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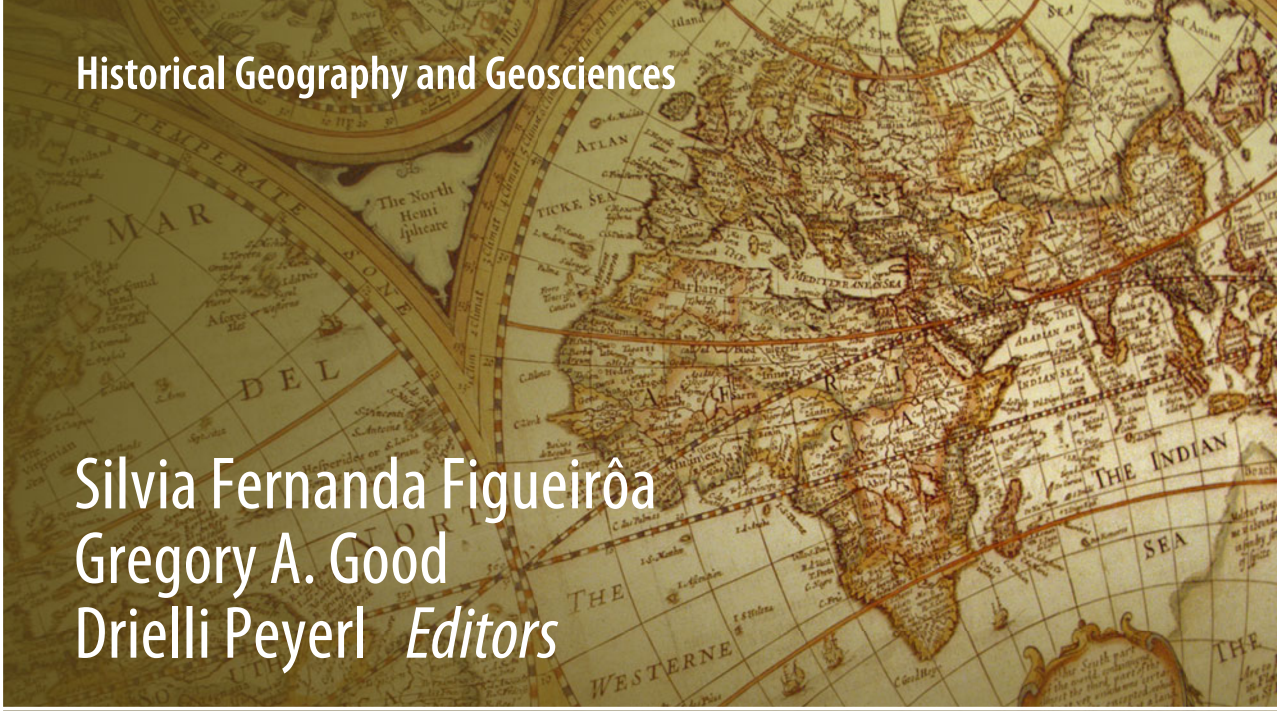

Silvia Fernanda Figueirôa
Gregory A. Good
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History, Exploration & Exploitation of Oil and Gas

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Silvia Fernanda Figueirôa ·
Gregory A. Good · Drielli Peyerl
Editors

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Editors
Silvia Fernanda Figueirôa
School of Education
State University of Campinas
(UNICAMP)
Campinas-SP, São Paulo, Brazil

Gregory A. Good
Center for History of Physics
American Institute of Physics
College Park, MD, USA

Drielli Peyerl
Institute of Energy and Environment
University of Sao Paulo
São Paulo, Brazil

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Contents

Introduction—Oil Geology in History

This book includes most of the papers presented in the symposium entitled *Black Gold: History, Exploration & Exploitation of oil and gas in national and international contexts*, sponsored by the International Commission on the History of Geological Sciences (INHIGEO) within the 25th International Congress of History of Science and Technology (Rio de Janeiro, RJ, Brazil, July 2017). The editors, also organizers of the symposium, invited other colleagues to join the project. The final result is now offered to both the academic and the general public.

The essays discuss scientific and technological aspects of the history of the oil and gas industry. As is known, the search for oil for industrial uses began in the nineteenth century, the first drillings made in Azerbaijan (Baku 1846) and the USA (Pennsylvania 1859). This intense search for a substance to become one of the most important energy sources was based upon ability as well as good fortune, resulting in knowledge and the development of prospecting and exploration technologies. The demand for oil improved expertise in geological science, in areas such as micropaleontology, stratigraphy or sedimentology and informed different disciplines such as geophysics. Developments made possible not only the discovery of new oil fields but new applications and methods of exploitation, too. Beyond the scientific and technological aspects, an industry that grew to such size impacted the political, economic, social, cultural, environmental and diplomatic issues of history. The book approaches such changes in different scales, countries, areas and perspectives, aiming at providing: (1) recent, updated analysis on a living subject; (2) broad geographical coverage (embracing three continents); (3) extensive temporal span (of about two centuries).

Editors intend to help fill up a gap in the available literature. A large body of the existing literature focuses on the economic and political aspects of the oil industry, somewhat less on its technical aspects, and even less on the more scientific questions of the origin of this mineral resource (Peyerl and Figueirôa 2016). The search through large academic databases surprisingly gives back few works specifically devoted to the history of petroleum geology. Some relevant papers, around 50 years old, are repeatedly cited, whether in other articles or technical books. That is the case of two of the far most cited papers, both authored by Marion King Hubert, namely: "History of petroleum geology and its bearing upon present and future exploration" (AAPG Bulletin, 50 (12), 1966); and "Degree of advancement of petroleum exploration in the United States", a chapter in the AAPG Special Series

"Degree of Advancement of Petroleum Exploration in United States" (1968). One also finds historical aspects in the "Sourcebook for petroleum geology", compiled by Robert Dott and Merrill Reynolds in 1969 for the American Association of Petroleum Geologists (AAPG). Last, the recent "Unconventional Petroleum Geology" (2012) by Caineng Zou includes ten pages on the history of petroleum worldwide, as well as in China. It is worth mentioning, also, the Journal *Oil–Industry History*, which has been publishing articles on the subject for about the past 20 years. In *Earth Sciences History*, it is possible, too, to find some papers dealing with the theme since the first volumes, published in the 1980s.

As it is known, controversies about the origin of oil were the focus of several debates and were especially frequent in the nineteenth and twentieth centuries, as a consequence of the fact that knowledge about oil, and its occurrence, became more widespread *pari passu* exploration increased. These debates classified oil simply as either organic or inorganic. Was it something that came from space during the formation of the earth? Alternatively, was it a thick fluid produced as a result of vast amounts of vegetation and animal remains buried in sediments for hundreds of millions of years? (Gold 1997, p. 13). Chemists, engineers and geologists engaged themselves in discussions defending one hypothesis or the other. In general, those involved in the USA and Europe strongly favored the biological origin of oil (Gold 1997, p. 13). In the former Soviet Union, however, much was written investigating both possibilities, as an attempt to resolve the debate. This discussion is not purely theoretical or as trivial as one might think at first glance, because it involves geological knowledge and thus interpretations of nature. It bears enormous economic impact as it directly affects the selection of areas for prospecting and exploration.

With many denominations—kerosene, naphtha, oil shale, mineral tar or petroleum—the discovery, either by itself or associated with other natural resources, demanded increasingly diversified and detailed studies of and research on so-called "black gold". The growing use of oil in different fields, roughly estimated to have happened around the Second Industrial Revolution, encouraged countries to start drilling their soil, for the discovery of an industrially exploitable well was half of what a nation needed to become economically independent. Roughly, one may say that we started within a monopolist coal-based system in the First Industrial Revolution and turned into an "oil (golden) era" in the twentieth century. Nowadays, the world is experiencing an inexorable energetic transition, during which the so-called "clean energies" are at the final goal. Nevertheless, the foreseen increase in the energetic demand for the next decade of around 22% indicates that it is still worth investing in fossil fuels (Lins and Pires 2018).

The collection of papers contained in this book brings specific, local facets to the general statements above. Readers will be led by Marianne Klemun to follow the efforts of nineteenth- and twentieth-century Austrian Empire, and by Martina Köbl-Ebert to Germany in the Cold War. On the North American side, Matt Silverman informs about the scandal surrounding Teapot Dome oil field that he calls "the most infamous presidential malfeasance of the early twentieth century". Those chapters demonstrate the imbricated technical, political, economic and even diplomatic issues involved in oil geology matters. Once arrived in Brazil, Margaret Lopes, Natasha Otoya and Silvia Figueirôa and Júlia Oliveira present the influential role played by the Brazilian government, whether in federal or state level, in the stimulus to both exploration and exploitation not only of oil but of other fossil fuels, too—and even alcohol as early as the 1920s. Prospection techniques, extremely relevant, are discussed in two chapters. Drielli Peyerl and Elvio Bosetti, on their side, disclose the making of the field of micropaleontology and its related community in Brazil. Particular topics related to perfecting the performance of exploration and exploitation, on the other hand, are at the core of the discussions conducted by Edmilson Santos and Drielli Peyerl, and Giovanna Gielfi, also illustrating the importance of partnership between oil companies and universities—a feature increasingly relevant in the present scenario. As a result, for instance, it made possible the extraction of oil from the Brazilian pre-salt deposits, whose production overcame the one from the post-salt reservoirs in June 2017. International relations and collaboration are a transversal feature across the chapters. Readers will find several repeated names throughout chapters, which are a patent, empirical testimony of the circulation of knowledge.

We hope that the inputs brought by this book will contribute, via the historical approach, to the discussions and collective, critical awareness of the weight of oil in our daily lives.

Silvia Fernanda Figueirôa
Gregory A. Good
Drielli Peyerl

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1 From Local to Global Petroleum Geology: Hans Höfer von Heimhalt's Contributions Between Empires, Economies and Epistemologies

Marianne Klemun

Abstract

The paper deals with three main publications at the beginning of the *coming into being* of petroleum geology contributed by the Austrian/Bohemian expert Hans Höfer von Heimhalt (1843–1924) in 1877, 1888 (often reprinted and translated in many languages), 1913–1919 in the context of his life and academic career in the Habsburg Monarchy. Trained at the Mining Academy in Leoben (Styria, Austria) and as professor at different mining academies within the Habsburg Empire and integrated in the *thought collective* of the *Imperial Geological Survey* in Vienna, Höfer's interest started with a local perspective on petroleum not in Europe but in North America after the Austrian Trade Ministry mandated his visit to the World Exhibition in Philadelphia 1876. There he encountered the new approaches in petroleum findings in the USA and published his first book about petroleum in North America (1877) in which he established his thesis about the causes of the origin and formation of petroleum, the anticlinal theory at the basis of his regional insight. Höfer's further books on petroleum represent the change from local surface indications to systematically applied petrology, sedimentology and stratigraphy to the search for hydrocarbon accumulations. Modern exploration methods and a worldwide mapping of all oil-known occurrences showed the global interest in this matter and the opening of doors to modern universal geochemical methods of exploration and the close connection between theory and practice, field geology and experiments.

M. Klemun (✉)
Department for History, University of Vienna, Universitätsring 1, 1010 Vienna, Austria
e-mail: Marianne.klemun@univie.ac.at

1.1 Introduction

Three early seminal publications on the *coming into being* of petroleum geology written by the Austrian/Bohemian expert Hans Höfer von Heimhalt from 1877 (Höfer 1877), 1888 (Höfer 1888, with further editions in 1906, 1912 until 1922) and 1913–1919 (Höfer 1913–1919) are the main focus of this article. When Höfer died in Vienna (Austria) in 1924, the *American Association of Petroleum Geologists,* founded in 1917, celebrated him as the most "eminent European petroleum geologist" (Wróblewski 1924, p. 534). Since 1973, the *Austrian Association for Oil Science* (*Österreichische Gesellschaft für Erdölwissenschaften*, ÖGEW), established in 1960, has recognised Höfer's lifetime achievements by naming its highest award (*Hans-Höfer-Medaille*) after him.

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Hans Höfer's (1843–1924) *fashioning of his self* (Biagioli 1993) as mining expert, geologist, teacher, professor, editor of mining journals, arctic explorer and petroleum geologist took place within different institutions and *spaces of knowledge* in the Habsburg Empire, mainly the *Imperial Geological Survey* (*k.k. Geologische Reichsanstalt*) in Vienna, the mining school in Klagenfurt in Carinthia (Austria) and the mining academies in Přibram in Bohemia (today Czech Republic) as well in Leoben (Styria, Austria). This was possible on account of his experience in different regions where he conducted his field studies. In 1876, he came into contact with the American petroleum industry by visiting the Philadelphia World Exhibition, and in subsequent years he developed a global contribution to oil exploration.

I will begin this paper with a brief summary of Höfer's biography, focusing mainly on the question of how his original regional interest in geology and mining turned into a profound and global expertise on petroleum and how he found his way from Carinthia (Austria) to the USA. I will show the impact of the *thought collectives* (*Denkkollektiv*) (Fleck 1980) of the *Imperial Geological Survey* (*K. K. Geologische Reichsanstalt*), in the principles of which he was integrated step by step. The *Denkstil* (Fleck 1980) and practices of this body framed Höfer's petroleum studies.

Historians of Science today are aware of the situational specificity of knowledge production and pay more attention to the stage where the real action of generating knowledge took place. Space is no longer seen as a neutral container where social life happens. It is, to use Martina Löw's definition, a sociologically determined phenomenon following a conception of space that is based on a social "action theory model" (Löw 2001, p. 131). This means that space inherits a relational dimension of activity as well as of ordering. For historians of science, it is now a category in terms of a "geography of science" that reveals "how scientific knowledge bears the imprint of its location" (Livingstone 2003, p. 13). It is a question of the setting and construction of knowledge in a given context and how it moves.

Most frequently, science starts at a local place or site and subsequently travels and reaches global and universal acceptance in a complex process of transformation. It moves by communication and circulation as knowledge "in transit" (Secord 2004). "The more local and specific knowledge becomes", Secord states, "the harder it is to see how it travels" (Secord 2004, p. 660). Every text, image, map and object we should analyse "as the trace of an act of communication" (Secord 2004, p. 661). Moreover, science also concerns physically and politically defined spaces which are far removed from the sites were they are produced. It is often based on or due to a broad range of intertwined intermediate levels and political notions such as region, territory, empire, state influence, economy and institutions as well as to their dynamics (Klemun 2012). These notions of space have to be taken into consideration in relation to each other in the mapping of Höfer's inputs.

In the second part of the article, I will develop some conceptual considerations related to Höfer's contribution to knowledge about petroleum, putting it in the context of epistemology, different lines of thinking and *thought collectives* (*Denkkollektiv*) (Fleck 1980), as well as of spatial scales between the Empires, the sites of production in the Habsburg Monarchy and that of the USA.

1.2 From Local to Global: A Brief Biography and the *Thought Collective* of the *Imperial Geological Survey*

Höfer was a scholar who travelled many different regions of the Habsburg Empire during his employment as a mining expert. He was born in 1843 in the small town of Elbogen in Bohemia (today known as Loket, in the Czech Republic). This was a town with about "9045 souls" (Sommer 1847, p. 3), mostly craftsman, and he was acquainted with the treasure of mining goods very early in his life in a region where iron, copper, zinc and vitriol (an archaic name for a sulphate) were extracted. In Elbogen (Loket), two porcelain factories were operated by the family of the Haidinger brothers and these employed more than 250 labourers (Sommer 1847, p. 3). The son of one of the brothers, Wilhelm Haidinger (1795–1871), made his career in the metropolis of the Habsburg Empire as the Director of the *Imperial Geological Survey* from 1849 on. It is not clear whether this possible connection led to Höfer's decision to study not at the Bohemian mining academy in Přibram but rather at the mining academy in the heart of the Empire in Leoben in Styria (Austria). After he had finished the courses of mining and metallurgy in 1864, he took up his first academic post as *Bergpraktikant* (Gattnar 1924) and was immediately appointed as the leading state official of the goldmine of Nagyág in Transylvania (today Romania). It was Franz Hauer (1822–1899), the second director of the *Imperial Geological Survey* in Vienna, who encouraged Höfer to undertake research. This is documented in letters he wrote at the *Geologische Bundesanstalt* to Hauer (Letters 1865–66), whom he greatly admired. At Nagyág, in 1865, he wrote his first paper, a study of the conglomerate of this locality (Höfer 1865). At that time he already dedicated his research, with many tributes (Höfer 1865, p. 334), to the geologist and second leader of the *Survey* in Vienna, Franz von Hauer, and also to Hauer and Stache's book about Transylvanian Geology (Hauer and Stache 1863). One year later, he enlarged his insight that the influence of neighbouring stones generates change in the ores (*Gänge*) and declared that trachyts belong to layers of "Cerethien", according to Hauer's approach. The *Survey* in Vienna appointed the 23-year-old Höfer to the status of *Bergwesen Expectant* and published again this paper that had already been published by the *German Geological Society*, now enriched with profiles and further arguments (Höfer 1866).

Höfer came thus closer to the *centre of calculation* (Latour 1987) of the experts in mining and geology in Vienna, a collective of scholars who dominated the scientific scene of geology in this period of the Monarchy (Klemun 2017). Höfer integrated himself emphatically in a *thought collective* that was framed by the *Imperial Geological Survey* in Vienna where field geology was dominant and which was quite different from the practices of petroleum geologists in the USA.

Two key aspects shaped the development of geology and the establishment of public institutions in the Habsburg Empire in this time: mining industries and natural history collections. As a result of the close relation between both, the *Imperial Geological Survey* (*k.k. Geologische Reichsanstalt*) was founded in Vienna in 1849 with repercussions on the (1) entire empire. The *Reichsanstalt* carried out a geological *Survey* of all territories of the Monarchy resulting in a unifying geological map (1867). The actors within the *Survey* and the court museums collaborated closely. Geology was triggered and accelerated not least by a gradual development of industrialisation processes during the nineteenth century. From the 1870s, geology no longer focused only on the empire and its provinces but took on a global perspective. From 1862, a growing number of university chairs of geology were established making the *new* academic discipline of geology visible. The internationally outstanding research work of Eduard Suess (1831–1914) contributed to this success story.

In 1865, Höfer moved to Přibram (today Czech Republic) where he worked on new methods of upgrading in the state-owned silver and lead mines. From here he visited the Bohemian coal deposits and the Silurian series (Gattnar 1924). His wish to become part of the *Imperial Geological Survey* (*k.k. Geologische Reichsanstalt*) in Vienna was granted, and he worked for this state institution in the region of the Hungarian–Galician border (today Western Ukraine) and in the High Tatra Mountains (Vysoké Mountains, today Slovakia). This was the last stage, within the *Imperial Geological Survey*, of Höfer's completion of the first geological maps of the entire Monarchy. These efforts and his cooperation with the chief geologist of the *Survey* in Vienna, Franz Foetterle (1823–1876), resulted in Höfer's first map showing the production of coal for the entire Austrian–Hungarian Empire (Foetterle and Höfer 1868). Already at this stage of his *Survey*, he remained not within a single area, as most of his colleagues had done, but rather progressed from a local perspective to one of the entire empire.

During the winter, Höfer attended the famous and inspiring lectures of Eduard Suess at the University of Vienna and those given by the geologist who mapped New Zealand, Ferdinand Hochstetter (1829–1884), at the *Technische Hochschule* (College of Technology) in Vienna, the forerunner of today's Technical University (Gattnar 1924). In so doing, he added theoretical insights to his practical experiences as a well-developed field geologist, guided by the most influential scholar and young geologist of the University of Vienna, Eduard Suess (1831–1914) and Ferdinand Hochstetter, who participated in the *Austrian Novara Expedition* (1857–1859) round the world. Höfer was remarkable for his desire to integrate into this group of geologists and for his ideas as a corresponding member of the *Imperial Geological Survey* (*k.k. Geologische Reichsanstalt*). This meant that he enjoyed high recognition within this particular *thought collective* (*Denkkollektiv*) (Fleck 1980), which was a very high-level field *Survey* group.

Höfer's new appointment as director of the newly founded mining school in Carinthia (Austria) in 1869 gave him the opportunity to combine theoretical and practical mining aspects and include them in the new curricula. When he took this appointment, the year 1868 had already yielded a turning point in the Carinthian mining industry: the *Hüttenberger Eisenwerks-Gesellschaft* was established, and private owners as well as state-run facilities of the lead and zinc mines formed a union (*The Bleiberger Bergwerks Union*). Miners and experts from Carinthia and Styria founded, together with Höfer as the leading scientific figure, the *Society of Mining* of Carinthia (*Berg- und Hüttenmänischer Verein für Kärnten)* and a journal. Mining industrialists were expected to contribute the financial maintenance of the school (Köstler 1990).

In Carinthia, Höfer addressed many different local research topics and wrote a book on minerals from the region (Höfer 1870) and on questions of the Ice Age (Höfer 1879). He also edited the journal of the *Society of Mining*. He travelled a lot, for instance to Montenegro, and he became part of the endeavour which followed the first famous *Austrian Expedition to the North Pole in 1872*, searching for the north-east passage to Asia (Klemun 1998). Based on this experience, he developed the first academic geography and geology of *Spitzbergen* (Svalbard) (Höfer 1874a, b). Höfer was recognised now by the public as a hero and adventurer who was celebrated in many festivities and public print media. Within the local Museum Club in Carinthia (*Verein Naturhistorisches Landesmuseum*), he even gave lectures for women, in January 1874, about his adventures in the North (Klagenfurter Zeitung 1874, January 8). He not only popularised his experience in the Arctic, but he also advocated systematic research about glaciers in the Habsburg Monarchy after the model of Swiss policy.

Famous in the Monarchy for being an Austrian scholar with a wide academic horizon on geographical matters and a unique expertise in practical mining as well as geological issues, he was commissioned by the trade ministry in Vienna to travel to the 1876 World Exhibition in Philadelphia in order to investigate the new and rapidly growing American oil industry (Höfer 1877). He later extended his knowledge of coal and iron mines and petroleum sites on his travels to England, France, Elba and Germany and became an expert in a wide range of topics regarding applied geology.

In August 1879, he was appointed professor of mining (*Bergbau und Markscheidekunde*) at the mining academy in Příbram (Wiener Zeitung 1879, Aug. 7). His fame increased the academy's reputation and two years later, in December 1881, he accepted an appointment as professor of mineralogy, geology and palaeontology at the Leoben Academy (today university) (Neue Freie Presse 1881, Dec. 7) where he later became vice chancellor from 1887 to 1889. During this time in Leoben, Höfer increasingly concentrated on petroleum studies (Höfer 1888). Within about thirty years, he visited most of the petroleum sites in Europe and also travelled to the Caucasus

Mountains and the Baku region in 1897 on his way to the Geological Congress that took place in St. Petersburg. His expertise in applied geology enabled him to address water access problems of many cities in the Austrian Monarchy such as Pola (today Slovenia) and Leoben. For 43 years, he was the editor of the *Austrian Journal for Mining and Metallurgy*, the main periodical in this field of knowledge in the empire. But it was more than simply a journal for the Empire: he also integrated information about innovations from many other countries. A total of 15 books and more than 150 articles accompanied his profession as both professor and diligent editor. In 1910, he gave up his professorial teaching post, moved to Vienna and joined the *Geological Society*. Until the end of his life, he dedicated his academic career to petroleum research.

1.3 The World Exhibition in Philadelphia: Höfer's Coming into Touch with Petroleum

To sum this up, we may conclude that Höfer led a fulfilled life with extensive travel activities. Trained at the Mining Academy in Leoben (Styria), his interest focused on different topics of geology and mining. He started with a local perspective on petroleum only, triggered by his visit to the 1876 World Exhibition in Philadelphia. The Austrian agriculture and trade ministry had commissioned him as an expert geologist to investigate the mining industry and its impact and also new approaches to petroleum research in the USA. After his field trip, he published his first book about petroleum in North America in 1877 (Höfer 1877).

Until then, there was no information in German on this increasing new industry and on American petroleum geology, apart from some isolated economic details published in a few newspapers on the oil boom and the increase of oil imports from the USA to Europe for lighting purposes. Although within the Habsburg Empire in Galicia (today Ukraine) petroleum has been discovered after 1810 and produced for lighting lamps, and this industry was indeed very successful, the government of the Habsburg Empire did not pay much attention to a deeper *Geological Survey* until World War I. From an economic point of view, there was only a slow upturn. The first attempts at distillation by Abraham Schreiner in Drohobycz led to the construction of a refinery in Chorwórka (in Poland) in 1852. But domestic production could not meet demand, and for this reason American oil began to make inroads in the Austrian market, being shipped from Hamburg up the Elbe. The state policy of import duty led to constantly rising customs charges on petroleum imports, and in an age of economic collapse, after the wars of 1859 and 1866, this led to a crisis which could only slowly be overcome. It also brought about a stronger growth in crude oil extraction from the 1880s (Szeczapanowski 1898; Good 1984).

Nevertheless, in the 1870s Austria was the third biggest petroleum producing economy after Russia and the USA. And in order to facilitate an increase in oil production, Höfer was sent to the World Exhibition in Philadelphia in 1876 to gather administrative, industrial and technical knowledge and transfer it back to the Austrian Empire.

Höfer was already part of the *Committee of the World Exhibition* in Vienna in 1873 (Wiener Weltausstellungszeitung 1872, Feb. 22). How did contemporaries respond to this kind of event? Let us examine the description by the Professor of Political Science in Prague, Karl Thomas Richter, who began his treatise on *The Progress of Culture*, a paper which is dedicated to the World Exhibitions and deals in particular with the Viennese event of 1873:

> Wherever one was looking in the wide spaces of the World Exhibition, to whichever Gallery of the Industrial Palace one went, one observed rich objects of the first group of the world exhibition, the materials from the realm of minerals, of mines and steel and iron works; the coal, iron and steel treasures of Europe´s cultural states; the mineral and metal treasures from Turkey, Persia and India were all presented. Most significant, and dominated by the clear spirit of science, were the coal, iron and steel exhibits from Germany, with Freiberg in Saxony, the University of German Mining, being at the forefront. (Richter 1877)

This statement gives evidence of the contemporaries' new view of raw materials, which will also be the topic of the following explanation of Höfer's activities. It has often been emphasised that World Exhibitions displayed nationalism, imperialism, consumption and technological rise so to speak as their incarnation (Kretschmer 1999). They are showpiece productions of historicism and the sciences. Both semantically and in terms of visual monumentality, abundance, speed, figures, statistics, expansions, sensations, novelties and topicality are all interconnected to form a phantasmagoria. This statement is super-elevated by the insignia of the new age, steel or iron and glass, both given their significance by the construct of progress. Under the roofs of industrial halls as particularly technological implementations and supported by lighting effects, exotic ornaments, both goods and machines, but also goods of knowledge of the most different kinds were presented. These "places of pilgrimage to the fetish of goods" (Benjamin 1991), as Walter Benjamin called the exhibitions, offered a kind of education by way of entertainment, edification by way of displaying knowledge as well as patterns of competition and comparison of the European nation states that served the development of identities. And something else that they offered was a stage for training and propagating a new concept of resource, connecting national uniqueness, availability and technological feasibility as never before in history. Impressed by the approach of the Exhibition in Vienna in 1873, the ministers felt obliged to find somebody who was able to attend the next event and describe new American petroleum industry that had developed so rapidly. In the first instance, Peter Tunner (1809–1897), director of the Leoben Academy, was chosen, but he surrendered the opportunity to Höfer. The state bureaucracy was eager to know more about the provinces in the USA which owned oil (Neue Freie Presse 1876, May 1) and asked Höfer for a short report about his observations. Höfer was supposed to travel with the steamship *China* and depart from Liverpool for the USA.

When Höfer's report on the petroleum industry in North America was even printed as a book (Höfer 1877), it exceeded all the expectations of the ministry: Höfer's volume contained a history of petroleum knowledge in the USA, with statistics about prices and production levels. Much of this information and the map were based on a publication of Henry E. Wrigley and colleagues on the geology of the Pennsylvanian formations (Wrigley et al. 1875) who were greatly admired by Höfer. He was fascinated by the way in which geologists in America documented the layers: "We should also mention here that it is customary among American geologists to characterise the individual layers with sequential numbers—a procedure that seems highly commendable in that the numbers give us an immediate picture of the spatial situation of the layer" (Höfer 1877, 55). Höfer's book also included his own observations, a description of oil rigs and the pipeline transport system, together with an analysis of the production of refined oil and by-products.

From a geological point of view, three aspects were important: first, in contrast to most other geologists of his day, Höfer believed that animal rather than plant remains were the original source of petroleum. Second, he was convinced that petroleum was probably based on the first deposit. Third, he defined the oil line—the line where oil concentrates and enrichments could be determined—by analogy to the anticlinal line.[1] Was Höfer the first to establish this theory or was this already known in the USA? We should take a closer look at this aspect.

1.4 Different Thought Collectives in Different Empires

It is worth mentioning that in the USA, chemists played a more important role than geologists in this line of research, which mostly consisted of laboratory tests of the crude oil from the seepages, to determine its commercial value, rather than of field surveys. As Frehner has argued, geologists in the USA had to fight for their

[1] An anticlinal is a fold with an arch-like shape and has its oldest beds in its core.

cultural and scientific recognition and it took from 1859 until 1900 before their reputation was established (Frehner 2011). In contrast, Höfer came from a country where geologists had close ties to the mining industry and the state *Survey* and were highly regarded by the government and the general public. Geologists of the Imperial *Survey* were even members of the Academy of Sciences (Klemun 2012). Höfer was a highly trained field geologist with practical skills as a mining expert and a man with a profound sense of duty towards society. His skills as a public writer were well developed. He made his own observations during his journey to the sites of oil deposits in North America. However, Höfer's first contribution to petroleum geology was not acknowledged as such in the USA.

Two different *thought collectives* (*Denkkollektiv*) (Fleck 1980) prevented a close cooperation between the Austrian geologist and his fellow scholars from the USA in this matter. In the 1860s and 1870s, oil studies in the USA, as elsewhere, were in their infancy, and geologists did not yet have precise knowledge on how to locate oil deposits. T. Sterry Hunt, E. B. Andrews and Alexander Winchell were among the early American actors in this area. Hunt (1826–1892) had been a chemistry student at Yale University taught by Benjamin Silliman, the leading chemist in oil studies. In 1847, he was appointed chemist and mineralogist of the *Geological Survey* of Canada. In this capacity, he observed that Canadian oil occurred "along the line of a low, broad anticlinal axis" (Merrill 1924, p. 400; Davenport 1951). This seemed to correspond with the findings of American historians of geology of the anticlinal fold associated with oil accumulation. "Hunt published his views in an article in the *Canadian Naturalist* of August 1861, and modern authorities claim that had he backed up his anticlinal reservoir theory with additional factual evidence based on actual field observation, he would have become an outstanding petroleum authority" (Davenport 1951, p. 27). According to a central European perspective, Höfer was the first in the German-speaking countries to develop the same theory 15 years later. Even if we concede that Höfer was not the original inventor, he did not know Hunt's article of 1861, and his contribution was based on his own observations from actual fieldwork and on strong, detailed arguments. He even quoted the geological and chemical essay written by Thomas Sterry Hunt in 1875, in which he did not mention the anticlinal theory (Höfer 1877, p. 89). Höfer extended his knowledge on oil sites in subsequent years and concentrated on European areas.

While Hunt was developing his theory in Canada, E. B. Andrews of Marietta College, Ohio, came to a similar conclusion, after he had examined the oil regions of Ohio and Pennsylvania, and this was published in December 1861 (Andrews 1861). However, neither his nor Hunt's report triggered the scientific debate that they deserved. John Franklin Carll (1828–1904), who was responsible for the petroleum department of the *Pennsylvania Survey* under J. Peter Lesley (1819–1903) from 1874 to 1885, regarded the belt-line theory the best of the old methods, but he was among those who demonstrated that it was not infallible (Davenport 1951). He described the belt method of oil prospecting as "an attempt, by means of compass lines, to keep on the axis of the sand deposit" (Carll 1886, p. 74), as shown by previous experience and oil well development (Carll 1877). It was unfortunate that the oil sands had been directed by the very unstable agent, water, and consequently had not been laid down on a straight and continuous line. This natural condition, he pointed out, was the fallacy in the oil belt theory. Unexpected breaks and curves in the oil sands and gravels made the application of a dogmatic formula of this type a risk and not a reliable guide in the search for new wells (Davenport 1951).

According to Carll, the best guides for the oil prospector were the rocks themselves. This was exactly what Höfer not only demanded for field geology in general but also applied in his own work. While Carll did not prematurely denounce the anticlinal theory, he was very sceptical of it and thought that it should be used prudently. He agreed with Alexander Winchell (1824–1892) that there should be a reservoir to hold the oil and a good impervious cover to prevent its escape.

Carll is known in the *Dictionary of American Biography* as the first geologist to describe thoroughly the structure of the Pennsylvania oil formations and as the creator of the geology of petroleum (Clendinning 1929). Carll's first report was published in 1875, two years before Höfer's book (Carll 1875). Later, in 1877 and 1886, other reports followed. In a lecture in 1908, Höfer, when he looked back, interpreted the arguments of Carll and other American geologists that he had not known at this time of his trip to the USA as a complete rejection of "his" theory:

> In Pennsylvania there was a tendency to derive oil from vegetable remains because it appeared to contain no nitrogen, the rich presence of nitrogen in the accompanying natural gases was overlooked. What was presupposed was a distillation of vegetable residue (algae) and a condensation of the vapours in higher–level sandstone ("oil–sands"), and because of this the anticlinal theory was simply rejected on the grounds that the oil–lines corresponded to ancient embankments. But soon the correctness of the anticlinal theory was recognised from another direction, by Orton and White; and the latter wrote to me later that Ashburner was also, until his death, a convinced supported of the anticlinal theory. (Höfer 1909, p. 137)

Both Carll and Höfer published their findings almost simultaneously, in some cases very soon after one another. This might have been why they frequently did not know about each other's works. It was left to Israel Charles White (1848–1927), the first state geologist of West Virginia, and Edward Orton (1829–1899) of Ohio (Orton 1887) to demonstrate and popularise the anticlinal theory after 1883 (Davenport 1951) although J. P. Lesley maintained his counterarguments. Orten pointed out that F W Minshall in Ohio was the first (Orten 1887, p. 51). White in particular was a prominent figure in the movement to convince oilmen that geological knowledge was indispensable to the economy of the industry. The fieldwork that he started in 1883 underlined this perspective.

Meanwhile, Höfer focused on summarising the knowledge and his own experience in another book on this topic with regard not just to a single region or country but to the entire planet (Höfer 1888). In this volume, he connected the history of exploration, stratigraphy and geological field knowledge, and also the exploratory efforts of 1888. He also included his three main theories, which he had already formulated in 1877, and extended his examples and arguments on a global scale. His unconditional support for the anticlinal theory made it the most successful explanatory concept ever, as Schollenberger has pointed out (Schollenberger 2007). What is also impressive are Höfer's comprehensive explanations of the history of the knowledge of petroleum since ancient times, and in these he shows himself to be a proven connoisseur of culture. Along with this book, Höfer published several articles on petroleum in different regions of the world: Madagascar, Alaska, Persia, Baku, Malaysia, the Island of Zante and Galicia.

Another of his paradigmatic insights was that the maturation processes of organic matter, which require high temperatures in laboratory experiments, could also be brought about in nature at lower temperatures, given sufficient time. At the same time, when Höfer drew on laboratory studies for his explanation of the origin of oil, American geologists turned away from this method and insisted that field geology was the most important method. Together with the German professor at the Karlsruhe Technical University, Carl Engler (1842–1925), who carried out trailblazing maturation experiments based on this concept, Höfer paved the way for modern geochemical exploration (Höfer and Engler 1913–1919).

In the course of the debates between German and Anglo-American geologists, it was no surprise that the Scottish geologist Edward Hubert Cunningham Craig, in the second edition of his handbook *Oil Finding* (Cunningham Craig 1921), criticised Höfer's contribution for the lack of field geology. Cunningham Craig represented a new generation of geologists and did not know that field geology was the most important but not the only method within Höfer's approach. Every year for one week, Höfer and his students travelled to a certain region for field-training purposes as part of his lecture programme at the Academy of Leoben, about which even the newspapers reported. He also published a guide with instructions for field geologists (Höfer 1916). It is an irony of history that by dismissing Höfer's theory of an animal origin of oil—and here Cunningham was right in his criticism—he also disqualified Höfer's innovative thoughts and experiments that paved the way for global exploration efforts and explanatory approaches.

It is more than likely that Cunningham met Hans von Höfer in person at the meeting of the *Institute of Mining Engineers* in London in 1914 (Cunningham Craig 1921). Although he considered him a scholar "with weight of authority and greater scientific care", he ridiculed Höfer's experiments by comparing his methods with "leaving a turkey long enough in cold storage [until] it will cook itself" (Cunningham Craig 1921, p. 22). Cunningham's sarcastic remarks on Höfer's approach from 1920 also had a politically disparaging tone by attributing them to a "Teutonic mind". Like German scientists, Austrian scholars were no longer invited to international conferences owing to Austria's geopolitical situation after World War I.

Höfer's handbook on petroleum *Das Erdöl und seine Verwandten* appeared as part of the compendium on chemical technology for the first time in 1888, and an expanded edition was printed in 1906 (1906). Until 1922, four editions followed. As early as 1895, an English and in 1922 a Russian translation were published. Höfer's book became a standard reference work, which shows that he was not only a "European petroleum researcher", as the American Association of Petroleum Geology conceded it in a limiting way (Wróblewski 1924, p. 534), but a petroleum geologist of a global standing. This book appeared at a time when oil extraction and production in Galicia, between 1884 and 1896, increased a 100-fold because of the introduction of improved drilling methods and the development of new oilfields, oil could now also be exported, accompanied—admittedly—by a simultaneous drop in price (Brusatti 1973; Frank 2005).

Höfer intensified his research and, together with Engler, edited five volumes on petroleum occurrences and global technologies of petroleum extraction (1913–1919). He himself contributed one volume to geology and transportation within this handbook (Höfer 1914). In a lecture given at the Geological Society in Vienna in 1908 (Höfer 1909), Höfer proposed finding an answer to the question of why the sudden death of fauna had occurred. This shows that he was influenced by biological discussions raised by the Austrian palaeontologist Melchior Neumayr (1845–1890), one of the most famous Darwinists in palaeontology.

1.5 Summary

Höfer's contributions represent the change from local surface indications to systematically applied petrology, from sedimentary stratigraphy and the search for hydrocarbon accumulations to a global perspective. Modern exploration methods and a worldwide mapping of all oil-known occurrences have shown the global interest in this matter and the opening of doors to modern universal geochemical methods of exploration, and the close connection between theory and practice, field geology and experiments.

No matter if we call it *spaces in between*—Höfer was subjected to the hegemonic balance between the global powers. In terms of academic disciplines, he operated between the different knowledge spaces of mining sciences and field geology, between theory and experimental approaches, as well as technical issues, and combined them in the handbooks that he published together with Engler. As a scientist, he moved between different institutions and as a traveller between different national identities of the Habsburg Empire based on the *thought collectives* of the *Imperial Geological Survey* of the state, which was undergoing a transformation.

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2 History of Oil Exploration in the State of São Paulo Before the Foundation of Petrobras (1872–1953)

Júlia C. T. Oliveira and Silvia F. de M. Figueirôa

Abstract

This paper brings to light a still poorly known history, which demonstrates the technological and intellectual momentum of the geology of the State of São Paulo, before the creation of Petrobras. Although the results regarding the presence of oil in significant amounts were disappointing, relevant geological results were achieved, as well as technical advances. The initial steps of oil exploration in the State of São Paulo were linked to private entrepreneurs, and date back to the year of 1872. Exploration and research attempts took place in the hinterland localities of Morro do Bofete and Águas de São Pedro, through geological studies performed by naturalists, engineers and geologists. In the 1920s, surveys were performed by the Geographical and Geological Commission of São Paulo (CGG), in cooperation with the Brazilian Geological and Mineralogical Survey (SGMB). A special subdivision was created within the CGG in 1927, and the North American petroleum geologist Chester Wesley Washburne (1883–1971) was hired in 1928. The set of documentation used includes private and official letters, besides other types of historical documents, in custody of the Historical Archives of the State Geological Institute of São Paulo.

2.1 Introduction

The history of petroleum in the State of São Paulo, Brazil, despite its great importance in the development of the country, has not yet been adequately presented and remains little known. Although there are books and documents on the subject, some are not available to the public, as they are rarities, but even the available ones have not received due attention yet. Therefore, this text intends to give an initial contribution to the history of petroleum in the State of São Paulo before the Petrobras monopoly, discussing the geopolitical reasons, the characters involved, and the geology of the analyzed region. Our principal sources are printed, little mentioned, and archival documents (primary sources), especially from the former Oil Exploration Service of the Geographical and Geological Commission of São Paulo, belonging to the Historical Archive of the Geological Institute of São Paulo.

As it is known, the oil industry was born in the mid-nineteenth century. A valuable well was drilled in Baku in 1846 (Mir-Babayev 2011). In Scotland, James Young discovered that oil could be extracted from coal and bituminous shale, thus

J. C. T. Oliveira
ARANZ Geo Ltd., Santiago, Chile

S. F. de M. Figueirôa (✉)
School of Education, University of Campinas, Campinas, São Paulo 13083–865, Brazil
e-mail: silviamf@unicamp.br

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creating refining processes. In 1859, American Edwin Laurentine Drake drilled the first oil well in Pennsylvania. One believes this well to be the reason for the birth of the modern oil industry, as the production of crude oil in the USA increased from 2000 barrels in 1859 to approximately 3 million in 1863, and to 10 million barrels in 1874 (Brice 2009).

Brazil also sought to tune into the demands of its time. Around the last quarter of nineteenth century, a significant economic growth due to coffee production and exportation, which since the 1840s was the primary export product of Brazil, had impacted the country on many fronts. That incentive in the economy led to a process of a conservative modernization, which tried to select from the modern what would help to overcome the obstacles for development in various fronts (Dantes et al. 2011). According to these authors, there were, approximately, two central challenges to be faced: "land challenges" and "human challenges." The "land challenges" implied the conquest of, and control over the territory, either by rearrangements of land property, by geographic and natural resources surveys, or by the setting up of transportation and communication systems. The "human challenges" concerned the lack of workforce, worsened by the abolition of slavery in 1888. Scientific principles and practices, and progress-oriented theoretical schemes (mainly Positivism, Darwinism, and Spencerism) appeared to be the solution for those challenges. The Brazilian elites, greatly concerned with the integration of the country into the "civilized world," adopted them all. Indeed, technical progress was not something they were willing only to hear about, but a step to reach the status of Modernity (Dantes et al. 2011).

Since the time of the Empire (1822–1889), the possibility of oil in Brazil had already been considered (Vaitsman et al. 2001). As shown by Peyerl and de Figueirôa (2016), several discussions about the origin and uses of petroleum arose in journals, newspapers, and other loci of debate during the nineteenth and twentieth centuries. In parallel, the development and application of new techniques in the exploration of oil also began to appear. In brief, oil began to be perceived as a basis of economic prosperity and future development for the industry. In Brazil, even before finding it in commercial quantities, they named local oil as *Brazolina* (Peyerl and de Figueirôa 2016). By the end of the nineteenth century, the first drillings for oil happened, some of them in the State of São Paulo.

Paiva (1970) proposed to subdivide the history of oil research in the State of São Paulo into four parts, as follows:

- The first period started with the work of Eugênio Ferreira Camargo (1869–1919) at the end of the nineteenth century, and with studies by the Belgian naturalist and engineer Auguste Collon (1869–1949), who produced a report in 1897, published as a historical document by the Geographical and Geological Institute in 1970.
- The second period goes from 1921 to 1932 when the federal government began its research through exploratory drillings, and there was an incentive for private companies researching in this sector in Brazil. At that time, important names of Brazilian intellectual circles began to engage in the quest for petroleum, such as the writer Monteiro Lobato (1882–1948).
- The third period is characterized by the engagement of the São Paulo State government in petroleum research, for which they hired the North American geologist Chester Washburne. He worked for two years evaluating the possible existence of oil in the state. In 1930, he published the book *Petroleum Geology of the State of São Paulo*, as this paper will further discuss.
- The presence of the National Petroleum Council (CNP) and, subsequently, of Petrobras in western São Paulo marks the last period. Guided by Washburne's publications, the CNP searched for petroleum in this region from 1945. Petrobras would come to the scene in 1954.

In Fig. 2.1, it is possible to see all the sites where drillings were performed.

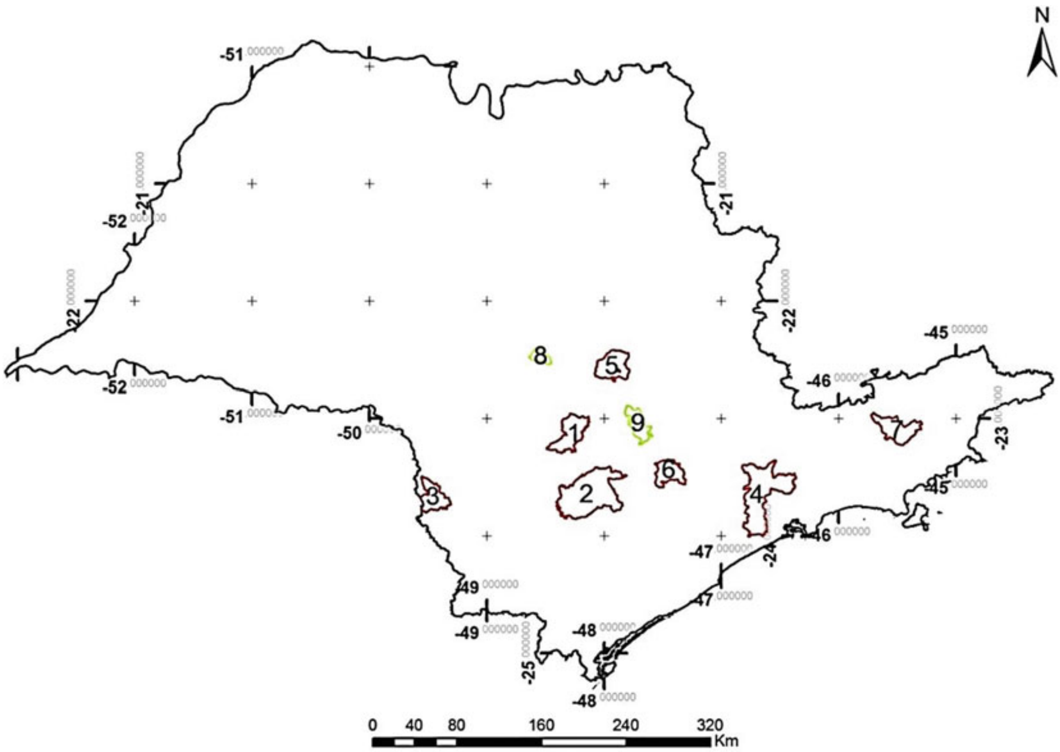

Fig. 2.1 Location map of oil research in the State of São Paulo from 1872 to 1953. Localities: 1. Bofete, 2. Bello Monte, 3. Piraju, 4. Ipanema, 5. Tietê, 6. Guarehy, 7. São Bento, 8. Xarqueada, 9. São Pedro. Original drawing by Júlia Oliveira

2.2 First Initiatives for Oil Research in the State of São Paulo

In 1897, when the Belgian Auguste Collon began his explorations in Morro do Bofete, in the region of Tatuí (about 150 km from the capital, the city of São Paulo), the geology of the State of São Paulo was still little known. This situation lasted despite the efforts of the Geographical and Geological Commission (CGG)—a Geological Survey that had been created about a decade before, in 1886 (Figueirôa 2007). All along its life, the CGG emphasized the economic value and the practical application of the investigations it undertook.

The economy turned around the coffee industry that was beginning to undergo a major crisis due to overproduction, which would lead the São Paulo government to seek alternatives and solutions. Collon settled in the Fazenda Brejão that may be considered as a center of scientific studies of the early nineteenth century (Felicissimo 1970, pp. 3–4):

> On February 11, 1897, in the splendor of the Fazenda Brejão, (…) where, along with the coffee culture, commend was given to the culture of the intellect, the young Belgian naturalist Auguste Collon of the University of Liège finished the last pages of his manuscript: 'Le Pétrole dans les environs du Mont de Bofete et de Porto Martins,' an initial milestone of the technical–scientific works dealing with oil in Brazil.
>
> Collon, a special guest of Eduardo Prado, surely found in that magnificent retreat, which he called 'Station Scientifique du Brejão,' excellent conditions for moments of quiet meditation, or heated discussions and gatherings with maximum exponents of the Brazilian geology, represented by the conspicuous trinity [Orville] Derby/Gonzaga de Campos/Paula Oliveira of the Geographical and Geological Commission of São Paulo, who were several times mentioned in his manuscript.

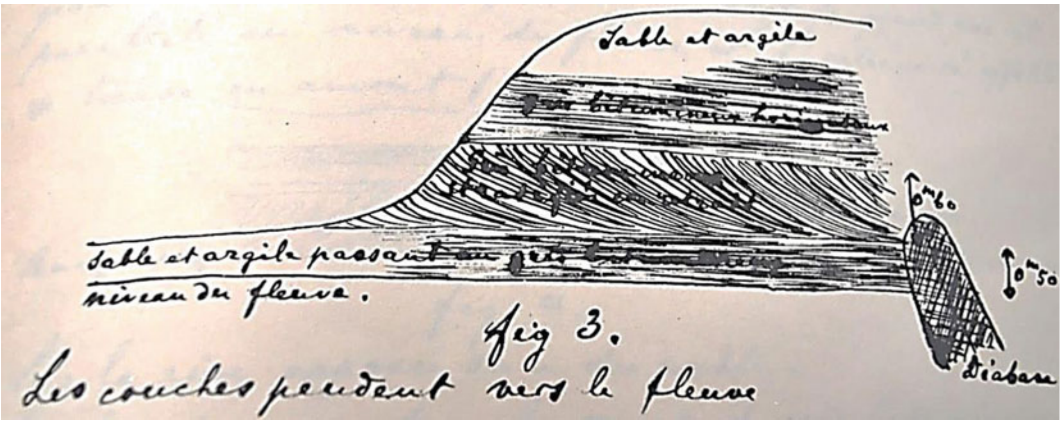

Fig. 2.2 Drawing of stratified layers of the Bofete region (In Collon, (1897))

The Fazenda Brejão belonged to Eduardo da Silva Prado (1860–1901),[1] who had there a library of more than 12,000 volumes and also promoted meetings for debates, with many of the intellectuals of the time. Through his indication, the farmer Eugênio Ferreira de Camargo hired Auguste Collon to investigate oil possibilities in the region of Morro do Bofete and Porto Martins (Fig. 2.2). This initiative was not an isolated one:

> Before this episode, we recorded other attempts to find oil in the State of São Paulo. Efforts to research fuel in Brazil, in a very restricted number, preceded the initiative of Eugênio Ferreira de Camargo, but almost all without technical–scientific foundations. (Felicissimo 1970, p. 13)

In the State of São Paulo, a review shows these attempts occurred in 1871 when Ângelo Thomas do Amaral, and Antônio Cândido da Rocha received a land grant to explore oil and other substances in the village named Iporanga, in the Ribeira Valley. In 1872, also Cyrino Antonio de Lemos and José Batista da Silva Gomes Barata had the concession of lands in the District of the Capital to explore mineral coal and oil. In 1872, a permit was granted to engineer Luiz Mateus Maylasky to exploit "petroleum and coal rock" in the Itu, Itapetininga, and Sorocaba regions. In 1882, João Crisóstomo do Amaral Brisola was authorized to survey mineral coal, asphalt, petroleum and naphtha in the municipality of Itapetininga (Paiva 1970, p. 40).

The engineer Luiz Matheus Maylasky (1838–1906)[2] engaged in oil exploration due to the high consumption of fuel by railroads, in particular by the one he established and directed. For instance, the English coal, coming from Cardiff, was paid in gold. To solve that problem, he decided to acquire land and drilling equipment, including a steam drill, which would later come to the hands of Eugênio Ferreira de Camargo. Therefore, the engineer Maylasky became a coal prospector in the surroundings of Tatuí. His research was the first to present better geological foundations, according to Collon. Maylasky performed two borings, one in the town of Taubaté and the other in the locality of Bofete, in the municipality of Rio Bonito. None of these went beyond 30 m deep.

After Maylasky, on the verge of the end of the Empire, authorization was granted to Colonel Tito Lívio Martins, who founded the Bofete Company. That company purchased three drills: one with a drilling capacity of 30 m, one with a drilling capacity of 100 m, and the third, a steam drill with a capacity of 600 m (Paiva 1970,

[1]Eduardo Prado was an outstanding lawyer, journalist, and writer of Monarchist political orientation. He was one of the founders of the Brazilian Academy of Letters (ABL) (Chair nº 40), and a very close friend of Orville Derby.

[2]Luiz Matheus Maylasky, born in Hungary, was the founder and the first President of the Sorocaba Railroad. He was honored, in Portugal, with the title of first Viscount of Sapucaí (1891), and died in France (Nice).

p. 40). He was authorized to explore oil and other minerals in the municipality of Tatuí, whose territory comprised the famous *Morro do Bofete* (Bofete Hill). Even with the advent of the Republican government in 1889, Tito Lívio Martins kept his concession, also obtaining the consent to constitute an anonymous company, organized in the country or abroad. The company performed two perforations with the small drill: one on the banks of the Bonito River, with a depth of 26 m, and the other down to 30 m, at the foot of the *Morro do Pinta* (Pinta Hill).

– Eugênio Ferreira Camargo and Auguste Collon

Eugênio Ferreira de Camargo (1869–1919), natural from Campinas, SP, belonged to a distinguished family of captains and other prominent representatives of the élites, whose names have for long been given to streets in the city of Campinas and region. Camargo studied in Europe, and although some authors state that he was in Paris (Paiva 1970), our data make us suppose he was in Belgium, where he probably met Collon, who was born in the same year as himself.

Eugênio Ferreira de Camargo acquired, with the help of his father Álvaro Xavier Camargo and his brother Antônio Ferreira de Camargo, the exploitation stock of Tito Lívio Martins. He endeavored to carry on the search for oil and thus acquired the necessary equipment for drilling—a steam-powered rotary Keystone drill:

> […] he transported it along the Morro do Bofete, and, with the assistance of Artur B. Reardon, a technician specially hired in the US, he made the first significant drilling targeting oil, which reached 448.50 meters of depth, the deepest ever achieved in Brazil. (Paiva, Preface, 1970, p. 15)

Camargo hired Auguste Collon in 1892, who then assisted him in the technical parts of the geological study, also assessing where the drilling of oil wells should happen.

Auguste Collon was born on April 30, 1869, in Mons, Belgium, and received a doctorate in 1890 in Natural Sciences from the University of Liège, where he had been attending courses from 1885 to 1891.[3] He arrived in Brazil at the age of 27, returning to his homeland in 1897. His *Curriculum vitae écrit à la machine pair AC, daté du 16 mars 1904*,[4] mentions his stay in the country, as well as other professional activities until that date:

> In early 1895, after being consulted by the Société Metallurgique Russo Belge concerning their mineral projects, I was invited to manage the research they were doing in Russia. On the same occasion, I received a proposal from Dr. Eduardo Prado, 'a Brazilian patron,' to come to Brazil for two years to perform petroleum studies. I preferred this proposal, because, in my opinion, it would allow me to complete my training to an advantage, before committing my responsibility to industrial research projects. I considered as decisive the dispatch of May 31, 1895, which freed me from academic functions and also assigned me the title of Honorary Assistant of the University of Liège. Also, the Belgian Government considered my stay in Brazil a scientific mission, as long as it would last. I spent two years in this country, where I set up a study laboratory at Fazenda Brejão, owned by Mr. Eduardo Prado. I carried out various mineralogical and geological explorations, especially in the State of São Paulo, on the mineral iron deposits of São José de Ipanema (Sorocaba), on the bituminous shales in the vicinity of Botucatu, etc. Despite the job offers that were made, I left Brazil when my contract expired and returned to Belgium, with the intention of devoting myself to industrial missions.

– Manuscript by Auguste Collon

Many geologists used the document produced by Collon, which remained in manuscript form, such as the North American geologist Israel C. White. During his works of prospecting for coal (the well-known federal initiative called *Comissão White*), White drew on it to review the geological column of southern Brazil in São Paulo, previously established by the

[3]Official letter from the Rectorate of the University of Liège, June 4, 1970. Reproduced in Collon (1897), pp. 27–28.

[4]Translation prepared by Mr. Júlio Manoel Domingues in 2008 (http://porangabasuahistoria.com/artigos-publicados/entrevista-julio-manoel-domingues/). Access on September 10, 2017.

Geographical and Geological Commission (Felicissimo 1970, p. 5):

> […] it should be noted that White transferred the geological stratigraphical column defined for São Paulo to Santa Catarina and there, establishing secure correlations with regional geological terms, adopted a new terminology to characterize units already discerned and implanted terminologically.

Collon carried out geological and chemical studies from Morro do Bofete toward the village of Rio Feio (nowadays part of the town of Porangaba, SP), on soils of Fazenda do Almeida, Bairro dos Fogaças, Fazenda Serrinha, in the direction of the city of Tatuí. In this work, Collon depicted the superficial geology observed in the region, starting from the area of Morro do Bofete, considered by him to be a possible old volcano because there is basalt on its slope. The text is subdivided into chapters and presents the geological and chemical descriptions in a set of tables. In Chap. 3, he described the geological environment of Porto Martins, where Collon observed bituminous sandstone and many fossils as well as oil lines in cross-stratification.

The synthesis of his observations made in Porto Martins and Morro do Bofete concluded by indicating the presence of two phases, one of bituminous shale and one of limestone with basic mineralogical composition. Because of these clues, Collon saw the need to search the area in greater depth and proposed drilling. He added that, despite the evidence, he believed Porto Martins was not a region in which oil should be exploited, and the signs should not be taken into account too seriously. He then commented on the oil possibilities of Bofete as well as on the appropriate initiative of proceeding with wildcat drilling[5]:

> Je me suis livré à l'étude géologique de Bofete et des environs; j'ai examiné les grès bitumineux de Bofete sous le point de vue industriel et chimique, et j'ai conclu favorablement à l'exécution de sondages plus profondes. (Collon (1897), p. 41)

Chapter 5 of his manuscript deals with the study of the bituminous sandstone of Bofete, presenting its physical properties and one industrial chemical test. In this chapter, Collon came to the conclusion that rock could be used directly to produce asphalt and gas. The rest of the material could be harnessed for use in industries, as the Bofete sandstone is rich in lubricants.

Collon, in his conclusions, claimed he believed that the formation of oil did not happen concurrently to the deposition. It could be confirmed through the existence of oil strata, whether situated in the Carboniferous or pre-Cambrian layers, and possibly housed in the fractures, or in the underlying layers. For him, the rise of hydrocarbons to these layers happened simultaneously to the subvolcanic eruptions:

> Cette étude a permis de faire reconnaître que le sol de cette partie de l'état de São Paulo est formée de couches bien stratifiées, presque horizontales, inclinant très légèrement dans leur allure générale, vers le Nord et ne présentant que de très faibles ondulations locales. (p. 32)
> […] que le pétrole ne s'est pas formé en même temps que se déposaient les sédiments qui le contiennent actuellement. (p. 36)
> […] qu'il existe une ou plusieurs nappes pétrolifères situées dans les couches carbonifères ou pré-carbonifères et que ce sont ces nappes qui, au certain, ont pénètré par des fentes et fractures dans les couches sub-jacentes. (p. 36)
> […] qu'il y a relation entre l'impregnation des couches par les substances bitumineuses, c'est à dire, entre les montées d'hydrocarbures et les éruptions locales de la diabase. L'impregnation daterait, dans ce cas, de l' époque triassique. (p. 37)

Collon concludes that Bofete was a "volcanic apparatus," whose lava, of augite porphyritic nature, would be the basalt cover of the hill. He also examined the bituminous sandstone of Porto Martins, close to the Tietê River, and interpreted it as being the reservoir rock. He quoted the geologist J. F. Carll's statement about Pennsylvania's oil sands, which contained 1/10 volume of oil and whose capacity, due to pressure, increased to 1/8. In comparison with the sandstone of Bofete, the latter could hold more than 10% of oil, due to its saturation in hydrocarbon.

[5]"Wildcat drilling" is an exploration process in an unproven area and for which there is, as yet, no prospect of commercial quantities.

In so doing, Collon established connections to the discoveries of the time, thus creating expectations as to the possible existence of oil in the region of São Paulo. He believed that those drillings then being performed would be a first attempt to find oil. In his opinion, it would be interesting to see whether that sandstone layer would be repeated further below, to ascertain the presence of oil (Collon 1897, p. 87). After having completed his researches, Collon discouraged drilling in the locality of Porto Martins because of the inconveniences due to the proximity of the Tietê River. The oil from Bofete, according to the chemical studies presented by him, contained 1.09% of gasoline, 15.5% of kerosene, 13.24% of a derivative equivalent to diesel (that name was unknown at the time), 13.20% of lubricants and 22.72% of greases.

2.3 Action of the Federal Government in the Oil Exploration in the State of São Paulo

Federal government decided to become a major player in the oil scene, not unlike what happened with other mineral resources such as iron and coal, in the beginning of the twentieth century (Figueirôa 2007). That interest in the petroleum research in São Paulo arose under the influence of Luiz Felipe Gonzaga de Campos, second Director of the Brazilian Geological and Mineralogical Survey (SGMB) and a former member of the technical staff of the São Paulo Geographical and Geological Commission (CGG). He was impressed by the abundance of bituminous sandstones in the state, in the vicinity of the town of São Pedro, based on what he learned from the studies made by Collon.

Gonzaga de Campos, as head of the Geological and Mineralogical Survey of Brazil (SGMB), was concerned with the systematic mapping of Brazilian geological formations and with the identification of mineral resources that could serve as a basis for economic development. The SGMB, founded on January 10, 1907, was charged with "making the scientific study of the geological structure, petrology, and mineral resources of the territory of the Republic, considering above all the exploitation of these mineral resources and both surface and subterranean water resources" (Figueirôa 2007). It intended to conduct studies for practical application, generally following the model of the geological surveys (Figueirôa 2007).

One of the SGMB annual reports mentioned that, near the city of São Pedro, there was an outcrop of green sandstone, impregnated with oil, and exhibiting the manifest presence of that fuel, possible to perceive through the exhalation of a characteristic odor. It also pointed out that there were no satisfactory maps to indicate the structural features of the layers accurately. Anyway, this fact caused a favorable impression for the occurrence of oil in commercial quantities, but only exploratory drillings could settle the question of the existence of oil more precisely. This statement in an official report, made by Gonzaga de Campos, the head of the SGMB, indeed served as the primary stimulus for the beginning of Federal initiatives:

> In no State in Brazil, as far as we know, has petroleum been found naturally. Only in one drilling carried out in São Paulo, near the Serra de Botucatu (Morro do Bofete), they say, two barrels of Crude Oil were extracted, at a depth of about 400 m. But this drilling stopped, and until today no other exploration was carried to term. (de Paiva 1975, p. 5)

In this quotation, it is possible to see that Gonzaga de Campos was familiar with Auguste Collon's research in Morro do Bofete, which served as a justification for the continuation of oil studies in the State of São Paulo, finally begun in 1919. In that year, the federal government executed the first of 22 more drillings that would be made until 1933 in the State of São Paulo (Paiva 1975, p. 2). An extra stimulation probably came from the technical and financial incapacity of the private sector, as well as the pressures generated by World War I: "From World War I (1914–1918) onwards, there was a significant worldwide interest in oil. In this process, one of the key factors was the replacement of coal by petroleum, through the use of its derivatives" (Peyerl

2010, p. 52). One of the last drillings performed by private initiative took place in 1917: a well drilled by the *Empresa Paulista de Petróleo* in the Bairro da Assistência (town of Rio Claro, SP), which reached a depth of 300 m. The company abandoned it as a result of lack of resources.

When the federal exploration drillings started, the SGMB had already finalized the recognition of the area. Following the previous studies, one believed that the most promising surface geology for petroleum occurred near the town of São Pedro. For that reason, the districts of Graminha, Alto do Araquá and Querosene, situated in terrains of Permo–Carboniferous age, were chosen for the drillings. The subsoil was little known, and this would be the next step allowed by the drilling. Several boreholes found diabase below the Itararé Formation (varied types of sandstones), as well as similar geological formations to those surveyed by Auguste Collon.

The federal initiative went more in-depth than the first nineteenth century drillings, thus discovering in February 1928, 60 m below the Irati formation, yellow oil that leaked 20 L, with a slight asphaltic residue. This well was drilled down to 758 m deep. The board of the SGMB summed up the work (Paiva 1975, pp. 6–7):

> As one can see, the results of soil borings in 1922, if not decisive in the discovery of liquid fuel, have, however, proven the existence of an unknown mineral resource in the country – natural gas. In 1922, one believed that the possible oil findings of São Paulo were lodged in the Rio do Rasto Group. The very capacity of the drills (2000 feet), of both the rotary (Ingersoll Rand) and percussion (Keystone) types, was a clear indication of what geologists thought at the time.

In many of the places studied, there was a diabase sill that made it difficult for the percussion drills to work, and the rotary's steel drill bit, running dry, without cutting, became damaged. This difficulty reflected in a gradual abandonment of the borings and a change in the percussion drill:

> In the South, research is taking place in the States of São Paulo and Paraná. Both have already found natural gas, and there are strong indications of the existence of oil. During 1923, exploratory drillings contributed little to the solution of the problem, the reason being the occurrence of thick sheets of diabase that severely hindered the march of the services, not allowing reaching the oil horizons. (Paiva 1975, p. 8)

The 1924 Report shows discouragement as compared with the enthusiasm in the early years of research. In 1927, geologist Euzébio Paulo de Oliveira risked general conclusions after the drilling initiatives under implementation since 1921, listing the main factors responsible for the presence of oil in the region, and the difficulty in finding it (quoted in Paiva 1975, p. 10):

> a) In the current state of petroleum research in the territory of São Paulo, the value of the surface evidence is zero;
>
> b) Exploratory drillings allowed to determine four petroleum horizons, one of natural gas and one of salt water and showed that the structure of the layers is monoclinal, modified by the action of the faults and variations of the layers dipping. A simple monoclinal structure contains significant amounts of oil in several countries. However, due to the small dipping of the layers and the limited number of borings performed, the problem of the location of boreholes is complicated, since the geological data, with which the structure is to be interpreted, is very scarce;
>
> c) Eruptive rocks can produce an anticlinal structure in the immediate area of their occurrence, and the faults can also act favorably in a monoclinal structure of oil as an anticlinal;
>
> d) Also, a variation in the dip in a monoclinal produces a terrace structure for the concentration of the oil, and, moreover, it behaves as a clasp or cover, avoiding the migration of the petroleum.

The SGMB annual report of 1926 presented the first movements for the purchase of equipment suitable for the development of oil research in the geological conditions found then. The list contains three Keystone Drill Co. and three National Supply drills, totaling US$ 500,000 at the time.[6]

From 1929 onwards, the activities of these federal drillings became almost nil, and only

[6]In update values for 2018, this would amount to circa USD 7,000,000.00 (http://www.saving.org/inflation/inflation.php?amount=500,000&year=1926, access on May 10, 2018).

what had been already initiated was completed. The previously visible enthusiasm declined year by year, due to unsuccessful campaigns and high expenses, within a political and economic crisis, as discussed in other chapters in this book.

2.4 Development of the Petroleum Industry in the State of São Paulo from 1930 Onwards

The growth of Brazilian industrialization after the World War I was incontestable (Suzigan 1986). As a consequence of the increasing demand, the government of São Paulo had to face one of its most significant problems: a shortage of energy. On December 9, 1927, the Congress of the State of São Paulo passed a law[7] providing for three thousand *Contos de Réis*[8] for the creation of the Subsoil Exploration Service as a department of the Geographical and Geological Commission. In that department, a "Petroleum Exploration Section" started to function. The purpose was to increase oil exploration and mining, enabling the Government to purchase materials and equipment, hire the staff needed for the studies, and sign agreements with the federal government for joint oil exploration services.

In May 1928, the CGG hired the North American geologist Chester Wesley Washburne (1883–1971),[9] to study the subsoil of São Paulo and check the possibilities of economically viable oil. Washburne had previously worked for the US Geological Survey and was a renowned oil researcher in several oil regions (Pratt 1974, pp. 211–214). He did fieldwork together with the CGG engineers Guilherme Florence and Joviano Pacheco, and the Brazilian oil expert engineer Domício Pacheco e Silva—who eventually donated the manuscript written by Collon to be published in 1970. Finally, in 1930, Washburne published the book *Petroleum Geology of the State of São Paulo* (Bulletin nº 22 of CGG), with one of the first geological maps of the entire state (Fig. 2.3).

The Bulletin nº 22 constituted what would be one of the first in-depth studies of the geology of the State of São Paulo. In it, Washburne presented the following aspects: (1) the geography, climate, and conditions for drilling wells; (2) a stratigraphic study of the sedimentary deposits; (3) a description of the Formations and Groups of the Paraná Basin in São Paulo; (4) a characterization of geological structures; (5) petroleum problems due to structures challenging to analyze; (6) signs of oil already found; (7) origin of the oil in São Paulo, among other factors not yet well studied. This book was a landmark for the geological research of São Paulo since it was one of the best-informed works presented on the subject since the reports by Auguste Collon. Unlike Collon's work, it was no longer a private but a state government initiative, and with more thorough studies, because it also analyzed the reports of all the wells already drilled in the region of São Pedro, whether by private or governmental projects.

In the end, Washburne made a few recommendations and presented conclusions about the possibility of the existence of oil (Washburne 1930, pp. 1–2):

> The stratigraphy and structure are appropriate for oil. The signs of heavy asphaltic oil, and residues of oil in the black shale of Irati, and above it, are individually small, except for two large outcrops of asphaltic sandstone, […]. The evidence in Irati and that above it would be better if the oil were not so heavy, probably due to oxidation. All samples come from depths of less than 1500 feet (500 meters), and most of them less than 600 feet (200 meters). Best quality oil may exist in the sands above Irati, in the southwestern part of the state, where the Irati shales occur in depths of 2000 feet (650 meters) or deeper, depending on location.
> An attractive possibility of obtaining larger wells, of higher quality oil, is presented with the opportunity of finding the Devonian shales present under the central and western parts of the state. This interference has theoretical grounds, such as the finding of light green oil traits, in four wells of the Glacial and Tatuí formations, and the presence of basal Devonian sandstones on all sides of the Paraná basin. […] The Devonian shales are considered as rocks generating high-quality oil in the large wells recently discovered in Bolivia Oriental, only 800 km away to the west of the Paraná Basin.

[7]State Law nº 2.219.

[8]In update values, circa $5000.00 in 2018.

[9]Document nº 1611, May 11, 1928. Historical Archive of the Geological Institute of São Paulo (AHIGSP), Box 56.

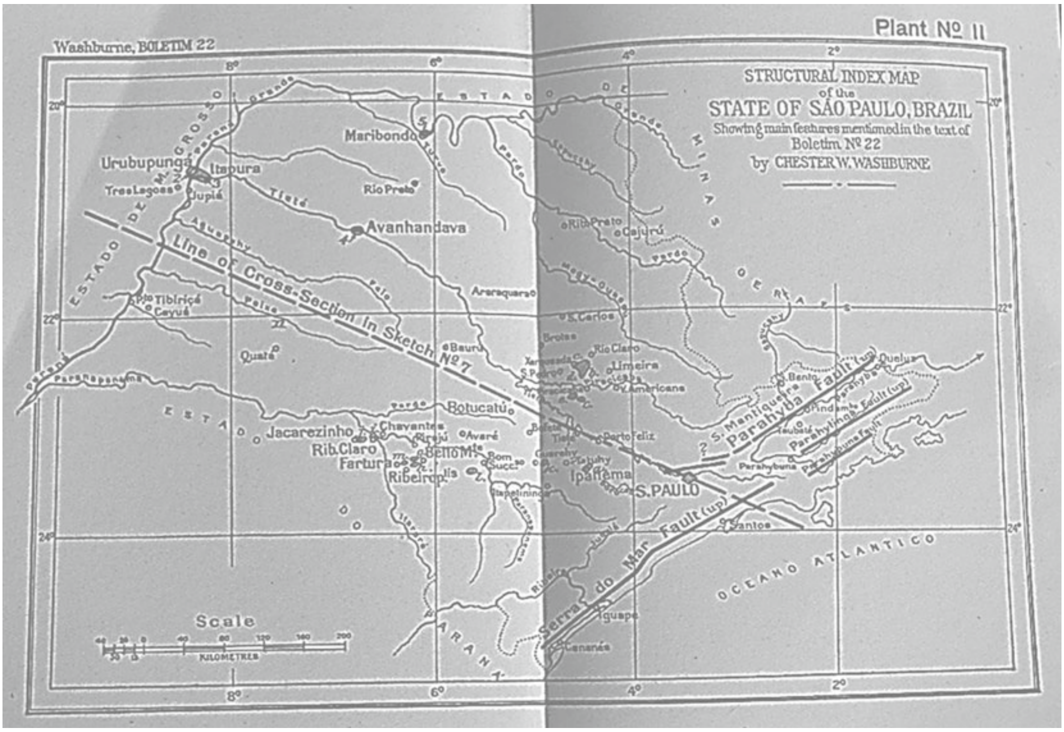

Fig. 2.3 Structural Index map of the State of São Paulo (Bulletin nº 22—CGG)

As it is possible to see, the author believed in the possibility of the existence of oil in the subsoil of the State of São Paulo, considering the most attractive areas for research those located in the southwest, although it would be necessary to drill unknown quantities of basalt. In the final recommendations, Washburne advocated the need to attract companies to look for oil in Brazil, through tax incentives and a market opening policy, because there was a need for a more technology-intensive survey than the country could bear at the moment. Based on the American model he knew, he stated that "if the government grant liberal terms to the oil researchers, he can expect to see them develop wealth for Brazil" (p. 185). He insisted that research was crucial, since, according to his understanding, oil survey consisted of attempts, and this required "gathering the accumulation of knowledge on all geological features. One never knows which feature, apparently useless today, may become significant in the search for oil and other minerals." (Washburne 1930, p. 187) In the last paragraph, he emphasized how oil research is a slow process, during which one has to keep up the enthusiasm and never lose hope because new findings arise every day:

> In other words, oil research is a game similar to buying a lottery ticket, except that application of science can reduce the risks. For this reason, US companies and oil men now employ about 3000 geologists trained in that particular line of work. (p. 187)

In short, Chester Washburne conclusions encouraged to research primarily by companies, which had the proper technology, pointing out the Brazilian failure to invigorate this field. He believed that although results were disappointing until then, there was a promise of a bright future.

At the same time, the Brazilian oil consumption grew every year. In 1932, Brazil consumed 12,000 barrels per day, making clear the necessity of creating an enterprise to sustain such consumption. In 1934, Federal government established the National Department of Mineral Production (DNPM), which then took the command of the initiatives in the search for oil (Chiaradia 2008, p. 57). In 1938, the National Petroleum Council (CNP) was created, whose responsibility was to assess the applications for surveying and supervise the activities of import, export, and transport, distribution and trade of oil. More detailed analysis of both federal initiatives and the CNP can be found in the chapters authored by Margaret Lopes and by Natasha Otoya in this book.

The CNP scope of responsibility for the Brazilian territory, however, did not directly influence oil research in São Paulo. Despite this set of federal efforts, the outcome remained that in the subsoil of the State of São Paulo, no oil in commercial quantities was found. However, the region of São Pedro turned out to be rich in groundwater. As this water almost always contains minerals and gas, i.e., it is mineral water, it allowed for the emergence of a node in the Tourism Waters Circuit of São Paulo. Indirectly, the research aimed initially at finding oil brought a different, nonpredictable path of economic development.

2.5 Final Remarks

The search for oil in the state of São Paulo began due to the interest in the exploitation of energy resources by the private sector, which saw the opportunity for hydrocarbon exploration. These entrepreneurs found inspiration and were in tune with what was going on abroad, noting the growing need and the qualities that petroleum had for energy production. At this time, intending to conduct research and exploration, they hired experts. Among them, Auguste Collon, a Belgian engineer employed by the farmer, landowner Eugênio Ferreira de Camargo. Collon wrote a manuscript describing the surface geology in the Bofete region, bringing recommendations on sites that should be explored in the search for oil in the area.

In the period of World War I, the federal government felt the need for investment in oil exploration. Public initiatives of the Federal Government began when Gonzaga de Campos, Director of SGMB, was impressed with the geology of the São Pedro region and its bituminous sandstones. Unfortunately, this enthusiasm did not result in successful exploration. Oil was not found. In 1931, federal government discontinued drillings in this region. In 1928, the state government hired the North American geologist Chester W. Washburne, an oil expert an employee at the US Geological Survey. In 1930, he authored in Bulletin No. 22 of the Geographical and Geological Commission of São Paulo a study on the petroleum geology of São Paulo. With these new studies, the state government also ventured in the continuation of the perforations that had been abandoned by the federal government, but the disappointing results remained the same.

On the other hand, oil research can be seen as a success if we consider the knowledge learned from the studies of Auguste Collon, engineers of the SGMB, and Chester W. Washburne, who produced scientific documents describing the geology of São Paulo. More recently, the discovery of natural gas reserves in the Santos Basin, of about more than 400 billion cubic meters, led to estimates that Brazil's reserves of oil would triple. Finally, after more than a century, the "golden dream" came true.

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Petroleum: New Energy Perspectives for Brazil in 1922

3

Maria Margaret Lopes

Abstract

The *Primeiro Congresso Brasileiro de Carvão e outros Combustíveis Nacionais* (first Brazilian Congress of Coal and other National Fuels) was held in 1922. The Congress embodied a broad discussion about the economic exploitation of coal in Brazil, the importance of bituminous shale, the use of alcohol as fuel, the studies on the occurrences and the investigations in progress on oil prospecting. Such strategic national resources for modernizing industrial projects, stimulated by World War I, had already been the objects of systematic research by geologists, engineers, and technicians of the Geographic and Geological Commission of São Paulo since the late nineteenth century. This article presents aspects of the papers and resolutions on oil in that Congress. It considers the Congress as an important mechanism to trace the conceptual frameworks related to discussions about the circulation of knowledge and technical and scientific practices regarding the exploitation of petroleum. The article argues that this Congress was one of the legitimizing strategies of the research and effective actions by the group of scientists and technicians associated with the Geological and Mineralogical Survey of Brazil, in its dialogs with the State and business groups. These strategies were focused on strengthening the geological investigations regarding the energy resources of the country.

3.1 Introduction

The *Primeiro Congresso Brasileiro de Carvão e outros Combustíveis Nacionais* (first Brazilian Congress of Coal and other National Fuels) (SGMB 1924) was held in 1922, from the October 28th to November 8th in Rio de Janeiro, Brazil, and received very little attention in the vast historiography of oil and energy resources in the country. Following Rudwick (1972), this Congress was just an "episode"—albeit in this case a significant one—in the history of Geology and Oil in Brazil. This Congress, like other ones, can be understood as a representation, a specific moment that allows us to visualize who the researchers and technicians were, the state-of-the-art in the discussions and technical–scientific research in progress, the political, and economic interests at stake.

This Congress did not initiate a process and it was not an isolated initiative. Since the end of the nineteenth century, oil had already aroused the interest of international companies and of the technicians who worked in geology in the country, in the institutions and societies such as the *Museu Nacional* (National Museum); the

M. M. Lopes (✉)
Information Science Graduate Program, Faculty of Information Science, University of Brasília, Brasília, Distrito Federal 70910–900, Brazil
e-mail: mariamargaretlopes@gmail.com

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Sociedade Auxiliadora da Indústria Nacional (Society for the Promotion of the National Industry); the *Escola Politécnica* (Polytechnic School) in Rio de Janeiro; the Ouro Preto School of Mines, in Minas Gerais; the *Comissão Geográfica e Geológica de São Paulo* (Geographical and Geological Commission of São Paulo); and now at the beginning of the twentieth century, the *Comissão de Estudos das Minas de Carvão de Pedra do Brasil* (Coal Commission), organized in 1904 and later incorporated into the *Serviço Geológico e Mineralógico do Brasil* (Geological and Mineralogical Survey of Brazil), organized in 1907. These institutions were the basis of Brazil's modernization processes (Dantes et al. 2011). The fundamental research role conducted by North American geologists in Brazil since that time, as well as the importance of the Geological and Mineralogical Survey of Brazil for the industrialization process of the country in the early twentieth century have been well discussed by Figueirôa (2007).

Until the first decades of the twentieth century, coal was still the main interest in terms of fossil fuels. The government, paying close attention to the costs of coal, iron and steel imports, and supported by nationalist professionals from the School of Mines, gathered in the Geological Survey, encouraged research on mineral and energy resources such as iron, manganese, coal, and oil. After World War I, the increase in fuel prices intensified the search for coal and oil also in Brazil.

But we should mention that in the early 1920s, Brazil was considered a region without oil. And research on oil was in the context of coal mining. The surveys that had been carried out since the end of the nineteenth century were focused on the demand for coal, but provided indications for the potential of bituminous shales and oil. So, this paper presents just a few aspects of the context of those years, mentions some aspects of the themes of the discussions on coal and alcohol, and points out the papers on oil presented by the Geological Survey technicians and resolutions on oil discussed in the Congress of Coal and other National Fuels.

3.2 The Early 1920 Years

In December 1921, the Brazilian government under the direction of the engineer Ernesto Lopes da Fonseca Costa (1891–1952) organized the *Estação Experimental de Combustíveis e Minérios* (Experimental Station of Fuels and Ores), as a section of the Geological and Mineralogical Survey of Brazil. The Experimental Station was the initiative of the geologist engineer Luis Felipe Gonzaga de Campos (1856–1925), who studied at the Ouro Preto School of Mines and during that period, directed the Geological Survey.

This was the first technological institution created in the country, which exists until now as the *Instituto Nacional de Tecnologia* (National Institute of Technology), in Rio de Janeiro (Costa 1934). Its specific objective was the economic investigation of the energy resources—especially coal. But since its organization, this Experimental Station was already researching oil and had hired technicians to initiate studies on alcohol in combustion engines (Schwartzman and Castro 1985). In the early twentieth century, Brazil followed the innovations of the French industry for the use of alcohol and was among the first countries seeking for new markets for the extensive production of sugar cane, such as the development of biofuels. An International Exhibition of Alcohol Products and Equipment and a Congress on the Industrial Applications of Alcohol had been held in Rio de Janeiro in 1903. Since then, it was already recommended the implementation of an infrastructure for the production of bioethanol for vehicles in Brazil. During World War I, the use of alcohol in several equipment of government institutions became mandatory (Moreira and Goldemberg 2005).

Thus, some months after the creation of the Experimental Station, the Congress was held as an initiative of the technicians from the Experimental Station and the Geological Survey. This paper argues that the Congress was aimed at valuing the local technical capacity and sought support for the research on coal, alcohol, and especially oil that was already underway.

1922 was the year of the centennial celebrations of the Independence of Brazil from Portugal. The Congress of Coal and other National Fuels was held in a climate of growing nationalism and future prospects for the country's progress and development. In the first preparatory meetings for the Congress, the representative of the government, the engineer Miguel Calmon du Pin and Almeida (1879–1935) former Minister of Agriculture, then president of the Agriculture National Society and one of the organizers of the Centennial Congresses, recommended that the Congress of Coal should turn its attention to the possibilities of new sources of energy that would ensure the country's economic independence.

And at the first meeting, the proposal was that this Congress be added to the International Congress of Engineers, where all questions related to the profession and fuels would apply. The proposal was presented "as a suggestion from the United States" by the Brazilian ambassador in Washington following the initiative of Verne Le Roy Havens editor of the publication Ingenieria Internacional published in New York (Sampaio 1922). This publication promoted the International Congress of Engineers in conjunction with the South American Railway Conference, which now counted on the adhesion of several countries which would also take place, in the same context of the exhibition in the Independence Centennial commemoration (Pires 1922).

The organizing committee of the Congress of Coal and other National Fuels—which included many of the Geological Survey's technicians—immediately rejected the proposal. They argued that in an international congress with a very comprehensive program, it would be very difficult to address the specific issues related to the problems of national fossil fuels with the depth of details needed and the proposal of urgent measures for the development of national industries. Having a voice in a specific Congress was part of the professionalization strategies of the Geological Survey and the advancement of research on the country's energy resources. This caused strong clashes between those who supported the Pan-American movements and those who were opposed to it, and who opposed the hegemony of the United States that was expanding in Latin America (Loguercio 2007). The newspapers highlighted these debates along with the highlights of the Congresses held during the Independence Centennial commemorations.

The Congress of Coal and other National Fuels was already inserted in a strategic planning perspective of some nationalist sectors aiming to achieve self-sufficiency in energy resources, the basis for the country's technological and industrial development. The initiative of the Congress was supported by emerging industrial sectors interested in new energy sources that depended mainly on the energy resources that the country imported at high costs, progressive military, and government sectors related to agriculture and transportation, especially Ildefonso Simões Lopes (1897–1904) then Minister of Agriculture, Industry and Commerce, who would later be the author of several protectionist laws for the exploitation of oil in the country (Peyerl 2017).

3.3 The Congress of Coal and Other National Fuels: Technical and Economic Sessions

The Congress of Coal and other National Fuels was organized in three sessions: technical and economic focused on coal and alcohol and scientific issues, prioritizing coal, and especially oil.

Representatives of the national industrial sectors felt that it was right for Congress to discuss technical and scientific issues related to coal but believed that the technicians already knew how to use domestic coal and increase its efficiency. They emphasized that the economic session was the most important, the essence of the Congress. They believed that the fundamental objective of the Congress should be about coal consumption: processing, improvement of the maritime and rail transportation, and protectionist measures that would allow coal to intervene beneficially in the Brazilian economy. They believed that the country was completely unprepared for these purposes. They recognized that scientific and technical work had already been developed by the Geological Survey and the Experimental Station. They also pointed out that as coal consumption increased, so too would the number of specialists and new solutions and technologies for its practical use in industry. Just the increased consumption would reduce the excessive import prices of foreign coal.[1]

The coal deposits in the south of the country were already in operation, but since this was not of the best quality, the work of the technicians of the Geological Survey and of Experimental Station revolved on the need to encourage the search for coal in other regions, to establish technical standards for the use of metallurgical coke and research on the processing of domestic coal for industrial use.

And in fact, the work and resolutions of the technical and economic sessions dealt mainly with the importance of establishing protectionist measures for the commercialization and expansion of the uses of national coal in the industry. These resolutions included specific recommendations, such as the Central Railroad of Brazil should acquire locomotives adapted to the use of national coal. Once the coal quality in the southern Brazilian state of Santa Catarina was recognized, the Congress proposed setting up an industrial demonstration plant that covered coal processing, coke production, pig iron production, and preparation and steel lamination, to establish a thermoelectric power plant for the production of special alloys related to the studies of Ouro Preto Mining School, in Minas Gerais. The Congress also discussed the implementation of railroads linking the coal-producing centers in the south of the country to the iron ore deposits of Minas Gerais, in the center of the country; improvements in ports and cargo ships for the transport of coal; compulsory maximum use of national coal in the Navy; as well as customs taxation and taxes on the importation of foreign fuels (Almeida et al. 1922).

Several recommendations of the Congress took effect and one year after the Congress, the Government enacted laws to promote studies on the industrial use of coal, the foundation of industries of by-products of national coal such as benzoyls and tar, and replacement, total or partial, of foreign coal by the country, in the manufacture of gas lighting (Belolli et al. 2002).

The articles on alcohol focused on the technical and economic sections of the Congress, addressing the work program of the Experimental Station that conducted research to obtain homogenous and stable mixtures of alcohol and air, their combustion speeds and temperatures and their behavior in combustion engines. The resolutions of the Congress on alcohol insisted on the importance of teaching their manufacture for industrial applications, the creation of cooperatives for the organization of large distilleries equipped with fermenting, distilling, and denaturing plants, with tank wagons for distribution, storage and transport; beverage taxation; incentive for alcohol use in specially built devices and machines for the use of alcohol; use of government vehicles for ethanol; technical improvements to use alcohol as fuel (Almeida et al. 1922). The research initiatives that were carried out at Experimental Station were crowned with success and led to the feasibility of the first alcohol-based car in Brazil in 1925 (Távora 2011). In 1938, prioritizing the search for oil, the director of the Geological Survey (at that time Serviço de Fomento da Produção Mineral), Avelino Ignacio de Oliveira (1891–1970) considered that the production of sugar cane-based alcohol engine would always be limited. It also argued that the alcohol industry could only survive at the expense of rates that ultimately made imported gasoline more expensive, and argued that "it was a nationalist solution and not an economic solution" (Oliveira 1938, p. 10).

The Engineering historian in Brazil, da Telles (1982) had already called attention to the need for further studies on this Congress on Coal. He believed the Congress was one of the most relevant events in the country's history of technological development and was upset by how his propositions about alcohol were only resumed

[1]Brazilian Congress on Coal. O Journal. Rio de Janeiro, Saturday 25 February 1922. Year 1922/Edition 00952 http://memoria.bn.br Access 03/08/2018.

much later, after the oil crisis of the 1970s. Years later, the alcohol-engine production would become an economical solution. After the 1980s, Brazil began to produce alcohol-fueled cars. The Fiat 147 was the first alcohol-powered car in 1978.

3.4 The Congress of Coal and Other National Fuels: Scientific Sessions on Oil

The Geological Survey technicians, organizers of the Congress, were particularly interested in the scientific session of the Congress to publicize and obtain support for the geological researches that were carried out in the country especially for oil. Fifty-six papers were presented at the Congress. In addition to the Geological Survey technicians, professors from the National Museum and Polytechnic School from Rio de Janeiro and the Ouro Preto School of Mines, Minas Gerais also participated in the meeting sessions. The Geological Survey technicians evaluated twenty-four papers and submitted nineteen papers in the scientific sessions of the Congress. All participants were important members of the geological community in the country (SGMB 1924).

In almost all the works presented there was some mention to the possibilities of oil occurrence. The articles presented followed the work strategy proposed by Euzébio Paulo de Oliveira (1883–1939). Euzébio de Oliveira was a prominent figure in the history of oil in Brazil. He was the acting director of the Geological Survey at the time of the Congress and was the effective director from 1925 until 1933. He was also the author of several papers presented at the Congress. Since 1915, Euzébio de Oliveira was in charge of the general direction of the petroleum research activities in the Geological Survey. The idea of a systematic survey operation in some parts of the country had been established for better knowledge-based information on the coal basins and better orientation for petroleum researches. In the first bulletin of the 1918 Geological Survey, published in 1920, Euzébio de Oliveira delimited the most promising sedimentary areas for the existence of oil in the country in three oil provinces: *Bacia do Paraná* (Paraná basin)—"Gondwana Province": São Paulo, Paraná, Santa Catarina, Rio Grande do Sul, and Mato Grosso do Sul); *Bacia do Amazonas* (Amazon basin) and Atlantic (coastal area from the northeast to the region of Campos, Rio de Janeiro) (Oliveira 1920). Some comments on some of the papers presented at the Congress, below, provide a general idea of the oil-related works developed in the Geological Survey at that time.

– The Paraná Basin

Euzébio de Oliveira begins his article "*Probabilidades da existência do petróleo no Brasil, de accordo com as theorias sobre sua origem*" (Probabilities of the existence of oil in Brazil according to theories about its origin) (Oliveira 1924d), firmly grounded in Engler and Hofer's theory of organic origin of oil (Peyerl and Figueirôa 2016). In this paper, the author returned to his criticism already presented in previous works (Oliveira 1915), contrary to the statements of the North American geologist Israel Charles White (1848–1927), known as a coal specialist, who had been hired by the Brazilian government to coordinate the Coal Commission in 1904. Francisco de Paula de Oliveira (1857–1935), a mining engineer and coal specialist, and one of the former directors of the National Museum of Rio de Janeiro, Euzébio de Oliveira's father, had held the position of engineer of the Coal Commission, and the son, Euzébio de Oliveira, was very familiar with the geology of the region.

The "White Report," known as the final report of the work of the Coal Commission laid the foundations for the geological knowledge of the southern regions of the country, not only for coal but also for the mapping of Gondwana in those regions. The paleontological studies allowed more evidence of the correspondence of these lands to the Karroo Formation of Africa. The Report also established what is considered to date as the basis of the stratigraphy of the Paraná basin (White 1908; Lopes 2015).

Asked about the possibilities of petroleum in the regions especially studied in the south of the country, Charles White considered "that the sedimentary beds of the Brazilian Permian, once held some petroleum is attested by the evidence of the *Iraty* black shale which gives off the characteristic odor of this substance from São Paulo to Rio Grande do Sul." Charles White, in his final work report, did not rule out the possibility of the occurrence of oil in other regions of the country which he did not know, but believed that "the result of the deep drilling at *Iraty*, which is distant from any known outcrop of igneous rocks, confirms this conclusion, that it is useless to expect petroleum deposits of any considerable quantity anywhere in South Brazil" (White 1908, p. 245).

The technicians of the Geological Survey disagreed. They followed the geological orientations of the North American Orville Derby (1851–1915)—former director of the São Paulo Geological Commission (1886–1905) and first director of the Geological Survey (1907–1915), and Euzébio de Oliveira's works. Since 1915, Euzébio de Oliveira drew attention to oil drilling in southern Brazil. This was based on the Permian and Triassic ages of the sedimentary rocks and the geological conditions of the vast region: "porous sedimentary rocks, arranged in gentle anticlines, of weak relief and sufficiently impermeable cover to avoid the flow of oil" (Oliveira 1915, p. 116). The following years they even insisted on the possibility of oil occurrence in the south of the country. From the beginning of the activities of the Geological Survey until 1933, there were only 38 drillings in the region, although this was the region where most surveys were carried out during that period (21 in São Paulo, 12 in Paraná and 5 in Santa Catarina).

As the bituminous shales from the *Iraty* Formation, in the Paraná Basin, were considered a promising source for petroleum, at the Congress, Othon Henry Leonardos (1899–1977)—another well-known engineer in geology in Brazil, then an employee of the Geological Survey—presented a paper on his research on tertiary bituminous shales of the north of São Paulo state; Euzébio de Oliveira presented another paper with more details on the geology of the bituminous shales from the *Iraty* Formation (Oliveira 1924a), and other authors presented papers on the petroleum potentialities of other bituminous shales of other regions of the country.

Furthermore, 1922 was an extremely productive year for research in the state of São Paulo and Paraná, in southern Brazil. The survey did not find oil but confirmed the existence of natural gas in the regions of the cities of São Pedro de Piracicaba in the state of São Paulo and of Marechal Mallet in the state of Paraná, which until then was unknown in the country. Samples of oil rocks where oil and gas were found were also exhibited at the Centennial International Exhibition (Brazil 1922), where the Congress was held, to further disseminate the success of the explorations carried out by the Geological Survey.

– The Amazon Basin

Following the strategy of the ongoing research in the Geological Survey in the three regions of the country, there was no shortage of studies in the Congress on the possibility of coal and oil in the Amazon valley. Since the nineteenth century, Orville Derby had conducted studies on the Amazonian carboniferous fauna (Derby 1877, 1894). Once in charge of the Geological Survey Derby proposed conducting research and surveys related to coal in this largely unknown geological region.

In the Congress, two papers on coal were presented by the technicians of the Geological Survey, one on lignite (known in Alto Solimões, Amazon, since 1861), and other on oil in the Amazon region. Campos (1924) followed Suess, attributing marine origin to the carboniferous deposits of the Amazon. He relied on numerous comparisons of the geology of the Amazon with other regions of occurrence of coal measures in the world, under the marine layers of the Upper Carboniferous, to consider that the possibility of coal in the Amazon was promising, contrary the opinion of the other well-known American geologist John Casper Branner (1850–1922).

Branner had extensively worked in Brazil and had recently published the geological map of Brazil. In his text on the Brazilian Geological Map, Branner considered that although it was expected to find coal in the Amazonian Upper Carboniferous, such deposits had not yet been located, since these layers were identified as being of marine origin, there was no possibility of finding coal there (Branner 1919). Gonzaga de Campos argued the need for more research in terms of the extension of the region and primarily the urgency of more drillings, since only these could clarify the complex geological structure of the region.

The possibility of oil in the Amazon valley was defended by the geologist from the Geological Survey, Mathias Gonsalves de Oliveira Roxo (1885–1954). His paper presented at the Congress reclaimed the geological history of the Amazon region, considering the Amazon valley as a vast syncline of slow and gentle uplift. The valley had been occupied by the sea in the Silurian and Devonian periods and by a shallow and smaller sea along the Carboniferous. The sea also occupied vast Amazonian areas in the Tertiary, but with no communication with the Pacific given the rise of the Andes, constituting a vast gulf, which sedimentation would gradually cover. It was based on the geological history of the region, studies by the technicians of the Geological Survey, and the "fossil wealth" of the successive periods, already analyzed by the well-known American paleontologist John Mason Clarke (1857–1925). Mathias Roxo's article recognized that well-conducted drilling in the areas of Tertiary brackish-water deposits would find oil, especially in the south of the states of Amazonas and Acre (Lower Amazon) (Roxo 1924b).

– The Atlantic Coast areas

The papers presented at the Congress about the Atlantic Coast areas focused on the research and surveys that were being carried out in the states of Alagoas, Sergipe, Bahia, and Rio de Janeiro.

It was in the Experimental Station that the oil proportions in these rocks and other samples obtained in these locations were specifically being analyzed. The regions of Graça Torta and Riacho Doce, a few kilometers from Maceió, capital of the state of Alagoas in the northeast of the country, the most important deposits of oil-rich bituminous shales were located, already surveyed by the Geological Survey.

In his paper presented in the Congress "*Folhelhos betuminosos da costa do Brasil*" (Bituminous Shales of the Brazilian Coast) Euzébio de Oliveira gave continuity to his first studies of the region since 1918, updating data of the chemical analysis of the collected samples (Oliveira 1924b). From those studies, the author started from the well-known assumption that there was no oil in bituminous shales, but rather its generating substance—hydrocarbons. He explained that chemical processes and in-depth heat generation, generally associated with eruptive rocks, could result in the formation of oil. Although there were no eruptive rocks in these regions, the author assumed that a set of existing geological fractures and joints showed that the heat from the friction of the rocks could have formed oil in the shales, even in small quantities. When subjected to atmospheric action, the petroleum formed lost its volatile components, generating the asphalt found in these regions of fractures. It was, therefore, vital to also intensify research in these areas.

Chemical analyses performed by technicians of the Experimental Station on samples collected in the mapping of peat occurrences at different locations in the state of Sergipe, indicated the presence of oil percentages, considered promising for further research. The presence of combustible substances similar to those already known in the peat of Maraú, Bahia, were presented to encourage the continuity of work in these regions (Alvin and Dutra 1924).

Articles on the progress of drillings in the region of Maraú and in other regions of the coast of Bahia were also presented. Since the nineteenth century, the Maraú region had been exploited for coal, peat, and bituminous shale for domestic use. The progress of the candle and soap factories from the oil exploration in Maraú also presented the "Marahú Petroleum Works" by Brazil, in the Louisiana Purchase Exposition in 1904 (Aguiar 1904, p. 26). The Maraú region had been studied by Derby and other geologists, and the works of Gonzaga de Campos had already demonstrated, based on fossiliferous studies, that the geological history of the Maraú basin formations was associated with that of the Sergipe basin. The main interest in the region was the deposits of the *Barreiras* Formation, where besides deposits of monazitic sands, there were tertiary deposits of bituminous rocks that Derby had named marahunite, identified as a kind of boghead coal, formed by the accumulation of algae. The occurrence of these materials, the sedimentary rocks characteristics, and the geological structure of these basins allowed to suppose the existence of deep oil deposits (Oliveira 1924c). Given the prospects of finding oil especially at depths of calcareous rocks in the region, new drillings continued to be carried out by the Geological Survey. It would be on the coast of Bahia that the first commercial oil exploration deposits were found in 1939 in the region of Lobato.

Other papers discussed the possibility of oil and the recommendation to carry out further drillings in the *Baixada Fluminense* in Macaé, Rio de Janeiro coast, and in the region of Campos, Rio de Janeiro. These areas are currently one of the main offshore oil-producing areas in the country.

Mathias Roxo studied the fossiliferous deposits in this region of flat ocean beaches, from Macaé to Cabo de São Tomé, where the sea was relatively shallow. In the surveys conducted, he found marine mollusks of the genus "Ostrea," thirty meters deep in the city of Campos, indicating that, undoubtedly, in the past, this location had been occupied by the sea. His work was based on the surveys performed, on fossiliferous evidence, and on information from the Navy about the existence of submerged stretches of the coastal gneisses mountains (*Serra do Mar*). In the author's opinion these submerged areas could, I quote "make up a deep-seated syncline where vast quantities of organic debris from marine animals could have been deposited, representing favorable oil formation environments" (Roxo 1924a, p. 58). Years later, his work was retaken to again be recommended, now as geophysical studies in the region (Lamego 1944).

Horace Elbert Williams, a North American geologist at the Geological Survey, also presented his work on the plains of Campos and on oil. In September 1921, Horace Williams published an article in the Brazilian Business newspaper about the possibility of oil in the Campos region of Rio de Janeiro. The title he gave to his article "The Paraiba Embayment as Possible Oil Field" was published with the flashy title of "Campos Brasil's Tampico," as a reference to the famous oil region of Mexico. This article was considered the first more informed suggestion about the possibility of oil occurrence in the region. In his article, Williams associated the geology of the Campos region with those of the important oil region of Tampico, Mexico. He assumed the continuity of Cretaceous and Tertiary formations submerged in the continental shelf along the coast. It was one of the first works of this period to present a general synthesis about the geology of the coastal strip from Rio de Janeiro to the state of Pernambuco, associating the sedimentary stratigraphy of northern Rio de Janeiro with the Tertiary and Cretaceous formations of Bahia. He also proposed that a dozen drillings should be carried out to verify the existence of oil or gas in those regions (Williams 1921).

In addition to these studies, Alberto Ribeiro Lamego stated again in the 1940s that although the general tectonics of the coast had not yet been outlined, the retreat of the continental margin had left unattainable deposits of oil along the platform, which the geologist could not predict—at least at that moment with the scarce data available (Lamego 1944). At that time, the surveys in the Campos region were land-based, but the geological knowledge of the region that would continue to expand in the following years already showed the possibility of offshore oil, which would later become one of the largest offshore oil-producing regions in Brazil.

The first resolutions of the Congress were related to petroleum research and to the support for the studies of the Geological Survey and continuity of coal drilling and the need for further oil drilling in the Tertiary of the Amazon. And the other resolutions of the scientific session referred to intensifying the research in each of the areas of the country with already identified oil potential, Sergipe, Bahia, Campos (northeast), São Paulo, and Paraná (south of the country). The emphasis focused on "the research and support for the continuity of the investigations in the vast extensions in which the bituminous shale of the Iraty Formation in Paraná occurs that could be a very important oil production source" (Almeida et al. 1922, p. 12). The resolutions also recommended that financial resources be made available for fieldwork and geological studies in the lesser-known regions of the country.

The works presented by the geologists of the first generation of Brazilian professionals discussed the status of knowledge on the geological studies of the territory. They argued, based on their own experiences in the field, against or in favor the existing works, mostly the result of the contributions of the American geologists who worked here.

And as we have already stated, the articles presented consolidated the strategic planning of the Geological Survey and the Congress was in a favorable context, in which sectors of government and industry were then seeking to formulate a strategic development program for diversified, competitive, and self-sustaining energy sources. Some bibliography also states that the strategic planning for oil in the country begins at the end of the 1930s, with the creation of the Conselho Nacional de Petróleo (National Petroleum Council) and the commercial production of petroleum in the country. However, the works of the Geological Survey presented at this Congress clearly show that the challenge in those years was to set goals, to plan, and to develop medium- and long-term programs involving public and private sectors, to invest in the research of energy resources and development and not only in the 1930s. That is why at this Congress, the emphasis was not only on coal, but particularly on oil and also alcohol.

The presented papers and the conclusions of the Congress insisted on the need to carry out intense deep drillings in order to prove the evidence of superficial oil and to discuss the best methods to make them viable. But to conduct drilling, the equipment and technicians capable of operating the imported machines would remain the greatest difficulties of the Geological Survey in the years to come (Peyerl 2017).

The Geological Survey continued to obtain government support, including in 1925 when Euzébio Paulo de Oliveira became the effective director, when new researchers were hired and geological studies were intensified in the country. In 1926, in a speech commemorating the 50th anniversary of the Ouro Preto School and Mines, where the majority of the Geological Service technicians had graduated from, director Euzébio Paula de Oliveira was optimistic about the surveys conducted in the city of São Pedro de Piracicaba in the state of São Paulo, where small quantities of oil had been extracted from a well. He stated that five years ago, very few people could have imagined the possibility of oil and gas occurrences in Brazil. With the positive results being found by the persistent work of the Geological Survey, he warned that it was now up to the government to guarantee ownership of these resources to the country so that they would not fall into the hands of fortune-hunters (Oliveira 1926).

Oil research continued, but in a limited manner, given the precariousness of the equipment and the technicians trained to operate them. The surveys continued to be carried out across the country. Most were carried out in the south, mostly in São Paulo, with no confirmation of oil (Figueirôa 1997). This would generate many problems for the Geological Survey. But, such surveys were justified if we consider the extension of the Paraná Basin; that Santa Catarina was the main coal-producing region; that gas had been found in Paraná; and that the State of São Paulo was the main industrial center of the country and one of the most well-known areas from the geological point of view, given the work of the Geographical and Geological Commission since 1886.

3.5 Final Considerations

The 1930s would usher in another period for the history of oil in Brazil (Dias and Quaglino 1993). Controversies over the rights of nationals or foreigners over oil exploration to be discovered remained and intensified not only in the 1930s but also in current days. Calling attention to this Congress, this paper wanted to highlight the fact that research on Brazilian petroleum was already part of the strategic planning of the Geological and Mineralogical Survey of Brazilian technicians and of the industrial and government sectors that were not always on top of the decisions made in that period. The Geological Survey technicians were aware of the need for long-term planning for geological research even if many were frustrated by the decisions. However, the studies developed were fundamental to establish, despite all the precariousness, the basic planning of the geological petroleum research in the Brazilian territory.

In another context, after leaving the Geological Survey, which in 1933 was expanded to become (first as General Directorate) the *Departamento Nacional da Produção Mineral* (National Department of Mineral Production), Euzébio de Oliveira accepted the responsibility for the years in which the oil drilling services were under his direction. He stated in the preface of his book *História da Pesquisa de Petróleo no Brasil* (History of Oil Research in Brazil*)* that "the results obtained in the discovery of oil in commercial quantities and new coal fields had been very disappointing" (Oliveira 1940, p. 4). But it is his own work that demonstrates how fundamental the perseverance on the geological research of the Brazilian territory really was, which despite all the precariousness of the time, already indicated the regions that would be confirmed as the most promising for the exploration of oil in the country.

In 1939, the discovery of oil in Lobato, in Bahia, 50 km from a drilling conducted in 1926, completely changed the panorama of petroleum research in the country. And it would be the Experimental Station, in 1939, that would carry out the chemical analyses that proved the quality of the first oil samples obtained.

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4 Petroleum and Science: The National Petroleum Council and the Development of Oil Geology in Brazil

Natascha de Vasconcellos Otoya

Abstract

Oil geology as a scientific field has developed in parallel with the start of oil exploration in Brazil at the end of the 1930s. This chapter analyzes some features of this process. It focuses on different aspects of the activities of the National Petroleum Council (CNP in Portuguese). In Brazil, the development of this scientific field was supported by a State agency, networks of scientists, private companies, and universities—both Brazilian and foreign. This suggests that there were political, economic, and ideological interests at stake in the production of new scientific knowledge. The political context of scientific production, the networks through which this production circulates, and the purposes for which it is used are crucial to the understanding of a *creole science*. A term coined by environmental historian Stuart McCook *creole science* encompasses both the impact other spheres have in the production of scientific knowledge and the on-the-ground experience of this production. It also considers the intersections of nature, scientific discoveries, politics, economics, and nationalism. Such reflections are essential for an analysis of the development of the Brazilian field of oil geology. Here we will analyze a previously unreleased collection of documents of the CNP. The studies, exchanges, and breakthroughs made by both Brazilian and foreign scientists reveal these interactions and contribute to a broader understanding of the field.

4.1 Introduction

Oil geology as a scientific field developed alongside the beginning of oil exploration in Brazil, particularly in the 1930s and 40s, through the activities of the National Petroleum Council (CNP). The development of a novel scientific field, promoted by a State agency, indicates that within the production of scientific knowledge there were political, economic, and ideological interests at play. These reflections will guide the present analysis of the development of the field of Brazilian oil geology. This chapter analyzes some aspects of this process, focusing

This text elaborates on Chap. 2 of my Master's thesis *Fúria moderna: uma história do petróleo brasileiro através dos arquivos do CNP* (Modern fury: a history of Brazilian oil through the CNP archives) (M.A. thesis, Universidade Federal do Rio de Janeiro, 2016). Most documents cited in this text are part of the recently opened document collection of the Brazilian National Petroleum Council, stored in the Brazilian National Archive (Hereon CNP/AN).

N. de Vasconcellos Otoya (✉)
Department of History, George Washington University, 37th and O Streets, Washington, DC 20057, USA
e-mail: nd515@georgetown.edu

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specifically on the activities of the Brazilian National Petroleum Council. Before that, we will examine the broader trajectory of the field, surveying the first State institutions to focus on Brazilian geology and their main actors. Some of whom were at the forefront of the development of oil geology in the country. We will then discuss instances such as CNP's desire to create teams of Brazilian geologists or to set up a laboratory with state-of-the-art equipment. This analysis will focus on some of the connections between science, nature, and politics, in the Brazilian experience with one of its most emblematic natural resources.

4.2 Brazilian Oil Geology as a Creole Science

In his book, S*tates of Nature—Science, Agriculture and the Environment in the Spanish Caribbean, 1760–1940*, Stuart McCook discusses the development of scientific fields in the Spanish Caribbean from the eighteenth to the twentieth century. His focus is on the creation of experimental laboratories of agricultural studies that produced research on the great plantations of the region: coffee, sugar, tobacco, fruits. McCook centers on the creation of a field that he classifies as creole science. The studies, experiments, discoveries, and breakthroughs made by scientists in Puerto Rico, Cuba, and Costa Rica highlight the interactions between foreign and local scientists, big farmers, rival political groups, peasants and, of course, the plants that interested all these groups in very different ways.

McCook suggests that the scientific production of the laboratories reflected these conflicts of interest as much as discoveries themselves. The conflicting relations between national and foreign scientists, large exporting producers and peasants, as well as the choices of which crops would be studied are indissociably connected to the process of producing knowledge about sugar, coffee, tobacco, and tropical fruits in the region. He highlights just how much politics, conflict, and ideology there is in the production of scientific knowledge.

The concept developed by McCook can be used to analyze the development of the field of Brazilian petroleum geology, since many of the intersections identified by the author in the Spanish Caribbean are also present in Brazil under Getúlio Vargas, who ruled the country from 1930 to 1945. During his government, a State-building project was set in motion that sought to modernize the country, largely through the promotion of industrialization, and therefore, in the 1930s and 1940s, the search for oil began to be systematized (de Dias and Quaglino 1993).

More broadly, locating the practices, developments, and advances of scientific fields in countries like Brazil is a way of transposing the classic Eurocentrism of many narratives that deal with scientific practices happening beyond "developed" countries. Indian historian of science Kapil Raj (2007) follows these ideas in his book, *Relocating Modern Science: Circulation and the Construction of Knowledge in South Asia and Europe, 1650–1900*. His work exemplifies the move away from the Eurocentric focus on the history of science. In Raj's book, which centers mainly around India, actors from that region of the world are described as active participants in scientific practices, endeavors, and education—a view that challenges the traditional notion of non-Europeans as being passive vessels that would simply receive and replicate knowledge produced elsewhere in the world.

Although Kapil Raj writes about a different part of the world, his work is widely read in Latin America and has contributed to a revision of the narratives about scientific production in the region, framing new historiography that advocates for the study of autonomous scientific fields, with their own characteristics and priorities. The ideas of circulation of scientific knowledge and the perspective of the creation of a creole science can highlight the performance of the National Petroleum Council (CNP) as a focal point for the development of an autonomous scientific field, with its own characteristics and priorities, not just a transplanted copy of a universal model from the Northern Hemisphere.

4.3 Geology in Brazil: The Construction of a National Scientific Field

One of the principal characteristics of the history of scientific practices in Brazil is the tension between Eurocentric models and the search for a national identity. The work of geologist and historian of science Silvia Figueirôa addresses this tension. Her book *Geological sciences in Brazil: a social and institutional history 1875–1934* (1997) analyzes the development of geology as a scientific field in the country. Figueirôa considers that as early as the Imperial period in Brazil (1822–1889), there was markedly a "Eurocentric position of the Brazilian elite of the time" in relation to science. After the establishment of the Republic in 1889, there was the desire to "inscribe the recently independent country in the hall of civilization." This patriotic feeling also "strongly compelled scientists, institutions and research programs, whether at the ideological level (of the discourse of scientists) or at the practical level (engaging in projects of data collection on the physical environment), tinting imported models with local colors" (de Figueirôa 1997, pp. 76–77).

The image of *local colors tinting imported models* throws light on the issue of the autonomy of national scientific production. Several national institutions fulfilled this role in shaping the field of a Brazilian geology. These include the Brazilian Historical and Geographical Institute (IHGB). The commitment of the IHGB in putting together a fully Brazilian scientific expedition is a good exemple of its role in shaping the national sciences. The expedition began to take shape in 1843 and culminated in the Scientific Commission of Exploration in 1856:

> In addition to the ideological role of valuing *Brazilian* scientific aspects, the Commission's work proposal also had a markedly technical character and touched on key points that, in my view, were fundamental to its viability: the possibility of discovering some mineral resource 'that could soon become most lucrative', providing subsidies for government action (communication channels, indigenous catechesis, mineral exploration) and a nationalist character to the work. (de Figueirôa 1997, pp. 86–87)

From the foundation of the IHGB in 1838 to the creation of the CNP in 1938, a centry passed in which scientific activity in the country was contantly intersected by issues of politics and varying brands of nationalist ideology. The rise of Getúlio Vargas in 1930 led to a growing drive for building State capacity countrywide. Its characteristic modernizing vision included the expansion of infrastructure, internal markets, and investments in industrialization. These engendered a new relationship between State and science through "a wide administrative reform that restructured, transferred or even extinguished a series of State agencies" (de Figueirôa 1997, p. 211)—several of which were directly responsible for the development of national geology.

At the end of the 1930s, when the CNP was established, scientific practices surrounding petroleum in Brazil were influenced by a number of issues: the pressing need for industrial development, the still difficult search for commercially viable oil fields, and lack of specialized workforce. These demands paved the way for intense international collaboration, mediated by the National Petroleum Council, having the USA as its main partner. These interactions included receiving US labor, materials, and technologies.

At a time of heated nationalist debate in the country's political landscape, collaboration with US government and private companies was viewed with reservation, if not with open suspicion.[1] The nationalist rhetoric promoted by the Vargas government had to be equalized with both economic interests and the need to develop modern scientific techniques for prospecting and exploring national oil. Thus, in the period prior to the creation of the state monopoly via Petrobras (founded in 1953), we identified the tensions created by the nationalist ideology present in the

[1] Monteiro Lobato's words are emblematic of this mistrust: "Oil is now practically monopolized by two huge trusts, Standard Oil and Royal Dutch Shell. Because they dominate oil they also dominate the finances, the banks, the money, the market; and because they dominate the money, they also dominate the governments and their administrative machine. This network of domination constitutes what in this book we call 'Hidden Interests'" Monteiro Lobato, *O escândalo do Petróleo* (São Paulo: Editora Brasiliense, 1951, pp. 9–10).

political sphere, the national economic development project under Vargas, and the technical and scientific needs that propelled international contact and collaboration.

These interactions shaped the development of oil geology in Brazil. The presence of foreign specialists, consulting partners, the importing of specialized machinery, scientific manuals and journals coalesced with the political and economic practices of the Vargas government, creating this new scientific specialization. Brazilian petroleum geology was permeated by all these dimensions from its beginning.

4.4 Oil and Geology in Brazil: Background and Trajectory of the Field

The search for oil in Brazil began in the Empire, and the first known document that featured the term *petroleum* in its text was a concession signed by emperor Dom Pedro II, in 1864. This was a decree authorizing English citizen Thomas Danny Sargent to extract peat, oil, and other minerals in the south of the province of Bahia for 90 years—the subsoil and its wealth were property of the Empire and, among several rules, the payment of taxes to the Imperial State was established. Despite being the first official initiative in Brazilian oil history, no oil production came from this enterprise (de Dias and Quaglino 1993).

With the transition to the Republic in 1889, mining activities were, for the first time, entirely in the hands of the private initiative.[2] In 1892, Eugênio Ferreira de Camargo obtained concessions to the region of Morro do Bofete, in São Paulo. Shouldering all the risks and costs of the search for oil, Camargo was faced with the limits of the private initiative: high costs, delay in producing results, and the difficult geology of the chosen area ended up determining the end of his activities.[3] More details on that initiative are discussed in the chapter authored by Oliveira and Figueirôa in this book.

In that period, technical knowledge of petroleum geology was the responsibility of (mainly foreign) engineers hired by the private initiative. Petroleum geology cannot yet be described as a scientific field in Brazil, since search attempts were undertaken sporadically, not constituting organized efforts—the field was still very much artisanal. The Ouro Preto Mining School (EMOP), in operation since 1876, had began to create a field of studies and research in mining engineering, metallurgy, and geology. Oil, however, was not yet studied by its engineers, and its search was based much more on empirical knowledge than on technical training.

The Geological Mineralogical Service of Brazil (SGMB), created in 1907, focused on promoting the "scientific study of the geological structure, mineralogy and resources of the territory of the Republic, especially in view of the use of mineral resources." It was, therefore, the "first institution dedicated to systematic geological surveys of national scope (…) and constituted an important institutional space that would accommodate mining engineers and, later, geologists" (de Figueirôa 1997, pp. 217–218).

The guidelines of the SGMB's operations are explained in the Service's regulations, which stated that the agency should "refrain from research guided by exclusively scientific targets (…) the economic, utilitarian side must be considered in all efforts" on the search for mineral

[2]According to Dias and Quaglino, the Brazilian 1891 Constitution draws on US legislation and breaks with the country's legal tradition by establishing that landownership included the subsoil. It also reduced the extent of public lands under Federal jurisdiction. These legal provisions deterred much mining due to "the endless quarrels that traditionally involved the land ownership in Brazil: disputes among heirs, uncertainties as to the title of possession and conflict of limits" (p. 8). There was also a growing inclination to deny the access to researchers looking for minerals in private properties, since landowners were not always willing to share the possible riches contained in the undergrounds that was now their property.

[3]"Without resources to continue the work, Eugênio Camargo ended the activities in Bofete. However, he had inscribed his name as the first Brazilian to find real traces of oil in Brazil." Mário Victor, *A batalha do petróleo brasileiro* (Rio de Janeiro: Civilização Brasileira, 1970, p. 33).

resources in the country (de Figueirôa 1997, pp. 225–226). These directions highlight the impact of other fields in the production of geological knowledge in Brazil—political, economic, and industrial interests intersect to ensure scientific research always had a practical goal and to guarantee it would promote national interests.[4]

In 1919, the SGMB officially took over oil research and exploration. The agency carried out drillings in several parts of the country: Paraná, São Paulo, Alagoas, Bahia (with emphasis in the region of Recôncavo), Pará, and Amazonas (de Dias and Quaglino 1993, p. 13). If, on the one hand, these efforts did not result in any discoveries, on the other hand, a wide range of information was gathered about Brazilian subsoil geology, techniques, and practical knowledge of the field and its instruments. In addition, the State maintained its interest in oil research, even with bureaucratic difficulties and poor institutional conditions. The SGMB can be considered the main predecessor in the formation of a specific field of oil geology in Brazil. It was responsible for the first surveys to identify potentially oil-bearing geological formations. Many of the SGMB staff were trained at EMOP, and the networks between this institution and the government technical agencies are unequivocal.[5]

The beginning of the 1930s brought more important changes to State institutions engaged in the search for oil: In 1933, the SGMB was extinct, and the National Department of Mineral Production (DNPM) was instituted. Oil gained further institutional importance, and finding it was increasingly seen as a matter of national dignity.[6] The SGMB was absorbed by the newly created DNPM, and many geologists and engineers of the former service joined the cadres of the new department. The influence of the Ouro Preto School of Mines in the connections between science and politics is visible in the DNPM. Several of these engineers were also active participants in the discussions that generated the Code of Mines of 1934.[7] The political dimension was an integral part of the scientific practices of these engineers turned bureaucrats. In their dual role, they were in a privileged position to lay the foundations not only for the development of the field of oil geology, but also to establish the rules for its operation at the national level. The Code of Mines of 1934 reflected their position by restricting the access of foreigners and making the national subsoil a State asset.

The work of these initial years of more systematic search for Brazilian oil was not made any easier by the fact that government employees were now at the forefront of the research. Even with the many surveys undertaken by the DNPM, national oil had not yet been discovered. This

[4]Here, we can see a striking similarity to McCook's analysis of political and economic influences on the production of scientific knowledge on soils and plants of the Spanish Caribbean: regulations "continued [to be] a problem […]: what scientists identified as a good biological solution to an agricultural problem was not always economically viable" (McCook, *States of Nature*, 25).

[5]de Carvalho (2002, p. 96) highlights the difficulty of placement in the labor market by EMOP graduates. In the early years of operation, "the almost exclusive occupation of former students was teaching"; the scenario began to change with the creation of state geological commissions, and employability increases with the creation of the SGMB, where, according to José Murilo, almost all positions were filled by graduates from the School.

[6]The nationwide repercussion of the debate of whether there was oil in Brazil or not was very public and well documented. de Dias and Quaglino (1993, p. 81) observe that it reached a double objective: "on the one hand … it broadened public interest, establishing with consumers, industrialists and investors a much closer relationship, giving rise to a sense of relevance of the problem in other circles beyond the official ones. […] On the other hand, […] it ended up reaching particularly sensitive targets. […] It radically condemned the State's lack of ability to lead the development of this industrial sector".

[7]de Carvalho (2002, p. 120) states: "The Mining Code and the Water Code […] were written by Domingos Fleury da Rocha [former student of EMOP], then director of DNPM, firmly supported by minister Juárez Távora and federal congressmen Furtado de Menezes and Euvaldo Lodi. The 1934 Code was the first in the country's history, [and] reduced the rights of landowners to mining concessions, in the case of existing mines. The mines unknown at the time of publication of the Code were declared State property. The creation of the National Petroleum Council was also Fleury's suggestion, as well as almost all oil legislation of the time (…). Fleury was vice president of the CNP from 1938 to 1944".

caused widespread discredit about State-run operations and contributed to various debates involving different sectors interested in finding oil. Thus, the 1930s and 1940s saw growing controversy in the industry. At first, about the existence or not of oil in Brazil. After oil was found in 1939, the debates turned to the participation of the private sector (both Brazilian and foreign) in the nascent industry. It was a politically charged time, in a world struck by a World War that increased the demand for mineral resources around the globe. The quality of DNPM's work (which throughout the 1930s had not been successful in its search for Brazilian oil) began to be questioned by independent parties, mostly business entrepreneurs dissatisfied with the agency's obstacles to private research.[8]

While in the public arena solutions were discussed for the development of an oil industry in the country, government technical staff saw other difficulties ahead. Issues ranged from bureaucratic difficulties imposed by the DNPM, to technical difficulties and lack of scientific expertise, since there was no specific training in oil geology in the country. Official initiatives lacked technical and financial resources and irritated the private sector with delays in producing the expected results. There was a clear tension between a nationalist political ideology, permeated by the desire of industrial development, and a private initiative eager for participating in the sector. Both aspects informed scientific practices and production of knowledge in the budding field of Brazilian oil geology.

The intersection of these spheres of influence can be seen in the sources. The DNPM's budget proposal for 1944, for example, raises concerns about all these issues. At the outset, Antônio José Alves de Sousa, warns: "I feel it is my duty as the director general of this department to draw the attention of the competent authorities to the absolute deficiency of technical personnel who have been increasingly resenting the [situation]." According to the director, the specialists (not specifically oil specialists, but geologists and mining engineers in general) were attracted by the wages and infrastructure offered by the private sector. He adds that "there is no real economic development in any country that does not rely on the creation (…) of basic industries" and continues:

> The fastest we establish these industries the more rapidly and completely the National Department of Mineral Production can study and evaluate our mineral resources (…) and the more efficiently it can collaborate with private and governmental initiatives, guiding the use of these resources.[9]

In this passage, we can get a glimpse of the place of science and scientific practices in that national context: They would facilitate the economic development and the material progress of the nation. Scientific circles such as DNPM, therefore, were privileged locus of production and circulation of specialized technical knowledge to that end.

From the outset, the development of the scientific field was intersected by political, economic, and technical issues. The nationalist imprint left by the graduates of the Ouro Preto School of Mines was visible in the guidelines of the DNPM, as it would later be in the CNP. Nevertheless, this was never a unanimous position, and it is possible to find among technical experts and bureaucrats many in favor of the inclusion of private companies and international investment.[10]

The trajectory of many former students of EMOP can be traced in a network that links their

[8]Monteiro Lobato's book on the situation is probably the best example of this dissatisfaction. His central argument is that the Brazilian government and international trusts work together behind the scenes so that oil is not extracted on Brazilian soil. To justify this argument, Lobato mentions laws, meetings, meetings, exchanges of letters, newspaper articles, and depositions on the subject. The author argues that because of this delay in extraction and production of Brazilian oil, the country was left at the margin of world progress. Lobato, *O escândalo do Petróleo*, 1st edition 1936.

[9]Proposta orçamentária DNPM 1944—Fundo DASP, caixa 411/Arquivo Nacional.

[10]"The nationalist state solution was not unanimous among the technical staff," state Dias and Quaglino about the DNPM technicians at the time of the discovery of Recôncavo's fields. Many "had no prejudice against private initiative and/or foreign capital" (p. 35). Given the large intersection between DNPM and CNP staff, it can be understood that this is also a plausible position for some Council technicians.

training period in the School of Mines, their work in the SGMB and in the DNPM, and their subsequent employment in the National Petroleum Council. It was in these institutional spaces that both scientific production and ideologies circulated. Avelino Ignácio de Oliveira, for example, graduated at EMOP in 1916 and became the head of the geological reconnaissance expeditions of the Amazon basin of the SGMB, where he remained for 15 years. After that, he took on administrative positions in other agencies, including DNPM, where he acted as Director General between 1936 and 1938. That year, Oliveira became the first Director of the Technical Division in the newly created National Petroleum Council.[11] In this same network is Pedro de Moura, also a graduate of the School of Mines. He graduated in 1925 and, in that same year, joined the Amazonian expeditions of the SGMB, contributing to the first geological mapping of the Tapajós region, in Northern Brazil. In 1944, Moura was appointed head of CNP's operations in Bahia, and he was responsible for finding the first commercially viable well in the Candeias field.[12]

The importance of these two actors in supervising CNP's work is evident. Oliveira and Moura were in a privileged position to set the pace and the priorities at the beginning of the exploration, production, and industrial development of Brazilian oil. Their similar training and professional trajectories help highlight the links that both Oliveira and Moura established between their work as scientists, the political sense of oil as a national wealth, and the nationalist aspiration of material development for Brazilian progress. Could they have been the first creole scientists of Brazilian oil geology?

[11]In 1951, Oliveira returned to his position as DNPM director and after retiring, he became one of the first Oil Geology professors at the School of Geology of the Rio de Janeiro Federal University, where he remained from 1961 to 1967 (Guedes 1992).

[12]de Moura and Carneiro (1976).

4.5 National Petroleum Council: Politics and Science in the Development of Brazilian Oil Geology

The National Petroleum Council played a vital role in the development of Brazilian oil industry. Established in 1938, it had a twofold mission: It would be a regulatory agency for the existing oil market, which included mainly oil importers, the refineries that processed the imported crude and distribution companies operating as gas stations; it also had a technical department responsible for the search of oil on national territory. This was later incorporated by Petrobras, the State-controlled oil company founded in 1953.[13] The Technical Division was at the forefront of research and exploration. It was where several geologists formerly in the DNPM were employed and there that they began to develop practices that fostered the development of oil geology in Brazil.

While the nationalist position gained predominance under Vargas, a specialized field of oil geology developed. The first president of CNP, General Horta Barbosa, was markedly nationalist and wanted to establish complete State monopoly over the resource.[14] His management, between 1938 and 1943, initially looked for State-run models like the

[13]The CNP carried on with its regulatory activities for many years and eventually went on to become the National Agency for Petroleum, Natural Gas and Biofuels (ANP in Portuguese). The ANP, established in 1997, is still active in its regulation of the national energy market. Further discussion of the role od the CNP and its State-building objetives can be found at OTOYA N (2018) Oil in 20th century Brazil: Energy dependence in the Second World War. Varia Hist 34(65):347–374. http://dx.doi.org/10.1590/0104-87752018000200004

[14]The profile of leaders of public science-oriented institutions has a consistent trajectory of militarism in Brazil. Since the beginning of the nineteenth century, with the creation of the Royal Military Academy, the purpose was "to form both army officers and technicians for several different jobs," according to Figueirôa, adding that this was an colonial tradition: "In Portugal it was customary for certain branches of the public service, such as the technical supervision of mineral activities, for example, to be the responsibility of military officers" (de Figueirôa 1997, pp. 54–55).

industries in Argentina and Uruguay.[15] The ties with the USA, however, grew closer with arrival of the American Technical Mission, in 1942. A year later, Colonel João Carlos Barreto substituted Horta Barbosa as president and the CNP became even more connected to the networks of American oil geology. Despite this collaboration, the political scene outside the CNP continued to point to a nationalization of mineral resources, which, with the start of World War II, became strategic for national security.

In early 1939, Brazil produced its first oil. It was the Lobato field, located on a peripheral region of the city of Salvador, capital of the Northeast state of Bahia. The field was immediately turned into State property, and access to private persons was prohibited. The links between the aspiration to develop a specialized scientific field, the need for technical knowledge imported from an imperialist nation, and the political desire for national control over the newly discovered oil converged to shape the field. The Council is a privileged place to analyze these spheres, since it was the agency that concentrated all efforts of search and exploration.

Three initiatives of CNP's Technical Division for geological work will be discussed in the following sections: (1) international collaboration, which aimed both at the acquisition of machinery and technical consulting of companies specializing in geology and geophysics; (2) the need for training a national workforce; and, finally, (3) the promotion of educational partnerships with Universities and Mining and Engineering Schools. These three factors reveal the pulls between political nationalism and economic development in the nascent scientific field of oil geology.

[15]One of Horta Barbosa's first missions was to travel to the two neighboring countries where the industrialization of oil was already being developed by the State: Uruguay and Argentina. After this visit—held in 1939, less than a year after the creation of the agency—General Horta Barbosa wrote a brief report outlining the advantages of the models he had seen followed by some conclusions that indicated possible ways for the industrialization of oil in the Brazil [Civil Office of the Presidency of the Republic, tin 508/ 1938-43 (CNP)—Brazilian National Archive].

4.6 International Collaboration

The international collaboration undertaken by the CNP began to happen more systematically with the arrival of the American Technical Mission, headed by Morris L. Cooke, also known as Cooke Mission.[16] Landing in Rio de Janeiro in September 1942, the twelve experts on the mission remained in Brazil until December of that year. Each of the specialists covered an area of interest and the Brazilian government appointed national counterparts, creating its own technical mission, in an effort that involved more than a hundred people. Oil had at first been excluded from the list of issues to be addressed by the team. The mission's oil expert, geologist William Kemnitzer, only arrived in Brazil in November of that year. One possible reason for this initial absence can be seen in the confidential reporte of CNP president Horta Barbosa to Getúlio Vargas. The General reported accompanying the envoy of the Technical Mission in order to show him "the reality of oil In the Recôncavo Baiano":

> I noted at the outset an evident reservation against the work of the Council, which faded as he examined the evidence before him. I later verified the origin of that suspicion when Mr. Kemnitzer told me that he was surprised by what he had observed, for in Washington, and even in Rio, they had tried to dissuade him from going to Bahia, where they said, there was nothing real![17]

The delay in including oil in the list of "Brazilian problems" to be studied by the Mission may have stemmed from this position. In describing the visit of the American geologist, Horta Barbosa noted that he "continually improved (…) the impression he had [of Brazilian oil]. And it was after these visits that he declared he was astonished at the discouragement he had heard in Rio." The CNP president

[16]For a broader discussion on the origins and impacts of the Cooke Mission, see Irene Rodrigues da Silva, *Missão Cooke: Estado Novo e a implantação da CSN* (Rio de Janeiro: E-papers, 2003).

[17]Excerpt from Horta Barbosa's letter to Getúlio Vargas. File no. 3300—Box 1276/CNP Collection—Brazilian National Archives.

also reported that he personally accompanied the geologist because he considered it important "to make him see, in the fields, that the oil in the Recôncavo Baiano is not only a hope based on vestiges or optimistic opinions—but an unmistakable reality."[18]

In addition to the field visits and conversations he had with the American geologist, Horta Barbosa also reported some of Kemnitzer's "realistic and cautious calculations" regarding the Bahia reserves. By his estimates, wells already in production would have a "proven potential" of approximately 3,500 barrels per day. Kemnitzer added that "any company or capitalist venture in the United States would easily give 13 million dollars (...) for what is done and in its current state." Horta Barbosa commented with enthusiasm that such sum "represents more than twice the total amount invested by the Council, since its establishment."[19] Despite his nationalist leanings, Horta Barbosa understood the importance of a technical opinion about national oil.

Kemnitzer's visit may have been brief—according to the sources, after a few days in the fields of Bahia[20], the geologist left Brazil. This first contact with US scientists, however, had rippling effects. Horta Barbosa accepted Kemnitzer's suggestion to carry out a plan of drilling 55 wells, concentrating the production effort in Bahia. To this end, it would be necessary to import approximately 16,000 tons of material to start drilling commercially viable wells, as well as to start prospecting at new locations. The war period, however, would be an obstacle to this large-scale import. A few months after the visit, Morris Cooke wrote Horta Barbosa, saying he was pleased with the General's approval of the plan proposed by the Technical Mission. But he also apologized for the delay in delivering the imports: "You understand, of course, how tragically limited is the total amount of material and shipping space available and how much competition for these exist as between the military and civilian requirements."[21] This was the beginning of USA–Brazil collaboration in promoting the development of a Brazilian oil industry. Despite wartime limitations, the USA would eventually ship the promised materials and continue to collaborate with technical expertise, materials, and specialized personnel.

From a technical perspective, it was imperative to develop a national oil industry. Thus, the presence of foreigners in the oil sector would only increase over the next decades. This, however, never meant that Brazilian government loosened its grip on the country's natural resources. The Vargas' regime promoted a mode of collaboration that allowed the presence of scientists and technical personnel but barred large capitalist interests to take hold of the national industry. Despite the many contending positions of government officials, technical personnel and elected politicians, decades of legislating about oil and of engaging technically with its geology resulted in an understanding that the state could be a major actor in the industrialization of natural resources. It could mediate the interactions of foreigners to serve its own agenda. In that sense, Brazil was able to develop its industry within its nationalist parameters, while still benefiting from international scientific knowledge. One of the most fruitful collaborations was with Texas-based geology consulting company, DeGolyer and MacNaughton. The company had several contracts with the Council starting in 1945 and supplied the agency with consultants who acted in practice as CNP bosses. This partnership also had an educational side—American experts worked as consultants at the same time as they shared their technical knowledge by training national successors for the positions of leadership they usually occupied.

[18]Ibid.

[19]File 3300–Box 1276 / CNP Collection–Brazilian National Archive.

[20]November 18 to 21, 1942.

[21]File 3300–Box 1276 / CNP Collection–Brazilian National Archive.

4.7 Building a National Workforce

The sources show an ongoing concern with the establishment of national crews. In a report about the renewal of the contract with DeGolyer and MacNaughton (extended in March 1948), the extent of duties (and influence) of the head consultant can be gauged:

> This representative is responsible for the supervision of geological field work, in close connection to the Presidency and the head of the Geological Services of the National Petroleum Council. (…) this representative delivers, at the end of each month, a report of the work done; he provides opinion, on a confidential basis, on the selection of foreign companies and technical personnel to perform the services; he assists the Council in arraging for contractins specialists and foreign companies as well as procuring materials in the USA; and he facilitates the training of Brazilian personnel.[22]

Here, we can see the many motivations the CNP had to engage in these partnerships. The development of a scientific field depended on several factors—specialized workforce, machinery, and networks to bring qualified professionals to the country. Thus, the work of the North American firm extended across several fields, expanding the contact between foreign and Brazilian geologists. In March 1950, Lewis MacNaughton invited the Director of the Technical Division, Avelino de Oliveira, to attend the annual meeting of the American Association of Petroleum Geologists to be held at the end of April of that year. MacNaughton also mentioned that he would attend a meeting of Brazilianists at Stanford University the following May, which aimed to discuss "Brazil and its possibilities." The American geologist suggested that Avelino's presence would be welcome, since, he stated "I will probably lead the discussions on the panel about natural sciences." These exchanges highlight how academic and scientific production started to circulate about the geological potential of Brazil as a producer of oil and of scientific knowlege about it as well.[23]

Another important feature of the American consulting firm is the provision of fieldwork: There were hundreds of memos and reports on the organization of field teams, personnel deployment across research areas, material requirements for each task performed.[24] It was an effort to set up an entire field of the natural sciences. Many documents provide accounts of this commitment. In a report on the work in Bahia, dated June 1945, consulting geologist A. H. Garner makes the following observations:

> As it is probable that the different geologists with different training and nationality will have varying methods of observing and reporting I have thought it advisable to have a definite method or standard for the work. To that end I have selected all rocks that we are likely to encounter into 12 divisions with descriptions of each. I have also specified the properties of the rocks that are to be reported and I have given some special instructions for field work.[25]

These educational instructions are crucial for understanding the field in formation. There was, at that time, little specific knowledge about the potentially oil-bearing geological formations in the country, and these notes have the role of filling this gap. The geologist continues:

> A small dictionary of geological terms in English and their Portuguese equivalents has also been prepared. The object of all this is to have each geologist use a geological term in the same way and mean the same thing.[26]

The concern in forming and educating the multinational teams is clear in this section. In the original document, these observations are underlined, revealing the importance of this initiative. In the same memorandum, Garner also suggested the creation of a geophysical laboratory for the study of rocks. This suggestion was promptly accepted by the CNP. Carlos Barreto, then president of the Council, wrote to Pedro de

[22]File n. 3590, 7º volume—Box 1282/CNP Collection—Brazilian National Archives.

[23]File n. 3590, vol. 6—Box 1284/CNP Collection—Brazilian National Archives.

[24]Geological Reports—File n. 3948 vols. 1–8—Boxes 1270–1278/CNP Collection—Brazilian National Archives.

[25]Geological Reports—File n. 3948 vol. 1—Box 1270/CNP Collection—Brazilian National Archives.

[26]Ibid.

Moura informing that "the President of the Republic authorized this Council to hire American geologists" and recommended taking "the first steps to organize a petrographic laboratory (…) assigning technical personnel chosen from our newly admitted engineers."[27] The estimate of cost and material required would also be the responsibility of the US consultancy, as well as the names of the foreign geologists involved.

These passages reveal yet another central issue in the CNP's technical work: It didn't intend to rely on foreign workforce for a long time. However, as it is clear in the terms used by Barreto, at that time they could only hire Brazilian *engineers*—geologists, however still had to be imported. In the various volumes of DeGolyer and MacNaughton reports, the growing importance of the creation of a national workforce is increasingly visible.

In a December 1944 report—whose cover warns of "Secret Communications"—Pedro de Moura gave details of his work as the head of the regional Bahia service. His extensive report addressed several practical issues and highlighted the precariousness he found in the field. He reported the need for adequate equipment, problems in the state of the vehicles and the shortage of workforce: "superficial geological works are paralyzed by lack of technical personnel." In dealing with geophysical work, the engineer reported: "As for training personnel, we are really struggling in this sector." Moura maintained, however, a positive attitude toward the near future: "I am very hopeful that within a year we will have our crews of national staff."[28]

Pedro de Moura's hopes would not come true so quickly. In a September 1949 report, Wilbur Sherman—the new chief consultant of DeGoyler MacNaughton, who would remain in Brazil until the end of the CNP contract—reported: "Both Dr. Avelino and Dr. Moura have discussed with me the possibilities of forming an all-Brazilian geophysical crew at some future date."[29] The consultant further informs:

> If the Conselho is definitely interested in a project of this type an effort should be directed towards the procurement of individuals with the proper educational background who will be qualified to undertake training in geophysical work.[30]

CNP technicians seemed determined in their "scientific independence" project. Joaquim Prestes dos Santos, head of the geophysics section, wrote a reply to the US consultant's memo: "national teams would be the nucleus in which a complete geophysical prospecting mentality would begin in Brazil." It was not only an important, but a possible project: "the Council already has most of the initial elements needed for such an undertaking." He believed, however, that there was a limit to this task—Santos feared that the CNP, by hiring only Brazilians and "losing contact with research and innovation centers [would] eventually lead to obsolete geophysics."[31] His suggestion was to keep an American consultant working in the Council.

This perception that Brazil was not—and would not become any time soon—a center of scientific innovation contrasted with other parts of the same report, where Santos considered that "this measure … will lead Brazil to increasingly tread a path of economic scientific independence." He also believed that the "progress of the country" would be a consequence of "resource utilization" and that technology and science would "drive the industry systematically and rationally through research and control activities."[32] Many intersections are visible in this document: The concern with the industrialization and progress of Brazil, and a certain brand of nationalism that wanted scientific independence, but at the same time, believed that science could only be produced in "research and innovation centers." In addition, the choice of words is symptomatic—the CNP employee spoke of "economic scientific independence," attaching the development of the scientific field to the economic development of the country, promoting the notion that it was through science that the use of the resource would

[27]Ibid.

[28]File n. 3002—Box 1274/CNP Collection—Brazilian National Archives.

[29]File n. 3948 vol. 5—Box 1270/CNP Collection—Brazilian National Archives.

[30]Ibid.

[31]Ibid.

[32]Ibid.

bring progress and modernization to Brazil. Here too the kind of nationalism posited by many of those involved in the search for oil appears: if it was impossible to dismiss North American know-how, the “control” of wealth must be national.

4.8 Education and Training

The third strategy adopted by the Council to foster the development of oil geology in Brazil was providing financial aid to engineering schools of the country’s universities. Sources show several applications for financial aid for national and international travel, mainly to other Latin American countries. The students and professors of the following institutions applied to the Council: School of Mining of Ouro Preto, National School of Engineering of the University of Brazil, Mines and Metallurgy course of the Polytechnic School of the University of São Paulo, and School of Engineering of University of Minas Gerais. The applications were always the same: They asked for funds to go on technical field trips that would be essential for “acquiring the necessary knowledge to practice the profession that we will embrace.”[33]

The Council was generally willing to provide financial assistance. Even when the amount “the engineers request as a contribution from this Council [was] excessive,” the CNP contributed with the values it deemed appropriate. Also noteworthy is the network created between the educational institutions and the CNP technical body. Writing about a trip to Uruguay, Argentina, and Chile, requested by the students of the National School of Mines of Ouro Preto, Avelino de Oliveira (Himself a former student of the institution) pointed out that “this [was] the same group that, in January this year [1945] was in Bahia visiting the operations of this Council.”[34] In addition to the subsidies to travel elsewhere, the Council usually welcomed students in its fields in Bahia, further promoting the technical education in oil geology.

The Council was not always able to contribute financially. In 1946 and 1947—a post-war period and a change of president for the first time in 15 years in Brazil—the Council was not able to contribute “in view of the great constriction of expenses repeatedly determined by the President of the Republic.” When declining applications, the CNP president, General Barreto, often stated that the agency “always sought to cooperate with the different universities of the country to help students of higher education in their familiarization with the problems of oil in Brazil.” In another negative reply, the general reiterated his position: “I regret to inform you that it was not possible to fulfill your request, despite the CNP’s interest in publicizing (…) the work it has been doing in the Recôncavo Baiano.” Engineer Afonso Cesário Alvim agreed. Writing about a field trip for students “wishing to study the oil situation in Bahia,” he stated: “There is no doubt that an excursion of this nature is of great use to the students and will certainly arouse enthusiasm for petroleum engineering, perhaps giving rise to the hiring of good elements for the Council’s staff.”[35] Once again, the close links between educational institutions and the Council are visible.

The relations between the CNP and educational institutions are an important link in the development of the field. The intention of forming national crews—which should not be understood as a nationalist radicalism, but as part of a State capacity-building project—could only be pursued if there was skilled workforce for it. The CNP’s three work fronts in oil geology—international consulting, training of Brazilian teams, and promoting oil studies academically—are part of this larger project: the creation of an economically and technically independent petroleum industry, which would give the country its much-desired progress. Consequently, all these spheres have an influence on scientific production. The sources analyzed here touch on the intertwining between nationalist politics,

[33] File n. 4101—Box 1248/CNP Collection—Brazilian National Archives.
[34] Ibid.
[35] Ibid.

economic growth, and industrial development in Brazil and the impacts these had on the production of scientific knowledge in the field of oil geology on the first half of the twentieth century.

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5 Teapot Dome: The Greatest Political Scandal in the History of the US Oil Industry

Matthew R. Silverman

Abstract

Warren G. Harding's presidential administration in the early 1920s is best remembered for the scandal surrounding Teapot Dome oil field in Wyoming, the most infamous presidential malfeasance of the early twentieth century. A Presidential Order in 1915 named Teapot Dome a Naval Petroleum Reserve. The advantages of petroleum over coal for naval fuel had proved irresistible, and the crude reserves were meant to provide a secure wartime supply. Harding chose Senator Albert B. Fall as his Secretary of Interior. Fall wrangled Teapot Dome away from the Navy Department, and then leased the field in 1922 to independent oil titan Harry Sinclair in a non-competitive deal. Senate hearings followed, Fall resigned, and Harding died suddenly a few months afterward. Investigators determined that Fall had received about $400,000 in "loans" from Sinclair. He was convicted and imprisoned for bribery. Sinclair was jailed for contempt, the leases were invalidated by the Supreme Court, and Teapot was returned to the Navy. Teapot is an asymmetrical anticline on the southwestern flank of the Powder River Basin. Its key producing zones are Cretaceous sandstones and shales, and there is substantial undeveloped potential for primary and enhanced oil recovery, as well as infill and horizontal drilling targets. In 2015, the field was acquired by Stranded Oil Resources in a public process. Transfer to a new, private operator after 100 years as a Naval Petroleum Reserve represents another exciting chapter in the history of America's most notorious oil field.

5.1 Introduction

Warren G. Harding's presidential administration was probably the most corrupt in American history, and the oil industry was right in the middle of the fun. The affair surrounding Wyoming's Teapot Dome oil field in the 1920s was the most infamous presidential scandal (Fig. 5.1) between the Grant administration in the 1870s and the Nixon administration 100 years later.

The story includes sex, bribes, scandal, oil barons, crooked politicians, bathtub gin, smoke-filled rooms, the Roaring '20s, blackmail, suicide, and murder. In short, it is just like today except that gin is made in craft distilleries and smoking is even less popular than fracking.

The scandal was enormous. Headlines screamed from newspapers across the country for years, and bitter partisanship ruled the day. The administration was crippled, one Cabinet member was jailed and other officials implicated, and

M. R. Silverman (✉)
Robert L. Bayless, Producer LLC, 621 17th Street, Suite 2300, Denver, CO 80293, USA
e-mail: msilverman@bayless-cos.com

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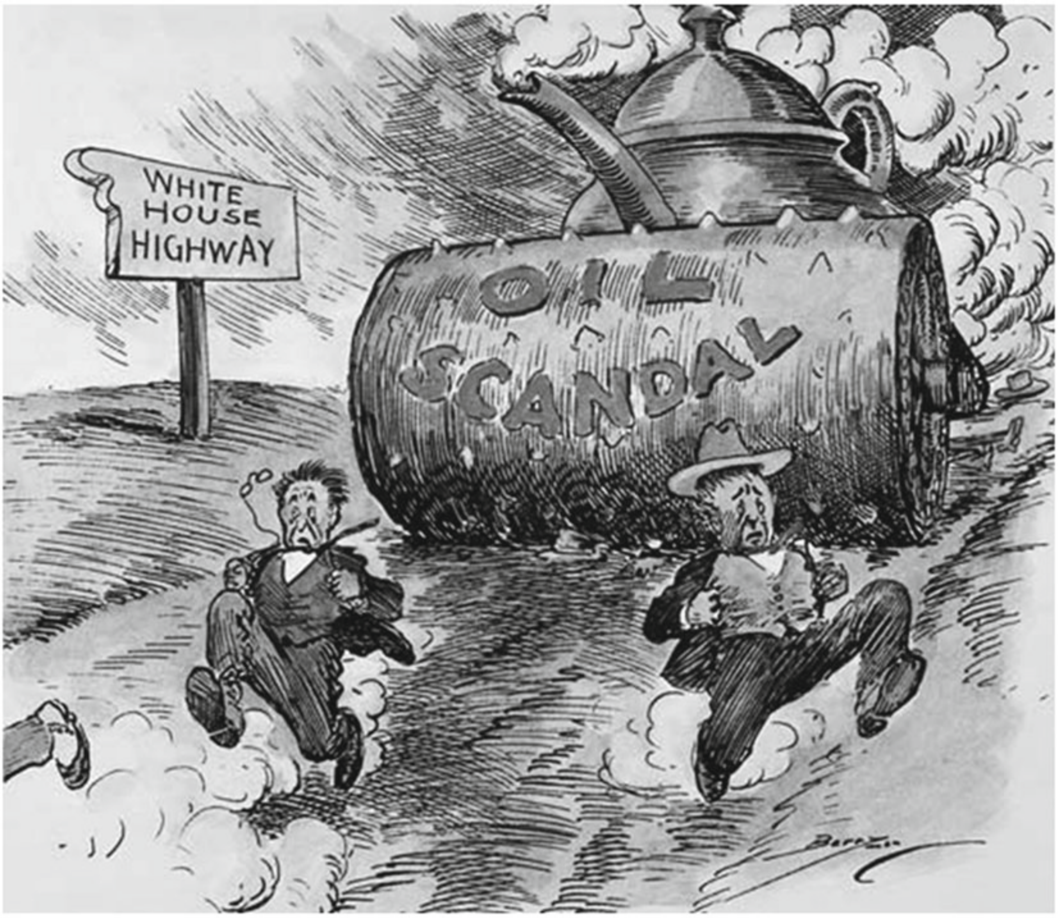

Fig. 5.1 Teapot was the greatest presidential scandal between the Grant and Nixon administrations (Cartoon from The Granger Collection)

witnesses and documents disappeared. On the windswept plains of central Wyoming, dusty Teapot Dome became a symbol for the greedy nexus of Jazz Age business and politics.

5.2 Fuel for the Fleet

A series of presidential orders between 1910 and 1923 created Naval Petroleum Reserves and Naval Oil Shale Reserves in California, Wyoming (Fig. 5.2), Colorado, Utah, and Alaska. For the US and Great Britain, the advantages of petroleum over coal for naval fuel had proved irresistible, and the reserves were meant to provide a secure American wartime supply.

Leading the charge for Great Britain in this effort was First Lord of the Admiralty Winston Churchill, who was committed to meeting Germany's challenge to Britain's naval supremacy on the eve of the Great War. "Mastery itself was the prize of the venture," he said later of the royal fleet's fuel conversion.

Under President Woodrow Wilson, Secretary of the Navy Josephus Daniels and Assistant Secretary Franklin D. Roosevelt (later to become the 32nd President) also embraced the promises of greater firepower, efficiency, and speed that oil-burning ships offered. "Speed is the best armor," goes an old maritime saying.

Carroll H. Wegemann of the US Geological Survey first described the Teapot Dome

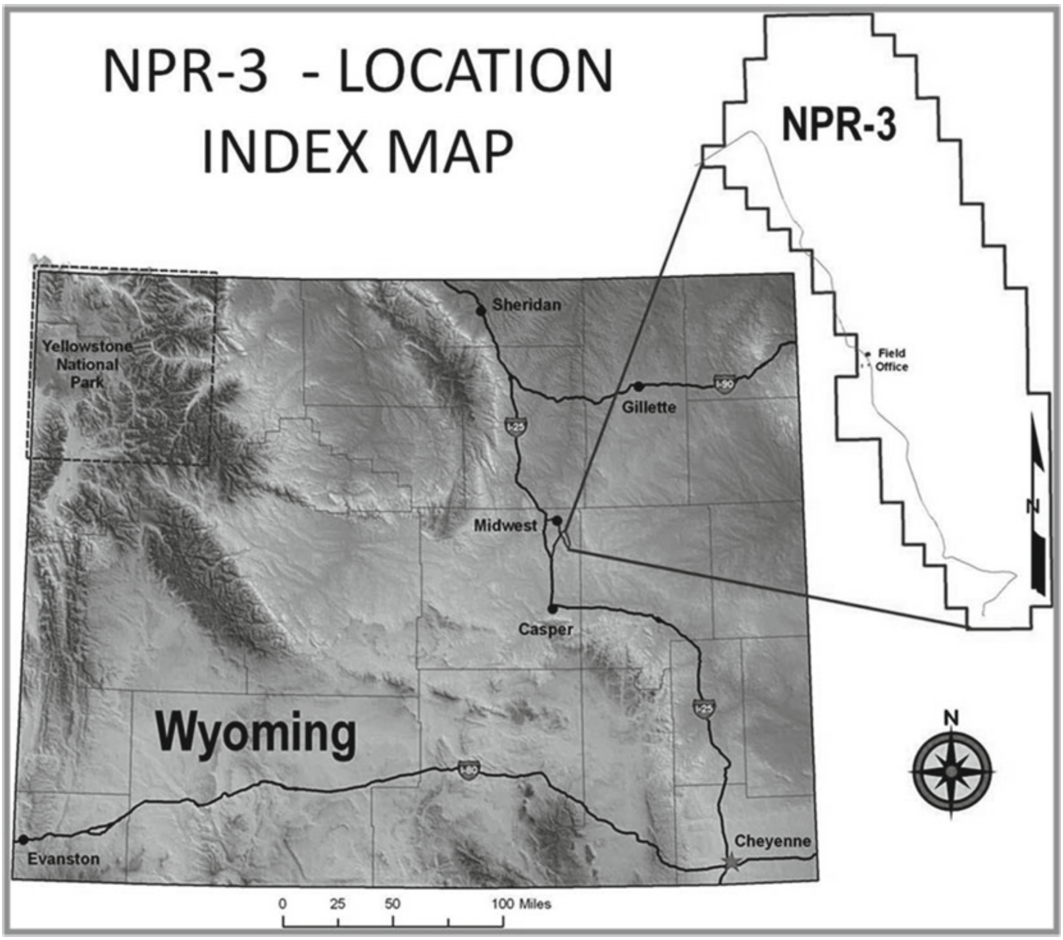

Fig. 5.2 Location of Teapot Dome, Naval Petroleum Reserve 3 (map from RE Davis report, 2014)

structure, southeast of the giant Salt Creek Field in Natrona County, Wyoming, about 40 miles (65 km) north of Casper (Wegemann 1911). He noted, "No drilling has yet been done in the Teapot dome, but the structural conditions here are very favorable for the accumulation of oil. There is a broad gathering ground to supply the oil, sufficient dip to cause it to accumulate and but few faults to break the continuity of the oil sands" (Wegemann 1911, p. 77).

In 1915, the Wilson administration created Naval Petroleum Reserve 3 at Teapot Dome. The prospective structure was exclusively set aside for US naval supply in case of emergency (The field was named for Teapot Creek, which in turn had been named for Teapot Rock, an iconic Parkman Sandstone landmark cropping out nearby. It is still visible from State Highway 259, but the "spout" and "handle" have since eroded away).

5.3 The Harding Administration

Handsome and likable, former newspaper publisher and Ohio Senator Warren G. Harding (Fig. 5.3) was easily elected president in 1920, after a protracted Republican nomination process that gave us the phrase "smoke-filled rooms." Among the wealthy smokers who supported Harding's candidacy with more self-interest than altruism were legendary oilmen Jake Hamon

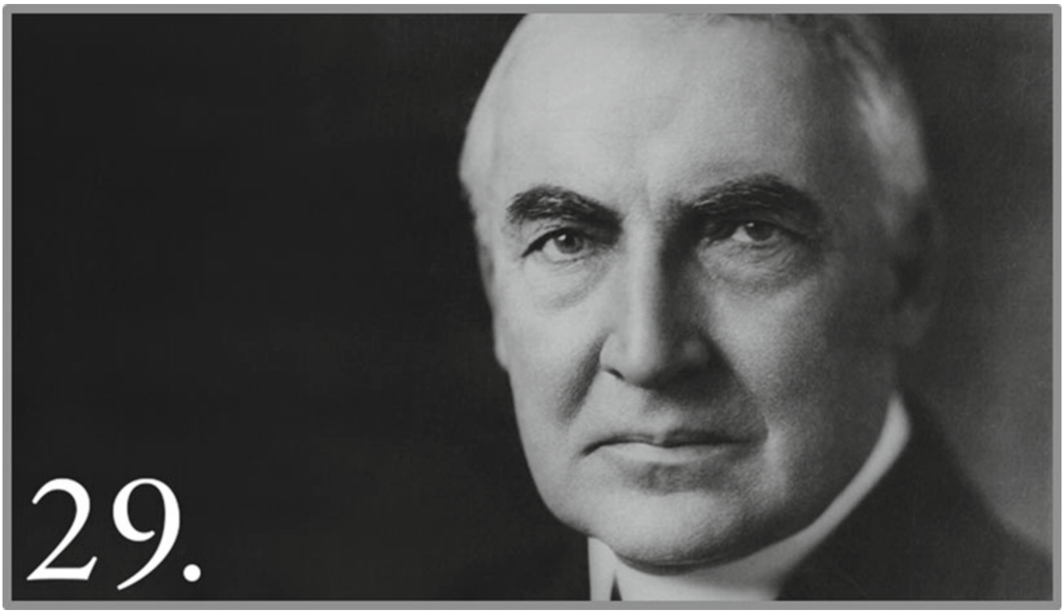

Fig. 5.3 Warren G. Harding, the twenty-nineth US president (whitehouse.gov)

("The Oil King of Oklahoma") and Harry Ford Sinclair, who had failed as a pharmacist but launched his fortune by selling timber for derricks in southeastern Kansas.

Harding chose a poker and drinking buddy, New Mexico Sen. Albert B. Fall, for his Secretary of the Interior (Fig. 5.4). Fall was said (Bliven 1924, pp. 302–303) to resemble "the frontiersman, the rough and ready, two-fisted fighter … who looks like an old-time Texas sheriff … a Zane Grey hero." He was a successful rancher, miner, and lawyer, but one whose enthusiasm for the private exploitation of the nation's strategic resources led the conservationist Gifford Pinchot (Noggle 1962, p. 13) to say, "It would have been possible to pick a worse man for secretary of interior, but not altogether easy."

The president promised "normalcy" and made several excellent appointments, but Fall was not among them. Married to Florence Mabel Harding, the president was distracted in office, having been blackmailed by a family friend and former

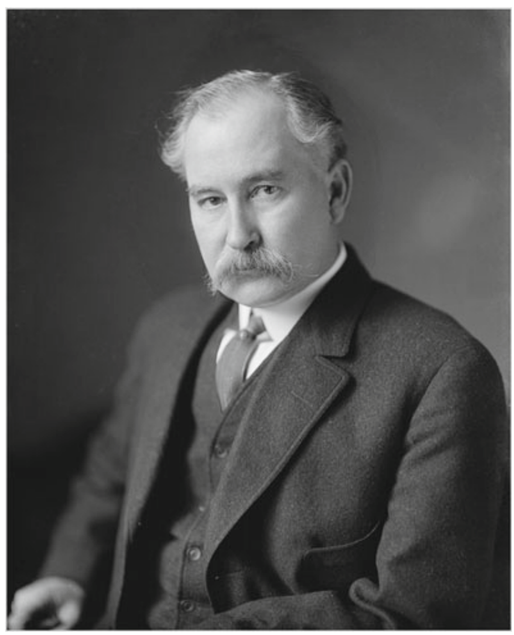

Fig. 5.4 Secretary of the Interior Albert B. Fall transferred Teapot Dome from the Navy to his department, then secretly leased it to Harry Sinclair (Harris and Ewing Collection, Library of Congress)

lover named Carrie Phillips. He was also engaged in an affair with much younger woman, Nan Britton, with whom he apparently had a daughter (Russell 1968).

He was a popular (and deeply mourned) president but is now a widely discredited chief executive. Historians generally consider him one of the nation's least capable presidents, though at least one biographer, John Dean (Richard Nixon's White House Counsel) offers a more sympathetic portrait (Dean 2004).

5.4 Tempest at Teapot

The Navy estimated that Teapot Dome, or NPR-3, contained 30 million barrels of oil reserves. The estimate proved to be realistic, but the protection offered by the reservation of these lands was fleeting.

In 1921, Fall wrangled NPR-3 away from the Navy, and then leased the field to independent oil titan Harry Sinclair in a secret, non-competitive deal. Naval Petroleum Reserves 1 and 2 (Elk Hills and Buena Vista fields, both in California) were leased secretly to Edward L. Doheny, the "Rockefeller of the West," under similar conditions. "Teapot Dome" became the popular name for the entire scandal.

A Wyoming operator spotted Sinclair operations on the reserve at Teapot Dome and informed his senator, who demanded an investigation. The Wall Street Journal broke a sensational, front-page story on the furtive deal, and the scandal captured headlines and public condemnation across the country.

Senate hearings followed, led by senators Thomas Walsh of Montana and Robert "Fighting Bob" La Follette of Wisconsin. After the scandal broke, Harding told Albert Lasker, a key campaign advisor (McCartney 2008, p. 114): "If Albert Fall isn't an honest man, I'm not fit to be president of the United States." Fall resigned less than a year later, Walsh became a national icon of probity and Harding died suddenly of a heart attack a few months afterward.

Harry Sinclair had made his first oil strike at the fabulous Glenn Pool in Oklahoma and was thought to be the richest man in Kansas by 1907. Founder of what is now the vertically integrated Sinclair Oil Corporation, he personally organized Mammoth Oil Company to operate Teapot and then sold Sinclair Consolidated a 25% stake in his private company.

Sinclair had managed to buy out most of the existing claims at Teapot Dome before he got title to NPR-3 from Fall. However, a title dispute involving the Mutual Oil Co. resulted in the Navy Department sending in the Marines. One captain and four well-armed Marines (along with a contingent of Interior officials and the press) shut down Mutual's drilling operation on the Reserve with much fanfare but no bloodshed in August, 1922 (This is the only known example of the Marines invading Wyoming).

Investigators determined that Sinclair had given "loans" to Fall totaling about $400,000 (over $5 million USD in today's dollars). Fall was convicted of bribery, fined and imprisoned for a felony committed in office, the only Cabinet officer ever to suffer such shame (so far!). His health broken, Fall served nine months in jail and died penniless in 1944.

Sinclair was acquitted of the bribery, ironically, but jailed for six months for contempt of court (jury tampering) and contempt of Congress. He returned to the helm at Sinclair Oil and prospered for another 30 years. Doheny was acquitted, underscoring the statement by progressive Senator George W. Norris that it was impossible to convict a hundred million dollars in the United States (Noggle 1962, p. 211).

Sinclair's Mammoth Oil Co. drilled almost 100 wells and produced about 3.5 million barrels of oil from 1922 to 1927. The leases were invalidated by the Supreme Court in 1927, and Teapot Dome was returned to the Navy (Mammoth Oil Co. v. U.S. 1927). Harding was succeeded by his vice president, Calvin Coolidge, famous for his conclusion: "The business of America is business."

Taciturn and proper, Silent Cal fired or forced the resignation of Harding's secretary of the Navy, attorney general and others to minimize the stain on the Republican party. Vilified by the press as the "Grand Oil Party," the Grand Old

Party (GOP) nonetheless went on to a surprising landslide win in 1924 (La Follette ran as a Progressive but finished third, carrying only his home state).

5.5 Field Development

From the late 1920s until the early 1950s, there was little activity at Teapot, and even during World War II no more wells were drilled. In the late 1950s and 1960s, Navy contractors drilled about 150 wells inside the reserve, mostly Shannon sandstone protection wells on the east flank of the field and Second Wall Creek wells adjacent to Salt Creek Field (Fig. 5.5).

In 1977, Teapot Dome was transferred from the Navy to the Department of Energy, which drilled over 1100 wells there. Peak production was about 5000 barrels of oil per day in 1980. Ultimately, NPR-3 was the last of four Naval Petroleum Reserves. Under federal management, it produced about 22 million barrels of oil and returned approximately $569 million (USD) to the Treasury. In 1993, the DOE created the Rocky Mountain Oilfield Testing Center at Teapot to be used in a public–private–academic partnership for real-world testing of new oil field technologies.

The field is an asymmetrical, Laramide anticline on the southwestern flank of the Powder River Basin. Teapot includes basement-seated north-south thrust faults that offset Pre-Cambrian to Cretaceous units on its western boundary. There are many deep, complex, and east-west faults throughout the field, as indicated by a 2001 3-D seismic survey. Teapot has about 200 ft (65 m) of structural closure. Cumulative

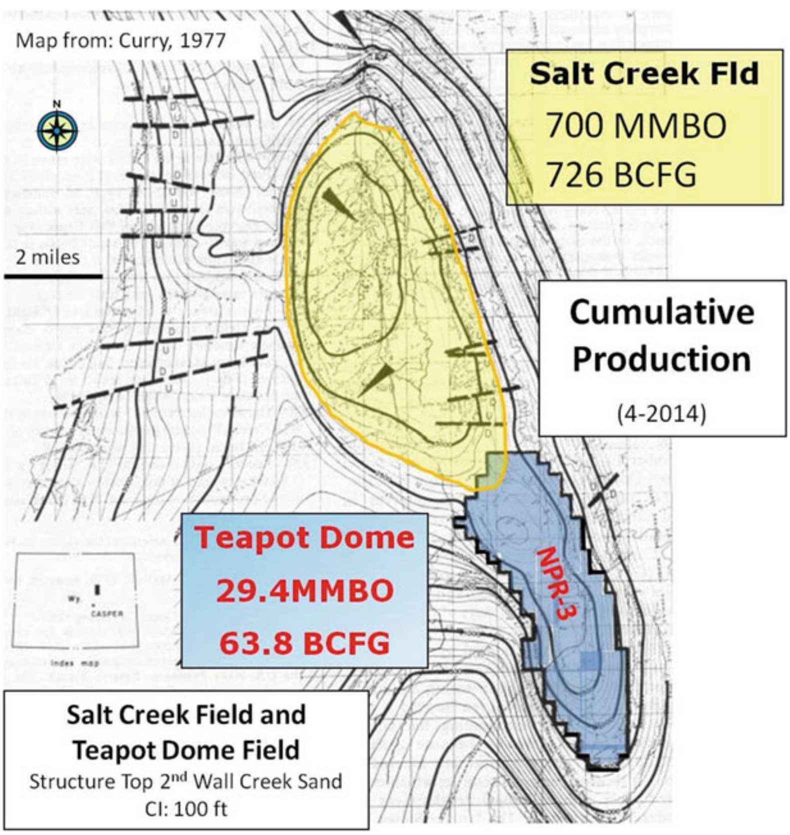

Fig. 5.5 Structure map and cumulative production from Salt Creek and Teapot Dome (modified by Davis, 2014 from Curry 1977)

production is about 29 million barrels of oil and 64 billion cubic feet of gas.

The key producing zones are Cretaceous sandstones and shales. The Shannon sandstone is the shallowest pay, consisting of two zones at only 300–400 ft deep. The Steele and Niobrara shales include some of the most prolific wells in the field. These reservoirs are fractured and thick, characterized by high producing rates and rapid depletion. The Second Wall Creek (or Frontier) sandstone produces from two structurally distinct pools. One 1923 well flowed 8000 barrels of oil per day from this zone. The Pennsylvanian Tensleep Formation has made about two million barrels of oil and untold millions of barrels of hot, fresh water from wells on the field's crest.

Teapot still produces a few hundred barrels of oil and many thousand barrels of water per day from about 350 stripper wells. There is substantial undeveloped potential for primary and enhanced oil recovery, as well as infill and horizontal drilling targets.

5.6 The Last Chapter

In 2014, the DOE retained Meagher Energy Advisors to solicit offers for Teapot Dome, effective January 30, 2015. There were multiple bidders and the field was purchased via a competitive data room process (Davis 2014) by Stranded Oil Resources Corp. (a subsidiary of Alleghany Capital Corp., NYSE: Y) for $45.2 million (USD). Transfer of title to a new, private operator after 100 years as a Naval Petroleum Reserve represents another exciting chapter in the history of America's most notorious oil field.

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6 Technique and Exploration: The Beginning of Micropaleontology in the Brazilian Oil Industry

Drielli Peyerl and Elvio Pinto Bosetti

Abstract

In 1953, the creation of Petrobras contributed not just for the Brazilian oil policy and economy, but also for the creation of a department focused on the research and exploration of oil in the Brazilian territory. Created in 1955, the Department of Exploration—DEPEX was divided in and performed by local districts situated in basins with oil potential, all directly subordinate to the Chief Superintendent, the North American geologist Walter Karl Link (1902–1982). It is necessary to point out the importance of the investments of Petrobras, and mainly of the Department of Exploration, in the laboratories of paleontology, stratigraphy, and subsequently in sedimentology. In the 1950s, the first Paleontology Laboratories were situated in Belém (Pará State), Ponta Grossa (Paraná State) and Salvador (Bahia State), and incorporated by these districts. Huge advances in scientific and technical expertise related specifically to micropaleontology were achieved. Professionals of the company performed their activities during this period, in particular the Brazilian paleontologist Frederico Waldemar Lange (1911–1988), who started developing the first studies on microfossils in 1955, mainly chitinozoans. From 1958 onward, we also have in the lab in Belém, the Danish Johannes Christian Troelsen (1913–?) and the German geologist and micropaleontologist Karl Krömmelbein (1920–1979), who continued their researches on foraminifera from the coastal basins in the north and in the northeast. The activities of the professionals continued to expand, contributing significantly for oil field research. Since the beginning, Petrobras invests in the qualification of his own labor force with courses and internships abroad. As two specific examples, we have the advanced course in micropaleontology, offered by the "Centro de Aperfeiçoamento e Pesquisas de Petróleo"—CENAP/Petrobras (Improvement and Oil Research Center), in 1961—with 6 months of duration, and the internship in micropaleontology (foraminifera and nannofossils, in oil companies abroad), in 1968. Thus, this summary confirms the first steps of the paleontological researches, highlighting the technic and scientific improvements of micropaleontology in the Brazilian development of oil exploration.

D. Peyerl
Institute of Energy and Environment, University of São Paulo, Professor Luciano Gualberto Avenue, 1289, Butantã, São Paulo 05508–010, Brazil
e-mail: driellipeyerl@gmail.com

E. P. Bosetti (✉)
Geoscience Department, State University of Ponta Grossa, Carlos Calvacanti, 9500, Uvaranas, Ponta Grossa, Paraná 84010–919, Brazil
e-mail: elviobosetti@gmail.com

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6.1 Introduction

Currently, micropaleontology is defined as "the science that studies calcareous, organic, siliceous or phosphatic microfossils, which can be found from continental environments to lagoon, estuarine and marine spaces" (Petró 2017: 130) and has contributed a lot to the oil industry. In the specific case of Brazil, micropaleontological studies "were very useful for the discovery of oil and gas and more recently the pre-salt" (da Silva Caminha and Leite 2015: 25).

In 1941, Carey Croneis (1901–1972)—with a distinguished career in Geology—published the article "Micropaleontology—Past and Future," which described the relation between academic and commercial micropaleontology connected since that period with the petroleum business, emphasizing the economic importance of microfossils (Croneis 1941). And that, "the development of the microscope was such an advance in optics which of course opened new avenues for research in many fields other than geology" (Croneis 1941: 1210–1211). Therefore, huge advances in scientific and technical expertise related specifically to micropaleontology were achieved. For a long time:

> (…) researches in the field of Geology and Paleontology were restricted to the field observations and of samples of sediments in the search for occasional fossiliferous findings. With the rapid expansion of exploratory research and the increasing volume of samples from drilled wells, there was a demand for precise studies of the fragmented sedimentary material, in order to describe the lithological characteristics and characteristic elements. The microfossils found in the perforated sediments have been shown to be important as indicators of the sediment deposition environment and for its dating, reducing costs and optimizing oil exploration. From this recognition, Micropaleontology proved to be a necessary tool in the exploration of petroleum. (Memórias da… 2003: 8)

In addition, "microfossils have many applications to petroleum geology[1]" and the oil industry uses microfossil smaller than one millimeter for dating and paleo-environmental reconstruction (Singh 2008: 3). For example, when the wells are deeping, the drill triturate the sediments together with the fossils. The smaller the fossil, the greater the chance of not being fragmented in this process.

It is emphasized that the great impulse of micropaleontology in Brazil occurred in the Paleontology Laboratories of Petrobras (Brazilian oil company), created in 1953 (Mendes In Ferri; Motoyama 1981). Thus, in this chapter of the book, we will discuss some points about the beginning of the scientific knowledge formation, the geoscientists work, the first Paleontology Laboratories of the oil industry in Brazil, and how the micropaleontology contributed to the discovery of oil in the Brazilian territory.

6.2 The Structuring of the Department of Exploration at Petrobras

In 1953, Brazilian oil company, Petrobras was created by Law no. 2004, a mixed joint stock corporation responsible for the state monopoly of oil. The company gradually absorbed the activities and the problems of the National Council of Oil, founded in 1938. The creation of Petrobras contributed not just to the Brazilian oil policy and economy, but also to the creation of departments focused on the exploration and production of oil in the Brazilian territory.

For the exploration, Petrobras, through the well-known oil geologist Arville Irving Levorsen (1894–1965),[2] contacted the North American

[1]Applications of Microfossils to Petroleum geology: "Microfossils have many applications to petroleum geology. The two most common uses are: biostratigraphy and paleoenvironmental analyses. Biostratigraphy is the differentiation of rock units based upon the fossils which they contain. Paleoenvironmental analysis is the interpretation of the depositional environment in which the rock unit formed, based upon the fossils found within the unit. There are many other uses of fossils besides these, including: paleoclimatology, biogeography, and thermal maturation. Recognition of unconformity in the subsurface is undoubtedly being done using geophysical techniques but they are also being done by biostratigraphic methods viz., absence of biozone" (Singh 2008: 3).

[2]Arville Irving Levorsen was born in July 1894, in Fergus Falls, Minnesota. Levorsen attended the University of Minnesota, graduating from the School of Mines in 1917 (Carlson 1965: 1534).

geologist Walter Link (1902–1982) to offer him the highest position in the Department of Exploration (Peyerl et al. 2016). Levorsen had an excellent value to the company. He also recommended the organization of Paleontology Laboratories and the hiring of micropaleontologists.

In October of 1954, Petrobras hired Walter Link (1902–1982) to chief, structure, and organize the Department of Exploration, having as his responsibility to find oil in other places in the Brazilian territory—the first oil discovery in Brazil occurred in 1939 in Lobato (Bahia State, Brazil). In 1955, the general structure of the company comprised thirteen units of operation acting in different areas: Department of Exploration, Department of Production, Cubatão refining, Mataripe refining, asphalt factory, X company (future subsidiary), Y company (future subsidiary), Z company (future subsidiary), National Oil Tanker Fleet, fertilizer factory, ethene factory, oil shale industrialization, and other units of operation (Organograma Básico da Petrobras 1955). Hence, the Department of Exploration is a of the object of this chapter book, which, together with the Department of Production, received most of the investment.

As mentioned, Petrobras hired Walter Link—considered one of the six best oil geologists in the petroleum industry (Eugênio… 1954)—to chief the Department of Exploration of Petrobras. When Link began his work in Brazil, he found bad and precarious conditions such as lack of professionals and that "the logistical support was inadequate due to the lack of material, transport, gas, and dynamite, among other things" (Link 1960, p. 1). Additionally, "for the Department of Exploration to begin its activities, it was necessary to organize this precarious situation" (Peyerl et al. 2016: 390–392). Then, Walter Link put in place an ambitious program of exploration in Brazil (de Dias and Quaglino 1993) which was essential to change the course of exploration in the country.

Walter Link and his team explored parts of the Brazilian territory, making extensive field trips to the states of Paraná, Maranhão, Rio Grande do Norte, Bahia, and Amazonas, in which the goal was to acquire knowledge about the "geology of the area," the works in progress, and the availability of workers (Link 1960; Peyerl et al. 2016). Therefore, the Department of Exploration was divided by local districts situated in basins with oil potential.

The Paleontology and Stratigraphy Laboratories were incorporated to these districts (Memórias da… 2003). It is important to highlight the importance of the investment of Petrobras mainly in laboratories of paleontology, stratigraphy and, soon after, of sedimentology. Major scientific advances and know-how formation were specifically related to micropaleontology and palynology carried out during this period by the company's professionals and continued to expand, significantly contributing to new oil discoveries (Peyerl 2017).

> In the beginning, Petrobras set up three regional laboratories in the cities of Belém (State of Pará), Salvador (State of Bahia), and Ponta Grossa (State of Paraná), intended to perform exploratory studies and search potential oil provinces. In this early phase of its exploration activities, Petrobras had only one laboratory of Paleontology, located in Belém, which was in charge of analyzing samples from the Amazonas Basin. After some time, the main research laboratory moved to Ponta Grossa (…). (Peyerl 2011: 7)

In the Paleontology Lab in Belém, the researches were focused on foraminifera from the coastal basins in the north and northeast, significantly contributing to new oil discoveries. The Paleontology Lab in Ponta Grossa was responsible for the Paraná Basin exploration. The Paraná Basin was considered a promising area due to the occurrence of bituminous sandstone and the presence of shale in sedimentary basin. The basin also demonstrated its energetic potential as a producer of coal (Organogram 6.1).

6.3 The Development of the Department of Sedimentary Basin of Paraná/Southern Exploration Department/Petrobras

Initially, the Department of Sedimentary Basin of Paraná was only a deposit of materials used for researches, an office, part of a support to the

Belém City (Pará State, Brazil)	Ponta Grossa City (Paraná State, Brazil)	Salvador City (Bahia State, Brazil)
• Setembrino Petri (1922-) - Brazilian (foraminifera) • Johannes Christian Troeslen (1913-?) – Danish (foraminifera, calcareous nannofossils) • Karl Krömmelbein (1920-1979) – German (ostracoda non-marine)	• Hélio Jesus Ferreira de Sá Brito (?)– Brazilian (macrofossils invertebrates, ostracode non-marine) • Frederico Waldemar Lange (1911-1988) - Brazilian (microfossils, chitinozoans and scolecodonts) • Roberto Ferreira Daemon (1936-1996) – Brazilian (palynology)	• Helmut Muller (?) - German (palynomorphs) • Rolf T. Weber (?) – German (ostracoda non-marine)

Organogram 1 Some of the earliest professionals that worked in the Paleontology Laboratories/Petrobras, Brazil

vehicles that left the field and a Laboratory of Paleontology. When they began to make the first holes in the Paraná Sedimentary Basin, the beginning of the research was carried out in subsurface, with the observation of the geological layers for the verification of petroleum evidences (Peyerl 2008).

According to the Petrobras report of April 25, 1955, the beginning of activities in the department was considered precarious due to the lack of instruments, apparatuses, and chemical products. There was only a private binocular microscope. Gradually, the department acquired acids and solutions that became indispensable for the execution of the services (Pal/Rel. 1 Resumo das… 1955; Peyerl 2011).

> The activities of this Lab were initiated in March 15 of the current year, under rather precarious conditions, since there were no instruments, equipment, or chemical products which we could use. (…). Later on, we bought some glassware and a set of sieves in Jacarezinho,[3] but we still remain short of equipment to split rocks and make thin sections, [and] to date we keep using the microscope of our property. The services performed, as related above, are naturally hampered by the unfavorable working conditions, with gaps that we will try to remedy as much as possible, according to our ability to acquire new materials. Furthermore, this lab does not have the necessary literature, which is most needed when it comes to analyzing materials from regions unfamiliar to us, like the Amazonas Basin; so far, we have resorted to our private library, but it would be of great usefulness if some indispensable works were acquired, such as the 'Catalogue of Foraminifera' and the 'Catalogue of Ostracoda'. (…). As soon as the above shortcomings are solved, we deem this lab will be ready to adequately perform all pertinent services. (Pal/Rel. 1 Resumo das… 1955) (Fig. 6.1)

In the mid-1960s, the Department of Sedimentary Basin of Paraná, now known as the Southern Exploration Department, was divided in three parts: Stratigraphic Sector, Paleontology Laboratory and Sedimentology Laboratory. The stratigraphy sector coordinated the work of the regional laboratories of paleontology and sedimentology. Technically, these laboratories were subordinated to the subsurface geology sector, and the main activity of Paleontology Laboratory was the examination of samples for the identification of the zones as a support for exploratory drilling.

The laboratories of the Southern Exploration Department were also responsible for other

[3]Jacarezinho is a city in Paraná State, Brazil.

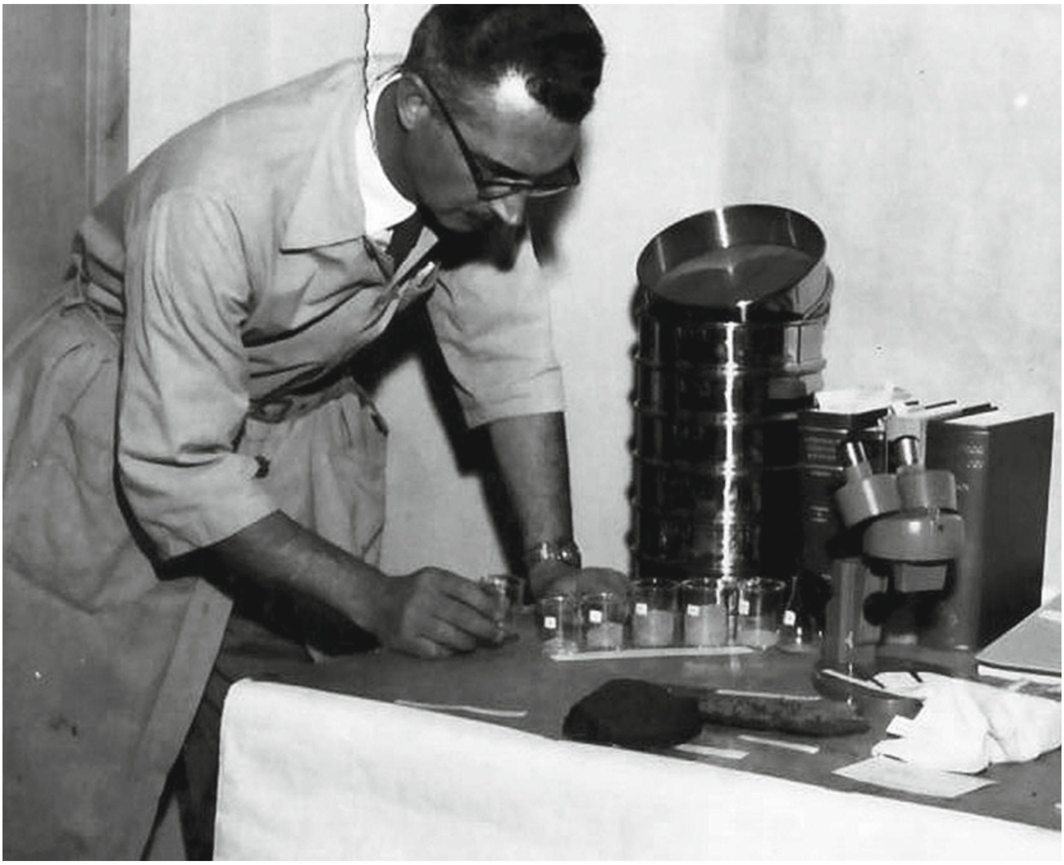

Fig. 6.1 Paleontologist Frederico Waldemar Lange in the Paleontology Lab for Petrobras (Mid-1950s). *Source* Frederico Waldemar Lange's Archive (1911–1988), State University of Ponta Grossa. Box [undated]. Caixa 82

research areas. As an example, in 1965, activities were carried out for the separation and processing of samples from the Paleozoic of the Amazon Basin, systematic studies, description and illustration of microfossils, and the elaboration of the report entitled "Biostratigraphic Subdivision and Review of the Siluro-Devonian Column of the Lower Amazon Basin." The preparation of samples and studies of microfossils of the Paraná Basin also began at the same period, and, in the following year, the microfossils studies of the Maranhão and Pernambuco States.

In 1968, the stratigraphy sector became responsible for planning and supervising the execution of the projects of paleontological and sedimentological studies and coordinating them with the works developed in the field of geology and geophysics. The main goal was to obtain the necessary data for the definition of origin and nature of the stratigraphic units, their lithological characteristics, and its physical–chemical properties, also contributing to the development of paleogeological maps, and others.

Still in the same period, the Laboratory of Paleontology aimed to improve the subdivision of the biostratigraphic column of the Paraná Sedimentary Basin. It was incumbent upon this laboratory to carry out the analysis of the paleontological composition of surface sections and well profiles of selected regions in order to establish the standardized columns of the whole stratigraphic sequence of the basin. The main activity was concentrated in the examination of samples for the identification of the zones, with support to the exploratory perforations. Paleontological samples from the entire country were analyzed mainly in the regional pole of Southern Exploration Department.

In the end of 1960s, the Paleontology Laboratory had already completed the study of the Devonian's zoning and paleogeographic development. They would then apply the same method of research to the succession of Carboniferous to Permian, using mainly the distribution of the spores and, when present, the acritarchs, as well as macrofossils characteristic of the different units. Other microfossils (Ostracoda, Conchostraca, and Algae) that occur in certain formations should be studied to determine the possibility of their use for zoning and correlations.

For the Sedimentology Laboratory, it was necessary to determine the lithological characteristics and physicochemical properties of the sediments, their origin, mode of transport, distribution and sedimentation, the depositional environment, how the post-depositional modifications sediments were submitted, and their generation and reservoir properties. The main activities were directed toward areas of economic interest. The basis of the studies carried out were regional lithostratigraphic establishments, whose correlation, through the basin, would provide information on the lateral and paleogeographic development of the units, allowing the elaboration of the corresponding maps.

6.4 The Professionals, the Paleontology Laboratories and the Petrobras

In the 1950s and in the early 1960s, there were different names that worked in Paleontology Labratories in Petrobras. A small group made the difference mainly for the studies in micropaleontology. One of the key steps for Paleontology Labs in Brazil was the network formed by different scientists from other countries such as France and Germany, and names such the German paleontologist Alfred Eisenack (1891–1982) (pioneer of micropaleontogy and palynology), and the French geologist André Combaz (?) (who introduced the term palynofacies). In the beginning of Paleontology Laboratory of Petrobras, there were neither instruments and equipment nor chemical products as already mentioned. The professionals gradually got sieves, books, and other equipment.

The Brazilian paleontologist, Frederico Waldemar Lange (1911–1988), in the Paleontological Lab in Department of Sedimentary Basin of Paraná/Southern Exploration Department/Petrobras, was the one who started developing the first studies on microfossils in 1955, mainly chitinozoa, which is a primordial tool in dating strata and in prospecting deposits of fossil fuels. With the studies on microfossils, Lange established the first biostratigraphic correlations between wells in the basin.

Frederico Waldemar Lange was pioneer in micropaleontology in the country, introducing and perfecting techniques in glass slides for the study and research of microfossils (*see* Bosetti et al. 2011). Therefore, already in the 1940s, Lange began his academic career in the field of paleontology and innovated with the study of micropaleontology in Brazil, becoming known as its precursor. Lange became known in the scientific community in 1942 for his work on Devonian scolecodont from Paraná and Devonian chitinozoan from Pará State.

Even before starting his work at Petrobras, Lange had already published new discoveries of microfossils: in 1949, Lange describes the microfossil *Conochitina biconstricta* of the Ponta Grossa Formation, Paraná series; in 1950, he described the new *Paulinites caniuensis* of the Ponta Grossa Formation, referring also to the depositional environment, to the faunistic association, to paleoecology, and to the problems related to these microfossils; in 1951, in a summary of the geology of Paraná, he cites the characteristic fossils that occur in various formations (Lange 1954).

One of Lange's major projects, which deserves reference, was the organization of a work on the commemoration of the centennial of Paraná (1954). Lange coordinated this project that culminated in the publication of a volume called "Paleontology of the State of Paraná." The initial objective for the publication of the volume provided for the reissue of all the works that deal with the paleontology of Paraná State. Subsequently, following a suggestion from paleontologist and geologist North American Professor Dr. Kenneth Edward Caster (1908–1992), it was decided to give the publication the form by which it was published, that is, containing a historical summary of the paleontological investigations related to the State of Paraná, accompanied by a list of the fossils found and of a bibliographical relation, and as part a series of original works, whose research was partly based on material collected by the authors themselves in Paraná and/or belonging to the paleontological collection of the Paranaense Museum. It contained articles of enormous interest, "among which the paleobotanic German Richard Kraüsel introducing a new Devonian Thallophyta of Paraná, *Spongiophyton*, and Kenneth E. Caster, describing a *Placocystella* of the same age and provenance" (Mendes in Ferri and Motoyama 1981, p. 61).

Relevant names of scientists related to paleontology of the participated in this volume, divided into nine chapters:

1. Paleontology of Paraná by Frederico Waldemar Lange;
2. The Fauna of Lamelibranchs of the Gondwanic System in Paraná by Karl Beurlen;
3. A Devonian Placocystoid Echinoderm from Paraná, Brazil by Kenneth E. Caster;
4. *Glossopteris Orbicularis Feistmantel* in Teixeira Soares, Paraná by Elias Dolianiti;
5. Contribution to the Study of Southern Pteridines by Jordano Maniero;
6. Permian Conchostraceans in the south of Brazil by Josué Camargo Mendes;
7. New Occurrences of Fossil Crustaceans of Irati Formation south of Brazil by Sergio Mezzalira;
8. Contribution to the Paleofitography of the Paraná State by Friedrich Wilhelm Sommer; and
9. *Spongiophyton Nov. Gen. (Thallophyta) und* Haplostigma Seward (Pteridophyta) im Unter-Devon von Parana by Richard Kräusel.

It is also worth noting that the development of Lange's work was based on studies, the monograph of Clarke (1913), who stood out for first describing the Devonian fauna of the State of Paraná.

On March 15, Lange initiated his professional career as paleontologist in Petrobras. In 1961, Lange became Chief of Department of Exploration in Rio de Janeiro city (Rio de Janeiro state, Brazil) "involved with administrative activities, including the installment of new laboratories in other districts, and the intensification of geological studies in the Amazonas region" (Peyerl 2011: 7). In 1962,

> (…) Sedimentology laboratories were installed in the Exploration Districts. Their activities were aimed to determine the depositional environments of formations with economical interest. Lange also carried out several biostratigraphy studies, one of these focused on hystrichosphaerid acritarchs from outcrops along the Rio Urubu, in the Amazonas Basin.
> (…)
> In 1964, Lange travelled to Europe in order to join meetings and make contacts on behalf of Petrobras research. He also became a member of the Commission International du Microflore du Paléozoïque (C.I.M.P.), in Bordeaux, France. (Peyerl 2011: 7)

From the works of Lange, many other scientists have had work and studies related to the paleontological area, among whom Josué Camargo Mendes (1918–?), Setembrino Petri (1922–), Carlos de Paula Couto (1910–1982), Rubens da Silva Santos (1918–1996), Júlio Magalhãe (?), Irajá Damiani Pinto (1919–2014), Ivan de Medeiros Tinoco (1927–2006), Nicéa Marchesini Trindade (?), Lélia Duarte (?–2013), Friedrich Wilhelm Sommer (1907–1994), Maria Eugênia Marchesini Santos (1932–), and Karl Beurlen (1901–1985) (for more information, see: Memórias da… 2003; de Ramos 1986) (Fig. 6.2).

In 1955, another relevant initiative of Petrobras was the creation of the Centro de Aperfeiçoamento e Pesquisa de Petróleo (CENAP) [Center for Petroleum Research and Research] and in 1963, the creation of Centro de Pesquisa e

Fig. 6.2 Paleontologist Frederico Waldemar Lange (on the right) in field work for Petrobras (Mid-1950s). *Source* Frederico Waldemar Lange's Archive (1911–1988), State University of Ponta Grossa. Box. [undated]. Caixa 82

Desenvolvimento Leopoldo Américo Miguez de Mello (CENPES) [Leopoldo Américo Miguez de Mello Research and Development Center]—but whose activities began in 1966. With these initiatives, we have technical and professional training courses on Brazilian labor performed by Petrobras related to research, exploration, and exploitation of oil. In addition to these factors, the paleontology contributed to the development in Brazil.

CENAP offered courses such as oil refining, oil equipment maintenance, introduction to geology, oil geology, and oil engineering. Particular reference to the courses related to geology, which contributed and influenced the first graduation course in geology in the country, only in 1957 (Peyerl 2017).

In 1966, CENAP is extinct and Centro de Pesquisa e Desenvolvimento Leopoldo Américo Miguez de Mello (CENPES) is created aimed to perform scientific and/or technological researches for oil industry—a diverse goal from CENAP. On the other hand, the improvement and professionalization courses continued to be offered in the company, as far as the company needed specific graduations in researches related to oil. In this process, Petrobras' activities become central in the economy and in the scientific, technological, and innovation researches of the country related to geosciences.

In 1968, Petrobras directs part of its research to the continental platform, starting a new cycle of technical knowledge of exploration with the discovery of the first well in the field Guaricema, Sergipe State, and the first drilling in Campos Basin, in the field of Guaricema, Rio de Janeiro State. In that same year, Petrobras invests in the training of its professionals in oil companies from other countries for courses in micropaleontology (foraminifera and nannofossils).

In 1968, Lange described in one of his reports the technical process performed with fossil samples. It emphasizes the technique used, organization, and how the work was done in the 1960s.

a) systematic classification of fossils of all categories recovered from surface samples and sampling of wells;

b) prepare fact sheets, by location and training, and tables of quantitative and qualitative distribution, per well, of all fossils recovered and identified;

c) describe and reproduce by drawings or photographs all types of representative or characteristic fossils;

d) to select the forms of broad geographical distribution and of restricted vertical amplitude for the definition of the zones and their subdivisions;

e) prepare the biostratigraphy columns, standardized according to the Stratigraphic Nomenclature Code, for each of the categories of fossils used to define the zones;

f) to ensure the correct application of the provisions of the International Codes of Zoology and Botany, in the part referring to the paleontological nomenclature, when the possible description of new species;

g) collaborate in the elaboration of regional paleogeographic maps and chronostratigraphic columns;

h) by comparative analysis, identify the depositional environment, the relative age of the fossils, and their interregional correlation;

i) to select the samples to be examined paleontologically, to distribute the work among the analysts instructing them on the methods to be used for the preparation and recovery of the fossils, and to control the result of the processing;

j) organize and keep up-to-date a catalog for recording the samples entered in the laboratory, indicating the origin and the analyzes performed;

k) prepare a systematic binder for the registration of all fossils studied;

l) to organize standardized sheets with quantitative and qualitative statistical data, for the possible digital processing aiming the analysis of the distribution and correlation;

m) organize collections of representative types of fossils, of which, whenever available, series should be prepared in duplicate for the exchange with the laboratories of the other units of the Company;

n) it is also up to the paleontology technicians to keep abreast of the systematics of paleontological classification and the development of new preparation techniques, to ensure the good conservation of the existing equipment in the laboratory, by acquiring the material necessary for the preparation of fossils and their assembly, guiding and supervising the training of technicians on stage, and collaborating in the organization of the Manual of Paleontology. (Technical Report on the Assignments and Organization of the Stratigraphy Sector—Report: Signed by F. W. Lange. Section of Paleontology—DIVEX/DEXPRO. Petrobras Exploration Department, Report, Belém, March 29, 1968).

Thus, Lange defined the objectives of the Petrobras Regional Stratigraphic Sector, with the purpose of guiding and supervising the execution of the stratigraphic, paleontological, and sedimentological works, in accordance with the established programs, in order to, through the integration of the data, define and classify the stratigraphic units, establish standardized stratigraphic columns, and prepare paleogeographic maps. Thus, Lange determined to the technicians and involved in the paleontology sectors, in the regional laboratories, and the following functions presented above.

6.5 Conclusion

In six short years, Walter Link changed the destiny of the exploratory and oil researches activities at Petrobras, consolidating a national industry of oil, which turned out to be a model for other companies. Since the beginning, Petrobras invested in the qualification of his own labor force with courses and internships abroad. Thus, this chapter confirms the first steps of the paleontological researches, highlighting the technical and scientific improvements of micropaleontology in the Brazilian development of oil exploration. Also noteworthy for Lange's work:

> As a paleontologist, Lange described new species of Mollusca, Gastropoda, Bivalvia, Brachiopoda, Annelida, and Chitinozoa. With respect to Ichnology, his work on the worm tubes of the Furnas Formation can also be considered pioneering in Paraná. In 1964, Sommer & Boekel honoured him with a new chitinozoan species, *Ancyrochitina langei*, and in 1985, Cruz & Quadros gave his name to another new species of Chitinozoa, *Sommerochitna langei*. Additionally, in recognition of Lange's outstanding scolecodont research, two scolecodont taxa – one new species (*Kettnerites langei*) and one new genus (*Langeites*) – were named in his honour, respectively by Šnajdr (1951) and Kielan-Jaworowska (1966). A Late Paleozoic lingulid genus from the Paraná Basin (*Langella* Mendes 1961) was also named after him. (Peyerl 2011: 7)

In addition, the creation of Petrobras contributed to the development of technical reports, publications and innovative techniques, organization mainly of the sectors of paleontology and stratigraphy, and formation of professionals related to the area of geosciences and societies.

> After World War II, around 1950, the great growth of the national industry brought a demand of geologists, stimulating the creation of several schools of geology in the main capitals. This allowed the formation of new professionals, who worked in the diffusion of Paleontology and in the appearance of new nuclei of studies.
> At Petrobras, research for the oil industry provided a major advance in the knowledge of the stratigraphy of the Brazilian sedimentary basins. New methods of work were introduced in paleontology, developing in this institution an important center of studies. (Cassab in Carvalho 2000, p. 13)

For some authors, four paleontologists from Petrobras, Frederico Waldemar Lange, Karl Krommelbein, Johannes Christian Troeslen, and Helmut Muller are considered as the fathers of paleontology at Petrobras. For it was they who guided and formed many of today's paleontologists. An example of this was the numerous courses and lectures given by these paleontologists (Peyerl 2010; Soares and Soares 1996).

The technical development in the field of paleontology by Petrobras contributed significantly to the development and application of the technique in the discovery of new oil wells and/or exploration sites. It should be noted that, starting in 1957, the first systematic work on the analysis of pollens (Palynology) concentrated on the continental formations of the Recôncavo Basin is also carried out. New methods were also introduced, such as the examination of nannofossils—for the study of Cretaceous and Tertiary marine formations (Peyerl 2017). All this process had an emphasis given to the area of paleontology based on the ideas of the paleontologist Diógenes Almeida Campos, who affirmed that the important need to find oil in Brazil provoked and stimulated the paleontology in the country (Diógenes de… s.d.).

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The paleontologist Frederico Waldemar Lange (on the right) in field work for Petrobras (Mid-1950s) Frederico Waldemar Lange's Archive (1911–1988), State University of Ponta Grossa. Box. [undated]. Caixa 82
The paleontologist Frederico Waldemar Lange in the Paleontology Lab for Petrobras (Mid-1950s). Frederico Waldemar Lange's Archive (1911–1988), State University of Ponta Grossa. Box [undated]. Caixa 82

7 From Colleague to Enemy? German Petroleum Geologists and the Cold War

Martina Kölbl-Ebert

Abstract

After World War II, the geological community in Germany was left in disarray. Most geoscience institutes, survey offices and museums had been damaged or destroyed. Geology, however, was in possession of crucial expertise for rebuilding the stricken country, which now was administrated by foreign military governments in four occupation areas. There were two nuclei for the revival of a German geological survey, the former *Reichsamt für Bodenforschung* in the Soviet Sector of Berlin and an important off-shoot of the *Reichsamt*, the Department of Petroleum Geology within the British occupation area in Celle near Hannover. It seemed only natural to assume that—once matters had settled down—Berlin would again play a vital role as a major centre of geology in years to come. Consequently, both offices cooperated, exchanging publications and geological information. Over the next couple of years, however, cooperation became progressively difficult. Berlin colleagues reported increasing political pressure and several had to answer for their naïve assumption that they still were part of a common all-German geological "family". Having sent information on petroleum to western colleagues, they found themselves charged with espionage and treason, facing imprisonment and potentially worse. At the same time, communist propaganda endeavoured to discredit western geologists as fascist–capitalist agents.

7.1 Introduction

Germany in winter 1945/46: Devastated cities, communication lines disrupted, refugees, hunger and cold. The country was divided into four occupation areas run by foreign military governments. The geological community, if there was still something left at all to deserve the name, had been disrupted as well. Most institutes, survey offices and museums had been severely damaged or destroyed completely.[1] Geology, however, was crucial for mineral resources and fossil fuels, for building projects in cities, for bridges and roads. And most importantly the service of hydrogeologists was in great demand because of the enormous amount of refugees streaming in from the east, causing towns and villages to outgrow their drinking water systems overnight (Martini 1965: xxiv–xxv; Hetzer 1987: 154; Kölbl-Ebert 2007: 138).

Consequently, some sort of geological survey was needed urgently. Before May 1945, the *Reichsamt für Bodenforschung* had been the

M. Kölbl-Ebert (✉)
Jura-Museum Eichstätt (SNSB-JME),
Willibaldsburg, 85072 Eichstätt, Germany
e-mail: Koelbl-Ebert@jura-museum.de

[1]For an introductory history of geology in Nazi Germany see Kölbl-Ebert (2017).

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centralized national geological survey of Germany. The main office of this large administrative body was in Berlin, Invalidenstraße 44, which now was in the Soviet Sector of the divided city. An important off-shoot of the survey during Nazi time had been the Department of Petroleum Geology, which since a decade or so had an additional office within the north-west German petroleum fields at Celle near Hannover. Late in 1944, the whole petroleum department had been evacuated there, including several train wagons full of papers, maps, books and samples. Thus after the war, the petroleum geologists of the Berlin Geological Survey, including their former department director Alfred Bentz,[2] found themselves stranded in the British Occupation Area now supervised by the British petroleum geologist Major Albert Everard Gunther.[3] Consequently, there were two nuclei, from which a German geological survey could potentially develop again. This is exactly, what happened, since both the Soviet and the British Occupation forces recognized quickly the importance of a geological survey for their area of responsibility.[4]

Whereas the political situation forced the establishment of individual geological surveys for each occupation area, people working in Celle or Berlin respectively were convinced that they still belonged to the same administrative body. Consequently, there were also first attempts to re-contact colleagues, although sending letters tended to take weeks—the postal service additionally being hampered by censorship. By August 1945, the survey office in Celle was already up and working; drawing in more and more geologists (AGV #20203, letter from Alfred Bentz to Wilhelm Haack, 13 August 1945).

In November 1945, a German Geological Survey was officially reopened in Berlin by Ferdinand Friedensburg,[5] President of the Central Administration for Combustibles, who then delegated the Presidency of the geological survey to Otto Barsch[6] (Hetzer 1996: 21; Kaemmel 2013: 26), but still both surveys acted under the conviction that one day, they would come together again. Gunther, Bentz, Friedensburg and Barsch all supported this attitude.

7.2 Attempts at Cooperation

In 1945/46, Major Gunther commuted several times between Celle and Berlin, buying geological maps in Berlin (Kaemmel 2013: 31) and bringing information on drill profiles in return. He also delivered letters both ways, retrieved suitcases with personal items that had been left in Berlin or brought gifts of potatoes and cigars to the stricken city (AGV #20205, letter by Wilhelm Haack to Alfred Bentz, 2 October 1945).

[2]Alfred Bentz (1897–1964) studied geology in Munich and Tübingen and took his Ph.D. in 1922 from the University of Tübingen. 1922–1923, he was assistant professor in Tübingen and then became geologist at the Geological Survey in Berlin. From 1934 onwards, he was director of the Institute for Petroleum Geology within the survey. In June 1945, he organized the reactivation of the Survey in Celle under the aegis of the British Military Government. He became director of the Geological Survey in Celle, later of the Geological Survey of West Germany. He retired in 1962 (Seibold and Seibold 2002; Kölbl-Ebert 2018).

[3]Albert Everard Gunther (1903–1998) studied geology in Oxford 1922–1925 and became a petroleum geologist for Shell Oil Co. He spent World War II in British military service. 1945–1947, he was supervisor of the German oil industry and the Geological Survey in the British Occupation Area. In 1947, he returned to Shell Oil Co. He retired around 1965 (Seibold Seibold 2002: 1087).

[4]For a timeline of political events, see Table 7.1.

[5]Ferdinand Friedensburg (1886–1972) studied mining and geology in Berlin and Marburg. In 1914, he obtained a doctorate degree in geology. He spent World War I as soldier and prisoner of war. 1920–1933, he had various occupations as journalist, administrator and politician. 1933, he was dismissed by the Nazi regime and in 1935 even imprisoned for some months. 1933–1945, he undertook research in mining geology as an independent, private scholar. In 1945, he became President of the Central Administration for Combustibles in the Soviet Zone. 1946–1952, he was Deputy Mayor of (West-) Berlin. From 1952–1965, he became a Member of Parliament in West Germany (Keiderling 2009).

[6]Otto Barsch (1879–1946) was leading geophysicist at the Berlin Geological Survey from 1907–1939. From 1939 to 1945, he possibly worked as military geologist. In 1945, he was appointed President of the Berlin Geological Survey (Kaemmel 2013: 24–29).

Table 7.1 Timeline (source: Stöver 2012)

February 1945: Yalta Conference divides Germany into four occupation areas
8/9 May 1945: German capitulation
4 July 1945: Arrival of the Western Allies in Berlin
July 1945: Potsdam Conference reveals mounting antipathy between the Soviet Union and the Western Allies; Truman informs Stalin that the United States possess a powerful new weapon
6 August 1945: Nuclear bomb on Hiroshima reveals US nuclear weapons programme
February to September 1946: Mounting confrontational attitude in both USA and Soviet Union
1 January 1947: United States and Britain merge their German occupation areas into "Bizonia"
16 April 1947: Bernard Baruch coins the term "Cold War" to describe the political situation between the USSR and USA
June 1947: Enactment of the Marshall Plan to rebuild democratic and economic systems of Europe countering perceived threats to Europe's balance of power
September 1947: Founding of the Cominform enforces orthodoxy within the international communist movement and tightens political control over Soviet satellite states
June 1948: Tito–Stalin split: Cominform expels Yugoslavia
24 June 1948: Begin of the Berlin Blockade
June 1948: Monetary reform in western zones of Germany creates the German Mark
January 1949: The Molotov Plan, i.e. the Soviet Union's alternative to the Marshall Plan, institutionalized as the Comecon
April 1949: Founding of the North Atlantic Treaty Organization (NATO)
April 1949: Founding of the Federal Republic of Germany (West Germany)
12 May 1949: End of Berlin Blockade
August 1949: First test of a nuclear bomb in the USSR
October 1949: Founding of the German Democratic Republic (East Germany)
1950–1953: Korean War
5 March 1953: Death of Joseph Stalin
17 June 1953: Civil Uprising in German Democratic Republic
1955–1975: Vietnam War
1956: Hungarian Uprising
13 August 1961: The Berlin Wall is built
October/November 1962: Cuba Crisis
1968 Prague Spring
17 September 1980: Founding of the Solidarność Trade Union in Poland
1985 Mikhail Gorbachev becomes General Secretary of the Communist Party of the Soviet Union; begin of *Glasnost* policy
1986 Chernobyl disaster
1986 Begin of Perestroika politics
1988 Spitak earthquake, Armenian Soviet Republic: USSR formally asking for western help
1989 Opening of the Berlin Wall; Romanian Revolution
1990 German Reunification
1990/1991 Declaration of Independence of the Baltic states Estonia, Latvia and Lithuania
1991 Failed coup d'état and dissolution of the Soviet Union

> Via Major Gunther I received your friendly letters of 2nd and 15th of October 1945: Thank you very much for those. He also reported about your very interesting plans, which you make within the Russian Zone. […] Of course, we look forward to supporting you with material for these projects and are currently putting the papers together. […] we will start with compiling the drilling records from the Russian Zone. The others, I assume, being less urgent. (AGV #20208, letter from Alfred Bentz to Wilhelm Haack, 9 November 1945)
>
> I am content with the selection of the commented profiles from the Russian Zone only. Of course, I also need commented profiles of drillings west of the demarcation boundary, because the geology of the salt domes in the Altmark area etc. cannot be sufficiently comprehended without those. […] The files from Flachstöckheim etc., desired by Mr Seitz, will be sent to you by Mr Kegel, who, however, first has someone to make copies of all important material for us. (AGV #20209, letter from Wilhelm Haack to Alfred Bentz, 24 November 1945)

7.3 Cold War

Matters changed significantly, when on 12 September 1946 Friedensburg was dismissed. Material collected by his deputy, Gustav Sobottka,[7] seemed to indicate that he had favoured former Nazi personnel.[8] Hardly a month later, Otto Barsch died; and Sobottka made Erich Lange[9] his successor (Keiderling 2009, p. 76; Kaemmel 2013, p. 29). Lange was an ardent communist and his “enemy” was the west. The “crime”, he detested most was collaboration with this “fascist–capitalist west”, represented by British and American authorities and those geologists, who worked for them. Consequently, he refused further cooperation with western geologists. When in October 1946, Major Gunther once again travelled to Berlin, Lange declined access to any more files on petroleum exploration (Kaemmel 2013, p. 29).

Later East German apologetics saw the issue as “[…] a first political test” (Gotte et al. 1985, p. 117) and justified proceedings by accusing western and western-friendly geologists of having been separatists and by denouncing the exchange of information as theft:

> The letters that have been found confirm, what the course of German history has shown […] in various ways: in which part of Germany the Separation began, which circles also among German geology have lent themselves as tools for the pervasive political particularism of the Western powers. Because:
>
> Not only in Berlin former civil servants and employees of the *Reichsamt für Bodenforschung* assembled! Under the protection of the British occupational administration, Alfred Bentz collected in Celle geologists and – geological

[7]Gustav Sobottka (1886–1953) was a mine worker since 1901. 1905–1908 saw him in military service. Since 1910, he was politically active in various parties (SPD, USPD, KPD) and miners’ unions. 1921–1932, he was a Member of the Prussian Parliament for the KPD. In 1933, he emigrated to the Saarland (then under French occupation), in 1935 he left for France. In November 1935, he immigrated to the Soviet Union and undertook political work for a miners’ union. 1938/39 he worked as a journalist for a German newspaper in Moscow, later he became political instructor in a camp for German prisoners of war. In May 1945, he returned to Germany and became Vice President of the Central Administration for Combustibles in November 1945. In August 1947, he was promoted President of this organization and in 1951 he was demoted to instructor in the mining industry (Weber 2010; https://www.bundesstiftung-aufarbeitung.de/wer-war-wer-in-der-ddr-%2363%3b-1424.html?ID=3321 [accessed 27 July 2017]).

[8]In all four occupation areas, there was some sort of denazification process, i.e. dismissal of Nazis from teaching positions and in administration and politics. Nevertheless, in August 1947, only 1.6% of former members of the Nazi Party NSDAP were unemployed in the Soviet Zone. As for the Berlin geologists, a commission of the Soviet Military Administration reviewing the political past of the Survey’s personnel found 1/3 of them to be former NSDAP members, among them several active National Socialists. However, none of them were subsequently dismissed (Kaemmel 2013: 9, 25).

[9]Erich Lange (1889–1965) worked as a geologist in Africa until 1914, when he was interned as German citizen by British authorities until 1918. In the 1920s, he was councillor for mineral resources at the Soviet Trade Mission in Berlin and worked for some time as a geologist in the Moscow Basin. In 1936, he became geologist at the Geological Survey in Berlin. Later in 1936 and until 1945, he worked as geologist for the German Colonial Office *Reichskolonialbund*. In 1945, he became geologist at the Soviet Scientific–Technical Office for the Coal Industry in the Soviet Occupation Area. In 1946, for a short time he was professor for fossil fuels at the Mining Academy in Freiberg. From October 1946–1955, he was employed as President of the Berlin Geological Survey. He was replaced in 1955 by Karl Neumann and parked as editor of the Survey’s journal (Kaemmel 2013, pp. 29–30; Remus 1987).

> documents. […] the acquisition of the documents, of archive and library material from Berlin as foundation for the office Celle personally was taken over by a British Major Gunther, whose affiliation with the petroleum company Shell provides sufficient information on his interests and of those of the 'gentlemen' in Celle. In the FRG, Mr Bentz and his British patron Gunther may be elevated as the enterprising founding fathers of the *Bundesanstalt für Geowissenschaften und Rohstoffe*[10] – everybody has his own traditions and role model – The removal, which was prepared at that time, i.e. the shameful robbery of the scientific material from the Invalidenstraße 44 was prevented by the German communist Bernhard Hirsch[11] and soviet military authorities, which had been called in for help. With orders #101 and 124 of the Soviet Military Administration in Germany (SMAD) it was finally and unmistakably ruled that buildings and inventory were exclusively handed over for use to the newly founded Geological Survey in Berlin and disposal of this property was allowed only with permission of the SMAD. This protection through the Soviet occupational administration secured jobs and working possibilities for the Berlin geologists. (Gotte et al. 1985, p. 118)

Lange was suspicious not only of the petroleum geologists in Celle but also of all those in Berlin, who had been in contact with Celle. Their situation became increasingly precarious in unison with mounting confrontational attitudes in both the USA and the Soviet Union. On 1 November 1946 Wilhelm Kegel,[12] Werner Paeckelmann[13] and Wilhelm Haack[14] were sacked by Sobottka without notice as accessories to the alleged theft of information by Major Gunther and as being suspect of having betrayed state secrets. Other dismissals followed.

> November 1946. The following rumour is told: in Berlin the President of the Geological Survey, the geophysicist Prof. Barsch has died. A Mr Lange became his successor. When Major Gunther drove there again to buy books and maps, it seems he was very explicitly complimented out of the survey building and German police had to check at the exit that he really did not take anything with him. Gunther came back very thoughtful and rather depressed and said, the "Iron Curtain" (Churchill) is now finally closed. Shortly afterwards, 20 geologists and employees of the Berlin office were dismissed, among them the Old Guard of geologists, all of the Non–Party–Members:[15] Haack, Kegel, Paeckelmann, Gothan,[16] Schindewolf,[17]

[10]I.e. the geological survey of West Germany.

[11]Bernhard Hirsch was head of the survey's planning department. Under the Nazi regime, he had been prosecuted due to his communist convictions and his Jewish descent (Kaemmel 2013, p. 35).

[12]Wilhelm O. Kegel (1890–1971) studied geosciences in Marburg and Göttingen and obtained a doctorate degree from the University of Göttingen in 1910. 1912–1939, he was a geologist at the Geological Survey in Berlin and a military geologist during World War II. In 1945, he returned to the Survey. In 1946, he fled to West Germany. In 1949, he became a geology professor in Brazil (https://de.wikipedia.org/wiki/Wilhelm_Kegel; accessed 11 May 2018).

[13]Werner Paeckelmann (1890–1952) studied geology in Marburg and obtained his doctorate degree in 1913. Afterwards, he worked for the Berlin Geological Survey. He was a soldier in World War I and returned to his survey post in 1918. From 1939 to 1944, he was sent by the Survey to occupied Poland. He was arrested on 27 December 1946 and died in prison (https://de.wikipedia.org/wiki/Werner_Paeckelmann, accessed 9 February 2016).

[14]Wilhelm G. A. Haack (1882–1947) studied geology in Göttingen and obtained his doctorate degree in 1907. From 1912 to 1939, he worked as geologist at the Geological Survey in Berlin. World War II, he spent as military geologist. In 1945, he returned to the Survey. In November 1946, he was arrested and died in prison (https://de.wikipedia.org/wiki/Wilhelm_Haack, accessed 9 February 2016).

[15]I.e. not members of the Nazi party NSDAP. Consequently, they were not subject to denazification.

[16]Walter Gothan (1879–1954) had studied geology and mining at the mining academies in Clausthal and Berlin as well as botany, chemistry and philosophy at the University of Jena. He obtained his doctorate degree with a palaeobotanical dissertation in 1905 from Jena. Since 1903, he worked at the Prussian Geological Survey (later named *Reichsamt für Bodenforschung*). In 1908, he qualified for professorship and lectured at the Berlin Mining Academy. He became honorary professor at the University of Berlin. Gothan left the survey in 1947 to become full professor for palaeobotany at the same university (Jahn 1964).

[17]Otto H. N. Schindewolf (1896–1971) studied science with a focus on geology and palaeontology in Göttingen and Marburg, obtaining a doctorate degree with a palaeontological thesis in 1919 from the University of Marburg. He became assistant in Marburg and qualified for professorship in 1921. He then worked at the Prussian Geological Survey and eventually became director of the collections and the library. In 1947, he became Chair of Palaeontology at the Berlin Humboldt University (East Berlin) but then moved to Tübingen on the palaeontological chair of the University of Tübingen (Zirnstein 2005).

> Berg[18] etc. A very nasty campaign in Berlin newspapers followed hinting at the reasons for the dismissal: Collaboration with the capitalist West and delivery of material to Shell agents. (Diary entry of Alfred Mayer Gürr, Mayer-Gürr 1987, p. 37)

Wilhelm Haack immediately contacted Bentz providing information and requesting support:

> What I have expected since a long time at least for me has happened yesterday […]: Kegel, Päckelmann and I have been evicted without notice and the pretext was our exchange with Celle. In the morning, there was at first a questioning with Mr S.[19] of the Central Administration in which we were reproached that we had – in violation of the expressed ban – handed over material and files without permission of the President of the Central Administration. They hardly heeded our defence; instead there appeared an inordinate distrust against us and especially the impression that everything was already a settled matter beforehand. The interrogation was ended by Mr S. with the remark that the proper investigation would still follow. He must, however, ban us from entering the office building upon further notice.
> In the evening, we all received an apparently identical letter in which our dismissal without notice from the service of the DGLA[20] was expressed and which says (among other things):
>
> "You also knew that your deeds would cause damage to the work of the DGLA and therefore meant to consciously damage the general interest of geological work". But really, the ban was announced to us only shortly before the death of poor Mr Barsch; they, however, claim that it was issued in November last year. Several times the word "treason" was used. Details I cannot mention now. I only want to beg you, if possible, to make a list of the delivered material, because we have no access to our things. (AGV #20221, letter by Wilhelm Haack to Alfred Bentz, 2 November 1946)

[18]Georg Berg (1878–1946) studied geology, mineralogy and mining at the Freiberg Mining Academy and at the University of Leipzig. He obtained his doctorate degree from Leipzig in 1903 with a mineralogical thesis. He then worked at the Prussian Geological Survey (https://de.wikipedia.org/wiki/Geor_Ernst_Wilhelm_Berg; accessed 11 May 2011).

[19]Sobottka.

[20]Short for *Deutsches Geologisches Landesamt*, i. e. German Geological Survey.

Bentz sent an official declaration:

> Re: Information provided by the *Deutsche Geologische Landesanstalt*
> […] We have only received such information or transcripts from you, i.e. the petroleum department which is related to the *Reich* drilling programme within the British Zone. The information respectively documents were needed here to complete the contracts of the *Reich* drilling subsidies,[21] which had been granted by the former *Reichsamt für Bodenforschung* in Berlin. If you hadn't provided us with the material, we would have had to turn to the individual loan receivers. This would have caused considerable difficulties to the administrative work, and also we would have been required to check the statements of the loan receivers in every case; in particular to verify the instalments already paid by the former *Reichsamt für Bodenforschung* in Berlin before the collapse [of the Nazi state].
> There has been not a single instance in which we received a loan contract residing at the DGLA. We only receive photocopies of such contracts.
> Naturally, our survey office has always provided the DGLA with all requested information on geological and geophysical work from the time before the collapse. The material delivered by us to the DGLA possibly was much more extensive than your information or copies directed to us. (AGV #20223, declaration by Alfred Bentz, 13 November 1946)

When he was dismissed, Kegel immediately fled into the British Sector and eventually ended up as a geology professor in Brazil. Haack and Paeckelmann, however, hesitated (Kaemmel 2013, p. 30). Haack still had hope that everything would be resolved in his favour:

> Concerning the dismissal proceedings: The date for charging Mr Paeckelmann – scheduled for the 16th of this month – was adjourned because important evidence on behalf of the defendant was missing; and similarly it will probably continue. Mr Kegel has relayed your friendly words to me concerning a possible position at your office, for which I want to thank you as well. Since I have the slight hope that matters will be solved again and moving to the West would be [emotionally] difficult for me, already because to our experience the climate of Hannover or Celle does not agree with my wife. Besides, one should not replant an old tree. […] perhaps, if all else fails, I would fall back on migration. Cooperation with yourself would be much easier for me than with certain people here.

[21]See Kölbl-Ebert (2018).

(AGV #20224, letter by Wilhelm Haack to Alfred Bentz, 21 December 1946)

Werner Paeckelmann, on the other hand, had already declared to Bentz that he planned to leave Berlin for Celle. Negotiations, however, dragged on, because Paeckelmann was unwilling to leave his private library in Berlin[22] (AGV #14067, letter by John Gibsone, Marburg, to Otto Schindewolf, 5 September 1948).

> I wait urgently for Mr Paeckelmann, who wanted to come here early in January, so that I receive information how these unbelievable matters have developed further. It seems that currently, a certain calming has taken place so that it can be hoped that some problems can be righted. However, poor Berg has died since, from grieve about the unjust treatment, as I should assume.
> Of course your personal fate caused me also much concern; however, I will assume that via Mr Stille[23] an acceptable arrangement has been found. Otherwise, you are here of course always welcome to me. (AGV #20225, letter by Alfred Bentz to Wilhelm Haack, 27 December 1946)

Meanwhile, rumours went round that Paeckelmann had been charged with some unknown crime and might have been arrested. Nevertheless, Haack himself did not seem to have felt immediately threatened. He was only worried that he was unable to continue his scientific work:

> Just now, I have returned for the umpteen's time from the industrial tribunal without outcome. He heard, however, that the public prosecutor has demanded a trial against Mr P.[24], but we do not know the cause. However, there seems to be more about it, and I am curious to learn, whether meanwhile Mr P. has arrived at yours or – as I fear – not.
> By questioning of Pr. S.[25] […], it has to be proven whether my dismissal followed an immediate order to that purpose. For this, the next date [of hearing] has been fixed on 10 February '47. […] Consequently, we have to gird ourselves with patience again. I realize that eventually we will have to use your friendly offer and go west. However, I first like to retrieve the many private things remaining in my office and that is also a difficult matter. […] Though some part I have already taken out, but especially the valuable publications of the survey, maps, essays etc. the others do not regard as private. That will still cause many struggles. What a waste of time! But this seems to be, what the work of the survey generally consists of these days. (AGV #20579, letter by Wilhelm Haack to Alfred Bentz, 20 January 1947)

Haack's wife, Alvine Haack, was genuinely worried and confided in Mrs Bentz, but even she did not perceive the immediate danger her husband was in to its full extent:

> It has hurt me so much that my poor husband, who is always so meticulous, has half been named a traitor after 37 ½ years of service. Let's hope that nothing terrible has happened to poor Mr P., but that he now has arrived safely with your husband. I would be much pleased, if my husband would not return to the survey, because it can no longer be a pleasure to work there. It seems, we will eventually still end with you; I only desire so very much to take with us the few things, which we have managed to buy again [after the war]. (AGV #20573, letter by Alvine Haack to Mrs Bentz, 20 January 1947)

Paeckelmann, indeed, had not shown up in Celle, but had been arrested. On 12 February 1947, Wilhelm Haack was detained as well, when he tried to retrieve private property from his former office thus delivering a convenient pretext. Another letter by Alvine Haack (to her daughter) documents the sequence of events:

> Around the 7th I was at the survey to return library books, because Daddy received a note that this was desirable. Daddy wanted to go [himself] but I said better not. I was also to talk to Gothan and he said

[22]From 24 June 1948 until 12 May 1949, road access to West Berlin was blocked by Soviet authorities and the city had to be supplied with food and medicine via airplanes.

[23]Hans Stille (1878–1966) studied chemistry and geology in Hannover and Göttingen. He obtained his doctorate degree in 1899 from the University of Göttingen with a tectonic thesis. After one year of military service, he came to the Prussian Geological Survey. In 1904, he qualified for a professorship. In 1908, he became chair of mineralogy, geology and smelting at the Technical University of Hannover. 1912, he was shortly professor at the University of Leipzig, but in 1913, he moved to the University of Göttingen. With the beginning of WWI, however, he was drafted as an officer and from 1917 onwards, he worked as a military geologist. After WWI, he returned to Göttingen. In 1932, he became chair of geology at Berlin University. In 1946, he founded an institute of geotectonics. He retired in 1950 and moved to West Germany (Sperling 2013).

[24]Paeckelmann.

[25]President Sobottka.

> to me, Daddy shouldn't be so timid and come without worrying […]. I then went home and told Daddy, and because he wanted to go there since a long time already to get his manuscript on Helgoland as well as various books, he went on 11th February. I was very restless, but thank God, he returned already after several hours and I was glad that he was back again. He had not caught anybody […]. Now he had a meeting date for the next day at 12 o'clock and also went. […] When Daddy had not yet returned at 5 o'clock, I became restless […] At […] a quarter past 7 there was knocking down at the door. […] A German policeman from the precinct of Zehlendorf came with a note, I should immediately bring something to eat, Daddy had been interned at the police station 61 at Prenzlauerberg. […] Daddy then told me that when he had arrived [at the survey]; he was immediately taken to his room. He immediately found the remaining library book, which I had not been able to find, and also what he was expected to take with him as well. Then he was taken to President Lange (SED[26]), where already sat a Russian officer and Daddy was interrogated for an hour. Not about what he had been accused of, but about how many children we had, what they are, where they are, which [military] decorations Daddy had, in which party he had ever been and so on. Then he took him to this police station. There we sat overnight […] Between 2 and 3 o'clock […] two [Russian] officers came […]. And then, they took Daddy with them. It was the most terrible moment in my life, but then I still believed that he would be released the next day.
> […] The American is much committed. He even has had our physician fetched with the car to testify about Daddy's condition of health. Now I plan to ask Dr Friedensburg whether I should go to Sobottka, the President of the Central Administration. Even this I would dare to endeavour.
> Today, I was again so see the doctor. He is touchingly concerned about Daddy. He thinks, they will release him because of his health condition. If only, it was already time for it.
> […] It is not to reach the newspapers, so as not to agitate the Russian further. I.e., it is not really the Russian, but our "dear" compatriots". (AGV #20575, excerpt from a letter by Alvine Haack to her daughter, made in Bentz's office, February 1947)

Both people arrested died in prison, Haack later the same year due to his bad heart condition and Paeckelmann in 1952 from influenza. Paeckelmann's wife, unable to deal with the situation any longer, had already committed suicide in 1947 (Kaemmel 2013, p. 30).

Whereas colleagues in Celle reacted shocked and depressed, proceedings in East Berlin followed the logic of the newly established political regime and were defended as "Overcoming the first clique, which had proved by extensive disruptive actions to be hostile to Socialism" (Hetzer 1987, p. 154). Consequently, it was deemed now the right time to define the place of geology within the task to "construct the antifascist–democratic order" (Hetzer 1987, p. 154):

> The Geological Survey has the task to scientifically investigate the territory of the Soviet Occupation Area with geological, geophysical, mining and other methods with the aim to provide the necessary foundation for the further development of industry and agriculture of the new, democratic Germany. (bylaws of the *Geologische Landesanstalt*, 27 April 1948, quoted after Hetzer 1987, p. 154)

In practice, geology was no longer regarded as a science, but was reduced to an industry providing mineral resources and thus facilitating the survival of the German Democratic Republic:

> Then and later, discussions weren't missing, whether geology was to be regarded as a branch of industry or whether due to the high proportion of scientific work, it deserved a special position. Apologists of a "peculiarity of geology" always overlooked that in other industrial branches as well extensive scientific work had and has to be done to secure further development. (Hetzer 1987, p. 154)

Any continuity between the old national geological survey of Germany, the *Reichsamt für Bodenforschung*, which had resided in the very same building in Berlin, and the new geological survey of communist East Germany was strictly denied on ideological grounds:

> At the process of inauguration of the antifascist–democratic state power in the GDR, there was no longer any space […] for any "successor organisation" of the fascist Reichsamt für Bodenforschung. The present Bundesanstalt für Geowissenschaften und Rohstoffe of the FRG deserves the claim to such a doubtful honour. (Hetzer 1987, p. 154)

Getting rid of old, more or less compromised personnel by any conceivable means and its

[26]Short for *Sozialistische Einheitspartei Deutschlands*, i.e. the state party of the former GDR.

replacement with younger geologists, who had been educated within the new ideological framework was the natural consequence:

> The following years are characterized by intensive work to carry out the tasks which the Party of the Working Class and the government of the GDR have decided for geology. […] for which new prerequisites existed considering the trained cadres which now had been educated with the philosophy of socialism in mind. (Hetzer 1987, p. 155)

7.4 Propaganda Offensive

Thus the geological survey in Berlin had become a battle ground of the Cold War. "Cleaning up" within the own institution was one strategy; the other was denigrating the former colleagues within the western off-shoot, now perceived as in league with a hostile force. In Berlin, such action seemed mandatory, because:

> In Berlin – the city divided in for sectors – the east–west contrast collided sharply. Tensions escalated markedly in the practise of information, culture and propaganda on both sides; polemic and hostile tone rapidly gained the upper hand. The political–military conflict of the superpowers appeared as a Cold War of Words. There was tough wrestling for control and manipulation of the mass media. The world views and societal models, already differentiated before, changed into doctrines in the sense of wieldable weapons in an ideologically conducted fight. "Freedom versus dictatorship" became a battle cry. In autumn 1947, East and West declared each other the unveiled propaganda war. (Keiderling 2009, p. 129)

This "propagandistic war" affected also the geological surveys, and the petroleum geologists, specifically Alfred Bentz, became a preferred target because of their former involvement with the war effort of Nazi Germany (see Kölbl-Ebert 2018):

> Who supports Prof. Dr Bentz?
> […] Göring[27] included the development of new petroleum fields in his Four Years Plan[28] in order to decisively influence the preparation of the war. He also established two commissioners for the German fuel industry. One of them, Prof. Dr Krauch[29] appeared as war criminal in the dock in Nuremberg, the other, however, Prof. Dr Bentz, became head of the *Reichsamt für Bodenforschung* and still has the same function today. With a decree of Göring, the authority of Professor Bentz was extended to Czechoslovakia and all occupied Polish territories. Finally, Mr Bentz was put in charge of all conquered petroleum fields, which by him were subordinated to the plans of the war economy. Göring then asked Bentz together with the *Reich* minister for armaments and munitions and the OKW[30] to make plans for Rumania, Hungary and Croatia, and to inform the General Commissioner for Special Issues of Chemistry about these. Germany's oil barons had always dreamt of a German petroleum empire. […]
> In September last year, the same Professor Bentz, who belongs on the list of war criminals, opened in Hannover a petroleum conference upon the instigation of the *Reichsamt für Bodenforschung*, whose director Bentz still is. The central issue of this conference was the founding of the *Deutsche Gesellschaft für Mineralölwirtschaft.*[31] (AGV #20501, newspaper clipping from the Berliner Zeitung, 8 April 1948).[32]

Alfred Bentz, who at that time still was looking forward to the completion of his denazification process,[33] was not in a position to take these allegations lightly and inquired on the occasion of earlier, similar newspaper articles including an anonymous defaming pamphlet in September 1947 as to the source of this campaign:

> Of course I investigated the matter and had to discover that it had been thought up in the former headquarters of the Geological Survey in Berlin. The present President of this administrative body is a communist in the truest colours, who has no inkling of geology. Since, however, I am mentioned very generally as a contender for such a post, he of course fears for his position and has all reason to at least slay me politically, because,

[27]Hermann Göring (1893–1946).

[28]See Kölbl-Ebert (2017, 2018).

[29]In 1938, the chemist Carl Krauch (1887–1968) became Commissioner General of the *Vierjahresplan* for the chemical industry, which also involved synthetic fuels and refineries for crude oil (Kölbl-Ebert 2018).

[30]Short for *Oberkommando der Wehrmacht*, i.e. the army high command.

[31]German Society for Petroleum Economy.

[32]While not incorrect as such, this is but a rather crude summary of the actual historical events. For details and context, see Kölbl-Ebert (2018) and references therein.

[33]Bentz was officially cleared of all charges on 29 July 1948 (letter by Alfred Bentz to his attorney, 2 August 1948, AGV #20321).

> of course, he cannot undertake anything against me on the field of scientific expertise. Meanwhile, I also know the creatures, who have acted as informers. The whole business was intended as a bomb to blow up the petroleum conference in Hannover and appeared in grand style in the Berlin SED papers. Obediently, of course, the communist newspaper *Hannoversche Volksstimme* took over the campaign and the pamphlet sent to you also comes from this devil's workshop.
> Objectively, the article brings nothing that would not be general knowledge here. The World Petroleum Congress is an international affair of the profession and my appointment for its President only proves my professional expertise and has nothing to do with German party politics, already because of the international nature of the board. Of course, my work for the Four Years Plan has been discussed in detail with the English authorities in charge, but since it is also a solely technical occupation and since today I perform exactly the same tasks under the same type of planned economy, they saw no reason for intervention. (AGV #20186, letter by Alfred Bentz to Fritz Evers, 20 December 1947)

In April 1948, when the topic was once again launched (see above), Bentz attributed the campaign against him as a result of more general political, ideological motivation rather than of personal resentments by Erich Lange:

> These press campaigns of the SED have only the purpose […] to disturb the rebuilding process in the western areas. However, since such occurrences repeat themselves daily, I do not believe that anything at all will be achieved thereby. (AGV #20502, letter by Alfred Bentz to Mr Zirkler, 27 April 1948)

In April 1949, the Federal Republic of Germany was founded in the west, imbedded in the likewise newly founded North Atlantic Treaty Organization (NATO) and in October followed the German Democratic Republic in East Germany as a satellite state of the Soviet Union.

7.5 Pompeckj Rise[34]

As a result of the two different political systems in East and West Germany, the respective geologists learned to apply different measures for the assessment of mineral resources and fossil fuels. Whereas in the west, prices for exploration and extraction had to compete with an increasingly global market, the east strove for planned economy, autarky and conservation of foreign currency. Consequently, what western geologists deemed to be negligible resources not worthy of pursuing were regarded by eastern geologist as valuable resources to fulfil a completely different set of goals with different standards.

> The prospection for nickel ores in the Saxonian Granulite Mountains, which ended with the confirmation of a minable deposit, was a substantial argument against the thesis, which was circulated by the opponents of the socialist restoration, that on the territory of the GDR no new mineral deposits were to be expected. (Hetzer 1987, p. 154)

However, rather than understanding these different goals and their resulting different priorities, they became the starting point of a curious incident:

> Erich Lange persecuted Hans Stille and the scientific father of the German petroleum geology, Alfred Bentz, with near pathological hatred. This became already evident in an essay […] published in 1955, where he […] accused them to have – possibly looking into the future – developed a theory stating that the Mesozoic in eastern Germany would be less favourably structured than in Lower Saxony and that consequently it would not be profitable to drill for oil in this area. (Hetzer 2004, p. 60)

Lange especially criticized Hans Stille, geology professor at the Humboldt University in East Berlin, accusing him to having defended the theory of a Pompeckj Rise even after 1945 and consequently arguing large parts of the GDR to be devoid of petroleum (Lange 1955, p. 5).

[34] In 1921, well before the theory of plate tectonics, a hypothetical Palaeozoic landmass in north–eastern Germany, the *Pompeckjsche Schwelle* (i.e. Pompeckj Rise), was postulated to explain differences between the trilobite faunas of Scandinavia and Bohemia. In the early 1930s, Alfred Bentz, considering limited drilling data, opted for a possible continuation of this elevation into the Mesozoic, which was, however, already doubted by Hans Stille. The existence of such a high-ground, whether terrestrial or submarine, would have led to sedimentation conditions unfavourable for the formation of petroleum. In 1932, Bentz delineated that the "rise" may not represent a homogenous topography and that more thorough investigations would be necessary to get a clearer picture (Hetzer and Krüger 2008, pp. 42–43).

Interestingly, Lange also mentioned that Rudolf von Zwerger[35] had published seismic data in 1944, which made matters seem less hopeless, thus inadvertently proving that the Berlin survey geologist had not been detained by any theoretical bias from looking more closely into the possibility of petroleum underneath the East German territory. Consequently, GDR geologists undertook first drillings in the early 1950s (Lange 1955, p. 6). Over the following pages, it does not become clear, where exactly Lange saw a problem, because the theory of the Pompeckj Rise does not seem to have disturbed thorough prospecting in any way. Nevertheless, Lange concluded:

> The branch of science, which is occupied with the prospecting of oil and gas deposits, is international. Since, however, petroleum and gas are especially important resources; since the trade with petroleum and petroleum products on the capitalist world marked surpasses the financial value of the trade of corn and coal together, the monopoly lords try to shackle petroleum science in front of their waggon, i.e. in front of their profit interests. We must recognize this scientifically hostile element, which tries everywhere to bend true scientific knowledge, to fraudulently alter it and to transform it into harmful legends and [we must] exclude its influence on our research in future. (Lange 1955, p. 9)

Despite Erich Lange's allegations, however, other GDR researchers such as Heinrich Kölbel stated:

> Summarizing, it can be said that the present petroleum prospection in the GDR – just as in West Germany – has not halted at the 'Pompeckj Rise'; that geologists had been versatile enough to adapt their working hypothesis to the respective state of knowledge. (Heinrich Kölbel in 1956, quoted in Hetzer and Krüger 2008, p. 44)

The geologists in the GDR undertook a comprehensive drilling campaign, which however, remained largely unsuccessful because of the low permeability of the targeted Jurassic and Early Cretaceous rocks (Hetzer and Krüger 2008, pp. 44–45).

The incidence of the Pompeckj Rise and Lange's polemics against western colleagues and such eastern colleagues he perceived as being infected by capitalist, anti-GDR notions was, however, no mere curiosity. It was part of the increasingly permeating political influence on life and work of East German geologists[36]:

> Around the end of the 1950s the slogan formulated by the Party of the Working Class "To learn from the Soviet Union is to learn to be victorious" had already become a perceptible action of tight cooperation between German and Soviet specialists in the field of geology. […] Simultaneously, members of the SED and progressive colleagues strengthened their propagandistic effort on dissemination of knowledge and to advance the achievements of the Soviet geological sciences. Erich Lange, Friedrich Stammberger[37] and others are to be remembered, who have been the path makers in this field and who in numerous ways have brought the progresses of the Soviet geology into the work. Special credit is also due to the *Zeitschrift für angewandte Geologie* [Journal for Applied Geology]. Since its [first] appearance in 1955, it proved to be an excellent and belligerent propagandist of the newest Soviet [scientific] insights. (Gotte et al. 1985, p. 119)

7.6 Terra Incognita

Nearly a decade after Lange's infamous paper, the mystic Pompeckj Rise again played a role in East German propaganda and this time quite literally. It featured in the theatrical play *terra incognita* (1964) by Kurt Barthel[38] (pseudonym:

[35]Rudolf von Zwerger (1902–1945) studied mining in Freiberg, Berlin and Clausthal 1921–1927 and obtained his PhD in 1929 from the Technical University of Aachen. 1928–1934, he worked in the oil industry in the USA and Germany. 1934, he joined the Prussian Geological Survey (later *Reichsamt für Bodenforschung*) as expert for seismic exploration. In 1944, he qualified for professorship. In April 1945, he was drafted to the *Volkssturm* and died in the battle for Berlin (Closs 1952).

[36]Kölbl-Ebert (2019).

[37]For a biography, see Kaemmel (2013).

[38]Kurt Barthel (1914–1967) learned painting and decoration. In 1931, he became a member of the Socialist Workers' Youth. In 1933, he emigrated to Czechoslovakia. In February 1934, he partook in political riots in Vienna. In 1938, he emigrated to the UK, where he worked as farmhand and construction worker. In 1946, he returned to Germany and became a writer. In 1960, he received an honorary Ph.D. from the University of Rostock (Hetzer and Krüger 2008, p. 50).

kuba), which—in the style of “socialist realism”—picked up Lange’s allegations in attributing the lack of success in petroleum exploration around Rostock to the petroleum geologists inherited from the old national socialist–capitalist regime, who still adhere to the idea of a Pompeckj Rise preventing the formation of petroleum, and who thus sabotage the efforts for oil prospecting due to their political–ideological defects. They are successfully opposed by young German scientists, educated in the Soviet Union, together with a Soviet specialist,[39] who consequently succeed in discovering a spectacular gusher (Hetzer and Krüger 2008, p. 45, Barthel 1964).

Terra incognita put the Cold War on stage in as much as the meagre success of the GDR’s petroleum exploration programme was attributed not to the contingencies of geological deposition but to the adverse influence of the political opponent:

> Grebe: Already when he was Vice–President of our Academy of Sciences, Leiser[40] said, the political demarcation boundary through Germany was also that of the German petroleum occurrence. And the most unfortunate in this was that petroleum is to be expected only west of this boundary. […]
> Koller: Now pay attention! Soon the theory of the Pompeckj Rise will make an appearance.
> Stüwe: Professor Leiser went west?
> Grebe: Nevertheless he is greatly honoured …
> Koller: He did a runner!
> Grebe: — today and in this country highly regarded as an expert.
> Koller: He is an expert; the question is for what and whom … […] // Only, Doctor Grebe, upon honour and conscience, to me you do not seem to be so anxious to find anything.
> Grebe: What do you want with this bad accusation, pray?
> Koller: Your whole little bit of theory would be overthrown. (kuba 1965: 15–18)

> Hülle: False doctrines, crooked theories are deployed to create warped ideology.
> Grebe: This poison creeps in through all pores.
> Hülle: Who only informs himself West German, English and American, is like an infectious louse. (kuba 1965, p. 130)

In the play, the defenders of the Pompeckj Rise, the fictitious geologists Grebe and Ingeborg Saupe are characterized as former Nazi geologists:

> Grebe: I ploughed Europe’s petroleum fields thoroughly, was down in Ploesti and up in Holstein, Western Slovakia –
> Koller: Has already under the Nazi petroleum and gas consortium illegally exchanges some raw oil for Slivovitz. (kuba 1965, p. 19).

> Grebe: “The beautiful Ingeborg […] was on top then as she is now. Professor Kral, her father, lectured petrography at the Karls–University in Prague. We German compatriots could not understand that she – a sun rune[41] tattooed on her breast – who together with us provoked the Czechs on Wenzel’s Square, not only obtained a doctorate as geologist but also in Slavonic studies. Yes, yes – the old Kral has looked far ahead into the future. The petroleum of the Caucasus: that was his idea of happiness. Reached Maikop[42] but did no longer find the way back, just as Ingeborg was lost out of sight. When we lost the war and gained reason, she rose again like Phoenix from the ashes. […] What I want to add: Her Slavonic studies come in handy now. (kuba 1965, p. 89)

Unsuccessful ventures recollected by the play’s characters are attributed to western sabotage, and geologists who left the GDR for West Germany[43] are regarded as spies:

> Raspe: We were supposed to reach 1800 metres. At 700 metres sudden stop was ordered. The hole was filled in; the drill cores had disappeared. […]
> Stüwe: The core disappeared?
> Raspe: With other words: was lost, was stolen.
> Stüwe: And the responsible geologist?
> Raspe: … was gone! Disappeared like the sausage from the sauerkraut. // […] // And hardly three months later and less than 1000 metres west the Preußag struck oil.
> Stüwe: Spooky!
> Raspe: […] Who has made the preparation work for the company? Heiligenkreuz! Same fun again! // Expert opinion: Drilling pointless, will strike

[39]Individual Soviet specialists were sent to East Germany for two to three years to supplement missing personnel in the early years of the GDR. They had a considerable authority on proceedings (Hetzer 2004, p. 61).

[40]I.e. Hans Stille: The German adjectives *still* and *leise* are synonymous, meaning *silent*.

[41]In this context, a euphemism for *Hakenkreuz*, i.e. a swastika.

[42]For the role of German petroleum geologists in World War II, see Kölbl-Ebert (2018).

[43]Via the open border in Berlin. This leak was plugged on 13 August 1961, when the Berlin Wall was built.

> water. – Enough! As is generally known: Through damage man becomes smart. We drilled and hit unexpectedly gas! Eruption! You have studied and know the oil business from theory. But have you already been present, when hurled as by a gigantic fist, several hundred meters of drill string like macaroni running amok are shooting across the scenery? The drilling table suddenly is wedged seven meters up in the derrick? You think the devil himself is clutching you in his fangs. Four days the drill hole blew without restraint, then lightning struck. Couldn't even pack. We were only able to run for our naked lives. Trailers blazed, the sheds and barracks. And then the whole forest around began to burn. […] I have very well memorized the handwriting of our misfortunes. Because high above us – and the sky–high flames were bright enough – the smoke wrote his black letters. The name Preußag stood in this fireball. And the others too were easily enough decipherable: such as Shell, Standard Oil and Wintershall. (kuba 1965, pp. 32–33)

The character Dr. Hülle, executive of the State Geological Commission at the Council of Ministers of the GDR, sees a clear continuation from the supporters of the former Nazi regime to present-day American capitalists. The additional allegation of theft of data and maps laid at Alfred Bentz's door harks back to the charges against Paeckelmann and Haack for collaboration with West German petroleum geologists:

> Hülle: Mr Hitler kaput – Mr Bentz smells the roast. With one half of his bottom he always sat in the [United] States. The petroleum sharks have betrayed each fatherland, even their own fascist one. // To make matters complete: [He] went over to the Yankees; with all his stuff. Drilling protocols, maps – all went west. Should we get lucky here, they will spare no means [to harm us]. (kuba 1965, p. 75)

The characters Zarge, political instructor of the Central Committee of the SED, and Dr. Hülle are left to draw the politically correct conclusion:

> Zarge: […] The [working] class must learn to subjugate science!
> Keutel: Those who study today are, however, basically ours.
> Hülle: Only – we allow too easily that they detach themselves from the [working] class front to dance like moths around the light of the bourgeoisie" (kuba 1965, p. 75).

The play as well as a corresponding movie, however, was no success in the GDR (Hetzer 2004, p. 60), and at least some geologists at the Berlin geological survey felt alienated by the unflattering depiction of their work:

> In youthful anger I wrote a little protest note, which of course ended up […] at the District [Party] Management in Rostock. Consequently, I – together with Gerhard Zindler – had to present myself to the First Secretary Harry Tisch.[44] There we were scolded in the presence of Kurt Barthel. We were told that only with the power of the Soviet specialists and people educated in the Soviet Union were the problems solvable, and therefore all purposeful pessimism had to be unveiled without mercy. (Hetzer 2004, p. 60).

7.7 Cold War in Hungary

Restructuring petroleum geology under the political logic of the Cold War was by no means a solely German phenomenon. After World War II, Alfred Betz not only sought contact with colleagues in Berlin, but he also inquired after petroleum geologists in Hungary, Rumania and Yugoslavia (AGV #20244, letter by Alfred Bentz to R. Janoschek, Vienna, 30 December 1946). Bentz established contact by letters as soon as possible. But as a consequence of the tribulations his cooperation had caused for colleagues in Berlin, he also inquired, whether such renewed contact to colleagues in now communist countries might not cause harm:

> You can count yourself lucky that you are happily out of the troubled Europe and can start afresh. The feeling of insecurity governs and paralyzes everything here and one cannot imagine how this might become better again someday. The connections are completely severed, especially with the East […]. The more so I have rejoiced to glean from your letter […] also the first authentic news about Mr Papp, about whom rumour around the end of the war had it that he was gravely ill. Do you know his present address and do you belief that I can write to him from here, without him getting into troubles by it? (AGV #20527, letter by Alfred Bentz to Janos Dinda, Caracas (Venezuela), 14 January 1948)

[44]Harry Tisch (1927–1995) was a high-ranking party official of the SED (cf. https://de.wikipedia.org/wiki/Harry_Tisch; accessed 11 Mai 2018).

Janos Dinda, a Hungarian geoscientist, who had emigrated to Venezuela, cautioned Bentz that indeed letters from the capitalist west might cause trouble for colleagues in Hungary:

> Professor, you ask whether a letter would cause Dr Papp trouble: I believe yes. My sister in law has reported that Engineer Angyal, who was my deputy […], has allegedly been imprisoned when my address was found with him. That Angyal was imprisoned, I know from American newspapers, whether the tale about my address is true, is not quite sure; however I believe that in case someone has already difficulties, a connection with the West will make matters worse. (AGV #20528, letter by Alfred Bentz to Janos Dinda, 21 August 1948)

Dinda continued thanking Alfred Bentz for his professional conduct during the war years, deploring that current all-out production endangered the long-term productivity of Hungarian oil fields:

> Your support allowed MAORT[45] to produce the Hungarian oilfields in a technically proper way, and thus over–exploitation which was demanded by the politicians could be avoided. It is sad that it was impossible to develop these fields in the same way under Russian occupation; and that these days they are practically plundered dry. (AGV #20528, letter by Janos Dinda to Alfred Bentz, 21 August 1948)

The rapidly declining productivity of Hungarian oils fields soon became a problem, but it was not attributed to unreasonable political demands and incautious production but instead another scapegoat was found in the Hungarian petroleum geologist Simon Papp[46] and several of his colleagues. Papp had played a significant role in 1945 in restoring Hungarian oil fields for post-war production. With the entry of Hungary 1941 into World War II as a German ally, the American management had to leave the country and Papp remained as their local representative. He continued as company director under German occupation thus collaborating with Alfred Bentz. After the war ended, Papp left for the USA. In November 1945, Soviet authorities took over responsibility for MAORT, and American company managers including Simon Papp returned to Hungary. Papp managed to retrieve essential company property, which had been taken by the Germans, and began production. There was, however, constant friction between the American company representatives and Soviet economic planners (https://hu.wikipedia.org/wiki/Papp_Simon; accessed 9 February 2016).

Apparently, Papp repeatedly warned political decision makers that increasing production without consideration for geological and technical issues would endanger long-term productivity of the wells severely. However, he was ignored and—as predicted—production went down dramatically in 1948. He and other MAORT officials were accused of sabotage. They were arrested on 12 August 1948 (http://www.rev.hu/history_of_56/szerviz/kislex/biograf/papp_uk.htm; accessed 9 February 2016):

> In the meantime, conditions in Hungary have worsened further. The American gentlemen […] were also arrested, but after the usual painful[47] interrogation were deported across the border. Unfortunately, Papp has been arrested too and it can hardly be doubted that he is heading for a terrible fate. There is no bargaining with this [political] system. (AGV #20529, letter by Alfred Bentz to Janos Dinda, 29 November 1948)

The company MAORT had been to 96% in American hands (as a daughter of Standard Oil), contracts with the Hungarian state provided Hungary with 15% of the oil production, but now

[45]Short for *Magyar–Amerikai Olajipari Rt.*, i.e. Hungarian–American Oil–Industry Ltd.

[46]Simon Papp (1886–1970) studied geosciences and mining, obtaining a doctorate degree in 1909. Papp then worked as geological prospector for several petroleum companies active in Hungary, Transylvania, Yugoslavia, Turkey, New Guinea, the United States and Germany. He also lectured at various Hungarian universities and mining schools. In 1938, Papp became head geologist and subsequently managing director of the petroleum company MAORT. In September 1944, he became professor at the Faculty of Oil Prospecting and Production at Sopron University, but continued to work for MAORT. In 1948, Papp was arrested under the suspicion of sabotage. He was released in an amnesty during the Hungarian Uprising 1956 and worked until his retirement in 1962 as geologist for the Hungarian petroleum industry (http://www.rev.hu/history_of_56/szerviz/kislex/biograf/papp_uk.htm; https://hu.wikipedia.org/wiki/Papp_Simon, both accessed 9 February 2016).

[47]"*peinlich*" here possible used in a more figurative sense, signifying the intensity and duration of the interrogation rather than implying actual torture.

under the new regime it was intended to nationalize the company.[48] In this light, the accusations against Papp and the Americans were a convenient pretext.

They were charged with sabotage by drilling at unpromising sites, forgery of documentation and thus deliberately causing harm to the People's Republic of Hungary. The American management was likewise accused and then extradited. Later they declared that they had been forced to give false evidence. The American government filed an official protest.[49] News reached Germany in December 1948:

> Our sombre predictions as to the fate of Mr Papp have unfortunately proved to be only too true, and unfortunately, there is no possibility from the western countries to influence the course of these matters. The news has shaken me terribly, because I have valued Mr Papp always as one of the most honourable people and most able geologists of my acquaintance. It is indescribably horrible that such an outstanding man now is to fall victim to political incitement. (AGV #20530, letter by Alfred Bentz to Janos Dinda, 30 December 1948)

Bentz included in his letter a transcript of an article from the Swiss newspaper *Neue Züricher Zeitung*:

> Hungary. Petroleum Specialists as Scapegoats. // Budapest, 9 Dec. ag (Reuter). // Dr Simon Papp, former chief geologist of the American petroleum company "M.A.O.R.T." has been sentenced to death by the People's Court under the charge of sabotage of the Hungarian petroleum production. A second engineer of the company, Dr Abel, received fifteen years imprisonment, whereas another geologist named Dr Bela Binder was sentenced to four years in prison. The fourth defendant, Dr Barbaras, was acquitted.
> During the trial, Dr Papp is said to have admitted that he had ordered a cutback of the Hungarian petroleum production for "political" reasons and upon the instigation of the Standard Oil Company in New Jersey, the head of the MAORT. It was informed that production in Hungary had sunk from 880.000 tons [per year] under German occupation to 500.000 tons this year. Papp is said to have given an extensive confession of his guilt. (AGV #20530, letter by Alfred Bentz to Janos Dinda, 30 December 1948)

In 1949, the death sentence was converted to lifelong imprisonment. Papp was divested of his civil rights, his family expatriated. During his imprisonment in Vác, he worked on oil and gas prospecting for the Hungarian Ministry of Heavy Industry and later the Ministry of Mining and Energy. Due to the Hungarian Uprising, Papp was released in the 4 June 1956 amnesty. He subsequently worked in the Hungarian petroleum industry until his retirement in 1962. In 1970, he died in Budapest. Posthumously, his eviction from the membership of the Hungarian Academy of Sciences was revoked in 1989.[50]

7.8 Conclusion

Petroleum was and is an important strategic resource. These deeply political issues made it impossible for individual petroleum geologists to strive for an all-embracing international community and to overcome politics for the sake of a fruitful international scientific exchange. Instead, as a consequence of Cold War politics, the international community of petroleum geologists was again severely disrupted and divided into friend and foe, whether they wanted or not.

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[48] http://www.rev.hu/history_of_56/szerviz/kislex/biograf/papp_uk.htm; accessed 9 February 2016.

[49] https://hu.wikipedia.org/wiki/Papp_Simon, accessed 9 February 2016.

[50] http://www.rev.hu/history_of_56/szerviz/kislex/biograf/papp_uk.htm, https://hu.wikipedia.org/wiki/Papp_Simon; both accessed 9 February 2016.

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8 The Incredible Transforming History of a Former Oil Refiner into a Major Deepwater Offshore Operator: Blending Audacity, Technology, Policy, and Luck from the 1970s Oil Crisis up to the 2000s Pre-salt Discoveries

Edmilson Moutinho dos Santos and Drielli Peyerl

Abstract

For many decades, the way to find oil was resulted from a tactile approach and some luck. In the early twentieth century, Brazil started building its National Approach regarding oil and gas. The country nationalized petroleum before even finding it with the creation in 1938 of the National Petroleum Council (Conselho Nacional do Petróleo). After numerous attempts, oil in Brazil was only found in 1939 in the state of Bahia. In 1953, the Brazilian National Oil Company, Petrobras, was created, kicking off a new period in the formation of domestic expertise and technology development, and state-led exploratory efforts. After important (although always insufficient) investments in the search of onshore oil fields, from 1968, Brazil turns to the seas and begins new exploratory cycles focused on the offshore oil research. The international oil prices had begun to escalate, leading to the shocks of the 1970s and the opening of new exploratory frontiers worldwide. The first offshore discovery was registered in a well drilled in shallow waters in the field Guaricema, Sergipe-Alagoas Basin. Nevertheless, Brazil's real offshore adventure started from the mid-1970s with the first drilling in the Southeastern Campos Basin. From shallow to ultra-deepwaters, the Brazilian NOC, born with the initial mission to build a major national refining industry, gradually transformed itself into a vertically integrated company and then into a major offshore operator. The process of industrialization and modernization of Petrobras will be discussed in this chapter book, with focus on history, technology, policy, and luck from the 1970s oil crisis up to the 2000s pre-salt discoveries. Consistent state efforts put Brazil on the Global Oil Map and allowed the country to develop a reputation as an attractive place for foreign investment.

8.1 Introduction

The history of the oil sector in Brazil has been playing a dynamic role in the country's industrialization and modernization processes over the last decades. For a long time, the oil activities

E. M. dos Santos (✉) · D. Peyerl
Institute of Energy and Environment, University of São Paulo, Avenue Professor Luciano Gualberto, 1289, Butantã, São Paulo City, São Paulo State 05508–010, Brazil
e-mail: edsantos@iee.usp.br

D. Peyerl
e-mail: driellipeyerl@gmail.com

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have been maintaining the level of investment in the country. In 1953, through Law No. 2004, Petróleo Brasileiro SA (Petrobras) was created, and main petroleum activities were nationalized and brought into monopolized regime under the National Oil Company's control. The company was created with the purpose of researching, mining, refining, trading, and transporting petroleum.

Since 1954, Petrobras had invested in a geological survey focused on the exploration of onshore oil. Yet, having low expectation to find oil in Brazil, Petrobras' first mission concentrated on the construction of the downstream oil industry. The country's post-Second World War (1939–1945) rapid urbanization, modernization, and industrialization were supposed to be fueled by imported crude oil rather than final products imports.

However, new cards were played from the late 1960s, when oil prices began the historic escalation, which would forever change the global oil landscape. New exploratory frontiers were opened especially in challenging offshore sedimentary basins. Petrobras was allowed and incited by the state to start and expand offshore exploration and production activities. That way, the absolute priority was given to increase crude oil production. In the late 1970s, Petrobras "forged even more boldly ahead with subsea technology in its Campos Basin development, eventually becoming the leading innovator in this area" (Priest 2007: 187).

From the late 1990s, the development model has changed. Primarily, after the opening of former national oil monopoly, through the Law No. 9.478 of 1997, the country aimed attracting more private investments and converting its NOC into a more market-orientated oil enterprise. The complete privatization of Petrobras was discarded, but a new political consensus was developed to place the national company in a more competitive environment, including in domestic activities, as a more effective strategy to improve its expertise, competitiveness, and leading role to face the challenges of the twenty-first century.

After 30 years of solid offshore developments from shallow to deep, and then ultra-deepwaters, innovative technologies, mixed with lucky, boosted the oil production in Brazil in more and more complex offshore oil fields. Then, the new discoveries of oil in 2007, the so-called pre-salt layer (extending from the coast of *Espírito Santo* State to *Santa Catarina* State), brought "new perspectives and challenges" to the country "given the huge potential reserves in the new frontier, Brazil would become a net exporter of oil and oil products" (Magalhães and Domingues 2014: 334).

Brazil has definitely entered the Global Oil Scene and developed a unique oil sector among the developing countries, with a strong level of technological competence and an important role in the development of sophisticated offshore upstream activities. Over the same period, after the boosts of the 1960s, 1970s, and early 1980s, the downstream sector consolidated and lost prominence in the national oil agenda, lagging behind as an engine for innovations and global leadership.

Petrobras unequivocally changed from a refining company into an integrated corporation, and increasingly becomes a major offshore operator. New approaches are demanded for the revitalization and modernization of the Brazilian downstream sector. Actually, with regard to the downstream, Brazil only stands out in the attempts of reducing oil product consumption by developing its biofuel industry, with particular emphasis on the ethanol for light vehicles.

In this way, this chapter of the book describes the historical evolution and the current panorama of the Brazilian oil industry with focus on technology, policy, and luck from the 1970s oil crisis up to the 2000s pre-salt discoveries.

8.2 The Historical Context of Oil in Brazil

In 1938, the National Petroleum Council (Conselho Nacional do Petróleo) was created. The oil was nationalized even before been found—a unique case in Latin American history. Until this date, all oil activities were developed by private investors (foreign and national) and government surveys (such as Geological and Mineralogical Survey of Brazil created in 1907) in various places of the national territory. The first concession for oil exploration covered an area in the state of Bahia and was granted during the Imperial Period (1822–1889) by the decree no. 3352-A, of November 30, 1864 (Peyerl 2017).

In 1897, the official presence of private companies, mainly foreign companies with the performance of *Standard Oil*, was consolidated and contributed to significant changes in the scenario of research and development of exploratory petroleum technique in Brazil. In the same year, the first deep survey also took place in an action that promoted the technical and empirical development of oil search. The late nineteenth century is thus a period marked by the assistance of foreign experts in the field.

In 1913, another foreign company to obtain operating authorization in Brazil was a British–Mexican rival of *Standard Oil*, *The Anglo Mexican Petroleum Products Company*.[1] The company also worked on the construction of tanks on the island of Barnabé (São Paulo State) for kerosene deposit for *The Caloric Company* and *Anglo Mexican Petroleum Company Limited*, including enclosure walls, platform, pump houses, drum washing and filling sheds, pipes, among others (Brasil 1933). However, political and economic changes worldwide, mainly after the First World War (1914–1918), transformed the positive perception of foreign oil and mineral exploration in Latin American countries.

Of these, a nationalist policy is pointed out as a new direction established by the Brazilian President Getúlio Vargas after the Brazilian 1930s Revolution. A new policy aimed to speed up the rhythm of geological exploration in Brazil. In 1934, Vargas decreed the Mining Code (Código de Minas 1934). In 1938, the Law No. 395 was promulgated and created the National Petroleum Council. The new political and legal environment marked the first wave of oil nationalism in Brazil. National Petroleum Council discovered the first oil well in the Lobato region of Bahia State (1939).

In the first decades of the twentieth century, the Brazilian State gradually increased investments in the search for hydrocarbons, strongly focusing the efforts on the search for coal. The priority was to find and search for fossil fuels that have mainly been used in locomotives. However, since the 1920s, the interests on fossil fuels increasingly moved to oil, with growing number of publications focusing on oil research, such as exploratory points, geological mapping, and the origin of oil.

In 1930, Brazil began a new path related to oil exploration in the Brazilian territory, through investments and application of new techniques such as geophysics. The Brazilian government also invested in instruments and equipment that frequently did not fit the geological reality of the Brazilian territory. The country suffered from a technological dependence on other countries, mainly the USA. Because of that, there was a big effort of Brazilian and foreign professionals to create their own geophysical instruments to use in the country (Peyerl 2017).

[1]*The Anglo Mexican Petroleum Products Company* was founded by the British engineer Weetman Dickinson Pearson (1856–1927). Pearson was the responsible for growing a family firm, focused on public works, from a regional to an international player. By 1905, S Pearson and Son employed 60,000 men and was the largest engineering firm in the world. By 1919, the Pearson group was by far the largest British business. As engineering company, Pearson disembarked in Mexico in 1890. Then, from 1901, encouraged by President Porfirio Diaz (1830–1915), Pearson began to acquire oil concessions in Mexico. After initial successes and disappointments, Pearson made a large oil discovery, the Dos Bocas field, in 1908, which was the largest oil deposit yet found in the world. The *Mexican Eagle Co* was formed to exploit this field in 1908 (more about the history of *Mexican Eagle* can be found at: http://letslookagain.com/tag/history-of-mexican-eagle/), and the company became a rival of *Standard Oil* and other US oil companies already operating in Mexico. By 1914 Mexico was the third largest oil producer in the world, just after the USA and Russia, and Pearson controlled around 60% of the country's output. At this same period, the company already had a marketing policy of petroleum products and gaining control of petroleum refinement in Latin American countries. By 1919, Shell took over Pearson's oil interests in Mexico.

The creation of the National Petroleum Council, in 1938, gave the country a bigger control of its oil industry and research, partially neutralizing the pressures from foreign capitals. Here, it is important to highlight that the state, through the National Petroleum Council, would be in charge of refining activities and of prospecting for and exploiting petroleum deposits. In 1939, two probes performed by National Department of Mineral Production in Lobato (Bahia State), numbered 153 and 163, reached "respectively 71.91 m and 228.38 m deep" (de Oliveira 1940: 29), and the last one founded the long-awaited oil.

The discovery in Lobato initially boosted a new level of interest in the domestic oil sector. By the end of the 1930s, oil search became a popular matter in Brazil as the prominent writer, Monteiro Lobato (1882–1948), associated to a *Swiss* petroleum engineer, Karl Werner Franke (1927–?), tried to create the first domestic private oil company, promoting an open conflict against Vargas's monopolistic view of the oil industry (Chiaradia 2008). However, this first impetus soon gave way to an emptying of initiatives and decapitalization of oil activities in most emerging countries as the world plunged into the gloomy years of the Second World War. Brazil would only open the eyes to oil issues again in the early 1950s.

In 1953, Petrobras is created by the Law No. 2004, after a huge ideological and political shock, between the so-called nationalists and serviles/giving-ins. With the creation of the National Oil Company, the Brazilian oil industry was confirmed to be ruled under a Federal monopoly. Petrobras gradually absorbed National Petroleum Council's activities/assets, and the biggest part of the investments of the company was directed to Department of Exploration and Department of Production (Peyerl 2017).

Petrobras vigorously expanded its exploration and production activities, and 15 significant onshore fields were discovered over the first decade of the company. In 1959, an offshore stratigraphic test was carried out in the Campos Basin (located in the territorial waters of Rio de Janeiro and Espírito Santo states). Nonetheless, before becoming a major offshore exploration company, Petrobras had been involved in upstream activities mainly through onshore initiatives, including drilling of the pioneer Socorro well in Bahia State (1958) (see Fig. 8.1).

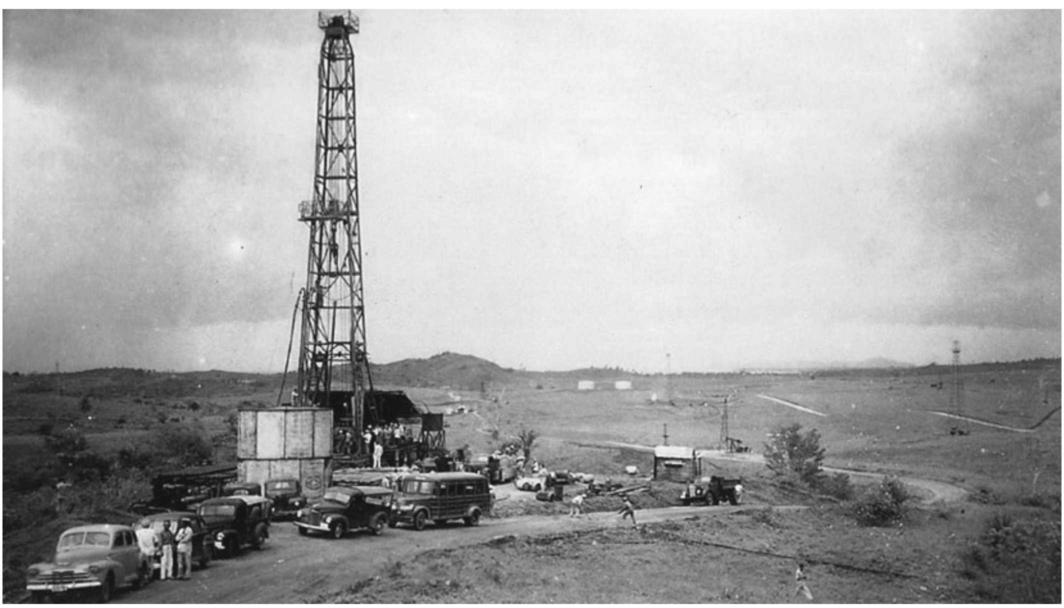

Fig. 8.1 Exploration of oil in Bahia State, Brazil, in the early of 1960s. *Source* Frederico Waldemar Lange's Archive (1911–1988), State University of Ponta Grossa. Box 82. [undated]

In 1960, "the domestic daily crude oil production reached 43,300 bbl/d, but consumption had already passed 200,000 bbl/d" (Rodriguez and Suslick 2009: 08). Over the 1960s, Petrobras continued active in exploration and developed campaigns in most of Brazil's onshore sedimentary basins. However, the Brazilian NOC lacked far behind the fast expansion of domestics needs in a country experiencing rapid urbanization, modernization, and industrialization processes. Oil dependence on imports increased vigorously.

That explains the priority given by Petrobras, and following similar approaches proposed by other NOCs, particularly in Europe, of primarily focusing on downstream developments and activities during the 1950s and up to the early 1980s. Under a typical Brazilian policy of import substitution, the aim was to nationalize crude oil refining and adding value domestically to crude imports. In brief words, Petrobras had some specific and historic moments that made the difference in the development of a domestic downstream company, such as

- 1955—Presidente Bernardes Refinery (RPBC) began its operations in Cubatão (São Paulo state);
- 1956—Construction of the Admiral Alves Câmara maritime terminal (Temadre) in the state of Bahia;
- 1957—Beginning of construction of the Duque de Caxias Refinery (Reduc) in the state of Rio de Janeiro;
- 1958—Doubling of the processing capacity of Landulpho Alves Refinery (RLAM) in the state of Bahia from 5000 to 10,000 b/d;
- 1959—Start of a third 43,000 b/d industrial unit in the RLAM complex;
- 1960—Expansion of RLAM with the installation of the first paraffin oil lubricant unit;
- 1961—Reduc refinery becomes operational;
- 1962—Initial construction begins in the Gabriel Passos Refinery (Regap) in Betim (Minas Gerais state) and the Alberto Pasqualini Refinery (Refap) in Canoas (Rio Grande do Sul state);
- 1967—Founding of Petrobras Química SA (Petroquisa);
- 1968—Regap and Refap refineries become operational;
- 1971—Founding of Petrobras Distribuidora SA;
- 1972—Paulina Refinery (Replan) in the state of São Paulo become operational;
- 1977—Araucária Refinery (Repar) become operational (now the President Getúlio Vargas unit);
- 1980—Henrique Lage Refinery (Revap) in São José dos Campos (São Paulo) becomes operational in March with a processing capacity of 226,000 b/d;
- 1982—Petrochemical Complex III installed in Triunfo in the state of Rio Grande do Sul. (Source: Petrobras. For more information, see: http://www.petrobras.com.br/en/about-us/our-history/).

8.3 The Development of the Offshore Oil Industry in Brazil

As already mentioned, new cards would be put available on the table for Petrobras and the whole Brazilian oil industry after 1968, when the global oil market changed from glut to a much tighter market, allowing the escalation of the international oil prices. In 1973, the first oil crises occurred, "raising oil prices from US$ 2/bbl to US$ 14/bbl, when Brazil's 170,000.00 bbl/d oil production was coming exclusively from three different onshore sedimentary basins: Recôncavo Baiano, Sergipe, Alagoas and Espírito Santo" (Rodriguez and Suslick 2009: 08).

The crises turned energy and petroleum into issues of national security. For example, "the government decided to take four main lines of action: increase control over its energy monopolies, establish risk contracts to increase oil exploration in the Brazilian territory, create an "alcohol as a fuel program", and start overseas oil operations through BRASPETRO" (Rosales 2014: 07).[2]

Yet, the most dramatic change pointed out in this chapter book is the launching of Petrobras into Brazil's offshore adventure. Brazil still imported around 70% of its rapidly growing crude oil consumption in the 1970s, and it was necessary to increase the country's oil production. In 1968, Petrobras' first offshore oil was found in the northeastern Sergipe-Alagoas Basin. From that year and on, Petrobras would start shifting its investment priorities from downstream and onshore to offshore upstream activities. In 1974, the first oil discovery in the Campos Basin occurred:

> […] when the ninth well drilled found Albian carbonate reservoirs (Garoupa Field) under a water depth of 120 m. Oil production started on August 13th, 1977, from the Enchova Field, which produced to a semi submersible platform moored at a water depth of 124 m. This was the beginning of a successful history that led Petrobras to become a world leader company in petroleum exploration and production in deep and ultra-deep waters. (Bruhn et al. 2003: 1)

When the Enchova field (Campos Basin) began its production in 1977, Petrobras used the semisubmersible production systems which "had the advantage of having a rather quit motion but the disadvantage of no storage capacity for produced crude" (Mau; Edmunson, 2015: 263). In the country, "semisubmersible production has been used in waters up to 1830 m deep, and today Brazil's submersible production fleet accounts for almost 50% of such units worldwide" (Mau and Edmunson 2015: 264). In 1979, Petrobras employed a floating production storage and offloading (FPSO) "for the Garoupa offshore oil field in 122 m of water off the coast of Brazil […]" (Mau and Edmunson 2015: 268).

In addition, Brazilian oil production increased consistently: 300,000 b/d at the end of 1982 and 500,000 b/d in 1984, peaking at 572,000 b/d in 1986 (the full history of oil production in Brazil can be found in the statistics published by the National Petroleum Agency, ANP, at: www.anp.gov.br).

The growing production came mostly from offshore fields in the Campos Basin. In 1984, Campos' production already represented 54% of total national production. By the late 1980s, this share was already over 60%, exceeding 70% by the end of the 1990s. In the mid-1980s prospecting and exploration activities increased significantly, and Petrobras made even larger discoveries in the Campos Basin. The most notable were the first two:

- The Albacora field, discovered in 1984 with the well 1–RJS–297, with a water depth of 293 m (961 ft);
- The Marlim field, discovered in 1985 with the well 1–RJS–219A at a water depth of 853 m (2798 ft)—with estimated reserves of 2.9 billion barrels this is certainly the largest Brazilian field and one of the largest in the world. (for more information, see: Awad 1997; Lorenzatto et al. 2004).

These two fields marked a new phase in the history of Brazilian upstream development, a phase which was marked by important technological challenges. Between 1979 and 1988, the company broke its first world record by putting well RJS–284 in the Marimbá field into production at a water depth of 383 meters (1256 ft). In 1986, the first of the Petrobras Technological Development Programme on Deepwater Production Systems began. In 1990, Petrobras discovered another giant field, Barracuda, which allowed the company to register 8.17% increase in proven reserves in 1991.

[2]Some interesting information about the Brazilian government decisions to increase control over the oil industry activities can be mentioned as: "the government strengthened its monopoly over petrochemicals (1967); distribution (1971); overseas exploration (1972); foreign trade (1976); and mining (1977)"; Petrobras was empowered to become an international upstream firm and to seek cheaper oil abroad in areas such as the Middle East and other Latin American countries, and, in 1972, Petrobras International S.A. (Braspetro) was founded; In 1975, the Brazilian government decided to open up its upstream sector to private (national and foreign) participation, through the establishment of the risk contract arrangement. Yet, Petrobras' independent efforts during the 1970s and the 1980s were much more successful, with the company discovering over 100 significant fields (Rosales 2014, p. 7).

Petrobras set successive world records for production and exploration in ever deeper waters, such as in 1992, Marlin field production at a water depth of 781 meters (2561 ft) and; in 1994, again Marlin field production at a water depth of 1027 meters (3368 ft) (Growth 2006). This effort is the basis of most of the technological achievements of the Brazilian oil industry.

In 1997, Marlim South–3B began a production at 1709 m (5607 ft) below sea level, setting another world record, which lasted until new records were set in the Roncador field, expected to produce at a depth of 1853 m (6079 ft) and in the Marlim field, with a well producing at a depth of 2444 m (8018 ft). The giant Roncador field was discovered in 1996 in the northern part of the Campos Basin, at water depths ranging from 1500 m (4922 ft) to more than 2000 m (6562 ft). However, the field has not yet been fully explored and may hold much greater reserves in ultra-deepwaters. South Marlim is a giant field discovered in 1987, whose depth ranges from 720 m (2320 ft) to 2600 m (8530 ft) and whose total reserves are estimated at 2 billion barrels. Initial studies suggest that the entire field, including the areas deeper than 2000 m (6562 ft), may hold more than 10 billion boe (Petrobras 2018).

In December 1997, the long-awaited 1 million b/d mark was finally reached when three platforms came into service in the Marlim, Barracuda, and South Marlim fields (in the Campos Basin), and with higher production from other fields in the states of Amazonas, Rio Grande do Norte, and Sergipe. Brazil then became part of the select group of nations producing more than 1 million b/d, with the Campos Basin representing 70% of the national production.

In 2000, the Campos Basin alone hit the production level of 1 million b/d, accounting for 78% of Brazil's total oil production of 1.3 million b/d. The 10 main fields in the Campos Basin hold more than 80% of the Brazilian total proven oil reserves. Not surprisingly, they were the mainstays of Petrobras' strategy to achieve its target of 1.8 million b/d by 2004. In 2006, Brazil reached self-sufficiency in oil production, and "between January and September of that year, Petrobrás produced 1.763 million barrels per day, 5% more than the year before" (Goldemberg and Lucon 2007: 13).

Despite the terrific offshore history developed by Petrobras in the "post-salt" Campos Basin, the biggest odds of Brazil's offshore industry only came with the striking of oil discoveries in the "pre-salt" layers by 2007. The "pre-salt" denomination is used to designate geologic layers that were formed before salt layer accumulated above it. In the end of 2007, great reserves of oil and natural gas were found in the "pre-salt" layer extending over a total area of about 150 thousand km^2 offshore between the Brazilian states of Espírito Santo and Santa Catarina (as illustrated by Fig. 8.2).

Waisberg (2011), summarizing technical papers presented at Offshore Technological Conferences (OTCs), held in Houston and Rio de Janeiro in 2009–2011, describes the discoveries in Brazil's Southeastern "pre-salt" province as a new (and likely most relevant) milestone in the Brazilian Offshore Adventure, which has the potential to transform Brazil in one of the biggest oil producers in the world. The exact amount of oil in the Brazilian "pre-salt" layer is not yet known, but estimates in already announced discoveries suggest that Brazilian known reserves should significantly expand from the current less than 20 billion of barrels up to eventually around 100 billion barrels. This would raise Brazilian oil stock to be among the greatest in the world.

Yet, untapping those huge reserves will require massive investments and facing a new frontier of offshore extraction technology. Indeed, the exploration of "pre-salt" layers is a very challenging enterprise in many instances. Some of the main difficulties include:

- Ultra-deepwaters (greater than 2000 m), deep carbonate reservoirs (greater than 5000 m), spread over very large areas, with high gas–oil ratio (e.g., GOR greater than 200 in Tupi area), CO_2 content (8–12% in Tupi), high

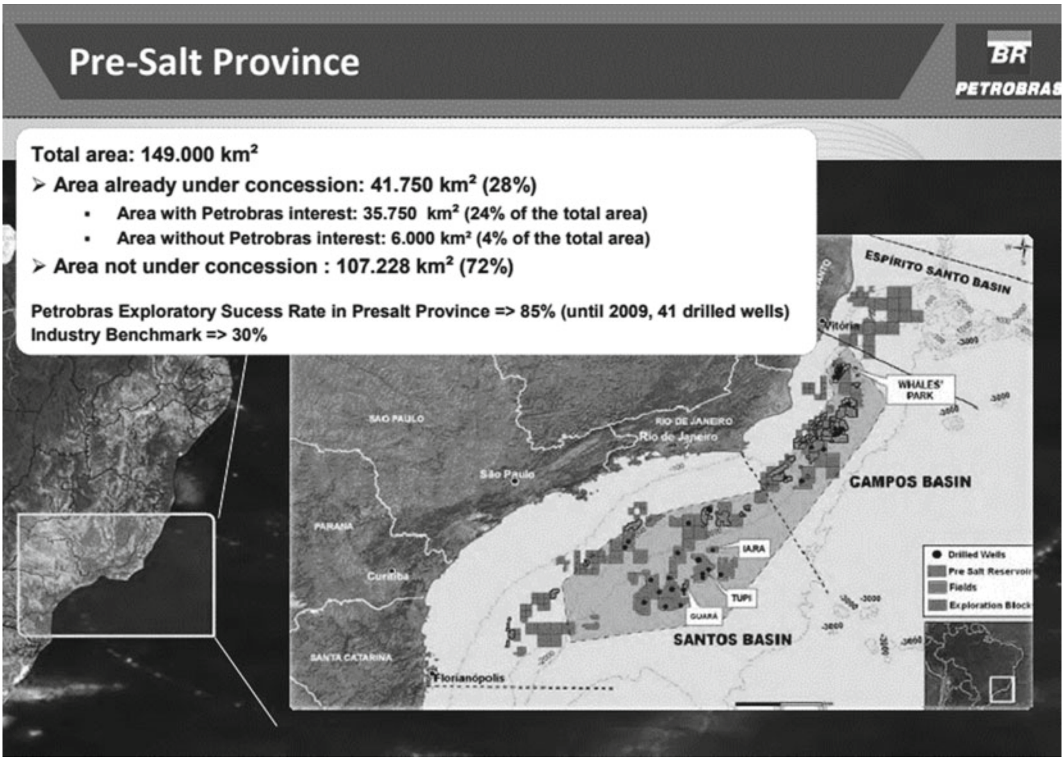

Fig. 8.2 Pre-salt province—challenges and opportunities for the Brazilian industry. *Source* Petrobras (2011) [*Source* http://www.investidorpetrobras.com.br/download/1374]

pressure and low temperature, laying below a thick salt layer (more than 2000 m of salt), location around 300 km from the coast and often severe oceanic conditions.

- Substantial development in offshore extraction capabilities, including well technologies and gas processing and exporting technologies (minimizing CO_2 emissions to the atmosphere).
- Hard interpretation of diagnostic seismic signals due to the thickness of salt layers.
- Lack of knowledge of how materials perform and last under high pressures.
- Other challenge is studying the geometry of rocks to optimize well positioning. Moreover, when it is perforated, the salt can exert tension and block the well; therefore, it is necessary to use a steel coating.
- Besides, when it leaves the rocks, the petroleum is extremely hot and can create precipitation in the flexible extraction lines, which are in contact with the cold sea water. Therefore, research is being done to find chemicals to inhibit precipitations and keep the lines in a low temperature (Waisberg 2011; Beltrão et al. 2009).

As the “pre-salt” layer potential, challenges and size are confirmed, Petrobras has definitively changed its business plan. Even though exploring and producing oil from the “pre-salt” layer is about twice more expensive than extracting oil from the Brazilian conventional “post-salt” layers, the focus of the company moved toward the pre-salt province, because of the higher-quality crude to be extracted as well as the much larger registered productivity.

According to Petrobras, the “pre-salt” province allows the company to produce increasingly “more and faster.” Petrobras’ daily oil output at the "pre-salt" progressed from the average of approximately 41,000 barrels per day, in 2010, to 1 million barrels per day in mid-2016, a nearly 24-fold increase. Moreover, the company had spent 45 years, since its creation, to reach the output of the first million barrels of oil in 1998. Such fast growth in production is primarily due to the high productivity of the wells in operation in the "pre-salt." Just as a historic comparison, in 1984, Petrobras needed 4108 producing wells to reach 500,000 barrels per day. In the pre-salt, in 2016, the same total output was achieved with only 52 wells. The average time to drill, complete, and put on service producing wells in the "pre-salt" region has been dropping dramatically with the progress made in knowledge about geology, with the introduction of state-of-the-art technologies, and improved design efficiency.

In 2015, Petrobras received the OTC Technology Award for the set of innovative technologies it has been developing with partners and suppliers to make the "pre-salt" exploitation technically and economically viable. The Offshore Technology Conference (OTC) has existed since 1969 and is the world's largest event dedicated to offshore oil and gas exploration and production. The OTC Distinguished Achievement Award for Companies, Organizations, and Institutions is the highest technology recognition an oil company can get as an offshore operator. Since the creation of the prize in 1971, only few global petroleum companies have ever received this distinction more than once.

The 2015 OTC Award was the third prize awarded by the OTC to Petrobras. The company had already received the award in 1992 (for its technical achievements related to the development of deepwater production systems in the Marlim field, at about 700 m of water depth in the "post-salt" of the Campos Basin) and in 2001 (for advances made in deepwater project technologies, at a depth of over 1800 m, which allowed a cost-effective development of the Roncador field, also in the "post-salt" of the Campos Basin). Petrobras' 2015 OTC Award prized the set of technologies developed for producing in the "pre-salt" layer.[3] New technologies enabled production in the inhospitable "pre-salt" conditions. They have been tested, proven, and turned into global paradigm, representing an important legacy from Petrobras for the global oil industry. Particularly highlighting was the need to design new concepts of CO_2 separation and injection systems to face the challenge of not releasing the large amount of CO_2 produced in the Brazilian "pre-salt" to the atmosphere.

8.4 Refining and Supply Infrastructure in Brazil Urging New Approaches

In refining and in almost everything regarding the downstream of oil and natural gas, Petrobras continues with its almost absolute monopoly intact, operating with complete control of its captive Brazilian market. As a matter of fact, since the approval of Law No. 9.478/97, which stated for major restructuring in the domestic oil markets, toward more competitive environment for downstream activities as well as more market-oriented pricing systems, the reality hardly changed over the last 20 years (Fig. 8.3).

By 2017, Petrobras still holds more than 98% of all refining capacity in Brazil. Six of the thirteen Brazilian refineries are located in the southeast of the country, close to the most populous and industrialized markets and to the source of the crude oil production in the Campos and Santos basins (Petrobras Annual Report

[3]Specifically, the 10 awarded Pre-Salt technologies included: (1) first buoy supporting risers (BSR); (2) first steel catenary risers (SCR); (3) deepest steel lazy wave riser (SLWR); (4) deepest flexible riser (in a water depth of 7021 ft); (5) first application of flexible risers with an integrated wire traction monitoring system; (6) water depth record (6900 ft) for a subsea well drilled using the pressurized mud cap drilling (PMCD) technique; (7) first intensive use of intelligent completion; (8) first separation of carbon dioxide (CO_2) associated with natural gas in ultra-deepwaters (7283 ft) with CO_2 injection into producing reservoirs; (9) deepest offshore well injecting gas with CO_2 (7283 ft meter water depth); (10) first use of the alternating water and gas injection method in ultra-deepwaters (7218 ft).

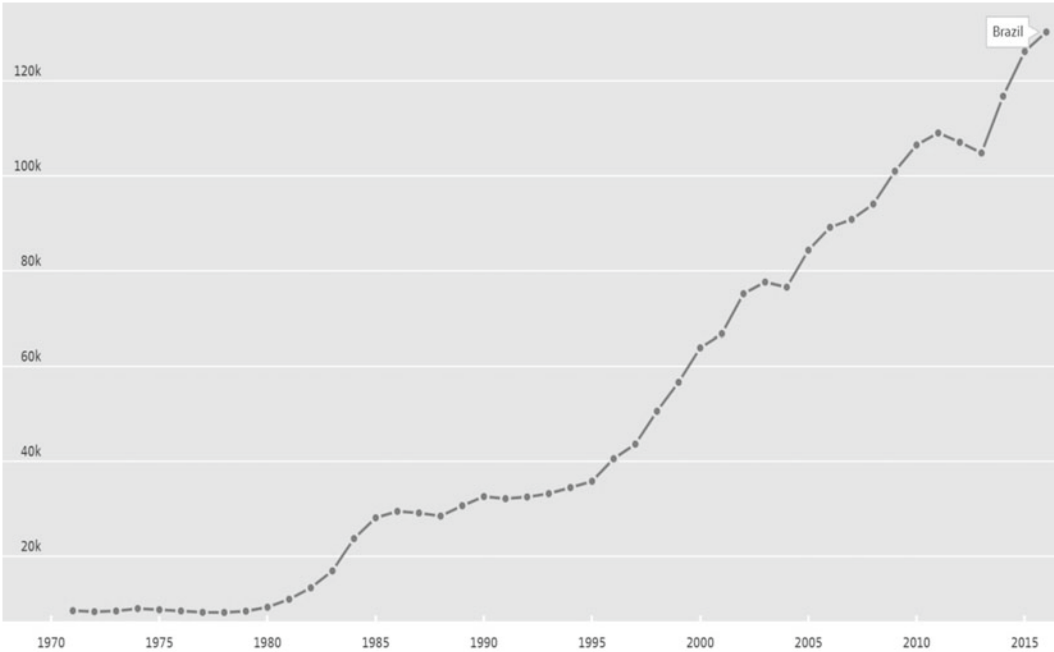

Fig. 8.3 Crude oil production Total (Brazil), Thousand toe, 1970–2016. *Source* IEA World Energy Statistics and Balances: Extended world energy balances. Available in: OECD (2019), Crude oil production (indicator). https://doi.org/10.1787/4747b431-en (Accessed on 25 February 2019).

2017). With the growing production of higher-quality crudes coming from the "pre-salt," there are much less incentives for those refineries to increase efficiency and complexity. Increasingly, the refining system in Brazil is easier way for Petrobras to monetize its oil reserves and maximize the profits coming primarily from the upstream business.

When the pre-salt oil reserves were discovered in 2007, the country hailed it as a miracle. Then, President Lula Ignacio da Silva announced that moment of Brazil's as a "second independence," triggering a new wave of oil nationalism in the country. The questions that remain opened are: whether the government should be the entity responsible for developing these resources, and in which extent the private sector should be allowed to participate in this new offshore adventure, etc. In one first movement promoted by then presidents Lula and Dilma Roussef, Petrobras was given privileges over the pre-salt resources and a clear leading role as the National Oil Company. More recently, the nationalistic approach was partially reverted as Petrobras is already under financial stress to promote its massive investment plans.

As far as the downstream is concerned, including all the major steps of an infant natural gas supply chain, the more market-oriented proposals of Law 9.478/97 have not resisted to the reality of a Petrobras that has regained financial and political power, falling into oblivion any strategic objective of creating more open and competitive domestic markets. As happened during the 1970s and 1980s, the transformation of Petrobras into a "direct agent of state intervention" to promote a faster economic developing agenda became an issue of "national security." As a result, Petrobras was incited (and supported) to take advantage of almost a decade of rising commodity prices (and increasing production capacity) to expand in any horizon of oil and gas supply chain, as well as far beyond its traditional oil and gas businesses.

Brazil's economic and political instabilities since 2016, as well as the collapsing of

Petrobras' economic pillars, as costs overrun, debts skyrocketed, and profits turned into heavy losses, including due to juridical charges in Brazil and abroad to compensate stakeholders from damages linked to revealed corruption scandals, have triggered another turning point. For the first time since the creation of the company, Petrobras and the Federal government agenda converged toward the need to promote greater competition in the domestic markets, more alignment to international prices, as well as major privatizations of downstream assets. Petrobras' Business Plan should focus primarily on the "pre-salt" development.

Particularly interesting are the issues regarding the definition of new price policies for fuels produced in the Brazilian refineries and that mostly serve the domestic markets. Since 1994, the Federal government has been changing the criteria for determining the fuel prices. The goal is gradually liberalized all fuel prices and to let them fluctuate according to international prices. Given the financial constraints imposed by a macroeconomic policy based on reasonably low inflation rates, the government, over different presidents, has been reducing the level of subsidies on motor fuels as well as on liquefied petroleum gas and naphtha.

In July 1998, a new pricing structure for oil products was announced, where domestic oil prices would follow the international parity. Domestic prices would be defined as the average of international prices, plus import costs (tax, freight, and port costs) and plus the exchange rate.

In 1999, the National Agency of Petroleum, Natural Gas and Biofuels (ANP) began to liberalize the refined products markets, including prices, imports, and even promoting marginal competition in the refining business. Initially, the Agency focused on more concentrated markets such as the aviation fuel, whose market was operated by only three companies, and petrochemical naphtha. In 2001, the market share of Petrobras in refining dropped from 98 to 91% after the three Brazilian petrochemical plants, COPENE, COPESUL, and PQU (União Petrochemical), were authorized to commercialize petrol, diesel, and liquefied petroleum gas. Previously, they had been required to return their production to Petrobras. The three petrochemical units held 7% of the market, while the two private small refineries accounted for 2%.

However, most of those trends were partially or totally reverted during the booming "nationalistic strengthening" of Petrobras under President Lula administration, and also during the second government of President Dilma Roussef, who set back price controls over motor fuels, as instrument for inflation control. For more than two years, the new policy overcame almost 20 years of energy deregulation and price liberalization. The new policy was implemented at a very unfavorable time for Petrobras, which was already experiencing increasing imbalances in its upstream activities. Trying to maintain the economic resilience of the "pre-salt," Petrobras looked for ways to reduce costs and debts to survive even in scenarios of crude prices halved. Even so, the Federal government, in the sense of preserving a populist approach, did not hesitate to generate severe losses to its NOC in the domestic downstream activities.

Since 2016, President Michel Temer has attempted to reestablish an "orthodox" economic agenda. Adjusting the public finances and revitalizing the modernization and liberalization processes of the oil markets in Brazil came to the scene again. Once more, Petrobras was given the prerogative to operate under more market-oriented conditions, including accelerating the process of international alignment of fuel prices marketed in Brazil. However, the political and economic instabilities of the country have not been instrumental.

In 2017 and 2018, greater devaluation of the national currency against the US dollar, and the (somewhat unexpected) recovery of international crude prices, reflected very negatively in a still reeling and decapitalized national economy, just coming out from more than two years of deep recession. This scenario led to the enormous strike of the country's dominant heavy transportation system, with truck drivers blocking the main roads, and generating a nationwide large shortage of other fuels and even consumer goods in supermarkets. The government was forced to negotiate facilitation for heavy diesel consumers, partially reducing taxes levied on diesel oil, but also, and again, imposing losses to Petrobras that might not be recovered in the future.

With so many issues pending without a clear solution, it is fair to say that private companies eventually interested in entering Brazil's downstream market are not only dependent upon Petrobras' future decisions of making assets available and go forward with the privatization process but must also watch the actions of the Federal government in order to assess its real political commitment vis-a-vis the deregulation and liberalization processes. Changes in the downstream activities are not expected to be as easily accepted as those in the upstream sector. Unless the government implements more dramatic measures, it is unlikely that Petrobras will unilaterally give up important shares in its captive domestic markets. Any major change will require sounding regulations to be established by the National Agency of Petroleum, Natural Gas and Biofuels (ANP).

8.5 Conclusion

One of the main problems faced by the National Petroleum Council was the lack of skilled labor in the national territory for the activities of the oil refining industry. One of the first alternatives of National Petroleum Council was the formalization of agreements with foreign companies hired by the agency to settle in the country and train Brazilians to perform the activities needed. The refining industry was growing and the search for new oil wells continued, requiring several professionals (Peyerl 2017).

In 1968, Petrobras directed part of its research to the sea, starting a new cycle of technical knowledge of exploration with the discovery of the first well in the field Guaricema, Sergipe-Alagoas Basin, and the first drilling in Campos Basin, (Rio de Janeiro and Espírito Santo states). Once again, Brazil passes through the same shock from past decades: hiring international companies and/or importing work force.

Brazil created in 1986 the Program of Technological Training in deep sea, "an innovation system that allowed oil exploration called "offshore". The innumerous discoveries through the years by Petrobras gave the institution the title of international leader in deep-sea exploration technology" (Neto and Costa 2007: 100). In August 1997, Petrobras' monopoly was broken and the company "opened its doors" to foreign capital. A new exploratory and development phase began.

Despite the country's current economic difficulties, the prospects for business opportunities in the oil sector are still promising. Brazil has certainly developed a unique oil sector among the developing countries, with a strong level of technological competence and a significant role in the development of sophisticated offshore upstream activities. The Brazilian market for oil products is also attractive, offering worthwhile opportunities in the country's large downstream sector.

In a few words, the evolution of oil production and development of oil industry in Brazil could be thought as five different steps: onshore (1939–1968); shallow water phase (1965–1984); deepwater (1984–1997); concession (1997–2010); pre-Salt (from 2010 on) (Peyerl 2017; Bruhn et al. 2017).

Currently, Petrobras is recognized internationally for all the work it has developed, especially in the last decades, with the development of technologies for exploration in the pre-salt area, thus boosting innovation in the sector. Petrobras has also invested in technologies that separate carbon dioxide (CO_2) from oil and natural gas, by injecting the gas back into the reservoirs. In this way, the company has contributed with the environment in the reduction of CO_2 and increasing the productivity of the pre-salt wells.

As a mentioned, Brazil has definitely entered the Global Oil Scene. The model of sharing and the entry of international oil companies have led to new issues surrounding the privatization or not of Petrobras. After the first pre-salt auction in 2013, Brazilian government affirm that the gross domestic product of Brazil is growing and that Petrobras gained more autonomy for its strategic management (oil and natural gas sector), strength in growth and employment (technological research, construction and operation of platforms and refineries, supply of materials), and stronger Petrobras in a more competitive auction. Actually, with regard to the downstream, Brazil only stands out in the attempts of reducing oil products consumption by developing its biofuel industry, with particular emphasis on the ethanol for light vehicles.

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Research Partnership Between Petrobras and Brazilian Universities in the Transition to the Twenty-First Century

9

Giovanna G. Gielfi

Abstract

This chapter gives an historical overview of the university–industry linkages in the Brazilian oil industry as an outcome of changes in the local science and technology (S&T) policy. Starting from the 1950s and up to 2014, we briefly outline the major changes that took place in the S&T policy and how they have affected the relationship between the Brazilian state-controlled oil company, Petrobras, and universities. We characterize these changes in two phases according to the main type of links involved in the Petrobras–university relationship. In phase 1, the most important link was human resources training. In phase 2, there was a reorientation of these links towards research collaboration, although the training of human resources remained important.

G. G. Gielfi (✉)
Department of Science and Technology Policy, Institute of Geosciences, University of Campinas, Campinas, São Paulo 13083–865, Brazil
e-mail: giggielfi@gmail.com

9.1 Introduction

The formation of the academic community, as well as the development of a scientific and technological infrastructure, is relatively recent events in Brazil, especially when compared with developed countries. Formally, this process started in the 1950s with the creation of the most important science and technology (S&T) public funding agency at the federal level, which began providing financial support to build up required infrastructure and its related research activities. This process marked the so-called institutionalization of the S&T policy in the country. Coincidentally, at the same time the Brazilian state-controlled oil company, Petrobras, was created, in 1953, to monopolistically exploit oil reserves, refining, and transport.

Throughout the 1960s and up to the end of the 1980s, the Brazilian S&T policy was mainly focused on the training of human resources, as well as the creation and consolidation of S&T infrastructure. In this period, state-owned enterprises (SOE), such as Petrobras, were in the centre of the technological policy, as these companies were the pillar of the technological development in the country—especially in terms of university–industry interactions.

The 1990s were marked by institutional reforms in the Brazilian economic, scientific, and technological framework. Under the context of neoliberal policies, an institutional reform in the Brazilian oil and gas industry occurred, bringing

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to an end the monopoly of Petrobras' activities. Likewise, a reform of S&T policy took place in Brazil.

In the mid-2000s, the Brazilian state promoted changes in the S&T framework in order to stimulate and enhance the national innovation system. These changes were particularly important to the development of the oil and gas innovation system in Brazil—especially regarding university–industry linkages—with the creation of R&D funding instruments for this sector. These R&D funding instruments had a central role in changing the orientation of Petrobras–university relationship from mostly human resources training towards research collaboration, as shown by this study. Also, pre-salt offshore discoveries and a favourable international conjuncture, as oil prices rose, overall during the period, kept an optimistic view about the potential contribution of oil industry to economic development.

The relationship between industrial firms and universities is shaped by a range of factors, such as structural issues (firm size, industrial context, R&D intensity), geographical proximity and firms' capabilities (e.g. absorptive capacity), and public policies. This study aims to explore the changes in Brazilian S&T policy and how it affects university–industry linkages, between Petrobras and universities, mainly the local universities. In order to do so, the paper is organized in a chronological perspective. Following this introduction, section two presents the period when S&T policy was mainly oriented to human resources training. Section three addresses the changes in S&T policy and their effects in reorienting university–industry links to research collaboration. Section four concludes the paper by discussing research and policy implications.

9.2 Focus on Human Resources Training: From 1950s to the Late 1980s

The Brazilian SOE, Petrobras, was created in 1953 to monopolistically drive oil and gas exploration, production, refining, and transport in the country. However, in the beginning of its operations, the company faced some technical and economic problems. Besides that, the lack of qualified human resources to work in oil industry activities was a major challenge that Petrobras had to overcome. Perhaps one of the most emblematic examples of this is the fact that, at the time of the firm's creation, there was not any course of geology at the university level in Brazil.

The lack of human resources was due to the early stages of the scientific and technological infrastructure in the country. Up to the beginning of the 1950s, Brazil had only a few important research institutions, mainly oriented to health and natural sciences. The process of institutionalization of S&T in the country started in this period, with the creation of the two most important S&T funding agencies at the federal level,[1] which would provide financial support to build up infrastructure and foster research activities, thus helping to fulfil the S&T policy agenda. The training of human resources was set as one of the main goals of this agenda. To accomplish it, the Brazilian government designed and launched some actions and large programmes, which started in the end of 1950s and continued through the following decades (1970/80s).

In this context, the Brazilian government launched a large programme, the National Programme for Graduate Studies (*PNPG—Programa Nacional de Pós–Graduação*, in Portuguese), which was officially organized in the end of 1960s and later edited in several versions. This programme was designed to accelerate the formation of human resources at the graduate level and thus to consolidate and to expand graduate studies programmes. To give an idea of the programme, its goal was to quadruple the number of graduates at master's level and triplicate the number of Ph.D. candidates from 1975 to 1979 (Morel 1979, p. 69). The PNPG

[1]The Coordination for the Improvement of Higher Education Personnel (CAPES) and the Brazilian National Council for Scientific and Technological Development (CNPq).

was successful in terms of its results: it helped to expand and consolidate graduate courses in Brazil by increasing the number of courses and sponsoring fellowships, to institutionalize and consolidate research groups, and to increase the country's scientific output seen by number of publications (Guimarães and Humann 1995).

However, with the creation of Petrobras, the training of geologists became a matter of state. Therefore, in January of 1957, the Brazilian government established the Campaign for Geology Studies (*CAGE—Campanha de Formação de Geólogos*) to promote the creation of undergraduate courses in Geology. The Campaign originated the first four geology courses in Brazilian universities, helping to fill the gap of trained personnel (Azevedo and Terra 2008).

Regarding the lack of qualified human resources to work in the oil industry, initially, Petrobras hired foreign workers, specially geologists and geophysicists, to deal with the lack of human resources (Morais 2013; Peyerl 2014). The company also sent its employees for training at American universities (Gall 2011). These actions were not sufficient, nevertheless, due to the growing demand for human resources by the sector and the company itself.

In order to face this challenge, Petrobras set forth its own strategic actions. In 1955, Petrobras created Centre for Improvement and Oil Research (*CENAP—Centro de Aperfeiçoamento e Pesquisa de Petróleo*) to promote formation and training of human resources at technical (post-secondary non-tertiary education), secondary, and tertiary (bachelor or equivalent) levels. The company signed several agreements with Brazilian universities in order to address the weaknesses of higher education in the country (see Table 9.1). At first, the company established agreements to create undergraduate courses, and then graduate studies courses. As a result, the number of technicians, with secondary education, employed by the company increased from 614 in 1958 to 2358 in 1967, which represents a growing rate of 384% in 10 years (Morais 2013, pp. 74–75).

The strategy of human resources training of Petrobras was designed to achieve two aims: first, to provide its technical staff the ability to purchase foreign technologies; secondly, to enable them to improve the operational capacity of the equipment and technologies used (Furtado 1995). Furthermore, this strategy was an embryo to foster the creation of Petrobras' Research and Development (R&D) Centre.

In addition to these agreements, Petrobras started providing financial and technical support to local universities, through granting fellowships/scholarships and sending its employees to tutor and/or to be trained there. Although the main purpose of these initiatives (training agreements included) was to provide trained human resources to the oil industry and Petrobras itself, they eventually nurtured the company's linkages with universities, which started to evolve towards research activities.

In 1966, Petrobras created its R&D Centre, the so-called CENPES, replacing CENAP activities. The creation of CENPES was a cornerstone for the technological and innovative capacity-building process of Petrobras. The strategic guidelines of the conception of CENPES established that: the Centre should be built nearby a Brazilian university, to facilitate knowledge and personnel exchange; and regarding its relationship with universities, the company should "stimulate oriented basic research programs to provide subsidies to the activities of technological research developed by CENPES" (Fonseca and Leitão 1988, p. 168).[2] As regards actions/strategies, training activities, and the qualification of human resources, the role of CENPES was restricted to cooperation with Brazilian universities for the execution of undergraduate and postgraduate courses, limited to the administration of teaching activities and/or internships in their facilities. Thus, CENPES continued some activities previously conducted by CENAP, "now with the training of professionals destined to research through the proposal of an annual program of improvement and professionalization in the country and abroad" (Peyerl 2014, p. 149) (see Footnote 2).

[2]Free translation.

Table 9.1 A summary of Petrobras–university agreements for the training of human resources

Courses	Year	University partner
Introduction to Geology and Petroleum Geology[e]	1957	Federal University of Bahia
Petroleum Drilling and Production Engineering[e] (posteriorly, Petroleum Engineering[d])	1957	Federal University of Bahia
Petroleum Equipment Maintenance[e]	1958	Aeronautics Institute of Technology
Reservoir Engineering[d]	1959	Taught by a foreign company
Basic Geophysics[e]	1950/60s	Federal University of Bahia
Petroleum Engineering[e]	1963	Federal University of Bahia
Petrochemical Processes and Maintenance Engineering[d]	1975	Federal University of Bahia Federal University of Rio Grande do Sul
Process Engineering[c]	1975	Federal University of Rio de Janeiro
Electrical Engineering[c]	1977	Federal University of Rio de Janeiro
Matrix Analysis of Offshore Structures[c]	1978; 1980–81	Federal University of Rio de Janeiro
Geophysics (master's degree)[c]	1980s	Federal University of Bahia
Geophysics (master's degree)[a]	1980s	Federal University of Pará
Petrology and Structural Geology (master's degree)[a]	1980s	Federal University of Ouro Preto
Stratigraphy (master's degree)[a,c]	1980s	Federal University of Rio Grande do Sul
Reservoir Geology (master's degree)[c]	1983	Federal University of Ouro Preto
Petroleum Engineering (master's degree)[b,c]	1987	University of Campinas
Automation, emphasis on oil refining processes (master's degree)[c]	1988	University of São Paulo

Source Author's own based on: [a]Furtado (1995); [b]Gielfi (2013); [c]Morais (2013); [d]Peyerl (2014); [e]Peyerl and Figueirôa (2012)

The first research agreement between Petrobras and a Brazilian university, the Federal University of Rio de Janeiro, was signed in 1967, as a follow-up of its training links. This research agreement resulted from two master theses from engineers of Petrobras, who developed their research at the Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering (COPPE), a research and learning centre of the Federal University of Rio de Janeiro. Prompted by their master theses, Petrobras and the university signed a research agreement in which the company's engineers flow into the university to create the first research laboratory of the Chemical Engineering Programme (Fonseca and Leitão 1988). It is worth stressing that the main outcome of this agreement is the long-term Petrobras–university relationship to carry out research activities related to oil industry.

During the mid-1970s, Petrobras started its activities of oil and natural gas exploration and production in offshore fields, which required massive investments of resources and a considerable technological development effort to make reaching the exploratory frontier technically and economically feasible. The exploration of the new exploratory frontier and the challenges imposed by it—such as new geological conditions, the depth of reserves, and the absence of internationally available technologies that allowed the exploration of oil at depths greater than 400 m—required Petrobras to deepen its activities in R&D and engineering, as well as the formation of a new generation of professionals with specialization in several areas.

In response to the need to train human resources in different areas of specialization, new agreements were signed with Brazilian universities, as well as training of professionals in other countries (as shown in Table 9.1). These early professionals from abroad, in the early 1980s, became key players in the establishment of some postgraduate courses at master's and doctoral levels at Brazilian universities. Hence, Petrobras–university linkages grew and became more diversified. It is worth highlighting that the expenditures of CENPES in Brazilian universities were around 5% of its total budget in 1986 (Fonseca and Leitão 1988, p. 170).

To sum up, after the replacement of CENAP by CENPES, Petrobras put more emphasis on research activities. In doing so, the company reoriented its human resources actions towards agreements with universities for the creation of postgraduate courses in several areas related to the petroleum sector—some of which were absorbed and incorporated permanently into the courses catalogue of these institutions. Additionally, Petrobras began to conduct collaborative research with universities—first to solve technical services, and then to advance to technological research itself. Such actions for the construction of its own knowledge body served as the basis for the formation of a broad technical–scientific network in oil and gas in the country.

9.3 Reorientation to Research Collaboration: Late 1990s to 2014

A major change in the Brazilian oil industry occurred in 1997, when the Petroleum Law (Law n. 9.478/97) was passed. This Law brought the monopoly of Petrobras to an end and, in return, created the Oil and Gas Sectoral Fund (BRASIL 1997). The creation of this Fund resulted from the S&T policy reform occurred in Brazil in the 1990s, in which new R&D funding instruments and mechanisms were set up to stimulate R&D and innovation in the business sector, in addition to fostering university–industry collaboration (Corder 2006). At the time, the main goal of the science and technology sectoral fund policy in Brazil was to provide more stable financial resources for science and technology activities in the country (Pereira 2005; Vieira 2001).

The Oil and Gas Sectoral Fund resources were assigned by the Petroleum Law, which established that 25% of royalty revenues that exceeded 5% of production should be destined to fund science and technology. These resources were directed to promote university–industry collaboration. However, the Fund had its performance hampered due to contingency of resources, as a share of its assets was redirected to increase primary surplus (Furtado 2003). Furthermore, in 2012, the Royalties Law (Law n. 12.734/12) undermined the Oil and Gas Sectoral Fund, reallocating its resources to the Social Fund (BRASIL 2012).

In addition, an "R&D Clause"[3] was included in new concession contracts for oil and gas exploration and production in Brazil. This clause was set by the National Petroleum Agency (ANP —*Agência Nacional do Petróleo*), which has been responsible for regulating the oil sector since its liberalization in 1997. The ANP R&D Clause established that any such firm must invest a minimum of 1% of their gross revenue generated by oil fields with high profitability or high productivity (ANP 2005a, b). At least half of this amount should be invested in Brazilian-based universities and research organizations accredited by ANP.

There was a significant difference in the amount of resources between these two R&D funding instruments, exhibited in Fig. 9.1. From 2001 to 2015, a total of BRL 5.366 billion were invested in R&D-related activities in the Brazilian oil sector. Of this amount, 16% came from the Oil and Gas Fund and 84% from the ANP R&D Clause. The share destined to training human resources actions was 24% of the fund resources and 38% of the ANP Clause. It is worth stressing that after the end of the monopoly of Petrobras, these investments on human resources training were carried out mostly via

[3]The ANP R&D Clause started in 1998, in the so-called Bidding Round Zero, but its investments only came into effect in 2005, when its regulation/statute was approved by ANP.

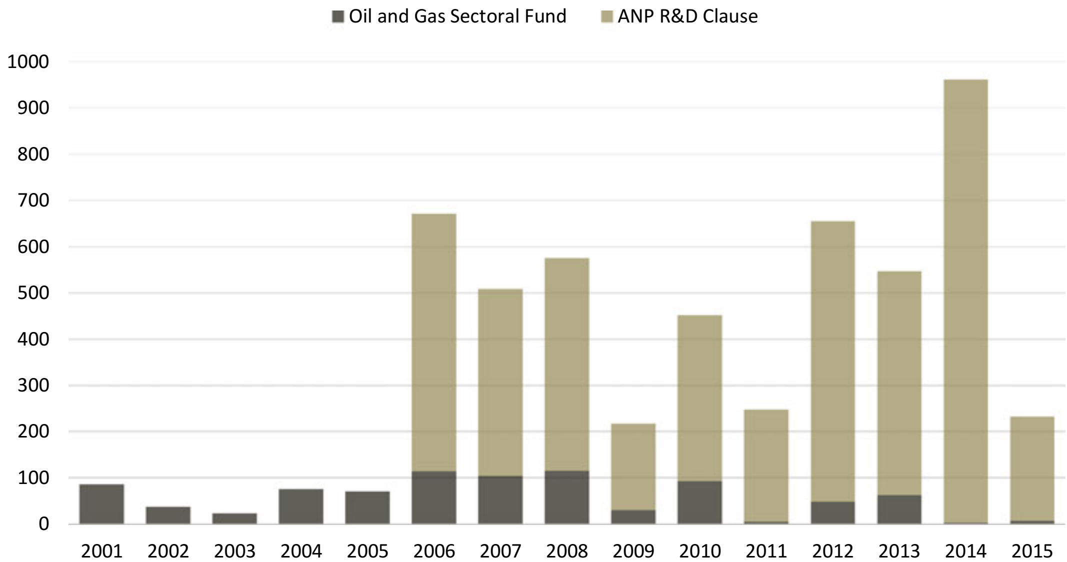

Fig. 9.1 Trend in R&D funding policy related to the Brazilian oil industry. *Source* Author's own based on ANP and MCTI data

scholarships and there were no courses/teaching agreements with Brazilian universities. The fact is that the Brazilian university system overcame its disabilities regarding the provision of qualified human resources and achieved a much more consolidated position in teaching and research, supplanting the complementary role played by Petrobras in the human resources policy of the country.

In the other hand, the Oil and Gas Sectoral Fund spent 23% of its resources on infrastructure to support R&D related to the oil sector, and the ANP Clause spent 48% of its resources on it. These investments had an undeniable impact on the scientific and technological capabilities of the Brazilian universities, supporting the creation and the refurbishment of laboratories and other research facilities, and broadening the research agenda of universities by means of the inclusion of at least 40 new research areas (Turchi et al. 2013).

All the investment made through these two R&D funding instruments led to an increasing collaboration in scientific research between Petrobras and Brazilian universities, as shown by Figs. 9.2 and 9.3. These figures exhibit the research collaboration of Petrobras with universities based on publications co-authored by the firm and at least one university; the publications are used as a *proxy* of scientific collaboration.[4] To capture policy changes and the effects on Petrobras–university collaboration, the data is analysed into two policy phases following the changes in the oil and gas regulatory framework regarding R&D funding. Thus, Fig. 9.2 shows Petrobras' collaborative network when the Oil and Gas Sectoral Fund was established and Fig. 9.3 shows the network of collaboration at the time of the ANP R&D Clause implementation.

These figures reveal a growing scientific collaboration between Petrobras and Brazilian universities, especially during the years ranging from 2006 to 2014. This significant increase in the number of partners reflects the effects of changes in oil and gas R&D funding due to considerable differences in the amount of resources between the Oil and Gas Sectoral Fund and the ANP R&D Clause, as exhibited in Fig. 9.1. In addition, as mentioned before, most of the resources from the Oil and Gas Sectoral

[4]More information about data and methodology is available on Gielfi et al. (2017).

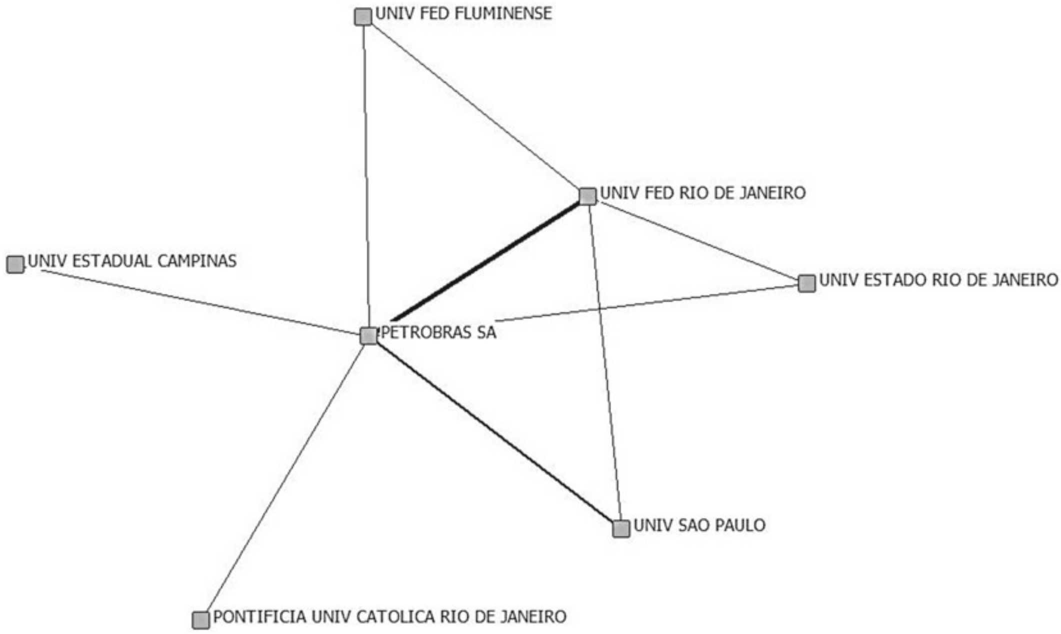

Fig. 9.2 Petrobras–university scientific collaboration network: 1999–2005. *Source* Gielfi et al. (2017)

Fund were not invested in R&D, but in the training of human resources.

Also, the configuration of collaborative networks was a deliberate effort of Petrobras. In 2006, the company launched a model of scientific and technological networks, which was called "Thematic Networks". These partnerships were oriented to the creation of cutting-edge laboratories and research and development activities (Poletto et al 2011).

9.4 Concluding Remarks

This paper analysed the relationship of Petrobras and Brazilian universities from the 1950s to 2014. Based on the main type of links involved in this relationship, two distinct phases were characterized. The first phase encompasses the period in which Petrobras monopolized oil and gas exploration and production activities in Brazil. In this period, the Brazilian S&T policy was mainly focused on the training of human resources, as well as the creation and consolidation of S&T infrastructure. This phase is also characterized by the absence of a specific science and technology sectoral policy to the oil and gas industry and by the very active role played by Petrobras on training human resources, complementing the governmental actions. The 1999–2014 phase is marked by the liberalization of the sector and changes in the regulatory framework regarding funding of R&D activities carried out by Brazilian universities and research institutes.

The results show that the changes in Brazilian S&T policy related to the oil industry echoed in the main type of links involved in Petrobras–university relationship. In the first phase, the main linkage between the company and Brazilian universities is the training of human resources. This result reflects the early stage of development of the local university system. In order to overcome the lack of qualified human resources required to the development of the oil sector, Petrobras assumed an active role in it. The strategic actions adopted by the company were fundamental to create its own technical staff and generate a spillover effect in the Brazilian university system.

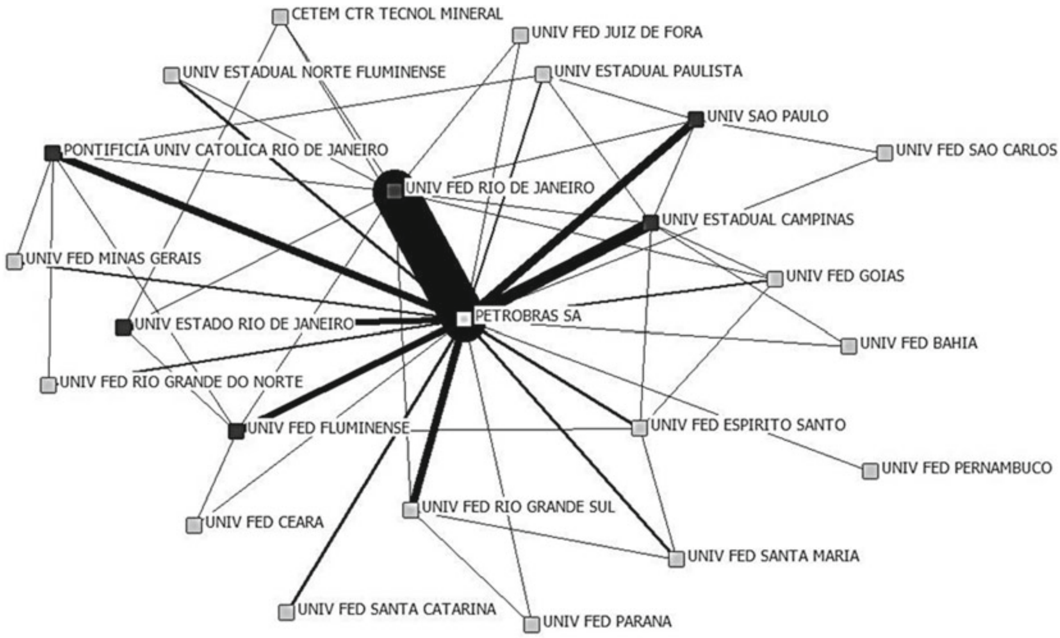

Fig. 9.3 Petrobras–university scientific collaboration network: 2006–2014. *Source* Gielfi et al. (2017)

It is undeniable that the previous actions of Petrobras and the Brazilian government to build, strengthen, and consolidate the S&T infrastructure (university system included) in the first phase served as a basis to the expansion of R&D activities related to oil and gas in the country in the years ranging from 1999 to 2014. The creation of R&D funding instruments related to oil and gas activities to promote university–industry collaboration gave the final thrust to evolve Petrobras–university relations from mostly human resources training to mainly research collaboration.

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