Mars on Earth

Seeking Martian landscapes close to home





The world is full of areas to discover; full of beautiful places where Earth's mysteries can be witnessed, explored, and unravelled.

Did you know that Earth does not only harbour her own treasures, but also those from her relatives? Something that you might not expect is that Earth reveals secrets of Mars. Secrets about its history, its current state and its future course.

A question that preoccupies us today is: might Earth also reveal secrets about extra-terrestrial life?

Join us on this journey on Earth to unravel some of Mars' secrets. Will this curious place really turn out to be a lonely planet?

Earth

Atmospheric composition: 0.04% carbon dioxide (CO_2) 20.9% oxygen (O_2) 78.1% nitrogen (N)

✓ 40.075 km
✓ ↔ 150 million km
T Between -88 and 58 °C
✓ 365.26 days (1 Earth year)
✓ 10 times Mars
✓ Animals, plants, fungi, bacteria

Mars

Atmospheric composition: 95.3% carbon dioxide (CO_2) 0.13% oxygen (O_2) 2.7 % nitrogen (N)

6

21,344 km 228 million km Between -153 and 20 °C 687 days (1.9 Earth year) 0.1 times earth



Life on Mars?

Is there life on Mars? It is thought that liquid water once made certain Martian areas inhabitable. Simple life, such as bacteria, might still be present underneath the planet's frozen surface.

To learn whether Martian life actually ever existed, more research on this planet's geology would be of great help. However, geological research on Mars is extremely expensive and, technically, not always possible.

Fortunately, we can go to Mars-like places on Earth, otherwise known as 'Mars

Did you know...

Whereas Earth's blue color is caused by its water, Mars got its red appearance due to its iron. Oxidation of the iron in the Martian rocks and dust causes a red rust colour.

analogue sites'. We can do research on the types of organisms that inhabit these places: how do they cope with certain environments and how did they originate in these spots? Learning about life forms in these places on Earth may teach us about possibile life forms, past or present, on Mars.

No single site on Earth is entirely representative of the Red Planet. However, several places have their own similarities to our planet's neighbour. For instance, whereas Mars has volcanic activity, lava also flows out the Sicilian Etna volcano and several volcanoes in Hawaii. The Atacama Desert in Chile is home to high temperatures and air conditions, and central Australia has impact craters that show many similarities to Mars.

MASE

Mars Analogues for Space Exploration

MASE is a research project, funded by the European Commision, that explores several (mostly) European analogue sites. Its name stands for Mars Analogues for Space Exploration. The project's scientists are studying possible life in extreme environments.

When thinking of possible life, you shouldn't think of Martians, humans or animal- like creatures. If life were to be found on Mars, it would most likely resemble extremophiles: these are microorganisms, such as bacteria, capable of living in extreme conditions. These are, for example, either extremely hot or cold environments, or spots in the deep sea where the pressure is very high. The five analogue sites that MASE is currently investigating are:

1. Iceland: Grænavatn, a cold acidic lake

- **2. England:** Boulby Mine
- **3. Germany:** Sulfidic springs near Regensburg
- **4. Spain:** Acidic deep subsurface environments in Río Tinto region
- **5.** Permafrost from
 - Canada: Herschel Island
 - Russia: Lena River Delta

This is a guide to the first site: the Icelandic lake named Grænavatn.







Land of Fire and Ice

Iceland contains many unusual environments. Interestingly, due to their extreme conditions, some of these environments are well-suited as Mars analogue sites.

The so called Land of Fire and Ice is a remote country, containing wide, raw landscapes. Natural phenomena include hot springs, craters, glaciers, waterfalls, fjords and caves. Woodland, on the other hand, is rare. Having this in mind, it is not hard to imagine Mars having similar areas. In fact, some places on Mars actually show similarities to Icelandic sites.

As attractive and intriguing this country's areas may be, it is important to be careful when visiting Iceland's diverse nature: some places can be dangerous. The weather changes fast and one must be aware of uncontrolled behavior of hot springs. Therefore, it is wise to stay on the beaten track.

Iceland is an island, which is part of Europe and lies between Greenland and Norway. It has 335,878 inhabitants and with a size of 103,000 square km, it is a sparsely populated country. Half of Iceland's population lives in Reykjavik, its capital.

Whereas Iceland's coast has a cold sea climate, most of the midland area is home to a tundra climate. In summer, the average day temperature in Reykjavik is around 13 $^{\circ}$ C, in winter around 3 $^{\circ}$ C. However, it can get colder more remote from the coastal areas.

Euan Monaghan/MASE)

Grænavatn

One of the Mars analogue sites in Iceland is a lake called Grænavatn. Grænavatn is located in the south of the country, approximately 25 km south-west of Reykjavík. In Icelandic, Grænavatn literally means 'green lake'. The lake's green color is due to its mineral content. The green color is more intense in the shallow parts of the lake, close to the edges. The deepest part of the lake is 45 m, which is quite deep for a small lake.

Grænavatn is not just any regular lake. It originated about 6,000 years ago as a vulcanic crater. The lake is a maar type crater, which means that a shallow hole in the landscape was caused by an explosion. This explosion occurred due to hot magma, emerging from below, mixing with cold groundwater. After this phenomenon, rain and groundwater filled up the hole, resulting in the lake there is today.

The images on page 11 show the MASE team measuring several of Grænavatn characteristics, such as its pH (top image), which is around 2, similar to lemon juice. Tourists are not recommended to visit Grænavatn and its surrounding area: the lake's acidity causes it to be quite a dangerous place. The green, acidic lake is rather cold as well; its average temperature is 4 °C.

There are several similarities between the lake and conditions on Mars. We know that liquid water once was present on this planet, and recent data suggests that liquid water even flows on Mars today. Due to research on samples from Martian meteorites, as well as orbital and surface missions to Mars, we know that the planet partly consists of basalt: a dark, volcanic rock. This is one more reason that makes Grænavatn an interesting analogue site to Mars, since the lake's rocks are basaltic.

Another striking characteristic of the lake is its periodic drying. This is because there is no water flowing out of the lake in a stream or river. Consequently, some of its water evaporates. When the atmosphere is dry, water evaporates, causing the lake's water level to decrease slightly. Contrastingly, rain and incoming groundwater will cause the water level to rise. This periodic drying is something that could also have happened on Mars, leaving its surface deprived of liquid water. One of the MASE researchers measuring the lake's pH. (Euan Monaghan/MASE)





Grænavatn's inhabitants

Although lake Grænavatn is not suitable for us to swim in, it is host to several life forms. The lake contains various microorganisms, many of which are bacteria. The species of bacteria that inhabit the lake live in extreme circumstances, such as high acidity, sulphur- rich water and low temperatures.

Life without oxygen

Most interestingly, the lake's organisms are adapted to live without oxygen. To us, this might seem unimaginable. However, it has been discovered that the first life on earth did not need oxygen either.

There is still much left to discover about how life on earth originated. One thing we do know is that the first forms of life originated in an oxygen-free (anaerobic) environment. These creatures were single-celled organisms that first appeared about four billion years ago.

Overall, knowledge about how life on Earth originated may tell us a lot about the possibilities of life on other planets. MASE is currently investigating the composition of Grænavatn's several life forms, since little is yet known about these organisms. Could it be that the lake's tiny inhabitants resemble our earliest ancestors? Could similar creatures once have populated Mars? These are some of the key questions the MASE project aspires to answer.

Did you know...

That oxygen initially led to a mass extinction? The first significant quantities of oxygen in our atmosphere arose about 2.3 billion years ago. Since the vast majority of organisms that lived until then were not adapted to oxygen, this molecule was extremely toxic to most species.

Today, photosynthesis is mainly known as the activity of plants that allows us to breathe. This same process caused the rise of oxygen in the atmosphere, 2.3 billion years ago. Back then, it's producers were algae- like bacteria.

Forms of life were also detected outside of the lake. These lcelandic horses showed great curiosity for the MASE team. (Euan Monaghan/MASE)



Lake Grænavatn



Part Mar

♥ low temperature

bacteria

pH: 2 Temp: 4 °C Maximum depth: 45 m

50m _____

Maars on Mars

Now that we have elaborated on one of Earth's most fascinating maar lakes, you might wonder how such a place would look like on Mars. The images below show a maar type crater on Earth as well as a similar structure on Mars. The Martian cones are thought to have come to exist due to hydrovolcanism: eruptions due to interaction of magma or lava with water, just as happened with Grænavatn. Notice that the Earth's crater on the top image has not developed into a lake, contrasting Grænavatn. This allows for better comparison to the Martian cavity on the bottom image.

Martian pitted cones located

in the Nephentes/Amenthes

region (Q. Myers)



Iceland and its extreme nature

Apart from Grænavatn, Iceland has several other places which have Martian properties. Some of these can be visited and are highly recommended to do so. The following pages will elaborate on the spots that are numbered 1-4 on the map below.



Reykjavík

Grænavatn

Iceland and its extreme nature

Iceland has numerous geothermal fields. Some of these are close to Reykjavik, such as Krýsuvík (1). All of these fields have different geothermal wells: pools of water, warmed up by the Earth's underground heat. The heating causes all wells to have temperatures ranging from 60 to 95 °C. Some wells contain minerals which give the water and banks a peculiar color. Another geothermal area, open for tourists, is the area around Geysir (2). As you might suspect, the word "geyser" is derived from this area. At the moment, Geysir is not active, whereas his neighbour Strokkur is. The geysers are surrounded by different hot (80 $^{\circ}$ C) pools.





Contrasting these hot pools are Iceland's cold, subglacial lakes (3). Logically, these are located below glaciers. What is interesting about these lakes is their cold temperature and the lack of oxygen, conditions similar to Mars.

In these lakes, scientists have found high amounts of extremophiles: sometimes up to half a million living single-celled organisms per milliltre. It is likely that similar conditions have occurred or currently occur on Mars. Subsequently, researching the extremophiles in subglacial lakes may provide insight in possible Martian life.

Did you know...

Iceland has many peculiar and fun sayings, which gain special attention during Easter. Inside of every Easter egg there will always be an old saying. Many people even prefer the saying inside their Easter egg more than the chocolate itself.

An attractive event for tourists is the yearly *Réttir* in September – one of the oldest cultural traditions where Icelandic sheep farmers invite people to help out with rounding-up the sheep.

One final interesting Icelandic location for Mars analogue research is Eyjafjallajökull (4): a volcano underneath an ice cap. Eyjafjallajökull is better known as the volcano that stopped all air traffic in 2010, due to releasing ash particles in the air.

These same ash particles are the elements that scientists are interested in. Microorganisms have been found not only in the ash, but also in ice covered by ash and from volcanic mud. Additionally, there is no oxygen present in the ash and mud. Therefore, this volcano offers a remarkable analogue to Mars.

Did you know...

The Icelandic language knows a lot of tongue twisters, like the volcano *Eyjafjallajökull* – which literally means *islandmountainglacier*.

The Icelandic alphabet consists of 32 letters. The letter z was used until 1973, when it was abolished, as it was only an etymological detail.

Whereas many languages use the same root of an existing word for new inventions, lcelanders are determined to make their own unique words for every word there is.

Did you know...

Naming

Inceland has an official naming committee, who decides upon which names are allowed to grant your child.

A person's last name is constructed by adding *son* (son) or *dóttir* (daughter) to their father's first name? So if you're a men and your father is named Olaf, your last name will be *Olafsson*. Pretty straightforward, right?

The Icelanders have a very inventive app...

93% of Iceland's inhabitants are born in Iceland and descend from one family, so it's not that hard to be some kind of family of one another. The *IslendingaApp* makes sure if you and a possible bed partner are family: 'Bump the app before you bump in bed'.

Icelanders is home to many writers

The *jólabókarflóð* (Christmas book flood) takes place just before every Christmas in which a lot of new books are being released.

Celebrations

Like any other folk, Icelanders love to celebrate. Unlike other folks, Icelanders celebrate the first day of summer already on the third Thursday of April. Whether there is snow or not. This is because they used to know only two seasons.

There is a food festival dedicated to 'disgusting' food, named Thorrablot. During this festival, traditional delicacies like *hákarl* (fermented shark), *mysa* (whey as a refreshing drink) and *svið* (boiled sheep head) are enjoyed very much by the lcelandic people.

Historical places

The Republic of Iceland was officially founded in 1944. It was founded in Þingvellir National Park. Therefore, this park plays an important role historically.

The most famous building in Reykjavik is the Höfði house, where Ronald Reagan and Mikahil Gorbatsjov met in 1986 to discuss the ending of the Cold War.



The Höfði house (Laurent Gauthier)

lcelandic waterfall (Milagro Elstak)

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Further reading mase.esf.org

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Chasma Boreale and the North Polar Ice Cap of Mars. Mars has bright polar caps of ice that are easily visible from telescopes on Earth. During the Martian year, a seasonal cover of carbon dioxide ice and snow is observed to enhance and reduce over the poles. (NASA) Will we ever detect life on Mars? Or will this curious sphere turn out to be, against all hopes and dreams, a lonely planet after all?

This booklet will take you on a journey to unearthly landscapes, searching for Martian life.

Surprisingly, these places are not as remote as you might suspect.



