Geology of System 5

Northern Dolomites

All the pages of the book of rocks – An uninterrupted story

This area is the most extensive of the UNESCO Dolomite systems. Here there is the widest range of rocks formed in the most continuous sequence. These mountains tell of the environments that succeeded one another over a period of over 270 million years, from the metamorphic base of the Palaeozoic era, over 300 million years ago, to the Tertiary, Oligocene-Miocene era of 30 million years ago that produced the outcrops on Monte Parei. This can be divided into three sections: Dolomiti di Sesto, Tre Cime and Dolomiti Cadorine, Settsass, Fanes, Sennes, Braies and Dolomiti Ampezzane.

Dolomiti di Sesto/Tre Cime and Dolomiti Cadorine

In the Sesto valley and Val Pusteria the sequence of Permian rocks tells the story of the erosion of the ancient Hercynian mountain range, Sexten conglomerate rock. The eroded material was carried down to a desert plain crossed by short-lived rivers, Val Gardena sandstone. Here are the fossilised remains of the first Dolomite sea that lapped at the coastal strips creating lagoons in a dry climate, the Bellerophon formation. The sea then invaded the entire area and, over a period of several million years it advanced and retreated in cycles, the Werfen formation.

In the Sesto and Cadore Dolomites rocks are preserved that recount the various stages in the evolution of the Triassic archipelago. The amazing temporal continuity of these specimens indicates that they suffered little disturbance from the volcanic activity of the mid-Triassic period. This area features a basal slab formed from the joining together of a number of fossil islands from the Anisian to the Carnian eras. This was followed by the extensive high plateaux of the rock that filled in the Carnian sea, leading to the disappearance of the Triassic archipelago, the Helingkreuz and Travenanzes formations. The various generations of islands and reefs are preserved in their original three-dimensional form.

The Ladinian island was extremely resilient and enabled some of the most famous peaks to take shape, among them Croda Rossa di Sesto, Cima

Undici, Monte Popera, Cima Bagni, Cima Una, Punta dei Tre Scarperi, Rocca dei Baranci, Croda dei Baranci and Marmarole).

The Picco di Vallandro area provides an excellent view of the geometry of the steep slope of the Carnian fossil island and of the relationship between this and the deep-sea deposits. Prato Piazza and Alpe di Specie are areas that have yielded significant fossil remains capable of painting a detailed picture of some of the fauna responsible for the growth of the Carnian islands.

The dizzying vertical rock faces, carved in Main Dolomite rock, of some of the most imposing peaks, such as Tre Cime di Lavaredo, Monte Paterno and Croda dei Toni, are formed from the residue of the great tidal plain established at the end of the Triassic period. The southern part, the Cadore Dolomites, display the geometry of the Carnian islands, clearly relating the stages in the disappearance of the Triassic Dolomite archipelago. Some footprints of theropod dinosaurs and fossil amber have been found in the HelingKreuz and Travenanzes formations of these rocks.

Finally, to the south of Val Ansiei (Marmarole, Croda Marcora, Sorapiss and Antelao peaks), it is possible to see rocks that tell of a massive tidal plain of Main Dolomite and of its gradual sinking that began at the end of the Triassic period, evident in Dachstein limestone, and continued in the Jurassic period.

Geomorphology

The most interesting geomorphological features in the Sesto/Tre Cime area are the great plateaux, Piani di Lavaredo and Piani di Cengia, the ledges and balconies that formed on the roof of the Dolomites, evidence of the Ladinian-Carnian islands, whose softer rocks contributed to the disappearance of the Dolomite archipelago. These plateaux form the base for the monumental towers, the Tre Cime di Lavaredo, Torre Toblin, Torre dei Tre Scarperi, the jagged crests of Croda de Toni and Monte Paterno, all carved in even layers out the Main Dolomite rock.

The dense network of faults and subvertical fractures that cut cleanly through the strata are responsible for the steps that appear in the plateaux, for all the spires and pinnacles crowding this place and for the geometry of the pinnacles, rock walls and the deep valleys running in straight lines radiating out from the plateaux (Val Fiscalina, Val di Campo di Dentro, Val Popena, Val Giralba, Val Marzon, Val de Ambata, etc.).

There are plenty of features caused by erosion and glacial deposits, such as cirques, sheepbacks, hanging valleys, banks of moraine and erratics from the late glacial age.

There is an abundance of Alpine lakes whose iridescent waters occupy the glacial depressions formed at the centre of cirques, for example Alta Val Giralba, Piani di Cengia and Laghi di Lavaredo. Two small snowfield glaciers still exist today at the foot of the eastern wall of Cima Undici. The constant freezing and thawing processes that afflict the walls lead to the formation of extensive debris fields and cones at the foot of the rock walls (Tre Cime, Tre Scarperi, Croda de Toni, etc.), also a source of debris, for example in Val Marzon.

Rock falls and collapses are common sources of landslides, such as the one in 2007 in Val Fiscalina, which was large enough to attract considerable media attention.

In the Cadore Dolomites the major thrust faults and folds running E-W, generated by movements in the crust, determine the main layout of the landscape. The marked asymmetry of the Marmarole and Antelao peaks, with their sheer southern faces can be attributed to the general northern inclination of the rock strata. Notable pinnacles isolated by faults are La Torre Sabbioni (Croda Marcora) and Il Pupo (Marmarole).

The northern slopes of the Antealo, Sorapiss and Marmarole peaks have been subject to karst and glaciokarst processes capable of enlarging the caves within the imposing banks of grey limestone. Many of the slopes are home to morphological features that are clearly the result of glaciation and can be traced back to the late glacial period and the little ice age. These include the hanging valleys and cirques of Sorapiss and Marmarole with their associated frontal moraines, sheepbacks and striations. Lakes such as Lago Vandelli, waterfalls and gorges are unique features of the Dolomite landscape. Two glaciers, an upper and lower one, still exist on Mount Antelao, although these are in rapid retreat. The large quantity of debris produced by the freezing and thawing process creates rapid debris flows that fan out extensively when they fall to the valley floor, as can be seen in Val Boite, Valle Ansiei and Val d'Oten. The Acquabona, Chiappuzza and, above all, the Cancia debris flows are much feared since they frequently hit the road infrastructure and people's homes resulting in deaths as recently as 2009. The high-energy forces at work in the landscape are responsible for the rock falls, collapses and landslides. Massive rock avalanches occurred in 1730 on the western face of Croda Marcora and on Mount Antelao in 1814, burying the villages of Chiappuzza, Taulen and Marceana, costing a total of 366 lives.

Settsass

This area merits separate treatment given its historic and scientific importance. The organic origin of the carbonate platforms found in many of the Dolomite mountain ranges was first postulated here.

The rocky outcrops around Settsass have always been much studied for their regular sections and the wealth of paleontological evidence. The micro and macro fossils found here can be precisely dated, providing great insight into the Carnian period in particular. This area is home to a Global Boundary Stratotype Section and Point (GSSP) among the rocks of Prati di Stuores, marking the beginning of the Carnian era, 228 million years ago. Another interesting feature is the perfectly preserved aborted reef, Piccolo Settsass- Richthofen Reef, at the base of the Settsass cliff face.

Fanes, Sennes, Braies e Dolomiti Ampezzane

This area is one of the most evocative Dolomite landscapes in which the sequence of rocks, over 3,000 metres thick, covers a period from 270 million to 25 million years ago. Here the mountains tell the story of the Triassic archipelago, providing insights into the geometry of the islands with their inner lagoons and the relationship between the islands and the deep-sea sediments that surround them. The Braies/Pra della Vacca area is of major scientific importance for the outcrops of Anisian rocks from the deep sea and continental basins due to the erosion of landmasses that had emerged. These are a treasure trove of fossils with the remains of plants, fish, metazoans, ammonites, reptiles, etc.

The Lagazuoi, Col dei Bos and Tofane area contains continuous layers of rocks that make it possible to reconstruct the Carnian environments and that document the end of the Dolomite archipelago. Fossil amber containing some of the oldest insects and mites ever studied have been found among these layers, in the Heilingkreuz formation. Among the other finds are dinosaur footprints and the skull of a stegocephalian amphibian.

The Fanes and Sennes areas feature extensive plateaux, their contours modelled from calcareous rocks of the late Triassic and Jurassic/Cretaceous periods. In this part of the Dolomites it is possible to trace the terminal phase in their marine history, marked by the transition from a widespread shallow sea to a deep pelagic seabed gradually filling up, subsequently to be raised up by the beginning of the Alpine collision.

The youngest of the Dolomite rocks, formed 25 million years ago, are found here, in Monte Parei and Col Bechei, and a study of these shows how, before their complete emergence from the sea, the Dolomites still retained the residue of that sea with scattered areas of raised land, the Alpine foothills,

with a rugged coastline that sometimes took the form of steep cliffs towering over the sea.

Geomorphology

The geomorphology of this area reflects the structural set-up of the rocky mass, more or less folded into a valley basin. The landscape in the central part is dominated by the plateaux of Fanes and Sennes, with outcrops of calcareous limestone and younger marly rocks of the Jurassic-Tertiary period, while the peripheral areas contain mainly isolated massifs, ridges and rugged mountain chains, such as Settsass, Tofane, Croda Rossa d'Ampezzo, Monte Cristallo, Picco di Vallandro, Sasso del Signore and Monti Muro, sculpted from the varied and complex sequence of rocks produced during the mid and late Triassic period.

The orientation of all the deep valleys that run across this area is dependent upon a complex network of thrust faults, in the Val Foresta, Valle di Braies Vecchia, Val di Fanes Grande, Val Padeon, etc., and sub-vertical faults, in the Val Boite, Val di Travenanzes, Val di Rudo, Valle di Fanes, Vallon Bianco, Val Salata, etc., some of which are still active. The prism-like geometry of the towering Principal Dolomite ramparts of mounts Cristallo and Tofane reflects the lay-out of the tectonic fractures. Examples of this are planar forms or shallow inclines such as ledges, balconies and small plateaux formed by selective erosion occurring where the lithological variation within the sequence is most marked.

The Fanes and Sennes plateaux are home to the most complete array of karst and glacio-karst phenomena in the whole of the Dolomites, both on the surface and underground. Lakes such as Lago Grande di Fosses, Lago Secco di Fanes Piccola and Lago di Limo sit on depressions of glacio-karst origin. There are widespread glacial morphologies including hanging valleys, cirques, step formations and sheepbacks. Less evident are the late-glacial and Little Ice Age banks of moraine that embellish the contours at higher altitudes. Lobes of moraine led to the formation of some lakes such as Lago Paron and Lago di Misurina. A glacial deposit, Col Bechei, has been discovered in the Fanes area and, in Limo Pass, there are conglomerates that precede the last Ice Age. Small glaciers are still active on mounts Cristallo and Croda Rossa d'Ampezzo.

Extensive debris fields and cones border the foot of the vertical walls, particular those made of Principal Dolomite rock, of mounts Tofane, Cristallo, Conturines and Croda del Becco. In the area of Braies, in Armentarola and in Ru da Voi, these deposits feed major debris flows. The eastern slopes of Croda Rossa d'Ampezzo contain significant active rock-glacier cirques, the subject of much research. Landslides due to collapse

and landslips along a stratum are most common in this part of the Dolomites. At the beginning of the late Glacial and early Holocene periods, major rock avalanches occurred, one of them damming the Valle di Braies thus forming the lake of the same name.

Text by Dolomiti Project Srl