31 Dobratsch: Landslides and Karst in Austria's Southernmost Nature Park

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Abstract

Dobratsch is a karst massif surrounded by tectonic faults near the southern border of Austria. It has been declared a nature park due to its outstanding natural features among which the "landslide landscape" is of special importance. It came into existence by a sequence of landslides which on the one hand shaped the south face of the mountain (summit elevation 2166 m asl) by detachment scarps and on the other hand transformed the valley beneath it into a hummocky deposition area extending over some 20 km^2. One of the landslides occurred in AD 1348 and was the reason for the widespread recognition of the mountain and its natural hazards in legends and historical records until today. The Dobratsch is mainly built of Mesozoic limestones which are intensively karstified. Dolines and especially vertical caves are the most prominent karst features. From the hydrological point of view, the karst aquifer is used for supplying drinking water to nearby city of Villach.

Keywords

Natural hazards • Landslide • Karst • Nature Park

31.1 Introduction

Dobratsch is the name of an isolated mountain massif at the western fringe of the Klagenfurt Basin in the Austrian federal state of Carinthia. The elevation of its summit is 2166 m asl, resulting in a remarkable vertical difference of 1665 m from the city of Villach situated at its eastern foot. The massif has a rather rectangular shape with a length of 17 km in WNW-ESE-direction and a width of 4–5 km. It is predominantly built of Mesozoic limestones which are intensively karstified, giving the mountain an outstanding density of surface as well as underground karst features. However, Dobratsch is above all famous for its southern face landslides, including a huge medieval one.

Because the mountain is so close to densely populated areas, there has been intense interaction between geomorphology and different socioeconomic activities throughout recorded history. For instance, the damages caused by the medieval landslide gave rise to several myths and legends which are regionally well-known until today. Besides landslides and rockfalls, also avalanches have to be considered in dealing with natural hazards. On the other hand, karst vulnerability represents a challenge to regional planning. Above all, Dobratsch is an attractive tourist destination due to the natural variety and the great views it offers over most of southern Austria and beyond.

31.2 Tectonic and Geological Setting

The Dobratsch massif belongs to the Gailtal Alps, a mountain range of the Southern Calcareous Alps which is separated from the Carnic Alps by the broad valley of the Gail River (Fig. 31.1). Its course is predetermined by one of the most important fault lines of the Austrian Alps, the Periadriatic lineament (PAL). As is the case with most large faults, there are also neighbouring fault lines running parallel or subparallel to the main one. An example of such a fault is the Bleiberg fault which is morphologically represented by the deeply incised valley of Bad Bleiberg. This valley runs roughly in a W–E-direction and borders the Dobratsch massif to the north. From a hydrological point of view, the valley is drained by two creeks, the Weißenbach flowing to the east and the Noetschbach to the west. In between, there is a low mountain pass which is barely noticeable when one drives through the valley. Its elevation of slightly above

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C. Embleton-Hamann (ed.), *Landscapes and Landforms of Austria*, World Geomorphological Landscapes,
https://doi.org/10.1007/978-3-030-92815-5_31

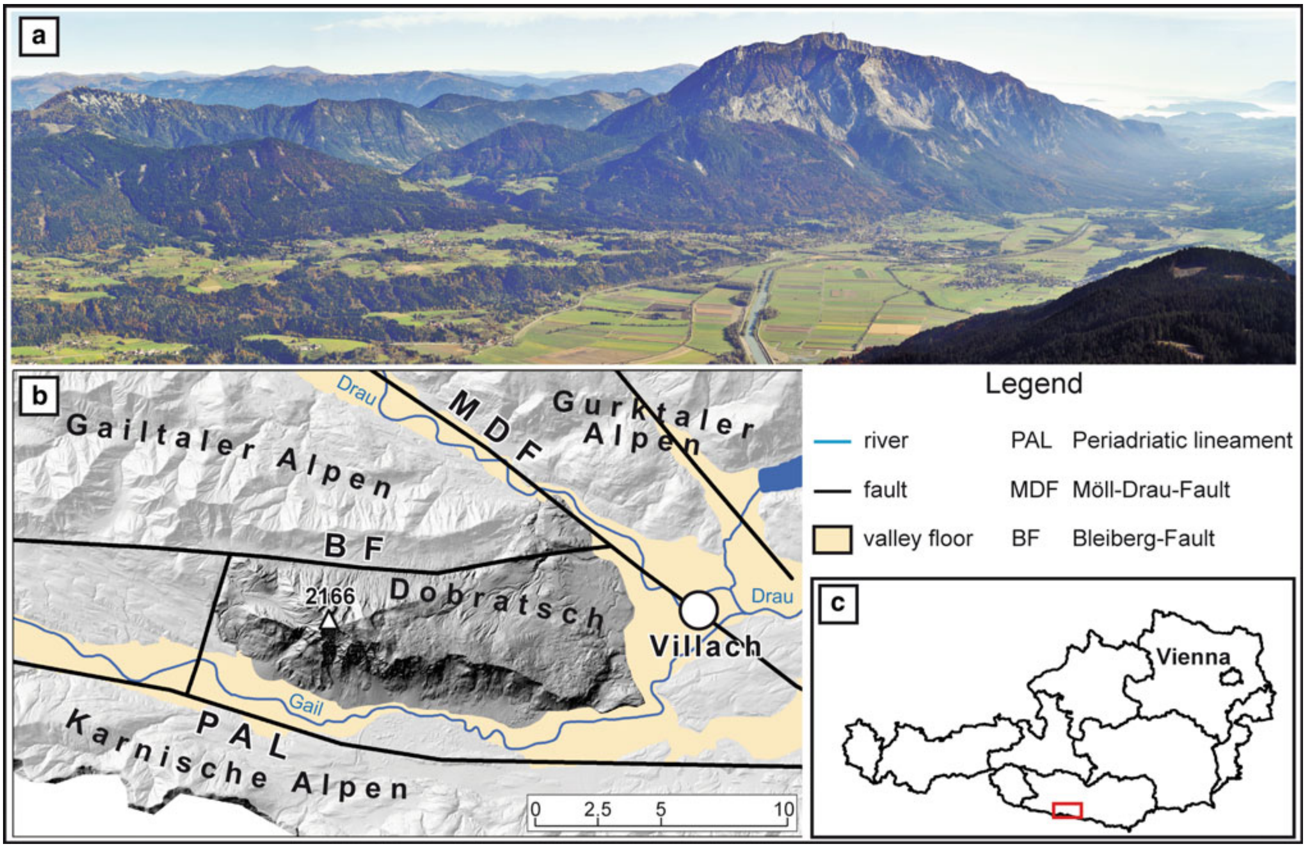

Fig. 31.1 Dobratsch massif. **a** Aerial view of the Dobratsch from SW illustrating the remarkable prominence of the massif; the broad valley bottom in the foreground is due to the fact that the Gail River has been dammed by the landslide deposits which fell down the south face of the massif (Photo C. Fatzi). **b** Tectonic setting featuring the Dobratsch massif as a horst-like structure surrounded by faults. Hillshade is based on an ALS-derived DTM, kindly provided by KAGIS (geographical information service of the federal government of Carinthia). **c** Position of map B within Austria

920 m asl gives the summit of Dobratsch 1250 m relative relief.

The Noetschbach only runs 3.5 km within the valley of Bad Bleiberg to the west, then changes its direction to a southern one and forms a gorge-like valley which separates the Dobratsch massif from the rest of the Gailtal Alps. Also, the course of this valley follows a fault line which runs orthogonally to the aforementioned faults, roughly N–S. Similar directions can also be found within the Dobratsch massif east of its summit in fault lines which run in NNW–SSE direction and have been described by Holler (1976). At each of those faults, the respective eastern block has moved downwards (Schulz 1982) forming a series of step faults. This tectonic setting is responsible for the character of the eastern slope of the Dobratsch massif which resembles a stairway. An early example of a geomorphological description of the plateau and a discussion of its morphogenesis can be found in Czermak (1951).

From a geological point of view, the Dobratsch massif and the Gailtal Alps belong to the so-called Drauzug. This term is used to denote the predominantly sedimentary Austroalpine rock units north of the PAL and south of the Drau Valley. Stratigraphy consists of rocks ranging in age from the Permian to the Triassic, resting on a crystalline base that is not exposed at the surface. The sequence of rocks is similar to that of other Austroalpine units, with the Wetterstein limestone (of Ladinian age) as the most widespread and thickest rock layer. In terms of the geomorphological considerations with focus on landslides and karst, the following aspects of geology and tectonics are of special relevance:

- The stratigraphy consists of metamorphic rocks at the base (weakly-metamorphosed sandstones and schists), which are overlain by Permo-Mesozoic rocks. The latter are dominated by Triassic carbonates: Alpiner Muschelkalk and Wettersteinkalk (partly dolomite).
- Due to overthrusting during the Alpine orogeny, the Mesozoic stratigraphic sequence occurs twice at the southern side of the Dobratsch massif. This leads to the situation that the rocks of the Raibl formation (Carnian) form a ductile base for the thick limestone layers (of Anisian and Ladinian age) towering above them.

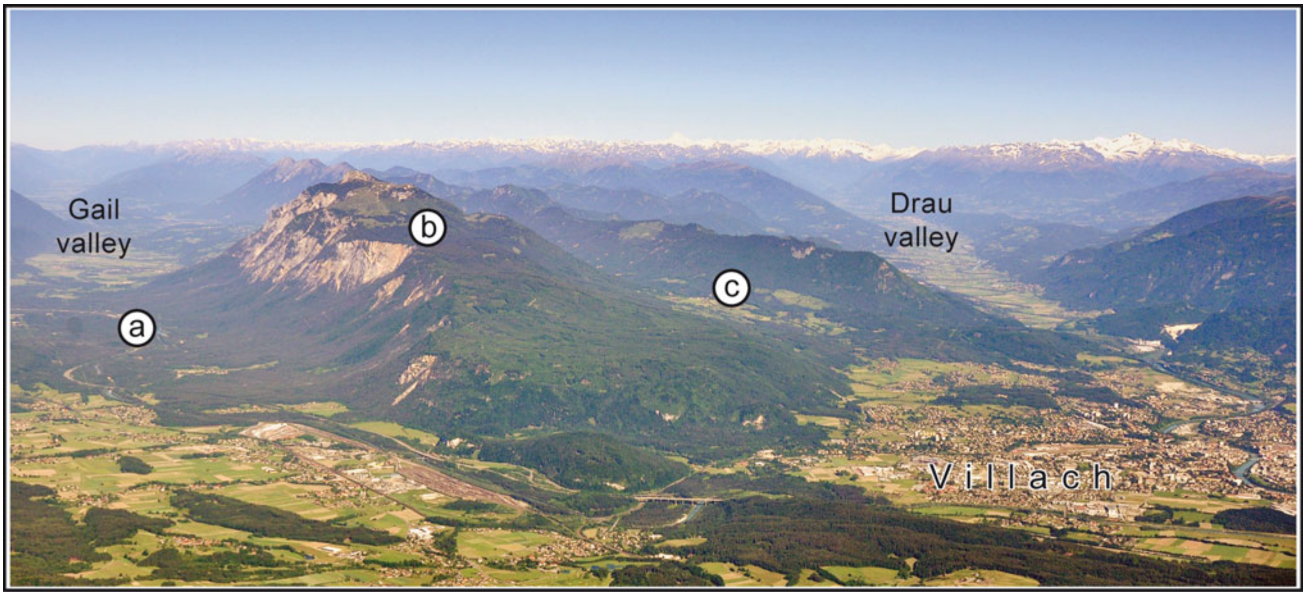

Fig. 31.2 Aerial view of the Dobratsch massif and its surroundings from the southeast. **a** = landslide deposition area which stands out due to its forest cover; **b** = Dobratsch plateau which is sharply demarcated by the detachment scarps of the landslides; **c** = valley of Bad Bleiberg. Note the asymmetry of the massif with steeper slopes from **b** to **a** than from **b** to **c**. Photo: C. Fatzi

- The entire rock sequence slightly dips to the north giving the Dobratsch massif an asymmetrical shape, with steep slopes looking to the south and a comparatively gently slope declining to the north (Fig. 31.2).

31.3 The Landslides

31.3.1 History of Research

Besides, e.g. Fernpass, Tschirgant, Köfels (see chap. "Giant "Bergsturz" Landscapes in the Tyrol"), Almtal and Wildalpen the landslides of Dobratsch are among the largest and best known in Austria, not only to the scientific community, but also to the general public. Not only is the landslide landscape spectacular to a lay observer, but the local community is well aware of a large, well-documented landslide event that occurred here in AD 1348 (Fig. 31.3a, b). The term "landslide landscape" will be used in the following text to label the entire landslide-affected terrain, from the detachment areas at the south face of Dobratsch massif to the deposition zone in the Gail Valley below. Furthermore, the awareness of the uniqueness of the landslide landscape was an important aspect in initiating environmental protection, finally leading to the establishment of a nature park (Sect. 31.5).

As already indicated, the landslides from Dobratsch did not have to be detected by scientists as they were regionally well known since the event, which took place on 25 January 1348. There are a lot of historical sources about the event most of them overestimating the effects of the landslides and mixing the information with the contemporaneous earthquake which was the main trigger of the landslide. For instance, a frequently cited chronicle (text in Golob et al. 2013, 15) reports incorrectly the destruction of 17 villages by the 1348 landslide, although the displaced rock masses did not reach beyond older landslide deposits which due to their unfavourable relief had never been settled (and still are not). Till (1907) wrote the first monographic study on the landslide landscape and recognized that there was more than one event.

Abele (1974) compared all large landslides of the Alps and critically evaluated available information, primarily by geomorphometric techniques. His comprehensive dataset allows comparison of the size of Alpine landslides showing that according to the area covered by landslide deposits (24 km^2) Dobratsch ranks third in the Alps, behind the landslides of Flims and Siders in Switzerland (Abele 1974). A further step in developing the knowledge of the landslide was the geological map provided by Anderle (1977), although the author was obviously more interested in the geology of solid rocks than of younger deposits. In the 1980s, the PhD thesis of Brandt (1981) and especially the critical reanalysis of the historical sources carried out by Neumann (1988a; b) (for more details see Sects. 3.3, 3.4) appeared. The different contributions in Golob et al. (2013, including references) provide an overview of current knowledge but do not replace a comprehensive study which is still needed. Smaller rockslide events in the last years (the latest one so far on 16 January 2015) have attracted attention

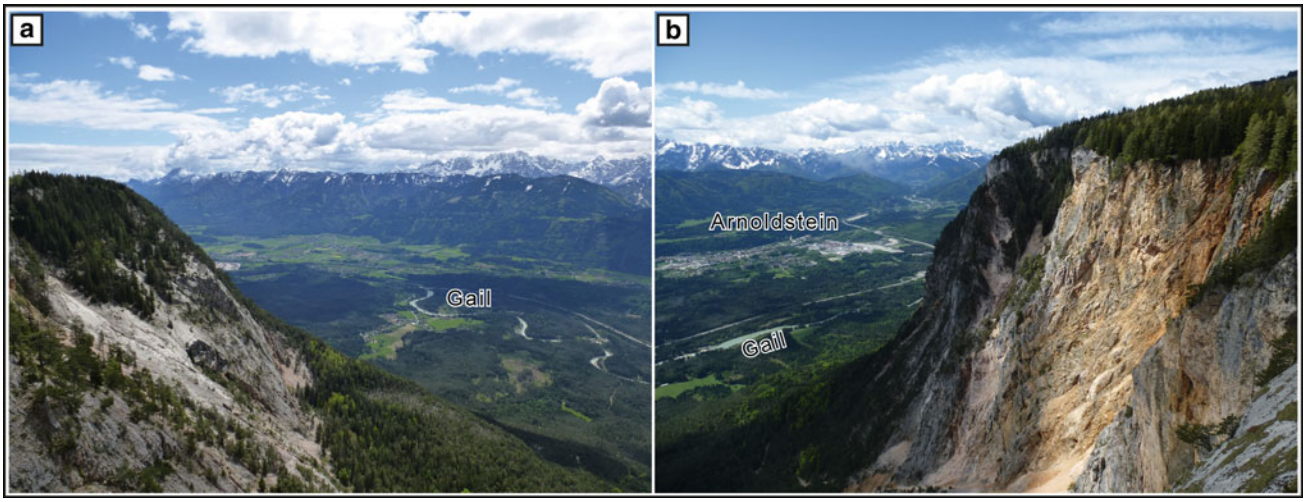

Fig. 31.3 Dobratsch "landslide landscape" as seen from the observation platform on the upper rim of the detachment scarp called Rote Wand (= red rockface). The vertical difference to the Gail River is almost 1000 m; the valley floor is widely covered by forests indicating the extent of the landslide deposits. **a** View in south-eastern direction with slide planes of older landslides in the foreground; **b** View in south-western direction with the small town Arnoldstein. In the background of both photographs are the Julian Alps in neighbouring Slovenia (**a**) and Italy (**b**). Photos G. K. Lieb

leading to local hazard evaluations based on analysis of preparatory factors or process modelling (e.g. Knafl 2015).

For preparing this chapter the extent of the landslide deposits was mapped using an ALS-derived DTM (1 × 1 m resolution), kindly provided by KAGIS (Fig. 31.4). The area where the hummocky deposits are visible at the surface (dark green in Fig. 31.4) comprises 19.75 km^2. This figure is by far lower than the 24 km^2 communicated by Abele (1974). Obviously, Abele's delineation of the deposition area also included landslide deposits that are nowadays covered by fluvial sediments, together with parts of the slopes. The light green area in Fig. 31.4 (8.23 km^2) shows the slopes which were affected by the sliding process and which are currently covered by talus and debris cones, both indicating the high intensity of recent geomorphodynamics (Sect. 3.3).

31.3.2 Landslide Susceptibility of the Dobratsch Massif

Landslide susceptibility means the propensity of an area to experience this type of physical hazard. As landslides are a manifestation of slope instability, susceptibility combines all destabilizing conditions. These include preparatory factors, such as oversteepening of slopes by erosion or undercutting, and preconditions such as material properties and slope geometry (Crozier 2004).

Addressing landslide susceptibility at the southern side of Dobratsch Krainer (in Golob et al. 2013, 62) emphasized the following three aspects which refer to the information given in Sect. 31.2.

- Steep south face of Dobratsch massif, mainly caused by (i) glacial erosion during the Pleistocene and supported by (ii) calcareous rocks and (iii) the dip of the strata to the north.
- Concerning lithology it is important that ductile rocks (like, e.g., the Raibl Formation) underlie the solid ones, which means that the base of the calcareous rocks of the upper part of Dobratsch is weak. This lithological precondition is often present in rockfall areas of the Calcareous Alps (cf. chap. "The World Heritage Site Hallstatt-Dachstein/Salzkammergut: A Fascinating Geomorphological Field Laboratory").
- The intensive friction of the rocks, both because of the tectonic setting (neighbourhood of PAL and the existence of transversal faults) and the gravitational tension in the oversteepened rock face, make rocks highly susceptible to gravitational processes (Fig. 31.5a, b).

The trigger of the AD 1348 event was an earthquake, which destroyed the city of Villach situated directly east of Dobratsch (Neumann 1988b; Lenhardt 2007). According to Pichorner (in Golob et al. 2013), there is evidence for high amounts of precipitation in the months before the event which might have decreased slope stability by high water pressure in the rock fissures. Because of the location at the seismically active PAL, also earlier landslide events may have been finally triggered by earthquakes.

31.3.3 Landslide Chronology

Till (1907) distinguished one prehistoric and one historic landslide from AD 1348 and assigned the detachment areas

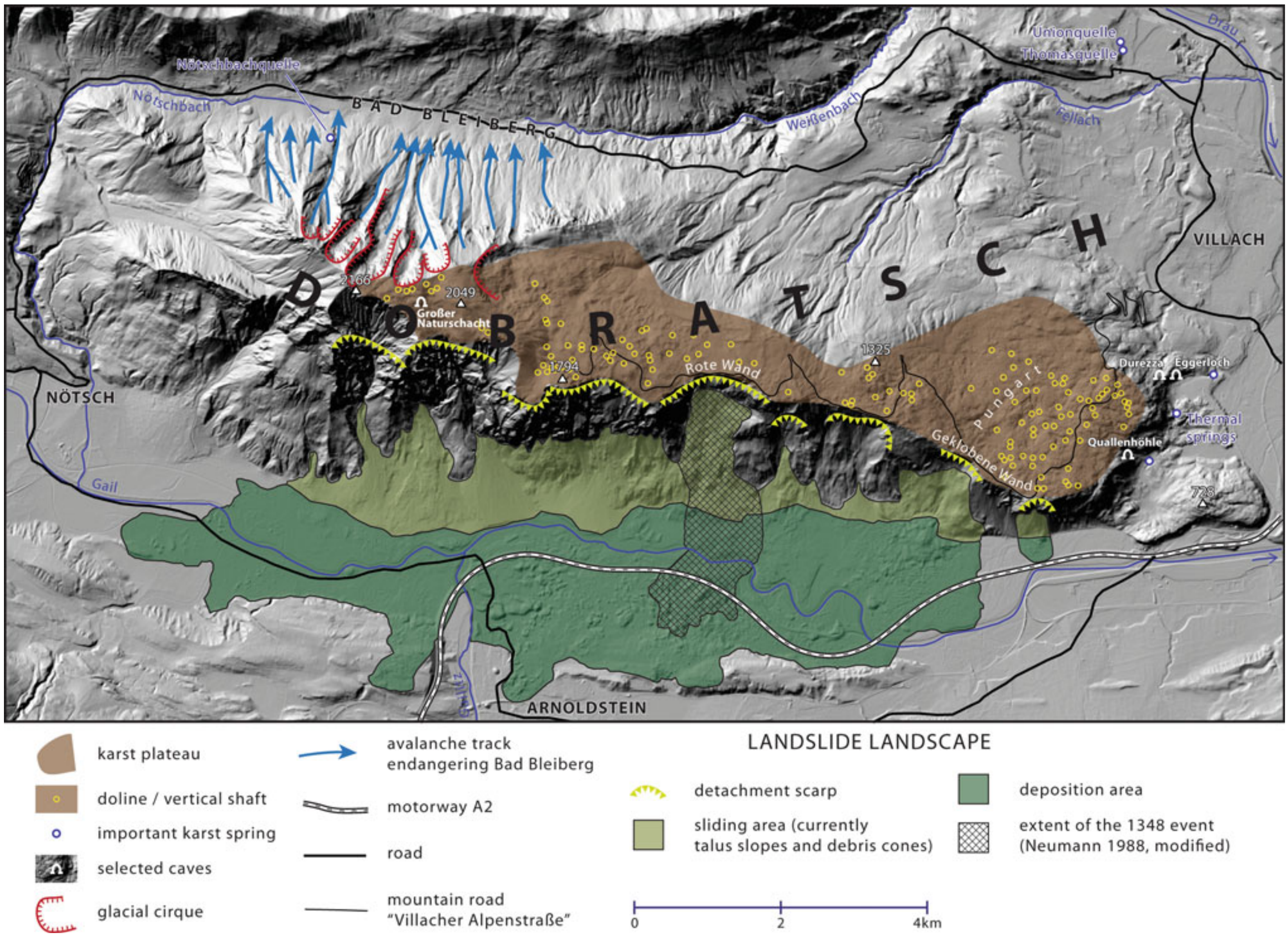

Fig. 31.4 Overview map of Dobratsch massif showing the main elements of the "landslides landscape" and some other features described in this chapter. The hillshade is based on an ALS-derived DTM, kindly provided by KAGIS (geographical information service of the federal government of Carinthia). Drawing: V. Damm & C. Bauer

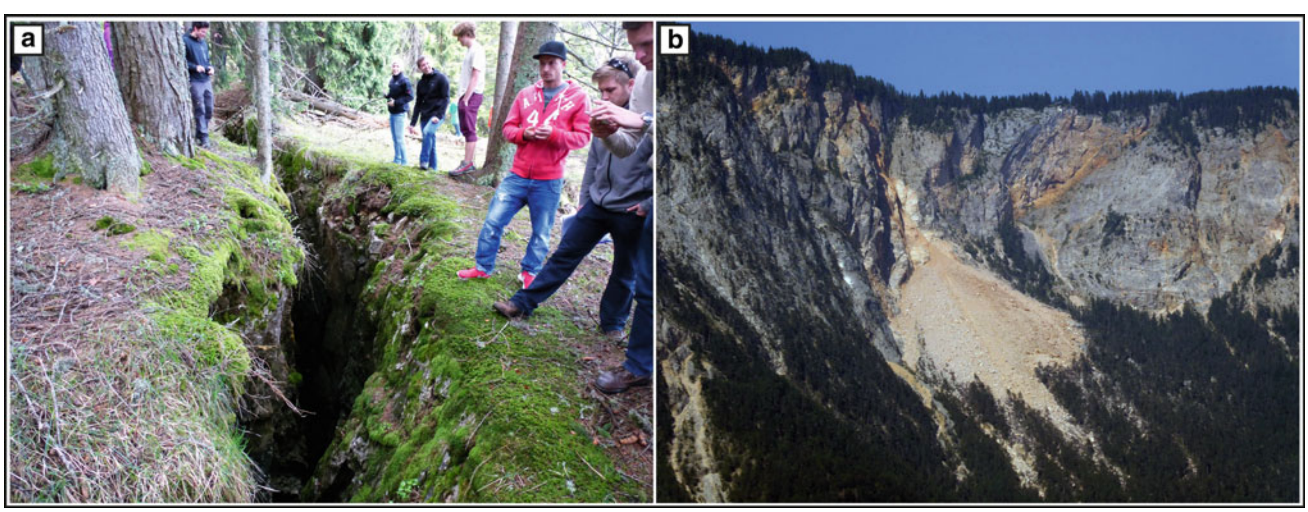

Fig. 31.5 Example of a tension crack parallel to the upper margin of the already existing detachment cavity of Rote Wand in May 2014 (**a**). At exactly this crack rock failure occurred causing a rockfall with a volume of 6000 m^3 on 16.01.2015 creating a talus apron on the slope below (**b**, Aug. 2016). Photos G. K. Lieb

in the south face of Dobratsch to these two events. This distinction has been accepted by the subsequent authors, among them Anderle (1977) who showed the extent of the two landslide generations in his map. Abele (1974) dealt with the question of age of the prehistoric landslides and proposed an event during the late Würm glaciation with the rock masses falling onto glacier ice which covered at least the western part of today's landslide landscape. As a proof for this assumption, he mentioned the hummocky relief east of the Gailitz River which he interpreted as toma relief (toma = steep, isolated hill) originating from the contact of landslide deposits with stagnant ice of a retreating glacier. However, the origin of similar landforms at other landslides has more recently been explained without the existence of ice (e.g. Abele 1997; van Husen et al. 2007). No current research on this problem has been carried out here.

The main argument for the distinction of older and younger sections of the landslide landscape was the lack of soil and looser vegetation cover of the latter (Fig. 31.6a, b). However, Neumann (1988a) questioned this statement and pointed out that the deposition area of the landslide has been used as forest and pasture over centuries and thus was significantly changed by human activities. Furthermore, he reported the age of an oak (found during power plant construction in 1959 and embedded in landslide deposits) which according to ^{14}C-dating was buried some 7800 years ago by a landslide. Thus, he concluded that there were not only two landslides but obviously more events.

The map shown in Lenhardt (2007, based on Brandt 1981) assigns 6 detachment scarps—among them Rote Wand and Kranzwand which are both visible in Fig. 31.6b—to the AD 1348 event. However, from historic sources the only landslide site which can definitely be assigned to the AD 1348 event is the area shown in Fig. 31.4 (beneath the large detachment scarp of Rote Wand). D. Neumann's mapping was checked and confirmed in the field by the authors in 2016. The deposits cover about 1.6 km^2 but have no clear boundary with older deposits, neither on the surface nor within the deposits. The latter statement can be made because deep excavations for the construction of the motorway (completed in 1984) did not show any stratigraphical distinction in the sediment body (Neumann 1988a).

31.3.4 Effects of the Landslides

According to the reanalysis of historical sources of the AD 1348 landslide by Neumann (1988b) far too high damages and losses of lives were reported in the older literature. We now know that the landslide itself did not affect settlements which never existed there (see above) but instead fell onto older landslide deposits. The deposits dammed the Gail River creating a lake of which remnants were visible at the surface until the eighteenth century, in a location named Seewiese (=lake meadow). However, in the Gail valley bottom two villages located above the landslide landscape had to be abandoned in the following years because of "dramatically deteriorated hydrological conditions" (Neumann in Golob et al 2013). Probably, there were no fatalities at all directly caused by the landslide. In this respect, the earthquake was far worse.

Nevertheless, the deposition area of the landslide has a particularly striking appearance with a chaotic, hummocky mesorelief (in the older as well as in the younger parts) and large boulders (Fig. 31.6a, b). Thus, as already mentioned, settlements and intense types of land utilization were prevented and the entire area contrasts with the deforested bottom of the Gail Valley upstream and downstream of the landslide landscape because of its forest cover. This dissimilarity to the neighbouring areas is also reflected by toponyms like Schütt (=gravel deposit) or Steingröffel (=sterile stone accumulation). However, the increased gradient of the Gail River due to the landslide barrier was the reason for constructing hydropower plants in 1911 and 1959 (Neumann in Golob et al. 2013).

31.4 Karst Features

Looking at the distribution map of karst caves in Austria (Fig. 3 in chap. "Karst Landscapes in Austria"), the Southern Calcareous Alps in general show a much lesser number than the Northern Calcareous Alps—except for one area and this is the Dobratsch massif. By the beginning of 2019, more than 210 caves are documented in the Austrian Cave Register (for details see chap. "Karst Landscapes in Austria"). There is a positive correlation between the high number of caves and a long history of research. Trimmel (1963, 1964) gave a first comprehensive overview of the status of knowledge and pointed to the striking high density of karst features and caves. Spötl (2016) confirmed an outstanding cave abundance together with the dominance of caves with high vertical dimensions. The Große Naturschacht and the Eggerloch, 112 m and 123 m deep, represent the deepest caves in the area so far. In some of the caves, perennial snow and ice exist (e.g. Großer Naturschacht in the summit area of the Dobratsch). There is a high concentration of caves in the eastern part of the Dobratsch plateau called Pungart (location see Fig. 31.4) and its slope towards the Klagenfurt Basin (e.g. Fig. 31.7b). Here, the longest cave (c. 700 m) of the Dobratsch massif, the so-called Eggerloch, is situated. One of the vertical shafts, the so-called Durezza (cf. Fig. 31.4), is also an important archaeologic site. Human remains (bone fragments from at least 36 children and 102 adults) indicate the use of the shaft as a burial site in the La Tène period (Galik 1998).

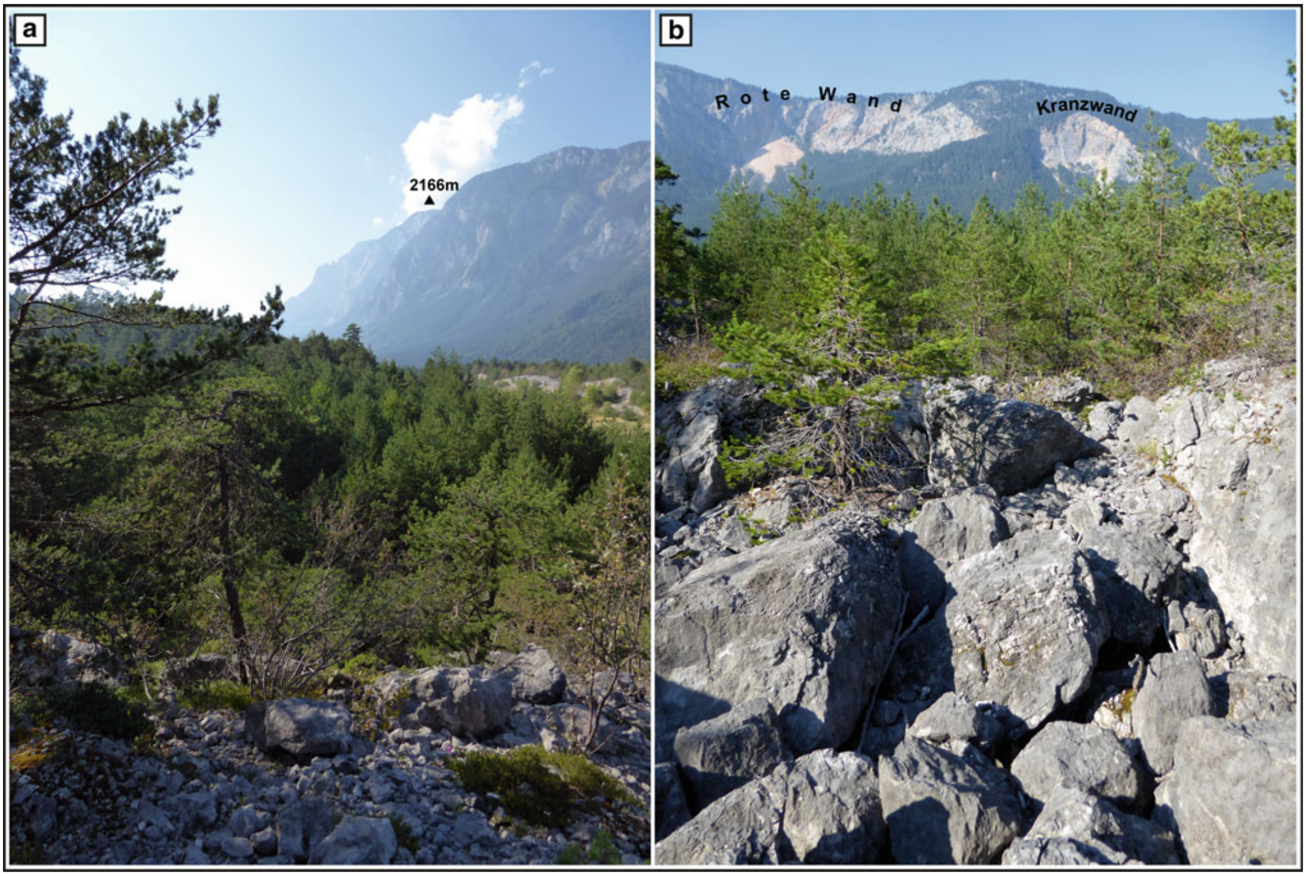

Fig. 31.6 Surface of the landslide deposits in the location "Steinernes Meer" (=sea of stones) showing a "fresh" appearance with coarse blocks, lack of soil and sparse vegetation (open pine woodland). Although at this specific site the sediments were deposited by the AD 1348 event, older parts of the "landslide landscape" look similar, making it a questionable indicator of age. **a** View in WNW direction, with the south face of the Dobratsch summit area representing older detachment scarps in the background; **b** View in northern direction with the Rote Wand detachment scarp of 1348 and another one of possibly the same age in the background. Photos G. K. Lieb

Spötl (2016) interprets the occurrence of caves in the context of the roughly N-S striking faults mentioned in Sect. 31.2. Furthermore, he discusses the possibility of cave development in the easternmost part of the Dobratsch massif by rising thermal water (referring to hypogene speleogenesis, cf. chap. "Karst Landscapes in Austria").

The faults also favour the development of karst landforms at the surface among which dolines (Fig. 31.7a) occur most frequently. There is no comprehensive analysis of the distribution, shape and size of the dolines so far. Preliminary conclusions can be drawn from the morphometric delineation based on the 10 m ALS-DTM and from observations during geographical excursions:

- Dolines occur all over the area indicated as plateau in Fig. 31.4.
- Fig. 31.4 illustrates dolines (as point elements) with an area larger than 200 m^2 and a depth of more than 2 m. There are slight concentrations at three levels of the plateau: (i) in its uppermost part, east of the summit (c. 2000 m asl); (ii) in the vicinity of the upper end of the touristic road (see Sect. 31.5) near Rosstratte (c. 1750 m asl) where they are best visible because the forest at these elevations has been cleared (probably already in the Middle Ages) in order to provide alpine pastures; (iii) in the densely wooded lowest part of the plateau called Pungart (c. 900 m asl).
- The concentrations of the dolines coincide with the concentration of vertical shafts, which especially applies to the Pungart plateau and points to the existence of local fault systems.

Another special karst feature is the hummocky ground of cultivated pastures. On the Dobratsch plateau, it can for instance be observed around Rosstratte (Fig. 31.7c). The hummocks consist of regolith and calcareous slope debris and have an average diameter of 2 to 4 m and alternate with pits, thereby exhibiting a remarkable regularity in the general distribution pattern. In the German geomorphological literature, this pit and mound microrelief is termed

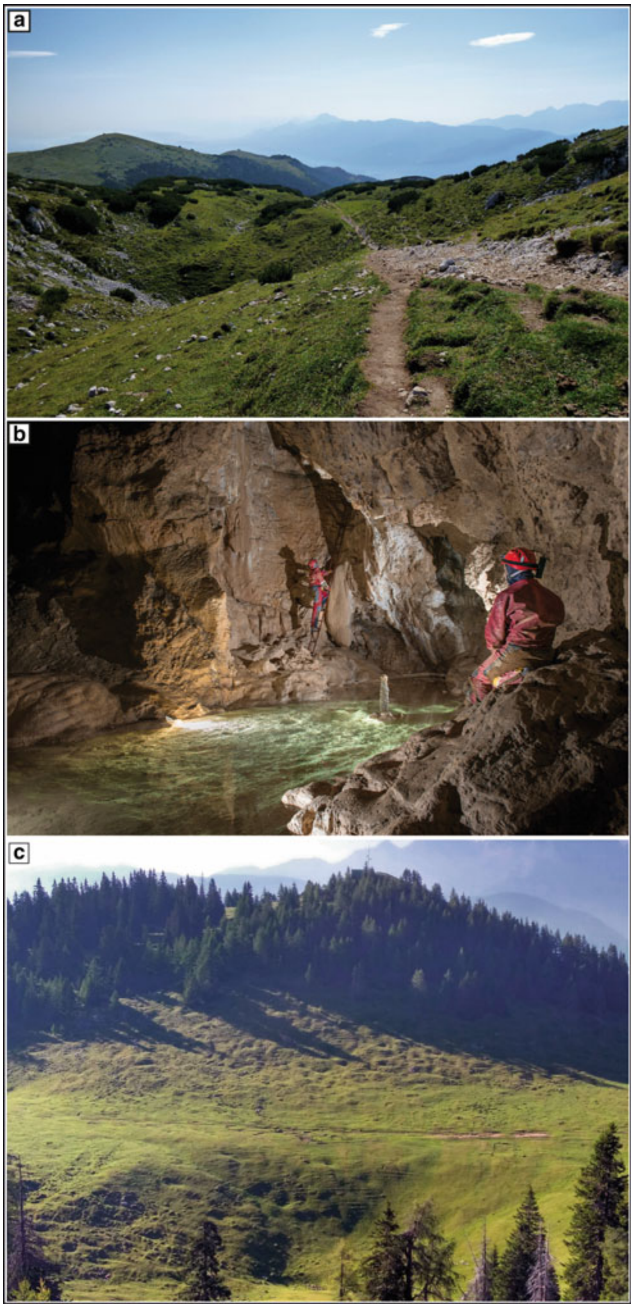

Fig. 31.7 Surface and subsurface karst features of the Dobratsch massif. **a** Dolines of medium size bound to local faults on the upper part of the Dobratsch plateau (c. 2000 m asl). Photo G. K. Lieb; **b** The cave Quallenhöhle at Pungart. Photo T. Exel; **c** View to the east from the first bend of the hiking trail starting at Rosstratte. The slopes below the forest and the slopes of the large doline in the foreground exhibit a Buckelwiesen microrelief. Its pit-to-mound vertical relief is 15–17 cm. This figure is low when compared to the mode of 50 cm in distinctively developed hummocky pastures elsewhere in the Austrian Calcareous Alps. Albeit observable, the Buckelwiesen on the Dobratsch is thus not very prominent. Photo C. Embleton-Hamann

"Buckelwiese" (literally: "hummocky meadow"). Buckelwiesen are initiated by the uprooting of trees during storms and then further developed by a concentrated limestone solution operating in the rootstock-pits, fostering their gradual subsidence, thereby giving the mounds between them increasing prominence (Embleton-Hamann 2004). As natural forest regeneration is likely to destroy a newly formed, small windthrow relief, Buckelwiesen genesis further affords that the blow-down site remains open until a concentric soil water flow in the pits and a self-enforcing solutional amplification of the microrelief is established. The data for mean solutional denudation rates in the Alps (cf. Plan 2016) suggests that this will take a minimum of 400–500 years. There is obviously a third causal factor involved in their genesis. This is the early presence of people, salvaging the windthrow timber and using the newly formed forest-gaps as pasture for cattle. Thus, the Buckelwiesen pastures may also be regarded as a special cultural heritage of the European Alps, which already had a substantial population during the Middle Ages (Embleton-Hamann 2013).

As most karst areas, the Dobratsch massif represents a karst aquifer. Because of the northerly tilting of the rock layers, it is mainly drained to the north, with the largest karst springs occurring near Bad Bleiberg (Noetschbachquelle) and northwest of the city of Villach (Thomasquelle, Unionquelle, Fig. 31.4). These two springs have a mean discharge of 400 l/s (Poltnig et al. 1996), providing 80% of the drinking water supply (Spötl 2016) of Villach with 61.000 inhabitants. Thus, the city is one of many examples of cities in Austria (among them the capital Vienna) which get their water from karst massifs. Because of the vulnerability of the karst water system, respective measures, especially the establishment of protected areas, have been taken in good accordance with other types of protection (see Sect. 31.5). Special features of karst hydrology are the thermal springs at the western outskirts of Villach, which have been used as spa already since Roman times. They are bound to the karst system with a deep-reaching water circulation along N–S orientated faults. These considerations lead to the interactions of the nature and society at the Dobratsch.

31.5 Dobratsch Massif and Humans

Golob et al. (2013) explored interactions of men and environment at Dobratsch in many ways. In addition to the above-mentioned provision of drinking water, the close relationship between the city of Villach and the mountain situated next to it also includes aspects like the use as destination in leisure time or an icon of the construction of nature contrasting city life. In German, such relations are referred to as "Hausberg" (i.e. something like home mountain). These interactions shall be demonstrated for agriculture, tourism, natural hazards and nature protection:

- The second name of Dobratsch, Villacher Alpe, reminds one of the fact that the upper parts of the mountain have been used as an alpine pasture by the citizens of Villach at least since the sixteenth century. As in other Alpine regions, cattle still grazes on the alpine meadows which have been expanded by lowering the timberline. The presence of people, which probably dates back to medieval times, is also proved by the construction of two churches at the summit already at the end of the seventeenth century.
- Since the turn of the eighteenth to the nineteenth-century Dobratsch has frequently been hiked, inducing the construction of a shelter hut near the summit already in 1810. The main motivation to visit the summit was pilgrimage to the churches and above all the extraordinary panoramic view which the mountain offers because of its geographical position—but not rock climbing due to the brittle rocks favouring gravitational processes. Since around 1900 several ideas to make the mountain accessible for mass tourism came up and finally resulted in the opening of a road in 1965 with its upper end at Rosstratte (1733 m asl); because of its pure touristic purpose, the course of the road was designed to touch as many natural sights and viewpoints as possible (such as Rote Wand, Fig. 31.3). In the period 1965–2002, the plateau up to Zehnernock (1956 m asl) and the north-eastern slopes were additionally used as a skiing resort which was then closed for environmental reasons (see below).
- Dobratsch comprises all aspects of high mountain relief including glacial cirques (Fig. 31.4), ecosystems (at least up to the alpine zone) and gravitational processes. Concerning natural hazards not only rock- and landslides but also debris flows and avalanches have to be mentioned. The latter especially occur on the northern side of the massif, endangering the small town of Bad Bleiberg which has developed there in spite of this hazard due to the occurrence of lead and zinc which have been mined from the Middle Ages until the 1980s (nowadays the main economic activity is tourism). The avalanche danger is very high because of (i) bowl-shaped glacial cirques (ii) in a lee position—the predominant wind direction is SW—collecting a lot of snow, (iii) the amount of which is high because of the position of the mountain in the precipitation-rich Southern Alps, and (iv) the high inclination of the slopes which is not interrupted by any less steep section. Thus, during heavy snowfall events avalanches can reach Bad Bleiberg (Figs. 31.4 and 31.8b). On 24.02.1879, avalanches destroyed 21 houses and killed 39 persons. Therefore, around 1900 first protection measures were taken, and during the period 1969–1985, the avalanche protection service implemented an integrative protection concept including protection structures at the plateau and in the detachment areas of the avalanches (Fig. 31.8a, b) as well as hazard zonation (Letter 2014).
- The first protected area around Dobratsch was established in 1942 within the landslide deposition area called "Schütt". This reflects the high regard for these ecosystems and their biodiversity. More protected areas of different kinds were added over time, finally leading to the

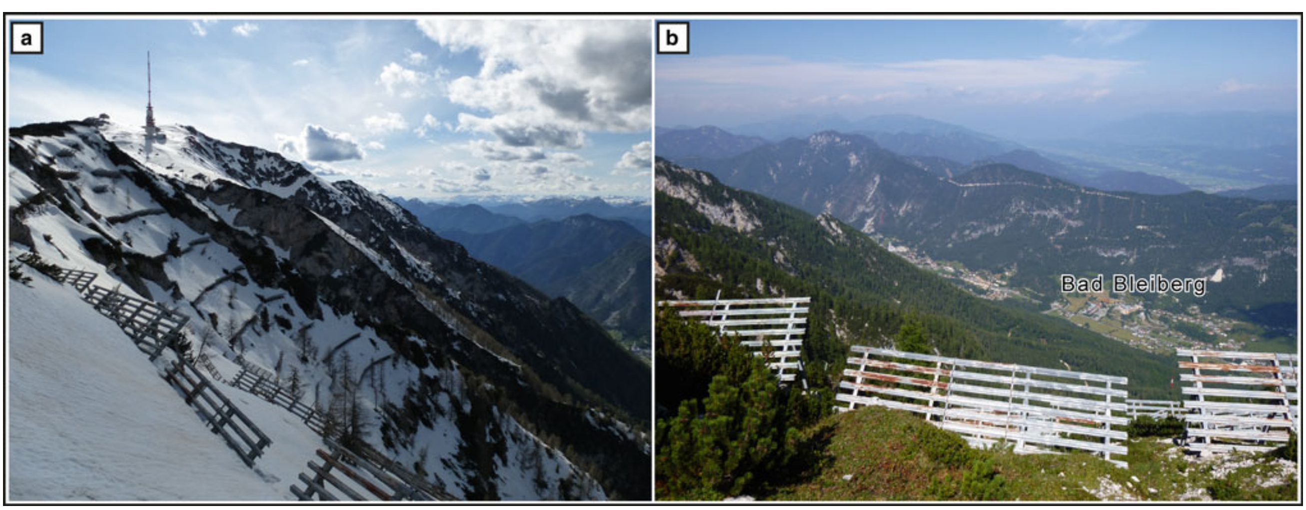

Fig. 31.8 Permanent avalanche barriers built after 1969 prohibit the detachment of avalanches which at the northern side of Dobratsch massif endanger the town of Bad Bleiberg more than 1000 m below. **a** View in western direction towards the summit of Dobratsch, **b** in north-western direction towards Bad Bleiberg. Photos G. K. Lieb

idea of protecting the entire mountain in a comprehensive way. For this purpose, the concept of an Austrian “nature park” (with the main management goals of protection, recreation, education and regional development) was debated since the 1980s and finally established by the regional government of Carinthia in 2002. Today the nature park comprises an area of 72.5 km^2 which equals the entire mountain massif with the exception of the lowest (forested) parts of the northern slope. The landslide landscape only partly belongs to the nature park but is strictly protected as a NATURA 2000 area. When in the 1990s, the decision had to be made whether the skiing resort should be relaunched (by establishing artificial snow-making) or closed, the second option was turned into reality in 2002. Although this decision was supported by financial considerations, it can be considered as sustainable, especially in the context of karst vulnerability (Poltnig et al. 1996, 89).

31.6 Conclusions

Dobratsch massif is a very good example of a karst mountain of the Southern Alps (in a geomorphological sense). It has become famous because of the landslide landscape in which rock falls still occur and will also occur in the future. As has been shown, this landslide landscape still reveals a lot of scientific problems to be solved. In contrast to the incomplete knowledge on the geomorphological processes and their age, biodiversity has been intensively investigated leading to results that helped to establish environmental protection. Thus, Dobratsch has become the southernmost nature park of Austria, a fact which also meets the requirements of drinking water protection in a karst environment. Finally, Dobratsch is excellently accessible and thus can be recommended as a high mountain excursion goal – not only from a geomorphological point of view.

Acknowledgements We would like to thank Christine Embleton-Hamann for her contributions about landslide susceptibility and especially about the Buckelwiesen microrelief.

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