position for long-term storage; otherwise palynomorphs do not stay in the original position but start moving if the mounting medium becomes viscous due to warm temperatures or deterioration. This is especially frustrating if figured specimens or types have to be relocated for further study. The Survey houses hundreds of slides which were used in benchmark studies published between the thirties and sixties of the past century (Fig. 36.2). When these slides were restudied it became apparent that nearly all figured specimens had changed their position. Despite considerable efforts not all

Fig. 36.2 Old microscope slide trays with slides produced in 1931 and 1932 for the study on Eocene palynomorphs (see Fig. 36.3) from the opencast mine "Grube Cecilie", Geiseltal (Potonié 1931, 1934). Cover slips are sealed with black varnish which retards desiccation of the glycerine jelly. On the left some glass slides have an additional label with a grid. A corresponding grid is etched into the lower side of the glass slide. Red circles on the label indicate the approximate position of types or figured specimens. The slide in the right tray in the compartment at the very bottom is from the material used by Bhardwaj (1957) for his palynological research on Pennsylvanian coals from the Saar district (see Fig. 36.4)

specimens could be relocated and some holotypes have since been regarded as missing.

In some slides the glycerine jelly is badly dried out. Sometimes it is possible to restore these slides by lifting the coverslip and adding fresh glycerine jelly. However, it is also possible to feed the specimens in a mixture of ethylene and xylene and photograph the specimens before the temporary medium evaporates. Before adding any organic solvents the varnish seal must be removed to prevent its dissolution and migration under the coverslip. Miospores in slides which are not yet dried out can easily be studied and in most cases types can be relocated. Even in very old slides dating from the late twenties and early thirties of the past century, miospores are still adequately preserved to recognize virtually all details in the exine. Since miospores

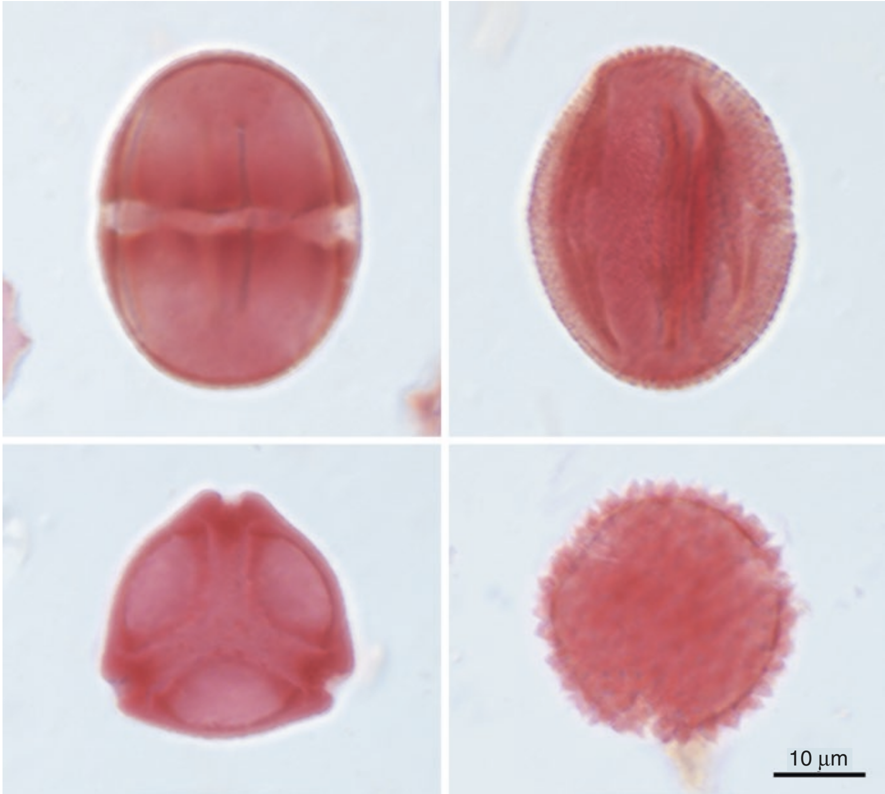

Fig. 36.3 Pollen grains from lignite of the opencast mine "Grube Cecilie", Geiseltal. Slide X 32, Oberstrosse Zone 3. The slide was made on May 13, 1931. The organic residue was stained, probably with fuchsine solution. The existing descriptions, line drawings and photographs in Potonié (1931, 1934) are hardly sufficient to allow firm taxonomic concepts. Provided that the slides are not yet dried out they can be used for designation of lectotypes/neotypes. The low contrast is probably due to the applied maceration technique which includes strong oxidation with HNO_3 and subsequent treatment with KOH. Photograph using Nomarski differential interference contrast

become flat and loose contrast with the course of time, the use of an oil immersion objective and differential interference contrast is advisable (Figs. 36.3 and 36.4).

36.2.8 Mesofossil Collection

This collection comprises almost exclusively raw sediment, washed residues, picked plant mesofossils and SEM stubs with plant mesofossils from Cretaceous karst infillings in the Rhenish Massif (Fig. 36.5) and from Neogene lignite bearing successions in the Lower Rhine Embayment. All of the material was saved during palaeontological conservation projects and is temporarily stored in the Survey. It will

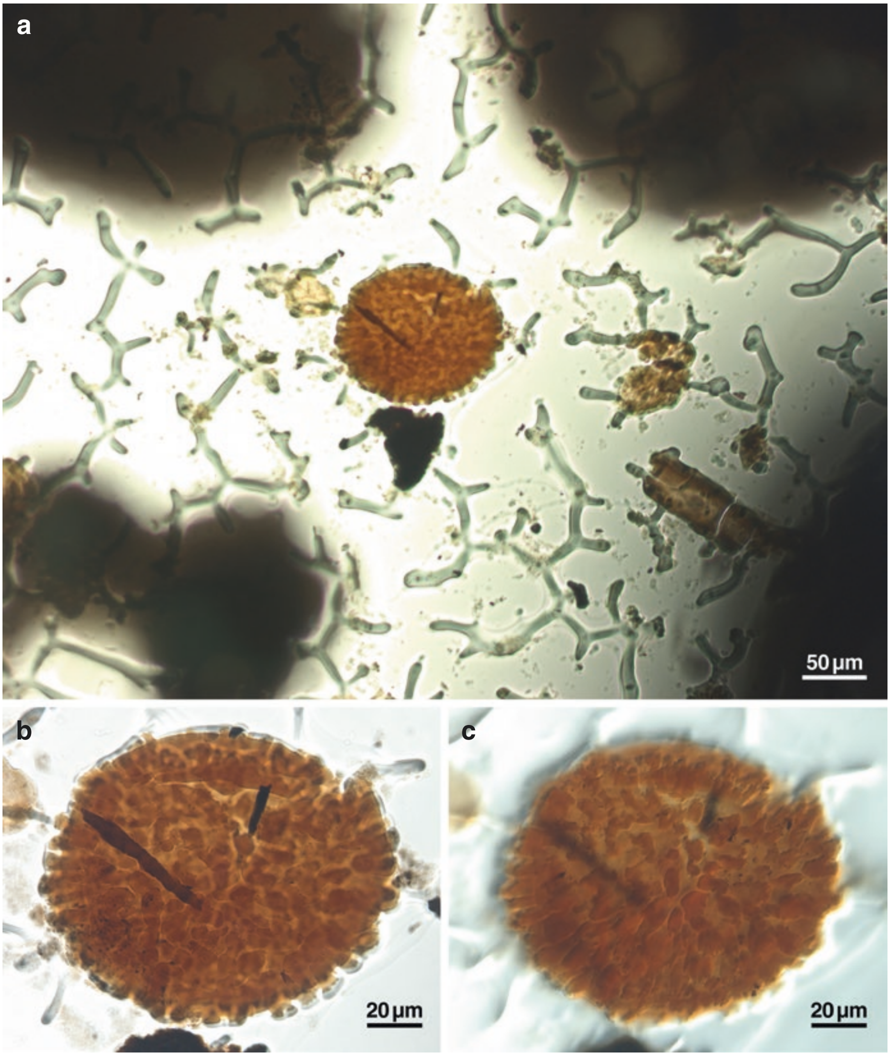

Fig. 36.4 *Raistrickia major* Bhardwaj 1957. Coal mine Labach near Breitenbach. Grenzkohle seam (= Breitenbach seam), Breitenbach Formation, Stephanian C. Slide 10705/1F. (**a**) Overview of the badly dried out slide with miospore in the centre. For easy relocation the position of the miospore was marked by four dots made with black glass ink. Trying to restore the mounting is risky as the specimen may be lost. (**b**) Although the quality of the slide is very poor all details of the miospore are still discernible. Transmitted light. (**c**) same as **b**, focused on the bacula and their apices. Nomarski differential interference contrast

be transferred to the Geological Collection of the Ruhr Museum. Based on an agreement between the LVR-Amt für Bodendenkmalpflege (Bonn) and the Ruhr Museum (Essen) all findings recovered during conservation projects will be stored in the museum after the publication of the results.

Fig. 36.5 Three-dimensionally preserved chloranthaceous androecium with pollen sacs (orange), attached nymphal mite (yellow) and faecal pellets (red). Karst infilling in Pragenhaus quarry near Wülfrath. Late Albian–early Cenomanian. Due to wildfires most of the mesofossils from Cretaceous karst infillings are charcoalified and excellently preserved (Hartkopf-Fröder et al. 2012, 2015). During limestone extraction and palaeontological conservation projects, numerous karst-bound fossil sites have been discovered in various quarries near Wülfrath and Wuppertal. Some tons of these very fossiliferous sediments are housed in the core and cuttings library of the Survey

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Chapter 37
LINZ: The Paleontological Collection of the Upper Austrian State Museum, Linz

Björn Berning

37.1 General Information

The modern Geoscientific Collections of the Upper Austrian State Museum comprise the Mineralogical, Petrological and Paleontological Collections. Their history goes back to the foundation of the museum itself in 1833. Although the early collection entries were predominantly minerals and rocks, the Paleontological Collection was the largest already by the end of the nineteenth century.

The most valuable part of the collection from a historical point of view comprises several hundred Triassic cephalopods from the Hallstatt region (Fig. 37.1), which were purchased from Johann Georg Ramsauer in the mid-nineteenth century. Ramsauer was then mine manager (*Bergmeister*) of the salt mine at Hallstatt, and, as an additional income, provided the early Austrian paleontologists with specimens from the richly fossiliferous limestones of the region.

Another nineteenth-century source yielding important fossils was the late Oligocene to early Miocene shallow-water sediments in the Linz region. These coastal sands contained marine mammals such as toothed and baleen whales (Marx et al. 2012; Figs. 37.2 and 37.3) as well as sea cows (Voss et al. 2016). Even terrestrial mammals, e.g. rhinocerotids, were occasionally found. From this material of the so-called Linz Sands, several species were newly described during the nineteenth and twentieth centuries.

Quaternary cave faunas represent another major part of the collection, dominated by cave bear remains. For instance, the material from a scientific excavation carried out in the Ramesch Cave (from the Alpine region *Totes Gebirge*) is in our collection (Rabeder et al. 2008, and references therein).

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Fig. 37.1 The ammonite *Rhacophyllites neojurensis* (Upper Triassic, Hallstatt) from the Ramsauer collection; diameter c. 40 cm

Fig. 37.2 The dolphin-like, toothed whale *Schizodelphis* sp. (lower Miocene, Pucking); length c. 2.3 m

The Paleontological Collection comprises some 11,000 inventory numbers, corresponding to many tens of thousands of objects (Berning 2013a). As the main scientific work has historically taken place at the Natural History Museum and the Geological Survey in Vienna, however, only some 11 types exist in Linz, most of which are terrestrial and marine mammals (Berning 2013b). During the last 4 years, the bulk of the Paleontological Collection was digitized, although the data are not publicly accessible yet. Incorporation of the information into the ZOBODAT-database of the Biology Center Linz (http://www.zobodat.at/) will take place in the near future.

While formally part of the Biology Center (comprising the natural science division of the Upper Austrian State Museum), the Paleontological Collection is housed separately for spatial reasons. Together with other collections of the museum it is accommodated in a former warehouse in Leonding, a suburb just south of Linz,

Fig. 37.3 Skull of the toothed whale *Patriocetus ehrlichii* (upper Oligocene, Linz); length c. 60 cm

since 2000. The premises of the Geoscience Collections comprise five rooms, the largest of which (c. 90 m^2) containing the Paleontological Collection. Associated with it is a laboratory and rooms containing the library as well as the Mineralogical and the Petrological Collections. The permanent staff consists of the Head of Collections and the Paleontological Preparator, while one or occasionally two free-lance collaborators aid in digitizing and curating the collections.

The annual budget has been sufficiently large over the last decade to gradually adapt the collection rooms that were originally built for different purposes (e.g. installment of a heating system, closure of openings in walls), to replace the wooden storage cabinets by mobile shelving (Fig. 37.4), and to buy consumables as well as laboratory equipment. While exhibitions are financed by a separate budget, single fossils or fossil collections offered by private collectors can also be acquired via the annual budget to a certain degree or, in exceptional cases, by a special request to the Friends of the Museum. Constant growth of the Paleontological Collection will make it necessary to expand the collection space within the next decade.

Fig. 37.4 The Paleontological Collection of the Upper Austrian State Museum

Exhibitions take place in both the Biology Center and in the Castle Museum (*Schlossmuseum*), the main exhibition building of the Upper Austrian State Museum that is situated in the city center of Linz. A permanent exhibition termed "Nature of Upper Austria", which has numerous fossils typical for the region on display, was opened in the Castle Museum in 2009, including a 50 m long "Path of Evolution". Special paleontological exhibitions of a duration of a half or full year are hosted in the Biology Center at regular intervals (amber: 2009, cephalopods: 2014), although even essentially biological exhibitions usually include fossil objects and paleontological information whenever possible. Moreover, paleontological exhibitions shown in other regional museums are supported with expertise and supplied with fossils of our collection.

37.2 Research

Owing to the low number of staff, scientific research can be exercised only intermittently during working hours. One focus is on the (type) specimens of the collection itself (e.g. Alba and Berning 2013; Marx et al. 2011; Voss et al. 2016), while international research activities center around the field of expertise of the Head of Collection, namely Cenozoic to Recent marine Bryozoa of the North Atlantic and Tethyan regions. Great potential concerning paleontological investigations of the Upper Austrian Mesozoic and Cenozoic lies in cooperation with private collectors as the quality and quantity of fossils in these collections are often exceptional, sometimes comprising material from outcrops that are no longer accessible. A mutual relationship between collector and museum is certainly advantageous for both sides.

National research networks are established with the University and the Natural History Museum of Vienna as well as with the other Austrian state museums. International relationships with institutions across Europe, such as the Natural History Museum of London and Paris, the University of the Azores (Portugal), and Senckenberg am Meer in Wilhelmshaven (Germany), are fostered during research projects and reciprocal visits of the collections. As the Biology Center is a member of the Consortium of European Taxonomic Facilities (CETAF), the Head of Collection regularly participates in CETAF-meetings, and is engaged in CETAF-Earth Science Working Group activities.

While scientific results are published in international, peer-reviewed journals, topics of local interest are often made public in regional, non-peer-reviewed journals brought out by other museums or amateur societies such as the *Oberösterreichische Geonachrichten* published by the Association of Upper Austrian Mineral and Fossil Collectors (e.g. Berning and Kostersitz 2015). Scientific books (e.g. Berning and Podenas 2009; Berning and Lukeneder 2014), as well as popular science books and booklets (e.g. Benedetter-Herramhof et al. 2009, 2014), which accompany and augment our exhibitions, are regularly published in the Biology Center's own series *Denisia*. Short reports are regularly being issued to inform the public as well as future museum staff about historically important fossils or parts of the collection, past and present curatorial issues, and significant preparatory works (e.g. Reiter and Mittermayr 2013).

Public outreach is further enhanced by regular talks on paleontological topics that take place in the Biology Center. There, as well as in the larger venue at the Castle Museum, we also organize national and international scientific meetings and conferences of professional paleontological societies. Moreover, a workshop on the evolution of Bryozoa is provided annually via the Distributed European School of Taxonomy (DEST).

37.3 Educational Work

Exhibition guides and educators form a significant part of the staff of the Upper Austrian State Museum as a large part of the visitors are school children. Education concepts for each exhibition are developed in close cooperation between educators and curators, and different didactic programs are offered for school children of all ages. Most of the text and images used in the exhibition are also provided in our accompanying booklets, which are sold for a very low price, so that knowledge can be recapitulated and expanded at home.

The Head of Collection regularly participates in the annual Kid's University in Linz or surrounding cities, offering workshops or lectures for kids between the ages 6 and 14. Concerning higher education, a cooperation between the Biology Center and the teacher training college of the Johannes Kepler University Linz has just been established where courses on biology and natural history will be provided by staff of the museum.

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Chapter 38
LÜBECK: Museum of Nature and Environment, Paleontological Collections

Susanne Füting

38.1 Museum of Nature and Environment, Lübeck

The "Museum für Natur und Umwelt"—Museum of Nature and Environment—is a municipal institution and belongs to an association of local museums called "die Lübecker Museen". The building is situated in the old town of Lübeck, next to the cathedral (Figs. 38.1 and 38.2).

Exhibitions present biological, geological and paleontological themes on 1300 m^2. The main emphasis is on natural history and biodiversity of the region, including the Baltic Sea area. Furthermore, temporary exhibitions highlight a wide range of current topics. Our key objectives are environmental and scientific education. We welcome in between 25,000 and 32,000 visitors every year.

38.2 Historical Background

The collections of Lübeck were primarily based on the private collections of the physician and passionate naturalist Johann Julius Walbaum. His intention was to teach natural sciences and worship of nature. After his death in 1799, his children donated his legacy for educational purposes. Since then, the collections have permanently been expanded.

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Fig. 38.1 View on museum and cathedral from above. Copyright Museum für Natur und Umwelt, Lübeck / Photo: Susanne Füting

Fig. 38.2 “Museum für Natur und Umwelt” in Lübeck today. Copyright Museum für Natur und Umwelt, Lübeck / Photo: Wolfram Eckloff

At first animals, plants and other objects collected worldwide were presented to the public in a “chamber of curiosities”. It was not until 1893 that due to the legacy of the local businessman Georg-Ludwig Blohm the collections could be shown in a new building. The “Museum am Dom” presented natural history, ethnology and art under one roof (Fig. 38.3).

In 1942, during World War II, bombs destroyed the museum building and its exhibitions and collections.

Later dedicated citizens of Lübeck started to build up new collections with focus on local nature. In 1963, the museum of natural history was reopened as “Naturhistorisches Museum—Museum für Natur und Naturgeschichte in Schleswig-Holstein” in a new building, but in the same place.

Since 1993, geological eras including the ice ages and a large Paleogene and Neogene collection including fossilized whales from the Miocene sea are being displayed in a newly installed exhibition area.

Educational work became more and more important so that a room for educational purposes was equipped and many new educational programmes were introduced. In 1998, the museum‘s new concept was expressed by changing the name to “Museum für Natur und Umwelt” (see Eckloff and Müller 1999).

The nature experience exhibition “Rivers and the Baltic Sea—Mermans’ Realm” was opened in 2008: It shows biosphere and inhabitants of the local rivers and the Bay of Lübeck and offers insights into the abundant flora and fauna around Lübeck.

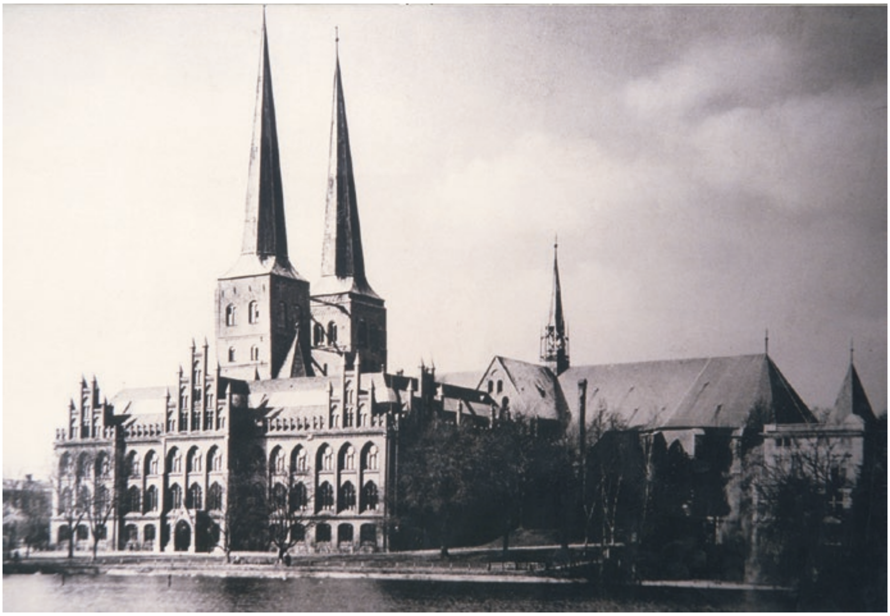

Fig. 38.3 The former “Museum am Dom” presented art, applied art, ethnology and natural history. Photo: Susanne Füting (photo of an old postcard)

38.3 Recent Collections

Today the collections of the Museum of Nature and Environment, Lübeck, consist of a herbarium, zoological, geological and paleontological collections. More than 200,000 objects primarily represent local wildlife and natural history. The zoological collections comprise indigenous insects, including various historical beetle collections and a historical collection of butterflies, as well as molluscs, vertebrates and skeletons.

Many volunteers and "citizen scientists" have greatly contributed to the collections and commitedly helped to expand them. This work is ongoing.

38.4 Geological and Paleontological Findings

The geological and paleontological collections comprise about 15,900 objects including rocks, sands, minerals and fossils. Remarkable are the numerous and excellent findings of drifts, collected on the nearby coast of the Baltic Sea and in gravel pits. They represent the different geological eras and offer a journey through time for visitors (Fig. 38.4).

The Neogene collection is large and comprises excellent pieces. Notably the fossil whale skeletons originating from the primordial North Sea are unique and of international significance. About 11-million-year-old baleen and tooth whales as well as a

Fig. 38.4 Exhibition view on fossils originating from the Neogene. Copyright Museum für Natur und Umwelt, Lübeck / Photo: Susanne Füting

Fig. 38.5 Miocene whale found in Groß Pampau (*Praemegaptera pampauensis* 1989/90). Copyright Museum für Natur und Umwelt, Lübeck / Photo: Susanne Füting

shark from the Miocene, were excavated near the small village of Groß Pampau, south of Lübeck and are shown at the Museum of Nature and Environment on the ground floor (see Höpfner 2014). The first finding of a fossil baleen whale in Pampau was in 1985 (*Thinocetus* spec.) Several findings followed. Some of the exceptional fossils of Pampau are holotypes. Together with numerous finds of molluscs (more than 160 different species) as well as bony fishes, rays, seals, turtles and other species they document the rich marine life in the primordial North Sea and a pal-ecological system.

Well-preserved and (partially) articulated skeletons of baleen whales were excavated in 1989/90 (Fig. 38.5) and 1992/93 (*Praemegaptera pampauensis,* see Behrmann 1995; Hampe 1999). A life-sized reconstruction of the baleen whale *Praemegaptera pampauensis* gives an idea of how the animal may have looked like. Behrmann thought that the find was a relative of the recent humpback whale, but later research suggests that it is probably more close to the recent minke whale.

The articulated find of a toothed whale excavated in 1989/90 was first known as *Steno* sp. later mentioned as *Atocetus* sp. (Moths and Höpfner 1993; Mietchen et al. 2008). New research on the "Dolphin" revealed a new species and the youngest known member of the kentriodontine subfamily to date could be described. The holotype is called *Kentriodon hoepfneri* after head of excavation Gerhard Höpfner (Kazár and Hampe 2014).

A remarkable extinct lamniform mackerel shark was discovered in 1989/90 in the gravel pit and unearthed from the Miocene mica clay. The fossilized vertebrae are very important finds because from cartilaginous fish usually only the teeth are left. The specimen represents the most complete individual of *Carcharamodus escheri*—a partial skeleton with slightly disarticulated teeth and numerous vertebrae (see Kriwet et al. 2015).

The 'Schlutuper Irish Elk' *(Megaloceros giganteus)* was found in a gravel pit in 1953 in the Schlutup district of Lübeck (Fig. 38.6). It was recovered from sediments of the river Trave, which correlate with Ice Age time. The Irish Elk lived about 12,000 years ago. It was a young adult male aged 6–8 years. Its shoulder height was about 1.75 m and its length is guessed at about 3.20 m. The antlers were reconstructed shortly after the discovery. Compared to other Irish Elk the span is not very

Fig. 38.6 Irish Elk of Lübeck. Copyright Museum für Natur und Umwelt, Lübeck / Photo: Susanne Füting

wide. Due to the large numbers of preserved bones, the discovery is seen as one of the most significant giant deer finds in Germany. It is acknowledged to be one of the tallest of its kind worldwide (see Pfeiffer 1999).

38.5 Collections, Exhibitions and Education

The "Museum für Natur und Umwelt"—Museum of Nature and Environment—presents biological and geological themes with emphasis on natural history and biodiversity of the North and the region of Lübeck. About one third of the exhibition space—the ground floor—is dedicated to geological eras, change of landscapes, ice age and the famous findings of Groß Pampau. The fossilized whale skeletons and the ensemble of finds from the primordial North Sea are unique in Europe. The exhibition is bilingual (German and English) and offers exciting insights. Many specimens of the Lübeck collections are displayed. The exhibition of rocks and drifts invites the visitors to a time journey through the geological eras. A model of a Miocene whale (Fig. 38.7) and a reconstruction of the skeleton of early whale *Dorudon atrox* are notable exhibits to introduce subjects as paleontological research, evolution and ancestry of whales. Fossils and research methods can been explored at the staging of a paleontological excavation site. In another part of the museum recent whales are presented to introduce life, biology and actual endangerment of the species and to give complementary information. The skeleton of a recent sperm whale as well as the small porpoises of the Baltic Sea and examples for vagrants are shown.

Fig. 38.7 Model of a Miocene whale. Copyright Museum für Natur und Umwelt, Lübeck / Lübecker Museen / Photo: Michael Haydn

Environmental and scientific education are key aspects of all museums activities and are based on collections and exhibitions. The museum is a certified educational institution of sustainability and offers numerous learning opportunities, i.e. lectures, seminars, vacation programmes, excursions, and events. Changing temporary exhibitions highlight relevant current themes.

38.6 Research and Perspectives

Digitalization of the collections has not been finished yet. So one of the challenges of the future will be to continue and complete digitalization and to cross-link Lübeck collections with other databases.

The museum is member of NORe, an association of natural history museums and natural science collections of the North and Baltic Sea area. Being Member of NORe the Lübeck Museum of Nature and Environment is also Member of CETAF (Consortium of European Taxonomic Facilities). Aim is to encourage scientific work on the collections and to benefit from joint skills and data.

Currently paleontological excavations take place in the gravel-pit in Groß Pampau, 45 min south of Lübeck City (Figs. 38.8, 38.9 and 38.10). Due to new clay

Fig. 38.8 Excavation of a baleen whale spine in 2013. Copyright Museum für Natur und Umwelt, Lübeck / Photo: Susanne Füting

Fig. 38.9 Excavation site in 2013 in Groß Pampau with team members Andreas Malchow, Uwe Havekost and Wolfgang Höpfner (from right to left). Copyright Museum für Natur und Umwelt, Lübeck / Photo: Susanne Füting

Fig. 38.10 Presentation of a big baleen whale in Groß Pampau with head of excavation team Gerhard Höpfner, author Susanne Füting and member of excavation team and finder of the whale Andreas Malchow (from right to left). Copyright Museum für Natur und Umwelt, Lübeck / Photo: Marion Höpfner

mining works the deposits of mica clay will be accessible again for a couple of years. The Museum and the excavation team lead by Gerhard Höpfner would like to thank the owners of the pit “Ohle & Lau”, who make research work possible and support it with heavy machines on their private company site. The Federal state of Schleswig-Holstein, the municipality Lübeck, several foundations and private persons kindly support excavations, research, educational projects and exhibition.

In 2016 the team uncovered parts of a seal and another well-preserved baleen whale together with rich accompanying fauna. More interesting new findings and scientific results are expected as the excavations continue.

The Lübeck Museum of Nature and Environment networks with other institutes and scientists in order to run different research projects on the Pampau Fossils. Notable is the long-standing and close cooperation with PD Dr. Oliver Hampe and his team of the Natural History Museum in Berlin (Museum für Naturkunde—Leibniz-Institut für Evolutions- und Biodiversitätsforschung).

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Chapter 39
MAINZ: Paleontological Collections of the University of Mainz (Geoscientific Collections)

Kirsten I. Grimm and Bernd R. Schöne

39.1 Historical Background

The Institute of Geosciences (University of Mainz) hosts several paleontological collections which are widely used for teaching and research purposes. Soon after the reopening of the University in the winter of 1946/47, the *Geologisch-Paläontologisches Institut* (Geological and Paleontological Institute) was established. At that time, no geoscientific collections existed at the institute. Most of the objects in today's collections were obtained during student field trips or during designated excavations organized by the Institute.

The founder of the paleontological collections, Univ.-Prof. Dr. Heinz Tobien, worked at the Institute from 1955 until 1978 (Falke et al. 1977). With a minimum of staff and financial resources, he established the Institute of Paleontology which today is one of eleven research groups of the Institute of Geosciences. During his time at the University of Mainz, Heinz Tobien continued to excavate the Höwenegg fossil site. In addition, a wealth of fossil material was obtained from western and southern Europe, Anatolia and Iran. Fossil material from the Rhine-Main area such as Messel, Mosbach and the Mainz Basin complemented the paleontological collections. They were further expanded with specimens from the Devonian and Permian by Tobien's successors, namely Univ.-Profs. Drs. Karlheinz Rothausen, Jürgen Boy, Dietrich Berg and Norbert Schmidt-Kittler. As such the paleontological collections

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reflect the research areas of the Institute of Geosciences (new name since 1977) during more than 65 years.

In 2006, the paleontological working group transformed from a vertebrate-dominated, taxonomic and palecological research into mollusk sclerochronological research focusing on paleoclimate and paleoenvironmental reconstructions, biomineralization and analysis of resource procurement strategies of indigenous people. Under the current head of the paleontological research team, Univ.-Prof. Dr. Bernd R. Schöne, the collection increases particularly by fossil and recent shells of bivalves and gastropods.

Material of completed research projects is predominantly of scientific or documentary value, but also used for teaching purposes. Prior to 2012, the fossil preparators were responsible for the collections. Since 2012, the University of Mainz provided several positions to coordinate the 30 university collections. One of these 50% positions is held by Apl.-Prof. Dr. Kirsten I. Grimm, who curates the geoscientific collections. The concept for the paleontological collections was established in 2012.

39.2 Recent Collections

Parts of the collections can be accessed via the web portal "Museum digital Rheinland-Pfalz" (www.museum-digital.de/rlp/). The portal shows 17 objects from the paleontological collections.

The paleontological collections houses more than 33,000 objects, mostly in very good condition, but the labeling and documentation is often inadequate (old incomplete inventory books and excerpt files in Excel format containing fragmentary information). With the help of students, we have started to digitize the information and re-inventorize the material. Up to now, nearly 50% are completed.

The collections can be subdivided into invertebrate and vertebrate collections as well as collections of the Mainz Basin, fossil plants, a general fossil collection and a historical geology collection mainly containing facies objects. Osteological material used for comparative purposes and mollusk sclerochronological samples complete the collections.

39.3 The Invertebrate Collection

Only a part of the invertebrate fossil collection is inventoried. For some taxonomic groups only rough estimates can be provided at this time. For example, the **Cephalopoda collection** contains ca. 600 specimens, the **Nattheim collection** more than 500 fossils (mainly corals). 478 objects of the fossil corals of Nattheim are inventoried, but it probably contains more than 800 objects. 292 objects are recorded within the **Paleozoic Brachiopoda collection** which amounts to about 700 brachiopods. The fossil **Echinodermata collection** is completely inventoried and contains 541 objects. The same applies to the fossil **arthropod collection** with 925 objects. The **collection of fossil bivalves and gastropods** contains ca. 4000 series and comprises a collection of Roger Rey, a French abbot and fossil hunter (Figs. 39.1 and 39.2).

39.4 The Vertebrate Collection

The vertebrate collection contains ca. 2000 **Paleozoic and Tertiary fish** specimens (Fig. 39.3). The **Pleistocene collection** mainly comprises material from the Rhine gravel and contains 793 inventoried specimens. Another 1000 specimens belong to the **Tertiary vertebrate collection** including 237 specimens from Höwenegg which are already inventoried. Material from excavations in Chios and Marageh remain unprepared. The **Mainz Basin collection** (ca. 2500 specimens) consists mainly of mollusks, but also other invertebrates and vertebrate remains. More than half of the **collection of fossil plants**—about 600 species, mainly from the Permian and Carboniferous—is also inventoried. Another ca. 1000 different fossil remains including fossil reptiles are combined in a **general fossil collection**.

Furthermore, 579 inventoried rock samples showing different types of facies and about 300 non-inventoried rocks are stored in the **historical geology collection.** The **osteology collection** consists of 700 inventoried specimens which were mainly acquired from the University of Heidelberg during the 1960s and later supplemented by professors with own material. The **sclerochronology** collection contains about 5000 samples which are (and were) used in research projects and over 120 publications in peer-reviewed journals as well as in bachelor, master and PhD theses. This collection is currently the most rapidly expanding portion of the paleontological collections (Fig. 39.4).

39.5 Infrastructure of Paleontological Collections

The paleontological collections are stored in the basement of the Institute of Geosciences distributed over nearly 140 steel cabinets. A digital image processing laboratory is available offering the possibility to study the paleontological samples with transmitted and reflected-light research microscopes as well as a scanning electron microscope.

39.6 Research

The geosciences collections are used for both research and teaching purposes. The new sclerochronological collection provides the core material for the Applied and Analytical Paleontology research team (e.g., Füllenbach et al. 2015; Holland et al.

2014; Walliser et al. 2015, 2016). However, the remainder of the large collection is used by researchers from various different fields. For example, Gerald Mayr recently investigated fossil bird remains from the Mainz Basin collection and published the data in Mayr (2015).

39.7 Educational Work

Guided tours are offered on request showing the collection facilities. Collection material is used also in projects of the *junior campus* Mainz. Some material is exhibited in the foyer of the Natural Sciences Building. Some display cases are decorated by students as part of their assignments. During these courses, they become familiarized with the inventory system and preservation procedures.

39.8 Existing Collaborations

The present curator, Kirsten I. Grimm maintains close cooperation with the Mainz Natural History Museum, the German Gem Museum in Idar-Oberstein as well as the Pollichia Museum in Bad Dürkheim.

Fig. 39.1 Fossil coral, Nattheim collection. Foto S. Sämmer

Fig. 39.2 *Glycymeris planicostalis* (Lamarck 1819), Mainz Basin collection. Foto T. Hartmann

Fig. 39.3 Mammoth tooth, Pleistocene collection. Foto S. Sämmer

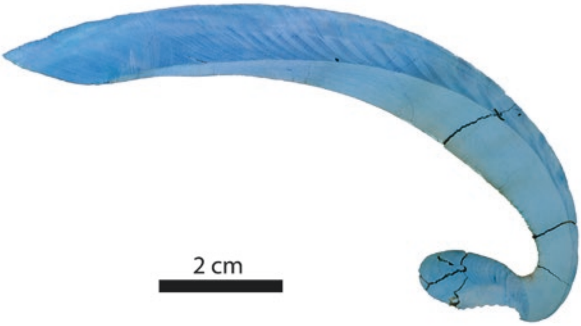

Fig. 39.4 *Glycymeris planicostalis* (Lamarck 1819), cross-section etched with Mutvei's solution, Sclerochronology collection. Foto E. Walliser

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Chapter 40
MAINZ: Palaeontological Collections of the Landesamt für Geologie Und Bergbau Rheinland-Pfalz (Rhineland-Palatinate, Germany)

Jürgen Gad, Winfried Kuhn, and Peter Schäfer

40.1 Micropalaeontological Collection

The micropalaeontological collection was founded by Prof. Dr. Volker Sonne in the early 1950s. It includes mainly Tertiary dinoflagellates, charophytes, foraminifers, ostracods and otoliths from the Mainz Basin, the Upper Rhine Graben and the Neuwied Basin. Some microfossil-assemblages from other regions are of Palaeozoic or Mesozoic age. This collection is arranged geographically. Inventory numbers begin with the number of the topographical map 1: 25,000, followed by a serial number which only reflects the sequence of recording the samples. However, in that way microfossil-assemblages from many locations, including boreholes, of Rhineland-Palatinate are documented. Each location is indicated by Gauss-Krüger-Coordinates. Different microfossil groups from one sample are kept in different cells, so that the same collection-number can have a cell with foraminifers, a cell with ostracods and so on (Fig. 40.1). If the micropalaeontological samples contain also shells of mollusks or remains of vertebrates they are also kept in that collection. Separated is a collection of mostly tertiary dinoflagellates compiled by Prof. Dr. Helmut Weiler. The specimens are preserved in vitreous microscope slides with serial numbers.

During the last decades the collection grew to more than 20,000 micropalaeontological samples (with several millions of specimens!) and many scientific researchers used the material for their publications, so that the collection today also includes type-material for species described first from the micropalaeontological collection of the Landesamt für Geologie und Bergbau Rheinland-Pfalz.

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Fig. 40.1 The inventory-number 6015/7266 with microfossil-assemblages is to assign to sample 7266 from the area of the topographical map 1: 25,000, sheet 6015 Mainz

Fig. 40.2 Rock piece with Lower Devonian brachiopods from the area of Koblenz (Schwerd collection)

40.2 Macropalaeontological Collection

The macropalaeontological collection consists mainly of fossils found by geological mapping in the Devonian of the Rhenish Massif. Especially there are individual pieces of rock showing fossils of variable systematic assignments from many different sites of the geological maps. A total of about 10,000 rock pieces is available. In the explanatory notes of the respective geological maps (scale 1: 25,000) fossil lists based on these materials are mentioned.In addition fossils of the palaeontological work group Koblenz (Paläontologischer Arbeitskreis Koblenz) and the Schwerd Collection, collected in the Lower Devonian in the vicinity of Koblenz, are available. Moreover the collection of Prof. Dr. Gerhard Solle with fossil material from the Devonian of the Olkenbach Mulde (Eifel) is kept in the macropalaeontological collection of the Landesamt für Geologie und Bergbau Rheinland-Pfalz. Also present are macrofossils (and partly microfossils like spores) as documentation for many scientific papers concerning the Devonian of Rhineland-Palatinate, which were published in the journal *Mainzer Geowissenschaftliche Mitteilungen* (Fig. 40.2).

Chapter 41
The Reiss-Engelhorn-Museen

Doris Döppes and Wilfried Rosendahl

41.1 General Information

Name, address:

Reiss-Engelhorn-Museen Mannheim, Zeughaus C4, D-68159 Mannheim, Germany

Number of staff, office space, ect:

The Reiss-Engelhorn-Museen Mannheim has 155 employees (rem, rem gGmbH, CEZA and research centers) and 231 volunteers. There are 77 offices, 1 lecture hall, 3 lecture rooms, laboratories (Clean Room Laboratory, Trace Element and Isotope Spectrometry Laboratory, Materials Analysis Laboratories, AMS-14C lab., preparation lab, taxidermy lab, restoration studios, 3D laboratory), 8000 qm collections rooms and a library. Four exhibition buildings cover a total exhibition area of 12,600 qm.

Team (Collection Natural History/paleontology):

Prof. Dr. Wilfried Rosendahl (director)

Dr. Doris Döppes (head of the collections)

Matthias Feuersenger (taxidermist)

For more information see: http://www.rem-mannheim.de, www.facebook.com/rem.mannheim, www.youtube.com/remmanneheim;

41.1.1 A Short History of the Museum

The roots of the collections date back to the time of the electors Carl Philipp and Carl Theodor, whose beginnings are dated in 1731. They set the foundation for the Art Gallery, the drawing and copper engraving cabinet, the naturalist cabinet, the

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collection of coins and medals, the collection of antiquities, the physical cabinet and the Treasury. But with the transfer of the court to Munich in 1777, the significance of the naturalist cabinet ended.

In 1777/1778 the Zeughaus, the centerpiece of the rem, was erected as a weapon arsenal under Elector Carl Theodor as planned by the architect Peter Anton von Verschaffelt. It is one of the most important architectural monuments of German early classicism in Mannheim.

The collections of the Mannheim antiquarian society (Mannheimer Altertumverein), founded in 1859, are combined with those of the Grand Ducal Antiquaries in the combined antiquarian collections.

Since 1908 the Zeughaus has been primarily used as a natural history museum.

In 1926 was the opening of the Schlossmuseum Mannheim. All the Electoral, then the Grand Ducal, and finally the Baden collections are left to the city. Through the exchange of Baden museums conducted in 1935, the anthropological collection was handed over to the University of Freiburg and the collection from Ancient Egypt to the University of Heidelberg, and in return Mannheim received several thousand ethnographical objects.

After the destruction in the Second World War the Reiss-Museum in Zeughaus could be opened to the public in 1957. In 1988, the extension for the Reiss-Museum was opened in D5 (Fig. 41.1). The today's Museum Weltkulturen was designed by the architect Carlfried Mutschler and the artist Erwin Bechtold.

In 2001, Curt Engelhorn founded a foundation for the Reiss Museum in Mannheim. The Curt Engelhorn Foundation for the Reiss-Engelhorn-Museen

Fig. 41.1 Museum Weltkulturen in D5

supports all research and exhibition work of the institution. The former Reiss-Museum, which already housed two independent museums under its roof, was renamed the Reiss-Engelhorn-Museen in honor of this donor.

The following research facilities and foundations have been established since 2001:

The Curt Engelhorn Foundation for the Reiss-Engelhorn-Museen, Forum International Photographie, Curt-Engelhorn Art and Cultural History Center, Curt Engelhorn Archaeometry Center, consisting of the Materials Analysis Laboratory and the Klaus Tschira Archaeometry Center, Bassermann Cultural Foundation Mannheim, Museums Management Mannheim GmbH (MMM), rem gGmbH, Brombeeren Foundation and dendrochronology laboratories.

41.1.2 Research at the rem

Since the establishment of the Curt Engelhorn Foundation in 2001, the Reiss-Engelhorn-Museen have established themselves as a center of scholarly excellence in the domain of national and international research.

The opening of the Curt Engelhorn Archaeometry Center (CEZA) with the Klaus Tschira Archaeometry Center and of the Curt Engelhorn Art and Cultural History Center has played a major role in this.

The Curt Engelhorn Art and Cultural History Center's research units and projects delve into the individual collections of the rem and connect them with international research.

The History and Cultural Heritage Research Center (FGKE) studies cultural and transcultural processes.

The rem have had a Department of Archaeological Heritage Preservation again since 1992. It has been entrusted by the government to preserve cultural heritage in both the city and environs of Mannheim.

At the rem, the latest 3D scanning and printing techniques have been applied in the 3D laboratory for own exhibition projects and for various external projects since 2013. The 3D data equipment consists of a handheld 3D scanner and an optical 3D scanner. With the mobile equipment, the employees can work directly at the objects so they do not have to travel. This eliminates the need for conservation, transport and insurance costs. This allows the lab to produce both interactive PDF files for home page presentations, as well as highly accurate 3D replicas of objects with various textures, sizes and geometries for exhibitions or other uses. Additional a 3D full-color printer completes the 3D lab.

41.2 The Palaeontological Collection

The paleontological collection in general consists of about 20,000 objects and includes findings i.e. from large mammals of the Pleistocene (Mauer) and Neogen (Eppelsheim), Paleogen (Messel) or Late and Early Jurassic (Solnhofen and Holzmaden).

41.2.1 History of the Collection Reis

The Reis collection from Deidesheim (SW Germany) is one of the largest and most important private quaternary-palaeontological collections in Europe, with more than 15,000 objects. The cranial and postcranial skeletal elements mainly come from the gravel pits of the northern Upper Rhine Graben between Darmstadt and Karlsruhe and were collected over a period of 30 years by Klaus Reis and his sons.

With regard to the temporal range of the collection objects, these mainly cover the Upper and Middle Pleistocene (up to about 600,000 years), but also the Lower Pleistocene is presented. Since the application of "suction dredge" technique recovering large objects is no longer possible. Complete skulls are an important aspect especially for palaeogenetic analyzes. Furthermore, the collection contains findings from various caves in Central Europe and a comparative collection of extant vertebrates. Detailed information on depths and sediment characteristics of the individual sites and finds are available. The complete collection was endowed for the Reis-Engelhorn-Museen (rem) at the end of 2016 by the Curt Engelhorn Foundation and now perfectly complements the existing quaternary-paleontological collection at the rem.

41.2.2 Locality and Stratigraphy

The vast majority of fossil mammals were collected in the gravel pits near Bobenheim-Roxheim in the Palatinate. In some cases the gravel pits are individually known: Willersinn, Kleiner, Skipiol. These pits were about 20 m deep at the time of discovery. Most of the finds were found in the underwater area. This means, on the one hand, the bones are well preserved and on the other hand the exact stratigraphy cannot be determined, despite the fact that it is possible to accumulate during embedding. Most remains have Upper Pleistocene age. Some finds came apparently from Holocene layers because of their strikingly fresh conservation conditions. Some may even be only a few hundred years old. A few finds are conspicuously older. They are from the early Middle Pleistocene. Because of their particular importance for the prehistory of the country, they are also taken into account in this research.

41.2.3 Research Activities

The Collection Reis offers an extensive collection of quaternary faunal remains and is an important addition to the quaternary-paleontological collection of the Reiss-Engelhorn Museen in Mannheim (Döppes et al. 2017).

In addition to a large number of skulls (Fig. 41.2) with associated lower jaws, the collection also includes complete skeletons and partial skeletons mainly from the Upper Rhine Graben as well as various cave sites in Central Europe. A reference collection is also available, which can be used for the determination of fossil bones and up to the investigation of variations of different animal species.

Particularly noteworthy are the remains of hippopotamus, water buffalo, woolly rhinoceros (several skulls with complete dentition), cave lion, cave hyena and a skull part of steppe goat (*Soergelia,* Fig. 41.3). Of the genus *Soergelia* there are only

Fig. 41.2 Collection Reis was exhibited partly in Deidesheim

Fig. 41.3 A skull fragment of *Soergelia* sp. (Bobenheim-Roxheim) from the Collection Reis

four documentations worldwide. Tool marks on mammoth, bison and hippo bones demonstrate the presence of man in the Upper Pleistocene.

The assignment of man, dog and roe deer bones from Roxheim and Eich also offers interesting questions. Remarkable is the fact that the human remains can without doubt be placed also in the Upper Pleistocene.

Six (of the seven) cave bear skeletons of the Collection Reis originate from the famous cave site Drachenhöhle near Mixnitz in Austria. Also finds from the Frankish locality Zoolithenhöhle are in the Collection Reis. The Zoolithenhöhle is famous fort he first descriptions of the cave bear (1794) and the cave lion (1810), which for the first time were determined and described as own and extinct species.

Therefore the project "Eiszeitfenster" Oberrheingraben—Klima und Umwelt im Ober- und Mittelpleistozän Südwestdeutschlands ("Ice Age Window" Upper Rhine Graben—Climate and Environment in the Upper and Middle Pleistocene of South West Germany) is financed by the Klaus Tschira Stiftung gGmbH in Heidelberg from 2016 till 2020 to answer climate and fauna history of the last millennium on the finds from the Collection Reis with the help of various analyzes (AMS, isotopes, genetics, etc.). The Klaus-Tschira laboratory of the Curt Engelhorn Archaeometry Center (CEZA) provides radiocarbon dating services using the AMS technique on small sample sizes. They use a MICADAS-type compact AMS spectrometer. Radiocarbon dating is well established as an universal and accurate dating tool in archaeology and geo-sciences. The datable age span covers historic times back to 50,000 years. All organic material recovered in archaeological context can be dated, such as wood, charcoal, bone, antler, detritus, macro fossils, textiles, hair and teeth. For bone they need 0.5–1 g. From bone samples the collagen is extracted and contamination is removed by ultrafiltration. With the new mass spectrometer the light elements (like H, N, C, O and S) can be analyzed as well. The Collection Reis will be used to carry out the first large-scale population-genetic study of non-human mammalian species—based on the latest results and technical advances in the area of paleogenomics.

41.3 Public Outreach in Palaeontology

An important part is the education, communicating and presenting of paleontology and its related sciences. In addition to the first large-scale family exhibition of the rem, the exhibition "Eiszeit-Safari" (www.eiszeit-safari.de), (Rosendahl & Friedland 2015, Rosendahl et al. 2016) which was opened for the first time in the

Landesmuseum Koblenz in March 2016, the research results and scientific findings of the project applied for are presented in a comprehensible and interactive way in the Reiss-Engelhorn-Museen from September 2020 to March 2021. Not only would this be the possibility to present the findings from the Collection Reis to a broad public in an attractive and child-friendly presentation, but also - and that is very important to us—the climate and environmental history of the last 600,000 years, which are hidden in the skeletal remains. The research project and the exhibition thus make an important contribution to the understanding of the region's oldest history since the time of *Homo heidelbergenis*, as well as to the current and international discussion on climate change and its impact on life and the environment through time to the future. The quaternary deposits and discoveries from the Upper Rhine Graben are one of the most important continental climate and environmental archives of the more recent earth history of Europe. They are also an important addition to climate archives on other continents.

The collection Reis will also complement the permanent exhibition about human Evolution und Prehistory "MenschenZeit" (Figs. 41.4 and 41.5) and thus be updated to the public (Rosendahl 2008).

Fig. 41.4 "Family meeting" with Neanderthals and anatomical modern Humans at the permanent exhibition "MenschenZeit"

Fig. 41.5 Reconstruction of a straight-tusked elephant at the permanent exhibition "MenschenZeit"

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Chapter 42
MARBURG: GeoArchive Marburg (Geological and Palaeontological Collections of the Former Faculty of Geosciences, Philipps University of Marburg)

Michael R. W. Amler, Günter Kauffmann, and Dieter Uhl

42.1 Introduction

The GeoArchive Marburg is the re-named collections of the former Institute of Geology and Palaeontology, Philipps University of Marburg, originally one of the larger geological and palaeontological university collections in Germany. It houses fossils and rock samples from all over the world, particularly from the Palaeozoic era and the Rhenish Slate Mountains (Rheinisches Schiefergebirge). The most important parts of the collections are the reference samples and type specimens of scientific papers dating back until 1790. Furthermore, the collections contain rocks and fossils from localities no longer accessible.

42.2 History

An account of the history of the Marburg collections is important for an understanding of its sections and relevance. The origin of the GeoArchive Marburg dates back to the foundation of the Hessisches Mineralien-Kabinett (Hessian Mineral Cabinet) in 1790 by Johann Gottlieb Waldin (1728–1795). He was a polymath in natural

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sciences, but lacked any kind of material for demonstration in his lectures. Following his suggestions, minerals, rocks and fossils were collected and gathered from Hessian mines and pits. In these early days of mineralogy and geognosy, geological, mineralogical, petrological and palaeontological objects were not differentiated as their origin was considered as rather ambiguous. Johann Christoph Ullmann (1771–1821), Professor of State Economy and Mining ("Staatswirtschaft und Berg- und Hüttenkunde"), from 1795–1821 head of the Hessisches Mineralien-Kabinett, lacked any budget for acquisition of rock samples, so the collections remained regionally confined to the state of Hesse. Similarly unsuccessful in expanding the collections was Ullmann's follower, J. Friedrich C. Hessel (1796–1872), who compiled a first catalogue of the Mineralien-Kabinett.

In 1841, the Mathematical-Physical Institute moved into a new building at the Renthof, where two rooms were also provided for the Mineralogical Institute. Thus, in 1842 the still rather humble collection of the Mineralien-Kabinett was also transferred from the Deutsches Haus (Deutschordenshaus) into the new institute. Internal separation into mineralogy and geology began in 1849, when C. A. Heinrich Girard (1814–1878) was appointed to the additional Professorship of Mineralogy and Geognosy designed to complement Hessel, the Professor of Mineralogy and Mining. Girard also got responsibility for the Hessisches Mineralien-Kabinett, re-organized the collections, acquired several substantial mineral collections and founded in 1853 the Kurhessische Geologische Landesanstalt in Marburg, but left Marburg in the same year. When in 1854 Wilhelm B. R. H. Dunker (1809–1885) (Fig. 42.1)

Fig. 42.1 Professor Wilhelm B. R. H. Dunker (1809–1885); oil on canvas; Museum of the Philipps University Marburg (photo: G. Kauffmann, Marburg)

became director of the Institute of Mineralogy, including the collections, for the first time a natural scientist of rather palaeontological and biological experience supervised the collections. However, more minerals were added in this period and even Adolf von Koenen (1837–1915), a geologist and palaeontologist, who took the Chair of Mineralogy after Hessel's death in 1872, did not add substantial palaeontological material and left Marburg in 1881. In the same year, Friedrich G. Klocke (1847–1884) was appointed to the Chair of Mineralogy and 1881 also marks the separation of the former Mineralogical Institute into an Institute of Mineralogy and an Institute of Geology and Palaeontology, the former headed by Klocke, the latter by Dunker. Lack of space also forced the authorities in 1881 to separate the respective collections: kept in about 20 cabinets, the mineralogical part of the collections moved back to the Deutsches Haus close to the Elisabeth Church in Marburg, whereas the geological and palaeontological samples bereft of their cabinets remained in the Renthof building now cased in boxes. Dunker, however, purchased additional fossils, e.g. a collection of fossils from the Kupferschiefer (upper Permian), fossil plants and an *Ichthyosaurus* from Holzmaden.

Fortunately, with the appointment of F. H. Emanuel Kayser (1845–1927) (Fig. 42.2) to the Professorship in Geology and Palaeontology in 1885, the latter division underwent substantial expansion. Extensive field work and collection expeditions expanded the number of samples and, furthermore, purchase, donations and specimen exchange added thousands of fossils and rock samples. Additionally, by

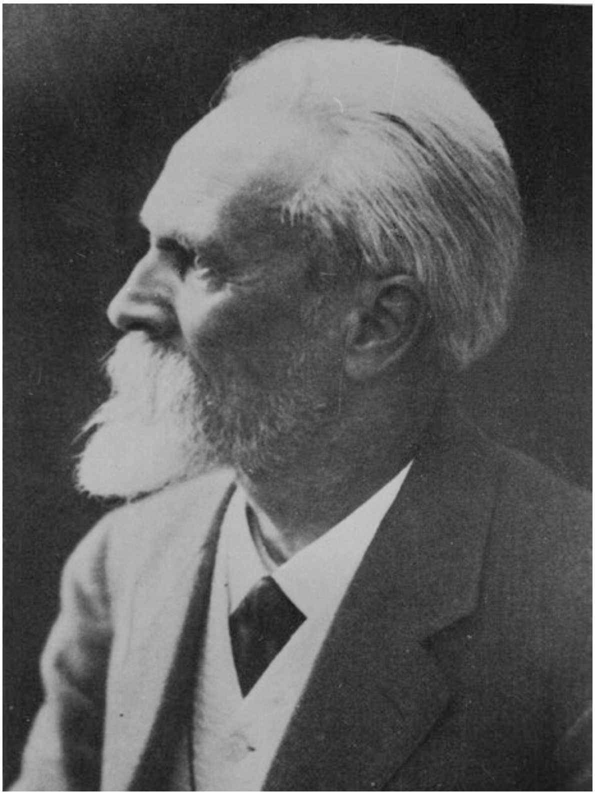

Fig. 42.2 Professor F. H. Emanuel Kayser (1845–1927) (photo: from Kauffmann 1978, Fig. 89)

contrast to earlier heads, Kayser held a personal budget and financial resources designed to acquire even larger and precious objects, e.g. a fossil palm, a fossil bear, fossil fishes and many fossils from the Hunsrück Slate. This period marks the real origin of the palaeontological and stratigraphical collections, and from 1891 onwards parts of the collections were on display to the public. In 1904, 22 years after the mineralogical division had been transferred, the Institute of Geology and Palaeontology and the geological collections also moved from the Renthof building into the Deutsches Haus, where the mineralogical collections were already stored and where, again, new exhibitions were arranged. After Kayser had become emeritus in 1917, his follower Rudolf Wedekind (1883–1961) expanded the stock through donations, acquisition of Recent marine molluscs and his own sampling of fossil corals. Between 1927 and 1935 the collection cabinets moved several times due to constructional defects in the Deutsches Haus. Although neglected in the 1940s, fortunately, the collections remained rather undamaged during World War II, but after the suspension of Wedekind in 1945, the institute and the collections remained orphaned for about 4 years.

In 1949, the appointment of Carl Walter Kockel (1898–1966) as ordinarius (chair) for geology and palaeontology led to further expansion of the collections from the research material of his students, especially from the Alps, the Buntsandstein (Lower Triassic) and conodonts. He was assisted by Reinhold Huckriede (1926–2014) who curated the geological and palaeontological collections between 1962 and 1971. In 1965/66 the Philipps University of Marburg decided to separate the two disciplines and founded the Chair of Palaeontology, taken by Wolfgang Schmidt (1914–1972), who was particularly interested in early vertebrates, especially armoured fishes. Contemporaneously, in 1966 Maurits Lindström (1932–2009) was appointed Chair of Geology. He was responsible for the last remarkable expansion of the collections particularly in micropalaeontological objects, when the Institute of Geology and Palaeontology of Marburg University became one of the world leading research institutions on conodont palaeobiology and stratigraphy. In cooperation with his colleague Willi Ziegler (1929–2002), who later became director of the Senckenberg Museum and Research Institution, and several scientists, in the 1970s and 1980s the Marburg Institute established one of the biggest collections of conodonts worldwide.

Political and structural reform of German universities in the 1960s as well as expansion of Marburg University offered both the Institute of Mineralogy and Crystallography and the Institute of Geology and Palaeontology the opportunity to move into a new building between 1972 and 1975 as a united Faculty of Geosciences. Plenty of space for teaching, research and archiving, notably about 500 new cabinets for storage of material, offered ample placement of the different divisions of the collections for curation and research. The time between 1972 and 1990 marks the last period of expansion and re-organization of the collections curated by Günter Kauffmann (*1939) from 1971–2004. In 2004 the “Collections of the Institute of Geology and Palaeontology of Marburg University” were re-named as “GeoArchive Marburg”. In 2007 the Hessian State Government decided to close down the Faculty of Geosciences at Marburg University, which was completed in 2010, when all the collection cabinets were temporarily stored in the former workshops of the institute. Under the obligation to keep the inventory of the GeoArchive Marburg within the state of Hesse, a new institution for storage of the homeless collections was in need to be found. Finally, in 2013 the collections of the GeoArchive Marburg moved to the Senckenberg Gesellschaft für Naturforschung (SGN), Frankfurt am Main, and since summer 2014 safely kept and curated within the Department of Palaeontology and Historical Geology, Section for Palaeoclimate and Palaeoenvironmental Research. Only the abiotic material of the Quaternary period, mostly from Hesse and collected by Reinhold Huckriede (1926–2014), is permanently housed in the Museum of Natural History Ottoneum in Kassel.

42.3 Collections

In total, the collections of the GeoArchive Marburg include some 165,000 samples and series, the latter being several specimens from the same locality and/or the same species, kept in about 150 cabinets containing up to 40 drawers each. About two thirds are palaeontological objects and one third mostly sedimentary rock samples. In addition, the collections contain more than 11,000 microfossil preparations and thousands of thin sections. Finally, reference material of Diploma and PhD theses as well as the type material of publications complete the collections.

Today, the GeoArchive Marburg is divided into separate parts. The most important division is the type-and-original collection. It includes more than 8000 specimens, e.g. the type material of species and genera and all the figured specimens of about 350 publications since the early nineteenth century. The oldest specimens belong to publications of J. G. Waldin and J. C. Ullmann from the latest eighteenth and earliest nineteenth century. Many other types belong to publications of well-known Marburg geologists and palaeontologists, e.g. Wilhelm Dunker (Fig. 42.3), Adolph von Koenen, Emanuel Kayser, Fritz Drevermann, Rudolf Wedekind, Otto Heinrich Schindewolf and Rudolf Richter. In addition, many external German and foreign scientists decided to store the type material of their publications in the GeoArchive Marburg, trusting that Marburg University would follow international rules for keeping, caring and curating the specimens (see International Code of Zoological Nomenclature, Article 72.F, London 1999).

With about 150,000 objects, the second and biggest part of the GeoArchive Marburg is the stratigraphic-regional collection. It contains fossils and representative rocks from all geological periods and many different areas of the World, sometimes from localities today no longer accessible, e.g. abandoned mines and quarries, clay pits and temporary outcrops of railway or motorway works or from boreholes. This collection is organized in stratigraphic and regional order. The material corresponds to the research projects and interests of the former Marburg scientists and comes from their expeditions and sampling campaigns, as well from many Diploma and PhD theses carried out at Philipps University of Marburg. These circumstances explain the large number of samples from the Late Palaeozoic

Fig. 42.3 *Germaropteris martinsii* (Germar in Kurtze, 1839) Kustatscher, Kerp et Van Konijnenburg-van Cittert from the Late Permian of Frankenberg-Geismar in NW-Hesse, Germany, Mbg. 1794; originally figured by Dunker (1846) (photo: D. Uhl, Senckenberg Institute, Frankfurt a. M)

(Devonian, Carboniferous, Permian), from the Triassic and the Tertiary. Project material from Marburg research groups has been integrated into the main collection until 1995; due to staff restrictions this procedure ceased.

Special palaeontological research projects led to the separation of certain fossil groups from the main collection, systematically organized and supplemented through fossil sampling campaigns of several Marburg scientists and research groups. Thus, the macropalaeontological collection (Fig. 42.4), composed of more than 15,000 palaeontological and biological objects and series, was separated. This division is organized after zoological and botanical systematics into vertebrates (Vertebrata), invertebrates (Invertebrata), plants (palaeobotany) and trace fossils (Ichnia). In particular, the collections include fossil Arthropoda (Fig. 42.5), Echinodermata, Cephalopoda, Coelenterata and Porifera as well as fossil fishes.

The micropalaeontological collection contains more than 11,000 microfossil preparations and thin sections and yields the largest collection of conodonts in Europe, based on the Marburg research focus between 1970 and 1990, with more

Fig. 42.4 View into a drawer of the GeoArchive Marburg - ceratitid ammonoids from the Triassic of Greece in the macropalaeontological collection (photo: Sven Tränkner, Senckenberg Institute, Frankfurt a. M)

Fig. 42.5 *Eurypterus lacustris* Harlan, 1834 from the Silurian of North America in the macropalaeontological collection. The specimen was donated to the GeoArchive Marburg in 1906 by the United States State National Museum (photo: Sven Tränkner, Senckenberg Institute, Frankfurt a. M.)

than 10,000 microfossil cells and hundreds of slate conodont specimens. Much of the material is still undetermined, but there is also the original material of more than 50 publications. Apart from conodonts, the micropalaeontological collection includes Ostracoda and material from DSDP projects. These samples are organized after the names of the researchers.

42.4 Access

All parts of the collections of the GeoArchive Marburg are accessible for research via the Senckenberg Gesellschaft für Naturforschung, Abteilung Paläontologie und Historische Geologie, Frankfurt am Main, Germany, or the Naturkundemuseum im Ottoneum, Kassel, respectively. In addition, all of the Senckenberg material is currently being registered in a database (AQUiLA) for direct search of specimens.

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Chapter 43
MÜNCHEN: The Fossil Collections of the Bavarian State Collections at Munich

Mike Reich and Gert Wörheide

43.1 Early Years (1759–1843)

The early history and formative years of the fossil collections at the Bavarian State Collection of Palaeontology and Geology (BSPG = *Bayerische Staatssammlung für Paläontologie und Geologie*; Fig. 43.1) are inextricably linked with the establishment of the natural history collections (especially mineralogy and zoology) by the Elector of Bavaria, Maximilian III Joseph (1727–1777) (e.g., Balß 1926; Broili 1926; Schröder 1949), who initiated the foundation of the *Churbaierische Akademie* (today *Bavarian Academy of Sciences and Humanities*) in Munich in 1759. Johann Georg von Lori (1723–1787) and Ildephons (Thomas) Kennedy (1722–1804) were appointed first secretaries of the academy; the two men shared an interest in natural history (Spindler 1959; Dehm 1977b, 1978), including geology and palaeontology. For example, Kennedy conducted research on Cenozoic proboscidean remains (relatives of modern elephants) from Bavaria (Kennedy 1769, 1785; Dehm 1977a) and von Lori (1764) published on the history of mining and mining legislature in Bavaria.

In 1777, Charles Theodore (1724–1799), Prince-elector and Count Palatine, became the new Duke of Bavaria. He decided to move large portions of his private natural history collection to Munich, where his Mannheim cabinet had already been incorporated into the collections of the Academy (1802). The Mannheim collections received wider recognition earn through publications of the Italian naturalist Cosimo

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Fig. 43.1 Atrium ("Lichthof") of the Munich Palaeontological Museum displaying several vertebrate skeletons, including a large Miocene proboscidean (*Gomphotherium*) from Bavaria [photograph SNSB-BSPG]

Alessandro Collini (1727–1806) in 1775 and 1784 (e.g., Petzl 1814; Mayr 1995; Reich 2016). The latter paper includes the first documented evidence of a flying reptile from the Solnhofen Plattenkalk deposits of Bavaria (Wellnhofer 1975) (Fig. 43.2).

Maximilian I Joseph (1756–1825; King of Bavaria since 1806) reorganized the natural history collections of the Academy of Sciences in 1807. As a result, the academy became a state institution. Joseph Petzl (1764–1817), professor of natural history, was appointed keeper of the geoscience section of the collections

Fig. 43.2 The Munich BSPG collections host numerous important fossil specimens, including type and figured material (**a**: Collini's *Pterodactylus antiquus*, 1785; **b**: Wagner's *Compsognathus longipes*, 1859; **c**: Wellnhofer's *Archaeopteryx bavarica*, 1993; **d**: von Meyer's *Archaeopteryx* feather, 1861; **e**: Wagner's *Mastodon atticus*, 1857; **f**: Broili's *Palaeopantopus maucheri*, 1929; **g**: Goldfuss' *Scyphia paradoxa*, 1829; **h**: Münster's Triassic *Cidaris* spines, 1841; **i**: Sternberg's *Zamites schmiedeli*, 1833; **j**: von Schafhäutel's *Nummulites guttula*, 1863; **k**: Bachofen von Echt's amber collection, 1958; **l**: Oppel's *Eryon arctiformis*, 1862) [photographs SNSB-BSPG]

(Anonymous 1877a). Moreover, the collections were officially opened to the public for the first time (1809; 1 day per week) (Petzl 1814; Kraft 2009).

In 1827, the Bavarian State University was moved from Landshut to the Bavarian capital, Munich. The various natural history collections housed in the university and academy were merged and taken to a former Jesuit monastery (1783–1944) at Neuhauser Straße 51 (later called Wilhelminum) (e.g., Kraft 2009). In the same year, Ludwig I (1786–1868), King of Bavaria, assigned the responsibilities for the curation of all collections to a State Conservator General, who also executed the office of president of the *Bavarian Academy of Sciences* (until 1927).

Approximately 50 smaller and larger acquisitions of material are recorded in the annals of the collection for the first decades of the 1800s (e.g., of Ignaz Pickl 1736–1818, Paul Joseph Ritter von Cobres 1737–1823 and Mathias von Flurl 1756–1823; e.g., Petzl 1814; Anonymous 1824; Goßner 1926; Jung et al. 2000). During this time, Samuel Thomas von Soemmerring (1755–1830) described fossil vertebrates from the collections in a series of papers. Rudolph Wagner (1805–1864) from Erlangen (later Göttingen) surveyed the holdings of the Munich fossil collections (e.g., Carboniferous plants of Palatinate, Jurassic Plattenkalk deposits of Solnhofen, Eocene of Monte Bolca/Italy, Cenozoic invertebrates and vertebrates of the Paris Basin,) in his publication *Nachrichten von der Petrefactensammlung der Königlichen Academie der Wissenschaften in München* (1829). Although the palaeontological section originally emerged from geognostic (geology) collections, the palaeontological specimens were usually curated by scientists and assistants of the zoological section (e.g., Johann Baptist Ritter von Spix 1781–1826; Gotthilf Heinrich von Schubert 1780–1860; Johann Georg Wagler 1800–1832; Johann Andreas Wagner 1797–1861).

43.2 Formation of the Bavarian State Collection of Palaeontology and Geology (BSPG)

A separate palaeontological section of the State Scientific Collections (*Wissenschaftliche Sammlungen des Staates*) was formally established in 1843, concomitant with the State Collection of Geognosy (Geology). Johann Andreas Wagner was appointed the first curator (1843) and professor of palaeontology (and zoology, in 1857) of the State Collection of Palaeontology. Wagner's main research interest was vertebrate palaeontology (Late Jurassic Plattenkalk of Solnhofen, Bavaria, and Neogene mammals of Pikermi, Greece) (e.g., Boué 1829; Schröder 1949; Dehm 1981; Wellnhofer 1996). During Wagner's tenure (1843–1861) several important collections were acquired, including the famous collection of Count Georg zu Münster (1776–1844) comprised of more than 60,000 specimens (>10,000 different fossil species, 1844/1845; Mayr 1988, 1993). Aquisitions also includes several older fossil collections, including materials assembled by Georg Wolfgang Knorr (1705–1761), Johann Friedrich Bauder (1713–1791), Emanuel Theophil Harrer

(1714–1776) and Casimir Christoph Schmi(e)del (1718–1792). Other acquisitions overseen by Wagner are the collections of Friedrich Carl Redenbacher (fossils from Solnhofen, 1851), Johannes Roth (1815–1858) (Tertiary mammals of Pikermi, 1853), Friedrich Karl Haeberlein (1787–1871) (Solnhofen fossils, 1856), Maximilian de Beauharnais, 3rd Duke of Leuchtenberg (1817–1852) (Solnhofen fossils etc., 1858) (e.g., Broili 1926; Goßner 1926; Wellnhofer 1980) (e.g., Fig. 43.3). In the year of the last mentioned acquisition (1858), Carl Albert Oppel (1831–1865), renowned for his scientific contributions on Jurassic biostratigraphy and invertebrates, became the museum's assistant director (Mayr 2002). In 1860, under Maximilian II of Bavaria (1811–1864), Oppel was promoted to supernumerary professor of palaeontology in Munich with intent to outcompete another offer to become a full professor at the University of Göttingen (Martin 1965). During this year, Oppel begun studying the first *Archaeopteryx* (the London) specimen from the Haeberlein collection (e.g., Wellnhofer 1985) (e.g. Fig. 43.4) that is now housed in the Natural History Museum London. Shortly thereafter, Oppel replaced Wagner (†1861) as ordinary professor of palaeontology (1862) in Munich. Unfortunately, Albert Oppel died from tuberculosis in late 1865, at the age of 34.

During Oppel's short tenure, the collections of brothers Hermann (1826–1882), Adolf (1829–1857) and Robert (1833–1885) Schlagintweit (Indian fossils), Gérard Paul Deshayes (1795–1875) (Tertiary invertebrates from the Paris Basin, 1865), Joseph Oberndorfer (1802–1873) (Late Jurassic Plattenkalk fossils, 1865) and Ludwig Hohenegger (1807–1864) (Jurassic/Cretaceous fossils of the Carpathians, 1865) were acquired (e.g., Anonymous 1877c, Moser 2017).

43.3 The First Zenith of Munich Palaeontology—The 'Zittel Era'

In 1866, under the reign of 'fairy-tale king' Ludwig II of Bavaria (1845–1886), Oppel was succeeded by Karl Alfred von Zittel (1839–1904; Fig. 43.5), formerly professor of mineralogy, geology and petrifactology at Karlsruhe.

Von Zittel significantly advanced the science of palaeontology in Germany, together with the Munich collections, and gave the Munich institutions worldwide visibility and international reputation. Moreover, he summarised the palaeontological knowledge of the mid-nineteenth century in a five-volume compendium, *Handbuch der Palaeontologie* (1876–1893). He also wrote the *Grundzüge der Paläontologie* (1895–1934), a very popular palaeontological textbook that was used by several generations of students. Both book series were subsequently translated into foreign languages (e.g., English and Russian), attesting to their wide international acclaim. Von Zittel also served as a co-editor and editor-in-chief of the famous palaeontological journal *Palaeontographica*, and supervised an impressive number (>50) of (later well-known) palaeontologists and geologists, including George Jenning Hinde (1839–1918), Carl Christian Gottsche (1855–1909, later professor at

Fig. 43.3 Large parts of the Munich BSPG archive were destroyed during WWII, but some material survived and now functions as the basis of the new archive (**a**: Oppel's drawing of the London specimen of *Archaeopteryx*, 1860; **b**: Oppel's, von Zittel's and Dehm's notebooks; **c**: photographs of several field campaigns, Dehm/Schröder 1939, Dehm et al. 1955/1956; **d**: group photograph of former students, 1889; **e**: institute correspondence; **f**: newspaper cuttings) [SNSB-BSPG archives]

Fig. 43.4 Historical Munich BSPG collection labels indicating the provenance of our material (often also found on the labels are the names of collectors, donors and scientists) [photographs SNSB-BSPG]

Hamburg university), Gustav Steinmann (1856–1929, later professor at Freiburg and Bonn university), Otto Jaekel (1863–1929, later professor at Greifswald and Sun Yat-sen University in Guangdong), Eberhard Fraas (1862–1915, later at Stuttgart museum), Ernst Stolley (1869–1944, later professor at Braunschweig university), Charles R. Eastman (1868–1918, later at Harvard university and the Carnegie Museum, Pittsburgh, PA), Felix Plieninger (1868–1954, later professor at Hohenheim university), Johan A. Kiær (1869–1931, later professor at Kristiania university), Max Semper (1870–1952, later professor at Aachen university), Johannes Wanner (1878–1959, later professor at Bonn university), and others (e.g., Mayr 1989).

In addition to numerous other duties, von Zittel also served as rector (university chancellor) of the Ludwig-Maximilians-Universität (1880–1881) and as president of the *Royal Bavarian Academy of Sciences* (1898–1904). In 1886, he received the knightly accolade (Karl Alfred Ritter von Zittel). Karl Emil von Schafhäutl (1803–1890; e.g., Hagn 1979) served as the curator of the State Collection of Geognosy (Geology) from 1843 until his death (Anonymous 1877b). In 1890, von Zittel replaced von Schafhäutl as curator of the geological collection, and both collections were subsequently merged (State Collections of Geology and Palaeontology; Schmidt 1977, Dehm 1978, Wellnhofer 1980); however, the petrographical and technological divisions were moved to the Mineralogical State Collection.

Fig. 43.5 Karl Alfred von Zittel, head of the *Bavarian State Collection of Palaeontology and Geology* from 1865 to 1904 [SNSB-BSPG archives]

The 'Zittel Era' in the second half of the nineteenth century saw a tremendous expansion of the Munich palaeontological collections. Important acquisitions during the era include the collections of Albert Oppel (Mesozoic molluscs, 1866; including figured material of Karl Hartwig von Zieten's *Die Versteinerungen Württembergs*), Josef Pauer (1819–1888) (Alpine fossils, 1873), August Wetzler (1821–1881) (Jurassic and Tertiary fossils from southern Germany, 1881), Heinrich Otto Günther and Florentino Ameghino (1854–1911) (Tertiary and Pleistocene mammals of South America, 1893/1897), Theodor Stützel (Tertiary vertebrates of Greece and North America, 1896/1898), David Rüst (1831–1916) (fossil radiolarians, 1898), Joseph Georg Egger (1824–1913) (Cretaceous microfossils from southern Germany, 1900), Karl Albert Haberer (1864–1941) (Tertiary and Pleistocene vertebrates from China, 1901). In addition, several larger collections in von Zittel's possession, as well as material from field campaigns (mostly vertebrates) [e.g., from the expedition of the German explorer Gerhard Rohlfs into the Libyan Desert (1873/1874, Zittel; e.g., Barthel 1980), Ferdinand Broili's (1874–1946) excavation campaign in Texas (1899/1901), Ernst Freiherr Stromer von Reichenbach's (1871–1952) expeditions to Egypt (1901/1902, 1903/1904) (see also Sternberg 1903, Smith et al. 2006)], were transferred to the Munich palaeontological collections (e.g. Fig. 43.6).

Fig. 43.6 Ernst Freiherr Stromer von Reichenbach, curator at the Bavarian State Collections of Palaeontology and Geology, with one of his dinosaur bones that was on display in the 'Old Academy' building

Through the years, the BSPG became a hallmark institution of palaeontological and geological research (e.g., von Zittel 1899), with substantial holdings of fossils from all over the world, and a museum that was sometimes factiously referred to as *Zittel's Museum* (Rothpletz 1905; Maucher 1959).

Longstanding efforts to move the growing institution to a new building 1901/1903 remained unsuccessful. Subtle but nevertheless important accomplishments concerned the facilities of the Munich 'Old Academy' building (Wilhelminum) that were finally upgraded through installation of a central heating system and electrical light. As a result, the Palaeontological State Museum (and others) could remain open to the public during the winter months.

43.4 Zittel's Aftermath—Rothpletz, Broili, Beurlen

The fate of the State Collections in the decades following von Zittel's death in 1904 were in the safe hands of several of his former students, including Max Schlosser (1854–1932), Ernst Freiherr Stromer von Reichenbach (1871–1952; Fig. 43.6), Ferdinand Broili (1874–1946), and Edgar Dacqué (1878–1945).

August Rothpletz (1853–1918), a leading Alpine geologist and stratigrapher, succeeded von Zittel as professor of palaeontology and geology. Rothpletz, since 1894 Associate Professor at Munich University, taught classes in Alpine geology and tectonics, as well as palaeobotany, and conducted research on a wide spectrum of subjects. In the same year, Josef Felix Pompeckj (1867–1930), assistant and curator at the Munich palaeontological collections (since 1894), became professor at Hohenheim agricultural college. Receipt (by donation in 1915/1917) of a larger lot of material from Johann Wanner's (1868–1956) West Timor/Indonesia expeditions of 1909/1911 is surely worth mentioning as an important acquisition during this period of time.

Rothpletz had bequeathed his private wealth to be used for the establishment of a chair and institute of geology. The Bavarian ministry approved this endowment in 1919. At approximately the same time (1920), the collections (and libraries) were divided and two separate institutions established: (1) *Bavarian State Collection of Palaeontology and Historical Geology* (headed by Ferdinand Broili), and (2) *Bavarian State Collection of General and Applied Geology* (headed by Erich Kaiser; cf. Kaiser 1926; Maucher 1959).

Ferdinand Broili was a palaeontologist who primarily worked on fossil vertebrates, although he also published on invertebrates from Lagerstätten deposits (e.g., Early Devonian Hunsrück Slates and the Late Jurassic Plattenkalks, both southern Germany).

Broili's tenure was characterised by the considerable expansion of all parts of the collections. The most important acquisitions of this time were the collections of Bernhard Stürtz (1845–1928) (Devonian fossils), Princess Theresa of Bavaria (1850–1925) (both in 1925), Hans Reck (1886–1937) (Olduvai Gorge fossils, 1931, to supplement the Wilhelm Kattwinkel collection, acquired in 1911; cf. MacCurdy 1914), Oskar Kuhn (1908–1990) (Jurassic invertebrates of Franconia, 1933/1936), Georg Grossarth (1885–1949) (fossil Karoo Fm reptiles and mammals, 1934), and Anton Schrammen (1869–1953) (fossil sponges, 1938/1940). Moreover, large quantities of material are gathered during several expeditions, e.g., the expedition of Leonore Margarethe Selenka (1860–1922) to the Dutch East Indies in 1907/1908 (Pleistocene mammals, 1909), Stromer von Reichenbach's expeditions to Egypt (1910/1911), Schlosser's campaigns in Bavaria and Tyrol (1904–1920), Joachim Schröder's (1891–1976) expedition to South Africa (Karoo Fm reptiles, 1927/1928), Friedrich von Huene's (1875–1969) and Rudolf Stahlecker's (1898–1977) expedition to Brazil (1928/1929), and Schröder's and Richard Dehm's journey to British India/Pakistan and East Australia (1939).

Additional substantial numbers of specimens were transferred to the Munich Palaeontological Museum in 1929 following the reorganisation of the Bavarian local mining authority (*Oberbergamt*). These collections include numerous type specimens, such as those forming the basis for the monographs and papers written by Joachim Barrande (1799–1883), Carl Wilhelm von Gümbel (1823–1898), Ludwig von Ammon (1850–1922), Otto M. Reis (1862–1934), and Adolf Wurm (1886–1968) (e.g., Förster 1980) (Fig. 43.4).

More than 30 rooms of the buildings of the Old Academy (Neuhauser Straße) were filled with a diverse and valuable stock of collections and exhibitions (Anonymous 1912, 1934; Dehm 1977b, 1978; Wellnhofer 1980; Jung et al. 1993). During a longer journey through Europe and Germany, William Diller Matthew (1871–1930; curator at the American Museum of Natural History and later director of the University of California Museum of Paleontology) called the Munich Palaeontological Museum "…the finest museum for fossil Vertebrata in Germany" (Matthew 1921).

However, in 1939 Ferdinand Broili retired early at age 65. Plans to optimise the premises in the Old Academy (e.g., to build an atrium with a glass roof to function as a dinosaur hall) abruptly stopped after the beginning of WWII (e.g., Dehm 1978).

Broili was succeeded by the invertebrate palaeontologist and geologist Karl Beurlen (1901–1985), who vigorously promoted Aryan Palaeontology during the National-Socialist era in Germany (Rieppel 2012). In 1941, the curators Edgar Dacqué and Joachim Schröder (with the help of others) began to evacuate important fossil types and other valuable (and moveable) collections, as well as library material, to Bavarian castles at Hohenburg (Lenggries), Greifenberg (Schondorf am Ammersee), and Oettingen (BSPG archives) to protect these items from damage or loss through allied bombing. However, most of the palaeontological collections (including archive material) remained in Munich, and unfortunately was destroyed during the bombardment of the city in the night from April 24 to 25, 1944, as well as during several successive air raids (e.g. Fig. 43.4). In July 1945, Beurlen lost his position at the University of Munich and was succeeded by interim chairman Joachim Schröder. In 1946, all surviving parts of the collections were moved from their shelters to the building of the Munich Central Collecting Point.

43.5 From the 1950s to the Present—Schröder, Dehm, Herm etc

In 1950, the *Bavarian State Collection of Palaeontology and Historical Geology* moved to the centre of Munich, into a building (formerly Kunstgewerbeschule/School of Arts and Crafts) located in Richard-Wagner-Strasse 10, where it remains today. In the same year, Richard Dehm (1907–1996) succeeded Joachim Schröder (interim head since 1945), and assumed the position of professor of palaeontology and historical geology at the university, as well as head of the *Bavarian State Collection of Palaeontology and Historical Geology*.

Two new sections (i.e., micropalaeontology and palaeobotany) were established (e.g., Hagn and Herm 1963; Hagn 1990) in addition to the two traditional focus areas of BSPG research and collection that already existed (i.e., fossil vertebrates and invertebrates).

All sections of the collection grew rapidly during the last six decades of the twentieth century; important acquisitions from this period of time include the collections of Adolf Bachofen von Echt (1864–1947) (Baltic amber, 1958), Johannes Rievers (1880–1955) (Hunsrück Slate, 1958), Othenio Abel (1875–1946) (palaeobiology, 1959/1960), Max Hirmer (1893–1981) (fossil plants, 1962), Karl Mägdefrau (1907–1999) (palaeobotany, 1971/1972), Friedrich Plumhoff (1928–1989) (micropalaeontology, 1989), Erlangen (in part) and Würzburg universities (2008), Friedrich Pfeil (b. 1950) (fossil fishes, 2013), Hannes Löser (b. 1962) (fossil corals, 2009/2014), and Helmut Keupp (b. 1949) (fossil cephalopods, 2014) (e.g. Fig. 43.2).

Additional, large collections of fossils from all over the world were gathered and brought to Munich by members of the permanent and temporary staff of the BSPG and LMU, including Richard Dehm, Therese zu Oettingen-Spielberg (1909–1991), Hans Karl Zöbelein (1910–1996), Herbert Hagn (1927–2003), Karl Werner Barthel (1928–1981), Walter Jung (b. 1931), Dietrich Herm (b. 1933), Axel von Hillebrandt (b. 1933), Volker Fahlbusch (1934–2008), Reinhard Förster (1935–1987), Gerhard Schairer (1938–2012), Norbert Schmidt-Kittler (b. 1940), Kurt Heißig (b. 1941), Franz Theodor Fürsich (b. 1947), Winfried Werner (b. 1950), H. Hermann Schleich (b. 1952), Robert Darga (b. 1957), as well as several other former and current personnel.

A sponsoring association (*Freunde der Bayerischen Staatssammlung für Paläontologie und Historische Geologie München e.V.*) aiming at providing financial support and manpower to the manifold of (palaeontology) activities of the Bavarian State Collection was founded in 1971.

In 1976, Richard Dehm was succeeded by the micropalaeontologist Dietrich Herm, who graduated at LMU and held professorships at the Universidad de Chile and Tübingen University before returning to Munich. When Herm retired in 1998, he was followed by Reinhold Leinfelder (b. 1957), with a brief interim by Peter Wellnhofer (b. 1936). In 2000, the *Bavarian State Collection of Palaeontology and Historical Geology* and the *Bavarian State Collection of Geology* were again merged, and the new name *Bavarian State Collection of Palaeontology and Geology* (BSPG) was introduced (Kölbl-Ebert et al. 2000). Leinfelder left Munich early in 2006, and the collection was headed interimly by Winfried Werner for the following 2 years. Since October 2008, Gert Wörheide is the Director of the BSPG and holds the Chair of Palaeontology and Geobiology at LMU München. Permanent scientific and technical staff of the BSPG currently comprises nearly 20 people, who work in the same building as all staff members of the LMU Chair of Palaeontology and Geobiology.

Past and present organismal diversity is the overriding theme of all palaeontological and biological research at the BSPG and LMU Chair of Palaeontology and Geobiology. This theme includes palaeobiology and biostratigraphy of vertebrates, invertebrates, plants and fungi, phylogenetics, phylogeography, biogeography, biomineralisation, and molecular geo- and palaeobiology.

Although our scientists conduct a great deal of field work, the collections represent our prime research asset. The BSPG currently keeps more than 2.5 million objects from all fields of palaeontology and geology, including micropalaeontology, palaeozoology, palaeobotany and palaeomycology. The focus has always been on fossils from Bavaria, the Alps and Europe, as well as different fossil lagerstätten deposits worldwide. The BSPG collections at Munich include type and figured materials of more than 20,000 scientific publications, dating back as from the eighteenth century. Two scientific journals (*Mitteilungen der Bayerischen Staatssammlung für Paläontologie und historische Geologie* since 1961, and *Zitteliana* since 1969) published by our institution since the 1960s, but were merged into one journal (*Zitteliana*) in 2003.

Research infrastructure currently available to staff and visiting scientists include different labs (Computers, Preparation, Micropalaeontology, Microscopy, Photography, Molecular Biology), libraries, as well as access to SEM (LMU Department of Earth and Environmental Sciences) and X-ray computed tomography (SNSB). All labs are equipped with state-of-the-art instruments.

In addition, the GeoBio-Center^LMU, founded in 2002, provides a platform for interdisciplinary research at the interface between geo- and biosciences through the integration of several LMU Faculties (Geosciences, Biology, Veterinary Sciences) with the SNSB. Moreover, the location of the BSPG building in the heart of Bavaria's capital facilitates outreach activities aimed at disseminating our collection holdings and research results to a broad audience from around the world. One of the premier attractions in the *Palaeontological Museum Munich* is the atrium featuring skeletons of fossil mammals, reptiles, and birds (Barthel 1962, 1966; Jung et al. 1991, 1993; Fig. 43.1). Other exhibition highlights currently include notable fossils from Bavaria (including *Archaeopteryx*) and a short tour through Earth History.

43.6 Perspective

The BSPG, one of Germany's most important scientific research institutions focusing on Palaeontology and Geobiology, houses more than 2.5 million specimens, as well as state-of-the-art research facilities allowing the institution to support and promote the research carried out by research staff, students, and visiting scientists. Moreover, in 2017 the BSPG received an extra financial support to modernise parts of the public exhibition at the Munich Palaeontological Museum that will certainly place Munich palaeontology into a new perspective.

Box 43.1: General information

Bavarian State Collection of Palaeontology and Geology (Bayerische Staatssammlung für Paläontologie und Geologie; BSPG), part of the *Bavarian Natural History Collections (Staatliche Naturwissenschaftliche Sammlungen Bayerns; SNSB)*

Postal address:	Richard-Wagner-Str. 10, 80333 München
Homepage:	www.palmuc.de and www.snsb.mwn.de
Contact:	Prof. Dr. Gert Wörheide (director) & PD Dr. Mike Reich (deputy director), pal.sammlung@lrz.uni-muenchen.de
Year of foundation:	1827 (SNSB) and 1843 (BSPG)
Number of specimens:	>2.5 million objects and series
Collections content:	Palaeozoology (vertebrates and invertebrates), palaeobotany (plants and fungi), micropalaeontology, geology—worldwide
Focal points:	Fossils from Bavaria and the Alps; large collections from fossil lagerstätten deposits as well as classic and new localities, e.g., Germany, UK, Greece, Egypt, Tanzania, Australia, Pakistan, Iran, South Africa and the USA
Current exhibitions:	Palaeontological Museum Munich—Richard-Wagner-Straße 10, 80333 München Geological Museum Munich—Luisenstraße 37, 80333 München

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Chapter 44
MÜNSTER: Geomuseum of the WWU

Markus Bertling

44.1 History

The history of the Geomuseum of the WWU (Westphalian Wilhelm's University) was last reviewed by Eitner and Oekentorp (1989). It goes back to 1821, when the zoologist G.M. Roedig started to assemble a teaching collection for the surgeon school of the "Akademische Lehranstalt". This comprised the relics of the first University of Münster, which had been founded in 1780 but was dismantled in 1818. Roedig founded the "museum mineralogicum et zoologicum" in 1824, thus making the Geomuseum the oldest natural history museum in Westphalia. It was housed in the so-called "Spanish Wing" of a Jesuit college that had formed the predecessor of the university, thus demonstrating the intimate connection of museum and university since the somewhat asynchronous beginnings.

After Roedig had tragically drowned in the North Sea, Caspar Friedrich Becks stepped in as curator of the museum. He was a geologist and privately collected rocks and fossils in the region, many Pleistocene and Cretaceous fossils among them. After his death in 1847, his specimens were bought for the museum, strongly increasing the amount and value of the collection. Becks' inventory book is still held in the museum (Fig. 44.1). It was maintained by his successor August Hosius, who added a multitude of German and European fossils (now mostly in the teaching collection of the parent institute), e.g. the famous fishes from the Upper Cretaceous of the hills surrounding Münster. Hosius was the first solely geological curator, as the zoological collections had grown to such an extent in 1876 that Hermann Landois was appointed as zoological curator. In 1880, the museum moved to its current location, a baroque three-wing court built 1703–1707 by Gottfried Laurenz Pictorius

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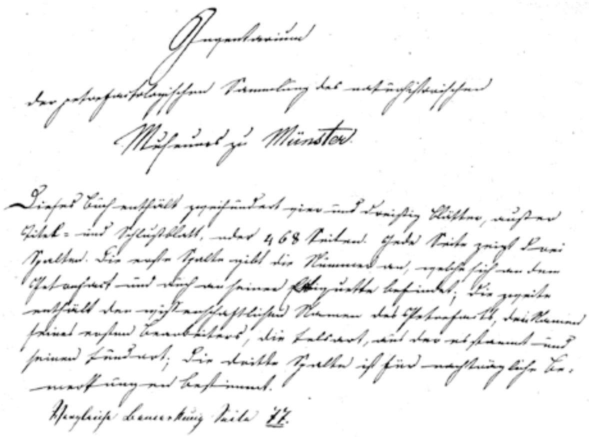

Fig. 44.1 Title page of the inventory book established by Caspar Friedrich Becks; the headline reads "Inventarium / der petrefaktologischen Sammlung des naturhistorischen / Museums zu Münster" (inventory of the petrefactological collections of the Natural History museum at Münster)

Fig. 44.2 The Landsberg Court (1703–1707) in the centre of Münster, home of the geological museum since 1880

(Fig. 44.2). A litte later, Landois spinned off his own museum in 1891, now the LWL Natural History Museum, which was given all zoological objects in 1906.

The effective split of the collections—85 years after their origination—was brought about by Theodor Wegner, who was the head of the museum since 1904. In the 1910s, he acquired the famous plesiosaurs from Gronau (Fig. 44.3) and the Ahlen mammoth, now the most prominent specimen for visitors of the museum.

Fig. 44.3 *Brancasauus brancai* Wegner, an almost complete skeleton of an Early Cretaceous (Valanginian) plesiosaur found in a clay pit in Gronau, Emsland, in 1910; length 3, 50 m (postcard of the 1970's)

Wegner also initiated expeditions to the Aegean island of Samos, collecting hundreds of ungulate bones from the local Miocene.

World War I had left Münster and the museum unaffected, but in 1938 the mineralogical collections left into a separate building nearby. As allied bombs began to fall on German cities in World War II, the far-sighted curator Hans Wehrli had the best exhibits removed from the building. This was destroyed in 1943, leaving many objects lost in the debris. The best specimens, however, escaped doom, and thus the most precious objects of the nineteenth century survive to the present day.

After World War II, Wehrli remained in charge and supervised the return of the collections. Few remarkable objects were acquired afterwards, except for a large collection of Devonian Anthozoa (Rugosa and Tabulata) from all over the World (1960s–1990s) and some 800 bones of iguanodontid ornithopods from the Nehden locality (1979–1982; the parent institute donated most of the latter to the LWL Natural History Museum later). We owe both gains to Klemens Oekentorp, who also expanded the exhibition space of the museum. Very few acquisitions are being made after Northrhine-Westphalia transferred the legal responsibility for regional palaeontological heritage to a different state-owned museum.

44.2 Current Situation

The geological/palaeontogical and mineralogical museums were reunified by the university in 2007, forming the new Geomuseum of the WWU. It is hosted by the two university institutes for geology/palaeontology and for mineralogy, respectively. Both have separate teaching collections but each assign one part-time curator to the Geomuseum, giving it one full curator position. Within this, one mineralogist and one palaeontologist take care of the material and develop special exhibitions based on the collection and on the subjects of research in the parent institutes. In addition to this single scientific position, there is one supervisor for the exhibitions as well as a varying number of student assistants, altogether working approximately 25 h per week. It is impossible, however, to specify which time they spend on the palaeontological part of the museum—depending on current tasks, this varies throughout the year.

The Geomuseum receives little financial support—the parent institutions each give 5000 Euro annually (as of 2017). In the attic of the building, there is one room for each part-time curator and a space for museum education. The Geomuseum does not have any laboratories of its own but has free access to all laboratories and workshops within the parent institutes. In addition, the university workshops for wood, metal and electricity may help occasionally, and no rent or fee for heating, water or power supply has to be paid. Larger exhibition projects demand individual fundraising. Given this as well as the minimal personnel, only one annual exhibition may be realised, ideally with a palaeontological subject every second year.

Various thematic collections take up approximately 1200 square metres in the cellars of the old building. Most of the original cellar floors and vaults still exist, posing special problems in maintaining high standards of curation. A little additional space in buildings adjacent to the parent institutes has taken parts of the collection that no longer fitted after the full conversion of the museum building.

44.3 Collections

The collection concept of the Geomuseum reflects its history. In the course of the reunification process, it was decided to maintain the rather diverging approaches of the former geological and mineralogical museums. This means that the palaeontogical department curates sedimentary rocks and fossils originating exclusively from Westphalian localities, whereas specimens of the crystallographic and systematic mineralogical collections come from all over the World.

About 110,000 objects in the collections are fossils. Many of them were found in the nineteenth century or early twentieth century, opening a unique window to long-lost localities. Fossils from the strata with regional importance, i.e. Late Cretaceous and Pleistocene, form the largest parts of the collections. For this reason, they are kept separate from the other parts of historically arranged collections.

The material is structured in the following way:

- Fossils of the Westphalian Ordovician to Neogene (41,000 specimens),
- Fossils of the Westphalian Cretaceous (43,000 specimens),
- Fossils of the Westphalian Pleistocene (14,000 specimens),
- Fossils from erratics (7000 specimens),
- Vertebrates from the Samos Miocene (2000 specimens),
- Scientific originals (5000 specimens).

44.3.1 Scientific Originals

Holotypes are the scientifically most important constituents of any biological collection. The Geomuseum keeps them under special security conditions separately from other fossils. Here, the types are joined by other reference material such as any figured specimens or fossils explicitly mentioned in the text of publications, e.g. by a number or a description. Two animal groups are most prominent in terms of quantity: (1) Palaeozoic corals from all over the World (mostly Devonian Rugosa) mainly collected by Alexander von Schouppé and Klemens Oekentorp in the 1960s through 1990s (Avlar 1991; Fig. 44.4), and (2) a superb array of Late Cretaceous (Campanian) fishes from the nearby locations Sendenhorst and Baumberge collected prior to 1880 (von der Marck 1863, Siegfried 1954; Fig. 44.5). But even today, any fossil published by members of the WWU institute for geology and palaeontology becomes part of this collection. Palaeobotanical types, however, are stored elsewhere (Busche and Siegfried 1968) for historical reasons and unfortunately are not part of the Geomuseum.

Fig. 44.4 Holotype of the rugose coral *Smithiphyllum kloeckneri* May from the Middle Devonian (Grünewiese Member, Ihmert Formation, Eifelian) of Iserlohn-Kesbern, Sauerland; size 15 × 10 cm

Fig. 44.5 The 45 cm long houndshark *Paratriakis decheni* von der Marck from the Late Cretaceous (Vorhelm-Member, Ahlen Formation, Early Late Campanian) from Sendenhorst near Münster; size 50 × 15 cm

44.3.2 Vertebrates from the Samos Miocene

While Theodor Wegner was the curator of the museum, several thousand bones of Late Miocene ungulates were recovered from the Greek island of Samos. Julius Andree published on some of them (Andree 1920, 1926), followed by Wehrli (1941). This part of the collections therefore comprises several holotypes and paratypes (Fig. 44.6), which are integrated in the underlying systematic order. The material is considered voluminous and coherent enough to form an entity of its own, rather than separating types and other material. Among the latter, there are two large wooden crates with smaller bone fragments still awaiting identification.

44.3.3 Fossils from Erratics

Due to the extensive cover of Pleistocene ground moraine in the Muenster area, fossils extracted from erratics form a significant part of the museum material. Within it, highly fossiliferous Silurian limestones of Swedish origin are most numerous. The majority of them was recovered in gravel pits of the Rheine area in the 1970s–1990s by the amateur Reinhard Schäfer, who donated his extensive collection before his death. The fossils may well be considered Westphalian finds despite their allochthonous nature.

44.3.4 Fossils of the Westphalian Pleistocene

The autochthonous fauna of the Westphalian Pleistocene largely consists of mammals. Due to technological changes most of the museum specimens were found in the late nineteenth century. They come from two sources: open gravel pits and

Fig. 44.6 Partial skull of *Samokeros minotaurus* Solounias, 1981, holotype of an antelope from the Miocene (Mytilini Formation, Messinian) of Samos, Greece; size 52 × 32 cm

karst caves. The former is dominated by megaherbivores such as woolly rhino and mammoth (Fig. 44.7), the latter by relics of the cave bear. This part of the collection is arranged heterogeneously according to the differing scientific approaches: Whereas lowland material is sorted systematically, cave finds are separated according to their localities, thus mirroring the different taphonomic situation in bear caves and hyaena dens.

44.3.5 Fossils of the Westphalian Cretaceous

The Muensterland is more or less identical with the Westphalian Cretaceous Basin. This system therefore provides most of the fossils in the Geomuseum. Among them are Early Cretaceous dinosaurs (Fig. 44.8) as well as Late Cretaceous fishes, but the full array of invertebrates from foraminifera and sponges to bryozoans and

Fig. 44.7 The woolly mammoth (*Mammuthus primigenius* Blumenbach) excavated from Pleistocene (Weichselian) clay in Ahlen near Münster in 1910, preliminary mount of 2016 in the preparator's workshop (photo courtesy of Oliver Kunze, Stuttgart)

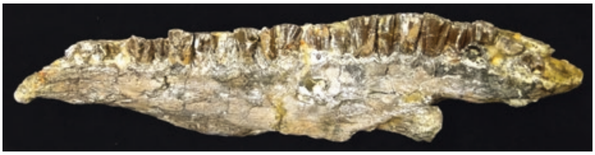

Fig. 44.8 Right lower jaw of *Iguanodon bernissartensis* Boulanger from the Early Cretaceous (Barremian) of Brilon-Nehden, Sauerland; size 30 × 6 cm

echinoids is represented as well. This part of the collection is arranged stratigraphically by stages at the top level, succeeding hierarchic levels being formed by biological systematics and locality.

44.3.6 Fossils of the Westphalian Ordovician to Neogene

The order of finds from the remaining parts of Earth history follow the same hierarchy as underlying the Cretaceous collection: Stratigraphic stage first, then systematics, geographic origin last. The mostly invertebrate material comprises Ordovician graptolites from an anticline in the Sauerland, the Devonian reef fauna, tree trunks and other floral remains from former coalmines, and cephalopods and bivalves from long abandoned clay pits in the Jurassic Wiehengebirge.

44.4 Research

Formerly, professors of the parent institute regularly published on the museum collections, resulting in an impressive list of reference material (Meiburg et al. 1968; Avlar 1991). Nowadays a single part-time curator is responsible for all duties circling around the collection and the museum. One person has to maintain the collections, produce exhibitions and cover all public activities from guided tours to Facebook postings. For this reason, there is no in-house research on the museum material. Scientists of the parent institute currently have different research interests; only their reference material thus becomes part of the collection. Student helpers engage in cataloguing but due to the strongly reduced volume of their training in the course of the Bologna process, both their knowledge and the time available usually do not suffice to perform a taxonomic thesis. As a result, the Geomuseum collections currently are research objects of exterior scientists (e.g., Dietze 2009; Hampe 2013; Danowitz et al. 2015) only.

44.5 Educational Work

The 1200 square metre permanent exhibition of the Geomuseum presents the most attractive specimens of the collections. The aim is to convey a state-of the-art overview of our current understanding of Earth processes. It thus consists of a largely geological to mineralogical part covering everything from the Big Bang and condensation of planetary matter to plate tectonics, ore deposits and crystal growth, and mainly palaeontological part highlighting steps in evolution as comprehensible in Westphalia.

About 500 square metres of the exhibition space are devoted to palaeontogical objects. They are grouped in the halls for the history of life on Earth, Carboniferous, Cretaceous, Pleistocene, cave deposits, and Holocene. This part of the exhibition fills the northern wing of the building, making it a rather comprehensive survey of regional Earth history. All fossils in the exhibition are originals, with epoxy resin additions in skeletal mounts clearly demarcated. Visitors thus should perceive the aura of “true” objects, with very little electronic distraction or pseudo-spectacular production of the exhibition.

At the time of going to press, the Geomuseum was still closed for a reconstruction of the building and a comprehensive re-design of all exhibitions. After its reopening, it will seek cooperation with all types of schools, aiming at becoming a regular learning location outside the classroom. In addition, freely bookable programmes are being developed for geoscience subjects relevant at various levels of education in the different school types. Individual visitors will be able to book or spontaneously attend tours through the museum guided by the curator.

For several years, the Geomuseum offers a series of public presentations by geologists talking about their travels. A wide audience hears about scientific impetus and logistic tasks as well as regional oddities this way. In addition, the museum has its Facebook account to spread news and it will receive an interactive website allowing visitors to plan and to echo their stay. For persons with deeper interest, the platform http://www.museum-digital.de/westfalen presents several hundred specimens from the collections including explanatory text.

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Chapter 45
NIERSTEIN: Paläontologisches Museum Nierstein

Lutz Kaecke

The privately established and run *Palaeontological Museum Nierstein* has its roots in the passion of Arnulf Stapf, who since the forties of the last century has made fossil excursions in the vicinity of his home town. The resulting palaeontological collection was first exhibited in just one room, provided by the town of Nierstein. Later almost the entire former town hall was filled with the exhibition (Fig. 45.1).

Over time, the museum which exists since 1973, has formed an extensive circle of supporters. Companies frequently provide materials for the museum, which is either free of charge or at a low price. Many collectors have proudly donated some of their best exhibits to the museum as well as provided evidence of new discoveries, and participated in the excavation activities of the museum. References to spe-

Fig. 45.1 The Nierstein Museum today

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cial findings were also made by employees of various quarries and sandpits, who were able to rely on a fast and professional recovery of fossils—without adversely affecting ongoing degradation.

The excavation activities of the Palaeontological Museum Nierstein span the whole of Europe from Scotland through Sweden, to the South of France. The museum's extensive collection is known to many scientists and is used intensively by international paleontologists. Correspondingly, many of the exhibits are characterized as typological examples or image originals. A special feature is the collection of large fossils, which were collected and prepared in the context and are also exhibited. This applies to invertebrates on clay from the Jurassic, as well as to tertiary vertebrate animals from the sand pits of the basin in Mainz or large-scale spilled living communities of Echinodermata.

Members of the museum are also involved in the development of rescue techniques, especially by the consolidation, securing and recovery of residential tubes in loose sands of the tertiary.

The precise execution of the excavation activities is documented in the large collection of small fossils, which, in addition to hundreds of Permian insects (Fig. 45.2), contains Branchiosaurs starting at the size of 4 mm.

Of the approximately 2000 exhibits in the permanent exhibition, most are shown in 50 showcases, many of which are on the walls of the exhibition rooms. The largest room contains a chronological summary with European fossils from the Cambrian to the Tertiary. In three further rooms visitors can view local finds from the Saar area as well as the basin of Mainz. The staircase and the anterooms are dedicated to spectacular individual objects such as large walls of life communities, tomb communities of vertebrate, colonies and geological plateaus. Exhibits and specimens that exceed the museum's capacities have been and still are often passed on to other museums. As an example, a plate with three Permian sharks of the genus *Orthacantus*, was prepared and exhibited by the *Naturhistorisches Museum Schleusingen*. The Paleontological Society nominated and announced this piece as fossil of the year in 2011.

Fig. 45.2 Fossil Ephemeroptera

The museum's strong internet presence also includes a professionally designed virtual tour, which conveys an optical impression of the collection rooms.

Guided tours are still offered by the founder of the museum, while preparation, collection activities and support of the archive are taken over by one of his sons. The approximately 250 members of the Association for the Promotion of the *Paleontological Museum Nierstein* provide a financial basis through their contributions, donations and practical help.

The special charm lies in the variety and exceptional quality of the fossils which are presented in a suitable ambience (Fig. 45.3).

Fig. 45.3 Visitors in front of a Tertiary sea cow from the Mainz basin

Chapter 46
SCHIFFWEILER (Landsweiler-Reden): Center for Biological Documentation (Zentrum für Biodokumention—ZfBS)

Edgar Müller

46.1 Geoscience Collections of the Center for Biological Documentation

Today, the geoscience collection in the Center for Biological Documentation combines two significant collections in this scientific field:

- The geological collection of the Deutsche Steinkohle AG (German Coal Inc.), and
- The geoscience collection of Saarland University

The Center for Biological Documentation has housed these two very extensive collections since March 2005. The consolidation created a collection which comprises specimens of regional geology, palaeontology and systematic mineralogy.

As the focus today is on establishing a "New Geoscience Collection", the specimens are being re-examined, re-registered, photographed, and categorized. Currently, the center is working on the most important part of the collection—"The Flora and Fauna of the Carboniferous"—which has achieved international recognition (Figs. 46.1–46.4).

Karl von Oeynhausen, a junior official at the mining supervisory authority, and his students already collected the first geological-mineralogical specimens for research and educational purposes from 1819 to1822.

The collection contains specimens which Dr. Karl Justus Andrä described in his 1860 publications on petrifications from the black coal mountain range in the state of Saarland.

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Fig. 46.1 *Cordaites palmaeformis* (leaf), Carboniferous, 45×15 cm

Fig. 46.2 *Ginkgophyllum mayus* (leaf), Itzenblitz mine, Carboniferous, 19×10 cm

Fig. 46.3 *Mariopteris nervosa* var. *hospitalis* (fern), Reden mine, Carboniferous, 19×4 cm

Fig. 46.4 *Saaropteris guthoerli* (fern), Heinitz mine, Carboniferous, 26×18 cm

However, the actual founder of the educational geological collection in Saarbrücken, in its present form, was Friedrich Goldenberg. He was one of the first scientists in the field of palaeontology to describe and assemble the teaching collection on a scientific basis. This can still be seen today in the many publications, accurate descriptions, and the resultant extensive teaching collection.

Of equal importance for the palaeontology of the Saarland carboniferous are the publications by Dr. Christian Weiß Dr. Ch. Ernst Weiss on the fossil floras of the Saarland Carboniferous and Permian, which were published only a few years later. In expanding the collection he provided the foundation for a stratigraphic classification of the Saarland carboniferous.

One of the most important and best-known exhibits is the find of a giant millipede (*Arthropleura armata*, Fig. 46.5). With a total length of approx. 95 cm and a width of approx. 30 cm this is the biggest body part of an *Arthropleura armata* which has ever been found in one piece. The original ("Fossil of the Year 2015") is on display in the "Geology of the Region" exhibition in Landsweiler-Reden.

Fig. 46.5 *Arthropleura armata* (part of carapace and leg), Maybach mine, Carboniferous, Westfal C, 23×15 cm

Important publications and papers on arthropods from the Saarland carboniferous were written by Moritz Kliver, coal mine surveyor at the Mining Authority (Oberbergamts-Markscheider). The specimens described at that time were for the most part included in the teaching collection.

At the beginning of WWII (1939) the collection was so comprehensive that it fulfilled all scientific needs in the fields of practical geology and, especially, mining geology, far beyond the scope of a teaching collection. Even in those days, scientists from all over Germany came to see the collection.

The present geoscience collection of the state of Saarland with its wide range of specimens is one of the most comprehensive collections in this field in South West Germany, and it has the most complete collection of finds from the black coal mountain range of Saarland (Figs. 46.6 and 46.7).

46.2 The Saarland University Geoscience Collection

The Saarland University geoscience collection had its beginnings in 1989–1992, when the geological collection was merged with the collection of the Mineralogical Institute. In the first few months of 2003, the collection, which comprises regional geology, palaeontology, systematic mineralogy and petrography as well as a number of special exhibitions, was transferred to a renovated building belonging to the former *Grube Reden* coal mine.

The geological collection was founded in 1950 by Prof. Dr. Nicolas Theobald. From 1953 to 1978 Prof. Dr. Fridolin Firtion and his assistants were in charge of the collection, and after that the task was continued by Prof. Dr. Horst Schneider and Prof. Dr. Erich Schneider (until 1982). It was managed by Kurt Schroeder.

Fig. 46.6 Main building of the former Reden mine, hosting today, among others, the center for Biological Documentation

Fig. 46.7 View on a part of the carboniferous exhibition ("Geology of the region")

In 1956, the mineralogical collection was assembled when a professorship in mineralogy was established at the university. At first Prof. Dr. Franz Rost was in charge of the mineralogical collection, and after his retirement in 1979 Prof. Dr. Günter Lensch und Dr. Arne Mihm took over. After the merger and following the retirement of the above-mentioned professors during the years 1993 to 1995, Dr. Mihm was solely in charge.

Initially, both collections were housed in the same building, but the mineralogical collection became independent in 1961, when the Department of Mineralogy was relocated to a new building.

Both collections enjoyed considerable growth until the late 1970s. After the discontinuation in 1984 of the departments of geology and mineralogy, a new Department of Applied Geochemistry was formed (which was itself closed in 1994) and the collections were consolidated and installed in the basement of the university cafeteria building (on about one third of the collection's original area). The official reopening took place in 1992.

The collection is divided into four main sections, but also includes a number of special areas and individual exhibits. It is a systematic teaching collection, not a museum set up for educational purposes. The drawers under the display cabinets contain many more specimens than are possible to exhibit.

The Department of Geology contributed an extensive palaeontological collection as well as a comprehensive collection showing the regional geology of the federal state of Saarland. The Department of Mineralogy contributed a detailed collection of systematic mineralogy und systematic petrography with a focus on (rock) metamorphosis and ultrabasic rocks. There are also special exhibitions (amongst others on mineral finds in the region, on technical mineralogy and technical petrography), as well as an incomplete collection for mineral economics.

Some complete private collections and most of the fossils and mineral finds were acquired by purchase; the rest, including the majority of rock samples, were collected during scientific field trips. In addition, French universities donated a number of specimens when the Geological Institute was founded.

Regional geology plays a major role among all natural conditions of a region, second only to the climate. It determines relief and natural resources and is significant for the local environment as well as agriculture, water management, and forestry. The corresponding part of the collection and the geological relief map contribute a great deal to understanding this relationship. Beyond the borders of the Saarland, the collection with its various subsections is of great significance due to the specimens which cannot be found anywhere else or which come from sources no longer accessible today.

The good location and the regular opening hours guarantee an effective use of the collection. A further improvement would be the enhancement of the educational content and the pedagogical design of the museum. Moreover, new digital cataloguing and a website would be helpful.

Chapter 47
SCHLEUSINGEN: Naturhistorisches Museum Schloss Bertholdsburg Schleusingen (Thuringia, Germany)—Home of Permian and Triassic Fossils

Ralf Werneburg

47.1 General Information

The Naturhistorisches Museum Schloss Bertholdsburg was founded in 1984 as the Museum of Natural Sciences in Southern Thuringia. Therefore, nearly all geological (inclusively paleontological) and biological collections of Southern Thuringia are housed in the castle Bertholdsburg since 1988 (Fig. 47.1). The unique exception is the paleontological collection of Rühle von Lilienstern from Bedheim in the Museum für Naturkunde Berlin since 1969.

The museum has three large exhibitions in the castle Bertholdsburg on an area of about 2000 m^2:

– Minerals—Captivation in Shape and Color
– 300 Million Years Thuringia
– History of the Hennebergian Earls and of its Metropolis Schleusingen.

The paleontological exhibition was opened in 2001 and exposed ca. 1000 fossils from the Upper Carboniferous, Permian, Triassic, Neogene and Quaternary of Thuringia. Many dioramas introduce into the earth history using about 100 different reconstruction models of animals and plants (Figs. 47.2, 47.3, 47.4 and 47.5).

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Fig. 47.1 The Naturhistorisches Museum with the paleontological collection is housed in the castle Bertholdsburg in Schleusingen, South Thuringia

47.2 Historical Background of Collection

The history of the collection is highly diverse now (Böhme 1967; Werneburg 2002; Werneburg and Schmidt 2006; Werneburg et al. 2009). The geological collections come from museums in Meiningen, Schmalkalden, Eisfeld, Hildburghausen, Sonneberg, Suhl and Schleusingen. The oldest part of collection with fossils and minerals is 300 years old and goes back to the Dukes of Meiningen. Here some interesting occasions follow in the context to the paleontological collection:

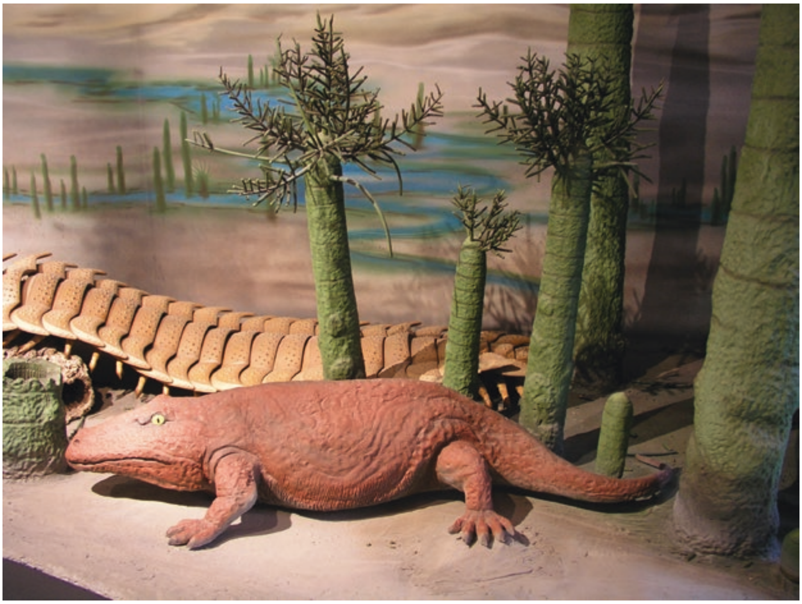

Fig. 47.2 In the exhibition "300 Million Years Thuringia": The 1.5 m large eryopid *Onchiodon* in the fluvial landscape of the Lower Permian Rotliegend together with the giant arthropod *Arthropleura* and the trees of *Calamites gigas*

Fig. 47.3 In the exhibition "300 Million Years Thuringia": The 3 m enlarged sauropterygian *Nothosaurus* in the Middle Triassic Muschelkalk-Sea

Fig. 47.4 In the exhibition “300 Million Years Thuringia”: The ‘Dinosaur hall’ with two dinosaur skeletons from the Upper Triassic Middle Keuper of Southern Thuringia: a plateosaurid and a theropod (*Liliensternus*) together with models of their descendants *Tyrannosaurus rex* and *Deinonychus*

Fig. 47.5 A large slab with three tetrapod footprint-tracks of *Chirotherium barthii* together with desiccation cracks from the Lower Triassic Bunter of Heßberg near Hildburghausen. It was bought by the Duke of Meiningen in 1837 (photo: H. Haubold)

47.2.1 Herzogliches Naturalienkabinett Meiningen

- 1706 First fossils and minerals from Duke Ernst Ludwig
- 1726 16 specimens of the famous "Würzburger Lügensteine" (porky-stones) were bought by Duke Anton Ulrich. In 1726, Professor J.B.A. Beringer described it in his monography "Lithographiae Wirceburgenis". This suite of porky-stones is the largest one outside of Bavaria; Schmidt and Werneburg 1994).
- 1798 Skeletal remains of the cave bear *Ursus spelaeus* from the Altenstein cave
- 1837 Acquisition of some slabs with footprints of *Chirotherium barthii* (Buntsandstein of Heßberg near Hildburghausen, Fig. 47.5; Haubold 2006; Werneburg 2012b).

47.2.2 Realschule Meiningen (1838–1917)

- Many fossils from H.F. Emmrich, H. Pröscholdt, J. Heim (plants of Lunz), W. Frantzen and H. Brehm.

47.2.3 Staatliche Museen Meiningen (1946–1980)

- Mastodont teeth and skeleton from Southern Thuringia by M. Lang, F. Schaarschmidt and G. Böhme (Fig. 47.6)
- Fossils from B. Hergt and W. Soergel (*Chirotherium barthii*) in exchange with the Museum für Ur- und Frühgeschichte Weimar
- Conchostracans from the Buntsandstein of Thuringia by H. Kozur.

47.2.4 Museum Schloss Wilhelmsburg Schmalkalden

- 1875 Important fossils from the Verein für Hennebergische Geschichte und Landeskunde Schmalkalden (Permian)
- 1973/74 Acquisition of one of the best European collections of Rotliegend-fossils, especially from the Thuringian Forest—the A. Arnhardt-collection with more than 100 originals and types.

47.2.5 Naturhistorisches Museum Schloss Bertholdsburg Schleusingen

- 1934 Exhibition "Geologisches FRANKE-Museum—das Heimatmuseum für Urgeschichte im Schloss Bertholdsburg Schleusingen" with fossils from H. Franke and P. Georgi (especially Permian and Triassic)

- 1957 Acquisition of the remaining fossil collection from P. Georgi (especially Permian and Triassic)
- 1987 ff. Fossils of Thuringia, and an important special suite of tetrapods from Carboniferous, Permian and Triassic of Thuringia and other regions by R. Werneburg
- 2001 Exhibition “300 Million Years Thuringia” with about 1000 fossils
- 2003 ff. Collection of important fossils from the Rotliegend of the Thuringian Forest by A. Amelang.

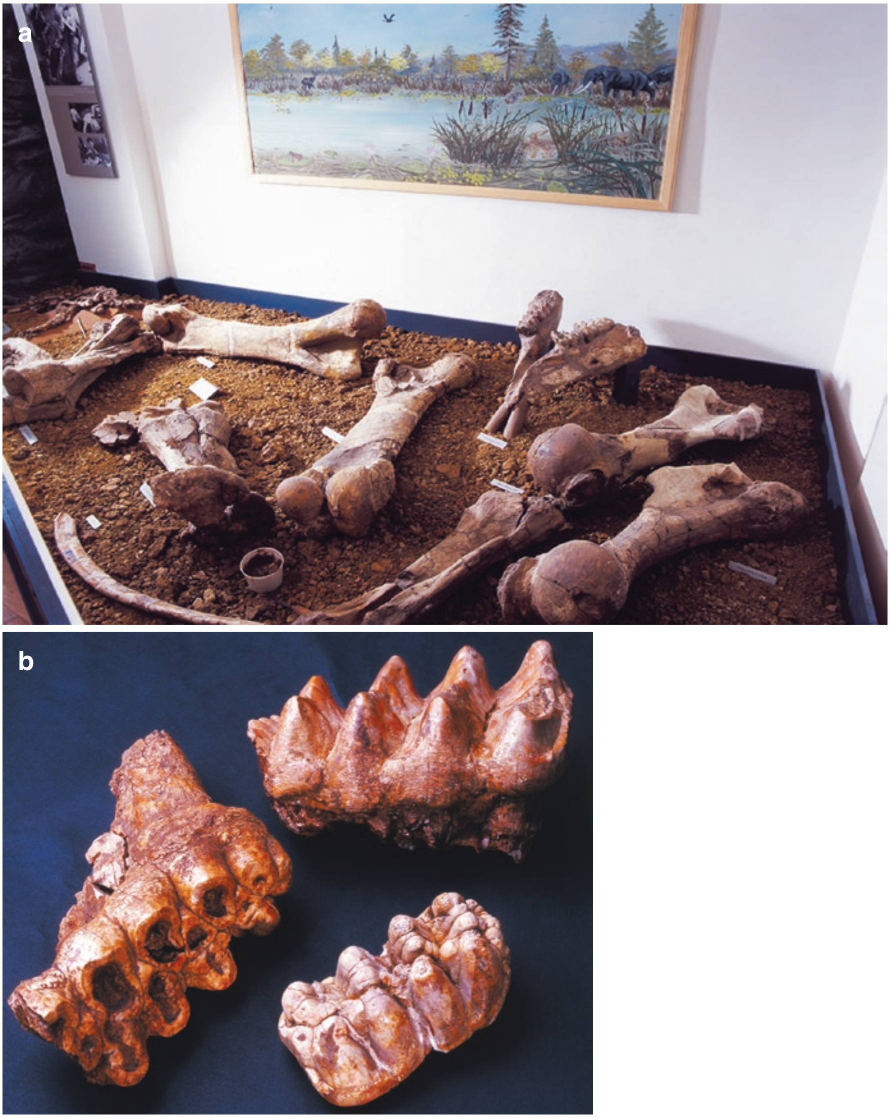

Fig. 47.6 Skeleton and teeth of the mastodontid elephants *'Mammut' borsoni* and *Anancus avernensis* from the Upper Pliocene of Kaltensundheim and Sülzfeld near Meiningen, SW-Thuringia

47.3 Collection

Today the palaeontological collection consists of ca. 35,000 items and is focused primarily on fossil material of the Permian with 20,000 specimens and of the Triassic with 5000 items. About 30 type specimens and ca. 400 figure-originals were published in about 80 papers.

Most important fossils are arranged in the permanent exhibition "300 Million Years Thuringia" (Werneburg 2003). The 1000 fossils are distributed to the following thematic sections:

47.3.1 Lower Permian

– *Rotliegend-Lake* with palaeoniscides, xenacanthid sharks, diverse branchiosaurids (Fig. 47.7) and temnospondyls, triopsids, conchostracans, insects, algae, stromatolithes, pteridosperms (Fig. 47.8) and conifers

Fig. 47.7 The skeleton of the branchiosaurid *Apateon dracyi* (10 cm in length) from the Lower Permian Rotliegend of Tabarz (Cabarz) in the Thuringian Forest

Fig. 47.8 A leaf of the pteridosperm *Dichophyllum flabellifera* (20 cm in length) from the Lower Permian Rotliegend of Tabarz (Cabarz) in the Thuringian Forest (photo: M. Barthel)

– *Rotliegend-Fluvial landscape* with large calamites and silicified trunks of conifers, an eryopid (Fig. 47.9) and a pelycosaur, the giant arthropod *Arthropleura* as well as diverse footprints of tetrapods
– *Rotliegend-Forest* with tree ferns, calamites, cordaites and small arthropods

47.3.2 Upper Permian

– *Zechstein-Sea* with palaeoniscides, hybodont sharks, coelacanthids, petalodontids, protorosaur, weigeltisaur, pteridosperms, ginkgophytes and conifers; reef algae and many invertebates

Fig. 47.9 The skull of the eryopid *Onchiodon thuringiensis* (holotype, 30 cm in length) from the Lower Permian Rotliegend of Manebach in the Thuringian Forest

47.3.3 Lower Triassic

– *Buntsandstein-Fluvial landscape* with footprints of diverse tetrapods, especially archosauromorphs (*Chirotherium* etc.), and a trematosaur
– *Buntsandstein-Sea* with pelecypodes, beneckeians, trace fossils

47.3.4 Middle Triassic

– *Muschelkalk-Sea* with diverse pelecypodes, snails, brachiopods, crinoids, beneckeians, ceratites, nautilids, palaeoniscides, hybodont sharks, coelacanthids, cymatosaur (Fig. 47.10), nothosaurs, tetrapod footprints and trace fossils
– *Lower Keuper-Lake and Coast* with large mastodonsaurs, plagiosaurs, palaeoniscides, hybodont sharks, coelacanthids, dipnoans, triopsids, conchostracans, and diverse plants
– *Lower Keuper-Sea* (Grenzdolomit) with diverse pelecypodes, snails, ceratites, a nautilid (Fig. 47.11) and nothosaurs

Fig. 47.10 The skull of the marine cymatosaur *Cymatosaurus minor* (holotype, 10 cm in length) from the Middle Triassic Lower Muschelkalk of Hetschburg near Bad Berka

Fig. 47.11 The nautilid *Germanonautilus bidorsatus* from the Middle Triassic Lower Keuper (Grenzdolomit) of Apolda

47.3.5 Upper Triassic

– *Middle Keuper-Fluvial landscape* with footprints of diverse tetrapods, especially archosauromorphs and dinosaurs, skeletal reconstructions of the dinosaurs *Liliensternus* and *Plateosaurus* together with some original bones of *Liliensternus* and *Ruehleia* (loan of Berlin Museum), conifers and trace fossils

47.3.6 Neogene

– *Miocene-Maar Lake* with osteichthiens, a frog, a bat, beetles and plants.
– *Pliocene-Doline Lake* with a skeleton and teeth of mastodontid elephants (Fig. 47.6) and a skeleton of a juvenile cervid

47.3.7 Quaternary

– *Pleistocene-Continental landscape* with characteristic animals and plants of glacial and interglacial periods.

A 290 million years old slab of 3 m in height shows three large xenacanthid shark skeletons from the Rotliegend of Niederkirchen in the Saar-Nahe basin (Fig. 47.12; Werneburg 2011, 2012a). They belong to *Orthacanthus (Lebachacanthus) senckenbergianus* (=*Lebachacanthus colosseus* after Heidtke 2007). The largest skeleton has a length of 2.15 m. The geoscience preparator of the Schleusingian Museum needed 1.5 years to prepare this unique fossil plate (Fig. 47.13; Werneburg and Sommer 2008). It was the 'FOSSIL OF THE YEAR 2011' in Germany and a highlight of the exhibition!

Fig. 47.12 The 3 m elongated slab with three large skeletons of the xenacanthid shark *Orthacanthus (Lebachacanthus) senckenbergianus* from the Lower Permian Rotliegend of Niederkirchen in the Saar-Nahe basin ('FOSSIL OF THE YEAR 2011' in Germany)

Fig. 47.13 Mechanical preparation of the large skeleton of the xenacanthid shark *Orthacanthus (Lebachacanthus) senckenbergianus* from the Lower Permian Rotliegend of Niederkirchen in the Saar-Nahe basin

The main part of the paleontological collection is housed in the late Romanesque arches of the castle depots. The collections with fossils of all periods, which formerly stayed in the museums of Meiningen, and of Schmalkalden, as well as of Schleusingen are important. Some fossils were lost in the Meiningen collection during World War II.

Special significance for Germany and Europe have the following three suites:

– *A*rnhardt- *and A*melang-*Collections of Rotliegend-Fossils from the Thuringian Forest, Germany*

  The collection of Alfred ARNHARDT (1888–1973) from Schmalkalden is very famous and includes 6662 fossils. Fourteen types are included and seven species plus genera are named after Arnhardt.

  Andree AMELANG (1963 ff.) from Stützerbach near Ilmenau collected in the sense of Arnhardt about 6000 fossils from more than 100 different finding locations.

  Both collections parts have more than 100 figure originals in about 30 papers.

– *T*etrapods from the *C*arboniferous*, P*ermian and *T*riassic

  This collection included about 6000 specimens, which belong mostly to the 'amphibians'. In 1987 Ralf WERNEBURG (1958 ff.) from the Schleusingen

Fig. 47.14 Source of research: 413 skeletons of the branchiosaurid *Apateon dracyi* with skin preservation from the Lower Permian Rotliegend of Tabarz (Cabarz) in the Thuringian Forest

Museum started with this special suite. About 10 types and 140 figure originals from more than 40 papers are part of this collection with ca. 100 different species. Ca. 5000 specimens are from the Lower Permian Rotliegend of the Thuringian Forest. The branchiosaurids are very common; some times more than hundred skeletons are on one slab (Fig. 47.14). Very famous is the large eryopid skeleton from Manebach with a massive skull of 30 cm in length (Fig. 47.9). Many stereospondyl bones from the Middle Triassic Lower Keuper of Thuringia are included in the suite too.

– *P*aleozoic *I*nsects of the *T*huringian *F*orest, *G*ermany

This suite consists of more than 1500 insect remains mainly from the Permian of two famous fossil Lagerstaetten in Tabarz (Cabarz) and Sperbersbach. It is one of the largest collections of Paleozoic insects in Europe. This special collection was established by Andree Amelang (1963 ff.) from Stützerbach, Stephan Brauner (1976 ff.) from Gotha and Jörg W. Schneider (1948 ff.) from Freiberg in the last 15 years. Most insect remains belong to the blattoid cockroaches, but different other groups are traceable.

47.4 Facilities

One full-time paleontologist and one geoscience preparator are employed at the Naturhistorisches Museum Schloss Bertholdsburg Schleusingen and cover all duties from management to exhibition and education. The facility includes a main storage in two large Romanesque Arch Halls with a cabinet system and a work-table with a binocular microscope. The museum has laboratories for rock fragmentation, mechanical fossil preparation, and chemical processing. The castle Bertholdsburg (Fig. 47.1) comprises 850 m^2 of paleontological exhibition space (Figs. 47.2, 47.3 and 47.4), several technical rooms, two offices, a library, and a conference room. The Landkreis Hildburghausen as county administration covers operating costs.

47.5 Research

The scientific investigations are focused on tetrapods from Carboniferous, Permian and Triassic. The main interest is in force to the dissorophoid and temnospondyl amphibians reaching from Germany to Sardinia and from New Mexico up to Siberia (e.g., Werneburg 2007, 2009, 2012c; Werneburg et al. 2010, 2013; Werneburg and Berman 2012). Active research partnerships exist with many institutions in Austria, Canada, Czech Republic, China, France, Germany, Italy, Morocco, Russia, and the U.S.A. For 20 years, the museum staff excavated many lake deposits as Lagerstaette in the Lower Permian Rotliegend of the Thuringian Forest together with the TU Bergakademie Freiberg. This is the source for collection and investigation. The German Science Foundation supported some research projects of the museum (2002–2015).

47.6 Educational Work

Most educational work is done in the exhibition "300 Million Years Thuringia". There are various programs for better understanding the content of exhibition, e.g. guided tours.

Regular educational activities also include geological field trips and thematic talks. The museum staff supervises several student apprentices from schools every year. Volunteer assistants accompany scientific excavations of our museum.

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Chapter 48
SIEGSDORF: The Siegsdorf Natural History and Mammoth Museum

Robert Darga

48.1 The Museum

When the skeleton of a mammoth was dug up at Siegsdorf, Bavaria, in 1985, the local municipality, which was responsible for the excavation, came up with the idea of building a “mammoth museum”. For practical reasons, the geology and the paleontology of southeastern Bavaria were added to the concept by and by. These topics resulted—amongst others—in the plan for the visitor guidance line. The visit begins in the museum square, where the time span from the earth formation to today is represented by an approximately 30 m long slab track. The most important events in the history of the earth are indicated on brass tags embedded in the stones. The track leads to a column in front of the entrance, the lower part of which is paneled with natural stone. It represents the period of the landscape development of southeast Bavaria from 250 million years b.p. to the present day (Fig. 48.1).

48.2 Geology

The development of the plate tectonics and their traces in the region are the core points of the geology department in the basement of the museum.

During the last 250 million years, the Alps formed, the great continent Pangaea broke apart, and new oceans (and seas) developed. The sediments of the former seafloors petrified and became rocks of the Alps and the Alpine foreland. A large part of these deposits which were formed during the Alpine development in the

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Fig. 48.1 The exterior view of the Siegsdorf Museum

area of south-east Bavaria, are fitted stratigraphically into the “Stone Wall”, a representative compilation of more than eighty important rocks from the region (Fig. 48.2).

48.3 Paleontology

The ground floor shows a variety of fossils which originate from the petrified sea floors mentioned above. The famous fossil sites of the Kressenberg near Neukirchen on the motorway Munich—Salzburg, and the incredibly rich fossiliferous sediments of Bad Adelholzen near Siegsdorf are brought back to life by means of dioramas. The presentation of the individual fossil groups is sorted by a simplified botanical and zoological system from lower to higher developed forms. The fossil groups are e.g. corals, gastropods, bivalves, cephalopods, echinoderms, arthropods, and of course vertebrates. Among the plant fossils, the amber finds from various geological ages and the Neogene leaf flora of Aubenham near Waldkraiburg are particularly noticeable.

Fig. 48.2 The stone wall in the basement

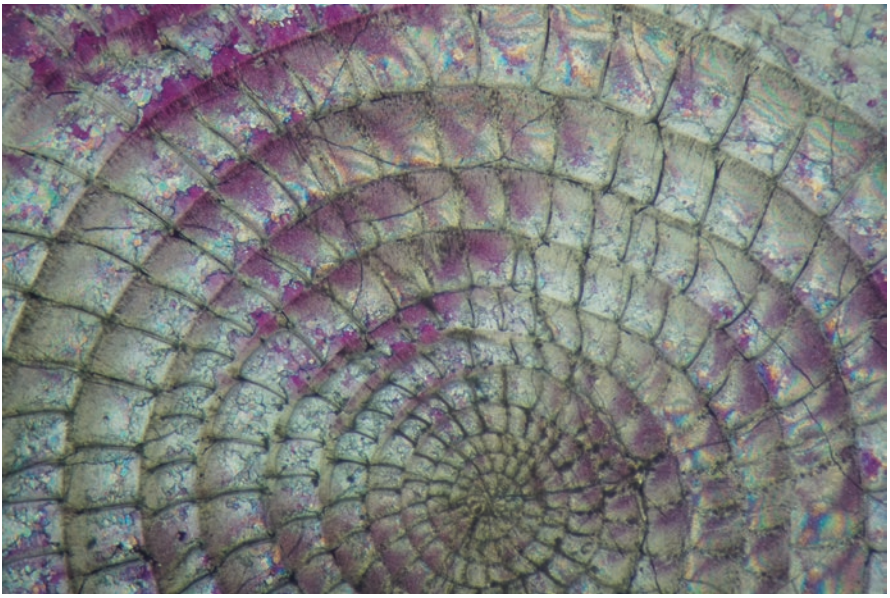

Fig. 48.3 Thin section of the foraminifera Assilina exponens under crossed nicols. Long side of the cutout approx. 9 mm

The surroundings of Siegsdorf are remarkably rich in huge single cell skeletons, which can reach sizes of up to 6 cm (Fig. 48.3). Also notable are the remains of a duckbill dinosaur, the first Dinosaur from the German Alps. The skull of the proboscidean *Gomphotherium*, generally known as the Mühldorf Elephant, leads to the third division, the Ice Age.

48.4 Ice and Stone Age

The first floor is dominated by the completed and mounted cast of the Siegsdorf mammoth skeleton (Fig. 48.4). The original bones are displayed on the opposite wall.

A comparatively complete skeleton of a cave lion was retrieved from the same excavation. Some of the lion bones show cutting marks which indicate that humans also were present at the approximately 45,000-year-old Siegsdorf mammoth site. In addition, the place also provided the remains of woolly-haired rhinoceroses, of giant deer, steppe bison and wolf, with numerous Hyena bite marks.

A nine square meter measuring model shows how the Chiemgau landscape looked like at the end of the last ice age with the retreating glaciers. Findings of cave bears in Chiemgau and nearby Austria inspired the construction of an accessible bear cave which covers aspects of speleology and paleontology.

Fig. 48.4 The supplemented cast of the Siegsdorf mammoth skeleton with a shoulder height of 3.60 m

The conclusion of the museum tour are the findings of Stone Age tools, which document the post-ice age settlement by humans between the rivers Inn and Salzach in the northern Alpine foothills.

The Stone Age Garden located next to the museum is open during the summer season. It completes the exhibition by inviting the visitors to put hands and mind on Stone Age material to experience the way of living of our Stone Age ancestors.

48.5 Collection

The number of specimens is approximately 10,000. Focal points are geology, paleontology, quaternary fauna and glaciers as well as the Stone Age of Southeast Bavaria and the neighbouring parts of Austria.

48.6 Research

The museum director is a qualified geologist and paleontologist. Areas of research are: Regional Cenozoic profiles, Quaternary phenomenons, Anthropocene.

Cooperations exist with the Bavarian State Collection for Paleontology and Geology, and with the University of Bremen.

48.7 Educational Work

Lectures and field trips in adult education and further education for teachers, imparting basic knowledge mainly in geology and palaeontology with accentuation of an interdisciplinary context.

Annual special exhibitions primarily on geological or palaeontological topics.

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Chapter 49
ST. GALLEN: Naturmuseum St. Gallen

Toni Bürgin

The St. Gallen museum of Nature, Switzerland, was founded in 1846. Its oldest specimen is a stuffed Nile crocodile, donated to the city of St. Gallen in 1623 and exhibited in the former boys monastery Saint Kathrin. The main part of the actual collection was assembled in the nineteenth century by members of the St. Gallen society of natural sciences, founded in 1819. The entire collection consists of about 300,000 specimens, one third of them being pressed and mounted plants in the herbarium. The paleontological collection holds about 25,000 specimens. The main focus here is on the fossils of cantons St. Gallen, Appenzell Innerrhoden and Appenzell Ausserrhoden.

The paleontological collection is stored in the new building that opened its doors in November 2016. The most important objects are on display in the permanent exhibition. These include an almost complete skeleton of an *Edmontosaurus regalis* from the late Cretaceous of Wyoming, USA, as well as some large ammonites from the Cretaceous of the Alpstein. Further important specimens are shark vertebrae from the Late Cretaceous of the Churfirsten und the skulls of two rhinoceroses from the local Aquitanian.

The paleontological collection is housed in a section of the earth history collection room. The specimens are stored in metal drawers. Their data are stored in a self-configured File Maker data base. There is neither a special laboratory nor a paleontological preparation room in the museum. The financial support is provided almost completely by the city of St. Gallen.

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49.1 Research

Actual research is focused on regional fossils from the Cretaceous, Paleogene and Neogene. Examples are shark vertebrae and ammonites from the cretaceous, as well as rhino skulls from the Aquitanien. Since most of the specimens are from old collections, there is a problem with the correct scientific names and their synonyms. Presently there is an project to publish a book and to show an exhibition on the local fossils, which will clarify many of these problems.

There are scientific cooperations with the universities of Zürich (Dr. Christian Klug) and Neuchâtel (Dr. Damian Becker), as well as with the private collectors Dr. Peter Kürsteiner (www.geo-alpstein.ch) and Urs Oberli, St. Gallen. Results of these cooperations are several publications in scientific journals and local news papers (Figs. 49.1, 49.2, 49.3 and 49.4).

49.2 Educational Work

The permanent exhibition showing fossils is entitled “Leben im Wandel” (changes in the history of life) and arranged as a kind of a tripartite cat walk. The first part is devoted to the beginning of the universe, the earth and the moon. It shows with a

Fig. 49.1 Permanent exhibition, “changes in the history of life”, in the new St.Gallen museum of nature

Fig. 49.2 Large ammonite, *Ermericiceras* sp., fossil and life-size reconstruction by Beat Scheffold

Fig. 49.3 Shark vertebrae, *Cretoxyrhina* sp., from the Late Cretaceous of the Churfirsten mountains

few, well chosen objects, some of the main stations of life in the Paleozoic. The second part exhibits the reign of the dinosaurs, ichthyosaurs and pterosaurs. The third part shows fossils from the Paleogene and Neogene, as well as a sample of recent vertebrates.

Fig. 49.4 Rhinoceros skull, *Diaceraterium* sp., from the Aquitanian of Bühler AR

Schools are one of the primary targets in visitor policies. They build up about one third of the approximate 40,000 annual visitors. The visits of school classes are supported by the museums educational staff as well as special handouts on various topics.

Facebook is used to announce special findings and results of scientific studies.

Chapter 50
Staatliches Museum für Naturkunde Stuttgart (SMNS)

Rainer Schoch and Johanna Kovar-Eder

50.1 Four Centuries of Collecting—In Württemberg and the World

The beginnings of collecting in Württemberg date back to the late sixteenth century. Then forming part of the art collection of the Duke of Württemberg, early natural history specimens include the huge antlers of the extinct deer *Megaloceros* on which the year 1600 was marked. By 1791, the first natural history collection was founded and became its own institution, the 'Naturalienkabinett'. By that time, the collections already encompassed more than 10,000 specimens. In the twentieth century, the formerly royal institution became the Staatliches Museum für Naturkunde Stuttgart. Throughout its history, regional geology and palaeontology have formed the major focus of collecting and research, although expeditions to various other countries yielded valuable additional material.

Specimens from southern German *fossillagerstätten* form the bulk of the material, which includes Muschelkalk and Keuper deposits (e.g., large amphibians, marine reptiles, early dinosaurs, and the most ancient turtles), but also invertebrates from the Alpine region (Dolomites). Valuable historic collections, such as many originals and types of von Alberti's and Quenstedt's works. Jurassic collections include the Posidonia Shale from the Holzmaden region (among them complete belemnite animals and several hundred skeletons of marine reptiles), as well as numerous Middle Jurassic ammonites, the rich Late Jurassic Nusplingen fauna and coral reefs from the eastern Swabian Alb (Figs. 50.1, 50.2, and 50.3). The Nusplingen collection alone preserves some 400 species, ranging from terrestrial plants, insects, crustaceans and fishes to marine crocodiles. Highly relevant for Jurassic stratigraphy in the nineteenth century, the ammonite collections continue to be of importance

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Fig. 50.1 The early dinosaur *Plateosaurus* from Trossingen, Middle Keuper, Upper Triassic

Fig. 50.2 Ichthyosaur *Stenopterygius*, with original skin preservation, Posidonia Shale of Holzmaden, Lower Jurassic

Fig. 50.3 Complete belemnite *Passaloteuthis bisulcata* with soft-part preservation, Posidonia Shale of Holzmaden, Lower Jurassic. Length 25 cm

Fig. 50.4 Shark *Pseudorhina acanthoderma* from the Nusplingen Plattenkalk. Upper Jurassic, Length 113 cm

for the study of high-resolution stratigraphy and ammonite evolution. Paleogene and Neogene collections encompass mollusks, insects, plants, and land mammals, from rich *fossillagerstätten* at Steinheim am Albuch, Ulm, Langenau, Randeck Maar, and Rauenberg (Frauenweiler). Quarternary finds encompass mammoths, cave bears, and the famous Reilingen and Steinheim human skulls, representing early relatives of neanderthals (Figs. 50.4, 50.5, 50.6, 50.7, and 50.8). A famous lagerstaette forms the travertine of Cannstatt.

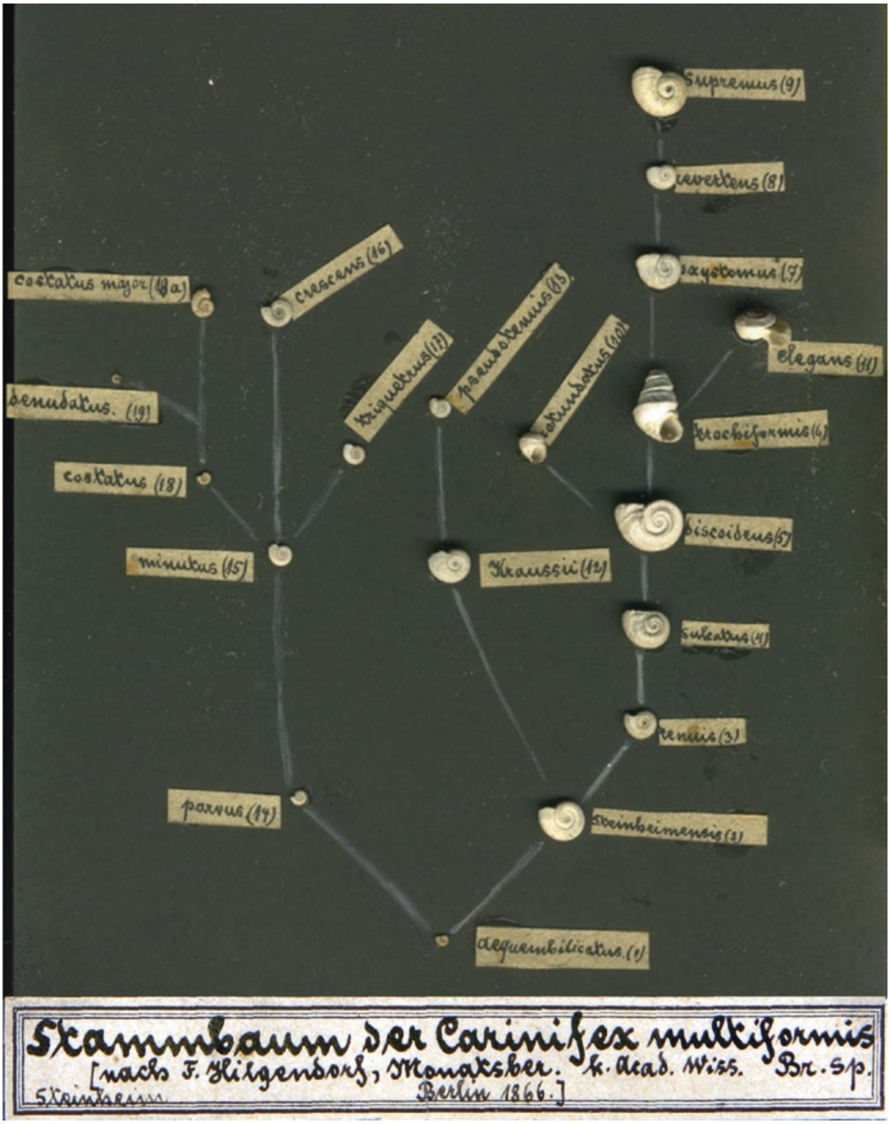

Fig. 50.5 Historically first phylogenetic tree, drawn by Hilgendorf in 1860, depicting the micro-evolution of freshwater snails in Steinheim am Albuch

Today, the plant collection encompasses 1500 types and originals, the fishes 40,000 specimens, and there are more than 100,000 remains of amphibians and reptiles as well as 160,000 mammal specimens. Among the invertebrates, the largest part of the collection includes about one million fossils from the Jurassic alone, and a further 40,000 Palaeozoic, 120,000 Triassic, and 250,000 Cenozoic invertebrates. Since the 1960s, the SMNS has acquired a large amber insect collection (30,000

Fig. 50.6 *Chaneya oeningensis*, a pentamerous flower-like fruit from the Miocene of Steinheim am Albuch

Fig. 50.7 Skull of proto-neanderthal *Homo steinheimensis*, ~250,000 year, Steinheim an der Murr

specimens) from Baltic and Lebanese localities, later supplemented by Dominican material and amber from Burma. Most recently, the SMNS acquired the probably most important private collection from the Early Triassic, the collection Louis

Fig. 50.8 Cave bear family *Ursus spelaeus* in its cave on the Swabian Alb

Grauvogel. The historical collections from abroad include Late Jurassic dinosaurs from Tanzania, Paleogene whales from Egypt (Fayum) and Neogene collections from badlands in the North American mid-west, Greece, and Peru.

50.2 Present Infrastructure of Collection

In its present state, the SMNS encompasses a well-equipped palaeontology department with seven curators and ten technicians. Facilities include an SEM microscope, a CT scanner, photo automontage system, and a laboratory for each technician. The curators cover (1) mammals, (2) terrestrial tetrapods, (3) aquatic tetrapods and fishes, (4) amber insects, (5) Cenozoic invertebrates, (6) Mesozoic invertebrates, and (7) plants. The technicians are specialized in particular fields as well (e.g., invertebrates, vertebrates, plants, excavations, exhibitions).

The collection of fossil plants is organized primarilly stratgraphically, followed by regions. A large portion of the collection is registered in an inventory database, which will be made accessible online in due course. Types and originals are already accessible online via the portal http://www.dbsmns.naturkundemuseum-bw.de/.

50.3 Research

Research is mostly specimen-based, conducted primarily on the basis of the vast collections. Publication in high-ranking international journals is given priority. This is carried out by curators and short-time researchers, as well as numerous visitors from all around the world. An increasing number of researchers from the United States, South America, and many European countries worked in the department during the last decade, which includes DAAD and Humboldt grants as well as awards.

Major excavation programs in the Triassic, Jurassic, and Neogene continue to yield thousands of specimens annually, which form important foci for research, embracing taxonomic, phylogenetic, palaeoecologic, and taphonomic studies. The formation of *fossillagerstätten* forms the most important department-wide research program. Further fields of research encompass (1) Paleogene/Neogene plant taxonomy and vegetation history, (2) palaeoclimate and palaeoecophysiology of Paleogene/Neogene plants, (3) Jurassic ammonites, crustaceans and stratigraphy, (4) Permo-Triassic tetrapods and the evolution of amphibians, (5) Mesozoic marine reptiles, (6) Cenozoic gastropods (7) Neogene mammals, and (8) amber insects.

The SMNS issues its own scientific open access journal, *Palaeodiversity*, the successor of Stuttgarter Beiträge zur Naturkunde (Serie B).

50.4 Outreach and Didactic Conception

The palaeontological exhibitions of the SMNS are housed in their own building, the 'Museum am Löwentor', which covers 3500 m^2 display area and was completed in 1985. The up to 14 m tall building contains a single exhibition room. It focuses on the development of life mainly based on regional palaeontology; since 2007 the permanent exhibition is renewed stepwise. The "Tertiary" is the last part to be finished in 2020. Highlights are dioramas (mainly in natural size) and excavation scenes which have been successively added to the existing display cabinets. The dioramas represent the most important *fossillagerstätten* in Baden-Württemberg (Buntsandstein, Muschelkalk, Keuper, Posidonia Shale, Upper Jurassic, Neogene, and Quaternary); they contain numerous models of animals and plants.

Four permanent outreach staff and a further six freelance collaborators organize guided tours through the exhibition, which includes a full range of activities such as tours for regular school classes, teachers and more specific topics such as evolution or earth history.

Chapter 51
THALLICHTENBERG: POLLICHIA Geoscience Collections at the Urweltmuseum GEOSKOP, Thallichtenberg (Germany)

Sebastian Voigt and Jan Fischer

51.1 Urweltmuseum GEOSKOP and POLLICHIA

The Urweltmuseum (=primeval world museum) GEOSKOP was founded in 1998 as the geoscientific branch of the Palatinate Museum of Natural History (Pfalzmuseum für Naturkunde——POLLICHIA-Museum), Bad Dürkheim, SW Germany. Located in a new building within the walls of 800-year-old Lichtenberg castle near Kusel, Rhineland-Palatinate, the GEOSKOP houses the POLLICHIA geoscience collections (Figs. 51.1 and 51.2). The POLLICHIA started in 1840 and is one of the oldest still-active societies of natural history in Germany. It was named after, and in honour of, Johann Adam Pollich (1741–1780), physician and naturalist from Kaiserslautern (Müller 1990). Today, the society has approximately 2600 members. One of the most famous geoscientists and former president of the POLLICHIA was the geophysicist and polar explorer Georg von Neumayer (1826–1909), the German research base in Antarctica is his namesake.

51.2 Facility

Two full-time paleontologists and one geoscience preparator are employed at the Urweltmuseum GEOSKOP and cover all duties from management to exhibition and education. The facility includes a main storage (Fig. 51.3) with a shutter cabinet system, work tables, and documentation station (binocular microscopes, digital photography, 3D scanning system). An oversize storage of 180 m^2 floor space is situated in a separate building outside the castle. The museum runs laboratories for

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Fig. 51.1 Logo of the Urweltmuseum GEOSKOP based on a stylized representation of the Permian temnospondyl amphibian *Archegosaurus*

Fig. 51.2 Exterior appearance of the Urweltmuseum GEOSKOP at Lichtenberg castle near Kusel, Rhineland-Palatinate, SW Germany

rock fragmentation, mechanical fossil preparation, and chemical processing. The main building additionally comprises 400 m^2 of exhibition space (Fig. 51.4), several technical rooms, three offices, a library, and a conference room. Operating costs are covered by an administrative union consisting of the Palatinate communal association (Bezirksverband Pfalz), Kusel county administration, and the POLLICHIA society. Future funding seems to be secured at the current level.

51.3 Collections

The POLLICHIA geoscience collections contain about 3000 rock samples, 5000 minerals, and 7000 fossil specimens (Voigt and Fischer 2015). There are three focal points of the paleontological collection: (1) Carboniferous and Permian continental

Fig. 51.3 Overview of the GEOSKOP main storage with shutter cabinet system

Fig. 51.4 Showcases of the GEOSKOP permanent exhibition with fossils from the Permian of the Saar-Nahe Basin

biota of the local Saar-Nahe Basin (e.g., stromatolites, macroflora, invertebrates, palaeoniscid fish, freshwater sharks, temnospondyl amphibians, "pelycosaurs"); (2) Quaternary mammals of the Palatinate Rhine Valley (predominantly large ice age mammals); and (3) Paleozoic tetrapod footprints worldwide. For the first 140 years of its existence, the geoscience collections accumulated almost exclusively from donations by POLLICHIA members. During the last three decades, however, the paleontological collection increased due to systematic excavations that have been performed by the POLLICHIA museum in cooperation with local partners (Rotliegend working group; Office for the Preservation of Natural Heritage Rhineland-Palatinate; former Museum of the Saar Coal Colliery etc.). The collection of Quaternary mammals is based on specimens transferred from the Historical Museum of the Palatinate in Speyer in the second half of the twentieth century and more recent donations from private collectors and regional museums. The collection of Paleozoic tetrapod footprints includes material from local collectors, museum excavations, exchange with national and international institutions and, quantitatively most important, specimens from the estate of specialized scientists (Voigt 2014). The POLLICHIA collections survived World War II more or less undamaged (Kaiser 1967; Wieland 2017).

51.4 Research

Research at the Urweltmuseum GEOSKOP is focused on Late Paleozoic continental ecosystems, freshwater sharks and the evolution of early tetrapods, especially from the paleoichnological point of view (e.g., Witzmann and Voigt 2015; Abu Hamad et al. 2016; Voigt and Lucas 2016). Active research partnerships exist with 27 different institutions in Austria, Canada, China, Denmark, Germany, Italy, Jordan, Morocco, Russia, and the U.S.A. In 2013, the museum staff discovered a lagerstaette near Kusel that yields exceptionally well-preserved and unique tetrapods from a 300-million-year old lake shoreline (Voigt et al. 2014). This site and its fossil specimens are the object of ongoing excavation and investigation (Figs. 51.5 and 51.6). Other research activities include the organization of student excavations, participation and organization of scientific meetings as well as the production of a lively stream of publications. The museum submits grant proposals to the German Science Foundation and sucessfully applied for a postdoctoral fellowship from the Alexander von Humboldt Foundation (2016–2018).

51.5 Educational Work

The Urweltmuseum GEOSKOP offers various programs and events for schools and visitors in general, ranging from the possibility to hold children's birthday parties up to overnight adventures. In cooperation with the youth hostel at Lichtenberg

Fig. 51.5 Preparation of plaster jacket with 300-million-year old tetrapod remains from Kusel, Rhineland Palatinate

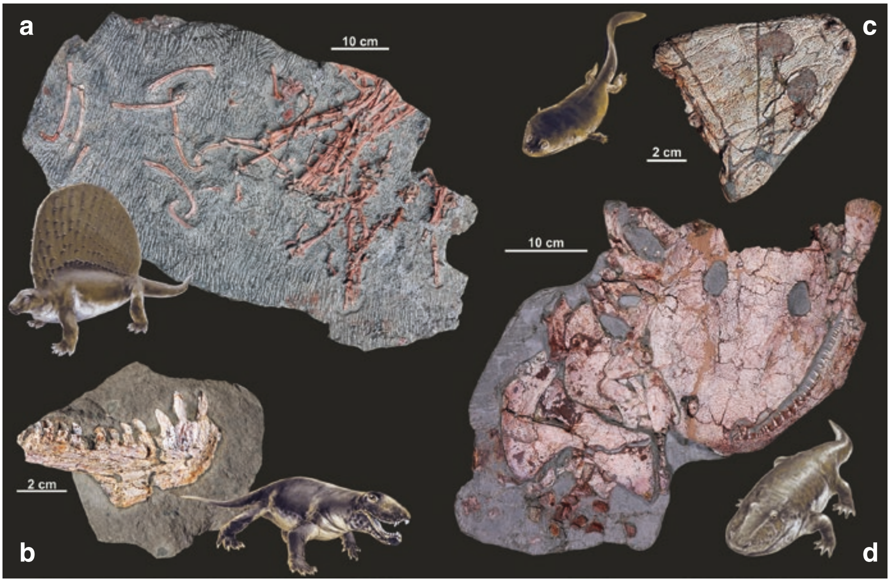

Fig. 51.6 Recently discovered Carboniferous-Permian tetrapod remains from Kusel, Rhineland-Palatinate: (**a**, **b**) edaphosaurid and sphenacodontid “pelycosaurs”, (**c**, **d**) dvinosaurian and eryopid amphibians

castle, the museum carries out a three-day school program for kids on class trips. Regular educational activities also include geological field trips, an academic forum with monthly talks, and diverse advanced training courses. The museum staff supervises several student apprentices from schools every year. Scientific excavations are accompanied by volunteer assistants; some of them are also trained to study fossils and publish scientific results.

51.6 Public Relations

The GEOSKOP maintains two websites (www.urweltmuseum-geoskop.de; www.burglichtenbergpfalz.de) that inform on museum activities and events. A separate website provides information on the main museum residence of the Palatine Museum (www.pfalzmuseum.de). Furthermore, the GEOSKOP is present on Facebook and advertises events by mailing list.

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Chapter 52
TÜBINGEN: The Palaeontologial Collection of Tübingen

Ingmar Werneburg and Madelaine Böhme

52.1 General Information

The Palaeontological Collection of the University of Tübingen comprises an estimated number of one million objects and it is one of the largest university collections in the world (Fig. 52.1a, h). Among the great diversity of fossil remains in our collection (Fig. 52.1b), the type specimens of more than 1,700 publications are available. Of particular value are the type specimens published by Friedrich August von Quenstedt (Fig. 52.1c) and by Friedrich Freiherr von Huene (Fig. 52.1d). Further original specimens are associated, among many others, to the publications of Auer, Branco, Broili, Bronn, Fraas, Hauff, Heer, Hemleben, Hennig, Jaeger, Koken, Mosbrugger, Naef, Pompeckj, Schindewolf, Schlegelmilch, Seilacher, Westphal, Wiedmann, Wendt and Zittel.

The origins of the Palaeontological Collection in the medieval town of Tübingen go back to the foundation of the university in 1477 when first lectures were given on "stones" in general (Engelhardt and Hölder 1977). The collection as such was first systematically organised in 1837, when Friedrich August von Quenstedt (1809–1889) became in charge of the collection and gave his own lectures (Koken 1904; Hennig 1919, 1923; Werneburg 2016). From this time on, the collection was assigned both to science and to teaching. Up to this date, our main aim is to provide access to the unique material for national and international scientists. Moreover, in being associated to the University of Tübingen, staff of the Palaeontological

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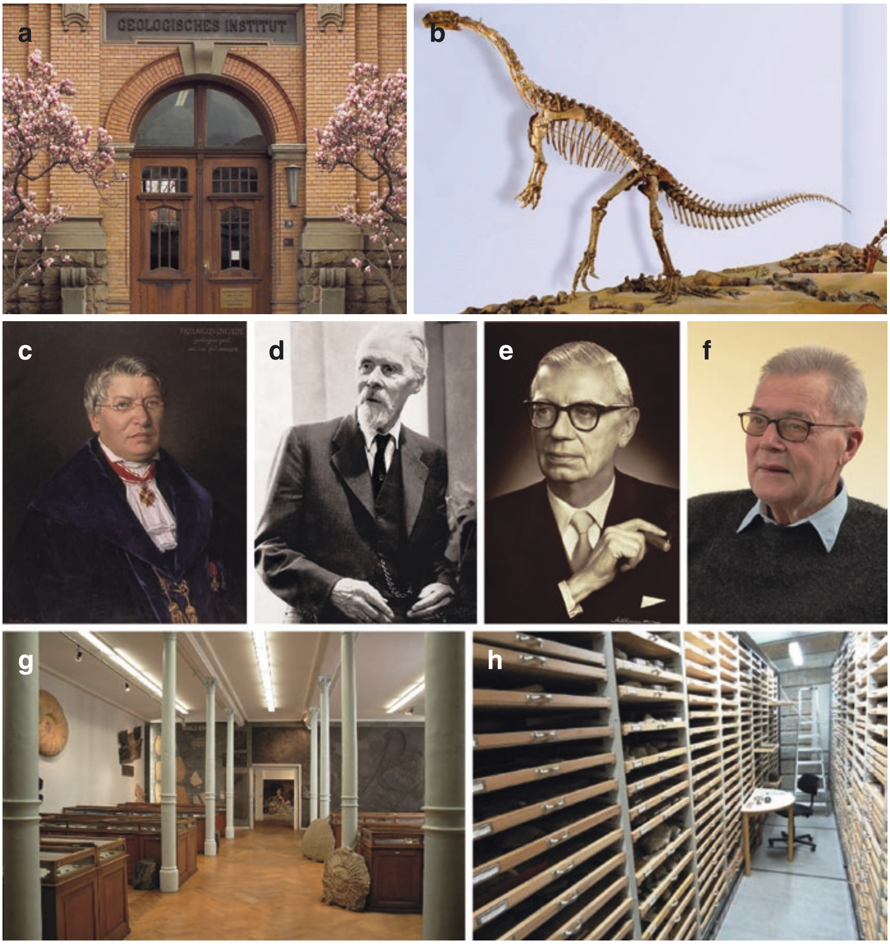

Fig. 52.1 (**a**) Entrance to the Palaeontological Collection Tübingen, Sigwartstraße 10 (built 1903). It is flanked by two flowering magnolias, which belong to the oldest lineage of living flowering plants (Angiospermae). Close relatives existed at the 'age of dinosaurs' and they were indigenous in middle Europe until the end of the last glacial period. (**b**) Mounted skeleton of *Plateosaurus engelhardti*, the so-called "Swabian Dragon", from Keuper-formation of Trossingen, Baden-Württemberg. (**c**–**f**) Famous researchers of the Palaeontological Collection: (**c**) Friedrich August von Quenstedt (1809–1889), (**d**) Friedrich Freiherr von Huene (1875–1969), (**e**) Otto Heinrich Schindewolf (1896–1971), (**f**) Adolf ('Dolf') Seilacher (1925–2014). View into (**g**) the historicising stratigraphical hall and into (**h**) a part of our compactus collection. Photos of this chapter were made by Wolfgang Gerber or are from the archive of the Palaeontological Collection

Collection feels obliged to teach students on how to handle palaeontological findings and to introduce them to palaeontological research (incl. field excursions).

The acronym of the collection "GPIT" is based on the old name of the institute: "Geologisch-Paläontologisches Institut Tübingen". Since 2010, the Palaeontological Collection and its exhibition is mainly managed and organised by employees of the

'Senckenberg Centre for Human Evolution and Palaeoenvironment (HEP)'. The vast majority of specimens, however, are property of Tübingen University. The collection is closely associated to the Department of Geology (Fachbereich Geowissenschaften) and, as such, we have access to a variety of laboratories, including labs for palaeontological preparations and thin sections.

52.2 Research

Comprehensive parts of the collection stem from the 19th and early 20th century. Tübingen and its collections were not destroyed during World War I and II (Seidl 2016), which makes our collection also valuable for researchers interested in the early development of German natural history collections.

Several invertebrates were included to the collection between 1950 and 1970 mirroring the research focus of the institute at the time. A number of valuable private collections were donated to the institute and enrich our comprehensive inventory. Just recently, the palaeontological material of the Herbarium Tubingense (Kretschmer 1974) was integrated into the collection.

Of particular importance are the collections and associated publications of Friedrich August von Quenstedt (1809–1889; Fig. 52.1c) on the Triassic and the Jurassic of the South German Scarplans (Quenstedt 1885). The famous vertebrate palaeontologist Friedrich Freiherr von Huene (1875–1969; Fig. 52.1d) collected and published, among others, on Triassic land vertebrates (Turner 2009). Otto Heinrich Schindewolf (1896–1971; Fig. 52.1e), an influential invertebrate palaeontologist and evolutionary theorist, worked on ammonites of the Jurassic and the Cretaceous. The founder of modern palaeoichnology, Adolf ('Dolf') Seilacher (1925–2014; Fig. 52.1f), created an exceptional collection of trace fossils. Since 2009, studies on Neogene terrestrial environments enriched the collection by more than 20,000 mainly mammalian fossils (Böhme et al. 2014).

In recent times, several national and international Bachelor-, Master-, Ph.D.- and Postdoc-projects are performed using fossil material from our collection, and we are part of the 'European Synthesys program for museum visits'. Current research in Tübingen, which comprehensively uses the material of the collection, is associated with several working groups. Among other topics, they study (1) terrestrial palaeoclimatology with a focus on Miocene fauna and stratigraphy of Eurasia (Böhme and Vasilyan 2014), (2) invertebrate palaeontology with a focus on echinoderm ecology and taphonomy (Mancosu and Nebelsick 2016), (3) terrestrial micropalaeontology (Junginger et al. 2014), (4) feeding ecology using stable isotope chemistry methods (Bocherens et al. 2015), and finally vertebrate (5) taxonomy (Maisch 2010), (6) functional (Hohloch 2013) and (7) comparative anatomy (Werneburg et al. 2015).

External visitors mainly work on vertebrate fossils stored in our collection, including ichthyosaurs and other marine reptiles, therapsids and plateosaur dinosaurs. Several (type) specimens await treatment with modern methods such as micro-computed tomography (μCT) to score for new taxonomically and phylogenetically relevant characters (Laaß et al. 2017).

Our comprehensive and valuable invertebrate and plant collections (Christner and Kühner 1989) are little known to the research community yet. One reason for this is that currently only a minor part of the collection is already catalogued and little information is accessible online. Specialists visiting and working in the collection, however, use to find and identify valuable material.

52.3 Educational Work

In order to teach and entertain earth history, biodiversity and organismic research to the public, a number of fascinating and unique fossils are presented in the exhibition. As such, the exhibition is an integrated part of the collection. Its structure and the preparation techniques used have a strong historicising character (Fig. 52.1g). This highlights the historical and scientific value of the collection. School and university students as well as kindergarden groups and the public are regularly guided through the exhibition.

Already in the entrance hall, the visitors can find a number of exceptionally preserved ichthyosaurs with embryos and marine crocodiles from the Posidonia Shale of the Lower Jurassic from Holzmaden (184 million years old).

The “Swabian dragon” is the colloquial name of *Plateosaurus*, an early prosauropod dinosaur from the Upper Triassic (Fig. 52.1b). The original skeletons from Trossingen quarry are shown (Weishampel and Westphal 1986). They are presented in an original manner as arranged by the excavator, Friedrich Freiherr von Huene, himself. A strongly armored *Kentrosaurus* from Tanzania and track slabs of the hand-beast *Chirotherium* belong to this impressive ensemble.

The fauna of the Jurassic sea is shown in the ‘marine reptile hall’ (Fig. 52.2a). We do not only show skeletons of ichthyosaurs of Posidonia Shale but also a number of marine crocodiles (Fig. 52.3d), plesiosaurs (Liebau and Westphal 1995), sharks and bony fishes, which lived in Germany and England about 200 to 145 million years ago. Among those specimens are large predators such as the 15-m long temnodontosaurs and bones of the coelacanth. Several skeletons of pterosaurs round-up the presentation of vertebrate findings associated to the Jurassic sea, the Tethys Ocean. A large concentrate-lagerstätte of ammonites and nautilids gives an impression of the diversity of Jurassic marine invertebrate fauna (Fig. 52.3e). In addition to those, up to 6-m long mesosaurs, top predators of the Cretaceous sea, are on display. In one hall, there are skeletons of the Upper Triassic placodont *Henodus chelyops*, an exceptional, turtle-like sauropterygian reptile, which is only known by eight specimens from the Goldersbach near Tübingen-Lustnau (Fig. 52.2b). Next to it, the holotype of the famous Upper Triassic stem turtle *Proganochelys quenstedti*, preserved as a steinkern of the shell (Quenstedt 1889), is one of the “secret” highlights of the exhibition.

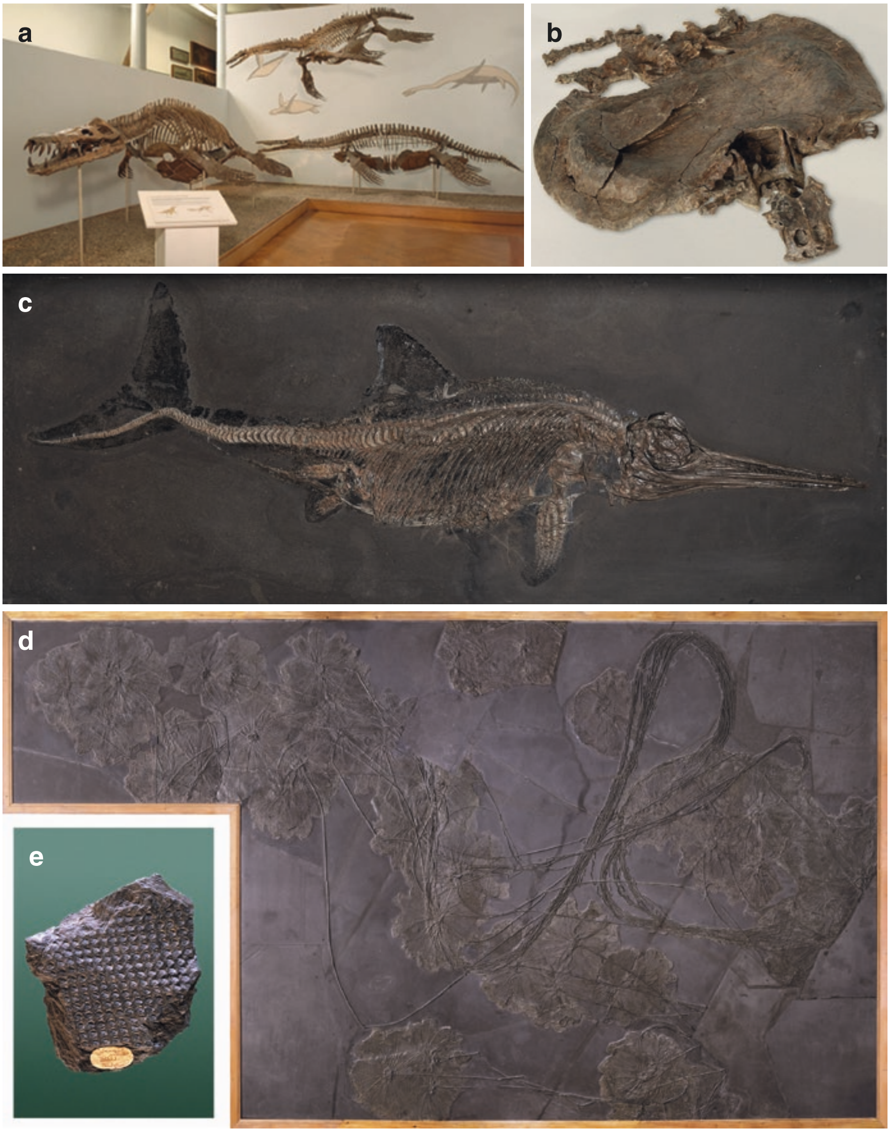

Fig. 52.2 (**a**) View into the marine reptile hall showing three plesiosaurs from the Middle Jurassic of Great Britain. (**b**) Skeleton of the turtle-like placodont *Henodus chelyops* from the Gipskeuper formation of Tübingen-Lustnau. (**c**) The ichthyosaurier *Stenopterygius quadriscissus* with soft tissue preservation. (**d**) The Jurassic sea lilie *Seirocrinus subangularis*, the so-called "Swabian medusa head", is related to sea urchins and starfishes. It is attached to driftwood. (**e**) Tree trunk imprint of the carboniferous species *Sigillaria oculata*. These clubmosses were up to 30-m high and their remains comprehensively contributed to the formation of coal deposits

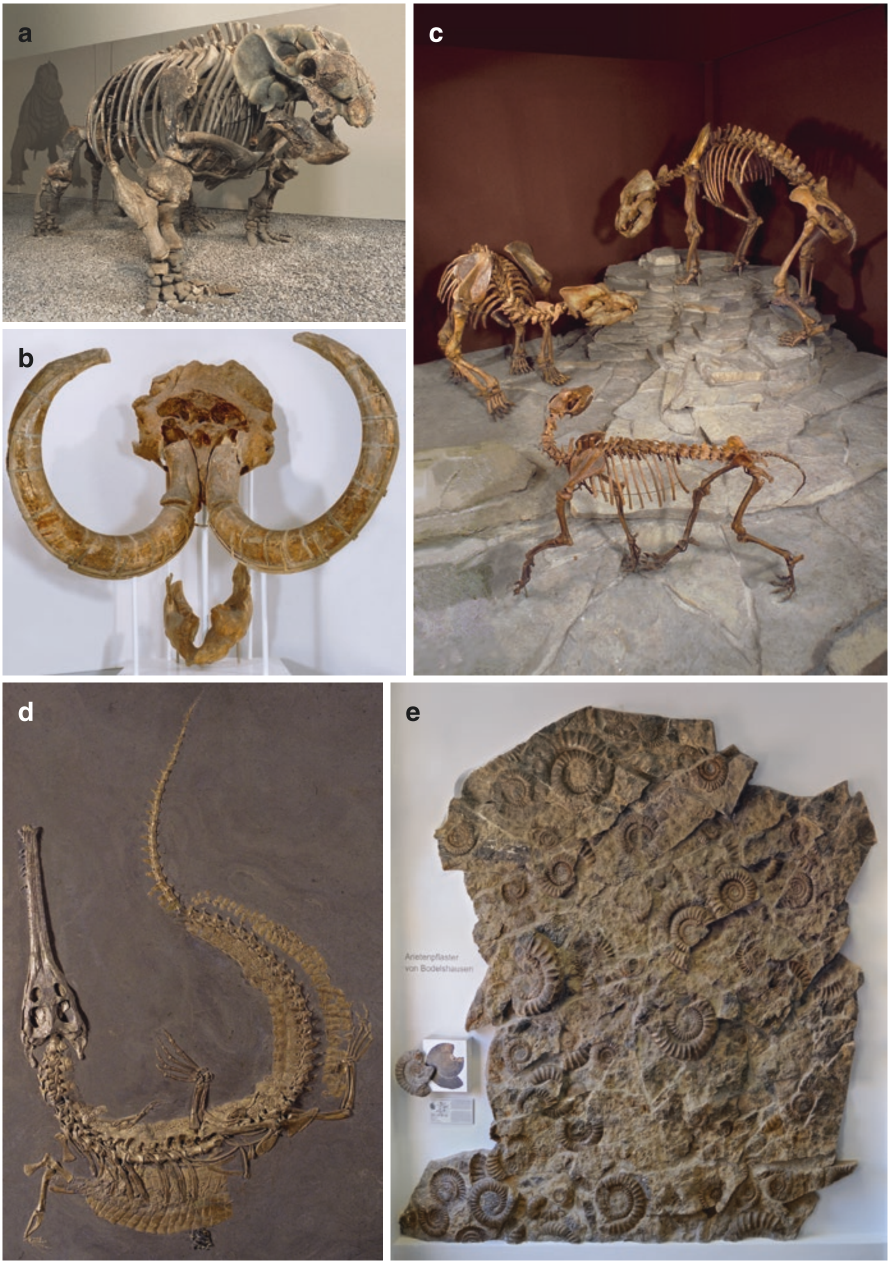

Fig. 52.3 (**a**) Skeleton of the synapsid *Stahleckeria potens* from the Middle Triassic of Brasil. (**b**) Skull of a Pleistocene woolly mammoth (*Mammuthus primigenius*) from Horn am Neckar. (**c**) Skeletons of two cave bears (*Ursus spelaeus*) and a wolf (*Canis lupus*) from Pleistocene sediments of Erpfingen bear's den at the Swabian Jura. (**d**) Skeleton of the marine crocodile *Steneosaurus bollensis* from the Posidonia Shale formation of Holzmaden. (**e**) Arietite ammonites and nautilid conchs from the lower Jurassic of Bodelshausen near Tübingen

Below the "Swabian Medusa head", which is a 4½-m tall colony of sea lilies from the Posidonian Shale of Ohmenhausen near Reutlingen (Fig. 52.2d), a comprehensive collection of fossils from all geological eras are shown in their stratigraphical sequence. The major steps of evolution within the last 500 million years are presented. The particular charm of this hall is how it resembles the natural history collections of the late 19th century with historical vitrines and collection cupboards made of oak (Fig. 52.1g). One of those cupboards contains an East Prussian amber collection with exceptional insect inclusions (Wichard et al. 2018).

The development of mammalian ancestors begins in the Paleozoic. The "reptilian-like" groups of therapsids (Fig. 52.3a) already show some adaptations that are typical for modern mammals including a specialised set of teeth, the posture of the limbs as well as the development of fur. Thanks to Friedrich von Huene, who did excavations in Africa and South America (Huene 1927), the university houses one of the most important collections of therapsids in the world (Westphal 1988; Kammerer et al. 2014). In the therapsid hall, as casts, also fossil humans and their close relatives are shown. In addition, the extremities of North American sauropod dinosaurs, which reached a live weight of up to 37 tons, are presented because the mammalian ancestors developed "in the shadow" of these herbivore reptiles (Fraser and Sues 1994).

Baden-Württemberg federal state belongs to the classical areas of geology and palaeontology. A great number of unique fossils permits an insight to the different ecosystems of Württemberg area through earth history. The oldest sediments were accumulated about 300 million years ago. Within the last ten thousands of years the sediments of the Erpfingen bear's den were formed. Its original cave bear skeletons can be observed in Tübingen (Fig. 52.3c). Opposite to them, an impressive skull of a mammoth from Horb am Neckar is on display (Fig. 52.3b).

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Chapter 53
WIEN: "To the Realm of Nature and its Exploration": The Paleontological Collections of the Natural History Museum Vienna

Mathias Harzhauser and Andreas Kroh

53.1 Year of Foundation, and Age of Parts of the Collection

In 1748 Emperor Franz I. Stephan von Lothringen (1708–1765), husband of Empress Maria Theresia (1717–1780), laid the founding stone for the collections of the Natural History Museum in Vienna. He bought the famous "museo" of Jean de Baillou, who was the general manager of the Medici gallery in Florence and of the gardens and mines in Tuscany. The collection was one of the largest at that time, consisting of about 30,000 objects, such as minerals, molluscs, corals and fossils (Riedl-Dorn 1998). In Vienna, the collection was displayed in a room of the Augustine Tract of the Hofburg Palace and Baillou was nominated as the managing director of this new "Naturalien Cabinet" (Natural History Cabinet). In 1802, this collection was united with the Physical-Astronomic Cabinet, the Arts-Cabinet and the "Natur-Thier-Cabinet" (Nature-Animal Cabinet) and Andreas Xaverius Stütz was appointed as director of the new "Vereinigtes Naturalien-, Physikalisches und Astronomisches Cabinet" (United Natural History, Physical and Astronomic Cabinet).

In 1806, Emperor Franz I appointed Carl von Schreibers as director of the renamed "Vereinigtes k.k. Naturalien-Cabinet" (United Imperial Royal Natural History Cabinet) and requested a complete reorganisation of the collections on a scientific basis. In 1811 the collection, which was previously privately owned by the Habsburgs, was converted to state property. During the Napoleonic Wars (1803–1815) parts of the collections were transferred to Budapest, Timișoara and other places to protect them from looting by French troops. In 1810 the museum was

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Fig. 53.1 A limestone-slab with the 150 Million year old herring *Anaethalion knorri* from Solnhofen in Germany, brought to Vienna during the Napoleonic Wars, is among the oldest artefacts documenting the correct interpretation of a fossil as formerly living animal

officially re-founded as "Die Vereinigten k.k. Naturalien-Cabinette" (United Imperial Royal Natural History Cabinet) and after the defeat of Napoleon, the collections were newly arranged in the Augustine Tract of the Hofburg Palace. During the Napelonic Wars also parts of the cabinet of art and curiosities of the castle of Ambras in Tyrol, dating back to the sixteenth century, were brought to safety to Vienna. This collection included a small but spectacular slab with a fossil fish accompanied by some Latin lines engraved in its lower part (Fig. 53.1). The Roman numeral M.D.XLIII dates the object into the year 1543. The poem represents a Vergil-Cento, uniting parts of the Aeneis and the Georgica. The unknown author reports on a deathly, everything annihilating flood. Obviously, he interpreted the fossil fish as victim of the Deluge. This was a revolutionary idea, as most scholars considered fossils to be mere freaks of nature at that time. Thus, the object is one of the oldest documents for the correct interpretation of a fossil as formerly living organism.

The focus of the collection strategy during the early nineteenth century was the internationalization and diversification of the paleontological collection by intense purchasing from private collectors and especially from professional sellers, such as the "Heidelberger Mineralien-Comptoir", the "Freyberger Mineralien Comptoir" and the "Mineralien-Geschäft von Krantz". Large collections arrived in Vienna also as donations, by exchange with or purchase from other important institutions, such as the Leverian Museum in London (1807) and the Musee d'Histoire Naturelle in Paris (1827). Consequently, the inventory books of these decades mirror the "who-is-who" of paleontology at that time with names such as Pierre André Latreille (Paris), Giovanni Michelotti (Torino), Joachim Barrande (Prague), Hanns Bruno Geinitz (Dresden) and even Johann Wolfgang von Goethe. An interesting example from this period is the purchase of the microfossil collection of Leopold von Fichtel and Johann Paul Carl von Moll, who were pioneers of micropaleontology, in 1812 (Rögl 1982).

In 1851 the collections were spilt into three independent cabinets and the paleontological objects remained in the "Mineralogisches Cabinet" (Mineralogical

Cabinet). During the revolutionary year of 1848, the cabinets suffered considerable losses, when the Hofburg was set on fire through artillery. Since then, the collections were greatly enlarged by numerous expeditions and collecting campaigns, and along with the growing understanding of nature and systematics, the collections were arranged according to newest scientific standards. The targets of many of these collection campaigns were exotic animals and plants, minerals and rock-samples, whilst paleontological objects were welcome but subordinate. The starting point of the geological-paleontological collections was the middle of the nineteenth century. Geology became established as an important science, and geologists were recognized to be of tremendous economic importance in terms of exploration, construction work and even water supply. Moreover, the “Gründerzeit”—a time of industrialization and urbanism between the 1840s and 1870s—started to reshape the cities of the Austrian Empire. Vienna, as its capital, saw an enormous building activity, which required new outcrops for building-stones and clay pits for millions of bricks – all leading to a renaissance of fossil collecting and paleontology (Fig. 53.2) (Harzhauser 2010).

The founders of Austrians paleontology, such as Franz von Hauer, Ferdinand von Hochstetter, Eduard Suess, Paul Maria Partsch, Moriz Hoernes and Johann August Edmund Mojsisovics Edler von Mojsvár, among others, continuously enriched the collections by sending Tertiary and Mesozoic fossils from the entire territory of the Habsburg monarchy.

In 1876 the museum was re-organised as “K.K. Naturhistorisches Hofmuseum” (Imperial Royal Court-Museum). Already in the late 1870s, Emperor Franz Joseph I decided to build a new museums complex for the natural history collections and the fine arts collections. In fall 1871, the excavations for the construction of the imperial buildings at the Burgring started. About 10 years later the building was completed and the collections were successively transferred to the new building and re-arranged. In 1885, the Geological-Paleontological Department was founded as separate unit with Theodor Fuchs as the first department director (Fig. 53.2).

On the 10th of August 1889, the new museum was inaugurated in the presence of the Emperor. His mission statement is still written on the face of the museum: “Dem Reiche der Natur und seiner Erforschung Kaiser FRANZ JOSEPH I” (To the realm of nature and its exploration—Emperor FRANZ JOSEF I). After World War I, the museum “lost” its K.K. in the title and is since then officially termed “Naturhistorisches Museum” to the present day.

53.2 Number of Species and/or Specimens, Focal Points

The Geological-Paleontological Department has a long-lasting tradition in Alpine Mesozoic and Eurasian Cainozoic research. This focus is also expressed in the systematic and stratigraphic collections, which have a pre-eminent position. The systematic foci are Cainozoic vertebrates, as well as Mesozoic and Oligocene-Miocene invertebrates. The importance of the collection is also emphasized by the large

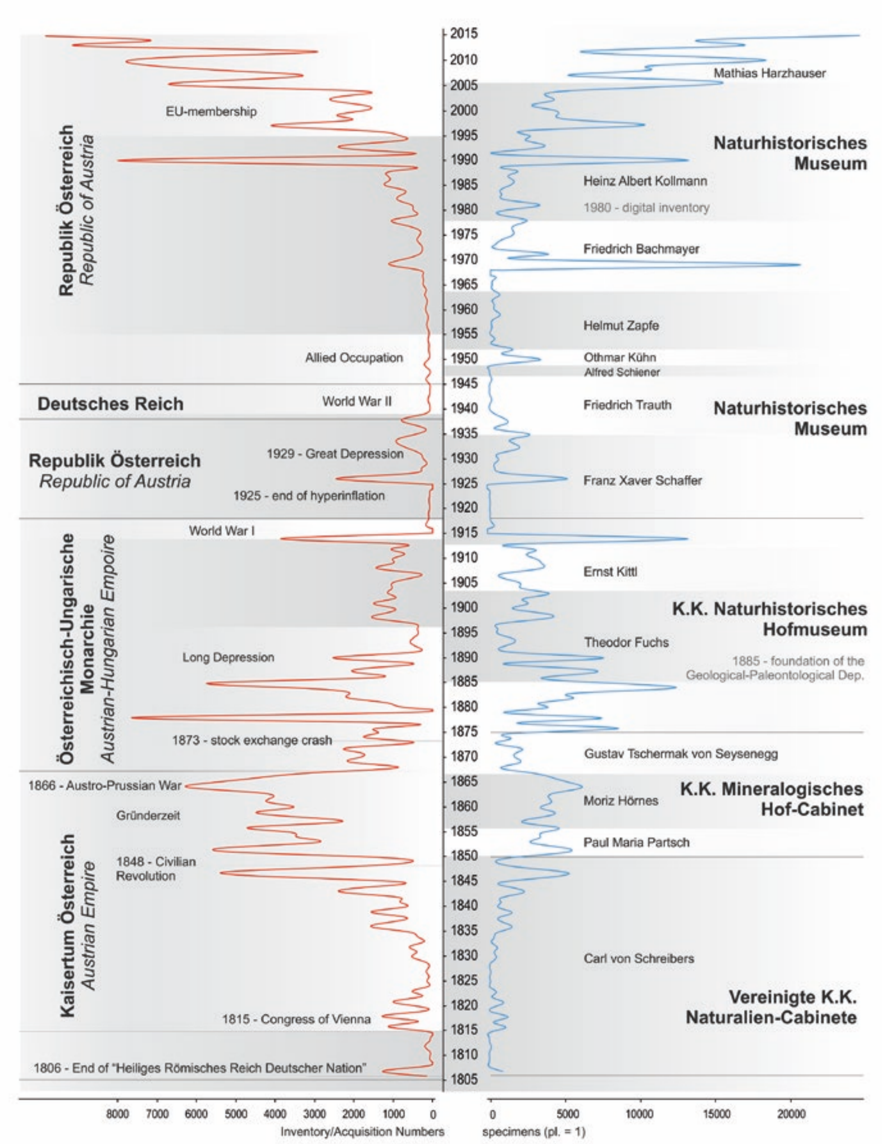

Fig. 53.2 Ups and downs of the collections of the Geological-Paleontological Department through the last 210 years. The fluctuations in acquisition numbers (left) and specimen numbers (right) listed in the inventory books are strikingly coincident with historical events. The names of the heads of the department and the respective official names of the Natural History Museum are given on the right

number of paleontological type specimens (Fig. 53.3). The total number of objects stored in the Geological-Paleontological Department ranges around 3.5 million, of which about 300,000 are already implemented in the digital inventory.

Fig. 53.3 One of the thousands of type specimens in the collection: Holotype of *Pachyophis woodwardi* from the Cretaceous of Bosnia and Herzegovina. This species represents one of the oldest and most ancestral snakes known to date

53.3 Today's Conditions of Infrastructure of the Paleontological Part (Staff, Rooms, Laboratories, Exhibitions, Financial Support, Perspectives)

The Geological-Paleontological Department has seven permanently employed scientists, who are both researchers and curators (five paleontologists, two speleologists). In addition, one collection manager, one secretary and three technicians have permanent positions. A fluctuating number of third-party funded PhDs and postdocs have temporary contracts. Finally, about eight volunteers are supporting inventory and laboratory work.

The department has 11 spacious offices and working rooms covering ca. 450 m^2. These rooms are partly also used for collections storage. 19 rooms (1180 m^2) are exclusively dedicated for the collections, of which four are equipped with roll shelves of Compactus-type. In addition, three laboratories (150 m^2) and several smaller rooms for material storage are part of the department.

The exhibition consists of five main galleries and the mezzanine, covering about 1500 m^2. All galleries have been re-arranged during the last two decades and try to combine modern scientific contents with the historical architecture (Fig. 53.4). Planning, organization, text modules, acquisition of objects and media units and even challenging technical solutions have been realized by staff members. This situation is unique for big and international museums where curators, researchers and exhibition staff are usually separated.

The Natural History Museum Vienna is a scientific institution under public law and not profit-based. It receives an annual basic remuneration of € 14.4 Mio. (2015) from the Republic of Austria to cover its ongoing maintenance, administrative costs and salaries. It has an additional income from entrance fees and various corporate events. Within this tight frame, however, funding of large scientific projects, new technical equipment and major innovations in the galleries depend on sponsoring and third-party projects. Aside from the moderately optimistic financial situation, the department is currently not threatened by a reduction of staff.

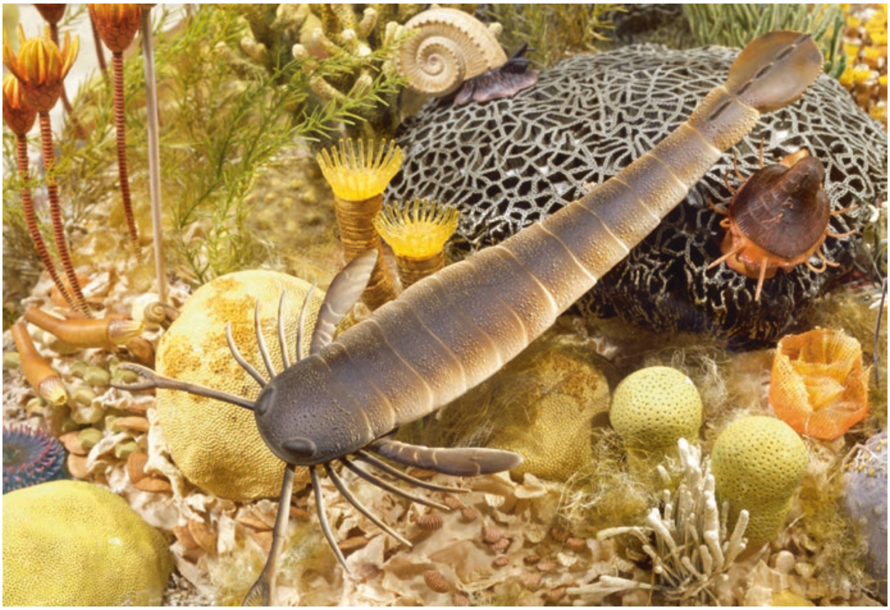

Fig. 53.4 Multimedia stations and dioramas, such as this reconstruction of a Silurian reef are partly integrated in the historical show cases

53.4 Research

53.4.1 Examples of Today's Research, Potencies

The self-perception of the Geological-Paleontological Department is that of a research unit. Research largely takes place within the frame of third-party funded projects. The main foci of research are Eurasian paleogeography and taxonomy-based biostratigraphy and integrated stratigraphy. Geochemical and geophysical methods became increasingly important for the staff's research during the last years. Results are published mainly in international, peer-reviewed journals. Generally, the current research covers four major topics:

- Oligocene and Miocene ecosystems of Eurasia—Climate and the change in marine, lacustrine and terrestrial environments: A series of projects was and is dedicated to the research on Oligocene and Miocene ecosystems. The geographic focus is Central and South-Eastern Europe and Central Asia. This topic has a backbone in the systematic collections of the department which are constantly enlarged during the various projects. The studies encompass analysis of the sedimentary sequences and biotic content (foraminifera, invertebrates, fishes) of the Paratethys Sea and the surrounding wetlands (invertebrates) as well as the terrestrial environments (vertebrates, paleobotany).
- Biogeography and Paleobiogeography around the closing Tethys Seaway: This topic has a long tradition at the NHMW, ranging back to 1870s and is thus also

documented by a strong focus in the collections. Field trips to N-India, S-India, Tanzania, Oman, Iran, Egypt, and eastern Turkey have been organized within several FWF and DFG projects during the last 20 years. These expeditions resulted in a distinct increase of the regional-geological collections and numerous papers on systematics, biogeography and stratigraphy of the eastern Mediterranean and Western Indo-Pacific. The goal of the studies is to understand the timing and biogeography around the closing Tethys Seaway during the Early Miocene and to compare the Oligocene and Miocene marine faunas of the early Mediterranean and the newly establishes Western Indo-Pacific.

- Mesozoic Ecosystems and integrated stratigraphy with emphasize on ammonite distribution: Several integrative, high resolution projects are running within this research topic with focus on Mesozoic climate, environmental changes, ecology, paleobiogeography and biostratigraphy.
- Phylogeny of Post-Paleozoic echinoids: the above mentioned focus on Cenozoic invertebrates sparked a long-lasting interest in the evolution of sea urchins, one of the major groups in shallow benthic ecosystems since the Late Jurassic. The goal is to understand the factors driving echinoid diversification and their roles in Late Mesozoic and Cenozoic ecosystems.

Outstanding current projects in cooperation with various national and international universities are:

"FreshGen" (Freshwater Gastropods of the European Neogene, FWF P25365-B25): a first detailed assessment of the composition of European freshwater gastropods during the Neogene and Quaternary at species, genus and family levels, with emphasis on lake faunas.

"Speleotect" (FWF P25884-N29): active tectonics and recent dynamics of micro-displacements along major fault systems of the Eastern Alps registered in caves.

"*Smart-Geology for the World's largest fossil oyster reef*" (FWF P 25883-N29): taphonomy, age structure and depositional environments of the largest fossil oyster biostrome based on a terrestrial laser scanning derived high resolution digital surface model. A key study to link paleontology with photogrammetry.

"*Phylogeny and evolution of edible sea urchins*" (FWF P29508-B25): an interdisciplinary study on fossil and modern echinoids of the order Camarodonta, a commercially exploited group of echinoid that plays a key role in Neogene and modern reefs.

53.4.2 National and International Network and Research

The most intense national co-operations are developed with the Department of Paleontology and the Department for Geodynamics and Sedimentology of the University Vienna and with the Institute for Earth Sciences of the Karl-Franzens University Graz. These co-operations are also intensified by the fact that many scientists of the department are habilitated at one of these universities, which contains the commitment of teaching at the respective university. Numerous additional national network- and research-partners are collaborating with the department within defined projects, usually within a limited time frame (e.g. Geological Survey of Austria, City of Vienna, County Lower Austria, Schlossmuseum Linz, Universalmuseum Graz, Technical University Vienna, numerous local museums). In addition, scientific projects have been repeatedly realized with the two Austrian Oil companies OMV and RAG. Similarly, international research co-operations on individual or on project-base are developed with numerous research institutions in Europe and the USA. In addition, researchers of the department are actively engaged in international database and biodiversity initiatives such as the World Register of Marine Species (WoRMS), and the Geosciences Collection Access Service (GeoCASe). On a European level, participation in the Earth Sciences Group of the Consortium of European Taxonomic Facilities (CETAF) ensures excellent integration into the international science and museum communities.

53.4.3 Publications, Written or Other Used New Media

Within the last 5 years (2012–2016) the department published 232 papers in peer reviewed journals with impact factor, 156 papers in other scientific journals and books, and 39 popular science articles in magazines and books. Three exhibition catalogues were published for the paleontological galleries (galleries 7–9), the dinosaur hall (gallery 10) (Fig. 53.5) and the earth-system exhibition (gallery 6). In

Fig. 53.5 The Dinosaur Gallery with the animatronics model of an *Allosaurus* proved to be a crowd puller

addition, a fourth exhibition catalogue was produced for the edutainment park "Fossilienwelt Weinviertel". Within the frame of a speleological project, a popular science movie was produced, explaining the effects of recent Alpine tectonics on caves (http://www.nhm-wien.ac.at/speleotect).

53.5 Educational Work

53.5.1 Didactic Conceptions of Exhibitions

The staff of the department was responsible for the didactic conception of following galleries: Gallery 6 "Gaia-Sphere—System Earth", Gallery 7 "The Paleozoic Era", Gallery 8 "The Mesozoic Era", Gallery 9 "The Cenozoic Era", Gallery 10 "The Dinosaur Hall", Mezzanine "Climate: Icehouse and Hothouse", Mezzanine "Evolution". Aside from these permanent exhibitions in the Natural History Museum, members of the department were planning and mentoring several large edutainment park exhibitions:

- Fossilienwelt Weinviertel: http://www.fossilienwelt.at/
- Geopark Steirische Eisenwurzen: http://www.eisenwurzen.com/unesco-global-geopark/
- GeoZentrum Gams: http://www.geodorf-gams.at/

53.5.2 Cooperation with Schools

Due to its outstanding position within Austrian's museums, the Natural History Museum is imperative for most kindergartens and schools. Visit by pupils is supported by free entrance for children and youth under 19 years. The paleontological exhibitions are among the most frequented and an own team of the museum's educational department offers programs, which are tailored to the participants' ages and previous knowledge. These offers are well received by the teachers. In addition, department staff supports selected pupils during their "pre-university thesis", which is part of the school leaving examination in several Austrian schools and supervises pupils during their compulsory "days of practical work experience".

53.5.3 Use of Social Media

The Natural History Museum and its departments are present on numerous social media where latest news and ongoing exhibitions are posted; e.g.

YouTube: https://www.youtube.com/channel/UCsKjfYfWMaqUcxINN7MJt2w

Facebook: https://www.facebook.com/Naturhistorisches.Museum.Wien

Twitter: https://twitter.com/nhm_wien

A very intuitive virtual visit of the galleries and its highlights is available at:

https://www.google.com/culturalinstitute/beta/partner/natural-history-museum-vienna

53.6 World War I and II—The Big Collections Crises

With the outbreak of World War I—or better the Great War, as it was known at the time—following the assassination of Archduke Franz Ferdinand, heir to the throne of the Austro-Hungarian Empire, by the Serbian nationalist Gavrilo Princip on June 28, 1914, the collection politics of the department changed drastically. Inventory books reflect a dramatic come-down of entries from several thousand objects per year in the early years of the twentieth century up to 1914 down to a few dozen during 1915–1918. Simultaneously, the international relations were cut. In the correspondence books, the war is reflected e.g. by the request of a copy vof a geological map of central Romania by the military geologists of 9th German Army under General Erich von Falkenhayn, following Romania's entry into war in 1916. The depressing situation continued after the end of the war for a decade until the collections started to increase again (Fig. 53.2).

The second collecting bottleneck with very low numbers of new acquisitions occurred during World War II. In contrast to many other institutions of Nazi Germany, the collections of Geological-Paleontological Department were not enlarged by Aryanization of Jewish property. Nevertheless, the inventory books document that six Jewish citizens sold collections of Mesozoic and Cainozoic rocks and fossils to the department (Riedl-Dorn 2009). These transfers were clearly not completely voluntary but resulted from the pressure by impending deportation. Although the objects concerned were of little scientific and economic value, their acquisition was an act of immorality. It was not until 1998 that the Austrian Parliament passed the Federal Act on the Restitution of Artworks from Austrian Federal Museums and Collections (Federal Law Gazette No. 1998/I/181), which also governs paleontological objects. Dossiers for each case were developed by the provenance researchers and forwarded to the federal Commission for Provenance Research. Based on these dossiers, an advisory council issued binding decisions on restitution of objects to the former owners or their heirs.

By the way, history is repeating itself—in July 1944, when the eastern front had already shifted to Romania, again geological maps of Romania were requested from the department by the Minister of Armaments Albert Speer. Like in World War I, this involvement of the paleontological department in the conflict was obviously not decisive for the war.

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Chapter 54
WIESBADEN: Museum Wiesbaden, Natural History Collections

Fritz Geller-Grimm

54.1 Historical Background

The natural history collections were first made available to the public on the premises of the palace of the crown prince of Nassau Wilhelm Georg August Heinrich Belgicus of Nassau (1792–1839) as a museum, initiated in 1829 by the Nassau Association of Natural History founded by citizens of Wiesbaden. Ownership of the collections was transferred to the city of Wiesbaden from 1901 to 1973 (Czysz 2004). With the growth and expansion of the collections, however, the museum required more space and a new building was constructed at the close of the nineteenth century. The collections final home is located today in the museum on Friedrich-Ebert-Allee. The structure, finished and furnished in 1915, was especially designed to house the three independent collections of antiquity, art, and natural history. In 1973, the State of Hesse united the collections to create a state museum (Geller-Grimm 2004). In 2009, ownership of the antiquities collection was transferred to the city of Wiesbaden. In 2013, the original exhibition rooms of the natural history collections were refurbished with a new face, while parts of the storerooms were renovated and the collections restructured (Geller-Grimm et al. 2015).

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54.2 Recent Collection

54.2.1 Structure

The natural history collections encompass basic geology, mineralogy, paleontology, botany, zoology and ethnology. In the absence of a university in the Duchy of Nassau, the collection and documentation of the region's natural world became essential. Yet from the very beginning, the collections incorporated specimens from other regions, as well. For example, the most significant of the founding collections encompassed natural objects from almost all over the world. Johann Isaak von Gerning (1767–1837) contributed one of the largest arthropod collections of the eighteenth century to the museum the year it was founded. With the foundation some first paleontological collections of the region were already included, in particular those from the Mayence Basin, the mountain chains further to the north, and the Nassau Quarries. Today's paleontological collections comprise around 55,000 fossils. Most of them were acquired in the nineteenth century and are distributed as follows: Palaeozoic 18,000 objects, Mesozoic 7000 objects, and Cenozoic 30,000 objects.

Focal areas of the collection are the regional deposits of the Mayence Quaternary Basin, especially the Mosbach Sands. The same applies to the Tertiary deposits on site. And finally, the Devonian of the Rhenish Slate Mountains makes up the largest collection.

The scientific collections are arranged in two main magazines, which could be renovated in recent years. At the beginning of the twentieth century a general collection was planned and realized in large part. Unfortunately, in the past it was not always possible to assume responsibility for the documentation entirely. As a consequence thereof, occasional problems with the identification of type material arise even today. To date, around 1400 specimens have been labelled as types, but it was not possible to gain completion as yet (Figs. 54.1, 54.2, 54.3, 54.4, and 54.5).

The current state of progress is extremely varying. This is particularly due to the absence of a paleontologist's office. Access is possible only by courtesy of voluntary workers like Dr. Doris Heidelberger, Dr. Jan Bohatý, Dieter Kadolsky, Charles Schouwenburg and Prof. Dr. Kirsten Grimm. On occasion, the museum cooperates with universities in the region, though not in a leading role, as the natural history collections can in most cases only serve as a custodian to science due to the nature of its infrastructure.

54.3 Recent Collection

54.3.1 Special Features

Amongst the most significant collections are those of Fridolin Sandberger (1826–1898) who was the curator of the Museum of Natural History at Wiesbaden from 1849 to 1854. His two major works pertaining to the Wiesbaden collection are: "*Beschreibung und Abbildung der Versteinerungen des rheinischen Schichtensystems*"

Fig. 54.1 The Time room. Photographer: Bernd Fickert, Museum Wiesbaden

Fig. 54.2 A view of the Mosbach sands display cabinet. Photographer: Bernd Fickert, Museum Wiesbaden

[“*Description and depiction of the fossils of the Rhenish stratigraphic system*”] (1848–1852) and “*Die Konchylien des Mainzer Tertiärbeckens”* [“*The Conchylia of the Mayence Tertiary Basin*”] (1858–1864). It was in Sandberger’s time that—in cooperation with conservator August Römer—the first main collection was also

Fig. 54.3 A further view of the Mosbach sands display cabinet. Photographer: Bernd Fickert, Museum Wiesbaden

Fig. 54.4 Molar of a mammoth. Photographer: Ed Restle, Museum Wiesbaden

established. On the one hand, it comprises a large number of Devonian fossils from the Rhenish Slate Mountains, which are exceedingly valuable owing to their richness in types. On the other hand, the Tertiary molluscs of the Mayence Basin are of great significance too. The “Mosbach Sands” are the third focus, since the oldest collections which exhibit a high species diversity and originate from fluviatile sediments from the Early and Middle Pleistocene period of the surrounding area are found in Wiesbaden. The name of Mosbach goes back to a village which was first incorporated

Fig. 54.5 A view of the Mayence Basin display cabinet. Photographer: Bernd Fickert, Museum Wiesbaden

into Biebrich and later, in 1926 into Wiesbaden. Until a decade ago sand, gravel and lime were mined in numerous quarries. So for instance, the Dyckerhoff corporation obtained the Portland cement from Miocene Hydrobia deposits in the Kastell Quarry. In 2015 it was possible to purchase a Devonian collection from Hans-Peter and Uwe Hein. These fossils, originating from Bergisches Land, have a direct relationship with Sandberger's collections.

54.3.2 Exhibitions

Today's two-department house for Art and Nature affords an opportunity to address phenomena which are important to natural scientists and artists alike: colours and forms in Nature, movement, time, and transformation.

The history and success of natural sciences are largely owed to the enlightenment as well as progress in the art of illustration. Therefore, it is the main purpose of this new presentation to encourage visitors to carry out their own research using a drawing pencil.

In the exhibition hall which was newly adapted to the "Time" theme in 2013, three regionally-significant areas are on display: the Quaternary with the Mosbach Sands, the Tertiary of the Mayence Basin and the Devonian of the Rhenish Slate Mountains. Visitors are provided with basic information and can subsequently get an idea of the thematised period of time through their own research. By reference to several reconstructions they can compare their own conceptions and possibly come to a new understanding. In the entire natural history department of the museum visitors are offered clipboards for the purpose of making drawings. They serve above all the gain of knowledge.

In the years ahead, a fifth themed room will be created to represent another general phenomenon. There are plans to convert the entrance hall of the museum into an exhibition on the subject of transformation in Nature. In the case of paleontology the theme will be fossilisation.

54.3.3 Perspectives

The natural history collections of the Hesse State Museum of Art and Nature have a transregional and, in part, regional focus. As such, the natural history collections hold a special position in Germany between larger institutions with a primary focus on research and the far more plentiful, small-scale museums with a primarily local emphasis. The latter often do not employ specialist staff, while the former employ highly qualified expert staff. Although the curators of the Wiesbaden Museum can be regarded as generalists, creating a new post for a paleontologist is urgently required.

In recent years all of the previous exhibition rooms could be reclaimed and equipped.

More than 800 out of 2500 square metres have been made available for special exhibitions. In this way it is possible to bring up to date and present more specific themes.

Wiesbaden is now well under way thanks to the funding by the management and the State of Hesse in recent years, and able to fulfill its responsibilities in large part.

Acknowledgments Sincere thanks are given to the colleagues of the natural history collections for their support and to Dr. Staci von Boeckmann, Dr. Elke Pischtschan and Mrs. Kathryn B. Johnson for their help with the translation. We would also like to thank editor Prof. Dr. Lothar A. Beck most sincerely for his initiative with regard to this project and its realisation, as a current overview is exceedingly helpful to researchers and all of the scientific collections.

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Chapter 55
ZURICH: The Geological-Palaeontological Collection at ETH Zurich

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55.1 General Information

The origin of the Earth Science Collections at ETH (Eidgenössische Technische Hochschule) Zurich date back to the collection assets of the Naturforschende Gesellschaft in Zurich (www.ngzh.ch, founded in 1746). These were acquired by the canton of Zurich in 1837 and soon after were integrated into the University of Zurich collections (www.uzh.ch, founded in 1833). After the foundation of ETH Zurich in 1855, the earth science collections were administrated jointly by the University of Zurich and ETH (formerly Polytechnikum). However, following a separation agreement in 1909 the collections were divided according to topics and provenance: the zoological collections of extant and fossil vertebrate species went to the University of Zurich while the majority of invertebrate fossils, the palaeobotanical holdings, the entire geological collection and the mineralogical collection went to ETH. Today, these collections are structured into three parts: the Geological-Palaeontological Collection, the Mineralogical-Petrographical Collection and the Relief Map Collection containing terrain models. The combined parts known as the Earth Science Collections are managed by ETH-Bibliothek in cooperation with the Department of Earth Sciences (Habel and Wiederkehr 2015). As an integral part of the natural science collections at ETH, they constitute an A-object (i.e. national

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significance) in the Swiss Inventory of Cultural Property of National and Regional Significance. Although the Earth Science Collections survived the two World Wars intact, they were damaged by a fire in 1990 and required major renovation works to clean the soot off the minerals and fossils.

55.2 Collection Contents and Structure

The Geological-Palaeontological Collection at ETH contains more than 500,000 fossil specimens from most parts of the world with a predominance of insect and plant taxa. It includes a large number of types and figured specimens (>2000). Fossils are housed in approximately 10,000 drawers (Fig. 55.1a) within mobile shelving systems at three separate locations at Naturwissenschaften Ost (NO) and Chemie Altbau (CAB) buildings on ETH's Zentrum campus and in the Heizzentrale (HEZ) building on the Hönggerberg campus. The collection is not open to the public; however, in the early days of ETH, the Geological-Palaeontological Collection was a prominent feature in the original Hauptgebäude (HG) and later in the NO building (Fig. 55.1b).

Selected specimens from the collection are on display in the permanent public exhibition of *focus*Terra, ETH Zurich's Earth Science Research and Information Centre (www.focusterra.ethz.ch, Fig. 55.1c). In addition, the Geological-Palaeontological Collection has an open access online database (http://geo-coll.ethz.ch/) which is linked to the international data exchange portal GeoCASe (http://www.geocase.eu/). Images on the E-Pics Earth Science Collections catalogue (http://ews.e-pics.ethz.ch) include photographs from the Oswald Heer Collection (around 1300 photos), the Albert Heim Collection (around 1100 photos) and the Gotthard Tunnel Collection (around 60 photos).

The Geological-Palaeontological Collection includes seven partly overlapping sub-collections generally classified according to taxon, stratigraphy, geography or sometimes by collector:

1. The **Historical Collection** comprises material from 12 important collectors (Table 55.1). Much of the material in these collections has been illustrated in publications dating back to the 1840s and the collections are rich in type specimens. The most important part of the Historical Collection is Oswald Heer's Oehningen Palaeontological collection of insect and plant fossils. This is described in more detail below.
2. Specimens in the **Palaeozoological Collection** are mostly invertebrates from Switzerland and surrounding regions of the Alps and Jura Mountains with a few from other parts of the world. The focus is on arthropods (mainly insects) and molluscs (mainly ammonites, gastropods and bivalves). Other invertebrates, such as echinoderms, trilobites, corals and sponges, are also represented. One of the highlights of the collection is the internationally recognised palaeoentomological collection of Oswald Heer (Fig. 55.2) with about 1000 fossilised insect species from Oehningen (Figs. 55.3 and 55.4). Another highlight is the Alphonse Jeannet ammonite collection from the iron oolite in the Herznach Formation

Fig. 55.1 (**a**) Current storage of specimens in mobile shelving systems. Note: drawers and type specimens are equipped with unique identifier barcodes so they can be managed in a digital database (image credit: Stefan Ungricht). (**b**) The Earth Science Collection in the atrium of the NO building ca. 1930 (image credit: ETH-Bibliothek Zürich, Image Archive). (**c**) *focus*Terra, the Earth Science Research and Information Centre of ETH Zurich, in the atrium of the NO Building today (image credit: ETH-Bibliothek Zürich, Frank Blaser)

(Fig. 55.5). From the smaller number of vertebrates housed in the Palaeozoological Collection, the most spectacular are the fossil fish from the Miocene sediment record of Lake Constance (Fig. 55.6). These fossil fish are part of the historical

Table 55.1 Twelve important historical collections in the ETH Geological-Palaeontological Collection (in alphabetical order by collector)

Collector	Taxonomic/geographic focus
Agassiz, Louis (1807–1873)	Fossil fishes
Appert, Otto (1930–2012)	Madagascar flora
de Loriol, Parceval (1828–1908)	Echinoidea
Desor, Edouard (1811–1882)	Echinoidea
Hantke, René (*1925)	Oehningen flora
Heer, Oswald (1809–1883)	Oehningen flora and fauna
Heim, Albert (1849–1937)	Geology of Swiss Alps
Jeannet, Alphonse (1883–1962)	Ammonoidea and Echinoidea
Mayer-Eymar, Charles (1826–1907)	Mollusca
Mösch, Casimir (1827–1898)	Swiss Ammonoidea
Oppliger, Fritz (1861–1932)	Sponges and corals
Rollier, Louis (1859–1931)	Invertebrata, Jura Mountains

Fig. 55.2 Bust of Oswald Heer in the old botanical garden of Zurich (image credit: Stefan Ungricht)

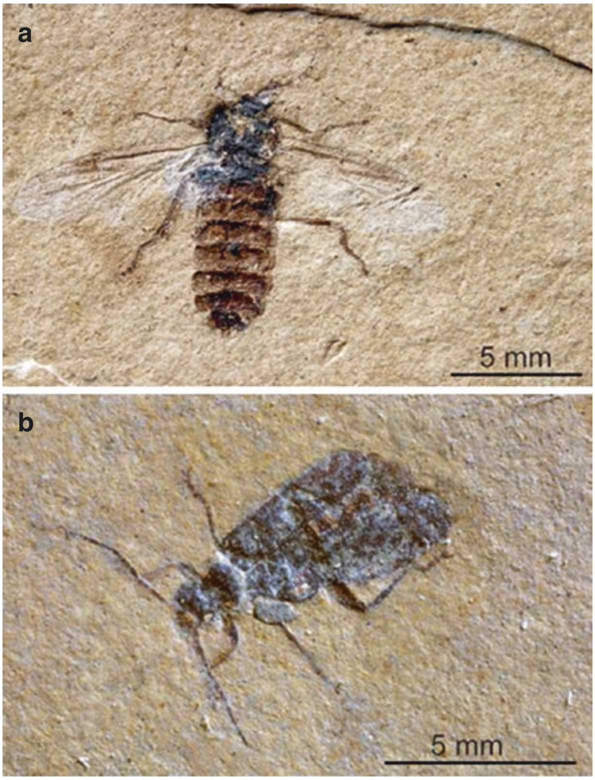

Fig. 55.3 Fossilised insects from the palaeoentomological collection of Oswald Heer, preserved in Miocene lake sediments from Oehningen. (**a**) *Bibio brevis* (Diptera). (**b**) *Telephorus fragilis* (Coleoptera)

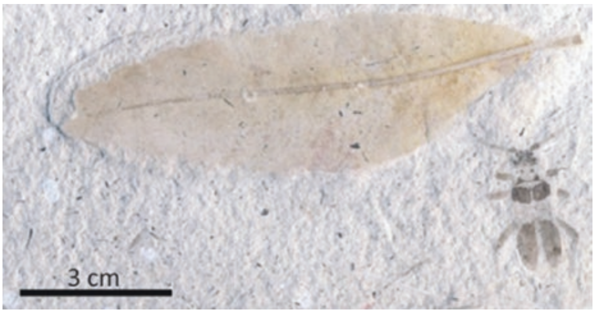

Fig. 55.4 Most fossils from Oehningen are insects and plants—this example shows the unusual combination of a laurel leaf (Lauraceae) and a long-horned beetle (Cerambycidae)

Fig. 55.5 Pyritised ammonite *Tenuisphinctes kruegeri* (Perisphinctidae) from the iron oolite in the Herznach Formation (Switzerland)

collection of Louis Agassiz (1807–1873), who later went on to found the Museum of Comparative Zoology at Harvard University in 1859.

3. The **Palaeobotanical Collection** contains specimens of fossilised plants (Figs. 55.4 and 55.7a), especially leaf compression fossils and an extensive worldwide collection of fossilised wood, fruits and seeds. The focal point of the Palaeobotanical Collection is the material described by Oswald Heer and René Hantke. These objects include valuable fossils from Oehningen (Germany), Schämbelen (Switzerland), Madeira (Portugal) and from the Arctic Region.
4. The **Reference Collection** is a portfolio of several important holdings of exemplars, types and figured specimens. Material contents of the collection partly overlap with the palaeobotanical, palaeozoological and historical collections.
5. The **Regional Collection** contains objects from geological expeditions, research trips and samples from excavations such as the Gotthard Railway Tunnel (1873–1882). The most prominent items in the Regional Collection are the collection of Augusto Gansser (1910–2012) especially those from Southern Asia. In addition to the important collection from the first “Swiss Expedition to the Himalayas” (1936) in Tibet and Nepal with Arnold Heim, numerous specimens originate from Gansser’s research trips to Ladakh, Bhutan, Tibet, Nepal, Pakistan, Iran, Afghanistan, Greenland, Colombia and Patagonia.

Fig. 55.6 Miocene fossil fishes from the sediment record of Lake Constance at Oehningen. (**a**) *Leuciscus oeningensis* (Cyprinidae). (**b**) *Tinca furcate* (Cyprinidae)

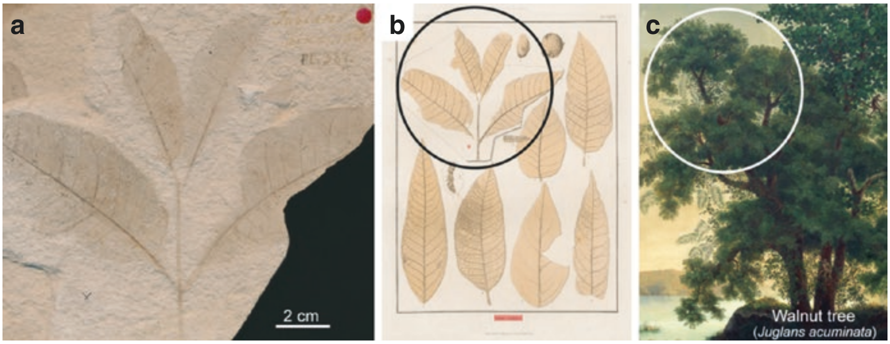

Fig. 55.7 (**a**) Fossilised leaves from a walnut tree, *Juglans acuminata* (Juglandaceae) in the lacustrine sediments of Lake Constance near Oehningen (DOI: https://doi.org/10.18748/ethz-a-000041992). (**b**) Scientific illustration from Heer (1855–1859) depicting the same leaves. (**c**) Artistic interpretation of the findings in the painting by Adolf Rudolf Holzhalb (Fig. 55.8)

6. The Geological-Palaeontological Collection contains several **Teaching Collections** on ETH's Zentrum campus including the Structural Geology Collection (focusing on the geology of Switzerland), a sedimentology collection, and a collection on Quaternary geology. There are also didactic collections on palaeobotany, weathering phenomena and bituminous rock. Albert Heim's historical teaching collection is particular noteworthy and has thus been digitised and is available online on the E-Pics Earth Science Collections catalogue (http://ews.e-pics.ethz.ch).

7. Lastly, the **Micropalaeontological Collection** contains microfossils from many international research projects such as the Ocean Drilling Program (ODP). This collection consists mostly of slides of fossil foraminifera, plant spores and pollen retrieved from marine as well as from lacustrine sediment cores.

Personal archives of papers, manuscripts, sketches, drawings, watercolours, photographs and letters from important geologists and palaeontologists are stored in the ETH archives. This includes extensive material from Albert Heim, Oswald Heer, Augusto Gansser, and Alphonse Jeannet. The personal papers index provides an overview of these holdings and can be viewed online at ETH E-Collection (http://e-collection.library.ethz.ch). Further information about the life and works of Palaeontologists may be found in our Earth Science library (www.library.ethz.ch). In addition, there is a collection of old, valuable and highly detailed geological maps including those of famous Swiss geologists (e.g. A. Gansser, R. Trümpy and R. Staub) that date back to the nineteenth Century.

55.3 Oehningen's Fossils—A Glimpse into the Miocene

"It is also safe to say that there is scarcely another site where fossils have been discovered in such a beautiful and natural condition, attracted general interest at such an early stage, and where the finds captured the attention of the entire academic world and promoted, fertilised and cemented the disciplines of geology and palaeontology, which were still in their infancy in the eighteenth and nineteenth centuries, to such an extent."

—*Stauber* (1939: 326, translated from German).

The Oehningen fossil site is located in the southwestern section of Lake Constance, close to the German village of Oehningen on the Swiss-German border. Around 13 million years old, the deposit dates back to the Upper Freshwater Molasse (OSM) during the Miocene. We owe the extraordinary variety of fossilised plants and animals and their excellent condition to the calm and at least intermittently oxygen-deficient sedimentation conditions with limy, marly sediments. Organisms were blown or washed in from the lake's surroundings and many are in excellent condition since they were preserved intact in the fine clayey lime sludge (Figs. 55.4, 55.5, 55.7, 55.8, and 55.10). A total of around 500 plant species and 1000 animal species, both aquatic and terrestrial were described for the first time from the quarries. The fossiliferous layers at Oehningen are located at depths of up to 8 m, but they have not been excavated for decades and today they are no longer accessible (Selmeier 1990).

Oehningen's significance as a fossil deposit and as an outstanding resource for interdisciplinary research was first recognised and then developed by three researchers in Zurich. In the early eighteenth century, the Oehningen layers and their fossils were studied for the first time by **Johann Jakob Scheuchzer (1672–1733)**, who as a believer in diluvian stratification interpreted the fossils as evidence of the Great Flood (Leu 2010, 2012).

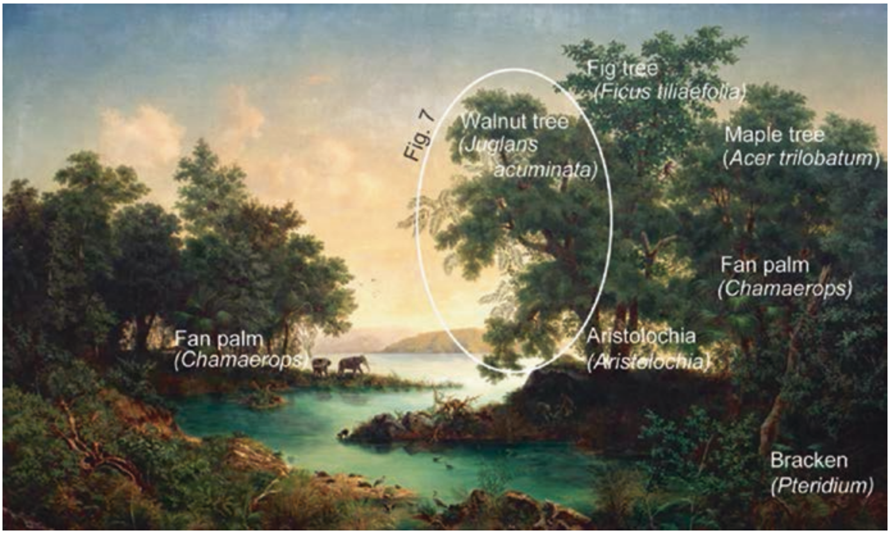

Fig. 55.8 The reconstructed world of the northern Alpine Foreland 13 million years ago. The monumental oil painting (3.5 m × 5.5 m) completed by Adolf Rudolf Holzhalb in 1871 is based on species described by Oswald Heer from the sediment record of Lake Constance near Oehningen. The original painting can be viewed at *focus*Terra (DOI: https://doi.org/10.21263/ethz-a-000000309)

In the nineteenth century, European palaeontology was strongly influenced by the great **Oswald Heer (1809–1883)**. Urged by his friend and mentor Arnold Escher von der Linth—Zurich's first geology professor—Heer turned his attention to the Oehningen fossils (Heer 1846), spending many years describing and depicting both the insects and the plants in detail (Heer 1847–1853, 1855–1859). The majority of these fossils are housed in the Palaeontological Collection at ETH. Heer described his scientific results - a portrait of prehistoric times in this part of our world - in his popular work *Die Urwelt der Schweiz* (Heer 1865, 1879/1883). The work was highly regarded worldwide and soon translated into English and French. In 1871, on the basis of Heer's descriptions, drawings and environmental reconstructions, Adolf R. Holzhalb, a professor for landscape painting at ETH Zurich, produced the monumental oil painting "Oeningen zur Miocenen Zeit" (Fig. 55.8). Hence, Heer's influence extended well beyond mere classification. His extensive collection and interdisciplinary interpretations became a cornerstone of research on the changes in climate and the diversity of life forms in prehistoric times. Heer's work was extended in the twentieth century by **René Hantke (*1925)**, who conducted research on palaeoclimatic, palaeoenvironmental as well as the palaeobotanical conditions in the Miocene based on approximately 15,000 plant remains from the Oehningen region (Hantke 1954).

Based on the holdings at ETH and insights of the aforementioned researchers, the character of Oehningen and of the northern Alpine Foreland around 13 million years ago can now be visualised. The climate is presumed to have been warm temperate to sub-tropical and rainy with an Atlantic influence (mild winters and

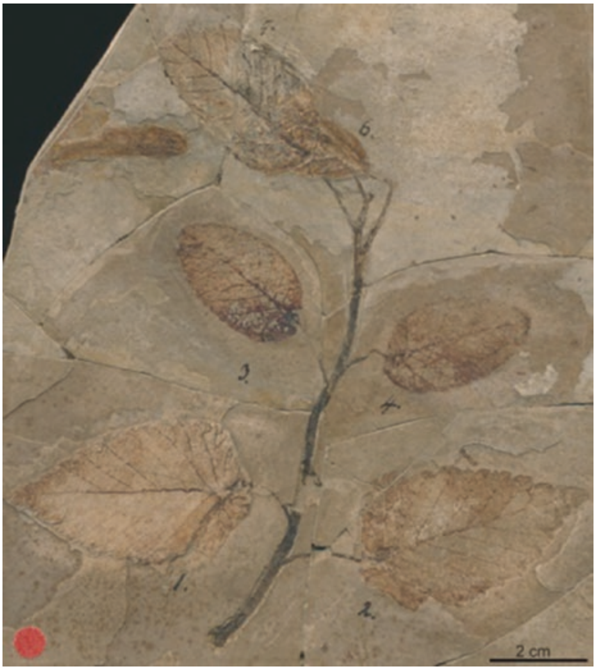

Fig. 55.9 Example of a palaeontological forgery composed from parts of three different species. Leaves 1 and 2 serve as a syntype and isosyntype for the hop-hornbeam *Ostrya oeningensis* (Betulaceae) described and depicted by Oswald Heer (Ungricht et al. 2013)

summers that were not too hot). The environmental conditions and the character of the vegetation corresponded to that of large parts of what is now south-eastern North America. As Mägdefrau (1968) suggested, the vegetation in Oehningen was also comparable to the evergreen laurel forests of Madeira and the Canary Islands.

Stauber (1939), Mägdefrau (1968) and Selmeier (1990) note that many fossils from Oehningen can also be found in other museums. Besides ETH, important collections are housed in the State Museum of Natural History Karlsruhe; Rosengartenmuseum Constance; Museum zu Allerheiligen Schaffhausen; Palaeontological Institute and Museum at the University of Zurich; and Heimatmuseum Höri-Fischerhaus Wangen. In addition, the nineteenth century natural history dealers Bernhard and August Schenk sold Oehningen material all over the world. Fossils from Oehningen therefore also had a monetary value, so numerous forgeries (i.e. fabricated composites, Fig. 55.9) were sold (Pfannenstiel 1958; Ungricht et al. 2013).

55.4 Teaching Activities and Public Outreach

Specimens from the Teaching Collections are regularly used for classes in Palaeobotany, Quaternary Geology and Collections in the Context of Science. The Geological-Palaeontological Collection represents an archive of the history of the earth and gives insights into all kinds of geological processes, thus a significant proportion of the objects in the collection has been digitised and can now be accessed online. In addition to this online database, we organise tours and talks that form an integral part of the collection activities. In these events, we showcase our most visually stimulating specimens and explain basic questions for a non-specialist audience, such as how the specimens were formed, how they got to where they were collected, which methods can be used to address research questions, and many more. For school classes and public groups, selected exhibits from the collection are presented in display cases in the permanent public exhibition of *focus*Terra. Furthermore, some textbook examples for students are shown in didactic display cases in the ambulatories of the NO building. Additional specimens are often used in temporary exhibitions on specific earth science topics at *focus*Terra.

55.5 Current Status

The scientific community continues to use our collection to answer key questions about geological processes as well as to reconstruct past climate and environmental changes. The main sub-collections used for research are:

- The Jurassic Ammonite Collection from the iron oolite in the Herznach Formation
- The Palaeobotanical Collection with its types and figured specimens from the Swiss Molasse
- The Palaeobotanical Collection with material related to Oswald Heer and Oehningen
- The Palaeoentomological Collection with fossilised insects from Oehningen, particularly the types of Oswald Heer.

The collection continues to grow through voucher material deposited from research projects and from donations. Current staffing levels maintain the status quo; however, to enable the outstanding holdings of the Earth Science Collections to be utilised adequately by future generations of researchers and the public, measures will need to be taken to index and conserve the originals, as well as present them digitally.

Tasks for the near future include high-resolution digital photography of all types and figured specimens to be viewed on the E-Pics platform (www.e-pics.ethz.ch). Another important task will be to georeference and digitise the old, highly detailed geological maps and to link them with the georeferenced locations of the most important specimens held in our collection. This will be of great benefit to the earth science students and researchers at ETH Zurich.

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Chapter 56
ZURICH: Palaeontological Museum of the University of Zurich

Christian Klug and Beat Scheffold

56.1 Foundation and Historical Background

The Palaeontological Museum of the University of Zurich is part of the Palaeontological Institute and Museum. It was founded in 1956, but palaeontological objects were already prepared and exhibited before in the Zoological Museum of the University of Zurich. The roots of our collections date much further back to the eighteenth century: Many of the fossil specimens published by Scheuchzer between 1731 and 1735 are stored in our collections (Fig. 56.1), and some specimens are even on display. These specimens were later incorporated in the "Vereinigte Zürcher Naturhistorische Sammlungen" of the Zürcher Naturforschende Gesellschaft, which was founded in 1745 by Johann Gessner. After a time interval of administrative dubieties, geological objects and fossil invertebrates were distributed to the geological collections while vertebrate fossils became part of the Zoological collections around 1909.

1918 marks an important date in the history of the Palaeontological Museum, because then, Prof. Bernhard Peyer (1885–1963) obtained his habilitation (postdoctoral lecture qualification). He recognized the importance of the Triassic localities of the UNESCO world heritage site Monte San Giorgio in the canton Ticino in southern Switzerland. In 1924, Peyer began with scientific excavations of the exceptionally preserved vertebrates of this region. These excavations are still continued on a somewhat irregular basis, although today, these excavations are not organized by members of the University of Zurich anymore; instead, it is now Dr. Rudolf Stockar from the Museo cantonale di storia naturale di Lugano who is carrying out excavations. As far as the Palaeontological Institute is concerned, the research focus shifted somewhat from Triassic marine vertebrates to Mesozoic invertebrates in the

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Fig. 56.1 Incomplete skeleton with complete skull of the giant salamander *Andrias scheuchzeri* from the Miocene of Öhningen (Germany). This specimen was studied by Johann Jakob Scheuchzer. Based on this and other specimens, he suggested in 1726 that these are skeletons of children that drowned in the biblical deluge. In 1811, Georges Cuvier proved that the skeleton belongs to a salamander. Image and copyright: Lukas Linder

seventies under Prof. Hans Rieber and later to Permian and Triassic invertebrates and mass extinctions under Prof. Hugo Bucher.

In any case, the exhibits as they exist today were installed in 1991 (Fig. 56.2); it is planned, however, to modernize them in the next decade. The current palaeontological exhibits cover around 500 square meters. The main focus is on the exceptionally preserved vertebrates excavated on Monte San Giorgio (Figs. 56.3, 56.4, 56.5 and 56.6) and other exceptional Triassic fossils (Figs. 56.7, 56.8 and 56.9). Furthermore, there are show cases displaying the largest turtle of Switzerland (Fig. 56.10), Mesozoic invertebrates and fossils of important Swiss localities such as the "Landesplattenberg" of the Engi and Elm region in the canton Glarus. Some large palaeontological objects were also integrated in the Zoological exhibit: skeletons of a nearly complete adult as well as a fragmentary skeleton of a baby mammoth from Niederwehningen (canton Zürich) and a skeleton of a southern American

Fig. 56.2 Showcases in the Palaeontological Museum of the Univeristy of Zurich. Foreground: A Neoproterozoic stromatolite from Greenland. Show case on the right: *Ceresiosaurus*, Middle Triassic, Monte San Giorgio. Image and copyright: Christian Klug

Fig. 56.3 One of the few land-dwelling reptiles found in the marine deposits of Monte San Giorgio: *Ticinosuchus ferox*, the probably most complete skeleton of a rauisuchid, an early relative of crocodiles. Length: 2.50 m. Image and copyright: Christian Klug

Megatherium (giant sloth) with its reconstruction compliment the more familiar zoological objects. The latter reconstruction has become an icon of the Zoological and Palaeontological Museums. The two museums form a spatial unit whose administration is handled to a large part by the Zoological Institute in close cooperation with our institute.

The collections of the Palaeontological Museum of the University of Zurich hold an estimated number of about 250,000 specimens kept on nearly 600 square metres

Fig. 56.4 Photo of a model of *Ticinosuchus ferox*. Model, image and copyright: Beat Scheffold

Fig. 56.5 The iconic *Tanystropheus longobardicus* from the Middle Triassic of Monte San Giorgio. Length: 1.46 m. In this animal, which grew to a length of nearly 6 m, the neck made up for almost two thirds of its complete length. Its neck was rather stiff because of the long vertebra and the very long cervical ribs. Before the discovery of complete skeletons on Monte San Giorgio, the isolated vertebra had been misinterpreted as arm bones of pterosaurs. Image and copyright: Christian Klug

of non-public collection space. Although the collections are world renowned for the vertebrates of Monte San Giorgio, we now have a world class collection of ammonoids with a main focus on the Triassic and Jurassic.

In addition to the museum and storage facilities, the institute has several labs for palaeontological preparation equipped with rock saws, sandblasters, air scribes, grinding machines etc., a wet lab for the preparation of embryos, a bone histology lab, a conodont lab, a micro-CT-lab, a 3D–lab with four workstations and a 3D–printer, and our own lecture hall with teaching collection.

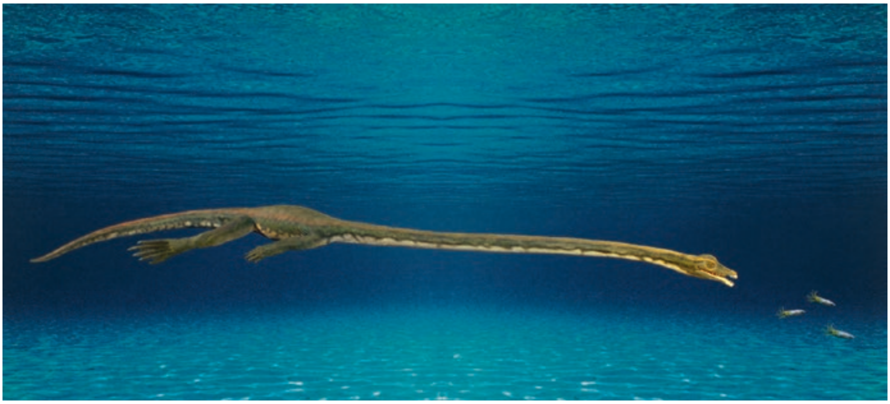

Fig. 56.6 Photo of a model of *Tanystropheus longobardicus*. Model, image and copyright: Beat Scheffold

Fig. 56.7 A huge vertebra of a Late Triassic ichthyosaur (family Shastasauridae) from the canton Grisons, discovered by Dr. Heinz Furrer. These giant, up to over 20 m long reptiles with fin-like paddles were perfectly adapted for the marine habitat and occurred in the seas around the planet. The owner of this vertebra was probably around 15–20 m long. Smaller representatives of this group occur also in Monte San Giorgio. Image and copyright: Christian Klug

At the moment, our institute's team consists of three preparators, one person in charge of the IT, one librarian, three collection assistants, two lab assistants, one museum receptionist, one MSc-student, 16 PhD-students, and five postdoctoral researchers. Heike Götzmann and Alexandra Wegmann are in charge of the administration. The scientific staff comprises Prof. Hugo Bucher, PD Dr. Winand Brinkmann, PD Dr. Torsten Scheyer, Dr. Hautmann and Dr. Schneebeli-Herrmann.

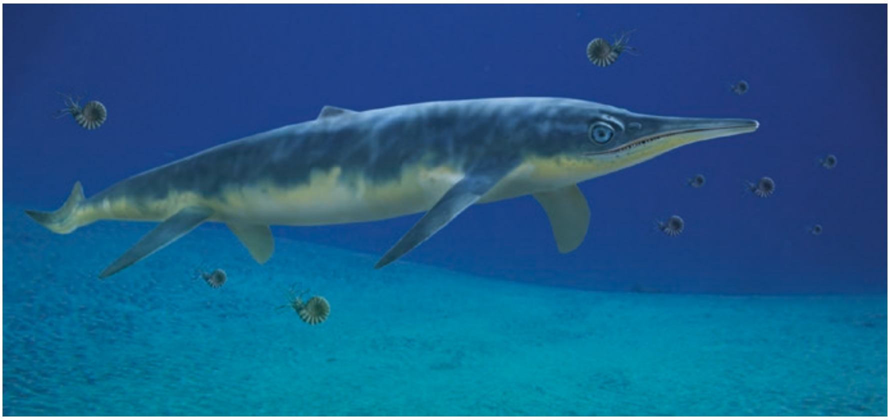

Fig. 56.8 Photo of a model of a shastasaurid. Model, image and copyright: Beat Scheffold

Fig. 56.9 Large gastropods, mainly of the genus *Gigantogonia*, from the Middle Triassic Esino limestone of Lombardia (Italy). Note the fine linear colour pattern. The largest conch is about 200 mm long. Image and copyright: Christian Klug

Fig. 56.10 The largest turtle of Switzerland: *Testudo vitodurana* from the Miocene of Schlieren. It was discovered during the construction of an underground bunker near Zurich in 1940. Image and copyright: Gabriel Aguirre Fernandez

Our team currently is directed by Prof. Marcelo Sánchez. Accordingly, this is the largest palaeontological institution of Switzerland.

Since these two museums are part of the University of Zurich and since this university is run by the canton of Zurich, it has been argued that university museums should not charge entrance fees. Thus, there are still no admission fees. Research funding is mainly provided by the Swiss National Science Foundation SNF. The museum is open every day except Mondays and some public holidays.

56.2 Research

As a university-based museum, a strong link between collecting activities, collection and exhibits to research activities existed from its beginnings, although the focuses constantly shift, depending on the persons carrying out research from MSc-students to professors. In its beginnings, research concentrated on Triassic vertebrates from Monte San Giorgio (Figs. 56.3, 56.4, 56.5, 56.6, 56.7 and 56.8) and other Triassic localities of Switzerland. Today, research on these fossils is still carried out, but other fields of research have become important, thus making research much more varied at our institute. Accordingly, we are working on topics of the entire Phanerozoic in our research and we have experts for most main groups of organisms, enabling us to cover the according fields in teaching and outreach as well.

Today, our institute comprises one workgroup researching the Permian/Triassic boundary and the main mass extinctions of that time as well as the rediversification processes. Invertebrate palaeontologists, vertebrate palaeontologists and palaeobotanists contribute their expertise to this research. Another workgroup concentrates on Paleogene and Neogene vertebrates from southern America. Evolutionary theory, ontogeny and evolutionary development are also important fields of research covered by colleagues of this second workgroup. A smaller workgroup explores macroecological changes of the Palaeozoic as well as cephalopod palaeobiology. Triassic vertebrate research currently deals with placodonts, ichthyosaurs (Figs. 56.7 and 56.8), early dinosaurs and the bizarre long-necked *Tanystropheus*, another iconic object of our institute (Figs. 56.5 and 56.6).

Although our institute does not have its own journal, editorial work of our staff is carried out for various journals including the Swiss Journal of Palaeontology and the Swiss Journal of Geosciences. In general, our scientific output is currently on a high standard with hundreds of articles published each year in many different international peer-reviewed journals of various fields.

In the last decades, several larger congresses were organized, namely the annual meeting of the German Paläontologische Gesellschaft in 1998, the British Palaeontological Association in 2013 and the International Symposiums Cephalopods—Present and past in combination with the International Symposium Coleoids Through Time in 2014.

56.3 Education and Outreach

The Palaeontological Museum offers guided tours and organizes monthly public talks on subjects related to palaeontology (in German). We also participate in the museum night, which is held on each first Saturday in September and in the outreach program “Scientifica”, held on the same weekend (both Federal Institute of Technology ETH and the University of Zurich contribute to this event).

Visitor counts are carried out jointly with the Zoological museum. In the past years, both museums had over 100,000 visitors and thus belong to the most visited museums in town. Kindergarten groups and school classes regularly use the opportunity to visit the museum, partially because there are no entrance fees.

Information on the Palaeontological Museum can be found on various websites in the internet:

http://www.pim.uzh.ch/museum/

http://www.museen-zuerich.ch/museen/museum/palaontologisches-museum-der-universitat-zurich

https://www.facebook.com/palaeontologicalmuseumzurich/

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Chapter 57
State Museum of Natural History Karlsruhe: Institute of Life and Earth Sciences

Eberhard Frey and H. Dieter Schreiber

57.1 History

The history of the State Museum of Natural History Karlsruhe (Staatliches Museum für Naturkunde Karlsruhe; Fig. 57.1), formerly the County Collections of Natural History (Badische Landessammlungen für Naturkunde), is tightly linked to the history of the City of Karlsruhe. Margrave Wilhelm von Baden founded Karlsruhe in the year 1715 as a planned, fan-shaped city and started a small natural history collection, which was housed in a small room of the castle. Already in 1760 the "cabinet of curiosities" of margrave Wilhelm had grown into a remarkable scientific collection and continued growing. Soon the collection required more space and was moved into the castle's drugstore.

The first person to scientifically promote the Karlsruhe natural history collections out of her own interest for minerals and fossils was margravine Karoline Luise (1723–1783). Together with her husband margrave Carl Friedrich von Baden-Durlach she expanded the collections to the recognised "Cabinet of Natural things" ("Naturalienkabinett"). Only a few items from these early days of the collection survived until today. Probably the most remarkable of them is a tusk fragment of the Efringen Mammoth that was first mentioned 3rd of February 1751 in the collection journal. The fragment was donated to the margraves by a Strasbourg pharmacist as "unicornu fossile", a fossil unicorn (Fig. 57.2).

The first official scientific curator of the "Naturalienkabinett" was the medical doctor and naturalist Carl Christian Gmelin (1762–1837). Under his curation the collections massively increased and consequently ran out of storage space again. Finally, in 1872, the collections moved into a new building, which was created as a

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Fig. 57.1 State Museum of Natural History Karlsruhe seen from Friedrichsplatz. The museum is at a five minutes foot walking distance from the city centre (photo Volker Griener)

Fig. 57.2 *Unicornu fossile*, tusk fragment of the Efringen Mammoth; this is the first specimen that was donated to Margravine Karoline Luise in the year 1751 (photo Volker Griener)

natural history museum, one of oldest worldwide. After having been destroyed during World War II, the building has rapidly achieved its former dimensions again. Its gates re-opened already in 1950. Today the State Museum of Natural history is one of the large natural history museums in Germany. The name "Staatliches Museum für Naturkunde Karlsruhe" ("State Museum of Natural History Karlsruhe") was established as late as 1989.

57.2 Exhibitions

With a few exceptions the palaeontology exhibition hall recapitulates evolution through time mostly based on fossils from regional localities such as the Triassic Muschelkalk and Buntsandstein, the Oligocene of Rauenberg and the Miocene of

Fig. 57.3 *Hatzegopteryx thambema* with a wing span of 11 m, the largest pterosaur model in the world (photo Volker Griener)

Höwenegg and Öhningen as well as from the Pleistocene of the Upper Rhine Valley. Fossils from other famous German localities fill the gaps: the Devonian of Central Germany, the Carboniferous deposits from Saarland and the famous Eocene Grube Messel at Darmstadt. All these localities are also well represented in the scientific collections, which however only form part of the entire scientific collections. An exception is the fossils from the Miocene of central Peru. The centre point of this exhibition part is the holotype of *Balaeonoptera siberi*, an about 8 m long mysticete.

A second hall with numerous fossils is the atrium in the central wing of the museum. Vertebrates, ammonites, crinoids and molluscs from the Holzmaden oil shale, numerous pterosaur fossils from Brazil and France and birds from the Eocene of Messel and the Oligocene of Rauenberg are on display but under scientific access at any time. Amongst precious original bird and pterosaur fossils an outstanding highlight of the museum is the largest pterosaur model in the world with a wingspan of eleven meters, which is suspended from the ceiling (Fig. 57.3). The main objectives of this hall are the evolution of birds and the life of pterosaurs.

57.3 Collections

The bulk of invertebrate collections are organised according to the stratigraphy. Dominating taxa are ammonites, especially ceratites, echinoderms, trilobites and corals. Worth to be mentioned is a small but precious collection of Cambrian fossils from China and the Canadian Burgess Shale. Insects from the laminated limestone of the Franconian Jura, chelicerates and chilopods and insects from the early Late Cretaceous Crato Formation (NE Brazil), as well as insects from the Palaeogene localities Céreste (France, Fig. 57.4) and Randeck Maar (Germany) form a separate collection complex that contains numerous holotypes. The Tertiary invertebrates also form a separate part of the invertebrate collections. Most of these were collected during a project that was carried out end 1980s, early 1990s.

The vertebrate collections are arranged in a taxonomical order and according to the localities. Much of the material has been collected during projects, some was obtained from the fossil market.

Some taxa are excellently represented from various localities, most importantly Actinopterygia, Sarcopterygia, Testudines, Crocodyliforms, Pterosauria, Aves and Mammalia. Most specimens come from the following localities, some of which are now closed: Devonian of Bundenbach and Odenspiel (Germany), Carboniferous of Bear Gulch (USA), Late Permian of Korbach and the Copper Shale of the Eder, Richelsdorf and Mansfeld regions (Germany, Fig. 57.7), Triassic of Kappel (Germany), late Early Cretaceous of Crato and Santana (NE Brazil), Eocene of Messel (Germany), Eocene of the Brule Formation (USA), Early Oligocene of Rauenberg (Germany, e.g. Fig. 57.5), Miocene of Höwenegg and Öhningen (Germany) and of Pisco (Peru) as well as from Pleistocene deposits of the Upper Rhine Valley (e.g. Fig. 57.6).

The State Museum of Natural history has a large palaeobotany collection ranging from Precambrian Stromatholites to Pleistocene wood and leaf samples. Highlights here are plant fossils from the Carboniferous of Saarland (Germany), Permian of Germany, namely the Copper Shale from the Eder, Richelsdorf and Mansfeld regions and especially the Geismar layers, the Eocene of Messel (Germany), and the

Fig. 57.4 Ceratite slabs, fossil seafloors from the Triassic of the Upper Muschelkalk, Eichelberg near Bruchsal (Germany; photo Volker Griener)

Fig. 57.5 Skull of the Merck Rhino (*Stephanorhinus kirchbergensis*); the skull was found in the year 1802 in the Rhine near Daxlanden and brought to the museum. The specimen represents one of the best preserved skulls of this species worldwide (Photo Volker Griener)

Fig. 57.6 Slab with *Pseudovoltzia* twigs from the Late Permian Geismar layers (Germany; photo Volker Griener)

Early Oligocene of Germany, namely the quarry field around Wiesloch and Rauenberg (Germany). The samples not only comprise wood samples, but also leaves and fructifications.

A small collection refers to life fossils such as ichnotaxa, especially from the Late Permian from Cornberg (Germany) and coprolites with a focus on the Eocene of Messel.

Fig. 57.7 One of the earliest known hummingbirds, *Eurotrochilus inexpectatus*, from the Early Oligocene Clay Pit "Unterfeld" at Rauenberg (Germany; photo Volker Griener)

57.3.1 Collection in Numbers

The collections of the State Museum of natural History Karlsruhe comprise approximately 55,000 invertebrates, 42,000 vertebrates, and 9200 palaeobotanical remains. However, the systematic evaluation of the collections is still under work. Final data are expected by end of 2019.

Suggested Further Reading

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