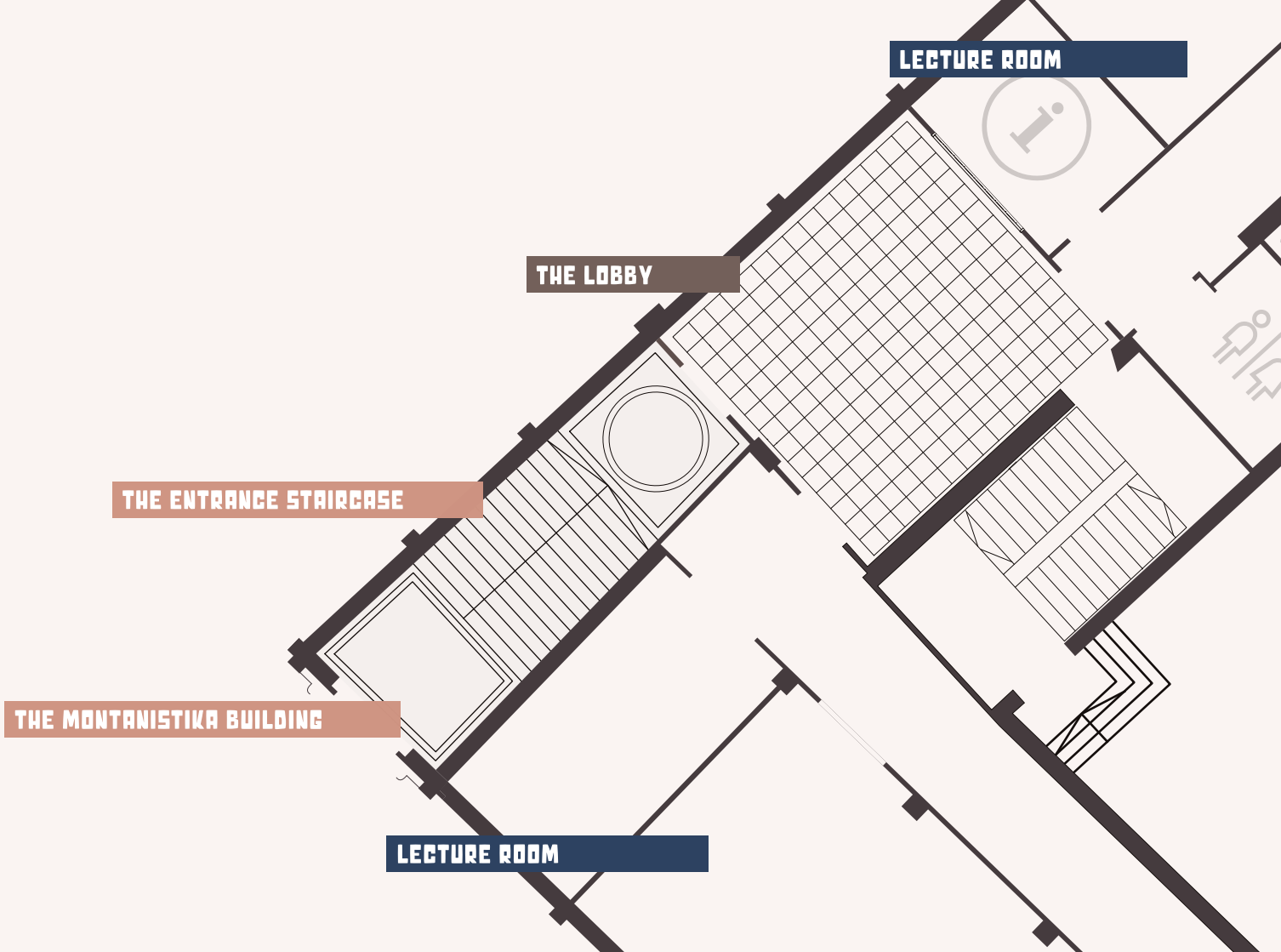
THE NATURAL STONE OF MONTANISTIKA

A guide through the natural stone of the Faculty of Natural Sciences and Engineering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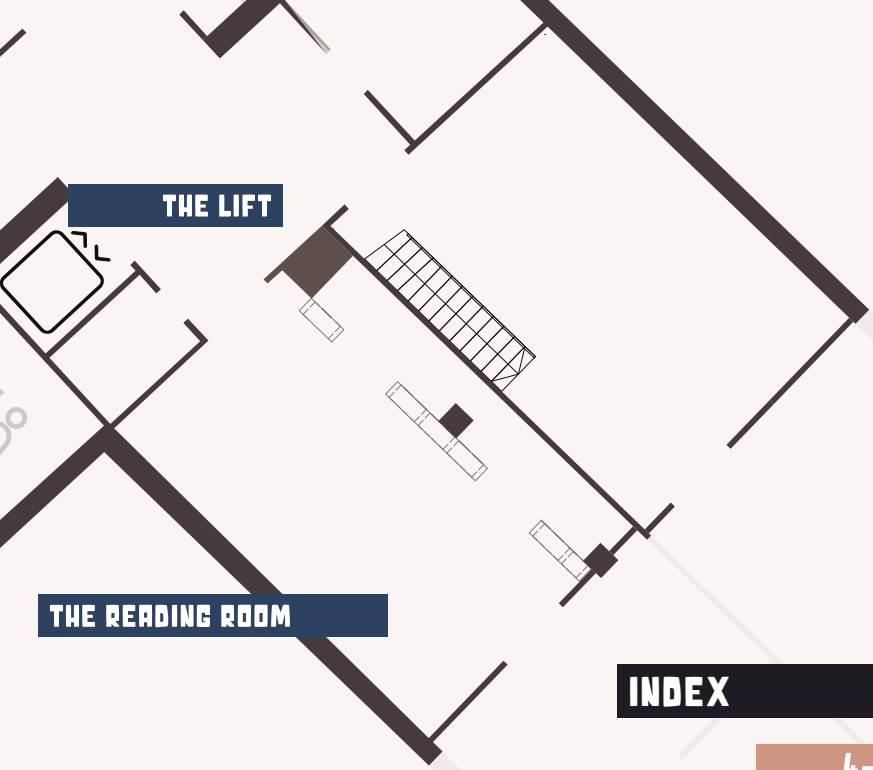

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THE MONTANISTIKA BUILDING

The Montanistika building was designed in 1937 by architect France Tomažič. The two hammers above the entrance indicate the meaning of the word montanistika, which derives from the Latin word for mountain (mons). Montanistics is the science of ores and mining and develops knowledge about the extraction of minerals from the Earth's crust. Today, the building houses the Department of Geology of the Faculty of Natural Sciences and Engineering, University of Ljubljana.

The building interior is decorated with some of the most beautiful architectural stones from Slovenia, joined by a few stones from the area of the former Yugoslavia, while two of the recently installed stones are of foreign origin. The stones used are also interesting because together they represent all three basic rock types. Sedimentary rocks are represented by

a variety of different limestones, metamorphic rocks by marble, and igneous stones by four varieties of plutonic rocks, among which the Pohorje cizlakite is certainly the most beautiful. We invite you to come in and discover the secrets hidden in the stones of Montanistika.

THE ENTRANCE STAIRCASE

Sedimentary rocks

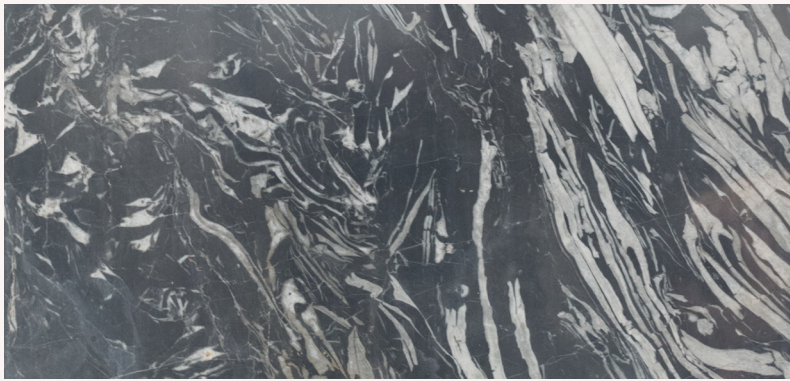
Sedimentary rocks are formed by the lithification of sediment that consists of accumulated sedimentary grains. Such accumulations occur when wind, water or gravity can no longer move the grains. This usually occurs at the foot of glaciers, in river valleys, in lakes, deserts, and especially in the world's seas and oceans. Sedimentary grains are formed in two ways. The first way is by the weathering and erosion of older rocks. The rock formed from such grains is called clastic sedimentary rock. In the second, sedimentary grains are formed by precipitation directly from the water solution. Such rocks are called chemical sedimentary rocks. Most of these grains are skeletons of various organisms (e.g. seashells), therefore such rocks are called biochemical sedimentary rocks. Mineralised skeletons consist almost entirely of calcium carbonate (mineral calcite or aragonite). When such a sediment lithifies, a rock called limestone is formed. If the skeletons are preserved, we can see them in the limestone as fossils, but if they are crushed they form fine-grained calcite mud, which gives the limestone a monotonous, usually grey appearance. As life throughout geological history has constantly changed and evolved, the fossil species found in a particular limestone depends primarily on its age.

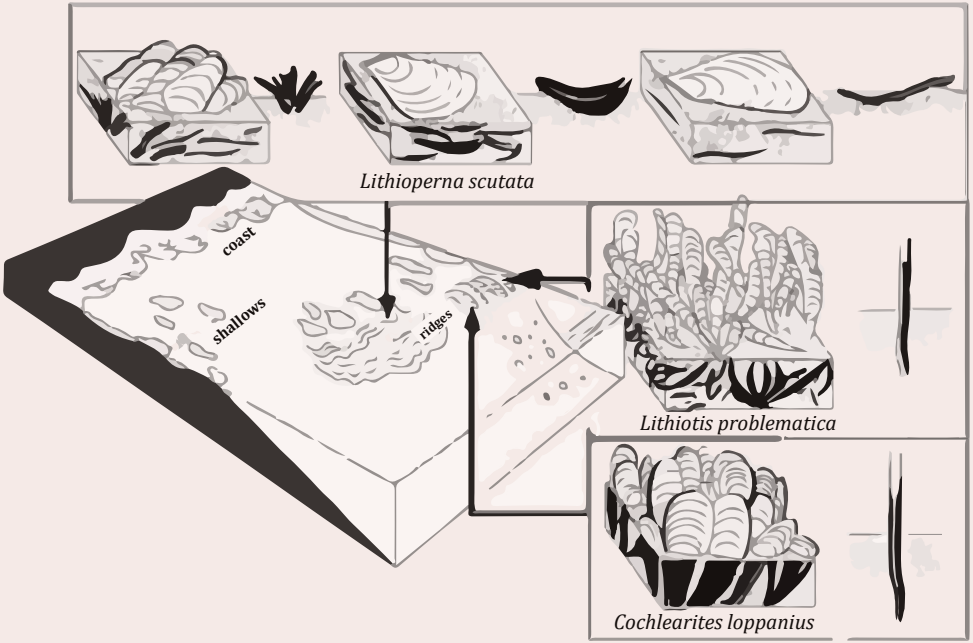
Sedimenary rocks of Montanistika

Limestones are very common and picturesque rocks in Slovenia. They include all of the examples of sedimentary rocks that are used as architectural stone in the Montanistika building. On the walls of the entrance staircase we find Jurassic limestone containing large lithiotid shells. Most of the floor slabs, stairs and other wall panels are fashioned from Cretaceous limestone, which is characterized by horn-like rudist shells.

Lithiotid limestone

On the walls of the entrance staircase the first thing we notice are black panels with long white stripes, which are cross-sections of lithiotid shells. Lithiotids are an extinct group of sesashells, most of which lived anchored in the muddy seabed and, together with their shape, are reminiscent of today's noble pen shells. They lived only in the middle part of the Early Jurassic, about 180–190 million years ago. The easiest to recognize are the long, thin, uneven longitudinal sections of the genera *Lithiotis* and *Cochlearites*, but we also see the short transverse sections and shorter sections of other genera.





Lithiotid seashells lived in tropical, shallow lagoons at the margins of the Tethys Ocean. The environment we call the Dinaric (sometimes Adriatic) carbonate platform resembled the present-day Bahamas. It is an extensive shallow sea, an almost flat platform, with fairly steep bends that merge into the surrounding deeper sea. Lithiotid seashells inhabited extensive shallow-water lawns and sometimes formed smaller reefs. Today, limestone with lithiotids can be found all along the entire Outer Dinarides (former Dinaric carbonate platform) from Trnovski gozd through central Slovenia all the way to Montenegro.

Adapted from Fraser et al., 2004

Podpeč limestone

All of the wall panels of the entrance staircase, even if they differ greatly from each other, were made from stone extracted from the same quarry in Podpeč, a good 10 km southwest of the centre of Ljubljana. The most picturesque, recognizable and appreciated variety is certainly limestone with lithiotids. In addition, on the walls we can see plates with other fossils, especially snails, brachiopods, sponges, tiny foraminifers and heart-shaped seashells. Ooid limestones are also visible. Ooids are very small, spherical grains with smooth surfaces that bear some resemblance to fish roe (fish eggs). With a magnifying lens you can often see in their cross-section that they are formed by concentric envelopes. They are formed by direct excretion from warm and turbulent shallow seawater. The other interesting grains are oncoids. They are lumpy grains up to a few centimetres in size with irregularly shaped concentric coatings. They are formed when a sedimentary grain or shell is overgrown with a slimy coating of cyanobacteria to which tiny carbonate silt adheres. Since the oncoids are constantly rolling, they take on an almost spherical shape with ever new layers. Several stone slabs are cut by brownish jagged lines, so-called stylolite seams. They form after the sediment has hardened into limestone with further compression. Since limestone cannot withstand high pressure, it begins to dissolve along the jagged surfaces, and the residues of insoluble minerals (e.g. clay minerals, pyrite and various oxides) contained in it remain accumulated in the seam, giving it a brownish colour.

The stairs of the entrance staircase are not made of Podpeč limestone. We will come back to the light grey limestone of the stairs a little later.

Podpeč quarry of Roman Emona and modern Ljubljana

Podpeč limestone was already quarried by the ancient Romans in the 2nd century. The stone blocks were transported along the Ljubljanica river and used to build Emona. Today we can see them in the remains of the Roman wall. After the decline of the Roman state, interest in the stone from

Podpeč dried up. Only at the end of the 18th and into the 19th century did stonemasonry workshops reappear there. After the devastating Ljubljana earthquake of 1895, a huge amount of the limestone from Podpeč was used to produce the lime needed for the reconstruction of the city. The most beautiful monument to the Podpeč limestone was designed by architect Jože Plečnik in the National and University Library. There, the variants of Podpeč limestones with beautiful lithiotids are responsible for the monumental appearance of the inner columnar staircase and the large central lobby. Limestone from Podpeč can also be found in the ground floor lobby of Nebotičnik (Ljubljana Skyscraper), on the outer staircase and in the inner arcade courtyard of Ljubljana's City Hall, in the Slovenian Parliament, and in the fountain in Zvezda Park.

THE LOBBY

Rudist limestone

The most frequently used architectural stone in the Montanistika building is the various types of rudist limestone. As its name suggests, it consists of whole or partially crushed rudist seashells. These were typical inhabitants of the shallow seas during the Cretaceous period. However, the most varied, most beautifully ornamented, and largest species lived during the Late Cretaceous 65 to 100 million years ago. Rudist seashells have one shell that is larger and elongated in the shape of a horn, while the other shell is smaller and serves only as a cap. They became extinct at the end of the Mesozoic, together with the dinosaurs and ammonites in the course of the mass extinction caused by the asteroid that fell on the area of the present-day Yucatan Peninsula in the Gulf of Mexico.

Like lithiotids, rudist seashells lived in the shallow marine environment of the Dinaric carbonate platform. They occur in the Cretaceous strata, which are mainly exposed in the coastal parts of the present-day Dinaric mountains. In Slovenia, they are mainly characteristic of the Kras, where most of the varieties of rudist limestone we see in the Montanistika building originate. Towards the south, rudist limestones occur along the entire coast of the Adriatic Sea and also form many islands. The wall panels in Montanistika come from the Dalmatian island of Brač, in Croatia. The rudist limestones of Montanistika differ mainly in colour and in the preservation of the rudist shells. This spectrum is due to the very different shallow marine environments in which they were formed. Dark variants with beautifully preserved fossils formed in the quiet parts of the platform, i.e. in the lagoons. The lighter ones are mainly characteristic of the marginal, more exposed parts, on which more robust rudist seashells have grown, forming large thickets. Although they were firmer and more robust, most were severely crushed, often to the point of unrecognizable rubble.

Rasotica limestone

The architectural stone from Brač, which lines the walls of Montanistika, is known as Rasotica. It is adorned with a spectrum of brown colours and many beautifully preserved light ochre rudist shells, which are preserved in this limestone – and we can see that the larger shells were attached to or anchored in the seabed. Rudist seashells usually lived in groups in which they supported each other, or where younger specimens lived attached to older ones. If there are only a few specimens in such a group we call it a bouquet; if there are several, it is a cluster; but if there are many, the group is called a thicket. The fossils are beautifully preserved, indicating that the environment in which the limestone formed was quiet, most likely a peaceful lagoon inhabited by snails, bryozoans, hydrozoans, foraminifers, crinoids, and even rare corals.

Kazlje limestone

In the Montanistika, the wall panels under the reception room, the dark floor panels in the lobby, the side panels of the stairs leading up to the higher floors, and the blocks on the staircase turners are all made of typically dark Kazlje limestone. It is also found in the railing posts on the staircase, in the base of the statue on the first floor, and under the benches. The entrance portal of the building is also made of this limestone, where the rock surface is already heavily weathered and therefore light grey in colour.

The dark limestones that were quarried near the villages of Avber and Kazlje are decorated with very well preserved rudist shells. These limestones were formed in closed lagoons or at their edges. Due to the calm lagoon sedimentation the fossil remains are beautifully preserved. In addition, a lot of organic matter has been preserved in the sediment, which is finely dispersed among the sedimentary grains. It is this admixture that gives the Kazlje limestone (as well as the Rasotica from Brač) its characteristic dark colour.

Repen limestone

The entrance staircase of the Montanistika leading to the lobby is made of Repen limestone. It was quarried at Repentabor in northeastern Italy and on the Slovenian side of the border in the quarries of Dolina near Vrhovlje, Povir, Lisično, Vitez and Polževo. Today, only the first two quarries are still active. This limestone is light grey. It consists of lighter thick-shelled rudists and a darker matrix of rudist debris. It formed at the edge of the platform in the immediate vicinity of extensive rudistic thickets, which adorned the folds of the platform leading into the deeper sea. As these areas were exposed to strong waves and storms, most rudist shells were crushed, but the more robust and resilient shells of the rudists belonging to the Caprinidae family were preserved.

Kopriva limestone

In Montanistika, light grey slabs paving the floor of the lobby and the stairs leading to the higher floors are made of Kopriva limestone. It was named after the village of Kopriva, where it was cut in an old quarry that is now a site of national importance. It was also cut near Gabrovica and Pliskovica. Today, these quarries are largely abandoned, and the stone is only cut in the Kopriva and Dolina quarries, where it passes into the Repen limestone. Unlike the Repen limestone, all of the rudist shells in the Kopriva limestone are crushed, which indicates a sedimentary environment of particularly high energy. Among the rudist debris we can observe beautifully preserved fossilised snails of the genus *Nerinea*, which were well adapted to life in such a turbulent environment. Due to the greater fragmentation of the shells, this limestone is more homogeneous and slightly darker in appearance.

Lipica limestone

Only one memorial plaque on the wall of the lobby of the Montanistika building is made of Lipica limestone. It is characterized by completely crushed rudist shells, as it was formed in the most turbulent of environments. The shells are often fragmented into millimetre-size grains, so that the limestone looks completely monochromatic, exhibiting light grey to slightly hazelnut tones. Today, it is still intensively quarried near Lipica, where it is known as "uniform" or "unito" limestone. However, some layers in the same quarry contain well-preserved rudist shells, whose cross-sections resemble flowers, which is why this type of limestone is called "rosy" or "fiorito" limestone.

Rudist limestones in Ljubljana

Repen limestone is one of the best known and most appreciated architectural stones from the Kras, as very large blocks can be extracted from it due to its massive makeup. It is also resistant to frost, which is why it is traditionally used in the Kras area for exterior parts of buildings (portals, window frames). It is also seen as an ornamental stone elsewhere in Slovenia. In Ljubljana, the pavement of the Historical Atrium of the City Hall and the pedestal of the Sidro monument in Zvezda Park are made from Repen limestone. The light-coloured facade slabs and the paving on the third floor of the Slovenian Parliament building are made of a related limestone from Kopriva. Both varieties of Lipica limestone are common in Ljubljana. They can be found in the main atrium of the City Hall, on the upper floors and in the passage of the Nebotičnik building (Ljubljana Skyscraper), in the Parliament building, and on the stairs and in the pedestals of the monuments in front of the University building and along Vegova Street. The inner side stairs and pavings of the Parliament and the pillars in the Nebotičnik café are made of Kazlje limestone. In Ljubljana, we can also find Rasotica limestone from Brač in the passage under Nebotičnik.

Metamorphic rocks

Metamorphic rocks are formed by the alteration or, scientifically speaking, metamorphosis of igneous, sedimentary or older metamorphic rocks. Metamorphosis happens at elevated pressures and temperatures and in the presence of liquids and gasses deep inside the Earth. It takes place at the junctions of tectonic plates, where one plate sinks below another (subduction) or due to the intrusion of magma into the solid Earth's crust. During the process of metamorphosis, the mineral composition and structure of the rock change, while the chemical composition remains unchanged.

According to the structure of metamorphic rocks, they are divided into granulose rocks, which consist of mineral grains of similar size without specific orientation, and schistose, in which the mineral grains are elongated or leafy and due to directed pressures during metamorphosis are arranged perpendicular to the direction of maximum pressure. As a result, such rocks are cut along the oriented minerals into thin slabs.

Marble

The light frame of the floor in the lobby of Montanistika is made of marble. Marble is a light granulose metamorphic rock. It is formed by the minerals calcite or dolomite, so its mineral composition is essentially identical to the carbonate rocks (limestone and/or dolomite) from which it is also formed. However, fossils are never preserved in marble, whereas they are often found in limestone (as well as in dolomites).

The mineral grains – the basic building blocks of rock – in marble can vary considerably in size, from microscopic sizes that we cannot see with the naked eye to several millimetres. If the marble is "pure", it can be completely white, while if it contains other non-carbonate minerals, it can be grey to black, pink, yellowish and more.

The name marble on the ornamental stone market often incorrectly refers very broadly to stones that are not marbles. The term is often used for all polished ornamental stones, regardless of their characteristics (e.g. Hotavlje limestone). The most famous marble quarries in the world are located in Carrara in the Italian province of Tuscany. Many world-famous monuments are made of Carrara marble, such as Pantheon in Rome, Michelangelo's statue of David in Florence, etc. In Ljubljana, the figures of the Robba fountain are carved from this marble. In Slovenia, marble is found only on the Pohorje, where it was cut and used by the Romans. The marble in Montanistika is most likely from Macedonia, where the marble used for the facade of Cankarjev dom was also taken from.

THE READING ROOM, THE LECTURE ROOM AND THE LIFT

Igneous rocks

Igneous rocks are formed by crystallization from magma, also called lava, when it rises and erupts to the surface. Depending on where they are formed, they are divided into intrusive (or plutonic) rocks formed from magma deep below the Earth's surface and extrusive (or volcanic) rocks formed from magma just below the Earth's surface or from lava at its surface. The crystallization and thus the formation of igneous rocks is a result of the cooling of the magma. This can take place very slowly, usually deep below the Earth's surface, giving the minerals enough time to crystallize beautifully. A rock is formed with mineral grains of about the same size and exhibiting a nice shape (phaneritic texture). This is typical for intrusive rocks. However, when magma and especially lava cools down quickly due to a rapid drop in temperature, the mineral grains only partially crystallize and the remaining melt solidifies in the so-called matrix (porphyritic texture). This is typical for extrusive rocks.

Igneous rocks differ considerably in colour. Which igneous rock crystallizes out of the melt (magma or lava) mainly depends on the origin and composition of the melt, since different minerals crystallize out of melts of different compositions. If the melt contained more silicon (SiO_2) and oxygen, the rocks are generally lighter, but if it contained more magnesium and iron, they are darker. Some minerals are more characteristic of light igneous rocks (e.g. quartz), while others are more characteristic of dark ones (e.g. olivine).

Cizlakite

Cizlakite can be found in the reading room of the Montanistika building, where it decorates the corner with a washbasin. Cizlakite has a green colour because it is mainly composed of the minerals pyroxene (light green), amphibole (dark green) and feldspar (white), as well as quartz. Bright aplite and pegmatite veins often intersect the parent rock. The rock is named after the village Cezlak on Pohorje, which is one of only five deposits in Europe.

Cizlakite is an intrusive igneous rock, i.e. it was formed deep inside the Earth, from where the rock was very quickly uplifted, because the cizlakite of Pohorje is a young rock that is only about 20 million years old. The main uplift of the Pohorje area and its surroundings, where we find the only plutonic and metamorphic rocks in Slovenia, probably took place during the last peak of Alpine orogeny about 10 million years ago.

Cizlakite is a highly valued Slovenian architectural stone. Due to limited resources, the quarry is closed today, and what is extracted is used exclusively for restoration purposes. Cizlakite in Ljubljana can be seen under the windows at the front of the Parliament building and inside the building on the main staircase. The facade panels of the City Art Gallery Ljubljana are also made of it.

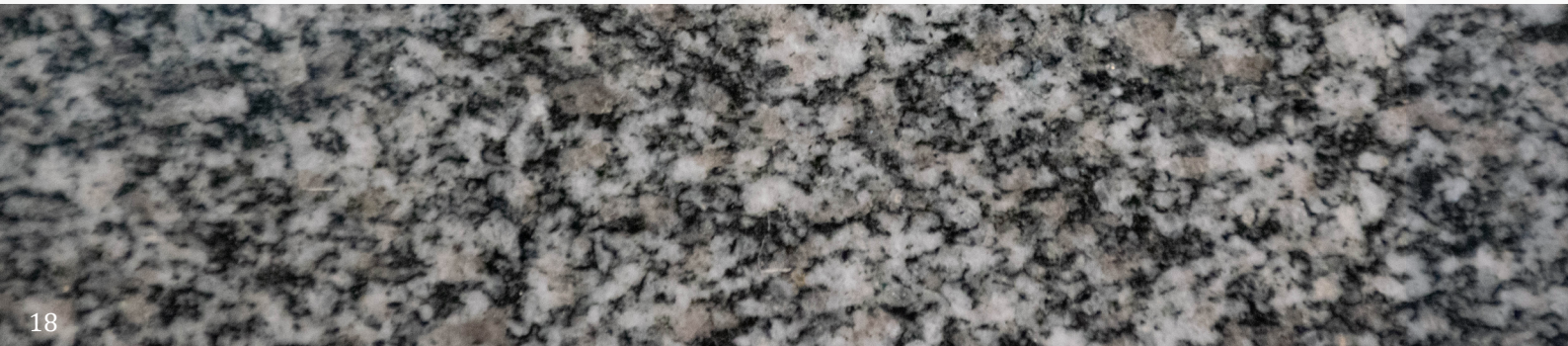
Granodiorite

In Montanistika, granodiorite is used inside the ground-floor lecture rooms for the washbasin corners.
Granodiorite is an igneous (plutonic) rock. It is composed of light minerals (quartz, orthoclase, and particularly plagioclase) as well as dark ones (biotite, hornblende), which gives it a greyish look. In name and composition, it is related

to the better-known granite, but its plagioclases contain more calcium. Bright aplite and pegmatite veins criss-cross through the granodiorite. Their composition is also similar to that of granite. Aplite is formed by very small and pegmatite by very large crystals, sometimes of semiprecious or precious minerals.

In Slovenia, granodiorite is quarried in the foothills of Pohorje in one of the largest operating quarries in the country, i.e. Cezlak I near Oplotnica. Close by, the quarry of a slightly older and more prestigious Cizlakite is also situated.

Pohorje granodiorite, which was also called Pohorje tonalite or Pohorje granite in the past, is cut for road bricks and pavers, as well as wall and floor panels. Due to its appearance and durability, granodiorite is the most commonly used natural stone for outdoor use in Slovenia. In Ljubljana, almost the entire surface of the Trg Republike square is covered with Pohorje granodiorite. The facades of the Maximarket building and two nearby towers are lined with such panels, and the market is paved with granodiorite bricks and tiles. Prešernov Trg square and Mestni Trg square are also paved with it, as are many other streets. The fountain on the Ajdovščina square is made of two monolithic blocks, the largest ever taken from the Pohorje quarry. The estimated total weight of the fountain is more than 200 tons, which is why it had to be transported to Ljubljana by a military tank-transport trailer.



Gabbro

In front of the lift in the Montanistika we find a gabbro paving stone. The same rock is also used for the base of the building's main entrance portal. Gabbro is an igneous rock of the intrusive type, usually dark grey to black (pyroxene and amphibole minerals), which can be greenish (hornblende mineral) with white patches, which are plagioclase minerals. It crystallizes deep below the Earth's surface from magma, which is rich in magnesium and iron. In its composition, gabbro is very similar to cizlakite, but does not contain the mineral quartz, which is mainly characteristic of light igneous rocks. The rock therefore crystallized from a melt with a slightly different composition.

On the market, the name “Africa nero” is often used for gabbro, because it is commonly obtained in Africa and because it is black; or it goes by the name “black granite”, which is not correct due to the completely different mineral composition of granite. The gabbro at the entrance to the elevator certainly comes from far away, perhaps from Africa, but we know that the gabbro from which the base of the entrance portal of the building is made comes from Jablanica in Bosnia and Herzegovina, where the base of the Prešeren monument at Tromostovje (three bridges) also comes from.

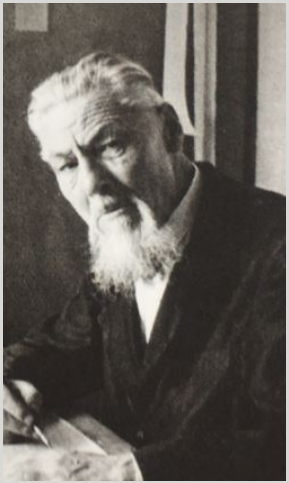
Granite

The floor in the elevator in the Montanistika building is made from granite. Granite is an intrusive igneous rock, formed deep below the Earth's surface. It is the most common rock of the continental Earth crust. The rock is light, white or pink coloured. It crystallized from magma rich in silicon and oxygen. Quartz and minerals of alkali feldspars, plagioclase and light mica give it a light colour. The granite in the elevator is white in colour and most probably comes from Brazil. Together with the gabbro, it could be called a geologically alien species in the Montanistika building. You can also see granite in Ljubljana on the upper part of the Prešeren monument.

CURIOSITIES

The architect and urbanist France Tomažič, who drew the plans for the Montanistika building, was an assistant to and worked with Prof. Jože Plečnik, perhaps the most respected and celebrated of Slovenian architects. Plečnik was a great admirer of Podpeč limestone, which can also be admired on the entrance staircase of Montanistika. Plečnik also used it in the construction of the Constitutional Court palace, for the facade and interior of the Triglav Insurance Company palace on Miklošičeva, the arcades on the Market Halls, the exterior staircase of the Ursuline Church, the facade of the Gymnasium on Šubičeva cesta, on St. Mary's Column on Levstikov trg, the monument to Simon Gregorčič near Križanke, and the pillars of the Bežigrad stadium.

Prof. Karel Hinterlechner is the most important Slovenian geologist of the first half of the 20th century. Hinterlechner founded the Slovenian geological school and was one of the first four full professors at the newly-founded University of Ljubljana. In addition to his pedagogical work, he served as vice-dean and dean of the Faculty of Engineering, as the sixth rector of the University, and as the head of two prestigious institutes. He was also involved in geotechnical research during the construction of Nebotičnik (Ljubljana Skyscraper) between 1930 and 1932. A memorial inscription is located in the entrance hall of the skyscraper, the walls of which are also lined with Podpeč limestone.



Jože Plečnik (1872–1957)

Karel Hinterlechner (1874–1932)

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