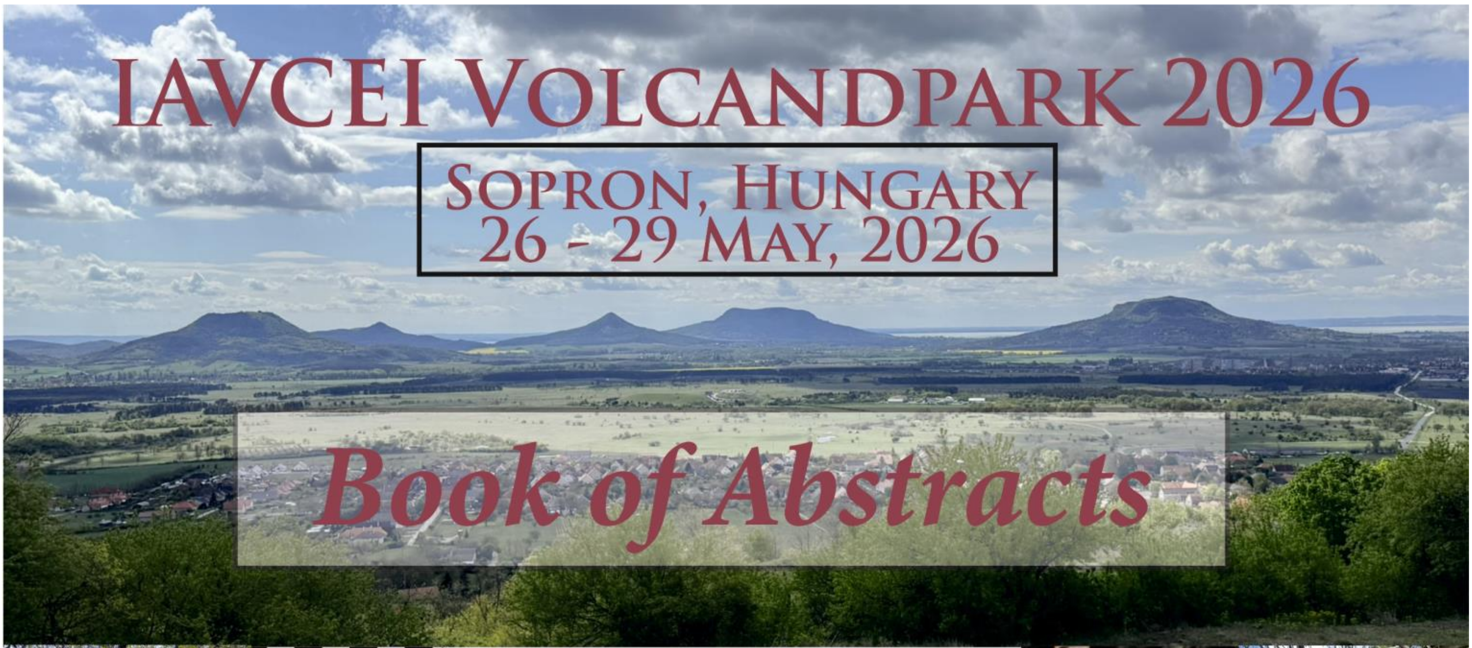
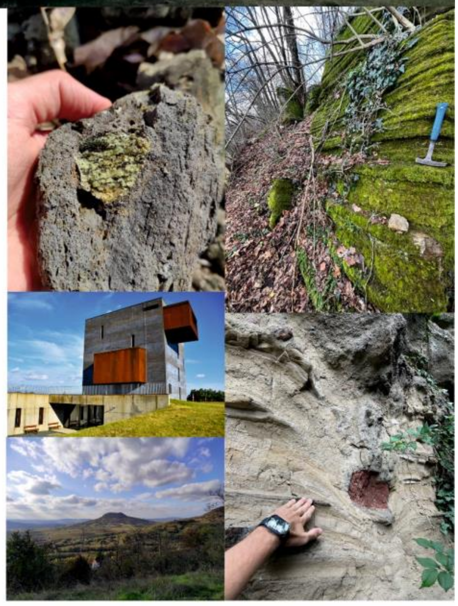
IAVCEI Volcandpark 2026

Sopron, Hungary
26 - 29 May, 2026

Book of Abstracts





Edited by

Mátyás Hencz
Károly Németh

Official event of the
IAVCEI Commission on Volcanic Geoheritage and Protected Volcanic Landscapes

HUN-REN Institute of Earth Physics and Space Science, Sopron, Hungary
2026

IAVCEI VOLCANDPARK 2026 CONFERENCE
Sopron, Hungary, 26–29 May 2026

BOOK OF ABSTRACTS

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IAVCEI Volcandpark 2026 Conference

Schedule – Oral Presentations

Sopron, Hungary · 25–29 May 2026

Venue: HUN-REN Institute of Earth Physics and Space Science (Csatkai Endre u. 6-8., Sopron)

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	09:20–09:30	**Sierd Cloetingh** — Opening presentation
	09:30–09:50	**Mátyás Hencz** — Introducing "Deep-Earth Geoheritage"
	09:50–10:10	**Karen Holmberg** — Thinking Like a Xenolith: Deep-Earth geoheritage in volcanology and climate change conceptions
	10:10–10:40	**Coffee break**
	10:40–11:00	**Maria Fernanda Martínez-Báez Téllez** — Geobiodiversity and geobioheritage of volcanoes: Life in Volcanpark
	11:00–11:20	**Yoshihiko Goto** — Entablature in a Quaternary dacitic lava at Gandate, Ontake volcano, Japan (Gandate Park): a supercooling model for the formation of small-diameter, irregular columnar joints
	11:20–11:40	**Károly Németh** — Volcanic geoheritage of effusive vents generated in 2021 Tajogaite monogenetic eruption (La Palma, Canary, Spain)
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	12:00–13:20	**Lunch (Deák restaurant)**
	13:20–13:40	**Froukje van der Zwan** — Geoheritage for geohazard awareness: towards an integrated framework for the Harrat Lunayyir volcanic field (Saudi Arabia)
	13:40–14:00	**Mohammed Benamrane** — Phreatomagmatic volcanic geoheritage in karst settings: the case of the Middle Atlas Volcanic Field (Morocco)
	14:00–14:20	**Marinel Kovács - Alexandru Szakács - Ágnes Gál** — Volcanic geoheritage in the new Gutâi-Maramureș UNESCO Geopark project, East Carpathians (NW Romania)
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	15:10–15:30	**Paraskevi Nomikou** — Linking Geodiversity, Biodiversity and Human Heritage in an active volcano: NISYROS
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	15:50–16:10	**Leslie Anthony** — British Columbia's Fire & Ice Aspiring GeoRegion: Overview, Opportunities and Challenges
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	16:30–16:50	**Steve Quane** — Vulcan's Scrapyard: Interpretive Geopark Development at a Dacite Volcanic Landscape in Active Industrial Use, Sea to Sky Region, British Columbia, Canada
	16:50–17:10	**Napsugár Trömböczky** — Geodiverse: material kinship across deep time Horizontal Collaboration Between Landscape, Science, Artist, and Audience
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	09:20–09:40	**Dávid Karátson** — Large-magnitude plinian eruption and exceptional geoheritage: insights from the Ipolytarnóc Fossil Site, Hungary
	09:40–10:00	**Károly Németh** — Volcanic geoheritage and natural hazard
	10:00–10:20	**Barnabás Korbély** — Local Stories of Our Volcanoes: at the intersection of creative expression and scientific communication
	10:20–10:50	**Coffee break**
	10:50–11:10	**Ingomar Fritz** — Geologicial (educational) programs in the "Steirisches Vulkanland"
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	13:50–14:10	**Joan Martí** — Exploring the Hidden Depths: The Significance of Deep-Earth Geoheritage
	14:10–14:30	**Monika Nowak** — Integrating artificial intelligence (AI) and R-based modelling to calculate Fe-Mg diffusion in olivines from Jeziorna ultramafic xenoliths (SW Poland): implications for Lithosphere - Crust magma storage timescales.
	14:30–14:50	**Gino Gonzalez Ilama** — Building a life in harmony between active volcanoes and the population in Costa Rica
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British Columbia's Fire & Ice Aspiring GeoRegion: Overview, Opportunities and Challenges

Anthony, Leslie[1], Quane, Steve[1], Russell, Lorne[1], Rae, John[1]
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The Sea to Sky corridor of British Columbia's south coast is Canada's most geologically active area – a land shaped by 200 million years of tectonic uplift and subduction, terrane accretion, episodic volcanic activity, cycles of continental glaciation, and large-scale wasting events that include debris flows, outburst flooding, and rock/landslides resulting from the interaction of natural geomorphological processes, weather extremes, and, increasingly, a rapidly changing climate.

The Fire & Ice Aspiring GeoRegion encompasses several nodes of geological significance within the corridor. Here, 61 geosites tell an end-to-end story of ongoing mountain-building, glaciation, volcanism and collapse – four geological pillars around which the GeoRegion's interpretive pedagogy is woven. Of particular note are the GeoRegion's numerous examples of supra- and subglacial volcanic eruptions that have resulted in a variety of ice-contact lava formations.

Significantly, the GeoRegion also sits wholly within the unceded, shared traditional territories of the Squamish and Lil'wat First Nations, who enjoy a unique ancient partnership that includes joint experiences and mythologies tied to the four geological pillars. Subsequent to the arrival of Europeans, the landscape's geological diversity supported its development as a globally recognized tourism destination with an abundance of activities, experiences and attractions. Interpretive materials that inform and educate around geological phenomena, geohazards, biodiversity, ecological processes, Indigenous culture, and post-contact industrial history exist throughout the corridor but are disconnected in relation to content and irregularly disseminated on the landscape. The Fire & Ice Aspiring GeoRegion seeks to unite these variable efforts under a single thematic umbrella that highlights the connectivity of their subjects, instills a collective sense of stewardship, and employs curatorial consistency in promoting the area's natural and cultural values as part of a more integrated and sustainable tourism vision. Overlap of the GeoRegion with the Atl'ka7tsem/Howe Sound UNESCO Biosphere Region adds additional impetus and cooperative partnership opportunities in shaping that message.

Challenges to this mission exist in bringing to the table a great and diverse number of stakeholders. Other challenges arise in seeking designation as a UNESCO Global Geopark – not least of which are colonial constructs of set-asides, boundaries and word usage related to these. Finally, the accelerating role of geohazards due to climate change is highlighting a need for better regional coordination around natural disasters.

Because we both shape and are shaped by where we live, it's not surprising that residents of the Sea to Sky corridor display a high degree of "topophilia" – love or emotional connection to a particular place. Though most have always simply adapted to the diverse and dynamic landscape with respect to impacts on livelihood and recreation, it is increasingly beneficial for all to more fully appreciate the role of geology and deep-time processes in their lives. This overview will touch on how each of these themes converge in the Fire & Ice Aspiring GeoRegion.

Figure 1. The andesite spire of *t'ak't'ak mu'yin tl'a in7in'a'xe7en* (Black Tusk), a subglacial volcano in the Fire & Ice Aspiring GeoRegion.

Volcanic xenoliths from Azrou-Timahdite quaternary basalts, Middle Atlas, Morocco as deep-Earth geoheritage site

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Mantle-derived xenoliths hosted in volcanic rocks provide a unique opportunity to investigate deep mantle structures within specific geological settings. As direct samples of the mantle, xenoliths preserve valuable information on the nature and evolution of the lithospheric mantle at the time of their transport to the surface by volcanism. In the Atlas chain of Morocco, Cenozoic intraplate volcanism has generated a wide range of alkaline lavas (Moukadiri and Kornprobst, 1984), some of which contain abundant mantle xenoliths (figure. 1).
The Eastern Middle Atlas (Azrou–Timahdite, Bou Ibalrhatene, Tafraoute) represents one of the most significant regions in North Africa for studying mantle and lower crust xenoliths brought to the surface by Cenozoic intraplate volcanism. These petrological and geochemical data provide a robust foundation for proposing a "Deep Earth geoheritage" geosite.
The Azrou–Timahdite volcanic field belongs to a Miocene–Pliocene to Quaternary intraplate alkaline province, related to lithospheric thinning and elevated heat flow (~80–85 mW/m^2) beneath the Middle Atlas (Orlando et al., 2025; Raffone et al., 2009; Natali et al., 2012; Lenaz et al., 2017; Chanouan et al., 2017). The maars of Bou Ibalrhatene and Tafraoute host numerous mantle and crustal xenoliths (Orlando et al., 2025; Raffone et al., 2009; Lenaz et al., 2014, 2017; Chanouan et al., 2017).
The occurrence of spinel lherzolites, harzburgites, wehrlites, pyroxenites, and amphibolites reveals a highly heterogeneous lithospheric mantle that experienced partial melting followed by intense metasomatism induced by carbonate- and silicate-rich alkaline melts (HIMU-like signatures). Closure temperatures of Cr-rich spinels (550–750 °C) suggest a relatively cold and shallow lithospheric mantle (20–30 km depth), located immediately beneath the lower crust (Lenaz et al., 2014, 2017; Chanouan et al., 2017).
Several monogenic volcanic fields in the Middle Atlas are already recognized as geosites (Baadi et al., 2021), and previous geosite inventories in Morocco (e.g., Drâa Valley, northeastern volcanic provinces) demonstrate the strong potential for promoting volcanic landscapes as sustainable geotourism resources (Beraaouz et al., 2019; Redouane et al., 2024).
The xenolith-bearing sites of the Eastern Middle Atlas combine key attributes required for geoheritage designation: excellent accessibility, abundance of well-preserved outcrops, high international scientific relevance (metasomatism, lithospheric thinning, UHT processes), and strong educational value. Mantle and crustal xenoliths from this region provide exceptional insights into the composition, thermal structure, and tectono-magmatic evolution of the North African lithosphere. Their preservation within well-developed maars and volcanic cones, together with extensive petrological and geochemical investigations, makes this region a prime candidate for designation as a "Deep Earth geoheritage" site of high scientific, educational, and geotouristic importance.

Figure 1. Hand specimen photograph of coarse-grained peridotite xenoliths from the Azrou–Timahdite Quaternary basalts, Middle Atlas, Morocco.

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Phreatomagmatic volcanic geoheritage in karst settings: the case of the Middle Atlas Volcanic Field (Morocco)

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The Middle Atlas Volcanic Field (MAVF) in central Morocco features over one hundred Plio-Quaternary monogenetic volcanoes on a karstified Jurassic-Cretaceous carbonate plateau (Figure 1). Although previous research has highlighted its geomorphological variety and geotourism appeal (Amine et al., 2019; Benamrane et al., 2022, 2023), little focus has been given to its specific geoheritage importance, which stems from the interaction between monogenetic volcanism and karst hydrogeological systems. This interaction creates distinctive volcanic landforms and eruptive sequences that are rarely found elsewhere in Northwest Africa.

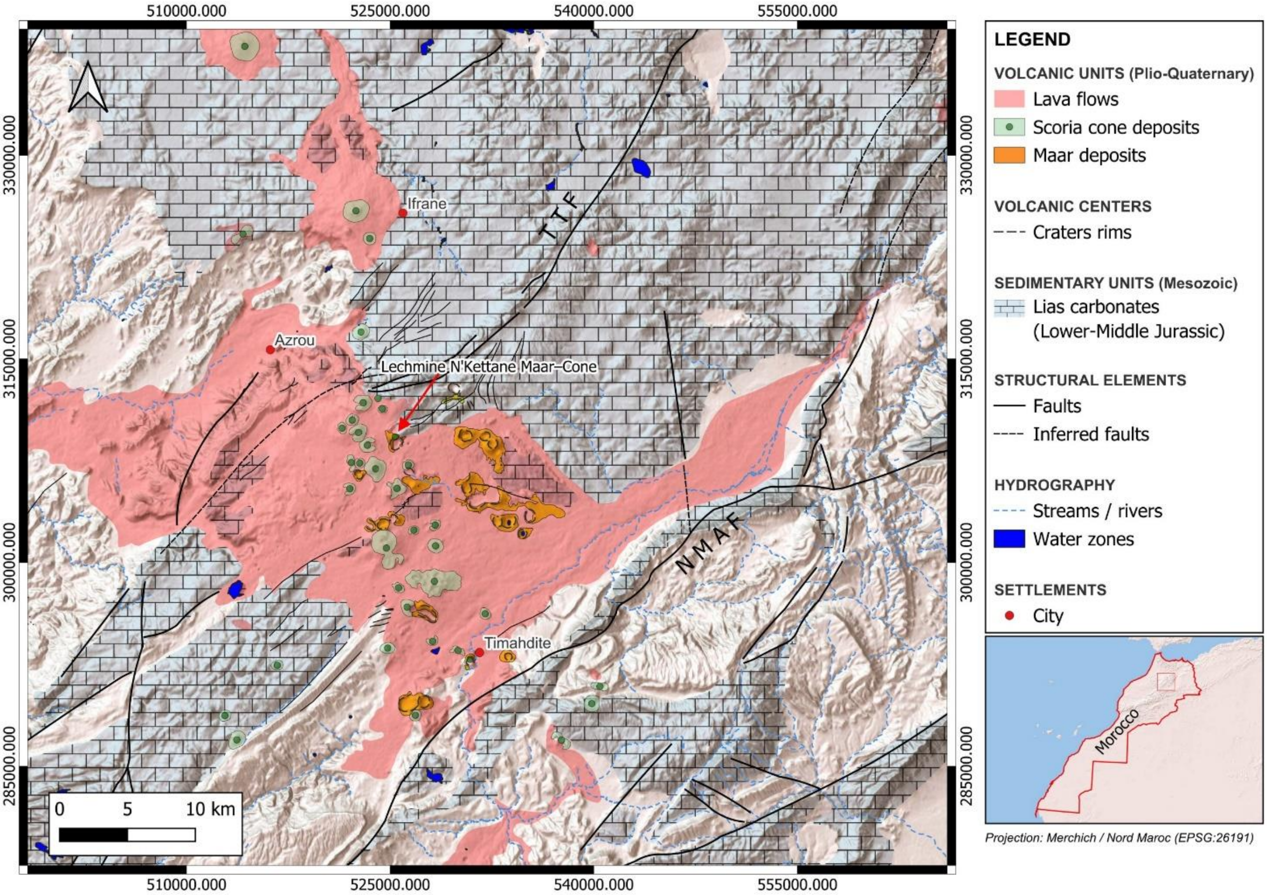

Figure 1. Overview map of the Middle Atlas Volcanic Field (MAVF) showing the distribution of monogenetic volcanoes on the karstified Jurassic-Cretaceous carbonate plateau.

This contribution examines the phreatomagmatic volcanic geoheritage of the MAVF, with particular focus on maar-scoria cone complexes developed at the interface between Liassic limestone substrates and Plio-Quaternary fluvio-lacustrine aquifers. Little is known about the heritage aspect of this volcanic site, illustrated here through the example of Lechmine N'Kettane volcano. The site corresponds to an elliptical maar crater (1130 x 750 m) excavated along a faulted contact between hard carbonate and soft saturated substrates, hosting four distinct eruptive phases that record the transition from phreatomagmatic to magmatic activity, driven by fluctuating water-magma interaction ratios. Additional geoheritage elements include peperite outcrops that document wet-sediment–magma mingling, base-surge deposits with accretionary lapilli, and exposed feeder dykes that offer cross-sectional views of shallow magmatic plumbing systems.

A qualitative geoheritage assessment indicates that these volcano-karst features have high scientific, educational, and geotouristic value due to their exceptional preservation, accessibility, and diversity within a small area that overlaps with the Ifrane National Park. However, they remain absent from existing geoheritage inventories (Baadi et al., 2021), which have focused on individual edifice morphology rather than on the diversity of eruptive processes.

We suggest that incorporating features of volcano-karst interactions into regional geoheritage frameworks could enhance ongoing geoconservation efforts and facilitate the development of volcanological geotourism routes linking the MAVF to broader North African volcanic heritage networks.

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The relevance of geoheritage research in Kamchatka

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The Scopus citation database was used to assess the current state of research on ecological tourism and the geoheritage of Kamchatka. A distinct cluster of knowledge related to volcanology, based on 7,086 publications since 2000, was identified using the word search within Title, Abstract and Keywords, "Kamchatka". When searching for the terms "Kamchatka volcano", the focus is shifted markedly on the study of the Tolbachik volcano and the discovery of new minerals within active volcanic systems of Kamchatka (Fig. 1). However, when searching for "Kamchatka tourism", only 28 publications are found, indicating limited research in this area.

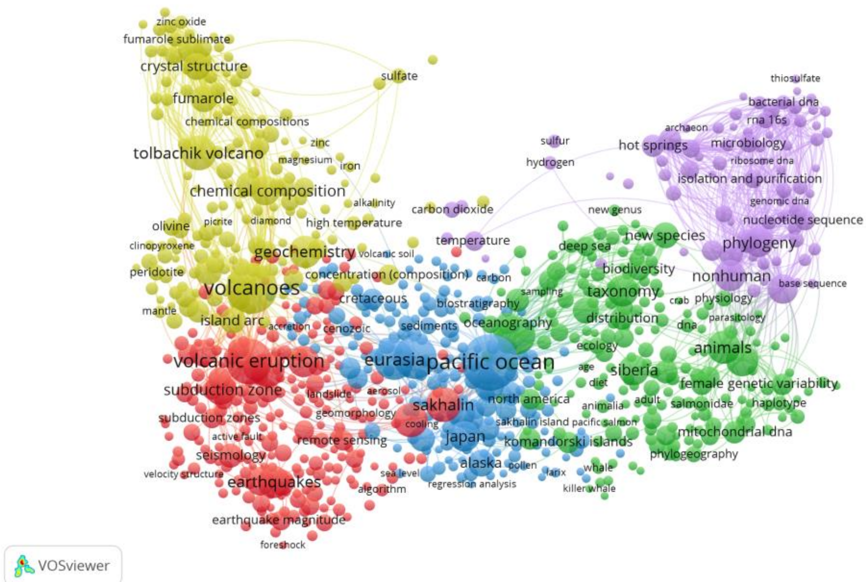

Figure 1. Analysis of the Scopus database using the keyword "Kamchatka" by VOSviewer 1.60 research network analytical software.

Most articles with the keywords "Kamchatka and tourism" focus on the impact of human activity on natural parks and protected areas. Geomorphology often determines the technological peculiarities of land location, and territory zoning, means of transport, and safety for the recreational system. This analysis, together with the people involved in recreational activities, was used to estimate the recreational attractiveness and geomorphological risks for recreational purposes in Nalychevo Park (Blinova, Bredikhin, 2015). Based on aerial photographs and field observations, a habitat map of the area around Avachinsky Pass was prepared, showing that tourism has negatively affected the area (Popov et al., 2024). Within the most visited section of the pass, plots covered by very scarce or no vegetation occupy 58%. Since tourists travel through these areas in a variety of vehicles, vegetation regrowth occurs slowly. Meanwhile, the Pass is located at the source of a river. Vegetation loss also increases the risk of catastrophic landslides (Popov et al., 2024). Prospects for ecological tourism in the Valley of Geysers following recent catastrophic landslides are evaluated based on field survey results (Vorobievsky et al., 2010). Characteristic properties of natural complexes of hydrothermal systems were outlined, and a classification of the kinds of recreational impacts was given on the Geizernaya River (Kronotskii State Nature Biosphere Reserve) (Zavadskaya, Golubeva, 2013). The research is based on the example of the natural complexes in the Uzon-Geyser area of the Kronotsky State Nature Biosphere Reserve, which underwent significant transformation due to operations in 1962-1976. This area was part of All-Union Tourist Route No. 264, which led to the Valley of Geysers and had a total length of approximately 160 kilometers. Hiking groups of 15-22 people each visited the route from July to October. In a 10-year period, approximately 15,000 tourists travelled along the route. Due to several negative environmental consequences, primarily affecting the natural complexes in the Valley of Geysers, the route was closed. However, research has shown that the impact of tourism on volcanic mountain tundra was no less serious (Golubeva and Zavadskaya, 2013). The importance of studying the tourism industry and preserving Kamchatka's geological heritage was emphasized by Sinnyovsky et al. (2023). Some publications discussed the development of domestic tourism in Russia (Levina et al., 2023) and its prospects for cooperation with China (Skidan et al., 2024).

Given the limited number of international publications on geotourism and geoheritage, it has become increasingly important to comprehensively explore the unique territories of Kamchatka. The aim of future research will be to strike a balance between human activity and the preservation of natural environments for future generations. This is the main purpose of ecotourism and geoheritage as emerging research subjects in the context of the volcanic geoheritage of Kamchatka.

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Geological (educational) programs in the “Steirisches Vulkanland”

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The “Steirisches Vulkanland” comprises an economic region and trademark in eastern Styria, Austria. Based on a 30 years lasting successful economic development to create a humanly – ecological – economical sustainability on their own authority the decision-makers are now focusing on the geological heritage, especially the volcanic history. Geological “highlights” are embedded (e.g. with information boards) in the available widespread trails network and connected with regional commercial enterprises.

Therefor a project focusing on volcanism and regional geology is currently being implemented. The aim is to create general intelligible information of the regional geology, to integrate outcrops with “speaking rocks” in the existing network of rambling trails and to establish localities for information and communication between science, schools, tourism organisations, companies of raw material economy or agriculture (e.g. winegrowers) and all persons who are interested on the geological fundament of the “Steirisches Vulkanland”. We want to create various information platforms for the local population and tourists.

One project focus is the training of "geology ambassadors". This includes a short theoretical training on the basics of earth sciences and their methodological approaches. These "geology ambassadors" (mainly interested laypersons, some of whom act as contact persons for cultural and scientific questions in communities) receive free basic geological training for their mostly voluntary work. Our goal is to ensure that the various multipliers (tourists, winegrowers, etc.) do not spread different geological "stories", but rather that a uniform (basic) information about the geological development of the region is presented. The first dates for these training-programs in April 2026 have been announced (Figure 1) – the interest is impressive. The presentation will showcase initial experiences and results of this training format.

Figure 1. Press release "Training to become a Geology Ambassador"

Acknowledgements – Supported by the federal government, federal provinces and the European Union.

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Morphology and geology of the Mitake volcanic complex in Fukue Volcanic Field, Goto Islands, Japan (Goto Geopark): implications to growth styles of basaltic large complex monogenetic volcanoes

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Monogenetic volcanoes are considered to form from a single eruptive event, as opposed to polygenetic volcanoes that have complex eruptive histories (Vespermann and Schmincke, 2000; Kereszturi and Németh, 2013). Representative monogenetic volcanoes, that were produced by explosive eruptions, are scoria cones, tuff cones and maars. Monogenetic volcanoes are generally smaller in size than polygenetic volcanoes. Geological studies of monogenetic volcanoes worldwide indicate some monogenetic volcanoes have relatively large, complex edifices. For example, Red Mountain in San Francisco volcanic field, USA, displays a flat-hat-like edifice, consisting of a lava platform 6 km across built around a scoria cone (Riggs and Duffield, 2008). Rangitoto in Auckland Volcanic Field, New Zealand, has a shield-like edifice 6 km across and several scoria cones (McGee, 2020). Such large complex monogenetic volcanoes could be a transition to polygenetic volcanoes, but their eruptive histories remain unresolved because their interiors are poorly exposed. Geological studies of young, large, complex monogenetic volcanoes that have well-exposed cross-section exposures are critical for better understanding of monogenetic volcanoes. The Mitake volcanic complex in Fukue Volcanic Field, Goto islands, Japan, is a Quaternary large complex monogenetic volcano, consisting of a basaltic lava platform 3 km across and two scoria cones. It is young (~30 ka) and displays excellent cross-sectional exposures along the seashore. It provides a rare opportunity to study internal structures of large complex monogenetic volcanoes. We describe here the morphology, geology and radiocarbon age of the Mitake volcanic complex and discuss the implications for the growth styles of large complex monogenetic volcanoes.
The Mitake volcanic complex consists of a lava platform, the Mitake scoria cone, Usudake scoria cone, and two small craters. The lava platform is elliptical in plan view, ranging in diameter from 1900 to 2900 m, and rises 50 m above sea level. In cross section, it has a slightly convex flat top. The lava platform comprises more than 15 basaltic lava flows, some of which have scoria rafts. The Mitake scoria cone (500–600 m across, 130 m high) and Usudake scoria cone (350–450 m across, 85 m high) show a conical morphology with a summit crater. They consist of basaltic scoria-fall deposits that contain spindle-shaped volcanic bombs. Geological sections indicate that these scoria-fall deposits are positioned above a pyroclastic surge deposit, and below the lava platform. The two small craters comprise the RC crater (circular, 170 m across, 30 m deep) and KM crater (fissure, 30×100 m across, 10 m deep). Vent locations of the Mitake scoria cone, Usudake scoria cone, and two small craters are aligned on a NE–SW-trending line, suggesting that the eruptive sites were controlled by regional faults. Radiocarbon dating of a humus soil below a scoria fall deposit indicates that the Mitake volcanic complex formed at ca. 30 ka. We suggest that the Mitake volcanic complex formed through the following processes. (1) Basaltic phreatomagmatic eruptions occurred in a wet subaerial environment, producing a pyroclastic surge deposit (Fig. 1a). (2) Basaltic magmatic eruptions occurred just after the phreatomagmatic eruptions. The magmatic eruptions shifted from wet explosive eruptions to dry Strombolian eruptions and resulted into the formation of the Mitake and Usudake scoria cones (Fig. 1b). (3) Basaltic lavas extruded from the base of the Mitake and Usudake scoria cones to form the lava platform (Fig. 1c). These lava effusions rafted parts of the cones, causing collapses of the scoria cones. (4) Small-scale strombolian eruptions occurred at the summit of the scoria cones and rebuilt the edifices of the scoria cones (Fig. 1d).

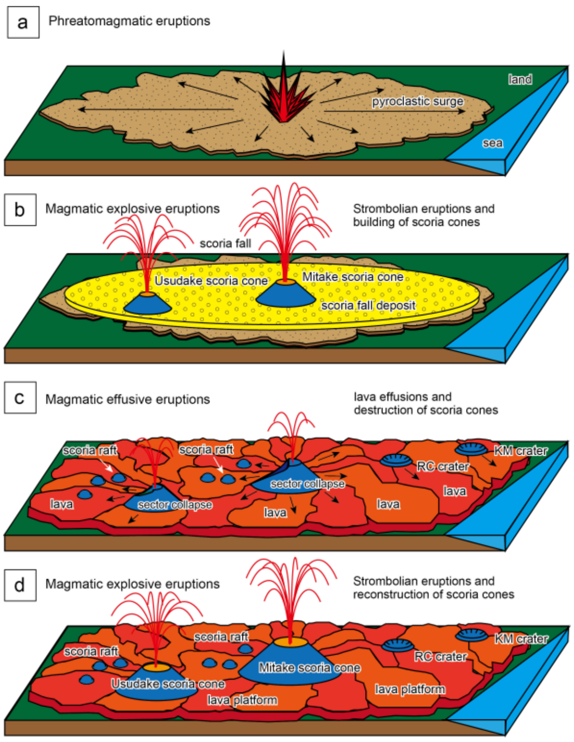

Figure 1. Schematic illustrations showing the evolution of Mitake volcanic complex.

We compare the Mitake volcanic complex with Red Mountain and Rangitoto. Red Mountain is a Quaternary basaltic volcanic complex (age 740±110 ka, Conway et al., 1997), consisting of a lava platform (5-7 km across, 100 m thick) built around a scoria cone (2 km across, 300 m high). Riggs and Duffield (2008) suggested that the Red Mountain evolved by (1) Strombolian eruptions that produced a scoria cone, (2) lava effusions from base of the scoria cone with cone-segment rafting, and (3) low fountaining and partial rebuilding of the scoria cone. Rangitoto is a Quaternary basaltic volcanic complex that comprises a shield-like volcanic edifice (6 km across, 260 m high) and several scoria cones. Rangitoto evolved by (1) 'lava shield' building at 650-550 BP, and (2) scoria cone building at 550-500 BP (Linnell et al., 2016; Hayward, 2017, 2019; Cronin et al. 2018; and McGee, 2020). Red Mountain and Rangitoto have opposite growth styles. Red Mountain formed by early scoria cone building and later lava effusions from the base of the scoria cone. In contrast, Rangitoto formed by early shield-like volcano building and later scoria cone formations at the summit. The growth style of Mitake volcanic complex closely resembles to that of Red Mountain. This growth style is identical with those of common scoria cones elsewhere in the world (e.g., SP Crater in San Francisco Volcanic Field), except for large lava volume. The flat-hat-like morphology of the Mitake volcanic complex and Red Mountain (lava platform built around a scoria cone) is attributed to progressive activities from early explosive to later effusive eruptions. Mitake volcanic complex and Red Mountain belong to a common category of monogenetic volcanoes. We nickname such a volcano 'flat-hat monogenetic volcano'. Rangitoto has a slightly different morphology from common monogenetic scoria cones and displays a low-elevated stratovolcano-like edifice with very gentle slopes. Rangitoto erupted two tephras that are separated by a thin peat layer, suggesting Rangitoto evolved by plural eruptive events with a hiatus between them. We thus infer that Rangitoto is excluded from a simple category of monogenetic volcanoes and may belong to a category of polygenetic volcanoes (small shield volcano or 'baby stratovolcano') or volcanoes that marks a transition from monogenetic to polygenetic activity.

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Entablature in a Quaternary dacitic lava at Gandate, Ontake volcano, Japan (Gandate Park): a supercooling model for the formation of small-diameter, irregular columnar joints

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Columnar joints provide clues to cooling history of lava flows. They display various joint patterns including colonnade and entablature (Forbes et al., 2014). Colonnade comprises regular, large-diameter columns, whereas entablature comprises more irregular, small-diameter columns. A set of lower colonnade, entablature and upper colonnade is common (Long and Wood, 1986). Formation of colonnade has been well studied by field observations and laboratory experiments. In contrast, studies of entablature are rare. A Quaternary dacitic lava at Gandate, Ontake volcano, central Japan (the Gandate Lava) displays well-preserved columnar joints (Figure 1). The Gandate Lava erupted at the summit area of the volcano and flowed to the northwest for >17 km. The lava consists of high-alkaline dacite (SiO_2 = 63wt.%; K_2O=2.9 wt.%, Na_2O=4.2 wt.%) containing phenocrysts of plagioclase, augite and hypersthene. The age of the lava is ~6 ka (Yamazaki et al., 2024). A vertical cross section of the lava is well exposed near the western termination of the lava (Gandate Gorge). Here, the lava is 120 m wide and 70 m thick. It overlies a fluvial deposit (>15 m thick) containing boulders 30-80 cm across. This outcrop is probably one of the best exposures of entablature in the world. The geological cross section of the Gandate Lava comprises six zones, from base to top: (1) lobate base; (2) lower colonnade, (3) 'herringbone' zone; (4) entablature, (5) upper colonnade; and (6) vesicular top. (1) The lobate base (thickness <5 m) consists of many lava lobes and hyaloclastite. The lava lobes are 1-5 m in diameter. Each lobe is composed of radially jointed massive core and glassy quenched rims 10 cm thick. The massive core consists of vesicular dacite. The hyaloclastite (<2 m thick) is composed of angular dacitic clasts 10-80 cm across and a coarse-grained matrix. The clasts contain amoeboid vesicles 1-5mm across. This zone grades upward into the lower colonnade, and each lava lobe is connected to the lower colonnade. (2) The lower colonnade (21-28 m thick) is characterized by subvertical, regularly spaced columnar joints 40-50 cm across. The columns are mostly hexagonal in cross section. Each column has well developed striae (chisel structure) 10 cm wide on the surfaces. This zone seems to have a sharp contact with the 'herringbone' zone in a large scale, although they are gradual in a small scale. (3) The 'herringbone' zone (0.5-3 m thick) is characterized by randomly oriented, messy joints 10-30 cm across ('cube joints' of Forbes et al., 2014). The dacite in this zone is glassy. This zone grades upward into the entablature. (4) The entablature (11-18 m thick) is composed of subvertical, small-diameter irregular columnar joints, 5-15 cm across. Some columnar joints show chevron arrangement fanning upwards. Each column has wavy surfaces with striae ~2 cm wide. This zone consists of glassy dacite. Some columns have perlite cracks 1-2 mm across on their surfaces. In cross section, the columns are hexagonal, pentagonal or quadrangular. Pseudo-pillow fractures are common in the uppermost part of the entablature, just below the contact with the upper colonnade. This zone grades upward into the upper colonnade. (5) The upper colonnade (20-24 m thick) is characterized by columnar or rectangular joints 60-100 cm across. The joints are irregular. This zone grades upwards into the vesicular top. (6) The vesicular top (~5 m thick) comprises highly vesicular dacite that has amoeboid vesicles 1-5 mm across. The geological section described above resembles to those described by Spry (1962), Long and Wood (1986) and Forbes et al. (2014). Morphological features of the entablature (small-diameter columns, wavy joint surfaces, perlite cracks, and pseudo-pillow fractures) all indicate very rapid cooling. Previous workers (Saemundsson, 1970; Long and Wood, 1986; Lyle, 2000; Forbes et al., 2014) suggested that entablature forms when an advancing subaerial lava flow dams a local river, causing overflow of the river water on top of the lava, and injection of the inundated river water into the lava interior along columnar joints within upper colonnade.

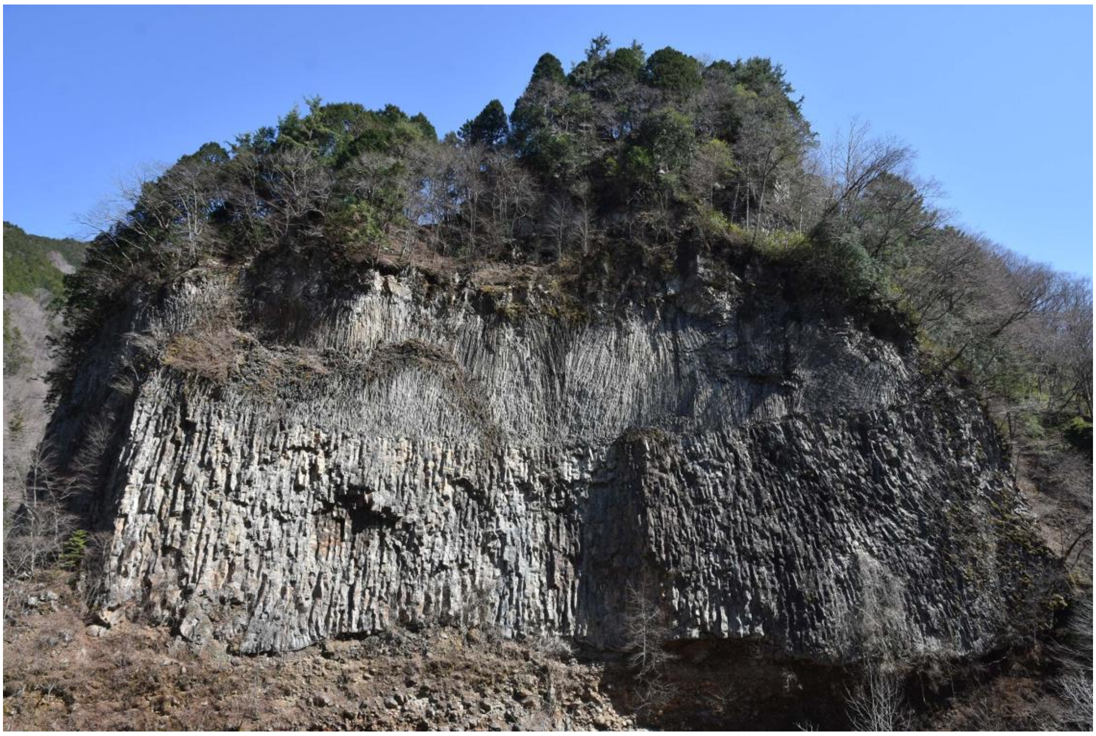

Figure 1. Photograph of a cross section of the dacitic Gandate Lava, Ontake volcano, Japan, showing a set of lower colonnade, entablature and upper colonnade.

Although this previous model has been widely accepted for decades, our field observations of the Gandate Lava indicate that open spaces along columnar and rectangular joints in the upper colonnade are mostly <5 mm wide and are not enough for transport of large amount of water. Therefore, this model seems to be impossible. Forming process of entablature is mysterious, because the interior of lava (entablature) is more quenched than the surface parts of the lava (lower and upper colonnade). There must be special processes for the formation of entablature. The author proposes that entablature forms by supercooling of hot molten lava. Supercooling is a process of lowering the temperature of a liquid below its freezing point without it becoming a solid. Supercooling of a liquid occurs due to the absence of seed crystals or nuclei around which a crystal structure can form. The author considers that the entablature of the Gandate Lava formed through the following processes. (1) A hot dacitic lava flowed in a V-shaped valley and emplaced. Many small lava lobes were extruded from the base of the lava. The surfaces of the lava lobes were quenched due to contact with river water. (2) The basal part of the lava cooled at a high cooling rate (rapidly) due to contact with water, forming the lower colonnade. In contrast, the upper part of the lava flow cooled at a low cooling rate (slowly) due to contact with air, forming the upper colonnade. (3) The molten part at the middle part of the lava was insulated by the lower colonnade and the upper colonnade, being a state of supercooling. (4) A trigger, such as physical shock by sheering between the lower colonnade and supercooling interior, caused sudden solidification of the supercooling interior, producing small-diameter, irregular columnar joints (entablature). The 'herringbone' zone may have formed by this sheering.

In general, entablature is common in subaerial lavas which uncounted river water or ice (i.e., subaerial lavas with pillowed or lobated base), but is uncommon in subaerial lavas without water, or in subaqueous lavas that emplaced in completely underwater. The author considers that entablature forms when a thick, crystal-poor subaerial lava emplaces on a shallow water and cools rapidly from the lava base, forming a supercooling state within the lava.

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Introducing Deep-Earth Geoheritage

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Geoheritage research has traditionally focused on surface and near-surface geological features, including landforms, stratigraphic successions, fossil localities, mineral occurrences, and volcanic landscapes. These elements are essential for geosite inventories, geoconservation, geopark development, and public communication of Earth history. However, geological materials are abundant in rocks (hereafter referred to as xenoliths) that originate from the deeper parts of the lithosphere but are now emplaced at the surface, e.g., in volcanic rocks. These rock types remain largely underrepresented in current geoheritage frameworks, despite their fundamental role in understanding the lithospheric structure beneath geoheritage sites and large-scale geological processes such as plate tectonics, magmatism, crust–mantle interaction, deep volatile cycling, and lithospheric evolution. To address this gap, we introduce the concept of Deep-Earth Geoheritage, defined as geological materials, features, and records that originate from different lithospheric levels and have been transported to the surface by geological processes, most commonly volcanic activity, while preserving otherwise inaccessible information on the physical, chemical, and petrological state of the Earth's interior. They provide rare, direct, and time-constrained snapshots of the lithosphere at the moment of their sampling by ascending magmas. Their mineral assemblages, textures, deformation features, geochemical signatures, and trapped fluids record pressure–temperature conditions, mantle heterogeneity, metasomatism, melt–rock interaction, and deep volatile reservoirs. Volcanic geoheritage sites that enclose such xenoliths therefore have increased value for preserving lithosphere-scale information, supporting a larger-scale approach.

Although xenoliths are widely recognized as scientifically valuable research samples, their broader geoheritage significance has rarely been explicitly considered. Xenolith-bearing outcrops are often small, spatially restricted, and vulnerable to weathering, quarrying, construction, vegetation cover, and uncontrolled sampling. Once destroyed, the geological information preserved in these outcrops cannot be recreated experimentally or resampled within the same temporal and geological context. This makes xenolith-bearing localities not only scientifically important but also non-renewable and fragile geoheritage assets.

As a case study, we present a Miocene–Pleistocene monogenetic basaltic volcanic field (Bakony-Balaton Highland, Hungary; BBHVF) in which volcanic activity transported abundant lithospheric mantle xenoliths to the surface (Hencz et al., 2026 and references therein). In our recent study, 164 upper-mantle xenoliths with known host-volcano ages and equilibrium temperatures were combined with newly modeled paleogeotherms to reconstruct their sampling depths and quantify geological CO_2 accumulation in the subcontinental lithospheric mantle during post-rift basin evolution.

The results demonstrate that xenoliths from the BBHVF sample span the full vertical extent of the subcontinental lithospheric mantle, from approximately 34 to 69 km depth. Their textures reveal a clear depth-related pattern: equigranular xenoliths dominate at shallower levels, whereas protogranular xenoliths originate at greater depths. Moreover, the deepest xenoliths become progressively deeper through time, indicating lithospheric thickening.

Fluid/melt inclusions, representing encapsulated, long-preserved 'droplets' of the fluid/melt phase during or after the crystallization of their host minerals, further increase the geoheritage significance of these samples. CO_2-rich fluid inclusions preserved in mantle minerals provide direct evidence of deep lithospheric fluids and constrain the mantle's volatile budget. Based on xenolith-derived depth reconstructions and plausible mantle CO_2 contents, the most likely scenario is that approximately 103 Gt of CO_2 accumulated beneath the Bakony–Balaton Highland Volcanic Field over the last 10 million years. This indicates that xenoliths and their fluid inclusions can preserve information relevant to long-term geological carbon cycling and the role of the lithospheric mantle as a carbon reservoir.

This case study illustrates why xenolith-bearing volcanic localities should be explicitly recognized as Deep-Earth Geoheritage. Their value lies in their scientific irreplaceability, temporal resolution, and ability to make deep-Earth processes tangible. Recognizing and protecting these sites is therefore essential to preserving unique natural archives of the Earth’s interior and to creating new opportunities for geoeducation, geotourism, and public communication of deep lithospheric processes.

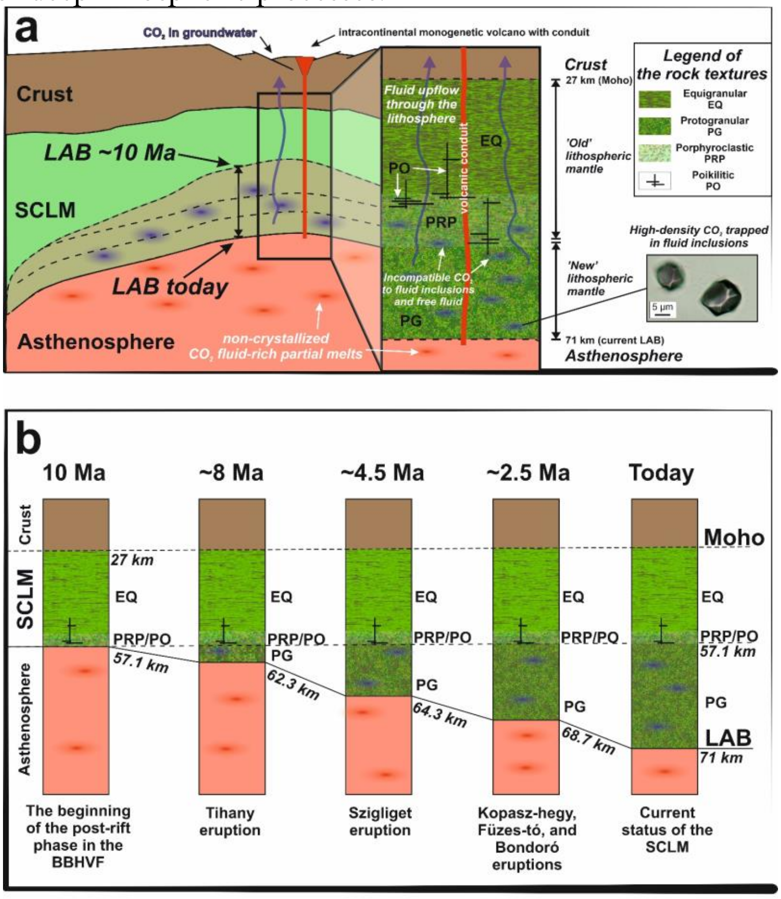

Figure 1. Schematic figure suggesting the structure of the subcontinental lithospheric mantle beneath the BBHVF averaged for the past 10 Ma. a) Schematic figure about the current state of the SCLM beneath the BBHVF. Ancient volcanic conduit indicates that magma flow may have sampled several types (textured) of mantle masses. Note the different dominant mantle xenolith texture types in different depth ranges. b) The process of lithospheric thickening in the xenolith-bearing volcanic eruptions with the different textures indicated. The legend is identical to that in a.

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Volcanic Geodiversity is Everyone's Business

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Volcanoes fascinate humans, whether through spectacular eruptions in active regions or the calm scenic landscape of volcanoes in repose. While dramatic eruptions capture global attention and attract millions of visitors through volcano tourism (Erfurt-Cooper, 2011), the everyday relevance of volcanic landscapes extends far beyond fascination. For communities living in volcanic regions, volcanoes constitute both material resources (e.g. mineral ores, geothermal energy, etc.) and powerful intangible anchors of identity, culture, spirituality, and historical memory. Recognizing the value of volcanic regions is generally the positive and beneficial aspect of human-volcano interactions. However, volcanic regions are also some of the most dangerous places on Earth due to the threat of volcanic eruptions: their cascading impacts and hazards expose local residents, visiting tourists, and during major events, even global population to significant risk. In the case of larger eruptions, this risk could extend to a wider regional and even global population.

This study focuses on the intricate and complex relationship between human society and volcanoes through a visual, conceptual framework that explicitly links the society to the geodiversity derived from volcanism (*volcanic geodiversity*) via the benefits and risks they obtain from it. By integrating the concept of *geosystem services* (Gray, 2011) and adopting the vulnerability-centered framework of volcanic risk reduction (Blaikie *et al.* 2014), this conceptual framework demonstrates why volcanic geodiversity matters to humans at multiple scales, from individual livelihoods to global systems.

Rather than treating geodiversity as a purely scientific inventory, this study also presents a feature-based volcanic geodiversity assessment of the Macolod Corridor volcanic field (Philippines) to provide an example of how the diversity of volcanic features and processes in a region can be communicated to the public as part of geoeducation and tourism programs. Lastly, this study provides examples of how this feature-based volcanic geodiversity mapping method can be utilized for volcanic landscape conservation and long-term volcanic risk reduction purposes from the local to global scales.

We argue that adopting this integrated framework and mapping presented in this study within volcanic geoparks and heritage initiatives can shift the discourse from simple quantification of natural diversity toward a more holistic recognition of volcanic geodiversity. This could inspire more and more people to recognize how volcanoes, volcanic resources, and volcanic hazards become relevant in their daily lives. The recognition of the importance of volcanic geodiversity is a crucial foundation in establishing sustainable volcanic resource management and effective risk reduction for local communities and global society alike.

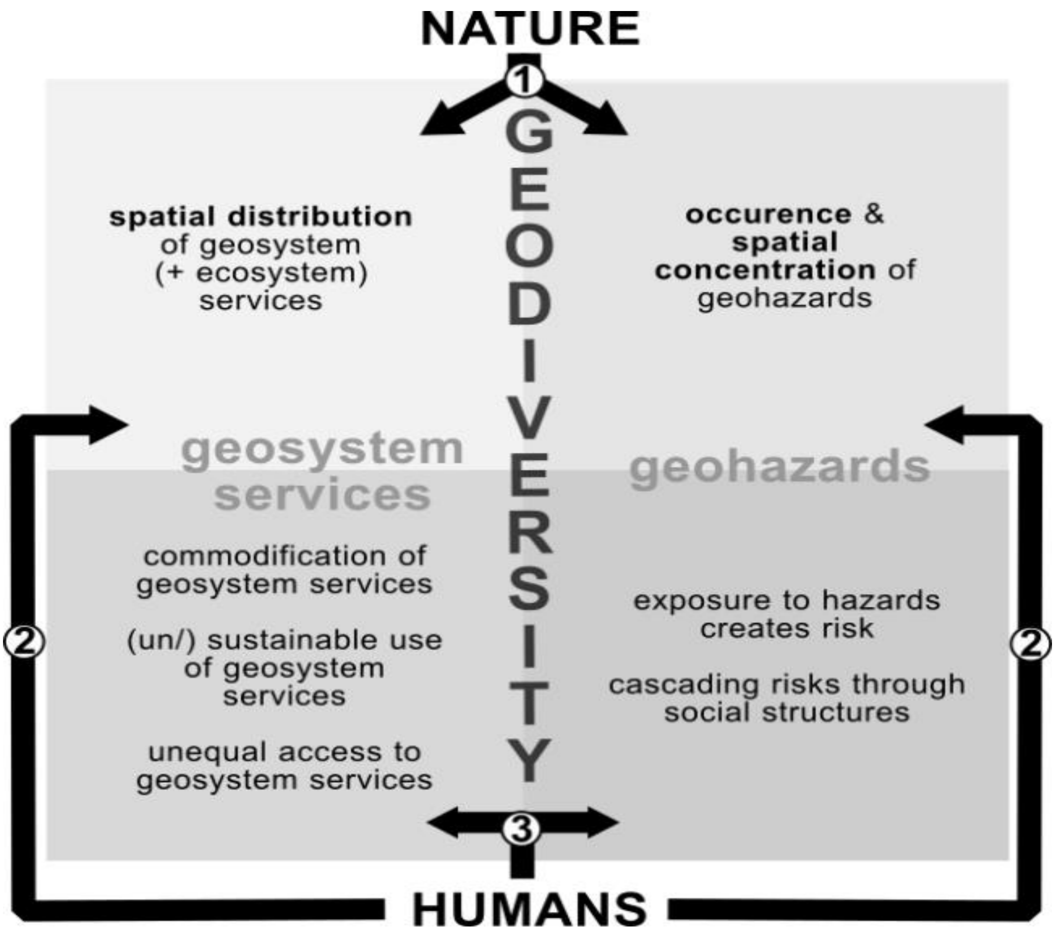

Figure 1. Conceptual framework for Human-Geodiversity interactions through geosystem services and geohazards from Irapta et al. (2026)

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Large-magnitude plinian eruption and exceptional geoheritage: insights from the Ipolytarnóc Fossil Site, Hungary

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The Middle Miocene fossil site of Ipolytarnóc, known for more than two centuries (Kubinyi 1842; Kordos et al. 2021), represents an exceptional window into past volcanic processes and the prevailing paleoenvironment. At the same time, it is considered one of Central Europe's most important examples of geoheritage conservation in practice. Beyond its volcanological significance, the site serves as a flagship locality demonstrating how geological heritage can be protected, interpreted, and integrated into broader nature conservation strategies.

During Earth's history, geosphere-biosphere interactions were often determined by momentary, catastrophic changes such as large explosive volcanic eruptions. The Miocene ignimbrite flare-up in the Pannonian Basin (Pantó et al. 1963; Szakács et al. 1998; Hencz et al. 2024), which is located along a complex convergent plate boundary between Europe and Africa, provides a superb example of this interaction.

In particular, a complex, prolonged Plinian eruption that devastated and, at the same time, preserved this unique paleoenvironment and paleohabitat has been reconstructed in detail by Karátson et al. (2022) in a multidisciplinary study published in Nature Scientific Reports. The eruption, dated to approximately 17.2 million years ago, originated south of the present-day Bükk Mountains (c. 10 km from Eger town), and occurred in at least four distinct phases of a prolonged, large-magnitude, silicic explosive activity (Figure 1).

The initial phase involved a highly energetic pyroclastic surge that travelled over 80 km in a matter of minutes, reaching the area of present-day Ipolytarnóc. Such extreme transport distances highlight the magnitude of the event, but equally important is the eruption style: magma interacted with external water sources (e.g. groundwater or a lake), resulting in strongly phreatomagmatic activity. At Ipolytarnóc, emplacement temperatures are estimated at around 150 °C—low enough to prevent complete combustion of organic material. As a result, the "wet" ash rapidly buried a coastal ecosystem, preserving tree trunks, intact leaves, and thousands of vertebrate (mammal and bird) footprints in remarkable detail.

From a geoconservation perspective, this combination of rapid burial and preservation of the contemporaneous environment created a unique geological archive of outstanding integrity. The site has been protected as a nature reserve since 1944, and was nominated for UNESCO World Heritage status in 2000.

The later eruptive phases involved pumice fall from a sustained plinian column, then column collapse and the emplacement of pyroclastic flows, resulting in a total thickness of about 40 m ignimbrite at Ipolytarnóc. These deposits also remained relatively cool, as evidenced by abundant charcoal fragments within the lowest part of the ignimbrite.

In terms of magnitude, based on isopach data (thickness distribution of the pyroclastic deposits), the eruption reached at least VEI 7, dispersing an estimated ~100 km^3 minimum bulk volume across an area extending from the Bükk Foreland to the foothills of the Mátra Mountains and northwestward toward Ipolytarnóc. This volume is comparable to that of the Minoan eruption, although erosion has removed a significant fraction of the original deposits.

From a geoheritage protection standpoint, Ipolytarnóc is now part of a geopark and operates under strict conservation regulations (see European Diploma areas, 2025). Both natural erosion and tourist impact are carefully controlled. Visitor access is allowed through designated pathways and guided interpretation, minimizing physical impact on the footprint-bearing surfaces. Protective shelters, continuous monitoring, and ongoing scientific research all contribute to safeguarding the site. Furthermore, the locality plays a major role in public education and sustainable geotourism. By interpreting the link between catastrophic volcanic events and exceptional fossil preservation, it helps communicate key Earth system processes to a broad audience. As a result, this educational function also strengthens societal engagement. In summary, Ipolytarnóc exemplifies how a large-magnitude volcanic eruption can generate a unique geological archive that can be successfully preserved as part of global geoheritage. The combination of outstanding preservation and well-developed conservation management makes it a benchmark site for volcanology, paleontology, and the sustainable use of Earth's geological legacy.

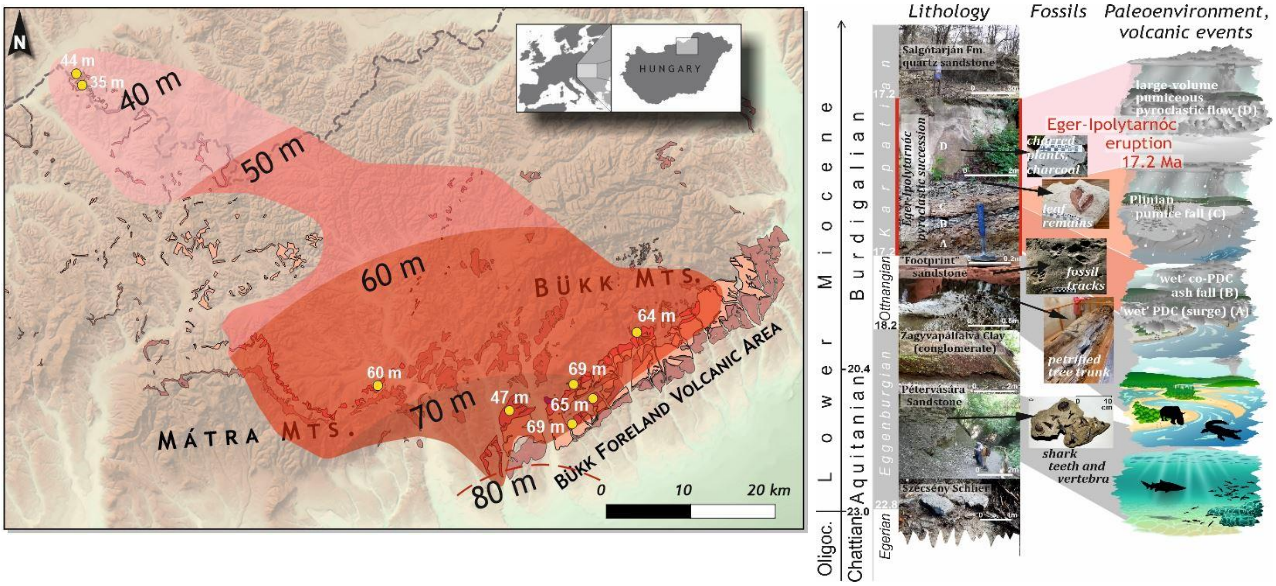

Figure 1. Left panel: Areal distribution of the c. 17.2 Ma Eger Ignimbrite (with observable and inferred thicknesses) that devastated and at the same time preserved the famous Ipolytarnóc Fossil Site (upper left corner). Right panel: Reconstructed paleoenvironments and proposed volcanic succession at Ipolytarnóc in the context of Central Paratethys stratigraphy (adapted from Karátson et al. 2022)

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Geoheritage aspects of Philippine churches recording volcanic and seismic disasters

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Volcanic and seismic events are often considered part of dark geoheritage (Scarlett & Riede, 2019; El Hamidy & Németh, 2026). Volcanic eruptions commonly modify the surrounding landscape, either through the excavation and erosion of landforms or the creation of new landscape features from volcanic deposits. In urban areas, these processes can damage built-structures and preserve them at the same time (as in the case of Pompeii) albeit limiting access to these sites. Earthquakes rarely preserve clear and enduring physical evidence, as their traces are often rapidly erased by natural processes or obscured during post-disaster reconstruction. Societal response typically focuses on rebuilding rather than on conserving the physical record of destruction. However, there are cases in which evidence for both kinds of disasters is preserved in cultural objects that remain accessible and continue to be used by the population. Here, we provide examples of volcanic and seismic disasters that left behind long-lasting traces on the most important buildings in Filipino settlements. In a predominantly Catholic and highly religious society like the Philippines, churches occupy a central role in community life and are the most enduring and well-maintained structures in many settlements. The Spanish colonial churches, therefore, provide an impressive record of both the effects of nature and the response of the society affected by disasters. Abandonment, relocation, adaptation, and repurposing are shown to be reactions of the community affected.

- Cagsawa (Albay) *abandoned* church as it looked like in 1934 (Fig. 1A): the ground floor of the belfry and church are buried. Pyroclastic flows and lahars from Mayon volcano in 1814 depopulated the region and buried the ground floor of the belfry and the church (Recto et al., 2016).
- Old Taal church (Batangas), buried by ashfall from Taal volcano in 1754 (Fig. 1B). The church was *relocated* a few km away.
- Bacolor (Pampanga) church was buried by lahars after the 1991 eruption of Pinatubo. Still under 6 m of sediment, it was *adapted* to the new floor level Fig. 1C).
- Bacarra (Ilocos Norte) belfry standing 28 m high. While still being used as a bell tower, it was *repurposed* as a lookout tower and earthquake garden, with large wall fragments collapsed during the earthquakes of 1931-1981 (Kázmér et al., 2026).

Volcanic and seismic geoheritage sites show different sides of disaster events. Still, the key message for geoeducation remains the same: knowledge and continuing memory of the destructive power of natural hazards. Risk reduction for these hazards relies on a knowledgeable, ready-to-respond population. Preservation of volcanic and seismic heritage is important in maintaining the risk perception of populations exposed to these hazards.

Churches, as holy sites, tend to be better preserved and longer-lasting than secular buildings, commonly associated with written history. This creates a unique coincidence or intertwining of widely appreciated cultural heritage, the less appreciated geoheritage, and the barely known disaster geoheritage. Volcanic geoheritage (Scarlett & Riede, 2019) and seismic geoheritage (El Hamidy & Németh, 2026) are both enhanced when directly associated with churches.

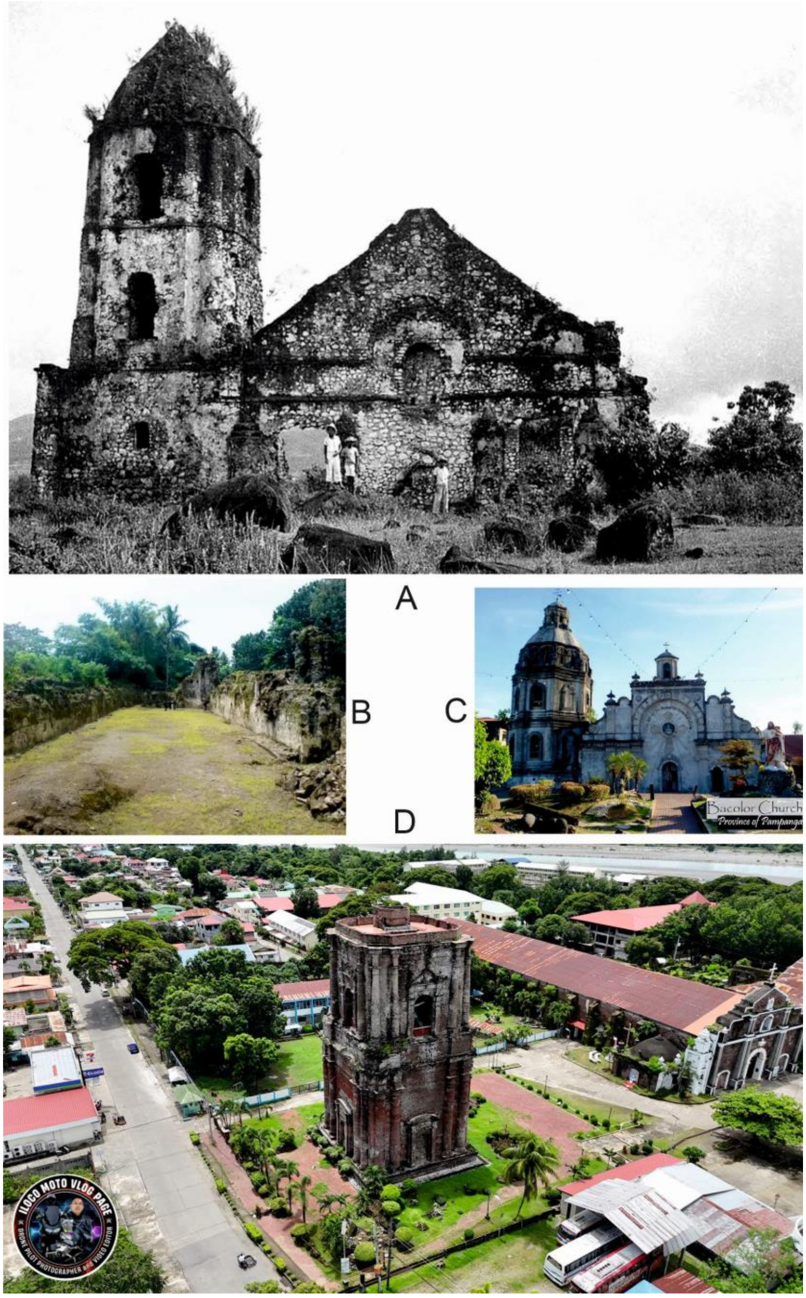

Figure 1. **A.** Cagsawa (Albay) *abandoned* church as it looked like in 1934: the ground floor of the belfry and church are buried. Pyroclastic flows and lahars from Mayon volcano in 1814 depopulated the region and buried the ground floor of the belfry and the church (Recto et al., 2016). **B.** Old Taal church (Batangas), buried by ashfa from Taal volcano in 1754. The church was *relocated* a few km away. **C.** Bacolor (Pampanga) church was buriec by lahars after the 1991 eruption of Pinatubo. Still under 6 m of sediment, it was *adapted* to the new floor level. **I** Bacarrara (Ilocos Norte) belfry standing 28 m high. While still being used as a bell tower, it was *repurposed* as a lookout tower and earthquake garden with large wall fragments collapsed during the earthquakes of 1931-1981.

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Plume-assisted rifting and the evolution of volcanism in the East African Rift System: Perspectives from thermo-mechanical modelling

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The East African Rift System (EARS) represents the largest ongoing continental rift and a key natural laboratory for understanding the coupling between lithospheric deformation, mantle dynamics, and volcanism (Ring, 2014). Despite extensive study, the mechanisms controlling rift initiation, strain localization, and the evolution of magmatism remain debated. In particular, the interplay between mantle plume activity (Koptev et al., 2015), inherited lithospheric heterogeneity (Brune et al., 2017), and gravitational potential energy (Medvedev, 2016) in driving both deformation and volcanic processes is not fully resolved.
The spatial and temporal distribution of the onset of magmatism in East Africa (Fig. 1a) is consistent with a two-plume framework (Pik et al., 2006; Chang & van der Lee, 2011). The earliest evidence of Cenozoic volcanism occurs in southern Ethiopia during the Eocene, with initial melting at ~45 Ma, marking the arrival of the Kenyan Plume. The magmatic imprint of this plume is characterized by a progressive southward migration. After first appearing in southern Ethiopia during the Middle Eocene, volcanism advanced to northern and central Kenya in the Oligocene and Middle Miocene, and eventually reached northern Tanzania in the Late Miocene (George et al., 1998). This evolution reflects the northward motion of the African Plate over a stationary mantle plume tail, resulting in a systematic southward propagation of melt-induced lithospheric weakening. Magmatic activity associated with the Afar Plume, which is first expressed in northern Ethiopia and Yemen during the Oligocene (Hofmann et al., 1997), and continues to the present in the Afar region (Ferguson et al., 2013), is marked by significantly higher magma production rates and eruption volumes, compared to the Kenyan Plume signature, which exhibits relatively low but clearly discernible magmatic output (Fig. 1b).
In this study, we investigate the physical conditions that govern strain localization, the onset of normal faulting, and the evolution of volcanism using thermo-mechanical numerical models under tectonically neutral boundary conditions. This approach allows us to evaluate whether internal processes alone, without imposed far-field extension, can drive both rifting and magmatic activity. Our models incorporate first-order geological features, including the thickened lithosphere of the Tanzanian Craton and the thermal influence of the Kenyan Plume, represented either as a predefined lithospheric thinning or as a dynamically evolving thermal anomaly within the mantle. Our results demonstrate that deformation localizes where gravitational potential energy associated with topographic uplift over the craton interacts with lithosphere that has been thermally and magmatically weakened by plume activity (Fig. 1c). This interaction promotes strain localization with patterns that closely resemble the internal fault architecture observed in the magma-rich Eastern Branch of the EARS, especially in the Kenya Rift segment.
By integrating numerical modelling with the tectonic and magmatic evolution of the EARS (Macgregor, 2015), we identify a temporal coincidence between major plate boundary reorganizations related to the closure of the Neo-Tethys Ocean and Afro-Arabian separation and the onset of rifting in the Early Miocene (~20 Ma), thus highlighting a substantial delay (~25 Ma) with respect to the first Cenozoic magmatism in East Africa, which marks the arrival

of the Kenyan Plume at ~45 Ma. This therefore suggests that a transition toward a near neutral external stress regime represents a key factor that allows plume-related processes to govern the evolution of rifting, as under these conditions gravitational potential energy becomes the dominant driver of deformation. We propose a self-consistent geodynamic framework linking structural inheritance, plume-induced lithospheric weakening, and evolving force balances to explain the initiation, localization, and evolution of the EARS. This highlights the critical role of mantle plumes in controlling both the timing and spatial distribution of volcanism and provides new insights into plume-assisted continental rifting.

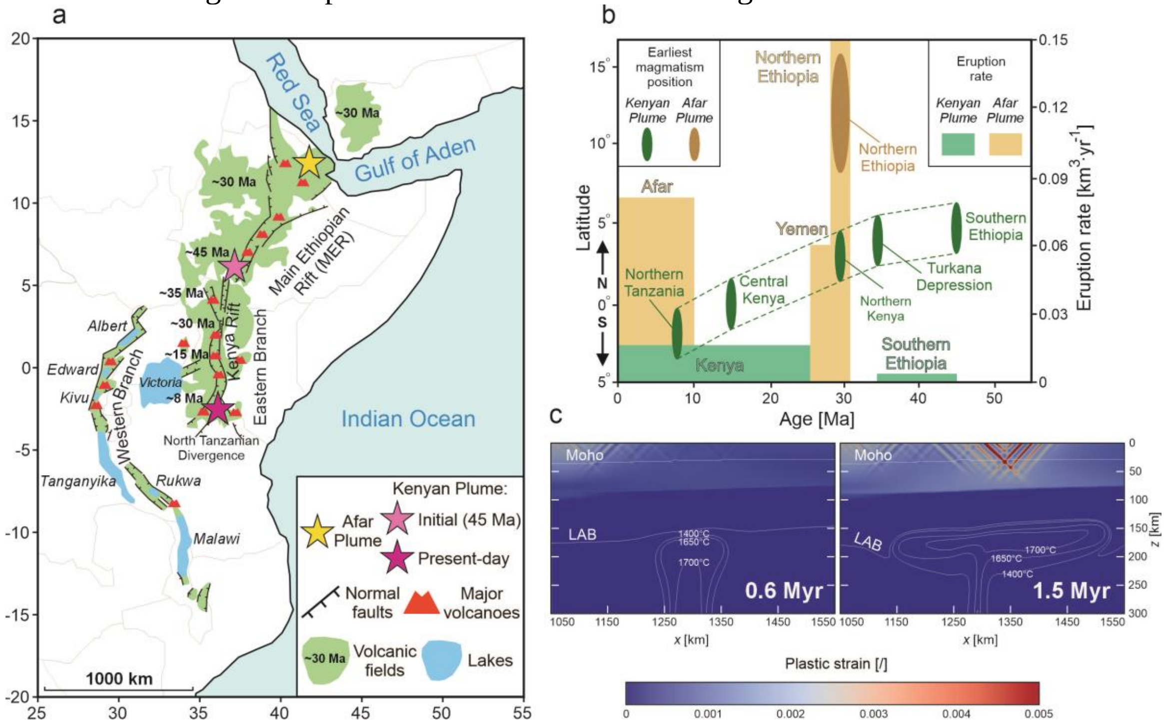

Figure 1. Cenozoic volcanism and mantle plumes in East Africa, and thermo-mechanical modelling of lithospheric deformation. (a) Cenozoic volcanic fields, major volcanoes, and two associated mantle plumes. (b) Age–latitude plot showing the southward progression of magmatism from southern Ethiopia through Kenya to northern Tanzania, with a comparison of eruption rates between the Kenyan and Afar Plumes. (c) Thermo-mechanical modelling of lithospheric deformation, showing accumulated plastic strain, with white lines indicating the Moho, lithosphere–asthenosphere boundary (LAB), and isotherms at key time steps marking plume arrival and the onset of rifting.

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Local Stories of Our Volcanoes: at the intersection of creative expression and scientific communication

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The volume "Local Stories of Our Volcanoes", published in 2026, is an innovative, collaborative publication emerging from the European Geoparks Network, promoted and coordinated by El Hierro UNESCO Global Geopark, Spain. The booklet represents a distinctive attempt to bridge geoscience and the humanities by bringing together geological knowledge and intangible cultural heritage through narrative forms. Drawing on contributions from fourteen geoparks across nine European countries, the publication offers a multilingual and interdisciplinary approach to communicating the significance of volcanic landscapes and their role in shaping human experience.

At the heart of the project lies the recognition that volcanic terrains are not only sites of scientific interest but also landscapes deeply embedded in cultural memory. Across Europe, communities living in proximity to volcanic features have historically developed rich traditions of storytelling, often interpreting geological phenomena through myths, legends and symbolic narratives. These stories reflect emotional, spiritual, and social responses to the dynamic forces of the Earth, providing insight into how people have understood, feared, and revered their environments over time. The book brings these diverse voices together, presenting them alongside concise geological explanations that contextualise the landscapes in scientific terms while remaining accessible to a broad audience.

The presentation will explore the conceptual framework underpinning the volume, particularly its emphasis on integrating geodiversity with cultural heritage. By positioning storytelling as a complementary mode of knowledge transmission, the project challenges conventional boundaries between scientific communication and creative expression. Each contribution in the book pairs a narrative with visual and geological elements, forming a composite representation of place that engages both cognitive and affective dimensions. This approach reflects a broader shift within geoscience outreach towards more inclusive and participatory forms of engagement, recognising the value of local knowledge and cultural interpretation in fostering environmental awareness.

A key feature of the publication is its multilingual structure, incorporating ten languages, including English and the native languages of participating UNESCO Global Geoparks. This linguistic diversity not only enhances accessibility but also preserves the authenticity of local narratives, allowing them to be experienced within their original cultural contexts. At the same time, the parallel presentation in English facilitates cross-cultural dialogue, enabling readers from different backgrounds to engage with shared themes and perspectives. The book thus functions as a platform for intercultural exchange, highlighting both the diversity and commonality of human responses to our volcanic heritage.

The presentation will also address the intended audience and educational potential of the volume. Designed with young people in mind, particularly those aged between 15 and 20, the book adopts an accessible tone and avoids overly technical language, thereby lowering barriers to engagement with geoscientific concepts. Through narrative immersion, readers are encouraged to connect emotionally with landscapes and to develop a deeper appreciation of the processes that shape them. This pedagogical strategy aligns with contemporary approaches to science communication that prioritise storytelling, visualisation, and experiential learning as effective tools for fostering curiosity and understanding.

Furthermore, the presentation will situate “Local Stories of Our Volcanoes” within the broader context of collaborative initiatives undertaken by the European Geoparks Network Working Group on Volcanic Areas. The book exemplifies how transnational cooperation can generate innovative outputs that extend beyond traditional scientific dissemination, contributing to public engagement, heritage preservation, and sustainable regional development. By linking multiple geoparks through a shared thematic focus, the project strengthens network cohesion and demonstrates the potential of collective action in addressing contemporary challenges in geoscience communication.

The illustrations by Adriana Sandec (Canary Islands, Spain) play a central role in “Local Stories of Our Volcanoes”, offering visually compelling interpretations of the narratives linked to volcanic landscapes. Rather than merely depicting scenes, they translate local legends into symbolic and atmospheric imagery, enhancing the emotional depth of each story. Created specifically for the volume, these artworks provide a unifying visual language across diverse cultural contexts, supporting engagement particularly among younger audiences.

In conclusion, this presentation argues that the publication, available as a PDF e-book with interactive links, offers a compelling model for integrating scientific and cultural narratives in the interpretation of geological heritage. By foregrounding the human dimension of volcanic landscapes, the book invites readers to reconsider their relationship with the Earth and to recognise the interconnectedness of natural processes and cultural identity. It highlights the enduring relevance of storytelling as a means of engaging diverse audiences and underscores the importance of interdisciplinary collaboration in enhancing the visibility and impact of geoscientific knowledge.

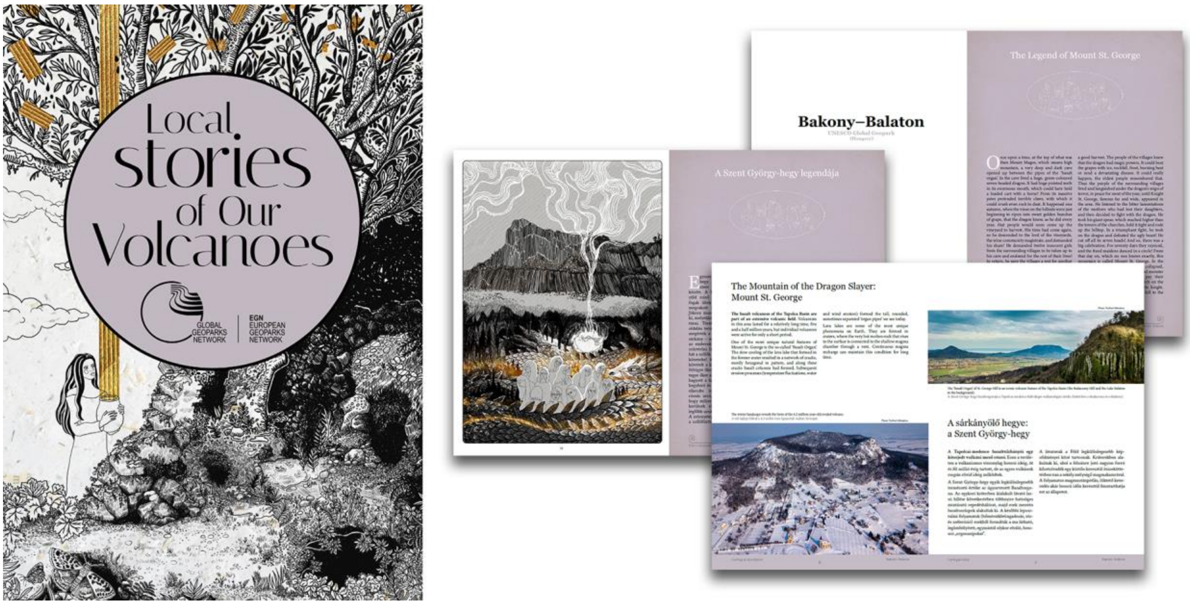

Figure 1. The cover page and some facing pages of the publication

Volcanic geoheritage in the Gutâi-Maramureș UNESCO Geopark project, East Carpathians (NW Romania)

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A new UNESCO Geopark project is developing in the Gutâi Volcanic Zone (GVZ), NW Romania within the framework of a partnership between local authorities, Earth Science institutions and NGOs involved in sustainable development and tourism promotion of the area. The GVZ belongs to the East Carpathian Neogene-Quaternary volcanic range built up during the Cenozoic geotectonic evolution of the broader Carpathian-Pannonian Region (CPR) megastructure of Eastern Europe. It is one of the most complex volcanic areas in the CPR, where Miocene volcanic activity took place during a long time-interval, between 15.4-7.0 Ma. In the area of the future Geopark numerous geological sites are found mostly located in areas dominated by volcanic rocks. Some of them have official protection status at the national level. Thirty-five volcanic sites were inventoried, described and assessed, covering almost the entire volcanic area of the Geopark and the entire time-span of volcanism, starting with the earliest felsic explosive volcanism and including the main phases of the following predominantly andesitic volcanism. Based on their quantitative assessment (Brilha, 2016) twenty-five volcanic sites can be considered as geoheritage sites/geosites and the others as geodiversity sites. The most important volcanic geosites are represented by: 1) volcanic structures - Mogoșa composite volcano resulted from 4-5 successive dome-generating effusive eruptive phases, Dănești-Cetățele composite volcanic dome structure representing the remnants of a petrographically well individualized composite volcanic edifice of felsic composition, Rotundu crater, among the largest (ca. 3 km diameter) in the whole East Carpathians; 2) shallow intrusive bodies - Șurdești basaltic andesite sill, Firiza dam basalt intrusive body, a small-sized intrusion representing the youngest (8.0-7.0 Ma) magmatic activity within the GVZ, „White Tulipe" and „Vlaicu's Church" composite dykes (Fig. 1e) consisting of light-colored dacites (with sanidine macrocrysts and large-sized gabbroic enclaves) enveloped by dark colored andesites; 3) rhyolite ignimbrites - columnar-jointed hydrothermalized welded ignimbrites in Nistru and Badenian rhyolite ignimbrites in the Romană valley; 4) lava cooling textures - Ilba andesite „Stone Rosette" (Fig. 1a), Limpedea andesite columns, "Lespezi" andesite columns, a 40-45 m high vertical cliff made of polygonal columns (Fig. 1c); 5) volcaniclastic deposits - "Red Stone" dacitic volcaniclastic sequences in Șurdești, "Falcon Stones" basaltic andesite volcaniclastic sequence in Cavnic, "Gutin Serpentines" andesitic volcaniclastic complex , "Stone Garden" residual volcaniclastic formation and landscape in Baia Sprie; 6) erosional volcanic landforms - „Rooster's Crest" dome-rocks sculptured erosional formation of the Gutâi extruziv dome (Fig. 1b), summit area of Igniș volcano with spectacular rock pillars, towers and tors, „Tătaru Gorges" andesite lavas-hosted canion of Runcu valley. Several volcanic geosites are very rare or unique in the East Carpathians volcanic range, such as the Ilba „Stone Rosette", the "Lespezi" andesite columns, „Rooster's Crest", „Tătaru Gorges" or in the whole CPR (e.g., the „White Tulipe" and „Vlaicu's Church" composite dykes). Mons Medius/Mine Hill in Baia Sprie town is a unique geosite, a volcano-tectonic structure (a graben filled with a 700 m thick pile of volcanics) hosting one of the most representative hydrothermal ore deposits in Europe with six minerals first described in the world. The newly studied geodiversity sites have a huge educational and touristic potential and they deserve to be inventoried, promoted and valorized together with the geosites in the future Geopark. The volcanic sites, together with other geosite types related to minerals, fossils, stratigraphy, tectonics, are part of the rich geological heritage of the future Geopark. They will be included in geoeducational trails and geotouristic routes. As a mandatory condition for accreditation as a UNESCO Geopark, the geosites will be

promoted in accordance with the geoeducation and geotourism concepts, both at the local, national and international level.

Figure 1. Representative geosites of the potential Gutâi-Maramureș UNESCO Geopark: a) Ilba "Stone Rosette"; b) „Rooster's Crest" extrusive dome; c) "Lespezi" andesite columnar jointing d) Mons Medius/Mine Hill, Baia Sprie; e) „Vlaicu's Church" composite dyke (A: andesite, D: dacite).

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Volcanism in Harrat Rahat, Saudi Arabia: Geoconservation of Young Monogenetic Cones and their Hazard Relevance.

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Harrat Rahat, one of the largest basaltic volcanic fields on the Arabian Plate, spans approximately 22,000 km² and contains over 968 vents in western Saudi Arabia, with activity dating from the Miocene to today (Murcia et al., 2014). The most recent documented eruption in 1256 CE produced lava flows that extended about 23 km towards Al-Madinah, a city now home to roughly 1.5 million residents and visitors (Dietterich et al., 2018; Kereszturi et al., 2016). Recent seismic swarms and crustal deformation suggest that the magmatic system remains active (Abdelwahed et al., 2016). Despite its societal importance, Harrat Rahat's recent eruptive history is not yet well understood in terms of its spatial and temporal scope, a vital factor for volcanic hazard assessment. A detailed eruption record is mostly available in the northern part of the broad Harrat Rahat. The eruptions are mainly basaltic but can include more evolved compositions, and are generally considered monogenetic, with each vent representing a separate eruptive event. The arid climate and sparse vegetation preserve these young eruptive centres exceptionally well, offering unique opportunities for detailed investigations, including volcano-geological mapping, stratigraphic analysis, and high-resolution chemical fingerprinting of pyroclasts and lavas, to better understand the associated geohazards and their potential for geoheritage.

This study examines a late Pleistocene-early Holocene monogenetic scoria cone in Harrat Rahat and its associated lava field, a well-preserved eruptive centre that enables detailed investigation of magma evolution, including crustal assimilation (Garcia-Paredes et al., 2026), in relation to lava flow morphology and emplacement processes. The selected cone, the Khamisah Cone, has an age of 29 ±3.9ka (Late Pleistocene) (Stelten et al., 2020), based on its youthful surface textures and remote sensing patterns, making it one of the youngest cones in Harrat Rahat. It features a moderately evolved alkaline composition (hawaiitic to mugearitic), with evidence of crustal assimilation (Garcia-Paredes, E.R, 2026,). Currently, this cone is extensively quarried, providing access to its interior and emphasising the importance of the current study before evidence of this eruption disappears.

Methods involve analyzing surface expressions, lava morphology, and eruptive structures to understand eruption dynamics, lava transport, and the influence of topography on flow confinement and dispersal. This includes using sophisticated GIS-based terrain analysis and lava flow inundation simulations with a high-resolution DEM (ALOS PALSAR, 12.5 m). Whole-rock geochemistry complements these observations, helping to differentiate units and explore magmatic processes. These data define key physical processes, such as eruption style, which is mainly effusive with some localized mild explosive phases. They also demonstrate how variations in magma composition, from hawaiite to mugearite, affect lava flow emplacement, including channel development and confinement.

Morphologically, the eruption consists of two separate lava transport channels, with thicknesses ranging from nearly zero at the edges to about 47 meters along the central pathway, and a cone reaching approximately 165 meters in height. The total lava volume is estimated at approximately

0.42 km^3, representing a bulk eruptive volume derived from pre- and post-emplacement surface reconstruction, consistent with the scale of other major eruptions at Harrat Rahat (Dietterich et al., 2018). Geochemical data, combined with lava morphology and flow architecture observations, suggest multiple magma batches were injected both before and during the eruption, resulting in a complex eruption history characterized by fluctuating effusion rates and changing magma properties during emplacement.

This study provides a physically grounded reconstruction of eruption dynamics at the scale of a single monogenetic centre, supporting more accurate and evidence-based volcanic hazard assessments in intraplate regions where even infrequent events can pose serious societal risks. The results demonstrate that preserved volcanic features in Harrat Rahat serve not only as geoheritage records of past eruptions but also as essential analogues for predicting future lava flow paths and hazard scenarios.

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Volcanic geoheritage and natural hazard

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Geoheritage is a developing field focused on identifying, recognising, and conserving Earth's abiotic environment. Over the past decade, research in geoheritage has expanded markedly, covering diverse approaches and topics, including palaeontology, sedimentology, structural geology, and volcanology, which are among the most common. In this relatively short time, geoheritage has become a well-established discipline that connects various geoscience areas and even other academic fields. Currently, it has developed a comprehensive range of inventory techniques used by planners, conservationists, urban designers, and geohazard teams. While understanding natural hazards remains a key practical focus, recent global and planetary changes have increased their significance in geoheritage research.
Viewing natural hazards through a geoheritage lens emphasizes their role as educational tools for fostering hazard-resilient communities. Key practical issues include how human activities and natural processes may threaten geosites, conservation areas, UNESCO heritage sites, and impact visitation and preservation efforts. A growing research network is developing, providing new approaches for evaluating geoheritage, pinpointing geosites, and leveraging geoheritage to boost societal resilience in hazard-prone regions like the SW Pacific (e.g., New Zealand, Vanuatu, and Samoa) and South America. Even in areas without ongoing volcanic activity, such as Saudi Arabia (Németh 2025), geoheritage is gaining recognition as a useful resource for communities and visitors to better understand this interconnected hazard landscape and to support tourism and sustainability objectives. Volcanic geoheritage includes landforms, rocks, and processes with scientific, educational, cultural, or aesthetic importance because they reveal how volcanic terrains develop, transform, and affect human societies. This embodies the "heritage of volcanism' — the tangible remnants of past eruptions and their associated cultural stories.
The relationship between geoheritage and natural hazards is usually studied in two main ways. One method examines how vulnerable specific geoheritage sites are to hazards from natural or human causes. The other method involves identifying geohazards within geoheritage either directly or through the geological record, as documented at geosites. Volcano-related geoheritage is particularly complex because it often involves rapid, localised events driven by volcanic hazards. Volcanoes are diverse geological features that shape landscapes through different eruption styles or rapidly form new terrain by adding or removing earth materials in sedimentary settings. These processes often attract human interest because of their benefits or risks; for example, they can be considered dark geoheritage due to their destructive effects. Furthermore, this complexity can enhance geotourism in volcanic regions, particularly active ones, by emphasising Earth's dynamic and constantly changing systems on a human timescale. Similarly, volcanic geoheritage sites are often exposed to volcanic hazards or related cascading risks, which can cause partial or complete destruction of geosites in the NW of Saudi Arabia, where geotourism development has identified regions with young Pleistocene-to-Holocene volcanoes as promising areas for tourism. Harrat Lunayyir, a monogenetic volcanic field that has been active in the last 600,000 years with eruptive episodes roughly every 100,000 years, illustrates this potential. Harrat Lunayyir is a prime example of using geodiversity assessment methods to identify volcanic geosites for geotourism, offering visualizations of eruption processes and products crucial for volcanic hazard resilience. This region is marked by an arid climate, unstable basement rock slopes known as horsts, and a wealth of ash and lapilli from past eruptions, which fuel complex sedimentary systems. Several non-volcanic hazards have been recognized, including rock falls, landslides, flash floods, and sediment remobilization, all of which threaten volcanic geosites. Future eruptions are expected to follow patterns observed

in volcanic research, primarily involving Strombolian-style explosive eruptions, Hawaiian-style lava fountain events, and lava flows that often pond and break out. The geosites are susceptible to various hazards. Although they are directly exposed to volcanic hazards, the most likely events could result in the formation of new geosites similar to those in the current regions. One of the most striking and well-studied locations in Saudi Arabia is the Northern Harrat Rahat, a Quaternary monogenetic volcanic field where the rapid expansion and urbanisation of the city of Al Madinah (Figure 1) pose direct human-induced hazards to volcanic geosites, while natural volcanic hazards must also be continuously considered as threats to existing geosites. This situation strongly suggests that natural and human-induced hazards on geosites, as well as the recognition of hazard elements and their use in shaping hazard-resilient societies, are vital and integrated parts of geoconservation and geoheritage characterisation.

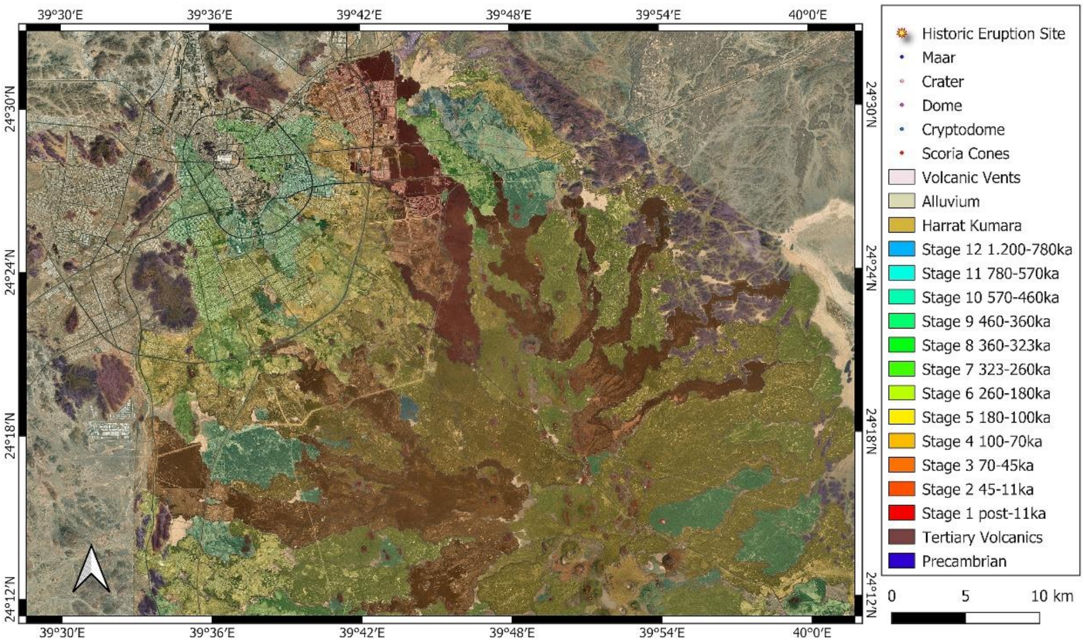

Figure 1 shows a geological map (scale 1:50,000) of Northern Harrat Rahat in Saudi Arabia, based on Drew et al. 2019. It clearly illustrates the distribution of lava flows and vents, many of which date to the Late Pleistocene to Holocene, with the most recent eruption occurring in 1256 CE. This eruption is about 25 km from the current center of Al Madinah. Rapid urban development has gradually covered the youngest lava flows and volcanic cones, which are important volcanic geoheritage sites. This loss reduces the opportunity to use these geosites to demonstrate volcanic hazards to the expanding city, especially along the eastern edge and near the dark lava flows. The map also highlights the quick succession of lava flows formed over a short time (a few hundred thousand years), indicating that volcanic hazards in the region directly threaten these geosites. Recording their features is crucial for heritage preservation, especially if future eruptions threaten to destroy them.

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Volcanic geoheritage of effusive vents generated in 2021 Tajogaite monogenetic eruption (La Palma, Canary, Spain)

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The monogenetic basaltic volcano of Tajogaite is located on the western flank of the Cumbre Vieja volcanic rift, La Palma Island, Spain. The eruption began on 21 September and ended on 13 December 2021. It was preceded by a volcanic crisis characterised by intense seismic activity, gas emissions, and ground deformation, culminating in an eruption within just one week. The eruptive fissure extended for 1 km in an NNW–SSE direction, between 840 and 1,100 m a.s.l., with multiple craters and fissures that opened and emitted gases, pyroclastic material, and large volumes of lava. The eruptive dynamics of Tajogaite ranged from Hawaiian-style activity, with lava fountains exceeding 100 m in height, to Strombolian (Fig. 1a) and violent Strombolian activity, with eruption columns reaching up to 8.5 km in height, during which hydromagmatic explosive phases were identified (Taddeucci et al., 2023). The eruption resulted in the construction of a complex, approximately 200 m-high scoria cone and an extensive lava field covering 12 km², with several effusive fissures identified.

The main volcanic geoheritage elements of the Tajogaite volcano are associated with pyroclasts (ash, lapilli, scoria, and bombs) and lava fields (Dóniz-Páez et al., 2022). The former is responsible for the formation of the scoria cone and the lapilli field. However, it is within the lava flows that the greatest geodiversity is found. In this regard, pāhoehoe, aa, blocky, and ball-shaped lava flows can be distinguished. Furthermore, within the lava field, a wide variety of volcanic landforms can be observed, such as effusive vents, lava tubes, jameos, lava channels, lava lakes, lava waterfalls, lava deltas, shatter rings, spatter cones, lava breakouts, accretionary lava balls, hornitos, and other morphologies. In addition, non-volcanic landforms must also be considered, including cliffs, ravines, debris flows, and beaches.

From a geoheritage perspective, attention has mainly focused on the principal volcanic landforms, such as the Tajogaite scoria cone and the ʻaʻa and pāhoehoe lava fields. However, a total of seven effusive vents have been identified within the lava field; these display significant geoheritage value associated with highly fragile volcanic landforms that are currently being affected by post-eruption reconstruction processes. Therefore, the aim of this research is, for the first time, to carry out an inventory and characterisation of the geoheritage of effusive vents, taking into account the risk of their disappearance. The methodology, based on several field surveys, was implemented between 2021 and 2025, and multiple drone flights (DJI Mavic 2 Pro equipped with a Hasselblad camera) were conducted to capture photographs and videos of the fissures.

One effusive vent is located to the north of the main cone (Fig. 1b), while the others are situated to the south, extending from the Las Manchas area to Las Norias (Fig. 1c–i). These are simple, linear fissures, except for one that branches into several *en echelon* segments (Fig. 1h). From a spatial perspective, the seven fissures can be grouped into two main categories: two that opened in areas unaffected by the eruption (Fig. 1c, e, and f), and five that developed on the Tajogaite lava flows. Most fissures opened transversely to the pre-existing topography, with E–W or NE–SW orientations, except for two that are oriented N–S (Fig. 1c and g). In terms of size, these are relatively small fissures, with lengths ranging from a few metres (Fig. 1i) to several hundred metres (Fig. 1b and h). Volcanic landforms associated with fissures can be divided into those formed by spatter emission and those formed by lava flows. The former includes hornitos (Fig.

1b and i) and spatter walls (Fig. 1c–h), both of which display a wide range of micromorphologies, such as lava droplets in shades of red, violet, blue, brown, and yellow (Fig. 1c and i). Features associated with the predominant pāhoehoe lava (e.g. ropy lava, toothpaste lava, finger lobes, inflated sheet lobes, slab lava) include lava tubes and jameos (large holes formed when the roofs of multiple levels of a lava-tube cave collapse), whereas ‘a‘a lava is associated with lava channels and levees. Furthermore, various anthropogenic technofossils must be considered, linked to the interaction between lava flows from these fissures and human infrastructure (Dóniz-Páez et al., 2025).

Figure 1. Eruptive fissures formed during the Tajogaite eruption: a-eruption; b-hornitos; c-fissure opening in a house; d-close-up of lava droplets inside a spatter walls; e-aerial view of the Montaña Cogote fissure (photo: R. Ubaldo); f-Montaña Cogote fissure emitting water vapour (2022); g-fissure in ‘a‘a lava; h-fissure in the Cristal house and i-fissure at Las Norias

This initial survey and characterisation of effusive vent geoforms highlights their significant volcanic geoheritage value, provides a basis for the effective management of these sites in the face of the real risk of their disappearance -as has already occurred in other areas- and opens up a new line of research aimed at applying assessment methodologies to the small-scale geoforms associated with these effusive vents.

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Integrating artificial intelligence (AI) and R-based modelling to calculate Fe-Mg diffusion in olivines from Jeziorna ultramafic xenoliths (SW Poland): implications for Lithosphere - Crust magma storage timescales

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The use of AI chatbots in science is currently expanding rapidly, yet it is accompanied by uncertainty regarding whether the content generated by AI is accurate. One of the most reliable ways to use artificial intelligence is to employ it for writing scripts or computational programs that automate calculations. This abstract presents R-based computational models developed with the support of the Copilot chatbot. These models were subsequently used to determine Mg–Fe diffusion rates in olivines derived from the Jeziorna ultramafic xenoliths (SW Poland). Working with the Copilot chatbot, four R-based diffusion models (the fourth in two variants: a simplified and a cooling-aware version) were developed.

Model 1 estimates the characteristic diffusion timescale along the c-axis in olivine using the composition-dependent parameterization and corrections for Fe–Mg interdiffusion provided in Dohmen & Chakraborty (2007, Part II, Erratum). **Model 2** extends Model 1 by adding pressure dependence derived from Holzapfel et al. (2007) and aligned with diffusion-chronometry practices outlined by Costa et al. (2020). **Model 3** estimates the time required to reach a prescribed diffusion length using closed-form solutions to Fick's second law, following methodological guidance from Watson & Baxter (2007) and Costa et al. (2020). **Model 4** estimates the time corresponding to the measured EPMA diffusion length using the Dohmen & Chakraborty (Part II, Erratum) parameterization, while **Model 4T** extends this approach by incorporating time-integrated diffusivity along a specified cooling path. Composition and pressure corrections follow Holzapfel et al. (2007) and are consistent with the approach outlined by Costa et al. (2020).

All models were adapted by Copilot into R scripts. **Model 1** uses D (T, X_{Fe}) (no pressure) with inputs Fo_{min}, Fo_{max}, T and distance "x". **Model 2** adds pressure PΔV (inputs: Fo_{min}, Fo_{max}, T, P, x). **Model 3** (error-function time-to-threshold at distance "x") uses D (T, X_{Fe}) with optional P. **Model 4** (isothermal inversion) requires Fo_{min}, Fo_x, Fo_{max}, "x", T (optional P). **Model 4T** extends Model 4 to cooling paths by integrating D ($T_{(t)}$, P) and requires Fo_{min}, Fo_x, Fo_{max} , "x", T_0, cooling rate (optional P). Fo_x is the measured intermediate value at distance "x", not a homogenization endpoint. All AI outputs were manually verified.

The proposed models were used to estimate timescales of Fe–Mg diffusion for xenoliths from the Jeziorna outcrop in the Polish sector of the Central European Volcanic Province. Jeziorna is an eroded volcanic neck with pre-1945 quarrying; it is smaller and less well known than Wilcza Góra (~3.5 km to the NE). The xenoliths are scarce, small, and include both peridotites and pyroxenites. Because Jeziorna basalts, compared with nearby outcrops, differ in whole-rock chemistry and mineralogy, the site is the most plausible candidate for a complex lithospheric ascent with stops at the lithosphere – crust boundary and/or within the crust. The magma temperatures calculated for this outcrop are approximately 1290 °C.

Thanks to the funding provided by the NCN Miniatura 4 project No. 2020/04/X/ST10/00542, it was possible to carry out chemical-composition analyses on nine xenoliths, using profiles that traversed each xenolith in full. In total, 17 profiles were measured, with the number of analytical points per profile ranging from 8 to 30. The spacing between points varied, averaging approximately 500 µm. Diffusion rates were calculated for seven xenoliths in locations where Fe–Mg diffusion was confirmed by chemical composition. Altogether, diffusion modelling was performed for 15 points.

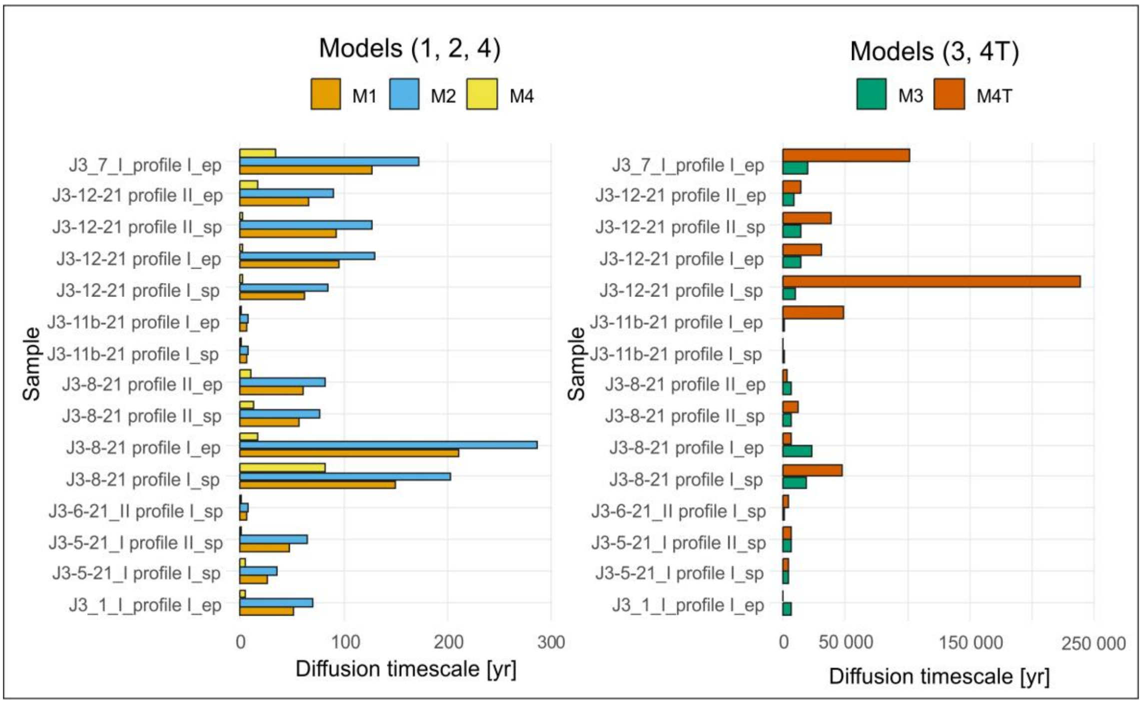

Figure 1. Diffusion timescales (yr) for Models 1, 2, and 4 (left) and Models 3 and 4T (right). Bars are grouped by sample; colors indicate the model.

The calculations indicate diffusion timescales ranging from a few years to up to a few hundred thousand years (Fig. 1), depending on the model applied. The differences and similarities between the models primarily reflect the theoretical assumptions of each modelling approach. In summary, the calculations performed for the xenoliths from Jeziorna indicate that diffusion occurring at depth (within the mantle or crust), under sustained high-temperature conditions (~1290 °C), would be limited to a maximum of roughly 80 years. In contrast, if diffusion took place within a shallow feeder dyke, cooling at an approximate rate of 300 °C per year, it could persist for up to about 250,000 years.

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Vulcan's Scrapyard: Interpretive Geopark Development at a Dacite Volcanic Landscape in Active Industrial Use, Sea to Sky Region, British Columbia, Canada

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The Fire & Ice Aspiring GeoRegion occupies ~10,000 km² of southwestern British Columbia, on the traditional shared territories of the Squamish and Lil'wat First Nations. The GeoRegion is centred on the Sea to Sky corridor north of Vancouver and includes the resort town of Whistler (host mountain for the 2010 Winter Olympics). It is oriented along two primary axes — Highway 99 (the Sea to Sky Highway) and the Sea to Sky Trail — and encompasses one of Canada's most geologically active regions, shaped by four interacting processes organized as interpretive pillars: mountain-building, glaciation, volcanism, and collapse. The aspiring designation is anchored by 61 geosites that collectively tell an end-to-end story of a landscape in motion, from submarine moraines at Porteau Cove in Howe Sound fjord to the glaciated, landslide-prone flanks of the Mt. Meager volcanic complex. All GeoRegion programming, branding, and interpretive infrastructure are organized around these four pillars, ensuring coherent public messaging across a large and geologically diverse territory.

Vulcan's Scrapyard, within the Cheakamus Community Forest within the boundary of the Resort Municipality of Whistler, is among the GeoRegion's most interpretively rich geosites. The site is centred on a dacite columnar jointing escarpment — the deeply eroded remnant of a lava dome originating from the Logger's Lake volcanic vent (Wilson & Russell, 2018). The high viscosity of dacitic magma caused the lava to build upward into a dome rather than spread laterally, forming the elevated mass that subsequent Pleistocene glaciation scoured and exposed as a towering cliff face of fractured hexagonal columns. Ongoing frost wedging, root-jacking by Douglas-fir, and gravitational collapse continue to reshape the escarpment today, making it a legible and active record of both the volcanism and collapse pillars simultaneously.

What distinguishes Vulcan's Scrapyard as a geopark interpretation case study is its adjacency to an active aggregate quarry extracting the same dacite for road construction, and its role as the source of decorative columnar joint material visible in public plazas and water features throughout the Sea to Sky corridor. This juxtaposition of scientific geoheritage with active industrial extraction and aesthetic cultural use creates productive interpretive tension. Vulcan's Scrapyard is a municipal park within the Resort Municipality of Whistler, developed through a collaboration between the municipality and the Fire & Ice GeoRegion, which contributed to the design and construction of the interpretive infrastructure. The park is intentionally accessed on foot or by bike from the Sea to Sky Trail, which runs directly past the site; a dirt road provides further accessibility but there is no on-site parking. This design philosophy encourages visitors to travel deeper into the GeoRegion rather than stopping for a quick roadside photograph, reinforcing a broader ethic of engaged, active geoheritage experience along the corridor. A suite of eight large-format Corten steel panels and inset science exhibits has been developed for the site (see Figure 1 for example). Large panels address the site's volcanic origin and glacial modification, human use and resource economics, geobiology and saxicolous ecology, and the surrounding mountain-and-glacier viewscape. Science insets treat columnar joint formation geometry, paleomagnetic age determination, comparative dacitegranodiorite crystallography, and the glaciovolcanic landscape of the adjacent Mt. Fee and Mt. Cayley volcanic field. Each panel is anchored to a physically visible or touchable specimen at the sign location, and all interpretive content is explicitly organized under the Geopark's four-pillar framework.

The Vulcan's Scrapyard interpretive development offers transferable lessons for geopark practitioners working at the intersection of active resource extraction and geological public education. Key design principles include anchoring each element to a directly observable feature, and prioritizing process diagrams and photomicrographs over generic landscape photography, since visitors already stand within the landscape. The formal opening of the park is planned as a Geology Discovery Day — a structured, curriculum-aligned field event for Whistler school students in Grades 3–7, aligned with the BC Science curriculum. Rather than a conventional ribbon-cutting, municipal dignitaries and elected officials will participate alongside students as they rotate through the park's four interpretive zones, engage in hands-on activities at each panel station, and take part in the sequential unveiling of the Corten steel panels. Three event formats of increasing depth and duration are offered to accommodate different grade levels and school schedules, ranging from a 90-minute introductory session to a 3.5-hour expedition format that incorporates a guided walk in along the Sea to Sky Trail. The event is designed to establish Vulcan's Scrapyard as an annual field trip destination for local schools, and to position the park explicitly as a community education resource from the moment of its opening. This approach — embedding geoheritage literacy into the community through the park's launch — reflects the GeoRegion's broader mandate and offers a transferable model for geopark site activation elsewhere. The site demonstrates that a volcanic landscape in concurrent industrial use can function simultaneously as a productive quarry, a biodiversity refuge, and a rigorous public science education facility, embodying the sustainable development mandate at the core of the UNESCO Global Geopark designation.

Figure 1. An example interpretive panel for the Vulcan's Scrapyard municipal geopark incorporating site geology and geoheritage.

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Dante Alighieri, a Medieval geotourist: how geothermal landscapes shaped Dante's Inferno

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Dante's interest in sciences, in particular astronomy, has often been underlined by scholars, while a minor effort has been devoted to Dante's interest in natural phenomena, often used as examples for the description of landscapes, or as metaphors. Dante's political activity, and later his exile, led him to know a large part of Central-Northern Italy, experiencing a number of different environments; the memory of these locations was used by him to draw the landscape of Hell and Purgatory. A detailed analysis of some cantos, depicting landscapes usually attributed to the Poet's fantasy, reflects a direct observation of extreme environments, such as geothermal gas emissions or methane vents and fires. Mofettes, natural geothermal emissions of sulphur and carbon dioxide located near thermal springs, have seldom been described by ancient geographers. Sometimes, they have been used in classic poetry (by Virgilius, above all) as a metaphor for chthonian world, in consequence of their strange and frightening features. In Dante's time, some of these phenomena had been dealt about by Albert the Great and Ristoro D'Arezzo (1976), that tried to explain them in accordance with Aristotle's cosmology. There is consensus about the fact that their works were known by Dante, but a thorough direct observation is suggested by Dante's detailed description of some characters of geothermal areas, never described, apparently, by previous Authors (Raschi, 2024), and by some precise geographical indications, evidencing the Poet's deep interest about what we call "geology" (still not existing as a science, in Dante's time). These points have seldom been noticed by critics (ignoring environmental sciences); yet, geothermal areas were known to Dante's contemporaries, in consequence of the renewed interest in hot spring bathing for medical purpose, and by the presence of geothermal phenomena along many of main roads, including the roads to Rome. This can be noticed, for instance, in the Cantos XII-XVI of the Inferno, in which the fiction built by Dante's fantasy is deeply interwoven with Dante's nonfictional knowledge of geothermal phenomena, such as mofettes and hot springs.

Much beyond description, when using natural phenomena as metaphors, Dante aims to interpretation, introducing the explanation provided by the science of his time (Romano, 2016), thus reflecting the "scientific culture" of the social classes to which the Commedia was addressed.

On the other hand, until a few decades ago, the scientific world was scarcely interested in the ecology of gas vents (von Faber, 1925): only recently they have been used as model ecosystems to study the adaptation of plants, arthropods and microorganisms to sulphur and carbon dioxide pollution (Miglietta et al., 1993).

The attention of tourism research to the interaction of tourists with naturalistic aspects of hot springs has also been scarce (Ugolini et al., 2016); the same can be said about the potential appeal of geothermal areas for literary tourism: little has been done, apart for the placement of a few commemorative plaques reporting Dante's verses, in some of the locations specifically mentioned in his poem.

This topic is discussed on the basis of a comparison between Dante, his contemporary authors, and recent scientific papers.

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Geodiverse: material kinship across deep time: Horizontal Collaboration Between Landscape, Science, Artist, and Audience

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"Holding a stone between my teeth.
My first cell was created by my grandma. My body was made of nothing, slowly becoming in the sea of the womb. My bones formed when I was twelve weeks old, taking away minerals from my mother's skeleton to create mine. Now my very young rocks – my teeth – hold their ancient ancestor firmly, but carefully. Balance. Biting into a past that cannot be penetrated."

This text was born during somatic encounters between the wonderfully iron-red Devonian sandstone walls in the deepest points of the Gauja Valley in Latvia. I had just lost my grandfather shortly before that, and as we were trying to connect with and understand the geological world around us, it brought me to looking at the hills as relatives, holding my weight when I need to rest. This is the kind of associative lamentation I wish to introduce to my audiences in my artistic practice – guiding them through a journey that combines intellect and sentiment, activating brain and body. The short reflective text then became part of a performance, or rather, the immersive slow-hike, Geodiverse, created by SVUNG, a movement based research and performative art collective. The first project was made in 2022 in Kű-Valley, together with Barnabás Korbély, head of group at the Bakony–Balaton UNESCO Global Geopark, as part of the Veszprém Capital of Culture events. Since then it was implemented in Latvia (Sigulda) and the Czech Republic as well – each locality turning it into a completely unique performance. In this project, our inspiration are the rocks, inviting us to landscapes that do not exist anymore – and to truly meet our material, we deconstruct conventions of performing:

- we leave the black box of theater, and go on site – for creation and performing as well
- we design the performance in conversation with the landscape – reflecting on the dramaturgy of geological history and the physical qualities of our site
- we co-create and perform Geodiverse with a local geology expert
- we spend 3-4 hours on a path you would comfortably walk in 25 minutes
- and our audience participates: they walk with us, and engage through a series of exercises, becoming co-performers and at the same time, observes of the collaboratively shaped performance

When people read our concept, they often think it is too much of a workshop to be called a performance, too much of a lecture to be an art workshop, too slow-walking and short-distance to be called a hike, and too artsy to be an educational walk. But if you experience it, you understand how these seemingly different disciplines support each other, resulting in a complexly interwoven encounter with all the stones that shape the landscape – gorgeous outcrops, invisible layers, the choreography of planets, and our own bones as they slowly move through the forest inside our bodies. We feel a material kinship that is simultaneously molecularly precise and poetically abstract. The performance allows heavy information to sink into emotional layers, and tactile discovery to merge with data and history. Constantly oscillating between personal and universal, micro and macro, sensible and intellectual, we dissolve Cartesian duality – similar to how the concept of geodiversity questions the harsh line between the living and non-living.
The undergoing ecological crisis and its inevitable influence on our everyday life pushes artists to include environmental themes into emerging works, and there is new calls and grants aimed at fostering art projects that center 'beyond-human kinship'; 'interspecies empathy' or simply 'ecological thinking'. Yet, these projects often do not include experts of relevant fields, or invite scientists only as a breathing source of knowledge, but rarely include them as consultants, almost never ask them what they think the goal/message or purpose of the project should be,

and equal collaboration is almost unprecedented. There are barely experts of environmental science invited or visiting the few Art&Science Conferences – and similarly, artists are not present at scientific conferences or discussions. I would like to see this change, and desire to join – or even: catalyze – this process of transformation.

I advocate for a horizontal collaboration between landscape, science, artist, and audience, and I believe that this approach, if taken seriously, brings the most meaningful, process-based result. This way, we can find something that would not be possible without the science expert or the artist, nor in a different landscape. Here, science is not merely serving the art project by providing exciting aesthetics, inspirational quotes, or cool data, but, with the involvement of the expert, provides the core content and overall center of gravity for the project. On the other hand, the artist is not only using the tools of art to illustrate or communicate the science. The artistic reflection's goal is to translate the knowledge – making it sensible and accessible. I have to mark an important quality here: accessibility has to be rooted in deep trust in our participants. Our goal is not to simplify, but to give time to engage, research, and discover, through artistic curiosity, play, and the art of noticing.

“In an accelerating digital age shaped by endless stimulation, attention extraction, and manufactured needs, the body is increasingly pulled between over-activation and anesthetization – caught in cycles of consumption that erode presence, relationality, and our capacity to respond to ecological and social crises. Ecosomatic practice emerges as a counter-movement, reclaiming the body as a living site of perception, relation, creativity, and care” writes Raffaele Rufo – and I believe, it is an essential language to meaningfully engage humans with geological sites.

My current research interest is to take the multidisciplinary applied theater methods of my practice, and create a knowledge sharing workshop and toolkit based on critical pedagogy, process based art and somatic tools, which will offer new tools to geoparks and natural parks, tour guides and (art)educators for the experience based communication of relevant ecological themes, geodiversity and the local natural environment. Other than this, we also need to rethink our infrastructures and institutions, and reflect on how we can create a system that reaches, invites and accommodates practitioners of various disciplines. By making cross-disciplinary collaborations possible, we enable the invention of new approaches that can innovate education and engagement, and support the turn of society towards a future based on sustainable co-existence.

With the Anthropocene now producing it’s own geological heritage through plastiglomerates, it is clear that the impact of humanity has to be understood on the scale of geological time. The idea of humans being small and insignificant compared to the history of our planet or the scale of our universe cannot be used to erase our responsibility anymore. Or, perhaps, we should embrace our impermanence, finding comfort in this embodied interconnectedness – maybe, if we all would experience, that we are inalienable part of this wonderfully diverse, ancient and magical world around us, we could slow down and give up on trying to build an everlasting empire made of toxic material in this never-ending greedy desire of a legacy that outlives us.

Geoheritage for geohazard awareness: towards an integrated framework for the Harrat Lunayyir volcanic field (Saudi Arabia)

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The "Harrats" are distributed volcanic fields of western Saudi Arabia that form one of the world's largest continental intraplate provinces, consisting of thousands of small-volume volcanic edifices and extensive lava flows that record volcanism since ~30 Ma (Camp & Roobol, 1992; Bosworth & Stockli, 2016). The Harrats are highly diverse in terms of morphology, composition, and eruption styles, making them ideal to study various continental intraplate volcanic processes (Németh & Moufti, 2024). In addition, due to the present day dry climate and limited vegetation, the volcanic fields are exceptionally well-preserved, providing a considerable geoheritage potential. However, with the latest recorded eruption in 1256 C.E. near the city of Madinah, and dike intrusions in 1999 and 2009, the Harrats also pose a significant geohazard potential (Pallister et al., 2010; Abdelwahed et al., 2016; Kereszturi et al., 2016; Dietterich et al., 2018). Despite this activity, awareness of volcanic hazards remains limited, as eruptions occur on timescales exceeding human experience, and education on the lava fields is limited.

We will introduce a new interdisciplinary project that will integrate geological investigation with a geoheritage framework to better understand and communicate volcanic hazards of the Harrats. Our project focuses on the predominantly basaltic Harrat Lunayyir, one of the youngest volcanic fields. Harrat Lunayyir exhibits high geodiversity, is part of a large tourist development area, and is also the site of the latest seismic unrest and dike intrusions in 2009, causing the evacuation of 40.000 residents (Pallister et al., 2010; Abdelwahed et al., 2016; Németh & Moufti, 2024). We will present our current understanding of Harrat Lunayyir's magma source, the activity of volcano-magmatic processes, and their evolution. Further, we will outline the objectives and approach of this project that will combine field observations, volcanology, sedimentology, geochronological constraints, and geochemical analyses of selected volcanic centres to refine our understanding of volcanism. This will form the basis for evaluating future eruption-related and post-eruptive dust mobilization hazards, as well as for determining the geoheritage value of this region amid rapid societal and infrastructural development.

By linking geological features to past volcanic activity and hazards, this approach aims to translate complex Earth system processes into accessible knowledge for local communities and stakeholders, in order to use geoheritage as a practical tool for risk awareness, resilience building, and sustainable management of volcanic landscapes (Reynard & Giusti, 2018).

Figure 1. Ash cone and ash covered lava in Harrat Lunayyir

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MDPI Geographies - Meet us at IAVCEI Volcandpark 2026

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Keynote Speakers

Exploring the hidden depths: The significance of Deep-Earth Geoheritage

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PhD in Geology, Research Professor at the CSIC, Ex-Director of Geosciences Barcelona, CSIC, Director of the NRAMS Survey at IDAEA-CSIC, Barcelona. specialist in physical volcanology and volcanic risk, and multihazard assessment and prevention. Former Secretary General of the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI). Former editor-in-chief of the Journal of Volcanology and Geothermal Research (Elsevier). Member of the European Academy. Honorary Fellow of the International Union of Geodesy and Geophysics. Member of the Royal Academy of Arts and Sciences of Barcelona.

Deep-Earth geoheritage refers to the preservation and study of geological features and processes originating from the Earth's interior. This emerging concept highlights the importance of Earth's subsurface in shaping planetary evolution, climate systems, and the ongoing dynamics of the lithosphere and mantle. Deep-Earth phenomena, such as volcanic activity, plate tectonics, and mantle plumes, offer critical insights into the history of our planet and its future evolution. By examining extraordinary geological processes, such as those found in subduction zones, mantle hot spots, and deep-sea hydrothermal systems, deep-Earth geoheritage contributes to a more holistic understanding of the geological framework of Earth. As advancements in geophysical technologies enable deeper exploration, the conservation of these extraordinary sites has become increasingly important for both scientific research and cultural heritage. Moreover, deep-Earth geoheritage connects with other disciplines such as climate science, environmental studies, and even astrobiology, since the processes occurring at the interior of the Earth might provide insights into the potential habitability of other planets. As examples of Deep-Earth Geoheritage sites we can think on geothermal systems, as examples of Deep-Earth heat anomalies influencing surface processes, tectonic boundaries such as subduction zones, mid-ocean ridges, or hot spot tracks, examples of dynamic zones linking the deep Earth to the surface, or mantle plumes and volcanoes, which are directly tied to the deep Earth's mantle processes. Finally, it is important to remark on the significance of public awareness of deep-Earth processes and the need for sustainable management of geoheritage sites that reflect internal dynamics of our planet. This contribution will explore the significance of Deep-Earth geoheritage, focusing on the potential for interdisciplinary research and the role these sites play in Earth sciences, climate research, and the future of planetary exploration. This research has been partially funded by VOLCANO grant (EC ECHO ref: 101193100).

Thinking Like a Xenolith: Deep-Earth geoheritage in volcanology and climate change conceptions

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Karen Holmberg is a volcanologist and archaeologist who examines the long-term experiences that humans have had with environments that change radically and unpredictably. She currently teaches as a professor of environmental science in the interdisciplinary Gallatin School at New York University. She is the co-founder and scientific director of the NYU Gallatin WetLab, an experimental art-science laboratory space on Governors Island in New York City that focuses upon public pedagogy in the face of the climate crisis. She serves as the Engineering Writing Fellow at The Cooper Union for the Advancement of Science and Art. She is deeply interested in how creative communication of science and engineering insights through collaboration with the arts can contribute to more sustainable and equitable societies.

Volcandpark 2026 introduces and examines the concept of "deep-Earth geoheritage" through xenoliths or other fragments of far away times or places of our planet. I take this as an invitation to consider the breadth and depth of the connections between humans and the geophysical Earth and the mutual incomprehensibility of human and geological temporalities. Aldo Leopold famously extolled us to think like a mountain in order to encourage an embrace of the inviolate interconnections, long-term consequences, and ethical responsibilities we have in thinking about and acting within the natural world. Playfully, I suggest that thinking like a xenolith could nudge us to a helpful shift in scientific perspective that embraces the interconnectedness of all elements of the Earth system. I draw on examples from my transdisciplinary fieldwork with volcanic landscapes in highland Panamá (Barú), Chilean Patagonia (Chaitén), and southern Italy (Campi Flegrei) to highlight the importance of different temporalities and creative expressions of them by people in the past and present. In terms of long-term consequences and ethical responsibilities tied to volcanic landscapes, I also take our confronting historical moment as an invitation to consider the geoheritage of Mauna Loa volcano and the future. The Keeling Curve record of atmospheric CO2 began in 1958 on Mauna Loa and may end as a casualty of US politics. What do such endings mean to the Earth itself? Perhaps thinking like a xenolith could help us move beyond human-centered vantages and see ourselves as an inextricable part of the natural world. We will never "conquer" climate, per Mike Hulme's memorable discussion. What is within our control is continued, creative approaches to studying and communicating geohazards to benefit those for whom it can make a difference.

Linking geodiversity, biodiversity, and human heritage in an active volcano: Nisyros

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Paraskevi (Evi) Nomikou is a marine geologist specializing in the morphology of underwater volcanoes, with extensive expertise in marine volcanism and seafloor extrusion processes. She is a Professor in the Department of Geology and Geoenvironment at the National and Kapodistrian University of Athens (Greece). Most recently, she has played a leading role in assessing the potential hazards linked to tectono-magmatic activity northeast of the Santorini volcano (February 2025). She is the Principal Investigator of SANTORY (SANTORini seafloor's observatorY), a project that monitors the Kolumbo submarine volcano and contributes to advancing understanding and mitigation strategies for the potential impacts of explosive volcanic eruptions. In addition, she serves as the Scientific Coordinator of the Nisyros aspiring UNESCO Global Geopark (aUGGp). Beyond her research, Professor Nomikou actively shares her passion for volcanology with students through university lectures and works to engage both local communities and visitors in appreciating and preserving the region's unique natural and cultural heritage. In recognition of her outstanding contributions, she was awarded the 2025 Fisher Medal by the International Association of Volcanology and Chemistry of the Earth's Interior.

The island of Nisyros, recently designated as a UNESCO Global Geopark (UGGp), stands as a definitive natural laboratory in the southeastern Hellenic Volcanic Arc. This prestigious status underscores its international significance as a site where geodiversity, biodiversity, and human heritage are not merely adjacent but are deeply and inextricably linked. For scientists, students, and the broader public, the island offers a rare opportunity to observe the heartbeat of an active volcanic system. The landscape is dominated by spectacular formations that serve as a chronological record of the volcano's evolution, from its early submarine phases to the dramatic subaerial events that shaped its present-day morphology. Central to this geological narrative is the island's massive collapse caldera, a geomorphological landmark that provides the stage for some of the most impressive hydrothermal activity in the Mediterranean. Within this caldera, the hydrothermal craters—most notably Stephanos—act as direct portals to the Earth's internal energy. Although the volcano is currently in a dormant magmatic state, it remains a site of high geodynamic intensity. This is evidenced by the continuous gaseous emissions from fumaroles, where temperatures consistently range between 960C and 1000C. Furthermore, the island's thermal springs, with temperatures fluctuating from 300C to 600C, demonstrate a centuries-old tradition of utilizing geothermal resources, bridging the gap between raw geological power and human utility.

The biological profile of Nisyros is equally compelling, dictated by the very volcanic soil that defines its terrain. The island's unique chemical composition and varied microclimates have fostered a hub of biodiversity that is recognized internationally. The entire Geopark area is integrated into the Natura 2000 network and includes three designated national wildlife refuges. These protected areas serve as a sanctuary for numerous endemic and rare species of flora, birds, and reptiles, creating an ecological mosaic that is vital to the Eastern Mediterranean's environmental health. The presence of these species highlights the resilience of life in high-energy volcanic environments and illustrates how geodiversity provides the essential framework for biological diversity to flourish.

Woven into this natural tapestry is a rich human history that dates back to antiquity, deeply colored by the island's explosive origins. In Greek mythology, Nisyros was born from the Gigantomachy, the battle between the Gods and the Giants, where Poseidon supposedly crushed the giant Polybotes under a fragment of Kos. This mythic identity is grounded in tangible archaeological landmarks like the Paleokastro, an ancient acropolis constructed from massive blocks of volcanic rock, and the monastery of Panagia Spiliani, which is built within a natural cave of the volcanic cliffside. These sites reflect a long-standing cultural identity that has been shaped by the island's restless foundations. The local population has historically adapted to the volcanic landscape, developing a unique socio-economic structure that respects the geological hazards while reaping the benefits of fertile soils and thermal waters.

In recent years, the transition to a UNESCO Global Geopark has catalyzed extensive efforts to highlight and disseminate this multifaceted heritage. The mission of the Geopark is to raise global awareness regarding the importance of preserving geological and biological diversity while educating the public on potential volcanic hazards. This is achieved through a comprehensive suite of initiatives, including specialized educational programs, interdisciplinary workshops, guided tours, and international summer schools. These programs are designed to connect diverse audiences—from local residents to international researchers—with the island's extraordinary narrative. To ensure broad accessibility, the Nisyros UGGp leverages modern communication technology, such as the Nisyros Geopark and Nisyros Volcano mobile applications, alongside its dedicated digital platform. These tools provide interactive and real-time information, making the complex science of volcanology engaging and understandable for the modern traveler.By achieving UNESCO Global Geopark status, Nisyros has solidified its role as a vital link between the Earth's volcanic past and our collective future. The Geopark does not merely preserve rocks and rare plants; it preserves a living relationship between a restless planet and the civilizations that call it home. It ensures that the island's geoheritage is not only celebrated and understood but also protected as a legacy for generations to come. This holistic approach to conservation—where the steaming fumarole, the rare orchid, and the ancient stone wall are treated as parts of a single, unified story—defines the essence of Nisyros as a jewel of the Aegean and a cornerstone of global geo-education.

Figure 1. Panoramic view of the Phreatic Craters of the Nisyros Caldera.

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Community resilience in volcanic parks

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Benjamin van Wyk de Vries is professor of volcanology at Université Clermont Auvergne, Observatoire du Physique du Globe de Clermont, Laboratoire Magmas et Volcans. He speaks and teaches in rough English, French and Spanish. His research and teaching is transdisciplinary (geology, geoheritage, risk, communication). He has a broad publication portfolio, with diverse subjects. He is coordinating a UNESCO International Geosciences Programme project 'Geoheritage for Resilience' and is part of an 'ECOS' Mexico – France exchange. For him there should be no separation between the community, scientific research and practical application when dealing with the environmental issues. The scientist must work within society, and natural heritage is a powerful way to do this.

Volcanic parks (that is all sorts of protected areas on volcanoes) can be integral to managing the potential risks faced by communities in such areas. These risks may be from the volcano, by environmental hazards such as eruptions, floods and landslides, or may be to the volcano such as from poor management and over-tourism. Volcanoes are more than their geological entity, being geobiodiverse and culturally diverse environments. Thus, this holistic volcanic environment, that includes biodiversity and culture, provides a place and livelihood that can nourish communities, can protect them and always needs protection and careful management. This is so even if the volcano environment also produces events considered as hazards. Community Resilience in this environment can be defined as where and when that community works in a holistic way to maintain and the geological, biological and cultural balance. As communities never exists in isolation, the actors include external actors, such as government, civil organizations, individuals, visitors and scientists. The role of parks and these externals in this volcanic environment can be, but is not always that of respecting and contributing to the community. This works best for scientists (and other actors) when they play a part in the community, and respect local customs and rules. In this talk we will look at examples of community resilience around the volcanic rocks of Arequipa, Peru; around the volcanoes in lake Nicaragua; and around the volcanic environs of Mexico City, and S. Chile. We'll explore the different contexts, and ways that different community actors (including scientists) have worked to improve resilience.

Geobiodiversity and geobioheritage of volcanoes: Life in Volcanpark

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Biologist, Doctor in Biological Sciences from UNAM, Mexico, with multidisciplinary research centered within the institute of geology. Her current research looks at the ecological interactions that occur in volcanic landscapes, such as ecological succession, soil formation bioreceptivity and bioweathering. Thirteen years of work in ecological restoration of the ecosystem established on the lava flow of Xitle volcano in Mexico City, with the Geopedregal project. Ten+ years of teaching and science communication. She seeks to share her view of the microscopic world both rocky and living, and to explore this interconnection that has guided the course of life on Earth.

Volcanoes have a highly variable structure, diverse deposits and morphology that provide many diverse habitats for life to settle. Volcanic edifices can support the comprehensive development of diverse and dynamic biological communities on their surface and interior. I will discuss the nature of these biological communities and explore the impact they have on the long-term evolution of lava flows that become geobiodiverse entities. I will present my research on the extensive Xitle lava flow in Mexico City, as well as observations in Central America and Europe, including lava-life interactions, ecological processes, and the possibilities for biological cooperation within a geological framework. The geobiological approach throughout this research, has resulted in the use of the terms geobiodiversity and geobioheritage.
Using these terms is a way to emphasize the need and value for both visions to come together. Geobiodiversity provides an enhanced vision of volcanic ecosystems and landscape ecology, while geobioheritage provides a vital link for science and society for all our planet's natural features. This is integral for ecosystem services, environmental impacts, natural resources and biodiversity in volcanic landscapes. Geobioheritage in volcanoes can be used widely to describe the integrated natural and human volcanic environment. It could be effectively used to enhance the protection of both.

Building a life in harmony between active volcanoes and the population in Costa Rica

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Born in Costa Rica. He holds a Bachelor's degree in Geology from the University of Costa Rica and a Master's degree in Disaster Management from the National Graduate Institute for Policy Studies (GRIPS), Tokyo, Japan, along with a Postgraduate Diploma in Seismology from the International Institute of Seismology and Earthquake Engineering, Tsukuba, Japan. The title of his master's thesis was "A new pathway to untangle the question: was the eruption triggered by the earthquake?" He obtained his PhD in Volcanology from the University of Bari (Italy). The title of his PhD thesis was "Stratigraphy, eruptive dynamics, sedimentology and distal dispersion of the Neapolitan Yellow Tuff, Campi Flegrei, Italy." He has worked in volcanic surveillance in Costa Rica since 2008 and has experienced several volcanic crises in the country over the years. In 2017, he co-founded the NGO "Volcanes sin Fronteras" with eight other volcano enthusiasts. He is currently a Postdoctoral Researcher at the Vesuvian Observatory of the National Institute of Geophysics and Volcanology (Italy) and serves as President of "Volcanes sin Fronteras." He is the author or co-author of more than ten papers published in international journals, including Nature, Scientific Reports, Earth, Planets and Space, Geological Society of London, and others.

Around 10% of the worldwide population lives less than 100 km of an active volcano (Holmberg and Small, 2016). This percentage increases drastically in some regions such as Central America. Costa Rica a country with a population of 5 million, where the >90% whitin a range of 100 km from an active volcano, denotes the necessity to show to the population how volcanoes work. In 2017, Volcanes sin Fronteras, an NGO was born with the mission to generate and transfer the actual knowledge about volcanoes, to reduce the vulnerability of the population and promote and take advance of their resources. Five different main projects have been carried out to reach this mission.

1. Volcanologist for a day: we bring to non-scientist population to understand the work of the volcanoes and how the costarican territory has been modelled by different volcanic processes.
2. Olympus mountain: we work with 13 schools (children 8-11 years old) located less than 20 km from actives volcanoes giving lessons, experiments and bringing these children to their nearest volcanoes. In this program, we evaluate the knowledge of the children with two drawings, before and after our course. In figure 1 you can see how different the children represent the volcano in colors, shape and volcanic elements of their closes volcano to the school.
3. Course of volcanology and their ecosystems: We create a two days course in different volcanic areas for tourists guides, where we give specific knowledge in these topics in order to spread more advanced information to the national and international tourist.
4. Journey to the Earth interior: We teach in a special 4 months course, divided in three different modules: A. Introductive geology. B. Seismology and Earthquake Geology. C. Vulcanism. These course was opened to the non scientific population to all age public.
5. Documentary films: we generated three different short-doccumentary, free access, related with historical volcano tragedies and recent activity of three active volcanoes of Costa Rica.

Our organization is now working in the promotion of the first geopark in Costa Rica in the area of Poás volcano, an active volcano, which is one of the most visited volcano of Latin America, where most than 100k people live in its proximities. We considered that a best quality of life is knowing where we are living and the different extraordinary natural processes involved to live in a beautiful country like Costa Rica.

Figure 1. Two different children 9 years old, drawing Turrialba volcano (upper) and Poas volcano before (left) and after (right) of the course called Monte Olimpo.

References

Holmberg, K and Small, C 2016. Quantifying populations in proximity to potentially active volcanoes. S.1.2, Cities on volcanoes, Puerto Varas, Chile.