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Geoparks in Volcanic Areas in Europe

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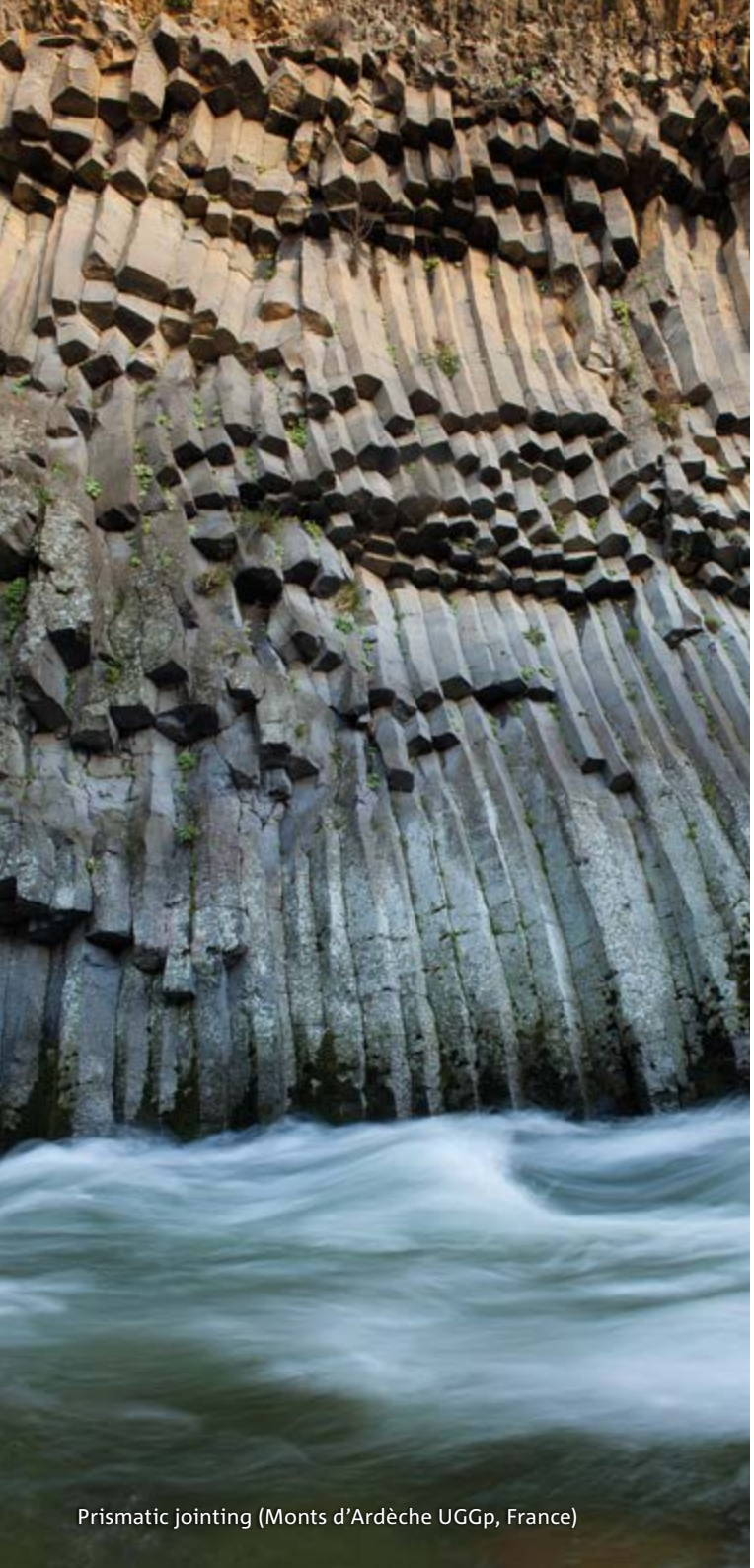

Prismatic jointing (Monts d'Ardèche UGGp, France)

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Santa Bárbara caldera – Terceira Island (Azores UGGp, Portugal)

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April 2021 eruption (Reykjanes UGGp, Iceland)

PREFACE

Bestowed with geological heritage of international importance, UNESCO Global Geoparks (UGGp) are truly remarkable territories where man's relation with the Earth is celebrated. Outstanding projects with local communities and visitors preserve, share and promote all the heritage of these dynamic areas. The collaborative spirit of their scientists, technical and managerial specialists drive international partnerships and joint outputs.

At the heart of the European Geoparks Network (EGN), structured through a series of themed working groups, these UGGp professionals come together to cooperate on common topics. Since its inception more than 20 years ago, several working groups have been established and have thrived in the EGN. These have produced excellent outcomes and initiatives in the topics of palaeontology, karst, geohazards, volcanoes, intangible heritage, education, sustainable development and many more. These working groups clearly demonstrate the networking and multidisciplinary approach that make this network stronger and more effective through the years.

Acting as a correspondent working group of the Global Geoparks Network (GGN), the European Geoparks Network Working Group on Volcanic Areas fosters international cooperation on the theme of volcanoes. Its main aims are to: i) let visitors and local people, especially students, broaden their knowledge on volcanic activity forming todays landforms and beautiful landscapes of UGGp's in volcanic areas; ii) understand the dynamic movement of Planet Earth through magmatic and volcanic activity, which brings the benefits but also occasionally serious hazards, and iii) promote sustainable geotourism in those areas. Under the scope of GGN working group, "volcanic areas" are herein defined as areas that meet at least one of the following conditions: 1) have active volcanism, this is, a territory with volcanic activity in Holocene time, the last 11,700 years; 2) at least half of its territory with Cenozoic (e.g. aged less than 66 million years) volcanism/volcanic rocks; 3) have singular and outstanding volcanic or subvolcanic landforms suitable or already used for general public interpretation.

Carefully prepared by the EGN Working Group on Volcanic Areas, this vibrant book "Geoparks in Volcanic Areas in Europe", is an excellent example of shared UGGp initiatives and the rich fruit they bear. The publication provides a colourful and dynamic snapshot of European UGGp's through the prism of volcanic heritage. Each chapter provides expert insight into the different natural, cultural and immaterial riches of these volcanic European territories.

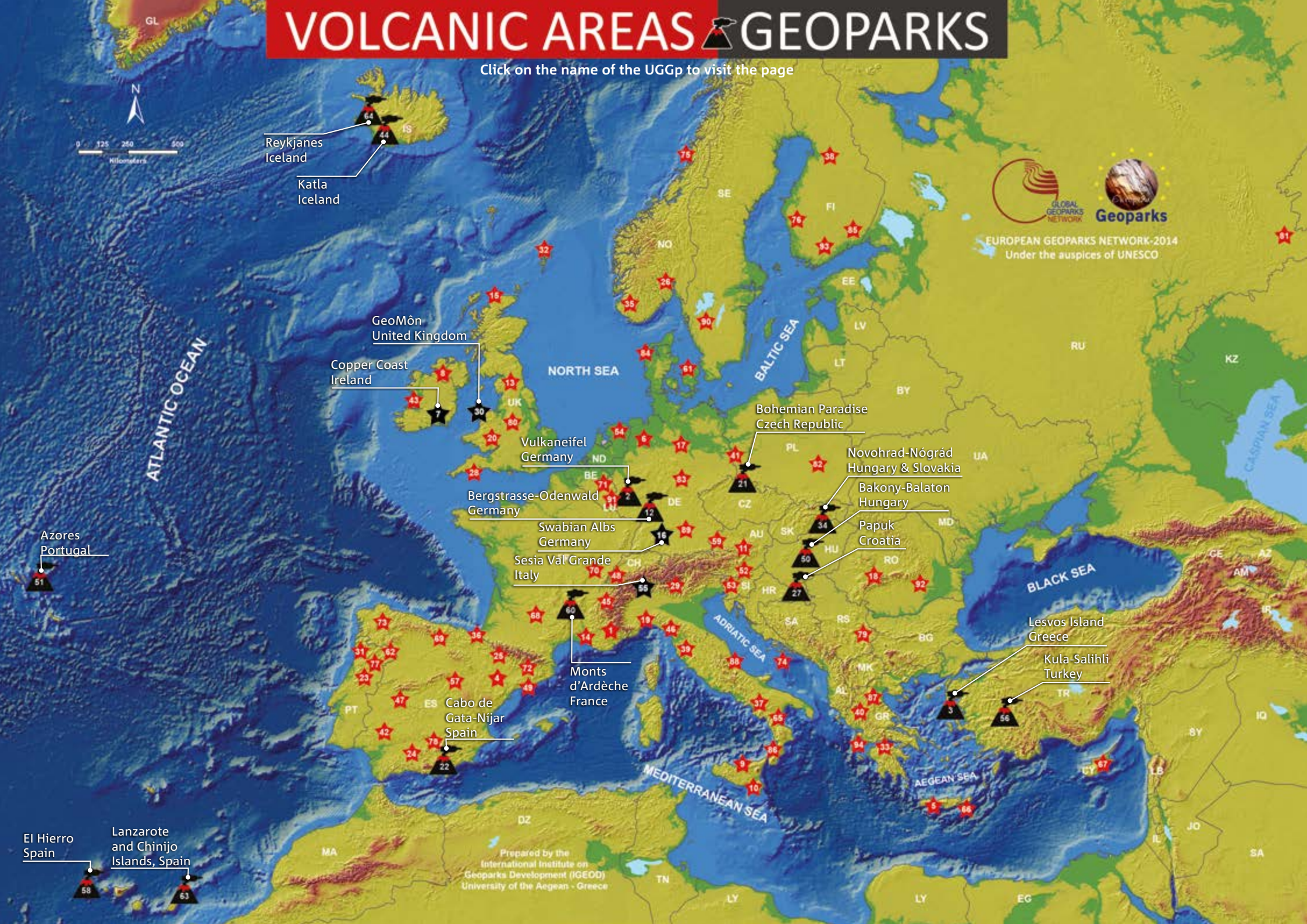
Sophie Justice & Charalambos Fassoulas,
European Geoparks Network Coordinators

João Carlos Nunes,
Catalyst of the EGN Working Group on Volcanic Areas

Cala del Bergantín beach area (Cabo de Gata-Níjar UGGp, Spain)

VOLCANIC AREAS GEOPARKS

Click on the name of the UGGp to visit the page



INTRODUCTION

Old or young, extinct, dormant or active, calm and relaxed or violent and explosive, small, big or super-big... those are the volcanoes in Europe and the World.
Some volcanoes live in European Geoparks, the special territories, designated by UNESCO, where Man meets Nature, walking together and aiming to help the well-being of local communities, to live in harmony and respect the value of nature. But sometimes volcanoes wake up in a bad mood and remind Man: "we make the rules"!
Volcanism is undoubtedly the most spectacular and fundamental geological process on Earth: it is responsible for the formation of our planet "Gaia", oceans and atmosphere. Occasionally volcanoes impose significant hazards to people living on and around them.
Well, but what is a volcano? *Vox populi* would simply say that a volcano is "a mountain that spits fire, ashes and stones", thus being a cone or edifice, more or less impressive, that expels lava from time to time. Nevertheless, a more scientific approach would term volcano as "a place at the Earth´s surface, where arrival of volcanic products occurred", independently of being a mountain, a depression or a simple crack at surface. Thus, the term "volcano" is applied to individual vents (like craters, measured in meters), or volcanic edifices such as polygenetic volcanoes measured in kilometers, or to volcanic fields, measured in hundreds of square kilometers*.
A key issue, when dealing with volcanoes, is to consider them as extinct - with no eruptions in the last tens of thousands of years – or active (or potentially active), meaning that they have erupted in Holocene times, or the past 11,700 years. Active volcanoes can be either dormant ("sleeping" in-between eruptions and expected to erupt again in the future), or in activity, meaning with an on-going eruption with the extrusion of lava (as pyroclasts or lava flows) and gases.
Many volcanic landscapes and landforms are known worldwide and are iconic places that become important tourist destinations: Etna Volcano (Italy) and Giants Causeway (Ireland), Mt. Fuji (Japan), Yellowstone National Park (USA), the Andean Volcanic Arc (South America), Ol Doinyo Lengai (Tanzania) and Rotorua Caldera (New Zealand), plus many oceanic islands, like Hawaii and the Macaronesia Islands (e.g. the Azores, Canaries, Cape Verde and Madeira islands) are among those places.
Visitors are attracted to volcanoes by their scenic views, the breathtaking environment and the "wow pictures" that volcanoes offer. But increasingly, it is the availability of those areas to provide positive experiences and at the same time offer local and genuine products and services – as well as strong engagement of the local communities and commitment with the sustainability of these places – that plays a major role in the attraction of such volcanic areas. This is why geotourism, offered under the umbrella of UNESCO Global Geoparks (UGGp), plays such an important role in the sustainable development of those territories.
This book, produced by the EGN Working Group on Volcanic Areas, highlights the main volcanic characteristics of the UGGp in Europe. It includes territories with active volcanism or with significant assemblages of Cenozoic volcanic rocks (all marked with a "volcano symbol" on the map aside), as well as geoparks that, even with just a few or very old volcanic rocks, include volcanoes on their public interpretation and communication tools (marked with a "black star" on the map aside).
We are grateful to all contributors, and to you, fellow reader, we wish you a pleasant ride!

João Carlos Nunes
Editor, PhD on Volcanology, Eurogeologist

(*) Encyclopedia of Volcanos, Haraldur Sigurdsson (Editor-in-Chief), Academic Press, 2000


Standing sequoia petrified tree trunk (Lesvos Island UGGp, Greece)

GEOPARK AZORES

...walking around on active volcanoes

LIVING VOLCANOES ...FANTASTIC EXPERIENCES

Azores UNESCO Global Geopark, Portugal
www.azoresgeopark.com

Pico Mountain: the third tallest volcano in the North Atlantic Ocean

The Azores islands comprise 27 main volcanic systems, including 16 large central volcanoes, 11 basaltic fissural areas and about 1,750 small, individual, varied-type volcanoes. Also, 121 geosites of international, national and regional value, 250 volcanic caves, 26 eruptions in historical times and 35 thermal waters are other figures of the Azores Geopark geodiversity, located in the middle of the North Atlantic Ocean, at the triple junction of the North American, Eurasian and African tectonic plates.

All the nine Azorean islands are oceanic volcanic islands that have grown from the surrounding sea floor, a process that started about 36 million years ago, forming the so-called Azores Plateau. The older rocks of the archipelago, with an estimated age of about 6 million years, are found at Santa Maria Island, while the youngest island of the archipelago, the Pico Island, was formed not more than 300 thousand years ago.

The Azores living and dynamic territory displays a wide range of landscape-types, rocks and structures on-land and in the marine areas of the Azores Plateau. Those features include central volcanoes, calderas, craters, scoria and spatter cones, trachyte domes and *coulées* (short viscous lava flows), pumice rings and tuff cones, *maars* and eruptive fissures. There are also several secondary manifestations of volcanism, such as thermal springs, fumaroles, CO_2-rich waters and shallow and deep marine hydrothermal fields. Additionally, there are non-volcanic features that mark the islands geology, such as sedimentary rocks, marine fossils, fault scarps, coastal lagoons and "fajãs", a local name for shoreline gravitational slope deposits.

This natural laboratory of geodiversity, coupled with other values of reference in The Azores, such as its rich terrestrial and marine biodiversity and the architectural, cultural, ethnographic and immaterial heritage of undeniable value, offers unique products, services and experiences to visitors that are part of the Azores geotourism offer. These can be explored in several thematic routes, as walking trails, volcanic caves, belvederes, thermal areas, science and interpretation centers, urban and littoral routes, all embraced by the most iconic tourism product of The Azores: its volcanoes and volcanic landscape.

Thus, visitors and tourists are welcome to use the walking trails, visit viewing points and tea plantations, go whale-watching, dive in the blue ocean, go bird-watching, enjoy the regional handicraft, taste the famous S. Jorge cheese or the "Furnas geo-cook" (cooked in the ground at a fumarolic field), enjoy the regional sweets and wines, or take a bath in warm and relaxing waters, as part of a fascinating experience in an active volcanic landscape.

The motto of the Azores UNESCO Global Geopark "Come to meet the Azorean volcanoes and enjoy an eruption... of Flavours, Smells and Experiences", says it all!

From the deep blue ocean emerges a submarine volcano

Period(s) of volcanic activity, millions of years ago

65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5

Bakony-Balaton Geopark

'Basalt organs' of Szent György Hill

EXTINCT VOLCANOES ACTIVE GEOTOURISM

Volcanic remnant hills in the Tapolca Basin

The Geopark has outstanding geodiversity with 172 rock formations but its most iconic landscapes were undoubtedly formed by volcanism. During the last phase of the Alpine orogeny, about 8 million years ago, basaltic magma rose up to the surface and one of the densest volcanic fields was formed in Europe: altogether approximately 50 volcanoes erupted in the Bakony–Balaton Uplands Volcanic Field. After the last eruptions 2.5 million years ago, differing erosional processes led to the formation of the basalt-capped volcanic remnant hills, landmarks of our Geopark.

Guided geotour

Balaton Uplands National Park Directorate, the management organization of the Geopark, operates 16 visitor centres and interpretive sites (mostly by contracted local entrepreneurs): some of these facilities are connected to the diverse volcanic heritage. Hegyestű, with its famous columnar jointed basalt cliff, is the most important geological interpretive site in the Geopark where a new volcanological exhibition to attract visitors with a set of science-based interactive attractions and visual take-home experiences.

The volcanic landscapes are popular destinations for our visitors: there are also many guided geotours along these geosites, offered by the Geopark staff and our Geopark Partners, most of them dedicated locals.

The very first volcanoes erupted in the present-day Tihany Peninsula. If you would like to become a real 'volcanic geotourist' in our Geopark, discover this breathtaking landscape! Due partly to its unique geological heritage, it is also a precious part of the National Park and a holder of the European Diploma. The Lavender House Visitor Centre here interprets this natural treasure chest. An amusing film about the volcanism of the region, an interactive exhibition and a shop with local products invite you to the Eastern Gate of the Geopark, just in the outskirts of the village of Tihany.

The picturesque Káli Basin is also an ideal place to learn about the volcanic, natural and cultural heritage. The new, 28-km-long 'Route of Fire' Nature Trail, between Hegyestű and Kopasz Hill, reveals various events in the history of the area, and an accompanying guide booklet provides a glimpse into the volcanic heritage of the region.

Probably Badacsony is the best known volcano in Hungary (Tapolca Basin), also famous for its wines, where the old nature trail was redesigned in 2018 (its new name is 'Ring of Fire'). The 'Basalt Organs' Nature Trail, with its emblematic pillars, also attracts many hikers on the remarkable Szent György Hill.

The displays of the fore-mentioned exhibitions, the easily understandable text and figures on the interpretive panels and booklet, are also in English, because our Geopark welcomes many visitors from abroad. We are waiting for you to come here and take a walk on the 'Land of Tame Volcanoes'!

A 48 Million years ago view into the land of volcanoes in the northern part of Bergstrasse-Oldenwald UGGp

A STONY BOOK OF ANCIENT LIFE


Basaltic colums of the Otzberg volcano, 21 Ma

The UNESCO World heritage Messel Pit Fossil Site is the northern entrance to the UNESCO Global Geopark Bergstrasse-Odenwald. Famous for its 48.2 million year old exquisitely preserved fossils, the Messel Pit is an Eocene *maar* volcano. It erupted as the Upper Rhine *Graben*, a major rift in the European crust, developed. This plate movement led to volcanic activity, which occurred in several phases beginning with the 65 million year old Cretaceous/Palaeocene "Katzenbuckel", the highest peak of the Odenwald. The volcanism is *maar*-type like the Messel volcano that erupted 48.2 Ma ago. The final eruption created the 21 million years old volcanoes of "Otzberg" and the "Rossberg". The *maar*-type Messel volcano tells a special story. When uprising magma mixed with ground water, a gigantic explosion created a big, deep hole in the ground. The resulting fracturing of the rocks and formation of steam filled the gaping hole with groundwater, resulting in a lake. This volcanic crater lake of the Messel *maar* had a diameter of around 2.4 km and a depth of more than 300 m. The lake sides were very steep, a deathly trap for animals in the surrounding subtropical rainforest, which fell into the lake. Due to anoxic water conditions, the animals and plants have been preserved extraordinarily well between the clay strata in the lake sediments. From the famous primeval horse, to "Ida", our probable former relative, the Messel fossils (e.g. crocodile) are like a "rock library" of ancient life and environment in Eocene times.

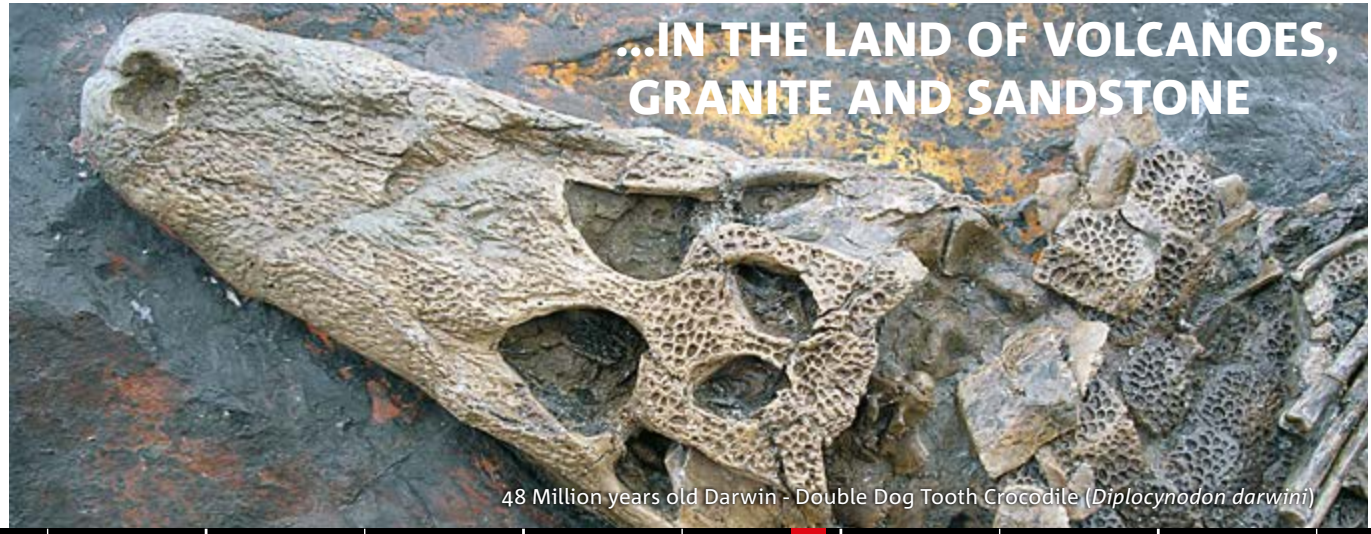
Each year, visitors are able to observe how paleontologists dig for the 48.2 million year old horses, giant birds, palms, crocodiles, bats, primates or the largest ants that have ever roamed the Earth.

Their excellent state of preservation includes soft tissues such as stomach content, feathers or skin impressions and sometimes even displaying their original colours. UNESCO counts the Messel Pit as one of the top four fossil sites in the world.

A visitor centre beside the pit welcomes the guests and gives them a deep insight into the "Time of the Messel World" including a virtual ride down a 433 m deep scientific drill hole to the volcanic eruption breccia. A treasure chamber, which showcases the most famous fossils, a shop and a bistro as well as a series of guided tours complete the comprehensive visitor service.

In 2010, Messel Pit was awarded one of the "geotopes of the year" in the UNESCO Global Geopark, and marks a very special window into the Earth history of the geopark. Besides the geotopes, the geopark offers 23 information facilities and more than 30 geo-trails. A team of Geopark Rangers guide visitors through the landscape, where they can partake in the fascinating stories of our Earth, the rocks, the nature, the landscape and the culture.

Our geological, biological and cultural diversity is a precious heritage – and UNESCO World Heritage Sites as well as UNESCO Global Geoparks protect, preserve, communicate and safeguard this heritage for the people of today and for tomorrow.



48 Million years old Darwin - Double Dog Tooth Crocodile (*Diplocynodon darwini*)

Bohemian Paradise
UNESCO GLOBAL GEOPARK

Čertí kopeček volcano

Bohemian Paradise UNESCO Global Geopark, Czech Republic
www.geoparkceskyraj.cz

THE VOLCANIC PARADISE

Czech Republic, situated in central Europe, is usually not considered to be a land rich in volcanoes. Despite the absence of active volcanoes, the Czech Republic geological history is associated with frequent volcanic activity of various styles and age. One of the most attractive areas is the UNESCO Global Geopark Bohemian Paradise.

The territory of Bohemian Paradise has been affected by at least three periods of significant volcanic eruptions. The oldest one took place in upper Paleozoic (250 million years ago), and two more during Neogene, 17 and 5 million years ago respectively. These volcanoes are in overwhelming majority quite small and offer great opportunity to study volcanic processes, even inside the feeding conduits.

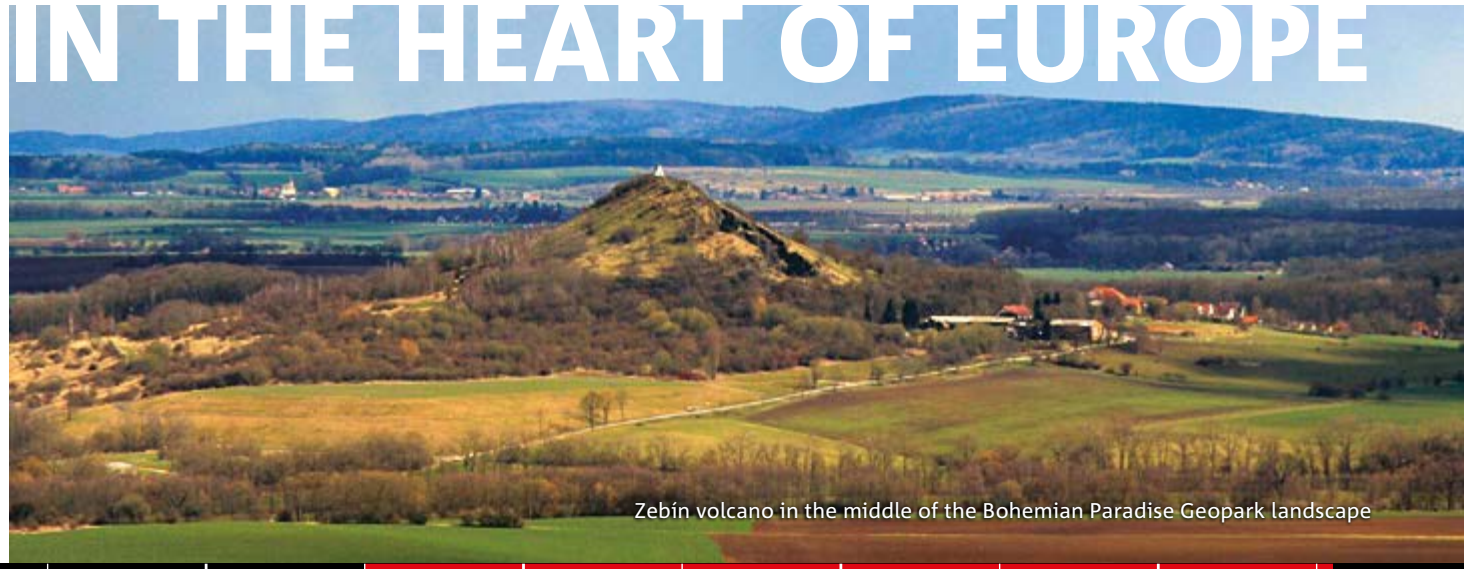
Except several former and active quarries, most of the upper Paleozoic (Permian) volcanoes are not well exposed on the surface of the Bohemian Paradise landscape, but lava flows of this age covered large parts of the Geopark area. The then volcanoes produced various types of lava, volcanic bombs and volcanic ash with abundant accretionary *lapilli*. Sub-surface basaltic rocks, usually called melaphyres, often contain attractive minerals, e.g. natural copper, gold, and principally dozens quartz varieties called “gem-stones”, including agates, chalcedony, crystal-quartz, amethyst, and many others. Due to this the area of the geopark is fairly attractive for collectors and there are numerous historically well-known finding places of “gem-stones”, e.g. Kozákov, Hvězda, Levín, etc. The world famous locality is Strážník hill, because of rich occurrence of star-shape quartz. Collecting, processing and trading in these minerals have several hundred years’ long tradition in Bohemian Paradise. Besides the “gem-stones” matter, the Paleozoic volcanic processes produced huge amount of silica-rich solutions that saturated parts of plants in the then tropical forests, especially stems of trees and their wood. Thanks to this the eastern part of the Geopark is world-wide known finding place of silicified stems, and is very interesting for palaeontologists.

Products of Neogene volcanic activity are very conspicuous in the landscape of the Bohemian Paradise, e.g. Zebín, Kumburk, and Čertí kopeček landmarks. One of them called Trosky is regarded as a symbol of entire Geopark Bohemian Paradise. Most of these volcanoes are about 17 million years old and are composed of dark basaltic rocks, representing feeding conduits of tuff- and scoria-cones. Several active and abandoned quarries enable to visit and study the internal structures of the volcanic edifices and processes that created them. Volcanic bombs up to 1 metre in diameter can be found on margins of some volcanoes.

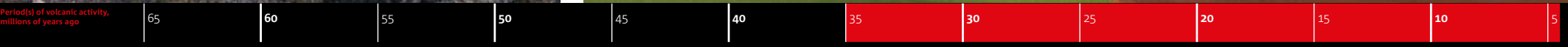
The volcanic activity in the Bohemian Paradise ceased out 5 million years ago when two smaller scoria cones Kozákov and Prackov were formed and Kozákov volcano emitted ca 12 km long lava flow.

Trosky castle

IN THE HEART OF EUROPE



Zebín volcano in the middle of the Bohemian Paradise Geopark landscape



PARQUE NATURAL
Cabo de
Gata-Níjar

Playa de Los Muertos

Cabo de Gata-Níjar UNESCO Global Geopark, Spain
www.juntadeandalucia.es/medioambiente/cabodegata-nijargeopark

LAVA UNDER THE MEDITERRANEAN SEA


El Barronal

Cabo de Gata-Nijar UNESCO Global Geopark is situated at the southeastern corner of the Iberian Peninsula, in the Andalusian province of Almería. This geopark covers an area of 352 km² in addition to 120.12 km² of protected marine areas surrounding this beautiful land.
Cabo de Gata-Nijar UNESCO Global Geopark has been a member of the European Geopark Network and the Global Geopark Network since 2006, and a Biosphere Reserve since 1997. Its volcanic facade, the coastal plain reef deposits, its crystal-clear waters and its ethnographic (scientific description of people and cultures) heritage are the hallmarks of the Geopark. The climate has a key role here, creating a sub-desert environment, unique in both Spain and Europe.
If we get closer to the Cabo de Gata Volcanic Complex, the geology is highly visible with its impressive scenery of spectacular cliffs that provide the most important record of submarine volcanism in the western Mediterranean. We must keep in mind that this is just a small part of a much bigger area that lies under the Alborán Sea. Volcanoes emerged from the sea 13 million years ago and continued growing in-land for the next 6 million years, producing an amazing landscape, like that of another planet. It is impossible to forget the mining heritage of the area, where the most important features are the former Gold Mines of Rodalquilar located at the Rodalquilar Volcanic Caldera.
In spite of the sub-desert nature of the soil, there are thousands of endemic florae: this is one of the most diverse and unique zone in the European continent. In terms of fauna, the steppe birds are important and, off course, the marine creatures on the coastal areas. With a population of 1500 different species of flora and fauna and the great Posidonia Oceanica meadows of the Mediterranean Sea, the Geopark provides a natural shelter for sea urchins, starfishes, sponges, mollusks, turtles, fishes and many more.
Cabo de Gata-Níjar UNESCO Global Geopark help us to understand the convoluted past of the Iberian Peninsula, at the time when Africa collided with Europe and the Sierra Nevada Mountains began to rise, generating a dramatic landscape with delicate beauty. This period generated the Mediterranean magic that could have been expected: volcanic rocks, blue skies and even bluest sea showing us how the European continent was shaped in fire and stone.

... EMBRACING THE DESERT


Prismatic jointing

Period(s) of volcanic activity, millions of years ago | 65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5

COPPER COAST
UNESCO Global Geopark

ANCIENT FORCES AND ROCKS SHAPED BOTH LANDSCAPE AND CULTURE

Over 460 million years ago, the world was a very different place. North and south 'Ireland' were separated by a vast ocean.

During this time, known as the Ordovician period, The northern part of the island of Ireland lay to the north of the equator. The southeastern part of the island, where the Copper Coast Geopark is now, was submerged near the south pole. Mudstones in the Copper Coast Geopark show how slimy mud - devoid of life, was laid down on the Ordovician seabed.

As time passed, shifting continental plates moved north and south 'Ireland' towards each other. All this movement created lots of volcanic activity. At first, these volcanic events resulted in thick, dark lava that slowly oozed out on the ocean floor and mixed with the sea floor mud. This magma slowly baked the sea floor and produced the shapes and textures we can see today along Stradbally cove.

The volcanic activity didn't stop once it met the seafloor. Lava continued to flow from the Earth's crust, uplifting the ocean floor close to the surface and into a zone where daylight, oxygen and eventually life could survive. Shells fossilised in the mudstones nearby Stage Cove prove that life flourished here when the volcanism paused.

Through millions of years, volcanic activity continued, but the chemistry of the lava changed. The treacly magma became more gaseous, sticky and explosive. At Annestown beach, we can see proof of explosive volcanic activity. The rocks of this beach show how eruptions ejected ash and blocks of lava up to 0.5m thick.

About 400 million years ago, the two parts of 'Ireland' finally came together. As part of this larger supercontinent, this 'stitched' together Ireland drifted northward towards the equator. A major mountain-building happened around this time too. Today we can see evidence of the mountains created during this period from Canada through Ireland, Scotland and Norway. In the Copper Coast, erosion of this mountain chain created sandstones and conglomerates containing boulders of previous sedimentary and volcanic rocks and white quartz pebbles.

At Ballydowane beach, you can see the 460 million-year-old green lava rocks below younger red rocks (which even contain pebbles of the green basalt). Between these rocks, 60 million years of Earth's history are missing.

The next geological era record in the Copper Coast is the ice age, which shaped much of our landscape. This time ended about 9500 years ago, and since then, the Copper Coast has had a rich history of human habitation. Within the Geopark, there are several burial sites (Dolmens) about 5000 years old, the most spectacular being at Gaulstown. The remains of an Iron age fortification system can be seen next to the lovely harbour of Boatstrand.

Our Geopark gets its name from the copper mining, which took place from 1825 to 1875. Miners from the local community elsewhere in Ireland and abroad extracted many thousands of tonnes of copper ore from here. The mining industry also employed over 2000 people at its peak. This made the Copper Coast a major industrial area at the time. However, when the ore ran out, and the mining ended, the community quickly left. Most migrated abroad to other mining regions in the USA, such as Butte in Montana and elsewhere.

But long before the 19th century, mining probably happened here too. With blue and green staining hard to miss along the cliffs, it's not hard to imagine the region's prehistoric human inhabitants noticing the metals contained in the rock. They would have used copper from here to make bronze tools.

El Hierro
GEOPARQUE

Lava channel in the Lajial *pahoehoe* lava field

THE ISLAND OF

El Hierro UNESCO Global Geopark, Spain
www.elhierrogeoparque.es

THREE MASSIVE LANDSLIDES

Columnar jointing and coastal arches in El Charco Manso

El Hierro is the youngest of the Canary Islands and the only region in Spain with ongoing volcanic activity. The area included in the Geopark is a little over a million years old. The small volcanic territory emerged from the seabed from five thousand metres below the surface, and now has risen to 1501 metres above sea level at Pico de Malpaso.

The young rocks of El Hierro are clearly seen on the island's surface, in the three volcanic ridges that create a unique inverted star shape. On these ridges, you can see signs showing how the island was formed by massive eruptions, the formation of lava flows and cinder cones. The cinder cones result from the accumulation of falling pyroclasts ejected out of the volcano and are the most characteristic feature of the island's landscape. Another prominent feature at the edges of each of the volcanic ridges to the south, east and west, is the lava flows, especially notable in the extensive El Lajial and El Verodal lava fields.

The most spectacular geological formations on the island are the massive landslides that resulted from rapid volcanic growth, which became unstable and consequently collapsed. The most impressive and obvious is El Golfo, where the landslide has created enormous cliffs like Tibataje in the north-eastern extreme of the curve as well as secondary volcanoes like El Tanganasoga in the collapsed area.

Las Playas is smaller in size but has resulted in an imposing land and seascape, crowned by Roque de la Bonanza. The south-western face of the island is covered by the El Julan slope deposits, a product of yet another massive landslide. The impressive scenery at Mar de las Calmas supports the island's marine reserve, home to underwater landscapes that provide one of Europe's leading diving locations, due to the magnificent scenery and abundant marine life in its deep waters.

It was in this area that the last volcanic eruption in the Canary Islands took place in 2011 - a volcanic episode that changed the contours of the seabed and its marine flora and fauna, however it has recovered quickly. El Hierro is a treasure trove of young volcanic landscapes that have been well-preserved and feature a rare mix of geological formations and thoughtful human intervention. It is an island whose identity is marked by its geology and life that is simply focussed in and around the volcano.

Columnar jointing and coastal geoforms: arches and sea stacks ("roques") in Puntas de Gutiérrez

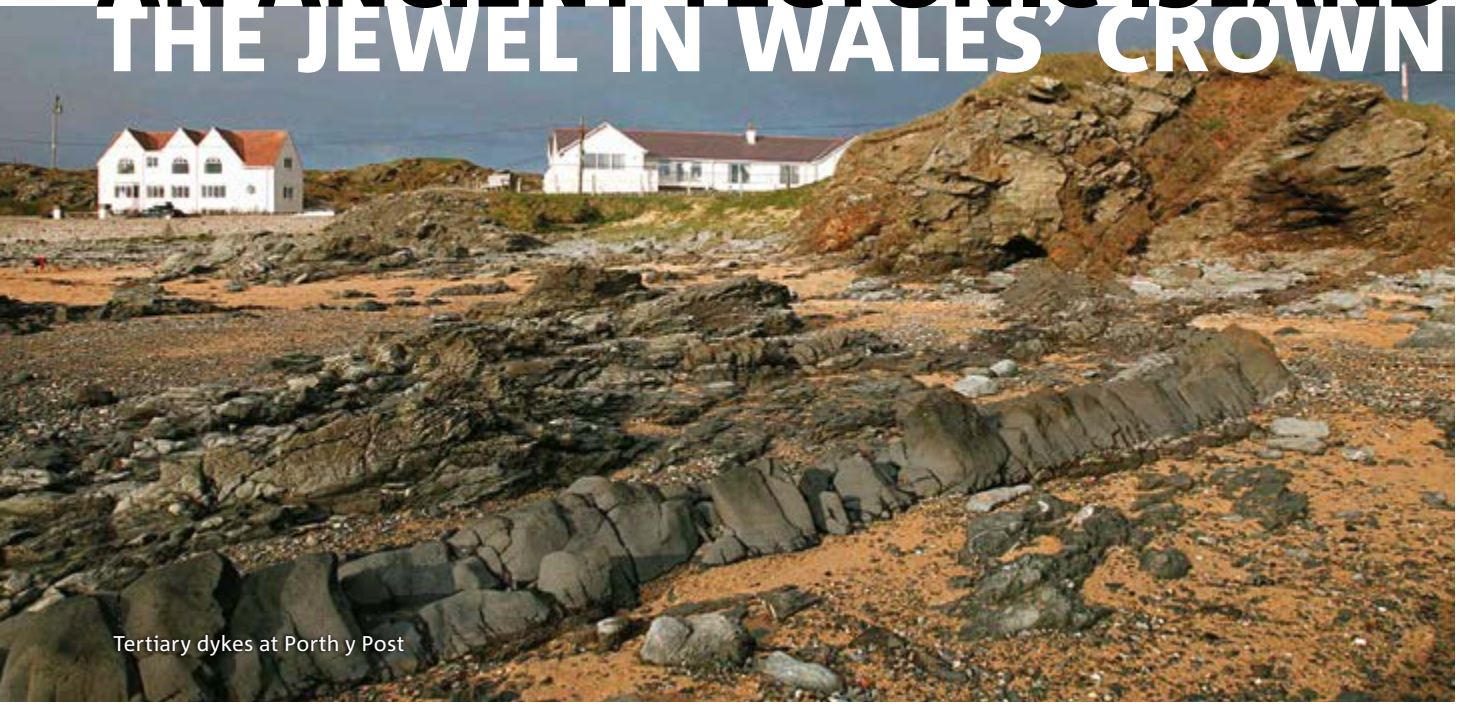
Period(s) of volcanic activity, millions of years ago

65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5

GeoMôn

Classic pillow lavas on Llanddwyn Island.

AN ANCIENT TECTONIC ISLAND
THE JEWEL IN WALES' CROWN


Tertiary dykes at Porth y Post

GeoMôn is in Anglesey, a 715 km² island, connected to North Wales by 2 bridges. It boasts rocks from every geological period except 2; the Jurassic and Cretaceous Periods when Anglesey became land and suffered erosion of its older rocks. GeoMôn therefore has an unusually comprehensive geological record in one small area. Some of the Rocks are particularly note-worthy, like the oldest fossils in the United Kingdom (Precambrian stromatolites best seen in Cemaes Bay), pillow lavas, and Palaeozoic dykes and sills.

The pillow lavas are best exposed in Newborough at the beach and in the forest where they have been geochemically altered by seawater and their minerals have been converted to albite felspar. The dykes of Anglesey comprise two main groups: the first about 500-350 Ma, consisting of several discrete phases of dyke injection; the second group, roughly 60-40 Ma, was caused by plate tectonic stresses and igneous activity associated with the rifting which led to formation of the North Atlantic Ocean.

GeoMôn also clearly demonstrates tectonic history, from its origins near the South Pole then its collision with Scotland on the continent North of the Iapetus Ocean to today's latitude 54°N of the equator. This has led to its collection of new rocks accumulated as it travelled over every climatic zone in the World. This collision caused the intense folding and faulting some 450 million years ago in the Caledonian Orogeny that metamorphosed, folded and faulted all of the rocks laid down before the Devonian Period. The earliest Precambrian rocks were formed shortly before and, in the Snowball Earth times and were all derived from volcanic or tectonic origins. A second volcanic phase occurred much later during the Tertiary Era. It was centred in Northern Ireland (Antrim) and created ring dykes and the lava flows that produced the Giants Causeway. The lava extended its tentacles in the form of dykes and flowed seawards then into Anglesey's fractured rocks.

GeoMôn uses this fantastic variety of plate tectonic history, geological periods and local rocks to teach the public and school and University students. Education includes field courses, displays and talks both in our centre and by using our many geosites as outdoor laboratories. We have produced a geology book about GeoMôn, and self-guided walks for more than 20 trails and information boards at 15 of our coastal geo-hotspots. We have 16 geoguides who can lead these trails. We also teach geokyaking in the Summer months and run a monthly programme of talks in a local centre. We work closely with other tourist, culture, heritage and history groups on our island. Our aim is to educate and entertain.


Palaeozoic dyke at Porth Tŵr Bach, Llanddwyn Island

Sandal Divlit Holocene-aged volcanic cone

Cave Paint

Kula-Salihli UNESCO Global Geopark, Turkey
kulasalihligeopark.com

PREHISTORIC HUMAN FOOTPRINTS

In the Manisa Province Geopark of Western Turkey there are 73 geosites. There you can see the physical evidence of more than 200 million years of Earth's history, from exposed Paleozoic metamorphic rocks, to a landmark volcanic landscape formed by one of the youngest volcanic fields in Turkey.

The visitor to the modern Geopark Visitors Centre can view on displays the best sites to be found within the Geopark and can choose which features to view and which of the marked routes in the geopark to follow. The displays and booklets in the Visitors Centre and around the geopark are comprehensive and easy to understand, with texts in English and Turkish. The local Geopark's staff are helpful and speak a variety of languages. Situated within the Geopark there are geo-archaeological sites with evidence of human occupation, which was in large part, fashioned by this landscape.

The Kula volcanic landscape is eye catching and recognised as such by the ancient geographer, Strabon, two thousand years ago and, this landscape has been attracting visitors and scientists ever since. With its volcanic cones and sea of lava flows, it looks as though they have just come freshly to the surface. It's not surprising that he called this region Katakekaumene, the burnt land, or, the Burnt Country. Then, as today, when a visitor walks across the lava flows, you can almost feel the heat from the molten lava that solidified into rock 3,000 years ago. It provides evidence of global climate and environmental change.

There are many geosites for geotourists to see in the geopark, such as the prehistoric human footprints left in the volcanic tuffs around the Sindel volcano cone and, also the ancient drawings that are thought to represent the volcanism at Kanlıkaya.

There are more than volcanic features to see, the geopark has a variety of fault structures, exposed rock strata, examples of fluvial, karstic and volcanic landforms, and a rich variety of erosional processes.

There are also the geo-archaeological sites within the Geopark. These date from the Lydian and Roman periods and include Sardes, the capital of Lydia, where coins were first minted and also the famous temple of Artemis as well as the giant molehills of Bintepeler, beneath which the nobles of ancient Lydia were buried.

Kula lava bridge

Period(s) of volcanic activity, millions of years ago

65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5

KATLA · UNESCO

KATLA GEOPARK

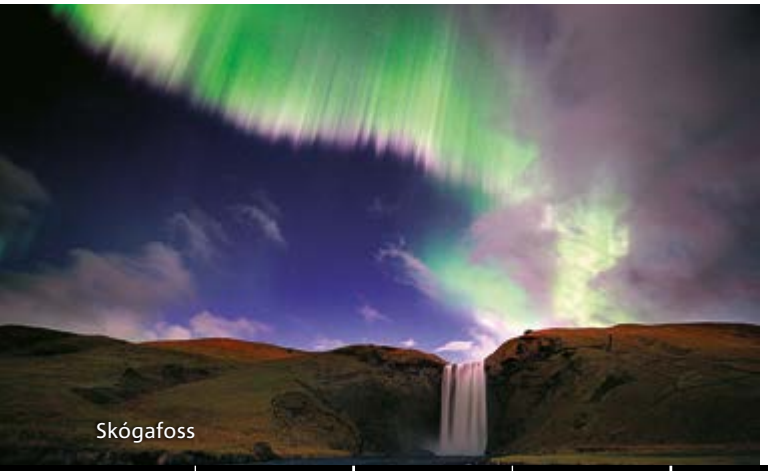
GLOBAL · GEOPARK

Reynisfjara

DYNAMIC DESTINATION
FIRE AND ICE


Eldmessutangi

Katla Geopark is in South Iceland and is characterized by the unusual combination of glaciers located on top of active volcanoes. This combination has several consequences. One of them is the formation of ash clouds due to the explosive interaction of the upcoming magma with glacial melt water. In 2010 one of our ice capped volcanoes, Eyjafjallajökull, produced such clouds of ash that it left millions of passengers stranded as 100,000 flights were cancelled in the northern hemisphere. Another unusual charactristic of the eruptions making their way through the ice, sometimes more than 700 m thick, is the massive outburst of glacial melt water (jökulhlaup), especially from the volcano Katla under the Mýrdalsjökull ice cap. In the 1918 eruption, it is believed to have dumped up to one cubic kilometre of tephra and other debris on the Sandur Plain in front of the glacier and added about 14 km² of new land to the coastline bordering the Atlantic ocean.


Skógafoss

Katla Geopark is the scene of the two largest flood-lava eruptions on Earth in the past millenium. These eruptions produced the Eldgjá lava flow (AD 934-940) and the Laki lava flow (AD 1783), which together cover about 1100 km², an area almost twenty times larger than Manhattan. Eruptions in Iceland are frequent, on average every five years, but an indication of the enormous size of the two eruptions mentioned above is that they produced more than half of the magma volume erupted in Iceland over the past 1000 years.

Bordering the Atlantic ocean in the south and, towering volcanic mountains in the north, Katla Geopark enjoys the highest rainfall in Iceland. It is the only region in the country where the land is green with vegetation, from the sea to the highest mountain tops. The fertility of the soil is also greatly enhanced by the tephra falls produced by volcanic eruptions. However, the landscape is constantly changing due to the volcanic activity.

Katla Geopark is big, about the size of Cyprus, but the population is tiny, only about 3,200 people. Sheep and dairy farming used to be the main occupation but, now the area is one of the magnets in the fast growing tourism industry, receiving over a million visitors every year. Popular sites include the waterfalls, Seljalandsfoss and Skógafoss, the outlet glacier Sólheimajökull, black beach and columnar basalt cliffs and cave of Reynisfjara, the canyon of Fjaðrárgljúfur and the 120- metre high promontory of Dyrhólaey with a massive arch created by the sea attacking the headland.

The lowland part of the Geopark is easily accessible all year, only about two hours drive from the international airport near Reykjavík, the capital of Iceland. Geotourism in Katla Geopark allows access to one of the most dynamic destinations in the world!

Lanzarote Geoparque
y Archipiélago Chinijo

The tuff cone of El Golfo, a hydrovolcanic edifice

Vineyards in a lapilli field, La Geria

A VOLCANIC TREASURE

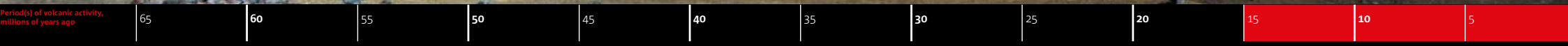
Lanzarote and Chinijo Islands UNESCO Global Geopark, Spain
geoparquelanzarote.org

MARS ON EARTH

Lanzarote and Chinijo Islands Geopark is a volcanic oceanic area located in the easternmost of the Canary Islands, which covers approximately 2500 km². The wider area includes Lanzarote, the small islands of La Graciosa, Montaña Clara, Roque del Este, Roque del Oeste, Alegranza and underwater islands.
The combination of geographic location, climate features and volcanic activity turned the Lanzarote geopark into an outdoor museum, with an extraordinary geodiversity of scientific, educational and touristic interests.

The geopark is almost completely formed of permeable volcanic rock and well-preserved eroded and sedimentary volcanic structures. It rises up from a shallow marine platform consisting of a large pre-Quaternary basalt plateau that locally emerged from the sea to form Los Ajaches (SW) and Famara (NE). Otherwise, the central part of the island is formed of Quaternary and recent volcanic products. Eruptive activity started in the Tertiary Era and has continued until recent times. Indeed, one of the latest phases of volcanic activity, the Timanfaya eruption, took place in 1730-1736 in the western part of the island. During this eruption, which is the second largest in recorded history, complex fissures occurred and more than one-third of the island was covered by pyroclastic rocks and lava flows.
The duration, extent and volume of volcanic materials emitted combined with the evolution of magmas of this eruption are unique and differ greatly from the usual pattern of historic volcanism in the Canary Islands. Due to its uniqueness, part of the area was declared a National Park in 1974 and is now one of the most visited National Parks in Spain. This is one of few places where visitors have the opportunity to explore lava fields riding camels or enjoy the effects of active volcanism whilst eating a meal prepared with the Earth's heat!
This outstanding volcanic landscape, together with a wide trail network all around the Geopark fosters geotourism, which is one of the essential targets of the geopark and through which the promotion of local and sustainable economic development and education is made possible. For this reason, many educational programs for students and adults are provided in order to spread awareness of the geological and natural heritage.
The Geopark is also important for its terrestrial and marine biodiversity. Indeed, it includes 13 Protected Areas and a Biosphere Reserve. In addition, there are 7 Centres of Art, Culture and Tourism of Lanzarote, created in order to protect and highlight natural and cultural heritage.

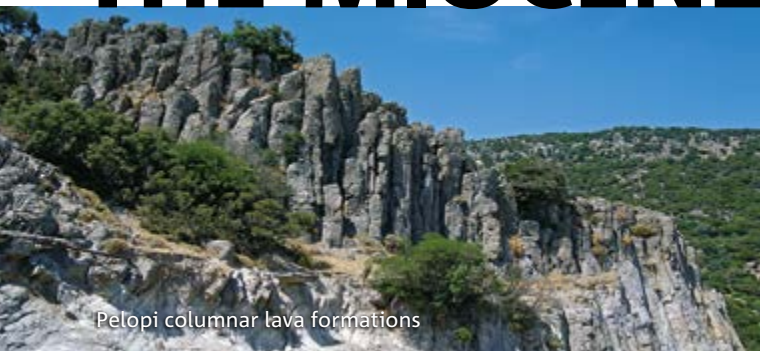
A bomb of Montaña Colorada



LESVOS
GEOPARK

Nissiopi Marine Petrified Forest Park

THE MIOCENE



Pelopi columnar lava formations

Lesvos island lies in the North Eastern Aegean Sea, and is part of a Miocene volcanic arc related to the subduction of the African lithosphere below the Eurasian tectonic plate.

Spectacular volcanic landforms and geosites are the dominant geological features on the island. A combination of these along with the fossils, rich ecosystems, beautiful landscapes and important cultural monuments compose the main elements of the Lesvos Island UNESCO Global Geopark.

Volcanic activity that took place 21.5 to 16 million years ago led to the creation of large volcanoes, such as those in Lepetymnos, Vatoussa, Agra, Mesotopos and Anemotia. The impressive lava domes in Mesotopos, Eresos and Ordymnos, the volcanic neck of Petra, the impressive columnar lava landforms in Lepetymnos and Ordymnos and the characteristic volcanic veins constitute the main volcanic geosites. The volcanic activity is connected with the occurrence of geothermal fields and several important hot springs: these are located in Polychnitos, (the warmest springs in Europe), Lisvori, Thermi, the Gera Gulf, Eftalou (which provides the most radioactive therapeutic waters of Lesvos), Argenos and in Krifti of Plomari.

Minerals and rocks related to the volcanic activity, such as quartz, opal, ignimbrite, andesite, alum, bentonite, lead, zinc and magnesite constitute valuable natural resources which have been exploited by man over the years, and have played a leading role in the productive economy of the island. In addition, many

Lesvos Island UNESCO Global Geopark, Greece
www.lesvosgeopark.gr

KINGDOM OF HEPHAESTUS

archaeological and religious monuments in Lesvos have been built using volcanic rocks. Andesite and ignimbrite were used as the common construction material for temples, castles, churches and monasteries.

The intense volcanic activity in the North Eastern Aegean islands, which according to Greek mythology hosts the underground laboratory of Hephaestus, the god of the volcanoes, is related to the creation of the Petrified Forest, a unique natural monument. In the western peninsula of Lesvos upright and lying fossilised tree trunks, remain in their original position and confirm the existence of a dense subtropical forest 20 million years ago. This occurred when the vegetation was covered by enormous quantities of volcanic ash and pyroclastic rocks. The circulation of geothermal fluids rich in silica then led to the fossilisation of the tree trunks. Thousands of standing and lying petrified trees are found today, not only on the island but also along the coast and at the bottom of the Aegean Sea, as a result of the recent geotectonic evolution of the area.

The Natural History Museum of the Lesvos Petrified Forest offers not only exhibitions and information but a unique experience of guided tours to see the richness of the geological wonders of Lesvos island. Provision of a series of year-round events, educational programs for students and adults, different permanent and temporary exhibitions, outdoor activities and promotion of local products and gastronomy, make Lesvos Island UNESCO Global Geopark an ideal place not just to visit but also to live!

Chidira waterfall

Period(s) of volcanic activity, millions of years ago

65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5

Parc naturel régional des Monts d'Ardèche

Rocher de Brion Volcano

THE LAND OF PHONOLITE DOMES AND BASALTIC FLOWS

field training course on volcanism

Monts d'Ardèche Global Geopark has been associated with volcanism for more than 12 million years. The volcanic activity is diverse providing many different landscapes including, strombolian craters, phonolite extrusions, *maars*, dykes, necks, and basaltic flows, all of which have shaped the landscape we see today.
Three major volcanic periods have been identified in Monts d'Ardèche. The first began more than 12 million years ago in the area of Mont Mezenc and Mont Gerbier, which lasted for more than 6 million years. This occurred after an intense strombolian phase and generated lavas flows of trachyte and phonolite. The viscous phonolite lavas have created domes and peaks locally called "Sucs". These forms and the later intense erosion have shaped a unique and scenic landscape, including the largest phonolitic massif in Europe. The most well-known places are Mont Gerbier de Joncs, easily identifiable with its typical sugarloaf shape which provides the source of the Loire River, and Mont Mezenc, which is horseshoe shaped and reaches an altitude of 1753 m. Suc de Sara, a ring dyke, provides a 360° viewpoint of numerous volcanic features.
The second period of Volcanism can be seen in the nearby massif of Coiron (-8 to -6 Mo years), which is characterized by more fluid basaltic lavas. The landscape exhibits various features including intruded dykes, volcanic necks and lava flow stacks.
The last major phase in the volcanic history of Monts d'Ardèche is the eruption of the so-called "Ardèche young volcanoes" some 168,000 years ago. These eruptions generated almost perfect strombolian volcanoes, still easily visible in the landscape despite the vegetation cover. They are relatively young, aged between -40,000 and -12,000 years ago depending on the dating methods used. This means that these volcanoes were contemporary with human settlement in Ardèche, notably marked by the Chauvet cave mural paintings that are known to be the oldest in the world (-36,000 years). While cooling down, lava flows originating from those volcanoes have created basalt columns showing a remarkable prismatic shape (columnar jointing). The longest of them is more than 20 km long and lies between the RayPic waterfall and a lava flow of an older volcano.
Around the young volcanoes, there are a number of *maars*, created by intense and violent phreatomagmatic activity. The largest of them in Monts d'Ardeche is Vestide du Pal, which has more than a 5 km circumference, probably the largest *maar* in Europe.

Young volcano in Jaujac

Period(s) of volcanic activity, millions of years ago

65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5

Bent hexagonal columnar basalt "*waterfall*" at the foot of the Somoska Castle Hill

BORDERLESS LABORATORY OF BOUNDLESS VOLCANOES

Samsonhaza quarry exposing the slope of an andesitic composite volcano

Novohrad-Nograd is in Central Europe with a peaceful cross border landscape surrounding us. But do not be mistaken, its geological past was harsh. Collision of micro tectonic plates pushed up the Carpathian Mountains and created a mosaic-like structure of accreted terrains, giving birth to the Pannonian Basin. Diverse volcanism shows that elemental forces were involved in the process, spanning the last 20 million years and ending just before our current Era. The volcanoes created during this process have created a laboratory of treasures for the Slovak-Hungarian Novohrad-Nógrád Geopark.

Luckily, the remnants of the rich volcanic heritage of the transboundary geopark are accessible, not only for the professionals but also for the public and visitors. There is easily read interpretation at the geosites to inform experts, local people and visitors of the importance of the volcanism to the local people and to enhance the economic value of this area by geotourism.

The fiery volcanic eruptions produced rhyolitic ignimbrites, devastating ash flows that covered tropical habitats in Kazar, preserving them, for example the world-famous fossils of Ipolytarnoc, a Prehistoric Pompeii. Later submarine and subaerial lava flows, fed by magma chambers, created andesitic composite volcanoes that formed isolated islands in the subtropical sea. Due to erosion, the inner structure of the andesitic volcanoes has exposed feeder dykes in several places. The alternation of lava flows and colourful tuffs with calcareous marine sediments appear like huge layered birthday cakes, as seen in the quarry of Sámsonháza. In higher areas there are uplifted and eroded blocks. There are also km-long volcanic vents and large dyke networks which expose veins of former extinct volcanoes; the roots of a hazardous past.

At Bér an exceptional outcrop exposes the curved columns of an andesite body, the so-called “andesite-slide”. The columns were formed when hot andesite lava flowed into a large depression and slowly cooled. As the lava cooled, it shrunk and joints and fractures formed perpendicular to its margins thus creating the columns.

The youngest volcanoes of the geopark created the Novohrad-Nógrád basalt volcanic field. They comprise almost 100 individual volcanic centres, formed periodically, in six active volcanic phases. The basalt volcanism started some 6 million years ago, with interruptions lasting several hundred thousand years and ending only 100 thousand years ago. During its dormant phases, further volcanism may have occurred. Additional volcanic basaltic features are to be seen in the areas nearby and these include “petrified” gas bubbles, lava *spatters*, *maar* volcanoes, scoria and cinder cones, lava flows and lava plateaus.

Today land and man work together, as in the volcanic peaks that are topped by medieval castles - thus linking human history with its geological past. The emblem of the Geopark depicts the Somoska Fortress, standing on basalt. At its foot runs the state border, which has divided the land and its communities since the First World War. Yet with its curved columnar basalt, its volcanic rocks, the shared castle hill could reunite the present with the past in this transnational geopark.

Somoska (Slovakia) and Salgo (Hungary) castles were built on basalt rock

PAPUK
Park prirode
Nature Park

Rupnika geosite

SILENT ORGAN PIPES
EVIDENCE OF THE VIOLENT VOLCANIC PAST


Tresnjevica geosite

The Geological diversity of Papuk Geopark is reflected in the various types of rock created in different geological Eras of the Earth's past. Aside from the numerous varieties of metamorphic and igneous rocks created, mostly in the Palaeozoic era, there are also carbonate rocks in which many caves, sinkholes (ponors) and other karst morphological forms have formed, as well as the most recently created sedimentary rocks, which are often abundant in fossils.

The important part of the geological mosaic on the mountain Papuk are the volcanic rocks created during Mesozoic (Cretaceous, ca. 80 million years ago), as well as volcanic products related to the Cenozoic (Neogene, ca. 16 million years ago). The latter are connected to the processes that created the Pannonian Basin. The most important geosite at the Papuk Geopark is Rupnica. This morphological feature is the columnar jointing of volcanic rocks popularly called organ pipes. This volcanic phenomenon is unique in Croatia and the site has been further protected as a geological nature monument since 1948. The volcanic rock at the site is albite rhyolite and the pipes were created 16 million years ago as magma slowly cooled either just below or on the Earth's surface . As the magma slowly cooled, fissure systems were created and formed prismatic columns with four, five, and six sides. Voćin volcanic mass is also characterised by the appearance of numerous volcanic dykes that penetrated through 400 million old metamorphic rocks of the Papuk Mountain. The tall slopes of the Trešnjevica Stone Quarry are an exceptional backdrop for the ancient geological event, painted by numerous dark volcanic dykes over the light, grey background of gneisses and granites. Further evidence that Papuk was volcanically active 16 million years ago is provided by the deposits of volcanic ash located at the bottom of the former lake at the geosite Poljanska.


Rupkós Geology School

Educational panels have been placed at both geosites, which can educate the visitors about the features of Papuk relating to volcanoes, but also describing European and World volcanoes. The Geosites Rupnica and Trešnjevica Stone Quarry are ideal open classrooms that implement the geological workshop programme "Rupko's Geology School" for schoolchildren.

The geological diversity of the mountain and, its biological features of many protected plant and animal species and their habitats, and the valuable historical heritage evident by the landscape that contains six medieval forts were the main reason to protect the area as a nature park in 1999. The valuable geological heritage of Papuk and the sustainable development policy based on geo-conservation, geo-education, and the development of geo-tourism was the next logical step in the process of joining the family of European and UNESCO Global Geoparks in 2007.

The “Bridge Between Continents”
A symbolic footbridge between the North American and Eurasian plates

REYKJANES PENINSULA

Reykjanes UNESCO Global Geopark, Iceland
reykjanesgeopark.is


The black sand beach at Sandvik

Reykjanes Geopark lies on major plate boundaries along the Mid-Atlantic Ridge, part of the 65,000 km mid-ocean ridge that encircles the earth like the seam of a baseball. Ocean ridges like the Mid-Atlantic are some of the largest geological features on the surface of the Earth. Although 90% of this mountain range lies deep below the surface of the ocean, it rises above sea-level here on the Reykjanes Peninsula, making this one of a few places one Earth where it is visible and easy accessible.

It is home to many important geological formations, some of which are unique, including many varied types of volcano in at least four separate volcanic systems with hundreds of open fissures and faults and vast lava fields.

The Reykjanes Peninsula is a continuation of the Mid-Atlantic Ridge. It rises from the sea at the very tip of the peninsula and crosses Iceland diagonally from the south-west to the north-east. You can read the area's geological history several hundred thousand years back in time, although most of the strata are less than 100–200 thousand years old. The last series of eruptions on the Reykjanes Peninsula began around AD 1000 and ended 250 years later. In 2021 a new volcanic era began.

The landscape that makes up the peninsula is characterised by tuff mountains and hyaloclastite ridges that formed in subglacial eruptions, as well as several series of craters and other large shield volcanoes from more recent times. In many places, there are lava stacks that formed in fissure eruptions as large volumes of lava flowed from the eruptive fissure vents. Eruptions in Reykjanes are rarely accompanied by ash, except when the volcanic fissures open underwater or in the sea, and volcanic activity in the Reykjanes Peninsula changes between its four volcanic systems along time.

Earthquakes are frequent due to the spreading of the tectonic plates and occur most commonly as earthquake swarms that can last for several years. Although most of these are minor, every so often they can be felt across the entire peninsula.

Reykjanes Peninsula is very accessible all year round. It is the gateway into Iceland for most visitors as they arrive via Keflavik International Airport, located on the northwest tip of the peninsula. It is the home to the Reykjanes UNESCO Global Geopark since 2015 where unique landscape surrounds you every step you take. An area where interesting interaction between nature and residential areas has shaped the way of life. Witness the undying forces of the Mid-Atlantic Ridge – with average rifting amounts to about 2 cm/year – and skip between the Eurasian and the North American tectonic plates by crossing the symbolic footbridge, The Bridge Between Continents. Step off the plane and you are only stonethrow away for a unique landscape!

A BRIDGE BETWEEN CONTINENTS


A group of vigorous mud pools and steam vents at Reykjanes

Period(s) of volcanic activity, millions of years ago

65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5

SESIA VAL GRANDE
GEOPARK

Sesia Val Grande UNESCO Global Geopark, Italy
www.sesiavalgrandegeopark.it

DEEP INSIDE A SUPERVOLCANO

Are you thinking about the next exciting trip. Why not take a trip inside a volcano down to the centre of the Earth? No, it is not a joke! You can do this in Sesia Val Grande UNESCO Global Geopark! But to explain how it is possible, you have to go back to another geological Era, in a very different world.

Everything started about 300 millions years ago in the supercontinent called "Pangea". In an area to the South of the equator where great volcanic activity was taking place. One day, a supervolcano exploded in a huge eruption, forming a large caldera and then slowly faded away. Millions of years passed by and tectonic plates carried Africa northwards unti it crashed into Europe forming the mountains we know today as the Alps. Thanks to this dramatic collision between two continents, the deepest part of the continental crust was exposed at the surface, showing not only the "old" volcano, but also their "roots". Today, visitors can walk on fragments of sub-crustal mantle. They can sit comfortably on a magma chamber and visit the contact between a massive gabbro intrusion and the rocks of the deep crust. They can see how granitic magma was formed and they can visit the roots and the roof of a granitic pluton and admire the chaotic breccias produced by the explosive super eruption that formed a caldera that is at least 15-km in diameter. A true trip inside a volcano down to the center of the Earth!!

Moreover, the Geopark area includes a complete section of rocks from the deep, middle and upper crust, which collectively have provided for decades an unprecedented model for the interpretation of geophysical data of the continental crust. It has been researched by scientists from all around the world. It can be considered the world's most accessible reference section for the continental crust. Furthermore, thrust sheets of rocks derived from Europe and Africa that were stacked to form the Alps are wonderfully displayed on Monte Rosa massif and along the lower Val d'Ossola. In the north-west part of the area, the public can visit also outcrops of ultra-high-pressure metamorphic rocks and fragments of the Tethys oceanic crust that once separated Europe and Africa.

If fire and earth were not enough, in the Geopark you can find also air and water to enjoy. In about 60 km you can go from the high peaks (above 4,000 m a.s.l.) of Monte Rosa to the placid coast of Maggiore Lake. This makes the Sesia Val Grande Geopark the highest and the steepest geopark in Europe. Moreover, extending from the Po Valley to the peaks of the Alps, the Sesia Val Grande Geopark offers visitors the opportunity to observe the effects of climate change recorded by the Pleistocene geomorphology by studying the recent retreat of glaciers, and patterns of human settlements dating from the Paleolithic.

In Sesia Val Grande UNESCO Global Geopark everything speaks about the deep relation to its own territory, geology and landscape, displaying the link between humans and nature.

Period(s) of volcanic activity, millions of years ago

65 | 60 | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5

Geopark

Schwäbische Alb

THE SWABIAN VOLCANO
A TERTIARY SUPERLATIVE

The Swabian Albs Geopark, Germany is well known as a paradise for fossils, caves and Ice Age art. However, there is still much more to discover: 360 extinct volcanic vents and a few volcanic cones such as the Limburg volcano grace the so called "Albtrauf", the northern escarpment of the Swabian Alb. With an area of 40 by 40 square km – comparable to Mount Etna – it is the largest volcanic region in Baden-Württemberg, but with little exposed volcanic rock.

The volcanic eruptions took place in the Miocene and started some time before the asteroid strikes in Nördlinger Ries and Steinheim about 14.8 million years ago. The Tertiary volcanic activities in the Geopark Swabian Alb are of "*maar* volcanism" type, comparable to the recent volcanism at Ukinrek, Alaska in 1977. Basaltic magma from 80-100 km deep, the upper mantle of the earth, with a temperature of more than 1100°C, penetrated through faults and cracks in the Jurassic rocks of the Alb. Through contact with karstic groundwater, the intruded magma triggered severe explosions of steam and discharge of gases. This led to more rock fragmentation and disintegration of the magma, producing ash and *lapilli* within the *maar*. Where the volcanic vent reached the earth surface, the ash and lava exploded into the air then settled on the land surface, with some falling back into the crater or vent. With continued access to groundwater, additional explosions followed and the diatreme (a volcanic pipe caused by a gaseous explosion) was extended downwards below the land surface. The erupted material which dropped back into the vent settled and compacted. During this event, the crater margins collapsed and the debris including the eroded ash and rock fragments slid down the crater rims and crater walls. From about 20 volcanic vents of the Swabian volcano, lavas followed, flowing gently, later to solidify in the vent. Examples are found at Eisenrüttel, Jusi, Sternberg, Feuerbölle and Hohenbol. Today remnants of these lava-filled vents are found at the land surface. In some places the surrounding limestone and younger sediments have been eroded around the vent. Commonly, the conduits are filled with vent breccia and tuff that contain distinct materials including volcanic ash, *lapilli*, rock fragments from the Jura, Keuper, Muschelkalk and Rotliegend as well as basaltic magma containing olivine.

The volcanic forms of this marvelous landscape are explosion conduits (diatremes) with relic blast cones (*maar*) having a maximum diameter of up to 1.2 km. Aside from the well-known "Randecker *Maar*" visitors may find additional *maar* craters and sediments of *maar* lakes on the Swabian Alb. Further, exposed volcanic vents such as the Limburg, Aichelberg or Georgenberg exist. Above water-impermeable vents, secondary biotopes (swamps, ponds) as well as settlements have been developed.

The Swabian Alb Geopark, promotes volcanoes as its geological highlight (geotopes) as well as involving itself in Geoscience educational programmes and by creating opportunities for Geotourism.

Lava bomb near the village Strohn

Vulkaneifel UNESCO Global Geopark, Germany
www.geopark-vulkaneifel.de

THE LAND OF MAARS AND VOLCANOES

The three Dauner maar lakes

Dramatic events and enormous explosions created the Vulkaneifel, a region in West Germany, where the beautiful landscape was created by various forms of volcanic activity. It includes 350 small and large volcanoes, *maars*, lava flows and large mineral water and carbon dioxide sources, all located in the Vulkaneifel, and are tangible evidence of a fiery past. The volcanic activity of the region is divided into two phases: The first took place during the Tertiary Era some 35 to 45 million years ago, and the second phase started about 700.000 years ago in the Quaternary Era. This ended with the most recent eruption of the Ulmener *Maar*, Germany´s youngest volcano. only 10,900 years ago. The volcanism in Vulkaneifel is not yet finished, it has just paused and awaits the next eruption. Due to this special geological heritage, and ongoing activity, the Vulkaneifel has been recognised as a UNESCO Global Geopark.

The water-filled *maar* lakes are probably the most well-known landmark of the Vulkaneifel Geopark. The circular deep blue lakes, bordered by green, wooded slopes, are also known as “the eyes” of the Eifel. With their natural beauty, powerful nativeness and calmness they are characteristic of this unique scenery. *Maars* are created when flowing magma meets water-bearing strata as it rises to the Earth´s surface. Upon contact, the water evaporates abruptly resulting in massive explosions. This blast creates a chamber which then collapses, leaving a deep hole on the Earth’s surface, known as a *maar*. It is surrounded by a ring-shaped ridge of volcanic debris. To date, 77 *maars* exist in the Vulkaneifel. Twelve of them are water-filled, the others are either completely dried up or silting up. In addition to the *maars*, the Windsborn crater lake in the Vulkaneifel is the only one North of the Alps and is filled permanently with water. These features are both fascinating to scientists, and the wider population, as the idyllic *maar* lakes have always been a popular subject for painters and poets and are frequently visited destinations for people from near and far. Also, many other geological features, such as the huge lava bomb near the village of Strohn or the caves in the Vulkaneifel are popular attractions and well worth visiting.

Several Geo-Museums provide fascinating information concerning the geological richness of the region as well as the provision of a substantial network of hiking trails and cycle tracks that lead to the treasures of the beautiful landscape. Furthermore, there are exciting tours with certified tour guides, where visitors can gain a better understanding of the explosive past of the Vulkaneifel. “Comprehension by experience” is the unique geological concept of this geopark that successfully creates a ‘hands on’ experience for its visitors.

Millstone cave near the village Roth

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