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EXTENDED ABSTRACT 356

Excavations in the Lesvos Petrified Forest - A significant geo-conservation project alomg the Kalloni-Sigri road, in the Lesvos island UNESCO Global Geopark, Greece.

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Introduction / Background

The Petrified Forest of Lesvos is a unique natural monument located in the western part of Lesvos Island, Greece. It was formed during the Lower Miocene due to intense volcanic activity in the North Eastern Aegean region.

The Lesvos Petrified Forest was declared a protected natural monument in 1985, and its protected area covers 15,000 hectares. In 2000, it became one of the first four European Geoparks. In 2004, it was a founding member of the Global Geoparks Network. Lesvos Island was designated a UNESCO Global Geopark in 2015 by the UNESCO General Conference. The Lesvos Petrified Forest is the primary geological heritage feature of international significance that led to the recognition of Lesvos Island as a UNESCO Global Geopark. Furthermore, it was recognized as one of the first 100 IUGS geological heritage sites by the International Union of Geological Sciences. Thus, the Lesvos Petrified Forest is one of the most important geological heritage sites for research, education, tourism, and sustainable development.

During the last decade, the new road connecting Kalloni with Sigri was constructed, traversing the western peninsula of Lesvos and specifically the protected area of the Lesvos Petrified Forest. During road construction, a large number of remarkable fossil sites with impressive fossilized tree trunks were unearthed, located along the roadside. Consequently, twelve fossiliferous localities along the Kalloni-Sigri road now constitute an open-air park, offering visitors a unique experience within the Lesvos Petrified Forest.

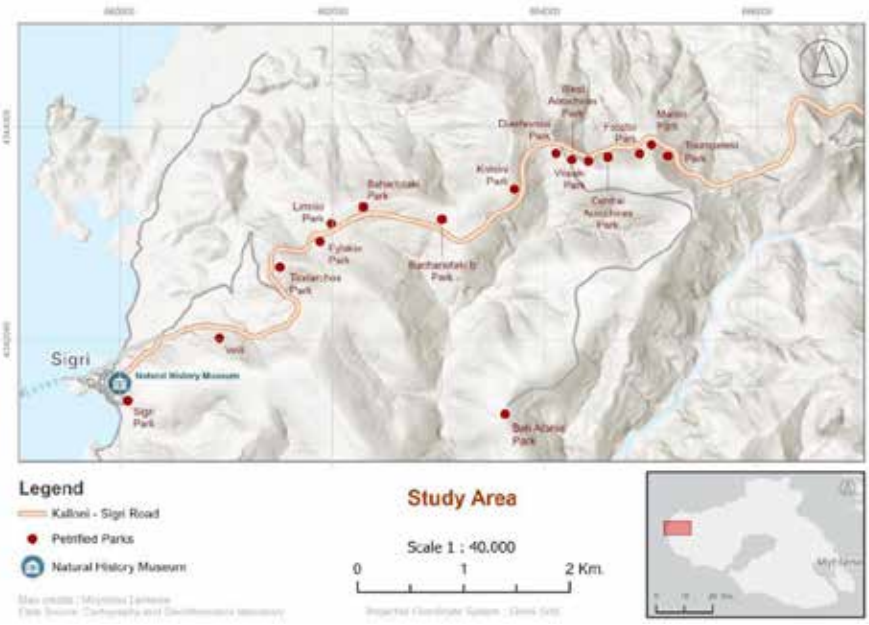

Fig. 1: Location map of the studied area within the Lesvos Island UNESCO Global Geopark, illustrating the 14 fossiliferous localities transformed into open-air parks along the Kalloni-Sigri road.

Geological setting

Lesvos Island is located in the northeastern Aegean Sea. Miocene volcanic rocks dominate western Lesvos and cover the metamorphic basement, which consists of schists and marbles principally of Permian age (Katsikatsos et al., 1982). The oldest Cenozoic rocks overlying the metamorphic basement are lacustrine marls, shales, sandstones, and lignites of the Gavathas Formation (Koufos et al., 2003). The Miocene volcanic sequence of Lesvos comprises andesite, dacite, and basalt lavas, ignimbrites, and a thick pyroclastic sequence (Pe-Piper, 1980; Pe-Piper & Piper, 1993, 2002), which hosts impressive numbers

of silicified tree trunks. The Sigri Pyroclastic Formation consists of several hundred meters of pyroclastic flow tuffs (unwelded ignimbrites) interbedded with fluvial conglomerate and volcaniclastic sandstone. The Sigri Pyroclastic Formation ranges in age from 21.5–22 Ma to younger than 18.4 Ma. Tuffs and fluvial conglomerates in the Sigri Pyroclastic Formation coarsen eastward. Fossiliferous localities with a large number of standing and lying petrified trees, as well as soil horizons, occur throughout the formation (Velitzelos & Zouros, 1997, 1998; Pe-Piper et al., 2019; Zouros et al., 2022).

Research, Excavations and Geoconservation activities in the Lesvos Petrified Forest

The Natural History Museum of the Lesvos Petrified Forest, established in 1995, is a public institution dedicated to the protection and sustainable management of the Lesvos Petrified Forest. Since 1997, the Museum has conducted research activities to identify and map fossiliferous localities in the western peninsula of Lesvos Island. These localities have been identified around Sigri village, in the Tsichliontas river valley, in the Akrocheiras hill range, in the areas of Gavathas and Lapsarna villages, the area north of the Tapsas river valley, the area of Skamiouda, and the area of Eressos village. Systematic excavations have been carried out in the area of Kyria Apolithomeni (Bali Alonia), owned by the Greek state, as well as in areas offered to the Museum by the Greek state, such as the Sigri, Plaka, and Nissiopi Parks (Velitzelos & Zouros, 1997; Zouros et al., 2007; Zouros, 2021). The Museum also conducts rescue excavations within the protected area of the Lesvos Petrified Forest in response to fossil findings during the construction of public and private works.

During the Kalloni-Sigri road construction, the Museum, with support from the Ministry of Public Works, implemented necessary measures, including revisions to the initial road plan, to ensure the protection of fossils and the preservation of significant fossil sites along the road (Zouros et al., 2022).

The Museum implemented a comprehensive geoconservation plan, which included significant challenges: conducting rescue excavations along the Kalloni-Sigri road during road construction, mapping and protecting the newly discovered fossil sites, collecting and conserving the vast number of unearthed fossils, transferring and storing the movable fossils, and protecting and preserving in situ the standing fossil trees and significant lying fossil tree assemblages. This rescue excavation project, which lasted ten years (2004-2014), represents the most extensive paleontological excavation in Greece.

The rescue excavation project was followed by a second project funded by the Operational Programme 2014-2020: North Aegean,.that included a series of interventions to improve accessibility to the fossiliferous sites, provide interpretation and information signage, and develop infrastructure for visitor services. The various fossiliferous sites along the Kalloni-Sigri road are now part of a new, globally unique open-air museum, offering Lesvos Geopark visitors a novel geotourism attraction. In addition to various awareness-raising activities, a new campaign entitled “Walk the Forest” introduces the new petrified forest parks to the public.

Material and Methods

The Museum’s research team monitored the construction work to detect and protect fossils along the new Kalloni-Sigri road. When a new fossiliferous location was encountered, construction work was halted, and the Museum’s excavation team, with the assistance of the Museum’s conservation team, uncovered the fossils from their pyroclastic cover. Detailed cleaning and conservation work took place in situ. Detailed information on the dimensions and stratigraphic location was recorded at 15 fossiliferous locations along the new Kalloni-Sigri road. For all fossils, detailed measurements and location data were taken. The main fossil assemblages, the most prominent fallen tree trunks, and the majority of the standing tree trunks were preserved in their original positions. The removed fossils were secured in plaster casts, and fossil fragments, as well as parts of the respective fossil leaf horizons, were stored in wooden boxes.

Results of the rescue excavations along the Kalloni - Sigri road

The Museum’s research team was monitoring the construction work to detect and protect fossils along the new Kalloni-Sigri road. Fifteen fossiliferous localities have been excavated, revealing numerous fossilized trees and leaves that offer new data on the creation and composition of the Lesvos Petrified Forest.

The **Taxiarchis** locality (Fig. 1) hosts two large conifer tree trunks rooted in tuffs and volcanic conglomerates of the Sigri Pyroclastic Formation, inclined towards the west. In the same locality, two other large conifer trees lie within the volcanic conglomerates, indicating a NNW-SSE tree fall direction.

The **Filakio** locality (Fig. 1) is a significant site hosting three successive paleosol horizons associated with standing tree trunks and extensive root systems. More than 31 standing and lying tree trunks are preserved in their original positions. In this location, six large and medium-sized conifer and angiosperm tree trunks lie within the pyroclastic horizons, indicating a N-S to NNW-SSE tree fall direction.

The **Bachariotaki** locality (Figs. 1, 2) features more than 35 lying and standing tree trunks preserved in their original positions. The majority of the lying tree trunks indicate a N-S to NNW-SSE tree fall direction.

The **Kotsini** locality (Figs. 1, 3) primarily hosts standing tree trunks covered by volcanic conglomerates overlying a very characteristic paleosol horizon. Two lying tree trunks indicate a N-S to NNW-SSE tree fall direction.

Fig. 2. General view of the Bachariotaki fossiliferous locality. N-S to NNW-SSE tree fall direction detected at the site, indicating the moving direction of the pyroclastic flow.

Fig. 3. Petrified tree trunk in Kotsini fossiliferous locality. The roots of the standing tree trunk are diveloped in the silicified paleosoil holizon dividing the lower tuffs with the upper pyroclastic conglomerate.

The **Diastavrosi** locality (Figs. 1, 4) features an intact petrified tree, 19 meters high, with its branches and roots unearthed. The tree was embedded and entombed by the cataclysmic volcanic eruptions of the Vatousa volcano, as the ESE-WNW tree fall direction indicates the moving direction of the pyroclastic flow that transported trees from their original growing location. This is a unique find worldwide. In the same location, two more fossilized trunks have been identified in their natural positions, along with five fossilized trunks, 30 parts of fossilized trunks, and 2,989 fragments of fossiliferous horizons with an abundance of fossilized leaves.

The **West Akrocheiras** locality (Fig. 1) exhibits seven successive paleosol horizons visible between the pyroclastic horizons. Five fossilized tree trunks are rooted in their natural positions. Additionally, 42 fossilized logs or parts of fossilized logs and 6,357 fragments of fossiliferous horizons with an abundance of fossilized leaves are present.

The **Vrysaki** locality (Fig. 1), a continuation of the previous site, also features successive paleosol horizons. Standing and lying tree trunks are embedded in the pyroclastic horizons, including a large standing conifer tree trunk. Ten fossilized trunks are found standing in their original positions. In the same locality, 30 lying fossilized trunks and 2,989 fragments of fossiliferous horizons with an abundance of fossilized leaves are present.

Fig. 4. General view of the Diastavrosi excavation site. 19 meters long tree found intact with its branches and roots with a fall direction towards 113°.

Fig. 5. General view of the Freation fossiliferous locality. E-W and NNW-SSE orientation of the tree fall direction indicate the moving direction of the pyroclastic flow that transported trees from their original site

Fig. 6. The western part of Freation fossiliferous locality. Several excavated tree trunks are covered by plaster cast to avoid damage during excavation works, while others are visible during excavation works

The **Central Akrocheiras** locality (Fig. 1) exhibits successive pyroclastic horizons. Six fossilized tree trunks are rooted in their natural positions. Additionally, 28 fossilized logs or parts of fossilized logs and 2,620 fragments of fossiliferous horizons with an abundance of fossilized leaves are present.

The **Freatio** locality (Figs. 1, 5, 6) is a significant site due to the exceptionally high number of fossilized trunks excavated and preserved on-site. In this locality, 400 silicified tree trunks have been excavated and remain in their excavation positions. Remnants of the trees are found embedded and entombed in pyroclastic flows created by cataclysmic volcanic eruptions from different volcanic centers located east and south of the excavation site. Successive horizons of tuffs are visible, with lying and standing tree trunks preserving evidence of large-scale mudflows. There are also 395 fossilized logs and parts of fossilized logs that have been removed to allow the excavation of the lower fossiliferous horizons. At the same location, 216 selected fragments of fossiliferous horizons with an abundance of fossilized leaves are present. Most of the fossil trunk fragments have been revealed from the Quaternary fluvial conglomerates overlying the pyroclastic tuffs. Three groups of fallen tree trunks are present. The lower group includes tree trunks in the N-S to NNE-SSW (180°-190°) direction, the middle group with an E-W direction (250°), including the longest tree trunks exceeding 25 meters, and the upper group with a NW-SE direction (140°).

Fig. 7: Panoramic view of the I. Toubelekis park fossiliferous locality, where five successive horizons of standing and rooted fossil trunks are visible

Table 1: Fossiliferus localities along the new Kalloni-Sigri road

A/A	Site name	Code	In situ fossils	Removed fossils	Fossil leaves
1	Veili	ΒΕΛ	1	655	
2	Taxiarchis	ΤΧ	2	31	
3	Fylakio	ΦΥ	31	88	
4	Limnio	ΜΡΤ	2	5	
5	Bachariotaki	ΜΠΤ	35	91	
6	Bachariotaki B	ΜΠΤ	4	3	
7	Kotsini	ΜΠΥ	20	2	55
8	Diastavrosi	ΔΜΠ	2	35	2.989
9	West Akrocheiras	ΑΚΥ	5	42	6.357
10	Vrysaki	ΒΡΥ	11	53	3.600
11	Central Akrocheiras	ΒΡΦ	6	28	2.620
12	Freatio	FRE	400	395	216
13	Mantri Toumpeleki	ΤΟΑ	243	0	281
14	I Toumpelekis	ΜΤΟ	127	75	236
15	Moni Ypsiloy	ΑΚΒ ΜΥΒ	2	6	
	Total		**909**	**1.491**	**16.354**

The **Mantri Toumbeleki** locality (Fig. 1) exhibits successive layers of tuffs with lying and standing tree trunks, preserving evidence of large-scale mudflows. The site hosts 243 lying and standing fossilized tree trunks. Additionally, 281 fragments of fossiliferous horizons with an abundance of fossilized leaves are present.
The **I. Toumbelekis** locality (Figs. 1, 7) is a significant site featuring successive layers of tuffs with lying and standing tree trunks. Five successive layers with standing and rooted fossil trunks are visible. The site hosts 127 lying and standing fossilized tree trunks. Furthermore, 395 fossilized logs and parts of fossilized logs have been transported from the site, and 236 fragments of fossiliferous horizons with a plethora of fossilized leaves are present.

Discussion

The excavated localities provide new data regarding the composition of the Lesvos Petrified Forest, its creation, and the stratigraphy of the Sigri Pyroclastic Formation (Zouros et al., 2015; Pe-Piper et al., 2019; Zouros, 2021; Papadopoulou et al., 2025). The vast amount of fossils recovered from the rescue excavation sites along the Kalloni-Sigri road, presented in Table 1, provides a unique archive with significant new data and research results on the composition of the flora, as already published (Zouros et al., 2015, 2022; Zouros, 2021; Kafetzidou et al., 2022; Liapi et al., 2022, 2024; Tsitsou et al., 2022; Zhu et al., 2024). The collected materials will yield further results as they are gradually studied in the coming years.
The rescue excavations along the Kalloni-Sigri road have demonstrated that the Petrified Forest of Lesvos is the result of successive cataclysmic volcanic eruptions that occurred during the period from 21 to 18 million years ago (Pe-Piper et al., 2019). The excavation sections revealed that the formation of the Lesvos Petrified Forest resulted from various eruptive events, leading to the presence of successive pyroclastic horizons hosting standing and rooted petrified trees, separated by paleosol horizons and erosional discontinuities. The collected data are consistent with the suggestion that the pyroclastic materials originated from a southeast-located volcanic center, possibly the one in Messotopos (Pe-Piper et al., 2019).

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UNESCO Global Geoparks and Global Geoparks Network : Protecting, promoting and managing Earth heritage - Building Sustainable Communities

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Introduction / Background

The Geopark concept was introduced at late 90's aiming to protect and promote Earth heritage sites through the sustainable local development of territories containing abiotic nature of significant value.

In June 2000 the first Geoparks Network was formed in Europe by four territories hosting geological heritage sites of international significance. The first four Geoparks in Europe were the Reserve Geologique Haute Provence - France, the VulkanEifer Geopark - Germany, the Petrified Forest of Lesvos - Greece and the Maestrazgo Cultural Park - Spain.

Geoparks adopted a bottom-up process involving all relevant local and regional stakeholders and authorities in the area (e.g. local authorities, heritage managing bodies, national/natural park managers, museums, landowners, community groups, tourism providers, community initiatives, indigenous people, and local associations). This process requires firm commitment by the local communities, a strong local multiple partnership, public and political support.

The European Geoparks Network (EGN) developed quickly including new territories from from the founding countries as well as from UK, Italy, Ireland and Austria offering a new model for the protection and sustainable management of the geological heritage monuments through the sustainable development of the local communities. Geoparks activities gain support of the United Nations Educational, Scientific and Cultural Organization (UNESCO) as part of it's official programme. UNESCO's Division of Earth Sciences supported the EGN development and signed a collaboration agreement in 2001. In 2004 the EGN included 17 members from 8 European countries.

Taking into account the success of the EGN as well as Geopark initiatives in China, UNESCO's Division of Earth Sciences started efforts for the creation of the Global Geoparks Network as a platform of cooperation between areas hosting and managing geological heritage of international significance.

The Global Geoparks Network (GGN) was established in 2004, under the umbrella of UNESCO, including 25 Global Geoparks from Europe and China. The GGN operated initially as an international voluntary network, bringing together protected geological heritage sites management bodies, government agencies, non-governmental organizations, scientists and experts from all countries around the world in a unique worldwide partnership.

Global Geoparks as members of GGN operate to share best practice and exchange know how on various aspects in order to protect, conserve and enhance the value of geological heritage sites, including landscapes and geological formations, which are key witnesses to the evolution of our planet and to promote the sustainable development of their territories through geo-tourism and education activities.

In 2014 after one decade of successful operation as a volunteer network the GGN gained legal personality in order to achieve a major goal, the recognition of the Geopark label, the officialization of it's relationship with UNESCO and the establishment of the third UNESCO site designation. The GGN General Assembly during the 6th International Geoparks Conference in Stonehammer Global Geopark, Canada agreed to the new GGN Statutes and the GGN became an international non-profit international association, subject to French legislation (the 1901 law on associations).

Thus the GGN became an International Association following the ICOM model, including institutional members - Global Geoparks and individual members - Global Geopark professionals. The GGN includes Regional Geopark Networks which foster international co-operation and promotion of the Geopark concept and activities at the regional level.

The 38th UNESCO General Conference on November 17th 2015, ratified the statutes of the new International Geoscience and Geoparks Programme and the UNESCO Global Geoparks Operational Guidelines, introducing the brand UNESCO Global Geopark as a label of excellence for areas that meet certain criteria. The GGN is maintaining formal relations with UNESCO and became the official partner for the operation of the UNESCO Global Geoparks programme under the umbrella of the International Geosciences and Geoparks Programme (IGGP).

21 years after its establishment the GGN includes 213 UNESCO Global Geoparks in 48 countries and during 2025 will add 16 new members, reaching 229 UNESCO Global Geoparks in 50 countries.

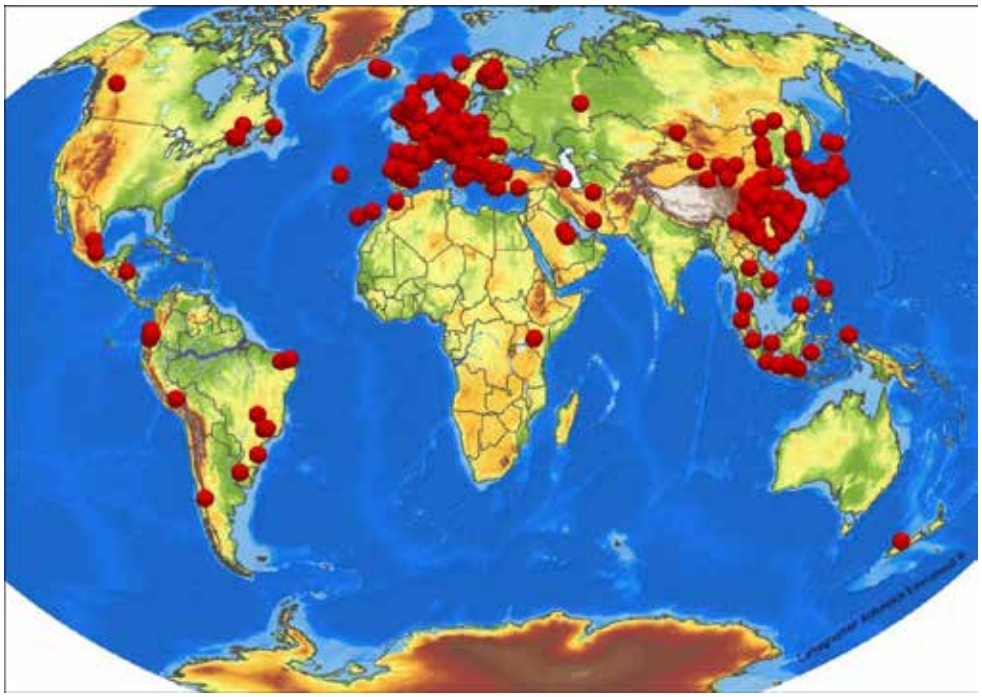

Fig. 1. The Global Geoparks Network includes 229 Geoparks in 50 Countries (2025). List of the UNESCO Global Geoparks at unesco.org

The UNESCO Global Geoparks

The UNESCO's decision introducing under the umbrella of the International Geosciences and Geoparks Programme (IGGP) the UNESCO Global Geoparks Programme (UGGp) together with the existing since 1972 International Geosciences Programme (IGCP) [originally termed the International Geological Correlation Programme], has legally establish the new UNESCO site designation "UNESCO Global Geopark" and endorsed the existing 120 Global Geoparks to become UNESCO Global Geoparks with immediate effect.

The UNESCO Global Geopark branding strongly contributed to raise UNESCO's visibility in Earth Sciences community but also to local communities around the globe in territories hosting exceptional geological heritage sites. The new Programme offer UNESCO a new field of activities and high-quality public outreach on sustainable development in rural territories linked with main global challenges such as the holistic environmental and heritage management, the geodiversity protection and conservation, the geo-hazards mitigation, the climate change adaptation and the sustainable use of natural resources.

Moreover it has been identified that this new UNESCO branding could also be of clear advantage for the development of Global Geoparks in those regions where none currently exist and will be the mechanism to assist countries in the development of Global Geoparks.

UNESCO Global Geoparks according to the Programmes statutes and operational guidelines should fulfill the following basic criteria (UNESCO, 2015):

i. UNESCO Global Geoparks must be single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education and sustainable development. The geological heritage sites of international significance should be independently verified by scientific professionals.

ii. UNESCO Global Geoparks should use that heritage, in connection with all other aspects of that area's natural and cultural heritage, to promote awareness of key issues facing society in the context of the dynamic planet we all live on, in particular to increase knowledge and understanding of: geohazards; climate change; the need for the sustainable use of Earth's natural resources; and the empowerment of indigenous peoples.

iii. UNESCO Global Geoparks should be areas with a management body having legal personality recognised under national legislation. The management bodies should be appropriately equipped to adequately address the area of the UNESCO Global Geopark in its entirety.

iv. UNESCO Global Geopark status shall add value by being both independently branded and in synergy with the other designations.

v. UNESCO Global Geoparks should actively involve local communities and indigenous peoples as key stakeholders in the Geopark. In partnership with local communities, a co-management plan needs to be drafted and implemented

that provides for the social and economic needs of local populations, protects the landscape in which they live and conserves their cultural identity.

vi. UNESCO Global Geoparks are encouraged to share their experience and advice and to undertake joint projects within the GGN. Membership of GGN is obligatory.

vii. A UNESCO Global Geopark must respect local and national laws relating to the protection of geological heritage. The defining geological heritage sites within a UNESCO Global Geopark must be legally protected in advance of any application. At the same time, a UNESCO Global Geopark should be used as leverage for promoting the protection of geological heritage locally and nationally. The management body must not participate directly in the sale of geological objects within the UNESCO Global Geopark (regardless of their origin) and should actively discourage unsustainable trade in geological materials.

UNESCO Global Geoparks are evaluated during the initial application by an independent team composed of desk-top advisors and field evaluators.

The justification of the international significance for the geological heritage sites present in an applicant territory is made by experts nominated by the IUGS Geoheritage Commission, through a desk top examination of the geological heritage section of the application. The assessment follows the agreed methodology described by the document Guidelines for the assessment of the international significance of geological heritage in UNESCO Global Geopark applications, which was adopted by the UNESCO Global Geoparks Council. (https://unesdoc.unesco.org/ark:/48223/ pf0000386952)

The evaluation of the Geopark application is made by field evaluators, nominated by the UNESCO Global Geoparks Bureau. The evaluators verify the application in the field using the Checklist to define an aspiring UNESCO Global Geopark (aUGGp). (https://unesdoc.unesco.org/ark:/48223/pf0000383838). The evaluators are submitting their evaluation report and proposal to the UNESCO Global Geoparks Council.

The field evaluators are currying out also the re-validation of the Geoparks operation and activities, submitting their re-validation report and proposal of a green, yellow or red card to the UNESCO Global Geoparks Council. Re-validation missions take place every 4 years (or two years in case of a yellow card).

The UNESO Secretariat in conjunction with the GGN has established and maintains a roster of field evaluators who undertake field evaluations of new applications for aspiring UNESCO Global Geoparks and the revalidations of the already recognized UNESCO Global Geoparks.

The UNESCO Global Geoparks Council, composed by 12 experts and 4 representatives of international bodies supporting Geoparks, is the decision making body for new UNESCO Global Geopark applications and the revalidation of the already recognized Geoparks. The Council takes proposes the new UNESCO Global Geoparks to the UNESCO Executive Board which is the responsible for the nomination of the new UNESCO Global Geoparks. It is also responsible for advising the UNESCO's Director-General on the strategy planning and implementation of the Global Geoparks activity of the IGGP.

During the last 21 years hundreds of Geopark evaluation and re-validations missions have been curried out by Geopark experts. Due to UNESCO's international recognition through Geopark evaluation and revalidation missions outstanding geological heritage sites were protected, conserved and rationally managed.

The Global Geoparks Network

Since its foundation in 2004, the Global Geoparks Networks (GGN) mission is to influence, encourage and assist local communities all over the world to protect and conserve geological heritage sites of international significance, to enhance the integrity and diversity of abiotic and biotic nature and to support economic and cultural development of local communities through the valorisation of their unique heritage and identity.

The GGN established ethical standards which must be adopted and respected by Global Geoparks and Global Geopark professionals.

Every two years the GGN organizes the International Conference on UNESCO Global Geoparks which takes place each time in a different UNESCO Global Geopark selected after a public bid.

The operation of the Global Geoparks Network is based on the active participation of its members through networking at the international, regional, national and local level.

The GGN Members meet every two years at the GGN General Assembly which takes place during the International Conference on UNESCO Global Geoparks, to discuss the GGN activities during the previous years and adopt the strategic action plan for the next biennium. The GGN General Assembly elects the Executive Board which is the decision making body of the Network and responsible to implement the decisions of the General Assembly.

The GGN Advisory Committee consists of the representatives of all the National Geopark Networks and is responsible to advice the GGN on the strategic planning issues. GGN Advisory Committee meets 4 times a year to discuss the implementation of the GGN Strategic Action Plan and to define the GGN Long Term strategy as well as the biannual Strategic Action Plan.

Fig.2. The GGN General Assembly during the 10th International Conference on UNESCO Global Geoparks organized by the M'Goun UNESCO Global Geopark, in Marrakesh, Morocco, September 2023

The GGN Executive Board established several Thematic Working Groups with the participation of GGN Regional Network representatives and Geopark professionals to elaborate proposals and activities in the respected session. The themes of the GGN Working Groups are : a. Geohazards, b. Climate change adaptation, c. Geological heritage and Geodiversity, d. Geodiversity and Biodiversity, e. Sustainable Development Goals, f. Education, g.Tourism, h. Geopark Cultural Heritage, i. Indigenous people, j. Island and coastal areas / Waters / Ocean, k. Gastronomy, l. Communication, m. Geoparks as therapeutic landscapes and n. International Networking.

The GGN Executive Board in order to strengthen the GGN logo visibility and use in activities aiming the promotion of the Geoparks brand, took measures to register and protect the GGN Graphic logo, acronym and the name "Global Geoparks Network" and created a series of combined GGN logos to be used by the different GGN bodies and Regional and National Networks, in order to enhance consistency, efficiency, and flexibility in communication and promotion of the Geopark brand.

GGN Capacity building activities

The GGN advances and disseminates knowledge through capacity building activities organized in collaboration with the UNESCO Secretariat. Capacity building activities include training courses for Geopark managers and staff, on disciplines related to Geopark management, geo-heritage and geo-diversity, geo-conservation, geo-tourism, geo-education and sustainable local development.

The International Intensive Course on UNESCO Global Geoparks is organized every June in Lesvos since 2007 as a join initiative between GGN and UNESCO Secretariat. It is organized by the University of the Aegean and the Natural History Museum with field trips in Lesvos island UNESCO Global Geopark. Since 2001 the UNESCO Chair on Geoparks and the sustainable development of insular and coastal areas at the University of the Aegean is operator for the Course academic programme.

The annual International Training Course on UNESCO Global Geoparks Management and Development has been successfully operated by the China University of Geosciences (Beijing) since 2016. This Course receives full support of UNESCO Global Geoparks Secretariat and Global Geoparks Network, as well as Asia Pacific Geoparks Network and the University of the Aegean. With the close collaboration of Yanqing, Fangshan, Taishan, Songshan, Yimengshan, Zhangye and Xiangxi UNESCO Global Geoparks, the last seven sessions of this Course took place successively in these geoparks, starting with just field lectures and gradually turning into both indoor and field lectures in geoparks.

Fig 3. The international capacity building activities of the Global Geoparks Network in Lesvos, Greece and Beijing, China

The lecturers of the courses are top international Geopark experts and experienced geoscientists and managers from UNESCO Global Geoparks, UNESCO officials, members of the UNESCO Global Geoparks Council and the Global Geoparks Network Executive Board and academic institutions.

Global Geoparks Network facilitates Geopark networking and international collaboration

The GGN encourages and supports co-operation, twinning agreements and exchanges between UNESCO Global Geoparks through common projects, initiatives and activities.
The GGN encourages and supports geopark networking through Geopark conferences, workshops, meetings, common projects and common promotional activities but mainly through the operation of its Regional Geopark Networks and National Geopark Geopark Networks/For a, including all GGN members in each region or country.
The GGN structure includes five regional geopark networks in Europe, Asia Pacific, Latin America and Caribbean, North America and Africa. Regional Networks operate , Thematic Workshops, Meetings and Promotional activities.
Geopark networking facilitates the development and transfer of new methodologies and approaches for the management of Geoparks. The holistic geopark approach in territorial heritage management includes biotic and abiotic factors, landscapes and cultural heritage, holistic nature conservation strategies and action plans, sharing of know-how and new approaches to improve landscape interpretation, awareness raising and public sensitization and the development of educational and touristic activities.
Geopark cooperation provides excellent outcomes and help Geoparks to achieve an effective management and a high level of services and infrastructure. The quick development of Global Geoparks around the globe during the last two decades proves the success of the Geopark concept as a new tool for holistic nature conservation and sustainable rural development through geo-tourism.
The Global Geopark Network seek for international cooperation with other partners on common interests. GGN is a statutory partner of UNESCO for the operation of the UNESCO Global Geoparks programme. GGN has affiliation relationship with the International Union of Geological Sciences (IUGS) and longstanding cooperation with International Union for Nature Conservation (IUCN) to support the Geoparks development. The GGN signed a cooperation agreement with the World Tourism Organization (UNWTO) for the International Year of Sustainable Tourism.

UNESCO Global Geoparks protecting and managing Geological Heritage

A main field of operation for a Geopark is the protection and management of the geological heritage within the Geopark territory. Geopark activities include scientific research, identification and mapping of the geological heritage sites, creation and management of an inventory of geological sites, protection and conservation of geological heritage sites, operation of open air parks, thematic museums and interpretation centers, interpretation and promotion of geological heritage sites, organization of scientific and cultural events.
Through Geoparks operation important geological sites gain worldwide recognition and benefit through the exchange of knowledge, expertise, experience and staff among Geoparks. The new initiative of the IUGS for the first 100 IUGS Geological Heritage Sites (announced in 2022 in Zumaia, Spain) and second 100 IUGS Geological Heritage Sites (announced during the 37th IGC in Busan, Republic of Korea) includes 38 outstanding Geological monuments located in UNESCO Global Geoparks. Among them, the Amonite slab in Digne-les-Bains (Haute Provence Geopark) France, the Lesvos petrified forest, (Lesvos Geopark) Greece, the Holocene Ulmen Maar (Vulkaneifel Geopark) Germany, the alpine superposed buckle folds in Aliaga (Maestrazgo Geopark) Spain, the Dashanpu dinosaus fossil site (Zigong Geopark) China, the Cretaceus-Paleogene Stratigraphic section in Zumaia (Basque Coast Geopark) Spain, the Genbudocave (Sanin Kaigan Geopark) Japan, the Messel Pit fossil site (Bergstrasse-Odenwald Geopark) Germany, the Lower pillow lavas of Troodos ophiolites (Troodos Geopark) Cyprus, the Ngorongoro Crater (Ngorongoro-Lengai Geopark) Tanzania, Shilin Karst (Shilin Geopark) China and Monte Perdito Massif Tectonic structure (Sobrarbe Geopark) Spain.
This recognition shows the value of the geological heritage sites included in UNESCO Global Geoparks as well as the importance of the Geopark label for safeguarding outstanding geological heritage sites, lacking proper management and propmotion.

UNESCO Global Geopark activities and sustainable local development

A broad range of activities combines the main components of a UNESCO Global Geopark operation such as geoconservation, geoeducation, geotourism, and sustainable development.
Geoparks promote themselves as educational territories for sustainability. Geopark educational activities include

a vast range of programmes for all levels of education, from kindengrden and elementary schools, highschools, university students, master courses, vocational training and lifelong learning. Main target group for educational activities in Geoparks are schoolchildren and University students.
Geoparks also promote themselves as ideal destinations for geotourism. Geo-tourism in a form of tourism that sustains, or even enhances, the identity of a place, such as its environment, culture, heritage, and the well-being of its residents.
During the last years Geoparks following the provisions of their management plan implemented a range of actions aimed at the further improvement of its geotourism infrastructure, services, activities and promotion.
The results of the Geopark operation show a significant increase in the number of visitors, the enrichment of their geotourism offer and services to visitors and improvement in geological heritage protection and management..
An important component of the Geopark operation is the support of the local economy. Geoparks create links with local tourist enterprises, restaurants and small hotels in order to provide the necessary infrastructure to meet the needs of the increasing number of park visitors. The majority of visits to the Geopark occur during the summer period, but the aim is to extend the visiting period to the spring and autumn seasons. Geoparks present impressive results in this field. In some cases the number of “Bed and Breakfast” accommodations has doubled over the last few years in order to meet the increasing demand. More importantly, visitors have increased the duration of their visit to the Geopark area. As a result many new enterprises are connected with the activities of the Geopark.
Geoparks support local handicrafts making such as the production of fossil casts and souvenirs by local enterprises. These items are on sale in the Geopark shop along with a variety of other locally made products and the Geopark promotes these products to its visitors.
GGN promotes local gastronomy as an important factor of the Geopark’s identity. Food is reflecting the traditions, history, and values of a territory. In Geoparks, where the conservation of local heritage is paramount, gastronomy serves as a means of celebrating and safeguarding traditional culinary practices, recipes, and food products. By promoting Geopark Gastronomy as a quality brand, local communities can strengthen their cultural identity and promote a sense of pride and belonging among residents and visitors alike. Whether through traditional food festivals, farm-to-table dining experiences, or culinary workshops, Geoparks engage visitors in authentic gastronomic experiences that create lasting memories and foster a deeper connection to the destination. Geoparks collaborate closely with women’s agrotouristic cooperatives and local organic food producers to offer their visitors the opportunity to taste and buy local food products (pasta, organic vegetables, wine, liquors, traditional sweets and marmalades etc). The catering for all Geopark events (conferences, meetings etc.) is supplied using the local traditional food. The Geoparks organize agro-touristic festivals, which promotes quality local products, food and drinks. The event brings local producers and potential customers together. The Women’s agrotouristic cooperative found that this festival provided them with an excellent opportunity to promote their products and their success lead to the creation of similar cooperatives in other villages.

Conclusions

Geoparks contribute significantly to territorial development by directly and indirectly creating new jobs. But what is even more important for the employment in the area is the number of other job opportunities which are created in tourist enterprises, small hotels, guest houses, restaurants and other activities connected with the increase of tourist flow in the Geopark area.
For more than 20 years UNESCO Global Geoparks have campaigned for a holistic understanding of our planet and its evolution, for the protection of Earth heritage and for the sustainable development of their territories. With their initiatives, environmental education and awareness programmes and projects, they place a special emphasis on conveying these natural interrelationships and the impact Man has on these. UNESCO Global Geoparks have been actively pursuing the Global Agenda 2030 with the 17 SDGs for a number of years. Their bottom-up approach with community participation and capacity building, their sustainable regional development activities make the UNESCO Global Geoparks ideal places to understand the relevance of the SDGs and also the responsibility of their implementation. The GGN provides through networking the opportunity for exchanging ideas with partners around the world. Thus the UNESCO Global Geoparks provide ideal model territories for implementing the Agenda 2030. They form the decisive interface between international declarations of intent and concrete on-the-spot activities – which means the transformation from strategy to action.

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EXTENDED ABSTRACT 358

Lemnos Island Geosites and their Geotourism and Education Potential

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Introduction / Background

Lemnos Island, located in the northeastern Aegean Sea, is an area rich in a wide variety of geological and geomorphological features, including fossiliferous sites, volcanic geosites, and impressive erosional landforms within sedimentary formations. These features are outstanding representatives of the island's geodiversity.

Geosites are protected under Greek environmental legislation (Law 1650/1986 and Law 3937/2011), as they serve as important witnesses to Earth's geological history. However, the geosites of Lemnos and their geotourism potential remain largely underexplored.

This paper presents the work undertaken to identify, map, and assess the geosites of Lemnos Island, with the aim of selecting the most representative ones—based primarily on their aesthetic value and potential for geotourism development.

The research team on geological heritage and geodiversity from the Department of Geography at the University of the Aegean, in collaboration with the Natural History Museum of the Lesvos Petrified Forest, initiated a project in 2012 to identify and map fossiliferous sites containing fossilized plants on Lemnos. As a result, the Lemnos Petrified Forest was declared a protected natural monument in 2013.

The research has since expanded to include the identification and mapping of a wider variety of geosites across the island. In line with the growing global interest in geotourism, the main objective has been to connect these geosites through thematic geotrails, linking them with other sites of ecological and cultural significance. This approach has the potential to foster greater community interest, engagement, and involvement in their sustainable management.

This initiative is supported by the North Aegean 2014–2020 Regional Operational Program through the action "Creation and Operation of Digital Applications for the Promotion of Geo-monuments of Lemnos." This project, implemented by the Natural History Museum of the Lesvos Petrified Forest in collaboration with the Municipality of Lemnos, focuses on promoting geological monuments, landscapes, and ecologically significant sites, with the aim of encouraging the development of alternative forms of tourism.

Geological setting

The island of Lemnos is the eighth-largest Greek island, covering an area of 476 km² and featuring a coastline of approximately 310 km. The island's morphology is generally smooth, with low relief on the eastern side, while the western part is more hilly. The highest point is Skopia (Vigla) in the northwest, reaching an elevation of 470 meters.

Lemnos lies on the southern margin of the North Aegean Trough, which is associated with the western extension of the North Anatolian Fault Zone. This 1,200 km-long dextral strike-slip fault and its branches that extend into the Aegean Sea facilitate the westward extrusion of the Anatolian Plate. The tectonic structures of Lemnos play a key role in understanding the recent geodynamic evolution of the broader region and the prevailing active transtensional stress regime (Pavlides et al., 1990).

The geological structure of Lemnos is relatively simple compared to other islands in the northeastern Aegean. It consists of two main units: a lower unit composed of sedimentary deposits dating from the Middle Eocene (Lutetian) to the Early Oligocene, and an upper unit of Lower Miocene volcanic rocks.

The lower sedimentary unit (Roussos et al., 1993; Innocenti et al., 1994) consists of conglomerates, sandstones, and claystones, which have been interpreted as deep-water deposits. Petrographic analysis of the sandstones indicates that the detritus is primarily composed of clasts from low- to medium-grade metamorphic and sedimentary rocks, sourced from the Rhodope Massif and the Circum-Rhodope Belt (Innocenti et al., 1994). During the Early Oligocene, these deposits were conformably overlain by shallow marine (shelf) sediments.

Volcanic activity began in the Early Miocene with the eruption of pyroclastic flows, followed by the emplacement of sills, lava flows, and domes. Three volcanic units, along with a small quartz-monzonite intrusion (the Fakos intrusion), cover much of the southwestern part of the island (Davis, 1959; Fytikas et al., 1980; Innocenti et al., 1994). These volcanic rocks include andesite, trachyandesite, trachyte, and dacite, featuring porphyritic plagioclase and alkali feldspar set in a microlitic groundmass composed of plagioclase, alkali feldspar, biotite, and quartz in varying proportions (Roussos et al., 1993).

Secondary mineral phases include micas, calcite, quartz, and clay minerals. Radiometric dating of these volcanic rocks yields ages ranging from 21 to 18.2 million years (Fytikas et al., 1984; Innocenti et al., 1994). The igneous rocks of Lemnos represent the earliest volcanic products in the North Aegean region, where volcanic activity ceased by the Middle Miocene.
The Miocene period concludes with the deposition of conglomerates, marls, and marly sandstones. Locally, Pleistocene porous calcareous and oolitic limestones occur, while Holocene alluvial deposits, coastal sediments, and dunes are also present.

Fig. 1: *Geotouristic map of Lemnos island*

Geosite identification and mapping
Fieldwork conducted between 2013 and 2020 led to the identification of 150 geosites distributed across the entire island of Lemnos.
These geosites were classified into the following categories:
a. fossiliferous sites,
b. volcanic sites,
c. stratigraphic–tectonic sites,
d. geomorphological sites (erosional and depositional),
e. other sites of interest.

The geosites were mapped using traditional field mapping methods. In parallel, Unmanned Aerial Systems (UASs) were employed, allowing for the creation of accurate, high-resolution 3D maps and models at various scales. The main objective of these maps was to promote the rich geological and geomorphological heritage of Lemnos and to effectively communicate geo-scientific concepts.
Additionally, 3D geovisualizations were developed using advanced multimedia techniques and technologies, including augmented reality, 360-degree panoramas, and ultra-high-resolution video.

Photo 1. The petrified tree trunk in Baros village. And Moudros area

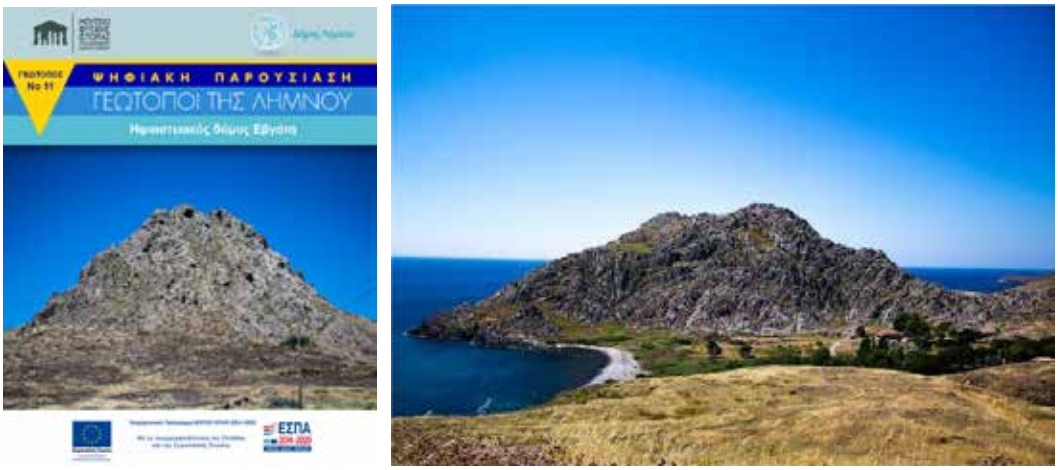

Photo 2 The volcanic domeσ of Evgatis and Agios Pavlos

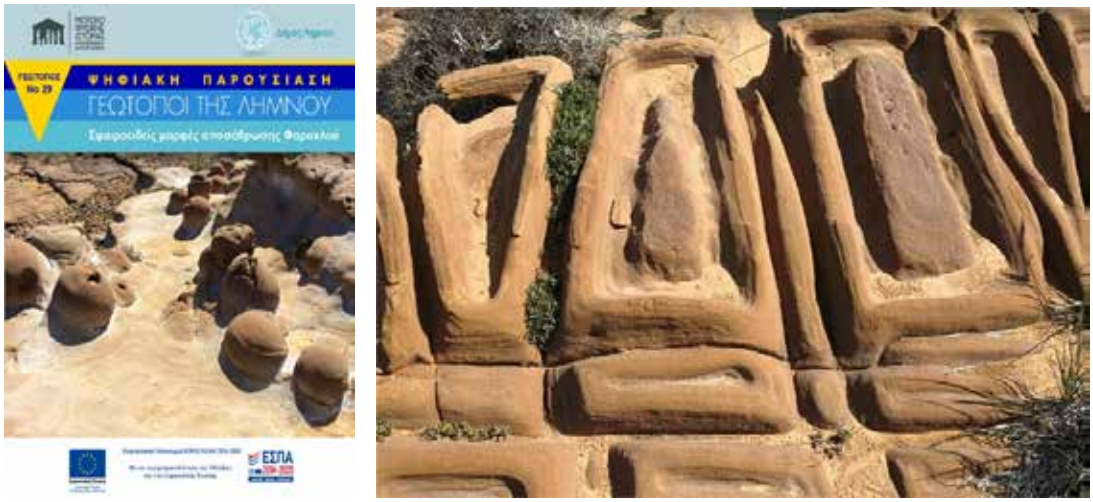

Photo 3 : The spheroidal geoforms at Farakla and Agios Ermolaos

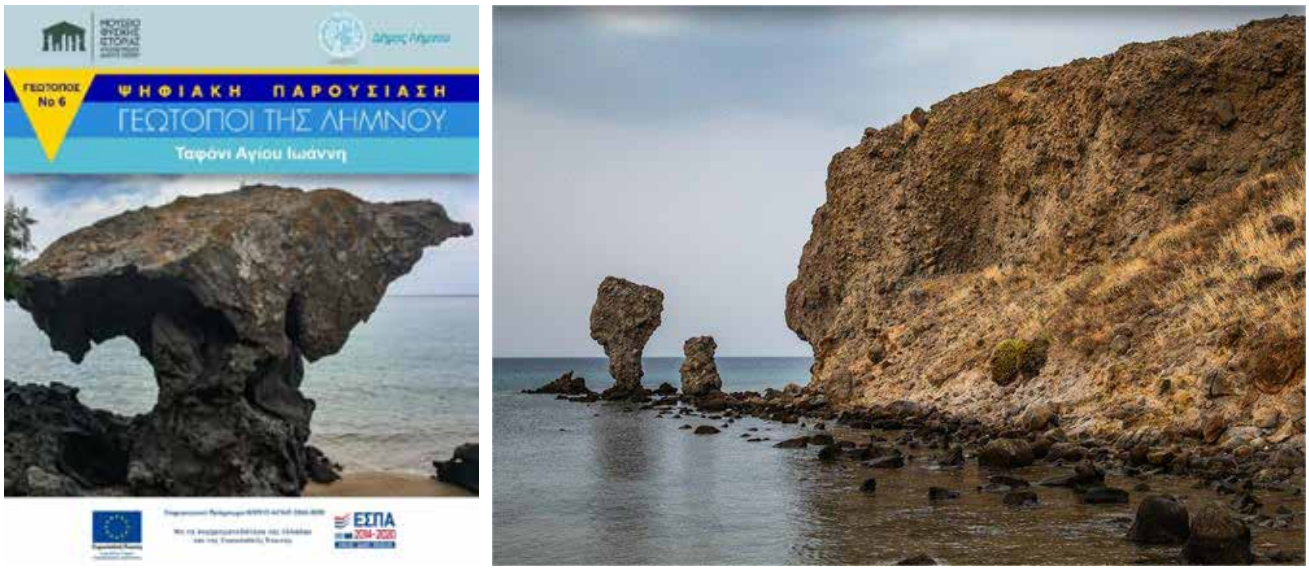

Photo 4 The Agios Ioanis tafoni structure and the sea stacks

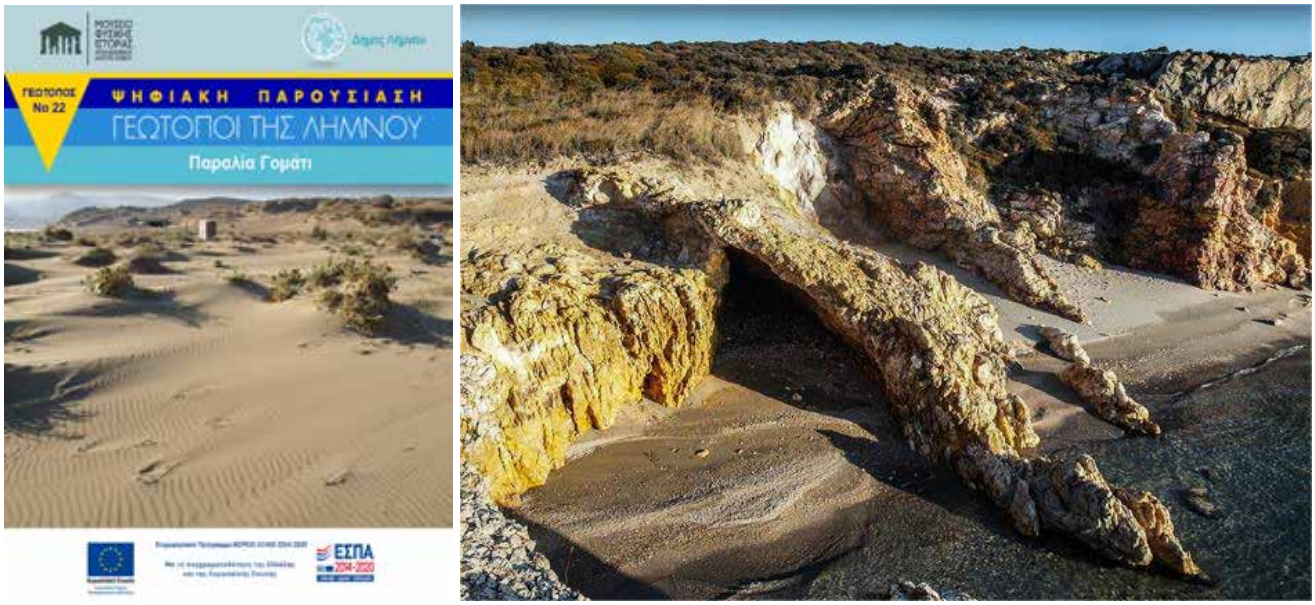

Photo 5 : The dunes at Gomati and the sea caves at Fanaraki

The geological and geomorphological heritage sites were assessed using the methodology proposed for the assessment of geomorphosites (Zouros 2007, 2009).
As a result the selection of the 50 representative geological and geomorphological heritage sites was made. The 50 geosites have been documented for their geoscientific significance. The information for these geosites are taken from field work and literature (Roussos et al., 1993, Innocenti et al.,1994, Maravelis et al. 2007, Chatzipetros et al., 2013).
These geological and geomorphological heritage sites as well as sites of ecological and cultural value, form the basis for the creation of the interpretative geotouristic map of Lemnos island, presenting a balanced proportion of scientific and touristic information.
The sites will be linked alond thematic “geo-tails” which will introduce the visitor to the main geological and geomorphological processes that created the landscapes of Lesmnos.

Interpretation and promotion of the Lemnos geological heritage sites
The promotion of Lemnos’ geological heritage is supported by a variety of tools developed throughout the project.

The geotouristic map of Lemnos is designed to highlight the island's rich geological and geomorphological heritage and to communicate geoscientific themes to a non-specialist audience. It offers the public an opportunity to understand fossils and fossilization processes, geomorphological and geological phenomena, rock types, landforms, and landscapes.
The website www.lemnosgeomonuments.gr was created to consolidate all available information about the island's geological heritage sites. It serves both the general public and visitors to Lemnos, as well as educators in local schools and special interest groups looking to explore the island's natural treasures.
To enhance the on-site user experience, a mobile navigation application was developed for smartphones, featuring visual, audio, and augmented reality (AR) content.
All interpretation and promotional tools were developed using advanced technologies, with a strong focus on user-friendly design and long-term sustainability.
Moreover, the promotion and utilization of this material—when combined with broader efforts to highlight the geoenvironment—can provide a competitive advantage in the development of alternative and sustainable tourism.
Finally, a Digital Information Center for the Petrified Forest and Geosites of Lemnos was established in Roussopouli. This center also serves as an information hub for special forms of tourism, including hiking, rural, geological, agritourism, and educational tourism.

Educational activities

Educational activities on geological heritage sites were designed and implemented using the interpretation and promotional tools developed during the project. Educational programs were offered to students and teachers of primary and secondary schools on Lemnos, focusing on the geological heritage of the island and presenting the main geosites identified, mapped, and recorded by the Natural History Museum of the Lesvos Petrified Forest. These classroom programs were complemented by field visits to key geosites, helping students to deepen their understanding of the significance of Lemnos' geological heritage.
Students, teachers, and parents from the 2nd Primary School of Myrina, the Primary School of Atsiki, the Middle School of Moudros, and the General Lyceum of Moudros participated in these educational activities. Additionally, the principals of primary and secondary schools on Lemnos took part in an educational workshop organized in collaboration with the Regional Directorate of Primary and Secondary Education of the North Aegean, as part of the project "Creation – Operation of Digital Applications for the Promotion of the Geo-Monuments of Lemnos."
During the activities, students had the opportunity to explore the impressive geological monuments and the Petrified Forest of Lemnos, as well as to learn about the geological processes that led to their formation. The students participated actively and enthusiastically, asking insightful questions not only about the Petrified Forest and its origins but also about volcanic activity and volcanic structures on the island.
The students of the 2nd Primary School of Myrina also participated in a model educational activity using newly developed virtual reality (VR) applications, created within the same project by the Natural History Museum of the Petrified Forest of Lesvos.
In addition, special informational sessions were held for teachers of primary and secondary education on Lemnos regarding the possibility of organizing educational visits to Lesvos—recognized by UNESCO as a Global Geopark—and its renowned Petrified Forest. Through a detailed presentation of a proposed three-day educational program and rich photographic material, teachers became familiar with the educational activities available on Lesvos, emphasizing the island's geological, natural, and cultural heritage. Special interest was shown in the educational programs of the Natural History Museum of the Petrified Forest of Lesvos, which are conducted within the protected area of the forest.

Conclusions

The systematic identification, documentation, and promotion of geosites on Lemnos Island have revealed the island's significant geodiversity and its potential as a destination for geotourism and geoscience education. Through fieldwork, geosite mapping, and the development of interpretive materials, 150 geosites were classified and assessed, highlighting fossiliferous areas, volcanic features, tectonic structures, and diverse geomorphological landforms.
Fifty of these sites were selected as the most representative of Lemnos' geological and geomorphological heritage and were integrated into an interpretive geotouristic map. These sites form the foundation for thematic geotrails, aiming to connect geological heritage with ecological and cultural landmarks across the island.
The use of innovative digital tools—including Unmanned Aerial Systems (UASs), high-resolution 3D mapping, augmented reality applications, and virtual reality educational modules—has significantly enhanced the ability to communicate geoscientific information in an accessible and engaging manner. The website www.lemnosgeomonuments.gr, the smartphone navigation app, and the establishment of the Digital Information Center in Roussopouli have created a robust framework for both public engagement and sustainable tourism development.

The educational activities implemented as part of the project have demonstrated strong local interest and participation, fostering greater understanding and appreciation of Lemnos' geological heritage among students, educators, and the broader community. The collaboration with the Regional Directorate of Education and the integration of innovative learning technologies have proven effective in bridging scientific knowledge with experiential learning.

There is a strong potential of Lemnos Island to serve as a model for the promotion of geodiversity through geotourism and education. With continued investment in infrastructure, interpretation, and local engagement, Lemnos can enhance its position as a destination for alternative and sustainable tourism, while preserving and valorizing its unique geological heritage for future generations.

The geomonuments of Lemnos will be used to promote the island's rich geological and geomorphological heritage and to communicate geoscientific themes to a non-specialist audience, offering opportunities to understand fossils and fossilization processes, geomorphological and geological phenomena, rock formations, and the island's recent evolution and ongoing geodynamic processes.

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