MONTANISTIKA

INDEX

Hi! In front of you is a guide that will take you into the mysterious world of the rocks of Montanistika. Some facts are revealed by the conversations between the fossils and minerals hidden in the rocks, while those more curious can find additional information in the info circles.
The printed guide has been upgraded with augmented reality (AR). Find the sign next to the fossil or mineral characters and indulge in a different view of the building.

SEDIMENTARY ROCKS

Hello! Have you noticed how we are decorating the entrance portal of the Montanistika building? It's surrounded by a wreath of flowers.

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.

We are rudist shells that come from Kazelje in the Kras/Karst.

My relatives in the building will tell you more about us. Now come on in, discover some different types of natural stone, and listen to the "petrified memories" of its inhabitants.

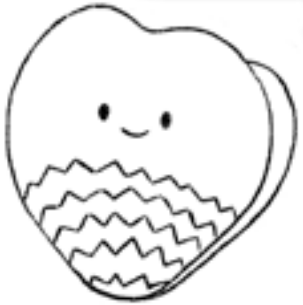
Welcome! My name is *Lithiotis problematica* and all the elongated white stripes are my sister lithiotides. Would you believe we are all seashells?

Lithiotids are an extinct group of seashells, 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 (common is *Opisoma*).

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.

I'm *Cochlearites*. These beautiful grey stone slabs are made of Podpeč limestone, which was cut in a quarry in Podpeč on the southern edge of the Ljubljana Moors.

I'm *Lithioperna*, and I would like to tell you that many of my sisters also adorn the ground floor lobby of the Nebotičnik building, the outer staircase and inner arcade courtyard of Ljubljana's City Hall, the interior of the Slovenian Parliament, and the fountain in Zvezda Park.



Karel Hinterlechner (1874–1932), the founder of the Slovenian geological school and one of the first four full professors at the University of Ljubljana, was involved in geotechnical research during the construction of Nebotičnik (Ljubljana Skyscraper) between 1930 and 1932. The memorial inscription is located in the entrance hall of the skyscraper, the walls of which are also lined with Podpeč limestone.

The most beautiful monument was made by the architect Jože Plečnik in the National and University Library. There, our friends look particularly incredible in the inner colonnaded staircase and the large central lobby.

Jože Plečnik (1872–1957), Slovenia's most important and celebrated architect, was a great admirer of Podpeč limestone. He also used it in the construction of the Constitutional Court palace, for the facade and interior of the Triglav Insurance Company palace on Miklošičeva street, the arcades on the Market Halls, the outer staircase of the Ursuline Church, the facade of the Gymnasium on Šubičeva street, the St. Mary's Column on Levstikov trg, the monument to Simon Gregorčič near Križanke, and on the pillars of the Bežigrad stadium. France Tomažič, the architect of the Montanistika building, was one of Plečnik's students and later worked with him.

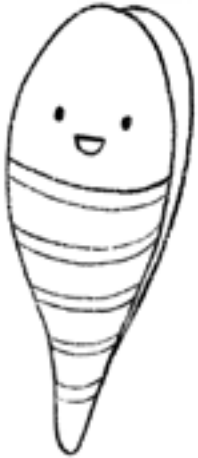
I will tell you the story of our arrival from the sea in Podpeč. Ohhhh, I remember the Alpine orogeny the most, those very turbulent years – millions of years – when we were constantly afraid of earthquakes. An earthquake caused a great cracking and uplift of the whole territory. Which is how we came to appear in the Dinaric mountains.

The rising of Slovenian territory took place during the Alpine orogeny, the youngest mountain-forming process, which lasted from the Jurassic to the Pliocene, and which is still going on today. During this time, the entire Alpine-Himalayan mountain range emerged. In Slovenia, the territory has risen the most in the last few tens of millions of years, with a peak in the Miocene about 10 million years ago.

When we died, our shells lay in limestone silt, on which more and more new layers were deposited. Later, our beautiful aragonite shells also completely recrystallized into larger calcite crystals.

The process of sediment forming into rock is called lithification. It is part of the diagenesis process, which encompasses all sedimentary grain changes from deposition to solid rock. If the sedimentary grains are composed of calcium carbonate (mineral calcite and aragonite), limestone is formed, one of the most common rocks in Slovenia. The process of diagenesis also includes later changes in the rock, e.g. brown serrated stylolite seams. They are formed during the strong compression of limestones, which are partly dissolved under pressure, and the residue of insoluble minerals (e.g. clay minerals, pyrite, and various oxides) forms bright seams.

I still remember my youth, when we lived in an idyllic warm lagoon, full of diverse life.



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.

Psssst, I would like to whisper something so that the lithiotids don't hear me. They always kept more to themselves, and everywhere else our fossil company was much more diverse.

Lithiotids only inhabited part of the lagoon, so they are only found in a few layers of the quarry. Life was obviously more varied in other parts of the lagoon, as there are many fossil snails, heart-shaped shells, brachiopods, sea sponges and foraminiferas preserved in the other layers of the quarry. The other interesting grains are oncoids, lumpy grains up to a few centimetres in size with an irregularly shaped concentric coating.

Oncoids are formed when a sedimentary grain or shell is overgrown with a slimy coating of cyanobacteria to which tiny limestone silt adheres. Since the oncoids are constantly rolling, they take an almost spherical shape with every new layer.

My name is *Gervilleioperna*, and I'm a lithiotid seashell with the most beautiful heart-shaped profile. I'd like to invite you into the lobby, where my younger relatives will tell you their story.

We already met at the entrance, and now it's time to introduce you to my extended family. We're rudist seashell, and you can remember us by our horn-shape.

Like lithiotids, rudist seashell lived in the shallow 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 Dalmatian island of Brač, in Croatia.

Rudist seashell (known also as rudists) 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 seashell 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.

We also come from the same Mesozoic shallows as lithiotid seashell, but we're much younger.

I come from the Croatian island of Brač, and my nickname is (k)Rasotica, which means very beautiful. I'll tell you all about how we lived at the height of our existence.

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.

Alora, and I come from the Kras, and I'll tell you how colourful this beautiful piece of the world was back in our day.

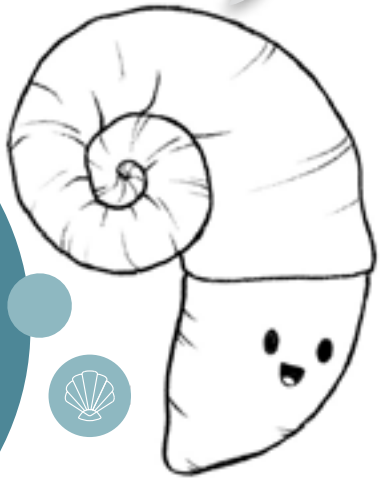
Several rudist limestones of Montanistika come from Kras. They differ mainly in colour and in their preservation of the rudist shells. This spectrum is due to the very different shallow marine environments in which they were formed. Dark variants with beautifully preserved fossils formed in the quiet 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.

I'm from the village of Avber, and despite my age I'm quite well preserved. Besides, the black colour suits me.

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.

Ciao, I'm caprinide from Repentabor in Italy. You could say there are quite a lot of my kind, but I can tell you why – we from the border zones need to have a tough skin.



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.

Repen limestone 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.

The entrance staircase of the Montanistika leading to the lobby is made of Repen limestone.

Kopriva limestone 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.

In Montanistika, light grey slabs paving the floor of the lobby and the stairs leading to the higher floors are made of Kopriva limestone.

Ah, the place the rudists of other limestones lived was still acceptable, but where we lived got to be so severe that today I'm still scattered all over the place.

The most crushed rudist shells are in **Lipica limestone**, 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.

Only one memorial plaque on the wall of the lobby of the Montanistika building is made of Lipica limestone. 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.

I also need to tell you that we have a lot of relatives elsewhere 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. 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.

Can I please say something? ... And without boiling over again! I'm the mineral calcite, and with my mineral siblings I'm part of a wonderful metamorphic rock called marble.

And let me tell you that the shells from limestone really don't know what hard times are. Ughhh, I prefer not to think about just how hot and tiring it really was.

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.

You probably know that the rock I make up with my brothers is a real star in the world of stone décor and fashion. After all, who hasn't heard of marble?

Marble is a light granulose metamorphic rock. It is formed by the minerals calcite or dolomite that 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).

But I have to admit, however, that unfortunately I can't tell you the kind of stories my friends from limestones can tell. As a result of all that heat and pressure, I don't even remember anything about my birthplace.

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 dolomite).

The rock I live in is very much loved in the world of architecture and art. That's why my relatives are dispersed all over the world.

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.

IGNEOUS ROCKS

I'm the mineral plagioclase. With my mineral friends we would like to share our life story, which we titled »From the depths«.

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.

We were lucky to have shaped ourselves so beautifully. If you look closely at us under the light, our crystal surfaces absolutely shine.

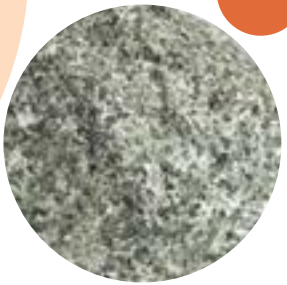
I'm the mineral pyroxene. I'm very proud of the rock we make up together with our friends. It's called cizlakite, and it's very special.

Yes, we came from down deep, from truly terrible depths. Are you interested in learning how that happened?

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 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.

Cizlakite is an intrusive igneous rock, which means that it was formed deep in the Earth's interior. Later, the rock was uplifted on the surface as the Pohorje massif and its surroundings, where the rock is found today. This area was uplifted very quickly; therefore, this is the only place in Slovenia where the igneous and metamorphic rocks, which are characteristic of the deeper parts of the crust. Since cizlakite is, at some mere 20 million years old, a young rock, the main uplift probably occurred during the last peak of Alpine orogeny about 10 million years ago.



I'm the mineral quartz, and I'm grateful that in Cizlakite the others have accepted me into their dark company. So far we've managed to smooth out at least some of the disputes between the lighter and darker minerals. If you don't understand what I'm talking about, take a look at these last three 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 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. pyroxene).

I also come from Pohorje and I'm part of a rock called granodiorite. We like the quartz in my rock, so you're always welcome. Find more about our society on the next page.

I really found a great sense of companionship. The minerals in this rock really understand each other very well.

Granodiorite is an igneous (plutonic) rock. It is composed of light minerals (quartz, orthoclase, and particularly plagioclase) as well as some dark ones (biotite, hornblende), which gives it a greyish look. In its name and in 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

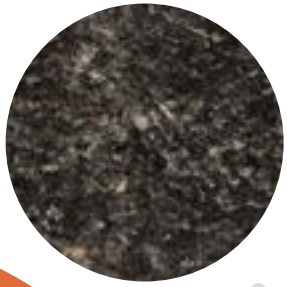
In Slovenia, granodiorite is quarried in the foothills of Pohorje in one of the largest operating quarries in the country, i.e. Cezlak I near Oplotnica. Close by, the quarry of a slightly older and more prestigious cizlakite is also situated.

Our beautiful Pohorje is really worth seeing. And we also have special neighbours, you've probably already heard something about them…

If the right minerals get together we are really very strong and solid. This is one of the reasons they like to invite us to take part in demanding road work, and to be part of various decoration schemes.

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 Montanistika, granodiorite is used inside the ground-floor lecture rooms for the washbasin corners. 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.

Recently, during the restoration of the interior of the Montanistika building, our relatives from the non-native rocks from distant lands joined us. Go and have a look at them in the elevator.



Cizlakite is really similar to my rock, but the minerals in it are all mixed up. I don't know how they can all live together! In my rock, like in granodiorite, everything is far more unified and orderly.

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. The rock therefore crystallized from a melt with a slightly different composition.

And just so as to avoid any confusion, even though we're also called »black granite«, we have nothing to do with that rock. Supposedly, it was easier to sell us as decorative natural stone.

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 as 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 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.

Title: MONTANISTIKA

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academic year 2018/2019

Copy editing: Jeff Bickert

Electronic edition

Ljubljana, January 2024

Kataložni zapis o publikaciji (CIP) pripravili v Narodni in univerzitetni knjižnici v Ljubljani
COBISS.SI-ID 105223171
ISBN 978-961-95766-0-1 (PDF)

This European Researchers' Night project is funded by the European Commission under the Marie Skłodowska-Curie Actions. The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 954337.

This project has received funding from the European Commission. The action reflects only the author's view. The Agency and the Commission are not responsible for any use that may be made of the information it contains.

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