EXPLANATORY TEXT

GEOLOGY TRAIL

A journey at the base of a Triassic reef

Since the 19th century the Geology trail "Frötschbach / Rio Freddo" has been known for its spectacular geology. The trail leads from Bad Ratzes / Bagni di Razzes to the mountain hut Prossliner Schwaige / Malga Prossliner and ends at a scenic overview of the Schlern / Sciliar plateau. 240-Million-year-old Triassic rock layers count as peculiarities of the "Frötschbach / Rio Freddo" trail. These layers consist of a close juxtaposition of tropical reefs and deep marine basins. The prevailing rocks are characterized by a wide variety of colors and textures, mainly comprising sandstones, conglomerates, limestones, dolomites, basalts, and clays.
Five representative locations illustrate the remarkable geological history of these rock formations.

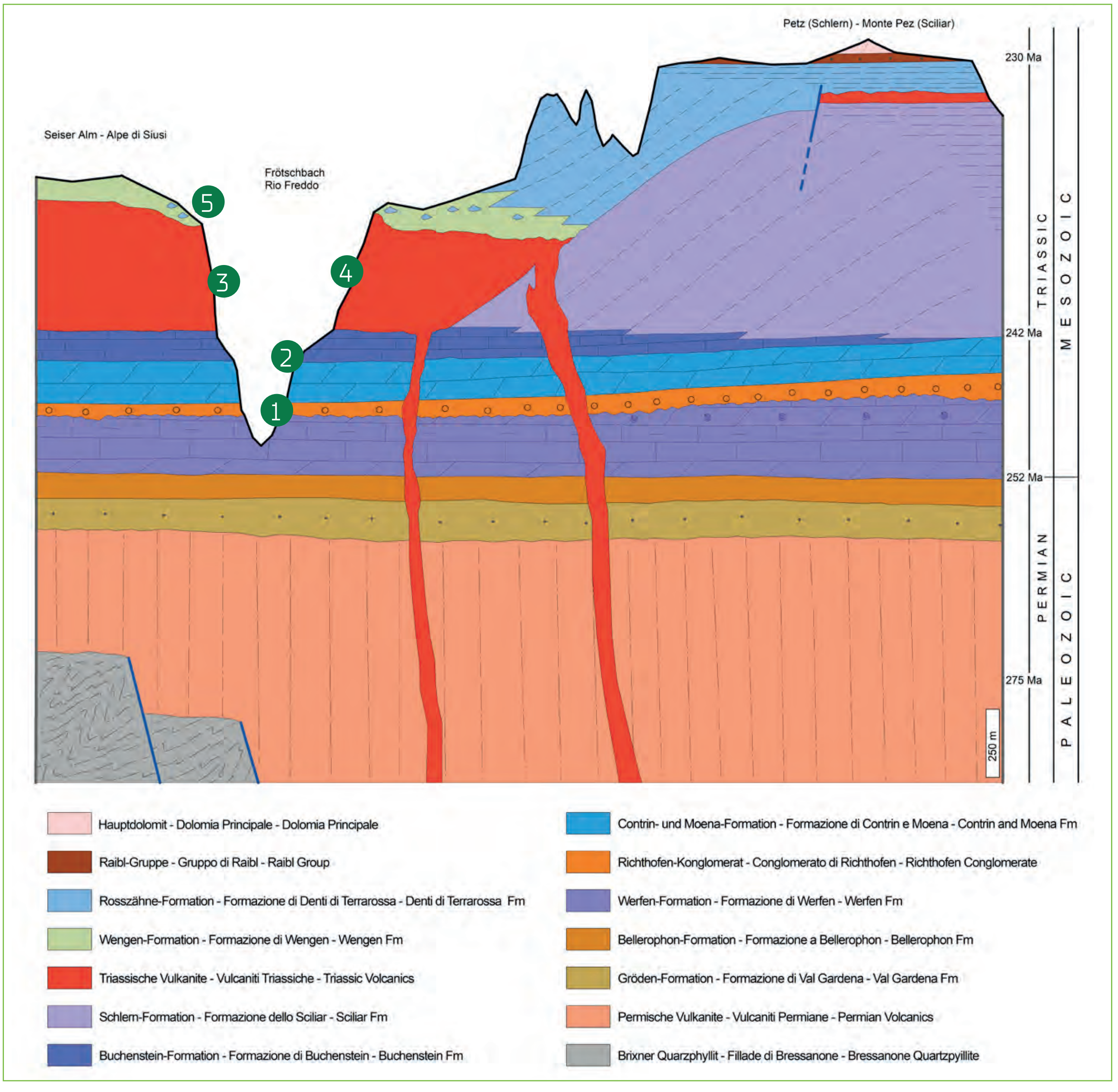
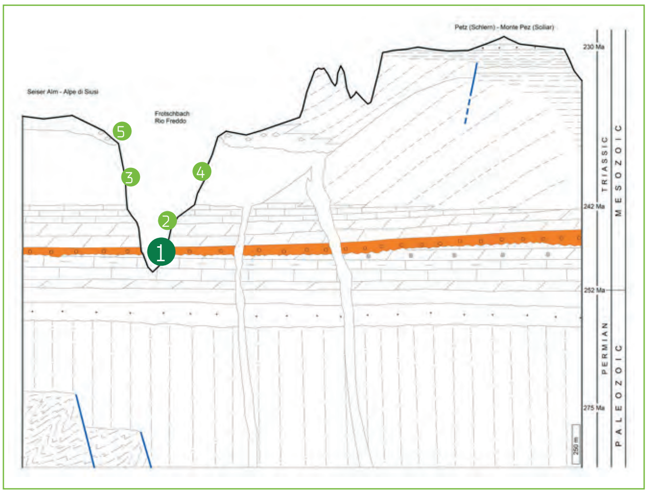


Fig. 1 – Simplified stratigraphic chart of the rock sequence covering the Alpe di Siusi-Sciliar area. The numbering indicates the position of the individual stops along the geologic trail. The corresponding time scale is laterally positioned.

1 The Richthofen-Conglomerate



Stratigraphic position of the stop

After leaving the starting point Bad Ratzes / Bad Razzes, the trail initially winds through the oldest strata of the Frötschbach / Rio Freddo Gorge that belong to the Werfen Formation. This formation comprises the first layers of clearly marine origin in the Dolomites, that have been deposited in an open coastal sea with water depths ranging from a few meters to a few tens of meters. The Werfen Formation is characterized by a rock sequence, whose color ranges from white, grey, yellow to red - depending on whether carbonate (limestone and dolomite) or sand and clay are predominant.

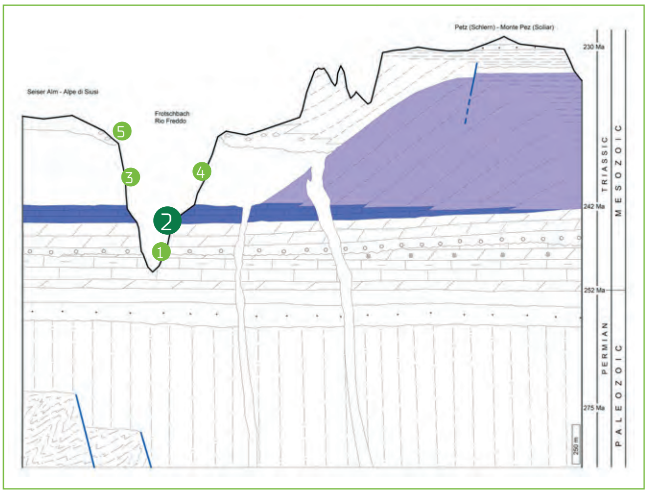
Arriving at display board no. 1, the overlying layers on the right above the path are clearly visible (Fig. 2). In the lower, vegetated area, a reddish rock unit stands out, which evolves into a well-stratified yellowish-grey sequence towards the top of the deposit. This sequence is overlain by a compact rock face of whitish dolomite, reaching a thickness of several tens of meters. The red-colored layers are defined as conglomerates - namely rocks that are composed of gravel and finer components.

The individual boulders mostly originate from the underlying (and consequently older) Werfen Formation, being subjected to transport and deposition by rivers and streams. Thus, these rock units mark a spectacular turning point in the Triassic marine landscape evolution: The former seabed was lifted to the surface, where activity of rivers and streams resulted in erosion of the strata and a gradual formation of the conglomerate. Subsequently, the superimposed layers were formed on the seabed, after being affected by tectonic activity.

This conglomerate's discovery and importance can be traced back to the famous geologist Ferdinand von Richthofen in the mid-19th century.

Fig. 2 – Layer sequence adjacent to the Geology trail at display board no. 1

2 The Buchenstein layers and the Sciliar Formation



Stratigraphic position of the stop

Between display board no. 1 and no.2, the trail crosses rock sequences that immediately outcrop on the right after display board no. 1. These sequences are identified as dolomitic rocks of the Contrin Formation, consisting of large, massive banks. A close look at the individual bank reveals indistinct laminated layers caused by the growth of algae - so-called stromatolites. These are easily comparable to similar structures on tidal flats of today's shallow low latitude shelf areas (e.g., Bahamas). The Contrin Formation is easily recognizable in many other places in the Dolomites. Specifically, the formation frequently appears in a 50- to 70-metre-thick coherent stack of layers consisting of white, compact rocks at the foot of the impressive dolomite walls. The Contrin Formation documents the development of the Dolomite Sea into a tropical archipelago, where the generation of the first biologically built reefs is traceable. In the meantime, the coastline has shifted far away to the west, causing that river loads (sandstones, silts and clays) no longer reach the depositional area. This implies that the formation of the first muds of purely carbonate nature can now form in this location, building up this approximately 70-metre-high cliff of dolomite.

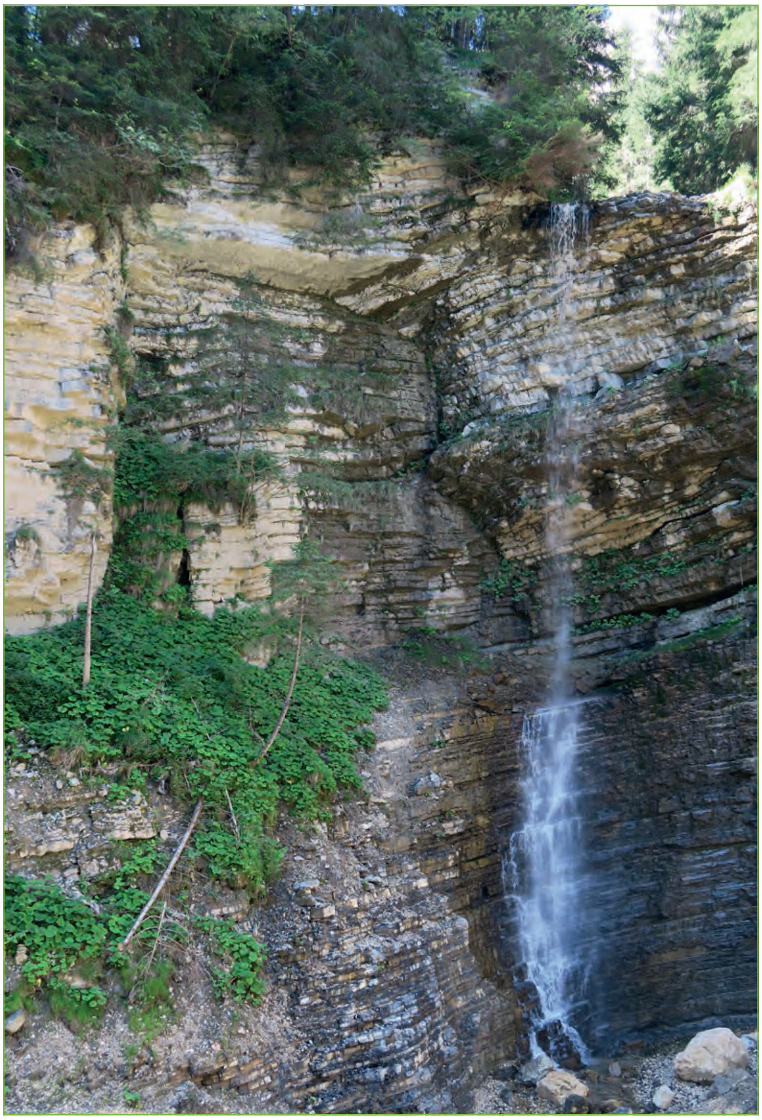


Fig. 3 – Buchenstein Formation at display board no. 2

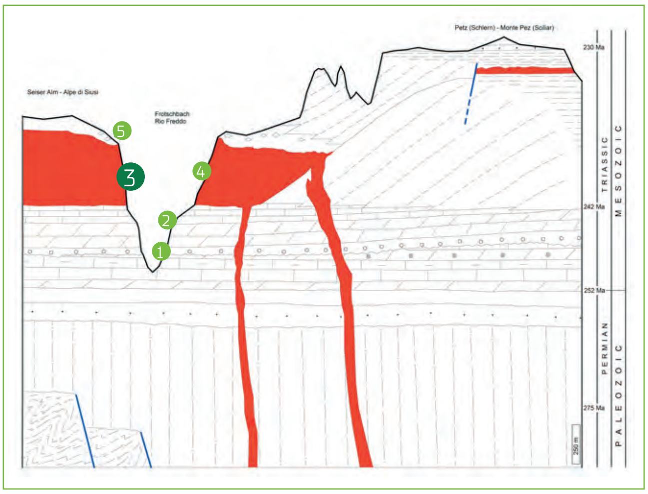
As soon as reaching display board no. 2, numerous centimeter-thick, whitish, stacked layers can directly be observed at the rock face of the waterfall (Fig. 3). Each of these individual limestone layers were slowly formed around 240 million years ago on the deep seabed at the foot of the Sciliar reef. Continuously, dead plankton and other fines, that were present in the warm seawater, trickled to the seabed until finally forming thin white layers. In between, chert (radiolarite) appears in form of harder, darker nodules. The original stratification was present in form of fine, laminted layers, that have subsequently been destroyed by the process of burrowing (bioturbation).

Between the calcareous layers, green ash or tufa layers (Pietra Verde) (Fig. 4) can sparsely be observed. Surprisingly, these layers originate from distant volcanic eruptions. They allow an exact dating of the entire sequence, that resembles the process of dating tree rings: in this precise location every meter covers about 45,000 years. Thus, the Buchenstein strata consist of a 70 m thick sequence that has been generated in over 3 million years. In contrast, the Sciliar reef in a few hundred meters of distance grew over 800 m in the same period! This implies that both the bioconstructed reef (Sciliar Formation) and the deep seabed (Buchenstein Formation) existed contemporarily in close vicinity. This spatial relationship is still perfectly preserved. The reef as a tropical island was connected to the deep seafloor on all sides by 30-40° steeply dipping reef slopes. Along these slopes, reef debris was gradually shifted towards the basin. As the reefs grew, so did these slopes, forming a series of coarse layers with a more or less constant angle of inclination. These layers are known as clinoforms.

Fig. 4 – Buchenstein Formation with an intercalated layer of „Pietra verde“ (see arrows)

3 Triassic vulcanites – Columnar basalt

Following the trial between display board no. 2 and 3, all the layers of the Buchenstein Formation are initially crossed. As soon as the path winds its way up the orographically right slope, the dark basaltic and andesitic lavas outcrop. They were generated by ancient submarine volcanic eruptions.



Stratigraphic position of the stop

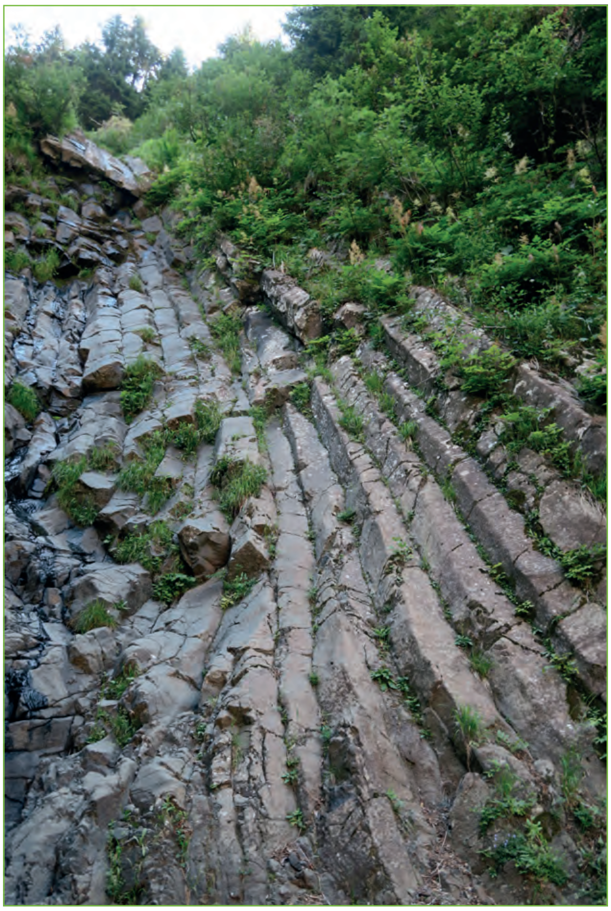
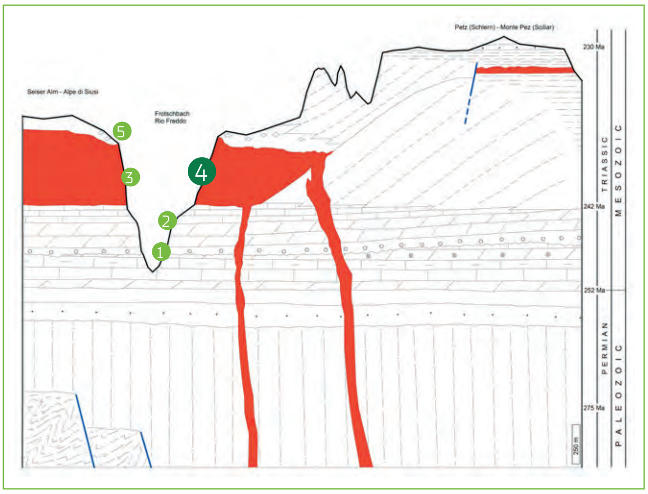


Fig. 5 – Sea-formed andesitic lavas, exhibiting typical columnar shapes generated by cooling.

In this precise location, the erosion of the Frötschbach / Rio Freddo stream allows a glimpse into the interior of a lava flow. The evenly distributed black rock units appear in 5-or 6-cornered columns. They were formed as the result of the slow cooling process of the lava (Fig. 5). After the eruption, the molten rock slowly contracted during the initial stage of the cooling process. Subsequently, singular fissures formed on the surface resembling dry cracks in muddy soil. These fissures deeply penetrated the rock, until finally obtaining columnar shapes with increasing depth.
The appearance of volcanoes during the Upper Ladin period (238 million years ago) brought drastic changes to the tropical landscape: the lush growth of the reefs was severely disrupted and stopped.

4 Volcanic eruptions in the sea – pillow lava

Many rock outcrops in the Dolomites, that bear Triassic lavas, are characterized by the occurrence of ellipsoidal spheres with diameters of up to one meter (Figs. 6 and 7). These characteristic structures are defined as pillow lava and are present in many other areas of the Earth: they are formed when glowing lava abruptly encounters cooling water. Thus, their presence confirms that the former eruptions must have taken place on the seabed.
From the stopping point of display board no. 4, these pillow lavas are observable in the rock face on the opposite side of the stream. On closer inspection, one can also make out several tens of meters long floes on both slopes, which consist of fragments of the underlying Buchenstein Formation.



Stratigraphic position of the stop

However, these floes are embedded in the lava layers. They were literally torn out of their original position by the rising magma and transported upwards.
The geological investigations carried out in this area have made it possible to reconstruct the presence of a large submarine volcanic body in the Schlern/Alpe di Siusi area. However, only a small fraction of the original rocks is nowadays preserved.

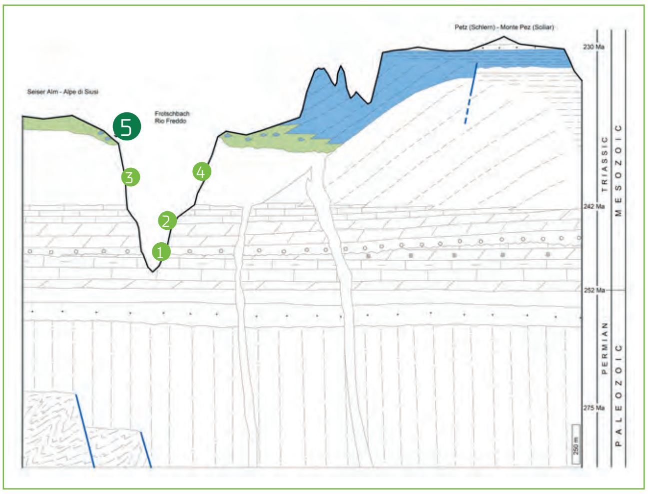
Fig. 6 – Andesitic lavas with characteristic pillow structures. In the lower right corner, parts of a huge floes of Buchenstein layers, being embedded in the lava, are visible.

Fig. 7 – Detailed view of a pillow. Note the white limestone areas, which originate from the seabed, being embedded in the spandrels between the pillows.

5 From the coral reef to the sea floor: the Cipit blocks

Between panels no. 4 and 5, the trail mainly runs within Ladin lavas. With one last effort we leave the gorge: before reaching the mountain hut Prossliner Schwaige / Malga Prossliner, the vastness of the landscape suddenly opens before our eyes: To the north, the Alpe di Siusi stretches out, while to the south, the former Triassic reef of the Schlern / Sciliar massif appears in all its glory. With a little imagination we can trace the former sea level above our heads. Besides the beauty of the landscape, the visitor appreciates the geological peculiarities of the Frötschbach / Rio Freddo Geology Trail, as taking part in a journey at the base of a fossilized tropical reef.

Past the Prossliner Schwaige, the path leads to the upper part of the stream (Cipit creek), which here, however, no longer flows in a furrowed gorge as it does further down in the valley.



Stratigraphic position of the stop

Fig. 8 – Well layered sequence at the base of the Wengen Formation.

As soon as we arrive at display board no. 6, the highest areas of the Ladin lavas are present under our feet, while well-layered dark-colored strata can be observed on the flanks of the stream (Fig. 8). These layers testify the presence of the first marine sedimentary deposit after volcanoes had become extinct. The dark color of the rock is attributable to volcanic components that were increasingly reworked by the decay of the volcanic buildings. These sequences are known as the Wengen Formation and consist of dark, volcanoclastic sandstones and marls, alternating with limestone layers, that are rich in fossils.

The "Cipit blocks" are noted as a special feature of the Wengen Formation. They appear as meter-sized limestone blocks (Cipit) that are embedded in the strata (Fig. 9). These blocks count as witnesses to former submarine landslides in which parts of the reef broke off, slid down the slope and finally came to rest in the mud of the seabed. Thereby, large blocks from the reef slope slid into the Wengen Formation and were spared from later dolomitization. Thus, well-preserved reef fossils are present, partly in their original composition of aragonite.

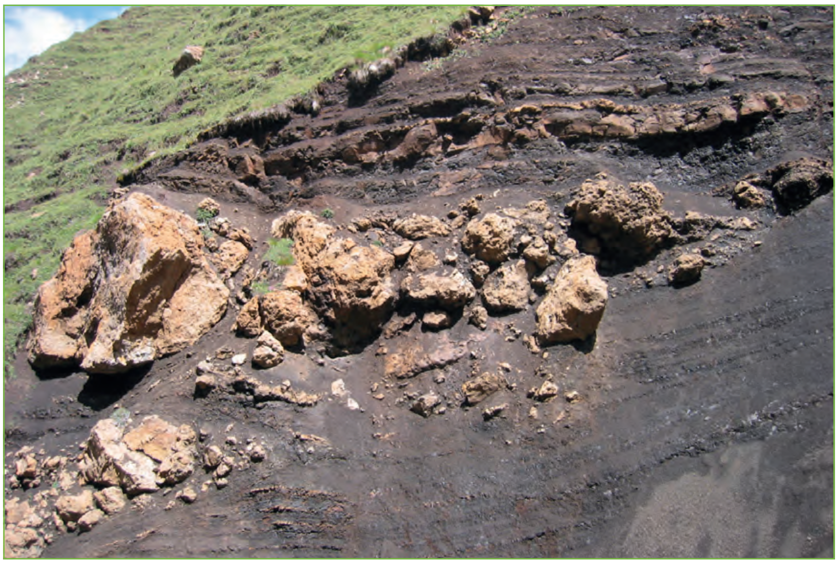


Fig. 9 – Cipit blocks (light-coloured limestones) embedded in the dark layers of the seabed (Wengen Formation).

The demonstrable and clearly visible primary emplacement of the blocks, that slid into the basin sediments, made this location (Cipit creek) world-famous. For this reason, the term "Cipit blocks" has entered the scientific literature.

But let's take another step back: due to strong volcanic activity organisms in the Dolomite region were almost extinct, resulting in the end of marine bioproduction. Likewise, the depositional process on the volcanic rocks was stopped for a long time. Slowly, however, life returned, organisms settled again, multiplied and the reefs grew again bearing real corals for the first time in history. A closer look in the direction of the Rosszähne / Denti di Terra Rossa reveals this development: the dark basin sediments of the Wengen Formation interlock with the steeply dipping layers of the reef slope of the post-volcanic Denti di Terra Rossa Formation (Fig. 10).

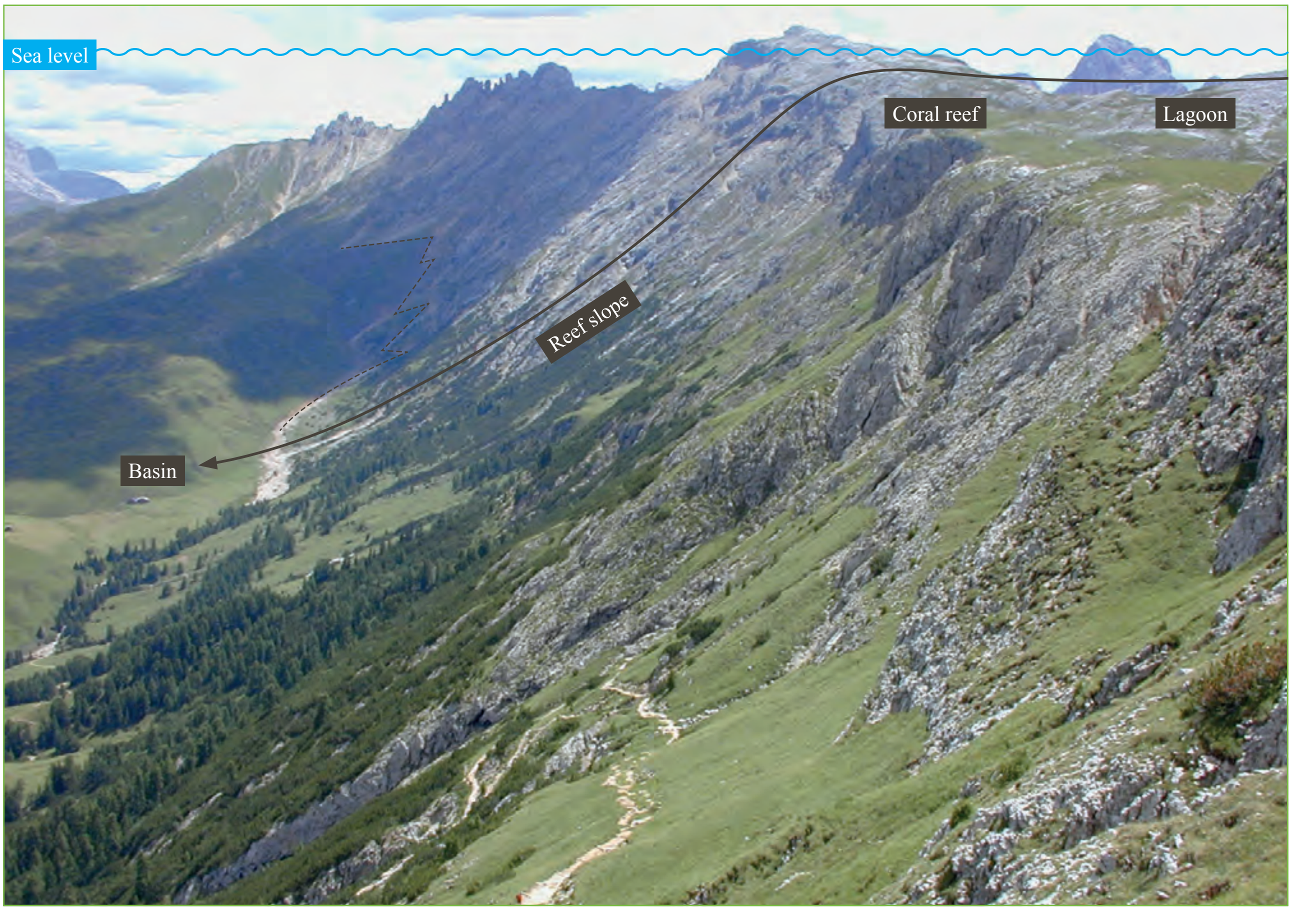


Fig. 10 – Overview towards the Denti di Terra Rossa, where all the elements of the coral reef and the adjacent seabed are perfectly preserved.

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This explanatory text is intended as accompanying material for the Geology Trail in Seis / Siusi. The trail starts in Bad Ratzes / Bagni di Razzes and leads along the Frötschbach / Rio Freddo stream to the Seiser Alm / Alpe di Siusi area. Further information on the topic can also be found at the Nature Park Visitor Center in Seis / Siusi.

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