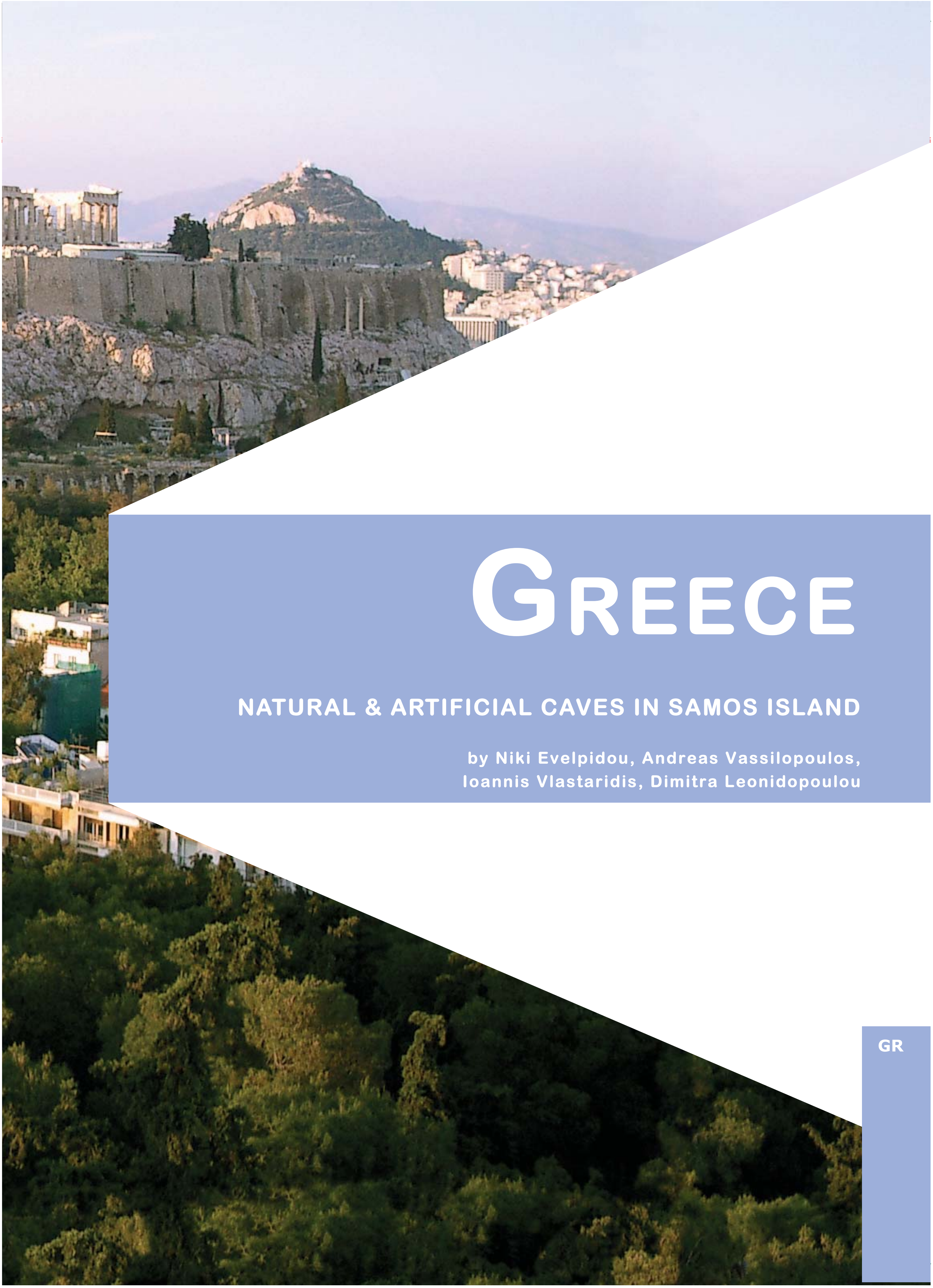

GREECE

NATURAL & ARTIFICIAL CAVES IN SAMOS ISLAND

by Niki Evelpidou, Andreas Vassilopoulos,
Ioannis Vlastaridis, Dimitra Leonidopoulou

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Introduction to the area

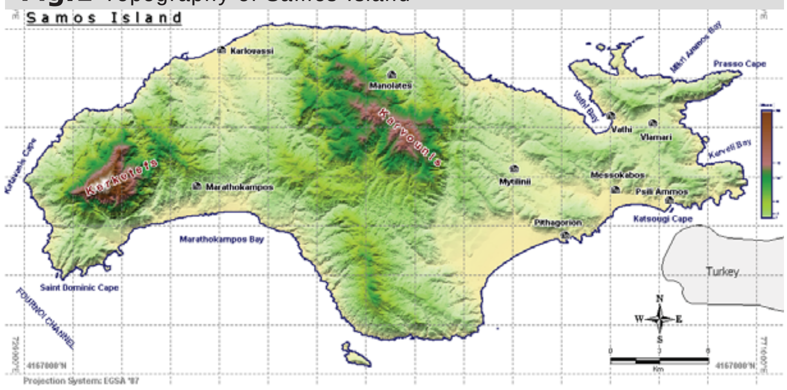
by Niki Evelpidou & Dimitra Leonidopoulou

Niki Evelpidou
Dr.Dr.MSc.
Lecturer, University of Athens
Panepistimiopolis, 15784, Greece
Tel. +30 2107274297
email evelpidou@geol.uoa.gr

Dimitra Leonidopoulou
Dr.Geologist
email dleonid@geol.uoa.gr

Samos island, which takes up an area of 490km^2, is one of the biggest islands in the Eastern Aegean (Fig.1). It is located only 3km away from the Turkish coast (Minor Asia) and its sister ancient cities of Ionia, Ephesus and Miletus, to which it is geologically and geographically related (Fig.2). Towards the East, the island of Samos is separated from Turkey by the "Eptastadio" channel (called Dar Bogaz in Turkish), which is only 1200 meters wide at its narrowest point. North of Samos one can find the chersonese of Erythrea (Turkey), northwest is Chios Island, west and southwest is Ikaria and Fournoi islands and to the South are the Dodecanese islands. The ones closest to Samos are Agathonisi, Arki and Patmos.

Fig.1 Topography of Samos Island



The total coastline of Samos is 86 nautical miles; its distance from Fournoi is 3.4nm, from Ikaria 9.8nm, from Agathonisi 9.3nm and from Chios Island 35nm. The island is populated by 33,814 inhabitants (2001 census) and it comprises of 4 municipalities: Vathi, Karlovasi, Pythagoreio and Marathokampos; its capital is Samos Town.

Fig.2 The Turkish coast (Minor Asia)

The biggest gulf of the island is the gulf of Samos. There are many smaller ones along the islands' coastline. The island is mountainous (Fig.3) and is characterised by two high masses. The first one is the rough and rocky mountain of Kerketeas (or Kerkis) with a height of 1443 meters and the second is the verdant and fertile mountain of Ambelos (or Karvounis) with a height of 1160 meters. Despite the general mountainous character there are a few plains, the largest one being the plain of Chora, which is in the south side of the island and is bounded by the villages of Chora, Py-

Fig.3 Samos is a mountainous island

thagoreio, Miloi and Pagondas.

The high mountains contribute to the many rainfalls that shower the island during wintertime. This is also the reason for the lush vegetation of Samos and the numerous freshwater springs. Due to the abundance of the island in surface and underground waters, its name during the ancient times was “Hydrele” (meaning rich in water). The island doesn’t have any rivers, but there are many torrents that carry water even in the summertime (Fig.4).

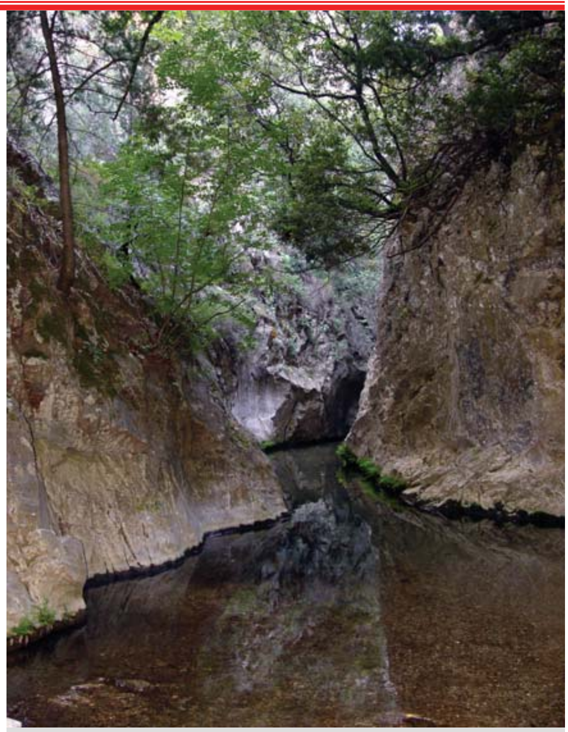


Fig.4 Potami torrent (by C. Centeri)

Samos produces various products. For that reason the ancient Greeks used to say “this island even produces birds' milk”. Its major products are the famous Samian oil and wine. Within the past few years, the tourist industry is also dynamically growing, ranking Samos as one of the major tourist destinations in Greece.

The island’s name seems to come from the very ancient root SAMA, which has to do with height. Actually, a range of mountains, rising to a height of nearly 1500m, runs in a direction from the east to the west and is the extension of the line of Mt. Samsun peninsula (ancient Mt. Mykale) in western Turkey. Tradition says that the island’s name is owed to Samos, son of Agaios, the settler of the island.

From evidence that has been found, we get to the conclusion that human beings have lived on Samos since the 3rd millennium BC, if not earlier. Its history, however, begins at the time of Polycrates, 6^{th} century BC. Before that, history is vague and obscure, mythical folklore being the only existing reference.

Fig.5 The capital of Samos Island

In ancient times, Samos, although small, played a truly significant role in culture and politics, not only for the region of Ionia, but for the entire ancient Greece.

Great culture has developed on this island and several famous artists, litterateurs and philosophers have lived on the island. The great mathematician and philosopher Pythagoras was born on Samos, whose theories influenced decisive the mathematic world. Another great personality, Aristarchos, was born and lived here. This great astronomer was Euklides student and the first one to declare that the earth is circling the sun whilst turning round its axis.

The first residents of the island were the Pelasgeans and later the Kares. During the tyranny of Polykrates (6th BC century) Samos met important growth. This growth concerned economic, artistic and intellectual sectors.

The first trireme was built on the island and named after it “Samaina”. Today may of these old shipyards are in use and produce boats. one can still see such shipyards in Marathokambos, Kokkari, and Ag. Isidoros.

Samos town is the island’s capital (Fig.5). It is a big natural harbour located on its north-eastern side and is inhabited by 7500 persons. The Pythagoras’ square with the eminent lion, which was set up there in 1930 for the celebration of 100 years from the revolution against the Turkish conquerors, is the most central

Geo-environmental aspects

by Niki Evelpidou, Andreas Vassilopoulos & Dimitra Leonidopoulou

Niki Evelpidou
Dr.Dr.MSc.
Lecturer, University of Athens
Panepistimiopolis, 15784, Greece
Tel. +30 2107274297
email evelpidou@geol.uoa.gr

Andreas Vassilopoulos
Dr.Dr.Geologist
President,
Geocultural Park of Eastern Aegean
Flias 13,
15125, Greece
Tel. +30 2108056448
email vassilopoulos@gcparks.com

Dimitra Leonidopoulou
Dr.Geologist
email dleonid@geol.uoa.gr

GEOMORPHOLOGY

Samos Island lies on a shallow plateau extending from the Mt. Samsun peninsula. The channel is less than 100m deep and the island was connected to the mainland during the Pliocene and most of the Pleistocene (Higgins et al., 1996). At the north coasts the high cliffs and steep slopes of the inland continue offshore where the sea floor drops off rapidly. To the south the sea is relative shallow. Hence the island of Samos is a horst, like Ikaria to the west.

To the western part of the island, one can find Mt. Kerketeas, the highest mountain amongst the Aegean Islands. Its highest peak, Vigla, reaches 1434m (Fig.1). The second most important mountain of Samos is Ambelos Mt. and is located in the central part of the island with a highest peak at Profitis Ilias, which reaches 1150m.

The plains and valleys which are found on Samos Island are limited. The most important plains of the island are Chora's plain (Fig.2), where the oldest capital of the Island used to lie. Other important plains are Mesokampos, Vlamaris and Karlovasi plains.

The most important torrent of the island is Myliotiko Rema, which flows through Ambelos Mountain and discharges at Hereon area. Other important torrents are Megalo Rema, Fourniotiko Rema and Rema (Fig.3).

It is easily noticeable that the topographic relief of Samos is strongly influenced by the erosional processes. Erosion is the exogenic process of the removal of weathered material. The erosional evolution depends on several factors such as:

Rainfall: Rainfall's erosivity depends on its duration, spatial distribution and intensity.

Morphology: It is expressed by slope and inclination, and defines the surficial water flow as well as the direction of sediment transfer.

Rocks' and surface deposits' properties: All the physical and chemical characteristics of the rocks such as their mineralogical composition, their schism, their tectonic alteration and their cracks, joints and discontinuities are parameters which affect their vulnerability.

Fig.1 Vigla: the highest peak of Mt. Kerketeas

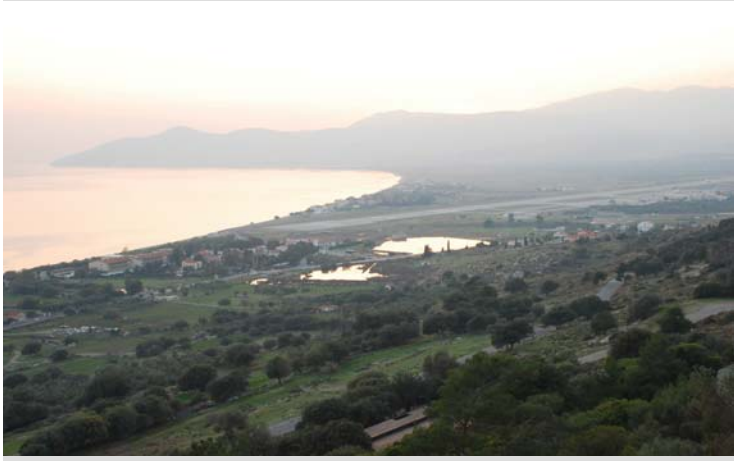


Fig.2 Chora's plain (by C. Centeri)

Vegetation: The existence of different types of vegetation cover slows down the processes of erosion.

The above factors define the region's flow regime, the Hortonian or not runoff, and finally the critical time and the amount of erosion. Areas susceptible to erosional phenomena are considered to be those influenced by the flow of the torrents that cross the island or those exposed in powerful winds. Indicative of the erosion's extent is the grant of torrents in sediment, the quantity of transferred material and, consequently, the deltaic depositions.

Fig.3
Chesia Rema

Forms of erosion

Erosion is a dynamic process which affects the formations in a different way each time according to the environmental conditions. We may distinguish the following forms of erosion:

- Soil erosion
- Planation surfaces
- Relict forms of erosion-buttes
- Gorges
- Coastal erosion
- Karst forms

Soil erosion

Areas susceptible to erosional phenomena are considered to be those influenced by the flow of torrents that cross the island or that are exposed in the powerful winds. Suspensive factors of erosion are the wooded land and the field terraces which retain the territorial cover and protect it from the erosive energy of the water the wind. Deforestation and destruction of the field terraces may intensify the erosional phenomena (Fig.4).

Planation surfaces

The planation surfaces are located in mountainous areas and they are characterised by a smooth relief. They are created mainly due to weathering processes over the rocks and erosion of the relief, under the affect of mild tectonics. Their current hypsometric location is the result of the uplifting movements of the mountainous volumes. Planation surfaces are of great importance because of the following characteristics:

Fig.4
Silt-flux in stripes (soil erosion) in western-central Samos

The planation surfaces represent periods of tectonic calm and hot-humid climate during the development of the mountain masses.

The current place of the planation surfaces shows the episodes of intense tectonics and elevation of mountainous volumes.

The planation surfaces which are found higher than others are chronologically older. The flat parts of the planation surfaces are being destroyed because of the evolution processes over the surface relief and mainly because of the exogenic factors.

Based on the altitude of the surface relief, we may estimate the formation of the planation surfaces and their elevation.

In Samos Island, we may distinguish the following planation surfaces:

Planation	Altitude (m)	Area
PS 1	>1400	on the crests of Kerketeas Mountain
PS 2	800-1000	on the crests of Ambelos Mountain
PS 3	500-700	on Ambelos in Kerketeas Mountain
PS 4	200-450	in Eastern Samos, Skouraiika-Marathokambos, Karlovassi

PS 4 planation surfaces are of great value for human development in the area, since their weathering and erosion produced the drainage network, the valleys, the karst valleys, the springs and all the others elements which favour soil creation and soil fertility.

The intense tectonic movements within the Aegean during Pleistocene, have also affected the wider area of Samos Island. The lowest planation surfaces (PS 4) were split up by cracks and the different terrains that were created moved vertically in upward or downward movements. The upward movement raised the PS 4 in their current altitude while, at the same time, the exogenic processes eroded them. A system of valleys and channels were created within the PS 4. On the contrary, the downward movement submerged large parts of the PS 4 beneath the Aegean sea.

The study of oceanographic maps, show that the submerged planation surfaces are mainly located at the depth of 50-100m, in a wide area extending from the south of Samos up to Kos Island. This area also includes the complex of Fourni, Lipsi, Patmos, Agathonisi, Leros, Kalymnos, Pserimos islands.

The PS 4 is of great importance in Eastern Samos island because it confirms morphologically the recent intense tectonic activity of the area. Moreover, PS 4 are of great value for human development, since their weathering and erosion produced the drainage network, the valleys, the karst valleys, the springs and all the others elements which favour soil creation and soil fertility.

Residual forms of erosion

Residual forms of erosion are the formations which have resisted the erosion processes that took place in the wider area. The erosive processes in the area were they appear are particularly intense. However, each lithological formation shows a different behaviour in these processes. After the action of the intense processes the most durable formations are presented as isolated hills with abrupt slopes within the large plains. Moreover, many residual forms also appear in the coastal areas of the island. These forms are created due to the different resistance of the rocks to the marine processes (Fig.5).

Fig.5
Karlovassi beach (relict form of erosion)

Gorges

Gorges are narrow valleys of much bigger height than width. Their development is guided by the existence of faults or joints and is located in places within the faulted zones, where weathering and erosion are favoured. Of course, climatic conditions are an important factor and the more humid the climate is, the more it affects the natural processes. Lithology is another important factor. The creation of gorges is favoured in areas of carbonate rocks, because carbonate formations are easily dissolved by water (Fig.6).

Fig.6 A gorge in Samos Island

Coastal landforms

In general, residual forms of erosion exist scattered across the coastline and many times are related with faults. The forms which are related with the drainage network are rather rare (Fig.7).

Fig.7 Notches in the northwestern part of Samos' coastal zone

Karstic forms

Karstic forms are created as a result of the water's dissolving activity in carbonate formations, calcareous and dolomitic rocks and rarely in gypsum and mining salt. The karstic mechanisms have two forms: surface formations and depth formations. The Lapiez, the Dolines, the Poljes, the Uvales, the Karst-schlotes and the Sculptures belong in the first category. The Potholes and the Caverns belong in the second one. In Greece, the appearance of karstic forms is extended due to the vast existence of carbonate rocks (Fig.8).

Fig.8 Samos island is full of karstic formations

GEOLOGY

Samos Island is located close to the Western Anatolian Coast, in the eastern Aegean Sea (Fig.9). The Pre-Neogene substratum of the island consists of five tectonic units containing marbles, dolomites, quartzites, phyllites, metamorphosed basic to ultrabasic rocks, and a younger nape of diabases, peridotites, cherts and limestones (Papanikolaou, 1979; Theodoropoulos, 1979). During Upper Miocene two major lacustrine basins were developed, namely the Karlovassi basin in the western part and the Mytilinii basin in the eastern part of the island. In Pliocene, both basins, as well as a small basin located about 5 km southeast of

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the city of Samos, were filled by travertine limestone and claystone of freshwater origin. The deposits of both basins are presumed to be continental facies and are Upper Miocene to Pliocene in age (Dermitzakis and Papanikolaou, 1981).

The Upper Miocene Mytilinii basin is characterised by the presence of a thick sedimentary succession that is characterised by white limestone and dolomite and, mainly, biogenic siliceous sediments ranging from calcareous diatomites to diatomaceous tuffites (Stamatakis, 1986; Stamatakis et al., 1989). The siliceous (opal-A-rich) succession is diagenetically altered under saline-alkaline conditions to porcelanite (opal-CT-rich) porcelanous limestone succession (Stamatakis et al., 1989).

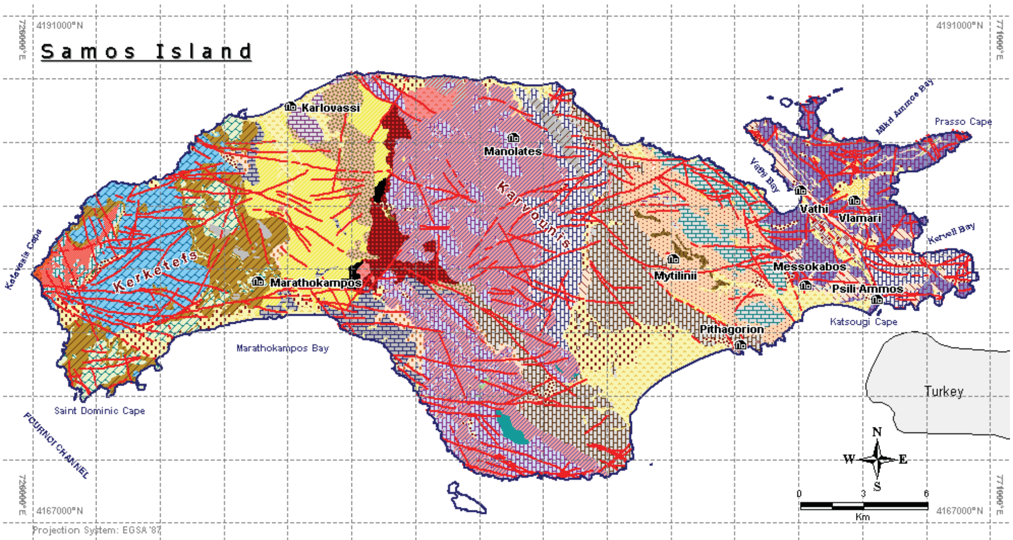

Fig.9
The geological map of Samos Island

Geological Characteristics

- Sliding area
- Coastal deposits
- Alluvial deposits
- Small interior basins alluvial deposits
- Recent scree and talus cones
- Old scree and talus cones
- Weathering of the surrounding rocks eluvial
- Torrential terrace
- Upper series travertine limestones of Mytilini basin
- Clastic series of Mytilini basin
- Travertine limestones intercalations
- Lower series travertine with siliceous limestone, diatomite, limestone, diaotmite & tuff/tuffite of Mytilinii basin
- Upper series travertine limestones of Karlovassi basin
- Clastic series of Karlovassi basin
- Hard marls with zeolitic tuffs & tuffites, claystone, marlstone of Karlovassi basin
- Lower series travertine, thick-bedded limestones of Karlovassi basin with tuffic materials
- Karlovassi basin formation with pyroclastic material, silicified sediments, volcanic bodies and saponite
- Lower series silicified sediments of Karlovassi basin
- Medium to thick-bedded travertine limestones of Palaeocastron basin
- Palaeocastron marls of low cohesion
- Basal conglomerate of Palaeocastron basin
- Volcanic rocks, lavas & tuffs
- Volcanic tuffs
- Upper Triassic - Jurassic limestones
- Basic intrusive rocks
- Peridotitic mass
- Clastic rocks
- Zoodochos Pigi marbles
- Zoodochos Pigi schist intercalations
- Kotsikias - Psili Ammos schists
- Kotsikias - Psili Ammos marble intercalations
- Vourliotes - Syrrachos marbles
- Vourliotes - Syrrachos schist intercalations
- Ampelos marbles
- Ampelos schists
- Ampelos schists with many small volcanic bodies
- Peridotites - serpentines of the central section of the island
- Ophiolite rocks
- Marbles of Kerketeas piedmonts
- Cipolines - cipoline marble - ankerites of Kerketeas piedmonts
- Marathokampos - Kosmadhei schists
- Kerketeas marbles
- Dyke igneous rocks of Kallithea

Faults

- Certain
- Possible

During Upper Miocene, the Karlovassi basin was successively filled with carbonates, ash-fall tuffs and tuffites, marlstones, claystones, siliceous limestones, porselanites (with abundant opal), and cherts (with abundant chalcedony) (Stamatakis, 1989a). At the margin of the basin there are occurrences of rhyolites, dacites, trachytes, and basalts of Neogene age (Theodoropoulos, 1979). These volcanic rocks are responsible for the local silicification and kaolinisation of the surrounding rocks (Stamatakis, 1989b). The tuffaceous horizons of the Karlovassi basin are mostly ash-tuffs and have undergone extensive diagenetic alterations in a saline-alkaline lake environment, resulting in the formation of the zeolite-rich and boron-bearing K-feldspar-rich tuffs (Stamatakis, 1989a&b; Hall and Stamatakis, 1992). In general, the tuff layers are frequently alternated to, either, claystone (NE part of the basin), or dolomitic marlstone (SW part of the basin). The spatial arrangement of the authigenic aluminosilicate minerals (i.e. the zeolites, analcite, clinoptilolite, mordenite and chabasite and K-feldspar) is characteristic of a saline-alkaline lake with its most alkaline part located in the area between Sourides and Kondeika villages. Within this area, evaporite minerals, such as gypsum, colemanite, ulexite, and celestite, have been detected (Stamatakis and Economou, 1991, Stamatakis et al., 1996). The borate occurrences of Samos represent the southwestern edge of the Borate district of the Eastern Aegean – Western Anatolian area (Stamatakis, 1989b, Helvaci et al., 1993).

The five tectonic units, which comprise Samos Island from west to east, are distinguished in:

- Kallithea Unit
- Kerketeas Unit
- St. John Unit
- Ambelos Unit
- Vourliotes-Zoodochos Pigi Unit

Kerketeas Unit

This tectonic unit comprises the basin of the island of Samos and consists of HP-LT (High Pressure, Low Temperature) metamorphic rocks, Kerketeas marbles and Marathokambos-Kosmadei schists. Kerketeas marbles are white to white-grey, very commonly dolomitic marbles (Fig.10, 11). They are medium-to thick-bedded and sometimes unbedded, coarse-crystalline, strongly faulted, karstic and without schist intercalations. The mountainous block of Kerketeas at the western part of the island consists almost totally, of these marbles. The visible thickness exceeds 1500m. Marathokambos-Kosmadei schists are discontinuously overlying Kerketeas marbles. They are mainly muscovite schists, quartz schists, chlorite and calcareous schists, frequently alternating in vertical and horizontal direction with local intercalations of prasinites, marbles and cipolines of various thicknesses. The schists' thickness, in the area of Palaeochori, in the western side of Kerketeas, is about 600m whereas in Marathokambos area, in the eastern side of Kerketeas, it is more than 1500m. The cipolines-cipoline marbles at Kerketeas' foot are occurring as intercalations within the Marathokambos-Kosmadei schists, in the western part of the island. Usually they are grey–brown and sometime greenish. These intercalations are generally of small thickness, laterally passing into calcareous schists. Limonite outcrops appear within the cipolines south of Kosmadei, in the form of a lenticular intercalation of 0,5m thickness and 10m length. Finally, the marbles of Kerketeas foot occur either overlying on Marathokambos-Kosmadei schists, in the western part of the island, as distinguished horizons of about 200m thickness (St. Kyriaki and Karlovassi areas) or as intercalations within these schists. They are grey to black-grey and sometimes white-grey, mainly fine-crystalline, very commonly dolomitic, thin to medium bedded, karstic and sometimes with cert intercalations. Their thickness varies from a few to 200m.

Fig.10
Pythagoras cave wider area

The nappe sequence of Samos Island consists of limestones (Kallithea Unit), basic intrusive rocks (St. John Unit) and metamorphic rocks (St. John Unit, Vourliotes Unit and Ambelos Unit).

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Fig.11 Sarantaskaliotissa cave at Kerketeas mountain

Kallithea Unit

The Upper Triassic-Jurassic limestones of Kallithea Unit are commonly sitting on the horizons of basic intrusive rocks of Kallithea-Drakea area. They are white or rose, at the base, unbedded, fine-crystalline and generally strongly tectonised. At higher stratigraphic positions, they locally pass to dolomitic compact to fine-crystalline, strongly karstic, bituminious, medium-to thick-bedded, grey to black-grey and sometimes ankeritised limestones. Around Kallithea village, they enclose Megalodon sp., of a size up to 12cm, which is of Upper Triassic age. In these limestone, not determinable Lamellibrances and Gastropods and in thin sections Ostracods and Radiolaria, were also found. Also in thin sections of samples, taken from the upper parts of this limestone horizon, Valvulinidae of Jurassic age have been found. Its maximum thickness is 150m. A peridotitic mass of limited dimensions appeared within the clastic sediments of the overthrusted series. It is a fairly preserved peridotite with easily distinguished pyroxenes. Finally, small outcrops of sandstones at the base of the overthrusted basic intrusive rocks Kallithea and Drakea villages, area. The sandstones are fine to medium grained, with intercalations of coarse-grained ones and grits. Their maximum observed thickness is about 50m.

St. John Unit

St. john unit consists of basic intrusive rocks, which comprise of great masses of submarine extrusions (pillow lavas), mainly of spilites and diabasic type rocks, in greenish or red-ruby colour, commonly widely altered and locally schistose. Generally these rocks show secondary pseudobedding and, only in few cases, they are unbedded. Often limestones and sandstones of small thickness are intercalated within these rocks. In thin sections of the limestones a microfauna of Middle-Upper Triassic age was found. The age of submarine extrusions is determined also by the following microfauna: Ostracods, Radiolaria, small sized Gastropods, fragments of microfossils, Involutina sp., Codiaceae, Diplopora sp., Thaumatoporella sp., Frondicularia. The basic intrusive rocks' thickness is estimated about 250m.

Ambelos Unit

Ambelos Unit is found in the central and western part of Samos Island. Ambelos marbles occur as intercalations or great banks of various thickness within schists of Ambelos. Various coloured as whitish, light grey or dark grey, mainly fine, crystalline, medium-bedded, partly karstic. At Spatharei area, where their thickness exceeds 300m, they are medium to coarse bedded, grey-white or grey and at the upper member black-grey. Many times, they are dolomitic and sometimes pure crystalline dolomites. In some cases intercalations of breccia-marbles occur e.g. between Dendria and Platanos area. Generally their thickness increases and decreases rapidly, with synchronous lateral passing to cipolines and calcareous schists. Commonly, they are strongly folded and faulted. Ampelos schists constitute the larger part of island's central section and more or less the upper extension of Marathokambos-Kosmadei schists of the western part of the island. They have various mineralogical composition, as mica schists, muscovite schists, quartz-muscovite schist and quartz schists. Epidote amphibolites, chloritic schists, epidote-muscovite-glaucophaneschists, hermatite schists and phyllites, also occur within them. Locally, intercalations of ultamafic igneous rocks are found, often schistose (Myli village area). Sometimes quartz-schists and quartzites with a thickness exceeding 100m in cases, dominate within the schists (western part of Ambelos mountainous block). The total thickness of Ambelos schists is more than 2500m. Ambelos schists with many small volcanic bodies occur around the great volcanic mass of Ambelos village.

Vourliotes-Zoodochos Pigi Unit

The Vourliotes-Zoodochos Pigi Unit is found mainly in the eastern part of the island and is superjacent to Ambelos Unit. Zoodochos Pigi marbles are occurring at the eastern part of the island overlying the schists of Kotsika-Psili Ammos. They are commonly medium to thick-bedded and locally thin-bedded, mainly at their upper parts where they pass into cipoline marbles, light grey to grey-black and sometimes white or grey-black, fine-crystalline and locally coarse-crystalline, sometimes with intercalations or lenses of cert. Many times the marbles enclose intercalations of dolomitic marbles and schists, mainly micaschist through out their stratigraphic range. In some cases the thickness of these intercalations reaches 50m. In the lower parts of the marbles occur deposits of emery. The maximum observed thickness of Zoodochos Pigi marbles reaches 500m. The Kotsika-Psili Ammos schists are mainly chloritic, muscovite schist, sericite, quartzschist and calcareous schist, alternating vertically and passing laterally from the one lithological type to the other, with intercalations of quarzites. Many times intercalations of marbles, cipoline marbles, ankerites and in one case intercalations of breccia marbles (Kotsikia area) 10m thick, are found within the schists. Sometimes are found strongly folded with strike of folding axis N65^{o}E. The maximum visible thickness of Kotsika-Psili Ammos schists is about 400m (found at Psili Ammos area, Fig.12). The Vourliotes-"Syrrachos" marbles constitute, almost totally, the eastern part of the central island's mountainous block and the SE area of the eastern island part, where the tectonic horn of "Syrrachos" is found. The marbles thickness at the eastern part of the central section of the island exceeds the 1000m, but at "Syrrachos" area reaches about 400m. The precise stratigraphic correlation of the marbles between central and eastern island parts is not possible because of the intercalations of the Mytilinii Neogene basin sediments. However, it is accepted that these marbles are of the same stratigraphic sequence and that "Syrrachos" marbles constitute the upper members of it. These marbles in central part area are generally light-coloured, usually grey-white, medium–to thick-bedded, fine-crystalline, very commonly dolomitic, partly karstic and micro-

Fig.12 Salt marshes at Psili Ammos area, turns to a lagoon during winter time (by C. Centeri)

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folded, with strike of folding axis N50°E.

ENVIRONMENT

Samos Island is differentiated for its rich physical environment and maintains very important ecosystems. Three areas on Samos Island have entered the Natura 2000 network (Fig.13).

The first one is the wetland in Alyki (code area: GR4120001), (Fig.14) which is located in the eastern part of the island and very near the coast of Asia Minor. Alyki used to produce salt, the best one in Greece. In 1965 it ceased its activities. Alyki became a wetland and today, in addition to its aesthetic value, it also has a wider ecological significance, as it is a rare ecosystem for the Aegean islands (Fig.15). The quality and importance of the region is mainly attributed to the great numbers of birds that visit or even reproduce every year in the

Fig.13 Natura 2000 protected areas

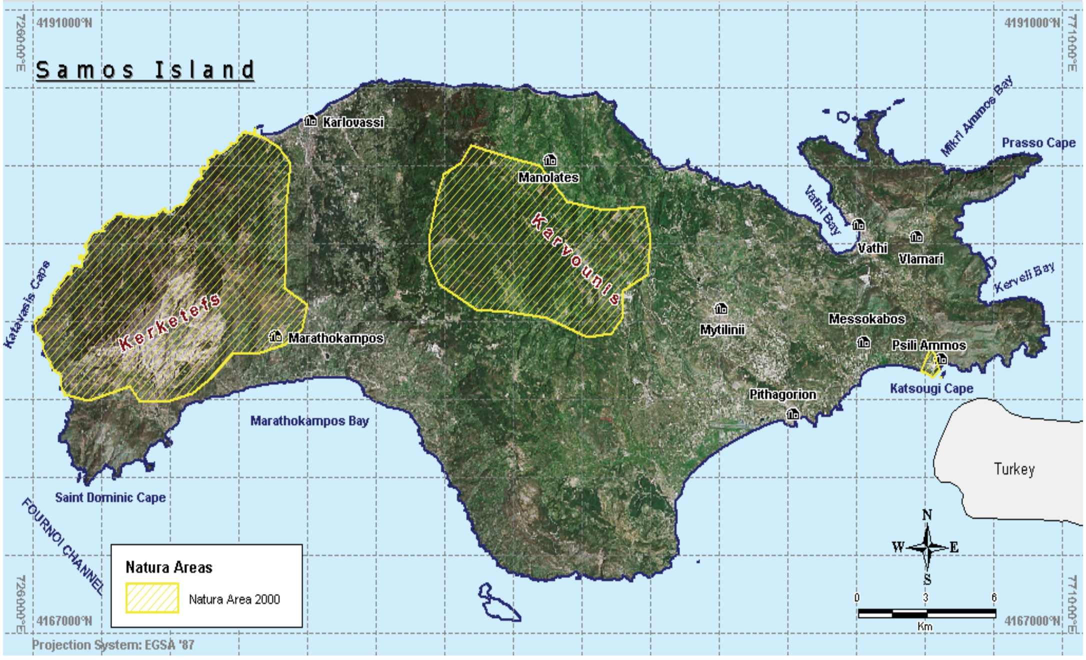

Fig.14 Alyki protected wetland

Fig.15 A view of the wetland in Alyki during the summer

Fig.16 Ambelos Mt. protected area

marsh. The wetland is tightly associated with the great wetlands in Asia Minor at the Delta of the Meander River and the Delta of the river Kastro, which are among those regions in Turkey that are highly significant for birds and are protected within the framework of our neighbouring country's legislation. For this reason, more birds find shelter in Alyki than in many other islands and thus it is a major stop for many migratory species. The region has been designated as a wetland in the list issued by EKBY and NATURA.

The most important threats within the site are tourism, illegal hunting, establishment of new tourist shelters, and human waste.

The location of the wetland adds scenic and aesthetics value the site, having as a result the attraction of many tourists each year. At the same time, the increase of tourism has had an unfavourable influence. Unfortunately, because of the ignorance of the importance of the wetland and the inadequacy in applying the laws for the protection of the wetlands, tourist settlements are overdeveloped, with neither hydrological nor environmental studies. Thereby, in virtue of land reclamations, fillings with rubble and building, the wetland is shrinking. Tourist development also leads to contamination of the wetland through domestic waste, which is deposited in the wetland since no study has been carried out.

Moreover, tourism increase leads to seasonal destruction of vegetation, which is caused by free camping and parking at the wetland site.

The wetland of Alyki, is easy to conquer because of its spacing, like all small wetlands, and is one of the most threatened ecosystems in Aegean Sea. The prohibition of any kind of human activity in or near the wetland should not comprise a conservation base for the wetland, because such a policy would be impractical. The maintenance of the wetland's function and value is not uncompromising with human activity, as long as that this activity will be well-balanced.

Ambelos Mt. is another area protected by Natura 2000 (area code: GR4120002), (Fig.16). Ampelos Mt. is located in the central part of the island. Its highest peak, Profitis Ilias, reaches 1153m.

This area is covered with dense vegetation which consists mainly of coniferous trees and brushwood. Grazing and farming have minimum affection on the upper parts of the mountain so that natural or semi-natural vegetation is still present. There are not main habituated areas within the site and due to absence of main roads, reaching the district by car is rather difficult. The traditional cultivation of cereals crops, vineyards and olive trees are still balanced, although they are limited nowadays.

The quality and importance of the site is the result of the great number of endemic and very rare plants and invertebrates living in the area. The high degree of endemism derives mainly from the geographical location of Samos island (very close to Asia Minor) as well as from the high altitudes and the fair variety of biotopes existing within the proposed site. It is worth noting that the plant species Asperula samia, Thymus samius and Erodium sibthorpianum ssp. vetteri are local endemics. It must be mentioned, as well, that due to the isolation

Fig.17
Kerketeas Mt. protected area

from the most important tourist areas of Samos Island and the limited human activities within the site, the Pinus brutia and P. pallasiana ssp. nigra, forests are at a very good conservation grade.

There are also species protected by the CITES Convention and others are included in the IUCN Red Data List (1993) in the category of rare and/ or threatened plants and are protected by the Greek Law (Presidential Decree 67/81).

Also, there are invertebrate species, such as Carcharodus flocciferus, Epallage fatime and Platycnemis pennipes, which are rare and threatened and in need of protection.

The main threats within and around the site are mainly modifications caused by human activities. The most important threat within the site is the man induced fires (intentionally or not intentionally) which, in combination with the flammable nature of the Mediterranean pine forests lead to the degradation and destruction of extended forest areas.

Kerketeas Mt., Mikro and Megalo Seitani, Kastania's and Lekka's forests are forming the other protected area by Natura 2000 (area code: GR4120003), (Fig.17). Kerketeas Mt. is located in the west part of the island, reaching highest altitude of 1434m. It comprises a summit area with oreo-, Mediterranean vegetation, valleys and forests to the north, limestone cliffs and unusually extensive areas of scree to the west. The mountainous block of Kerketeas consists mainly of schists and marbles. The site is a well forested area, with coniferous trees (mainly Pinus brutia and Cupressus sempervirens) and brushwood.

The zonal vegetation of the area is divided into the following four zones:

1. Oleo-Ceratonion occupies the coastal warmer areas and reaches up to 250-300m high.

2. Quercion ilicis begins at the upper limits of Oleo-Ceratonion and reaches up to 600-700m high. This zone is characterised by the dominance of Quercus ilex, Fraxinus ornus and Arbutus unedo. Pinus brutia is best developed in this zone.

3. Quercetalia pubescentis extends from the 600-700m to the 900-1000m high, where forest vegetation ends. The zone typifies the dominance of different species of deciduous shrubs Crateogus spp., Prunus spp., Rosa spp., Quercus pubescens et al., as well as, individuals of Pinus pallasiana ssp. nigra.

4. Daphno-Festucetalia appears on the highest peaks of Kerketeas. The prevalence of spiny shrubs with the characteristic species Astragalus spp., Genista parnassica, Acantholimon androsaceum etc., is impressive. Except Juniperus foenicea and Juniperus oxycedrus, which also appear in the lower zones, Juniperus foetidisima is found with a characteristic creeping form. In this zone the most endemics are also found, such as Alyssum samium, Erodium sibthorpi-

The most important threat within the site is the man induced fires (intentionally or not intentionally) which, in combination with the flammable nature of the Mediterranean pine forests lead to the degradation and destruction of extended forest areas.

anum subsp vetteri, Anthemis rosea and Centaurea xylobasis.

The biggest part of the coastline consists of rocky and craggy coasts, while the sandy beaches are limited. Mikro and Megalo Seitani are an example of sandy beaches (Fig.18), of great aesthetic and ecological value, located at the north part of the site.

Kastania's and Lekka's forests are well forested areas located at the western part of the site, characterised by vegetation of Cupressus sempervirens (Fig.19).

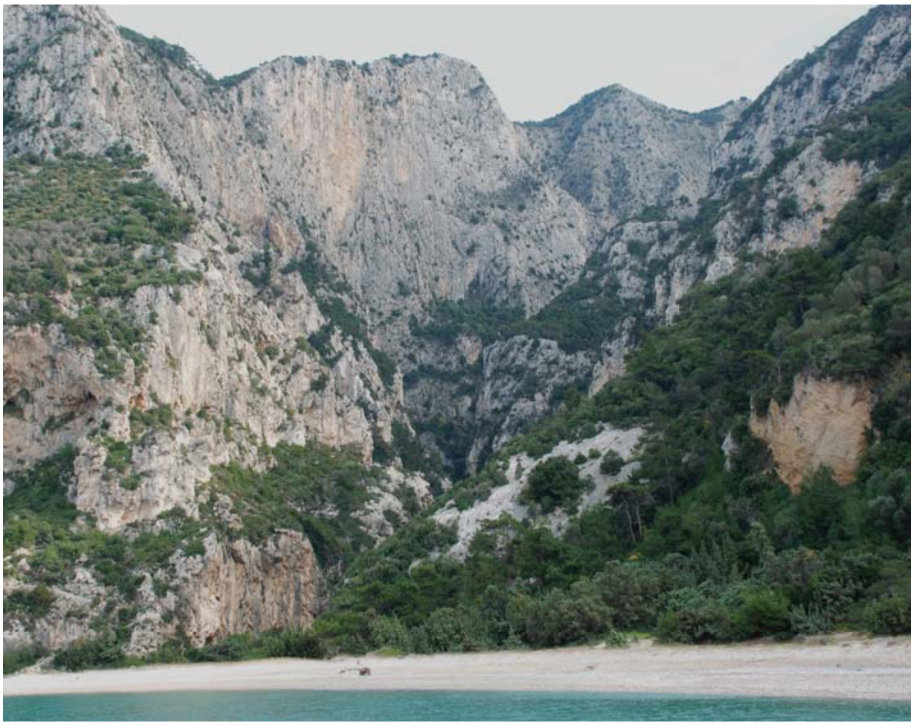

Fig.18 Mikro and Megalo Seitani protected areas (by C. Centeri)

In this case, grazing and farming have also minimum affection on the upper parts of the mountain, so that natural or semi-natural vegetation is still present. There are not a lot of habituated areas within the site and due to absence of main roads, reaching the district by car is rather difficult. The decline of agricultural activities has lead many cultivated areas to be abandoned, especially on the higher altitudes. Many vineyards and olive groves are not being cultivated any more and have been taken over by natural vegetation. As a result the site's natural vegetation is barely affected by agriculture and develops undisturbed and extends wherever possible, even into cultivated areas.

As in Ambelos Mt., the quality and importance of the site result mainly from the great number of very rare plants and invertebrates existing in the area. It is worth saying that the plant species, such as Alyssum samium, Anthemis rosea ssp. rosea, Centaurea xylobasis, Muscari kerkis, Consolida samia and Erodium sibthorpianum ssp. vetteri are local endemics. Pinus brutia and Cupressus sempervirens forests are also at a very good preservation grade. The area is a very important staging post for bird migration on the Turkish coast flyway, due to the vicinity the Turkish mainland and this is why is described as one of the Important Bird Areas (IBA) in Europe according to the Directive 79/409/EEC. The area of Mikro and Megalo Seitani is very important, as is the area where Caretta Caretta and Monachus Monachus live and reproduce.

There are also many species, which are protected by the CITES Convention. The species Cruciata taurica ssp. occidentalis is endemic to Samos and SW Anatolia, while the species Scutellaria rubicunda ssp. icarica (=Scutellaria brevibracteata ssp. icarica) is endemic to Samos and Ikaria. Some plant species are included in the IUCN Red Data List in the category of threatened plants and are protected by the Greek Law (Presidential Decree 67/81). The species Tordylium hirtocarpum is protected by the Greek Law (Presidential Decree 67/81).

Moreover, there are invertebrate species, such as Pontia chloridice, Charaxes jacius, archon appollinus, Allancastria cerisy, Papilio alexanor, Pieris ergane and Hipparchia aristaeus are protected by the Greek Law 67/1981.

The most important threat within the site is the man induced fire (intentionally

Fig.19
Kastania's and Lekka's forests protected areas (by C. Centeri)

or not intentionally). Fires during summer, especially during particular hot and dry years, cause serious damage. During resent years the increase of tourism especially at the area of Mikro and Megalo Seitani, has had an unfavourable influence, particularly on the littoral zone of vegetation. There is seasonal destruction of vegetation caused by free camping and parking.

The mountains of Samos maintain within their body an abundance of natural caves (Fig.20) and ancient mines (Fig.21).

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Fig.21 Ancient Mines in Samos Island

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Fig.20 Natural Cave in Samos Island

Cultural aspects

by Ioannis Vlastaridis & Niki Evelpidou

Ioannis Vlastaridis
Geologist
Ephorate of Palaeoanthropology & Speleology
Tel. +30 2310410185
email gohnydgeo@in.gr

Niki Evelpidou
Dr.Dr.MSc.
Lecturer, University of Athens
Panepistimiopolis, 15784, Greece
Tel. +30 2107274297
email evelpidou@geol.uoa.gr

IMPORTANCE OF CAVITIES

Geological-Hydrogeological importance

Geology and tectonic activity, or folds and faults within the earth's crust, is directly obvious in caves. Cave walls, ceiling, and floor can show fractures and folds in rock layers. Cave passages cutting through the rock layers are making rock identification an easier task.

Inside caves, aquifer recharge process can be observed. The water supply within the aquifer is slowly recharged with each water droplet that falls from the cave ceiling to the floor below (Fig.1), forming the cave's decoration, at the same time.

Water flow paths are recorded by the location and patterns of formations throughout the cave passage (Musgrove et al., 2001). Curtains of stalactites, twisting hangings, or a line of stalagmites can be formed, as water flows through rock fractures.

Fig.1 Water drops falling from the cave ceiling recharging the aquifer and forming the cave's decoration

Biological importance

There are many important species living in caves, which create a considerable ecosystem. The fauna living in caves are often classified as troglobites (cave-limited species), troglophiles (species which can live their entire lives in caves, but also in other environments), trogloxenes (species which use caves, but cannot complete their life only in caves) and accidentals (animals, which don't belong in one of the previous categories).

Troglobites are perhaps the most unusual organisms (Fig.2). Troglobitic species have a number of characteristics, termed troglomorphies, which are associated with their adjustment to underground life. Cave insects are troglophiles, reaching up to 1.7mm in length. They

Fig.2 Troglobites living in Samos' caves

We can find large stalactite caves, public caves with small chapels and about 100 ancient Mines of geological interest.

have extensive distribution and have been studied quite extensively. Bats are categorised in trogloxenes and are often found in caves.

Because of the delicate nature of the cave ecosystem, caves are inhabited by a number of species in danger of extinction.

Fig.3 A small chapel inside Panagia Makrini cave

Archaeological and sociological importance

The human history preserved in caves can be amazingly interesting. Caves have been the site of spiritual and religion practices throughout Greek history. The caves used to be gateways to the world of death, but also a safe place in human imagination.

Outlaws, early Christians, and Neanderthals have taken shelter underground, to run away of persecution, the law, or an ice age. In severely cold or hot climates, caves usually retain a stable and temperate temperature throughout the seasons.

Palaeontological importance

Bones and teeth fossils from animals and humans of great palaeontological value are very often found in caves. Skeletal remnants in caves are typically Quaternary age. This time period a lot of dramatic climatic alterations took place, such as, the numerous glacial progressions and retrogressions, the reorganisation of biological communities in reaction to climate change, the extinction of large mammals (e.g., mammoths, mastodons), and the arrival of humans on the continent.

In Samos Island, there are more than 40 discovered caves and ancient mines many of which are still in use.

Samos caves

In Samos Island, there are more than 40 discovered caves and ancient mines many of which are still in use. These caves are big stalactite caves, public caves with small chapels and ancient Mines of geological interest. Samos' inhabitants used the caves as natural water tanks, in order to store water for the possible dry seasons. The caves where also used as shelter for animals and humans. Furthermore, they were used as pilgrimage and ascetic places, as there are many examples of caves in Samos Island, where there are small chapels inside the area of the cave (Fig.3).

Samos' caves where first explored in 1952 from Petrochilos Ioannis. Nowadays, the speleological trained members of the "Efpalinos Club Samos" are exploring the caves and mines. The club finds support from the Prefecture Samos, the Municipalities of Samos and the Hellenic Federation of Speleology.

The caves are distributed in all Municipalities of Samos. Four caves have been discovered in Vathi Mu-

Fig.4 Sarantaskaliotissa Cave

Fig.5 A chapel inside the Panagia Makrini cave is still in use

Fig.6 Nerotrouvia Cave 1

Fig.7 Nerotrouvia Cave 2

Fig.8
The stalagmitic decoration assembling to an eagle in Nerotrouvia Cave 2

nicipality, four in Karlovassi Municipality, seven in Marathokampos Municipality and 25 in Pythagorio Municipality.

In Marathokampos, at the foot of Mt. Kerketeas, there is Sarantaskaliotissa Cave (Fig.4). The cave is located to the eastern part of Kerketeas Mt. at 320m altitude. Inside the cave, there is a small chapel devoted to Mother Mary built by St. Paul Latrinos who wanted to be an ascetic. The upper part of the cave is divided into 2 rooms. The left one is 10x5m and about 3m high. The right room is 40x10m and 6m high. Both rooms end up in shafts, the one of which ends up in a water tank. Sarantaskaliotissa Cave consists of many rooms, others with poor stalactitic and stalagmitic decoration and others with rich and remarkable one.

Another important cave is Panagia Makrini Cave located in Kallithea area, to the west of Mount Kerkis. Inside the cave there is a small chapel, Panagia Makrini Chapel (Fig.5), which was built in the year 800 AD, by Pavlos Latrinos. The Chapel's roof is only 15 m high.

Nerotrouvia Caves are three correlative caves, which are located in Myli area, at 93m altitude. Nerotrouvia Cave 1 is horizontal on its first stage with extraordinary decoration of stalactites and stalagmites (Fig.6). Few meters away of the entrance of Nerotrouvia Cave 1 is the entrance Nerotrouvia Cave 2, which is also a horizontal cave of 25 length (Fig.7). In this cave there is a remarkable stalagmitic decoration assembling to an eagle (Fig.8). The entrance of the Cave Nerotrouvia 3 is 110m away (Fig.9). This cave is a vertical shaft leading to rooms with impressive stalagmitic and stalactitic decoration and an underground lake. The water level of the lake depends on the precipitation.

Tsakalotrypa Cave (Fig.10) is located in Pyhtagorio area at 102m altitude. This cave is divided into 2 sections and both sections have remarkable coloured stalagmitic and stalactitic decoration.

In Marathokampos, in the foot of Mt. Kerketeas, there is another cave, the Siderenia Porta Cave. The cave is located to the eastern part of Kerketeas Mt. and at 320m altitude and has a variety of rooms of different sizes and different morphology. All rooms are very rich in stalagmitic and stalactitic decoration. The first

Fig.9 Nerotrouvia Cave

and central room seems to be supported by two column stalagmites 5m high.

HISTORICAL BACKGROUND

Samos Island due to its geographical place in the eastern Aegean was always ensuring easy communication with the coast of Asia Minor and thus was one of the most important centres of political and cultural developments from the pre-historic age (4th mil. BC) up to Middle Age. Many civilisations have inhabited the island during historic ages. The remains of Pythagorion, an ancient fortified port with Greek and Roman monuments and a spectacular tunnel – aqueduct, as well as the Heraion, temple of the Samian Hera, can still be seen. These sites exhibit an important development in technology, architecture, town-planning and landscape design.

Fig.10 Tsakalotrypa Cave

Pythagorion is a classic site from the period of Greek colonisation, situated around a good natural harbour on a peninsula that is protected by steep mountains behind it. It also had the advantage of being very close to the mainland of Asia Minor. The earliest findings are pre-classical, dating back to the 4th or 3rd millennium BC, but the main settlement began in the 16th century BC, when it was colonised by Minoans from Crete, later to be supplanted by the Mycenaeans.

The great Temple of Hera, or Heraion, had its origins in the 8th century BC, when it was the first Greek temple to be surrounded by a peristyle of columns; its 7th century successor was also innovatory since it was the first temple to have a double row of columns across the front. But these were surpassed by the temple which begun being built around 570 BC by Rhoecus and Theodorus, a colossal structure measuring 45m by 80m, the earliest in the new Ionic order. It was supported by at least 100 columns, whose moulded bases were turned on a lathe designed by Theodorus. Thirty years later this temple was destroyed in a Persian raid and a replacement was planned on an even vaster scale, but it was never to be completed.

The Efpalinio origma (tunnel – aqueduct) constitutes a marvel of ancient mechanics and Technology that was created in 550 BC in order to constitute the system of water feeder of Pythagorion, in the years of Tyrant Polykrates (Fig.11, Fig.12). The manufacturer was Efpalinos of Megarea. The opening up of the tunnel began from the two mountain edges and finally, with

Fig.11 The Efpalinio origma

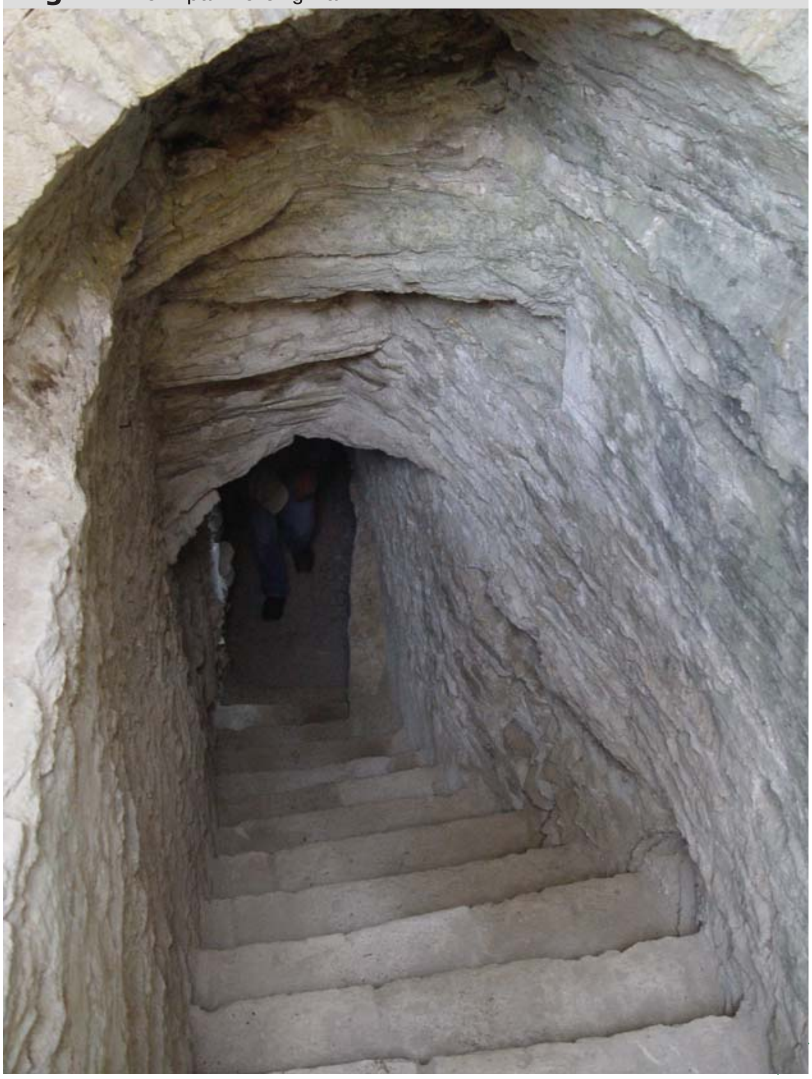

Fig.12
Efpalinio tunnel

mathematic calculations, the two sides of the work met itself in the middle with minimal divergence. The tunnel has two layers with 4-8m altitude difference. The upper layer was for the humans and the other for the water. The Greek authorities promoted the international recognition of the great value of the Efpalinio origma (tunnel–aqueduct) which is now registered in the UNESCO WORLD HERITAGE LIST.

In Mytilinii area, one of the biggest villages of Samos, 45 caves have been found around the hill, which comprise the entrances of an ancient mine (Fig.13). The entrances, found at 147m altitude, are standing due to hand made sculpt columns. These columns witness the study, the spacing and the fine construction, in order to hold on the mountainous blocks rising above. Inside the mine, the explorers found 8 stages of 1km length, having the same supporting system, reaching -70m total depth.

According to archaeologists, this mine was used to excavate building material for the construction of temple of the Samian Hera and the other buildings inside the area of the temple. Furthermore, according to other references, the mine worked as saltpetre mine during the Greek Revolution in 1821. A monk named Ignatios used the nitric salts to create gunpowder.

Fig.13
Ancient mine in Mytilinii area

In Mytilinii area, a dry well of 10m depth is located at 280m altitude. Speleologists suppose that this well might have been a mine's airway, a getaway or an entrance to other tunnels of an ancient mine. Ceramic relicts have been found next to it witnessing the existence of an ancient settlement. This well has not been explored yet.

Greece follows the European directions about the protection and the management of Caves which are included in the category of Monuments and they are considered as an integral part of our Geocultural Heritage. The protection of caves includes also all the palaeoanthropological and archaeological findings which are found inside them.

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A natural cave at the Potami area (Samos-Greece)

Preservation and management

by Andreas Vassilopoulos

Andreas Vassilopoulos
President of Geocultural Park of Eastern Aegean
Flias 13, Maroussi
15125, Greece
Tel. +30 2108056448
email vassilopoulos@gcparks.com

RISK AND SAFETY

Scientific research is the first important step aiming at the protection of caves. Through research it is possible to encounter all the risks concerning caves (findings that were found within them are also included) and their visitors. Since the risks are analysed in detail, more effective ways of protection are possible to be found. The Management of geoculture is focused on the maintenance of the monuments while aiming at the development of the geocultural environment through its international promotion.

The analysis of the risks and the ways of protection concerns two directions: caves and cave visitors.

Human alteration of the caves which may be deliberate or from negligence is very common. Perpetrators of the Greek Legislation alter and damage the environment of the cave in many ways such as:

- Usage of caves as storages.
- Usage as animal yards (pollution of karstic waters).
- Disposal and burn of rubbish (pollution of karstic waters).
- Exploitation/trading of speleological landforms (e.g. stalactites, stalagmites).

In organised and official visits, the rules and special conditions defined by the Greek Legislation are not always followed.

Valorisation of the caves is not always suitable. Valorisation includes risks from: (i) events that do not follow the rules (ii) interior interventions in order to make the cave visitable.

Many important monuments are usually found inside caves. These monuments constitute part of our Cultural Heritage and they include monuments of praise such as old churches and monasteries and places related with ancient philosophers.

Furthermore, apart from monuments, many important findings have been located within the caves. These findings are usually related with the human existence and they are considered as archaeological objects. Palaeontological and palaeoanthropological findings have been also detected. Risks for monuments and findings of all kinds derive from the natural effects:

- Underground torrents constitute a danger because there is risk of washing them away or cover them under the alluvial deposits.
- Underground collapses also threat monuments with destruction.

Moreover, risks for monuments and findings of all kinds derive from the human actions, as:

- Usage of caves as animal yards.
- Starting of fires or the disposal of rubbish.
- Exploitation/trading of findings.

Unsuitable valorisation of caves: for example inappropriate interior illumination which may alterate the temperature of the cave.