Dobratsch Rocklides

(Arben Kociu)

WGS Co-ordinates:	Lon: 13°44'09" E; Lat: 46°35'53" N (Rote Wand)
Site, County:	Dobratsch in the Villacher Alps, Carinthia
Type of slope failure:	Rockslide (rock avalanche)
Other specifications:	Active toe zone with clear evidence of the influence of the stress relaxation of joints parallel to slope.
Specific area:	The southern slope of Dobratsch, between Nötsch im Gailtal and Unterfederaum. The total area covered is 24 km²
Volume:	800-900 million m³ (estimates vary greatly with regard to the volume)
Ages:	Post glacial: prehistoric and historic (25th January 1348; 1368)

On the highway from Tarvis (Italy) to Villach, north of the small town of Arnoldstein, we pass the Sturzstrom deposits of the Dobratsch Rockslide. Our first stop will be at the A2 Arnoldstein Autobahn service area (No. 1 on Fig. 1b). From here, we will have a view of the multiple scarps of the Dobratsch Rockslides (Fig. 2b). The prehistoric and historic rockslides of Dobratsch are located in the southern province of Carinthia, Austria.

Dobratsch is a massive mountain with a length of 17 km and a width of 6 km, which to the east concludes the long elongated range of the Gailtal Alps. Because of the variety of possibilities it offers, the whole massif, and most particularly its highest peak (2,166 m asl), is a very popular recreation area. It's easily accessible from the Villacher Alpenstraße and the panorama from the summit is immense. The area of Dobratsch is protected as a Nature Park.

Dobratsch rises directly above the town of Villach (Population: 59,000), where Gail River flows into Drau River. The eastern slopes of the mountain rise steadily; here the mountain is broad and elevated above tree line. The most impressive slopes are the southern ones, as these are characterised by steep rocky walls and gravel slopes that descend in the direction of Gail River (Fig. 1a, b).

Figure 1a. Oblique 3D view of the southern slope of Dobratsch with the rockfall scarp faces. In the foreground is the valley with the meandering river Gail. The valley marks the Gailtal fault line in their east-west orientation. (©2010 Google).

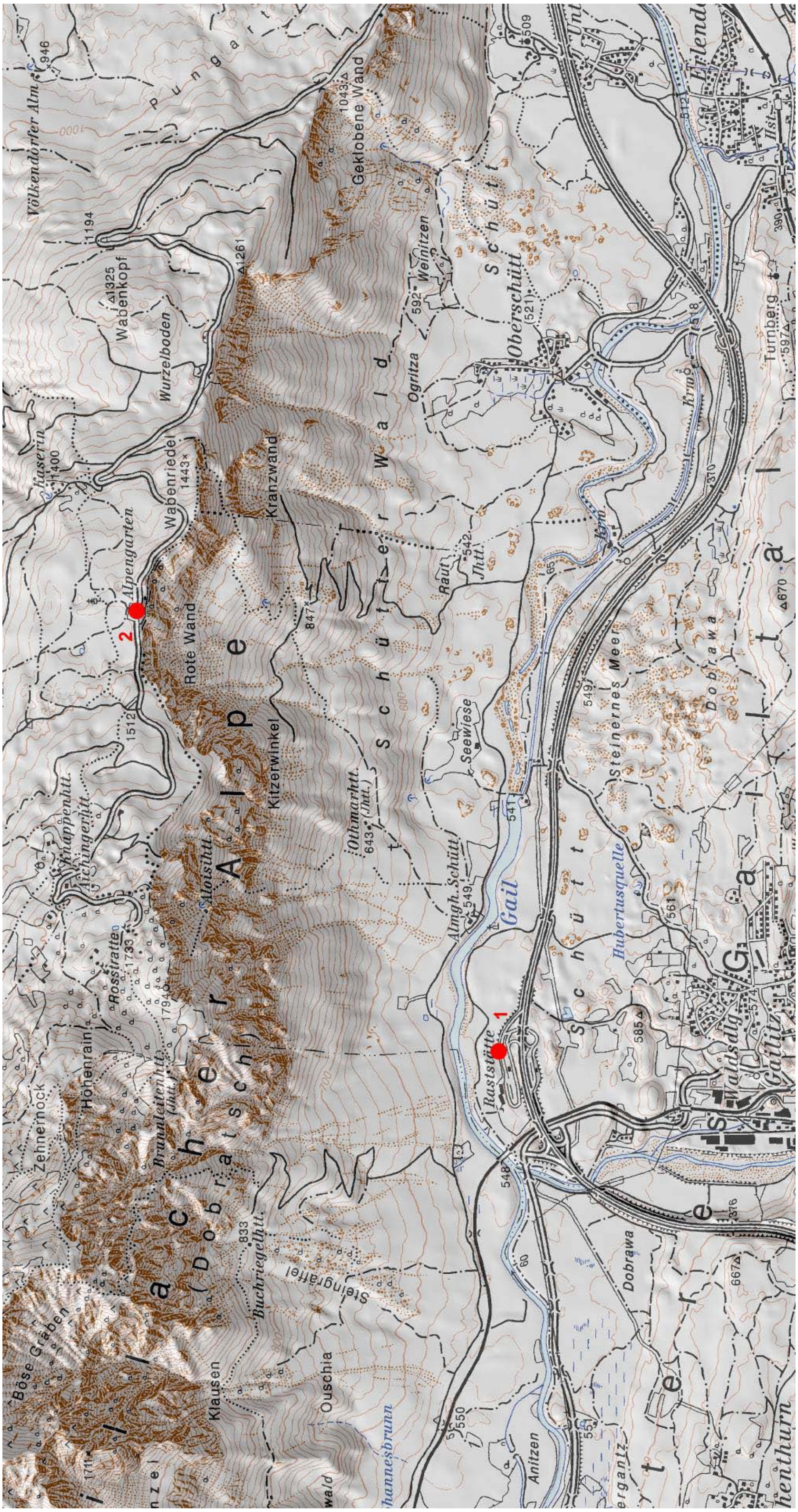

Figure 1b. A topographic map of the Dobratsch Site with marked the location of our stops (base map: BEV).

Figure 2: View to the scarps of the Dobratsch Rockslide from the Arnoldstein Autobahn service area (Stop 1)

The geology of Dobratsch (Villacher Alps)

Dobratsch is located in the Villacher Alps, and as eastern offset of the Gailtaler Alps, belong to the so–called Drauzug. (Fig. 3). In this area, the Drauzug is represented by a permotriassic Austroalpine unit sedimentary sequence. The facies shows notable similarities to both the Northern Calcareous Alps ("Nördliche Kalkalpen") and the Southern Alps (Hauser et al, 1982). The Villacher Alps are dominated by a Permian-Triassic sequence that begins with the red sandstones of the Permoskyth and the "Werfener Schichten". Geologically, Dobratsch is divided into two tectonic units (Fig. 4).

The Permoskyth sequence is formed by fine to moderate red sandstones separated by coarse clastic layers. The boundary between the Permoskyth sandstone layers and the "Werfener Schichten" is marked by a colour change from predominantly red to grey-light brown. At the boundary, there is a marked increase in clay content and decrease in quartz gravel.

The grey, grey-green, brownish to blackish "Werfener Schichten" represents a series of sandy marls, marls, clays, silts and sandstones. The hanging wall layers are often cellular dolomite (Rauwacke) and cause cavities, indicative of saline solution. The Muschelkalk begins here with an alternating storage sequence of clay slate and dolomite, followed by pure dolomite (Hauser et al, 1982). Above this is Middle Triassic sequence of light-gray intermediate dolomite combined with volcanic sediments with a thin tuff layer. They are overlain by limestone and dolomites of the Wetterstein lagoon. At Dobratsch, the Wetterstein limestones and dolomites attain thicknesses of up to 700m. It is a mainly brittle rock formation.

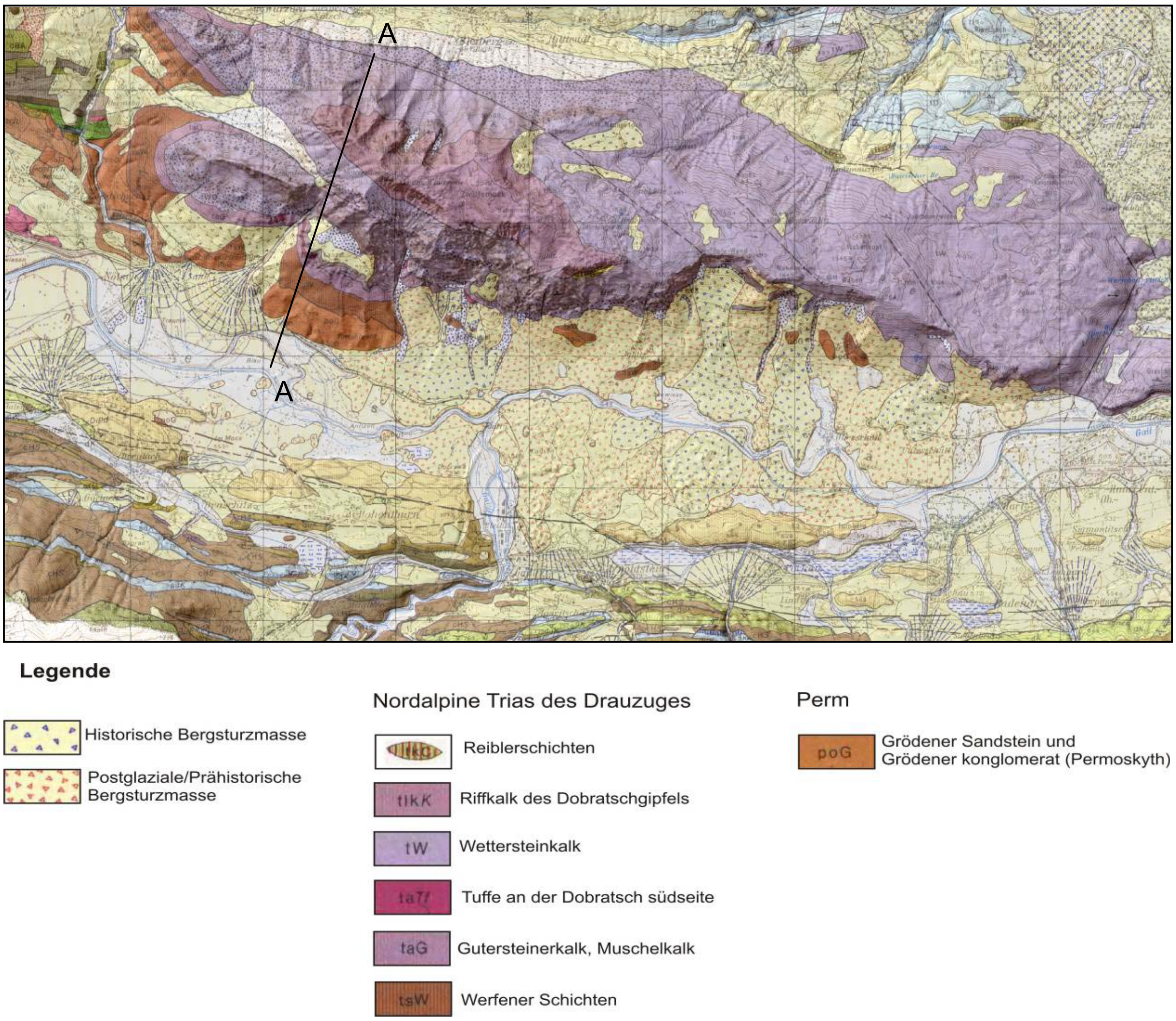

Figure 3: A geological map of the Villacher Alps 1:50 000 (Geologische Karte der Republik Österreich, OEK Blatt 200 Arnoldstein - Wien 1982)

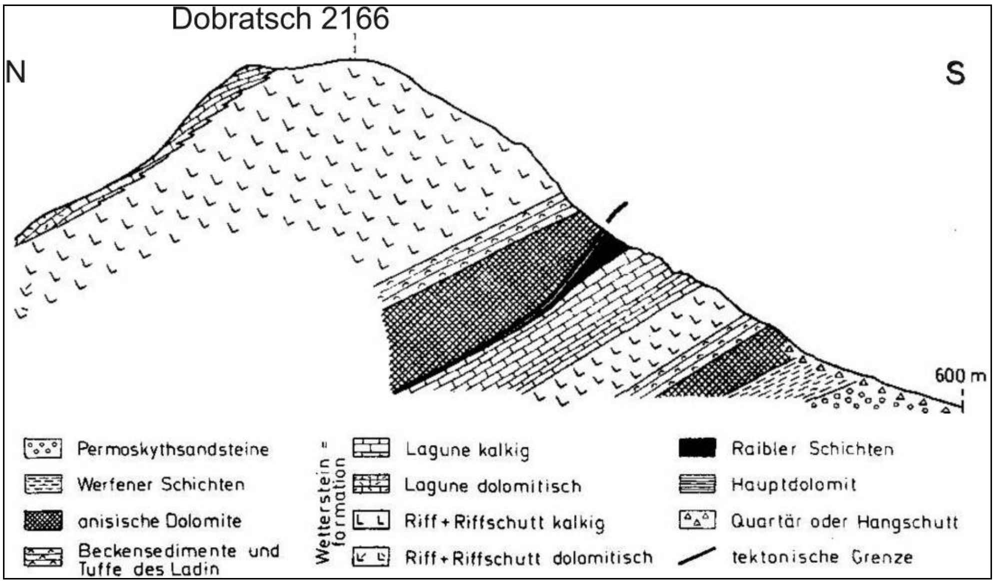

Figure 4: A simplified N-S geological cross section through the mountain of Dobratsch, A-A (for the location of the cross section see Fig 3). The reverse fault of Dobratsch has divided it in to two tectonic units (after HAUSER et al, 1982).

The Dobratsch Rockslides

The historic rockslide of Dobratsch was reported in a number of chronicles. It is considered to be the largest recorded landslide in Austria. On 25th January 1348, 30-100 million m^3 of rock descended from the southern slopes of Dobratsch and into the Gail Valley (TILL, 1907; BRANDT, 1981). The trigger, although not the cause, of this disaster was an earthquake in the area of Friuli (LENHARDT, 2007); more than one hundred contemporary sources, mainly annals and chronicles, contain information relating to this event (HAMMERL, 1994). Along the southern slopes of Dobratsch, six contemporaneous rockslides and rockfalls occured (see Fig. 5). In terms of their volume, the rockslides along the so-called "Rote Wand" were by far the largest. In the deeply fractured scarp area of the Dobratsch Rockslide, "Rote Wand" is mainly composed of bedded Middle Triassic carbonates (Muschelkalk, Buntkalke, and Wettersteinkalke). The debris flow (Schuttstrom) from "Rote Wand" had an average thickness of 5 meters and covered an area of 2 km² (NEUMANN, 1988), enough to block Gail River. The disaster, therefore, was not caused by the rockslide itself but as a result of the flooding that occurred after the river finally broke through the rockfall barrier.

TILL (1907) demonstrated that the majority of the deposited rockslide material does not actually relate to the historic rockslide in 1348. It instead comes from a much older, prehistoric, event. We can see evidence for the two events both in the scarp areas in which the rockslides were initiated and in the deposits of the Gail and Gailitz Valleys. The scarp areas relating to the older event have already weathered grey, whereas the scarp areas relating to younger events are still fresh and reddish in colour. These two generations of rockslide deposit are shown separately on the geological map (1:50 000; see Fig. 3).

The deposit area of the rockslide material covers approximately 30 km^2 with a total volume of approximately 800-900 million m^3 (BRANDT, 1981). The prehistoric rockslide deposits are deeply weathered and carry a humus layer that incorporates some of the younger rockslide deposits. The prehistoric and historic rockslides on the southern slopes of Dobratsch affected an area with a total length of about 15 km.

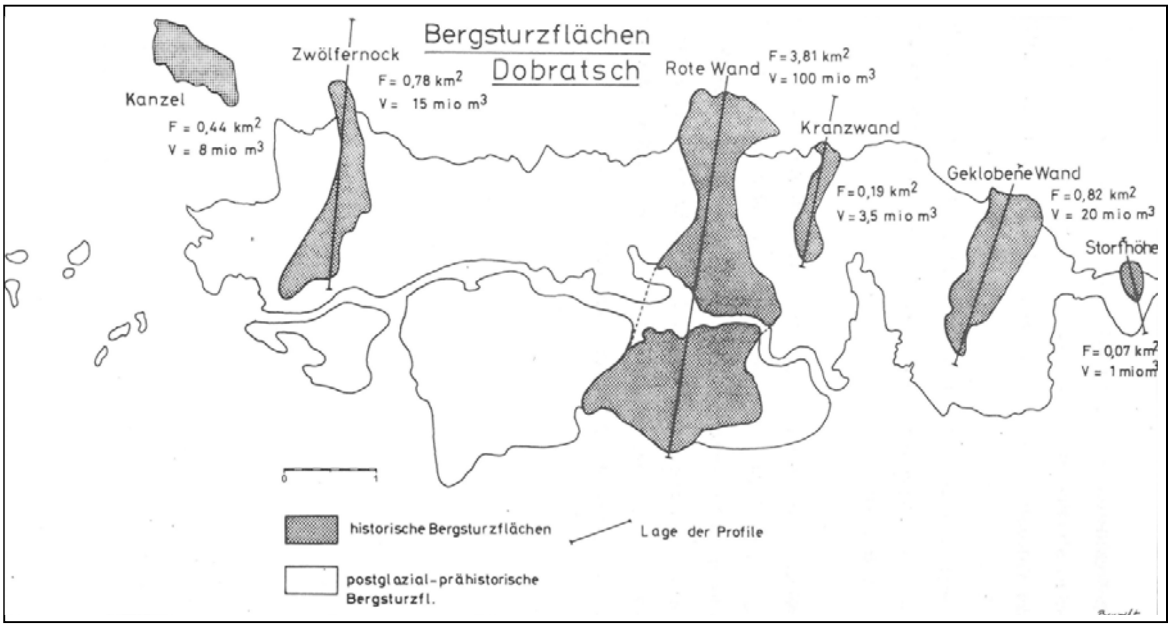

Figure 5: A sketch of the rockslide events following the earthquake on 25 January 1348 (after BRANDT, 1981).

The first stop (No. 1 on Fig. 1a) is located on the lower part of the rockslide, namely in the deposit area of the prehistoric rockslide and rock avalanche – in the topographical map named as "Alte Schutt". The blocky, water-permeable deposits of "Wettersteinkalk" and "Wettersteindolomite" have formed hills with heights of up to 80 m (KRAINER 1997). An almost continuous soil cover has developed over the rockslide deposit, occasionally interrupted by large blocks. The type vegetation depends on the degree of soil development, but it mainly comprises mixed forests of Pine, Scots Pine, Spruce, and Beech.

In the area north of Arnoldstein, the landslide deposit consists of small hills interspersed with trough-synclinal depressions. In these depressions, silty clayey sediment with a high mica content has accumulated to thicknesses of about 1 m. It may be that this sediment represents material deposited in the reservoir that formed following damming of the Gail and Gailitz Rivers by the rockslide in 1348. The isolated remnants of rockslide material southeast of Stop 1 (west of the Gailitz Valley) are best explained by an impounded reservoir. The condition of the blocks demonstrates that these deposits belong to the prehistoric event. They are roundish, weathered, and show grinding marks.

The second generation of deposits consists of multiple rockslide or rockfall masses that were triggered by the earthquake of 1348. These recent deposits, because of the high water permeability, show no soil formation. Consequently, they are only sparsely vegetated with small pines and other undemanding plants. The surface consists predominantly of larger rock blocks that are less weathered. In terms of their volumes, the historic rockslides in 1348 are smaller than the prehistoric event. These are, therefore, regarded as secondary rockslide events.

Failure mechanism of the Dobratsch Rockslides (after A. BRANDT).

Studies of rockslide kinematics at Dobratsch show that the processes are very complex. Structural measurements in the rockslide or rockfall source areas along the southern slope show that the discontinuities are characterised by divergent orientations (HUTSCHLER & BRANDT, 1981) (see Fig 6). The most common joint direction is broadly west-east and, therefore, the dominant detaching joints for rockfall processes follow the main fault system of “Gailtal-Störung”. Consequently, the majority of joints are more or less parallel to the southern slope and dip steeply to the S or SW. A subordinate north-south discontinuity feature is also present, which can be explained by young tectonic fractures that developed during the subsidence of the eastward Klagenfurt Basin.

The west-east tensile stresses have previously been recognised during an earlier phase of reverse faulting at Dobratsch, from south to north. Therefore, it is possible that these discontinuities were present prior to the rockslide. To summarise, the cause of the parallel fractures on the southern slope may be due to the following factors: (i) tensile strain vertical to the slope, (ii) unstable formations underlying the “Werfener Schichten”, and (iii) the Gailtal fault line.

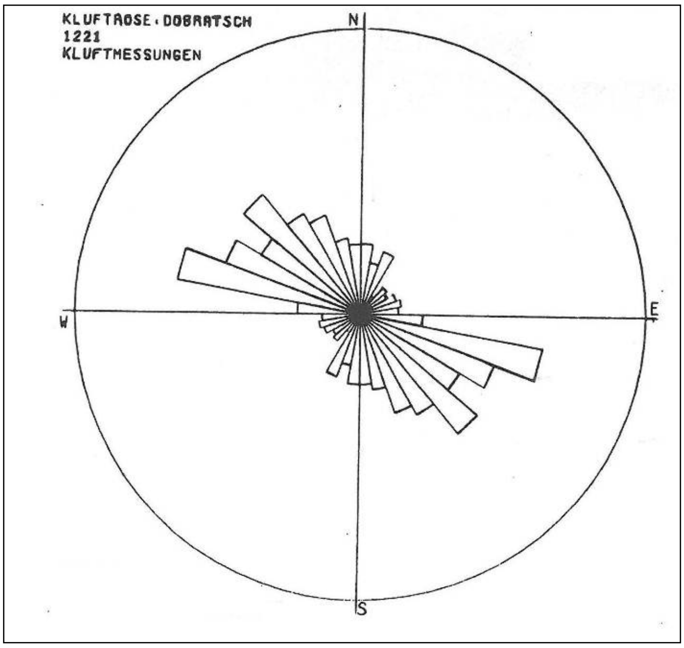

Figure 6: The distribution and dominant detachment joints in the area of the southern slope of Dobratsch (n: 1221) (after BRANDT, 1981).

In addition to the intense disintegration of the rock face by the Dobratsch reverse fault and the strong tectonic movements that occurred during the Alpine Orogeny, the instability caused by the marked joint system approximately parallel to the southern slope appears to be an important factor for the development of potential rockslides in this area.

On the way along the Villach Alpine Road from Villach-Möltschach (550 m asl) to Dobratsch, parking lot no. 11 "Rosstratte" (1,732 m asl), the excursion route passes the main scarps of the rockslide. A number of rest areas (parking lots) and information points along the road invite you to look to the face of the rockslide and to the deposit area, at the toe of the slope and in Gail Valley. For example, from parking lot No. 4 "Schuttblick" (1,020 m asl), we have an impressive view to the deposit area "Alte Schutt" as well as to the "Julische Alps" and to the "Karawanken".

Figure 7: (a) A view of the deposit area from parking lot No.4 "Schutt" and (b) from "Rote Wand" towards the southeast.

The second stop will be, if we have enough time, at parking lot No. 6 (1,400 m asl). From the observation deck "Rote Wand", we will have a view onto the main scarp of the largest historic rockslide in 1348.

The most pronounced fracture systems can be seen in the steep cliff, which has a height of 800 m, of "Rote Wand" (BRANDT, 1981). In the upper wall area there are frequent rock overhangs. At the top of the rock wall on the western flank of "Rote Wand" are deep tensional cracks; this area is associated with the largest rockslide to have occurred in 1348 ("Red Wall"). These cracks may have formed as a result of the unstable basement that comprises the gypsum-bearing sediments of "Werfener Schichten". The multiple sliding surfaces here are remarkable; all steeply inclined towards the south at around 50°. The slide planes are very smooth and usually have slickensides structures (see Fig. 8). It is believed, therefore, that the Gailtal fault line with its considerable amount of displacement and graben-like mechanism played a role that should not be underestimated.

On the southwestern part of the "Rote Wand" are rock towers that attain heights of over 100 m. These have been formed by vertical cracks (see Fig. 9). The strong earthquake of 25 January 1348 caused a subsequent rupture and later rockslide.

Figure 8: Outcrop on western part of the "Rote Wand". (a) The different discontinuities: red colours show the dominant joint plane; (b) A view of the slide plane, which is steeply inclined towards the south.

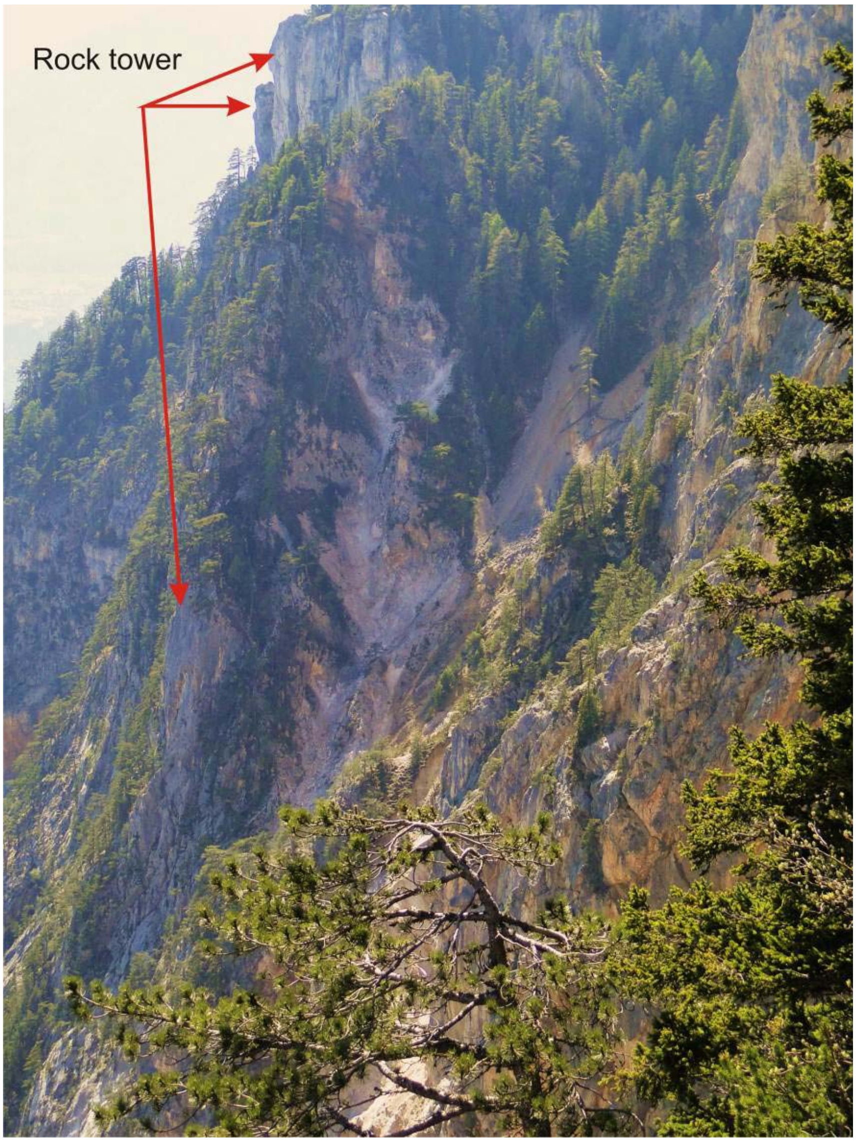

Figure 9: Rock towers forming on the west wall of the "Rote Wand"

The western flank of "Rote Wand" is also the area with the greatest potential for rockfall processes. It is expect that volumes may be up to 10 000 m³. The vertical rocky wall of the southern slope, with overhangs and wide, open, tensional cracks, has the greatest potential for rockfall processes. One example is the rockfall beneath Zwölfernock, which has a volume of about 5000 m³.

Figure 10: An overview of those areas with a high potential for rockfall processes (after BRANDT, 1981).

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