



88th EFG SPRING COUNCIL MEETING "Industrial Minerals and their Contribution to European Development"



Milos Island - Greece
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Field trip Guide

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1. Introduction and Geological Setting

The Aegean region represents an active convergent zone, where continental microplates exhibit a complex interaction under the influence of the overall N-S convergence between the African and the Eurasian plates. Apart from the compressional trench zone, the rest of the Aegean region is dominated by an extensional regime as evidenced by predominantly extensional fault plane and the presence of numerous normal faults (Mckenzie, 1972; Angelier et al., 1977; Dewey and Sengor, 1979). Motion of Africa with respect to Europe in the Mediterranean region shows a deceleration since 35 Ma, and in the eastern Mediterranean by 10 Ma declined to a very low overall convergence rate of a few mm/yr (see Savostin et al., 1986; Rosenbaum et al., 2004).

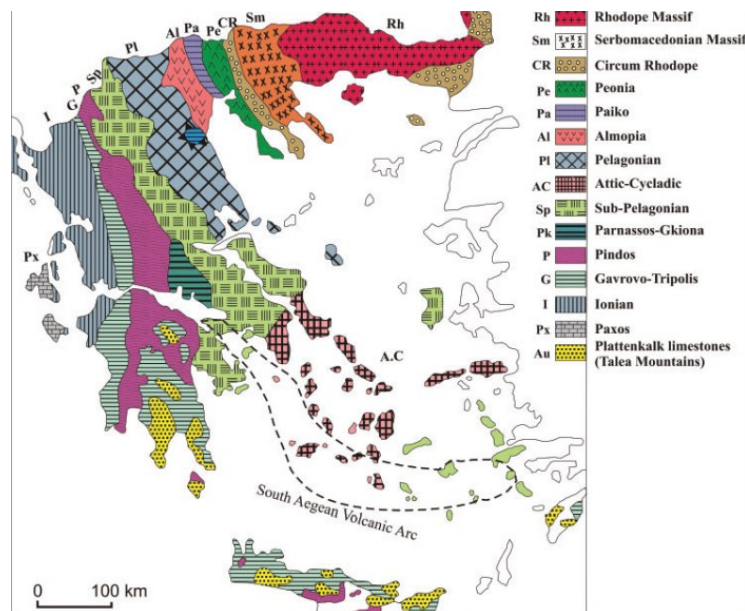


Figure 1. Geotectonic zones of Greece (according Mountrakis, 2010).

Significant changes of the convergence rate between the African and European plate occurred at ~35 Ma, ~20 Ma, and ~10 Ma (Savostin et al. 1986). However, the roll-back of the Hellenic sector of the subducting African slab began in this interval causing localized more rapid subduction (presently ~35 mm/yr in the central part of the arc) and a broad extensional event in the Aegean occurred as a result (e.g. McClusky et al., 2000).

The volcanic arc lays ca. 150 km above the subduction zone, which forms an amphitheatre-like conical plane, with a maximum depth of 190 km at the central part of the South Aegean Volcanic Arc. (Spakman et al., 1988; Truffert et al., 1992; Papadopoulos et al., 1986; Papazachos, 1990).

The stratigraphy of Milos Island is composed, from the bottom to the top, by altered crystalline metamorphic basement, Neogene sediments, old volcanic tuffaceous

formations, ignimbrites, old rhyolitic rocks, old dacitic and andesitic members, pyroclastic rocks, younger tuffs, lahar in different places, younger volcanics of acid composition and quaternary formations. Regarding its geological characteristics, the intensively eroded crystalline metamorphic basement appears in a very limited area (SE coastline). A not continuous series of Mio–Pliocene marine sediments is lying above the crystalline basement; it begins with reddish conglomerates and ends up with well-bedded limestones, which at places turn to sandstones (Fytikas, 1977).

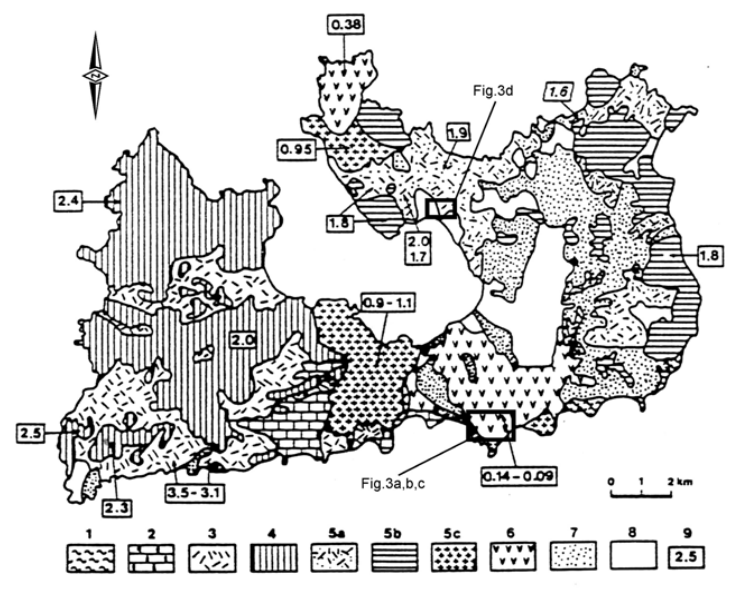


Figure 2. Main geological units of Milos volcanic island (From Fytikas, 1976 modified).
1=Metamorphic basement; 2=Neogene sediments; 3=Basal pyroclastic series (Middle-Upper Pliocene); 4=complexes of domes and lava flows (Upper Pliocene); 5=Upper Pleistocene volcanics: pyroclastic series (5a), lava domes (5b) and Halepa and Plaka domes (5c); 6=Fyriplaka and Trachilas Rhyolitic complexes of Upper Pleistocene; 7= freatic activity products; 8=Quaternary sediments; 9=Radiometric ages from Angelier et al. (1977), Bigazzi and Radi (1981), Fytikas et al. (1976)

From Upper Pliocene Milos was affected by an extensive volcanism, which lasted until late Quaternary (Fytikas et al., 1986). The composition of Milos volcanic rocks shows a calc-alkaline character ranging from andesites to rhyolites. Also, columnar joint basalts are present at Glaronissia small volcanic outcrop. The youngest Upper Pleistocene volcanic activity is concentrated in correspondence of the volcanic centres of Fyriplaka in the South and Trachilas in the North. A decrease in the water content interacting with the magma is generally observed in the evolution of the eruptions: they usually start as phreatic and successively evolve into phreatomagmatic and magmatic activity; lava flows close the eruptive cycles (Fytikas et al., 1986).

2. Volcanological and Petrological Characteristics

Rhyolitic magmatism has characterized the younger volcanic history of Milos Island (Cyclades, Southern Aegean Sea). As mentioned above the volcanic formations on Milos belong to the calc-alkaline association. Most rocks are andesites,

dacites, and rhyolites; basalts are completely absent and basaltic andesites are rare. Nearly all the volcanic products are porphyritic; only some rhyolitic members are completely glassy. In the less evolved rocks, phenocrysts are typically represented by zoned plagioclase, generally augitic clinopyroxene, orthopyroxene, and magnetite microphenocrysts. Unstable olivine and hornblende are sporadically present. The ground mass always contains a variable amount of glass, together with the same phases forming the phenocrysts. In the dacitic rocks, the phenocrysts are characterized by plagioclase, orthopyroxene, and clinopyroxene; hornblende appears widely spread and there are occasionally rims of clinopyroxene; biotite and strongly corroded quartz are sporadically observed. The variability in the chemistry of the more evolved rocks (rhyolites more recent than 1 Ma), seems particularly significant. Two main groups can be distinguished:

a) Low-Ca rhyolites: showing CaO contents usually lower than 1%, thus with normative anorthite of around 2-3 %, and the Na₂O/K₂O ratio < 1; the petrographical observations suggest a plagioclase quartz - sanidine sequence of crystallization of silicic minerals; feric minerals are essentially represented by biotite.

b) High-Ca rhyolites: these rocks show CaO contents invariably greater than 1%, with normative anorthite ranging from 5 % to 11 %; the Na₂O/K₂O ratio > 1; silicic phenocrysts are represented by plagioclase and quartz, sanidine being typically absent; mafic minerals are biotite and amphibole, present only in older products. The first of the two distinct groups (low-Ca rhyolites), is typical of the Trachilas complex, whereas the second is observed in the Halepa and Fyriplaka eruptive systems. Systematic sampling showed reasonable homogeneity within each individual eruptive system, as regards both the major and trace elements. This suggests the lack of any major zonation, within the magma chamber, which fed the volcanic activity.

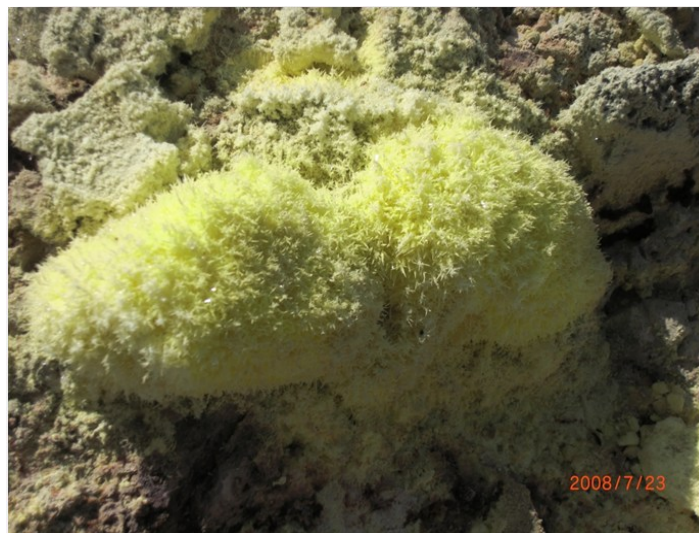


Figure 3. Sulphur authigenic crystals at Kalamos volcanic gas emanation area

2.1. Age of volcanic activity

The volcanic activity on Milos Island began at 2.66 ± 0.07 Ma and has been continuous since then. Subaerial emergence probably occurred at 1.44 ± 0.08 Ma, in response to a combination of volcanic constructional processes and fault-controlled volcano-

tectonic uplift. The architecture of the dominantly felsic-intermediate volcanic succession reflects contrasts in eruption style, proximity to source, depositional environment and emplacement processes.

A variety of dating techniques has been applied to the volcanic units on Milos: K-Ar radiometric dating of biotite and amphibole (Fytikas et al. 1976; Angelier et al. 1977; Fytikas et al. 1986), fission track dating of felsic glasses (Bigazzi and Radi 1981), ^{14}C measurements on Roman pot fragments (Traineau and Dalabakis 1989; Principe et al. 2002, 2003), and sensitive high-resolution ion microprobe (SHRIMP II) analyses of $^{206}\text{Pb}/^{238}\text{U}$ in zircons (Electronic Supplementary material. The geochronological results indicate that the volcanic activity on Milos began during the Late Pliocene (around 3 Ma) and has continued to relatively recent times (200 BC to 200 AD).

The submarine pumice breccias at the base of the succession are interbedded with sedimentary units that contain Late Pliocene marine fossils (cf. Fytikas et al. 1977). A K-Ar date on a non-juvenile rhyolite clast in submarine pumice breccia suggests a maximum age of 3.08 ± 0.14 Ma (Fytikas et al. 1986). SHRIMP U-Pb dating of zircon in juvenile pumice clasts in the Filakopi Pumice Breccia (Stewart and McPhie 2004) provides an upper age limit for the submarine pumice breccias at about 2.66 ± 0.07 Ma. Two main rhyolitic complexes were built during the last 400 ka: Trachilas, in the northern sector of the island, and Fyriplaka to the South. The age of the first is about 0.38 Ma while Fyriplaka is younger, being dated between 90 ka and 19 ka. Both centres were built by an alternation of effusive and explosive phases, these lasts leading to the formation of tuff ring. A common feature of both complexes is the presence of enclaves in the lava flows. These enclaves have dacitic composition in the Fyriplaka lavas, while those in the lavas of Trachilas are rhyolitic. Petrography and geochemistry of lavas, pyroclastic products and enclaves of the two centres have been carried out to study the younger volcanic system of Milos Island.

Trachilas volcano

In Trachilas the explosive activity began with the formation of a tuff ring mainly composed by pyroclastic surges; the surge deposits gradually pass to block and lapilli and finally to lava flows (Fytikas et al., 1986; Mitropoulos et al., 1987; Kelepertzis and Kyriakopoulos, 1991; Kyriakopoulos, 1998).

In the Trachilas volcanic formations the presence of two feldspars (sanidine and plagioclase) allowed to apply the Stormer geothermometer. To apply this method, it is necessary to know the pressure, a datum that we cannot infer for Trachilas. We therefore performed the calculation in two different cases: 1) a hypothesis of a shallow magma chamber (depth of 5-6 km, corresponding to a pressure of 2 kbars) 2) a hypothesis of a deeper magma chamber (15 km, about 5 kbars). In the first case we obtained a pre-eruptive temperature of 690°C , in the second a slightly higher temperature (730°C) (Donato et al. 2008).

As in Trachilas rocks there is only one kind of oxide it is not possible to calculate the oxygen fugacity; indication on this parameter however come from the biotite composition: it has in facts been demonstrated that the Mg content of hydrous phases strongly depends on the oxygen fugacity (Berndt et al., 2001). As we have shown

before Trachilas biotite is less Mg - rich than that of Fyriplaka; this suggests that the Trachilas magma was in relatively less oxidizing conditions before the eruption.



Figure 4. Part of the pyroclastic sequence at the slope of Trachilas volcano (North part of Milos Island)

Fyriplaka volcano

In the Fyriplaka area at least two tuff rings can be identified: a larger one (about 1500 m in internal diameter) and an inner and smaller one. The explosive activity leading to the formation of these tuffs' rings alternated with effusive episodes producing lava flows which ran to the NW and reached the sea inside the Gulf of Milos (Fytikas et al., 1986).



Figure 5. View of the Fyriplaka crater volcano (south part of Milos Island)

The presence of mineral pairs allows constraining, of course only in a preliminary way, the pre-eruptive conditions of the two magmas. The simultaneous occurrence of two different oxides (ilmenite and magnetite) allowed us to obtain both the pre-eruptive temperature and oxygen fugacity. Temperature before eruption was about 740°C, while $-\log f_{O_2}$ resulted 14. The temperature data were also confirmed by the Hush and Luhr geothermometer (1991) based on the plagioclase- melt equilibrium; in the hypothesis of a pressure of 2 kbars (corresponding to a depth of the magma chamber of about 6 km) we obtained a temperature of 720°C.

2.2. Hydrothermal Activity

The results of a widespread hydrothermal activity, represented by fossil and active thermal manifestations, craters of phreatic explosions, etc., are evident in the biggest part of Milos. The age of hydrothermal activity is relatively recent and is connected to Pleistocene phase tectonism and the great geothermal anomalies, the development of which is attributed to the formation of shallow magma chambers. The activity has led to the creation of several mineral deposits, both by transformation and deposition. The most important effect of this is the transformation of the volcanics into clay minerals. Depending on local conditions, we have “bentonization” in the deeper hot environment and “kaolinization” in the shallower ones (Fytikas & Marinelli, 1976). The temperature of the hydrothermal phases’ formation was initially around 100°C. As the permeability of the surface volcanites was reduced by “self-sealing”, due to the thermal transformations, a progressive uplift of the isotherms took place. Thus, the presence of a good “cover”, and hot hydrothermal fluids at shallow depths, resulted in the occurrence of phreatic explosions. By making simple considerations, the temperature necessary for such explosions for the craters north of Zephyria has been estimated to be 325°C. This estimation was later verified by measurements in 5 production wells in the same area. On the island, several small thermal manifestations can be observed: fumaroles, hot springs, hot grounds, submarine gas escapes. They are mainly located in the central and eastern part of Milos, and occasionally on the sea bottom. The maximum measured temperature of the fumaroles is 101°C, of the hot grounds, 100°C (30cm below surface), and of the hot springs, 76°C.

3. Description of the stops on Milos Island

DAY 2 – Thursday, 14 May 2026

Field trip 1: Volcanic and Industrial Mineral Sites

Stop-1 - Alykes east: Upper Neogene ivory bentonite stockpiling

At the eastern part of Alyki lagoon, an artificial yard hosts piles of almost white to bluish bentonite, extracted from Rema Upper Neogene deposits at the eastern part of the island. The material is stockpiled for shipments abroad.

Stop 2 - Airport SW on the road: Pleistocene Perlite of Achivadolimni

Passing from the junction to the airport on the road from Adamas to Provatas, new Perlite outcrops and old mining works exist. The rock has a sugar-like appearance where biotite crystals are clearly visible. This distinguishes textural feature gives the name “Zacharopetra” sugar-rock to the local perlite. Many old private and domestic buildings and churches (ruined St George) have been constructed by this perlite-type. Currently, the same fashion returns and we may see new walls, fences and buildings made by Zacharopetra throughout the island.

Stop 3 - Provatas/Panagia Kipoi: Pliocene Zeolite ash-tuffs

In Milos and the neighboring islands of Kimolos and Poliegos both zeolite minerals clinoptilolite and mordenite occur. The zeolites are found in two forms, wool-like (mordenite) and tabular (clinoptilolite). The presence of almost pure mordenite and pure clinoptilolite in several places of the three islands judges for differences in heat flow rates, the highest related with mordenite. An initial glassy acidic tuff was turned in an opal-CT- and mordenite or clinoptilolite-rich tuff in a shallow marine alkaline environment. In the southwest part of Milos, in the site of Provatas-Panagia Kipoi, fine-grained greenish/off-white zeolite tuff occurs sandwiched in between andesitic lava. The zeolite tuff there is covered by hard andesitic lavas that probably formed a geo-autoclave that helped the transformation of glass to zeolites. Other areas of Milos in which zeolites have been detected are the lower stratigraphic levels of the Aggeria bentonite, in Fyropotamos beach steep outcrops, and recently in Rema white bentonite (Stamatakis et al., 2019).

Stop 4 - Psathi/Panorama St. Helias volcanics with gold mineralization; barite/limonite hosted in Late Miocene shallow marine marlstone/limestone

Passing from the small village of Psathi, on the road from Provatas (Stop 3) to Xylokeratia (Stop 5), a substantial Panorama is exposed westwards. Main geological formations are: i- the Upper Miocene limestone-marlstone of shallow marine origin which host bands of reddish iron oxides-barite assemblages, ii- the overlying clayey and tuffaceous rocks which have yellowish-greenish colors, and iii- the sharp landscape of Profet Helias andesite volcano where a series of boreholes have been conducted some 20 years ago for locating gold-bearing quartz veins. Even though Au concentration was high in several boreholes, the project was stopped due to several environmental and technical difficulties.

Stop 5 - Xylokeratia – Pliocene Pozzolanas -tuff/diatomite of TITAN and Heracles cement companies' quarries, crushers and loading bridges for shipments

Xylokeratia area, which is located at the SW edge of Milos Island, hosts two major quarries of Pozzolana cement additive (450 acres) belonging to Interbeton SA, subsidiary of TITAN Cement Company and to LAVA SA, subsidiary of Herakles Cement, member of the Lafarge-Holcim Group. The extracted pozzolana is shipped for the TITAN factories of Patras and Kamari Boeotia [Eleusis Port] and Heracles factories at Volos and Milaki of Evia Island. The annual production of Milos in pozzolana was reached to 700.000 tons/year dropping recently to 50.000 tons/year, due to economic reformation. Now, only the Lava quarry is in production, as INTERBETON uses the perlite of Gyali, Dodecanese islands, Aegean Sea, as pozzolanic additive. The raw material in both the quarries is non-homogeneous, since it consists of sandy lapilli tuffs, volcanic bombs, volcanic ashes [Milos earth] pumice tuffs and almost pure-lightweight, white diatomite beds up to two meters each.

The exploitation of the pozzolanic material of Milos Island began after the closure (for environmental reasons) of the quarries of Santorini Island. Alternate sources of pozzolanic raw material of volcanic origin are the Pliocene tuffs of Aridea volcanic Terrain, Macedonia, and periodically the black gravelly volcanic deposits and the white pumice tuffs that form the overburden of the white bentonite deposits of Kimolos Island.

DAY 3 – Friday, 15 May 2026

Field trip 2: Mining Operations and Geological Formations

Stop 1 - Trachilas – Plio-Pleistocene perlite quarries – IMERYSA SA

Greece is the world's second largest producer of perlite providing around 15 % of total world production at present. In the sites of Trachilas (North) and Firiplaka (South), there exist perlite mining quarries of IMERYSA SA. These deposits have an exceptional quality compared to other deposits worldwide, as its mass has been more hydrated and in sudden heating at temperatures 700-800°C is easier to bulge. Iron content is less than 0.1%.

Perlite swelling ability is inversely proportional to its crystalline phases content. Not only the presence of quartz crystals, but biotite, feldspar, plagioclase ones etc., (which obviously don't swell) reduces perlite swelling ability ratio. Because volcanic glass is not thermodynamically stable, during devitrification process, original amorphous material is converted to a submicroscopic mixture of various minerals. This mixed agglomerate is weakly birefringent, and in few cases only, it's possible to distinguish particular types of minerals. As devitrification products, fine-grained feldspars, plagioclase, clay minerals and various silica forms can be identified. As devitrification process proceeds, perlite swelling ability ratio is reduced. It is obvious that glass devitrification is more intense as rock age increases. It is noted that older Miocene

rocks contain mostly devitrification glass and not fresh glass.

Quartz microliths in raw material are presented in adhesion with glass, meaning that separation before swelling is impossible. During the process, a part of microcrystalline quartz will be released, a part will be trapped inside expanded perlite bubbles and a small part will be incorporated in bubbles walls.

During the expansion of perlite, the majority of non-expandable materials such large crystals feldspar, plagioclase, quartz and metal minerals remain in the bottom of the furnace. But, mainly quartz and other minerals crystals and microliths are often lured with expanded perlite. Expanded perlite often shows higher quartz content compared to other crystalline phases of the raw material. Biotite is the second in abundance crystalline mineral phase in Milos perlite. Perlite is mined in open pits using explosives and then crawler loaders. Trachila's quarry production reaches 1.500 tons per day.

The last years, from this particular quarry, are mined approximately 150.000 tons perlite per year. The integrated perlite processing method from the first to the last stage is presented below:

1. Extraction
2. Transfer to the factory
3. Pre-crushing
4. Crushing
5. Drying
6. Classification
7. Storage
8. Loading

Landscape restoration is conducted by the same procedure as in Kastriani location, with the difference that hydroseeding is not possible due to strong winds, but usually plants seeds are placed in furrows.

A perlite friability map, that is useful for its industrial treatment and swelling ability, has been composed for Trachilas area. Generally, although perlite has the same swelling ability as deposit, its friable part is the one that can be swelled more easily.

Perlite's total reserves were estimated by S&B Industrial Minerals to 83.5 million tons in Greece and 8 million tons overseas. Under the current demand circumstances, stocks are sufficient to cover customers' needs for at least the next 30 years. It should be noted that Greece is the second country worldwide regarding in perlite production.

The main uses of expanded perlite are:

- In agriculture, as soil additive, to retain moisture and soil limpness
- As filler
- As insulation material
- As intermediate filter for liquid - solid separation in beer, wine, sugar, water and oil industries, as well as pharmaceuticals.

Stop 2: Aggeria Upper Neogene bentonite deposits. Tectonic contact of kaolin/silica with bentonite

➤ **Voudia-Aggeria unpaved road: Tectonic contact of kaolin and bentonite**

Before the huge Aggeria bentonite Quarry, there is a distinct outcrop in which a tectonic contact of bentonitised and kaolinitised tuffs can be seen. Bentonites are described in the next stop, but the kaolin outcrop is similar in origin and mineral content with the currently abandoned and restored kaolin quarries of Ninos, Rallaki, Kastriani and Filis. Kaolin is composed of various amounts of kaolinite, silica polymorphs, mainly opal-CT and microcrystalline quartz, alunite, sulphur. The reddish irregularly oriented patches within the white kaolin deposits contain minor amounts of iron oxides [$\text{Fe}_2\text{O}_3 \sim 0.5-1.5\%$].

Kaolin was formed by the action of fumaroles on volcanic rocks, as a result of feldspar and volcanic glass alteration. The Kaolin of Milos Island is a product of hydrothermal alteration by sulfur and iron rich liquids, that's why it contains various undesirable admixtures for white fillers industry, such as iron oxides/hydroxides, native sulfur, alunite and sometimes barite. Due to its quality the kaolin of Milos is not suitable for porcelain or paper production but is partly or mainly used for white cement production, with frequent monitoring of its quality parameters. Kaolin is mined in open pits, while in the past kaolin extraction was carried out in small galleries at places selected on the basis of quality, whiteness, and content of kaolin deposits.

➤ **Aggeria (Bentonite Deposits)**

Greece is the world's second largest bentonite producer after USA, with the overwhelming majority of its production originating on Milos Island.

Milos bentonites consist mainly of dioctahedral (Ca-rich) smectite with variable amounts of quartz, potassium feldspar and plagioclase. There are also minor amounts of opal, zeolites, alunite, barytes, gypsum, sulphides, and iron and titanium oxides. The composition of smectite (mainly montmorillonite of several mineralogic types and traces of beidellite) is to some extent dependent on the composition of the volcanic parent rocks.

In Voudia – Pollonia location, there are three neighboring bentonite quarries (Aggeria – the larger one-, Aghia Irini, Koufi), belonging to IMERYS SA. Company's target, over the next few years, is their union integration in a development axis of E - W direction, 1600 m long, for their full exploitation. A lot of older bentonite mines in the area have been filled with overburden materials from other mines and have been fully restored.

Milos bentonite is a smectite group minerals-rich rock and originates from volcanic tuffs alteration in alkaline environment [shallow marine environment, open hydrological system]. As Milos bentonite is of calcareous type and not Na-rich, which is more active for the majority of applications, the company converts it with ion exchange treatment [activation] with sodium carbonate (~5%) into Na-rich one by admixing and exposing the mixture under atmospheric conditions.



Figure 6. The Aggeria Bentonite Quarry

Quarry operation is divided into two periods, the winter one (November - April) and the summer one (May-October). During winter period, bentonite deposits are uncovered at the mine by excavating and removing the overburden material, which hadn't any commercial interest until recently, when it started to be used as pozzolanic cement additive. Overburden materials are also transferred for covering, filling and closing of older mines. If they are not sufficient, then other materials from surrounding areas are transferred. During summer period, bentonite extraction is conducted using repels, depending on deposit's forehead stability, and then processing inside factory facilities. The highest extraction point is at 120m and the lowest at -30m, while deposit continues deeper, enriched in zeolite.

Bentonite as a clay material is impermeable when wet. However, in the quarry two inflows of underground waters are occurring. The first one is observed within the contact of overburden material (permeable) and bentonite (impermeable), where an almost fresh water spring occurs (Cl – 900 ppm) from the aquifer. The other one occurs in 4 m altitude, providing 180cm³/h of brackish water by freshwater/ seawater mixing, originating from faults. In order to avoid unwanted water, the company has built a small bentonite dam and, with an underground canal, water is loaded into a pool and then into tanks for sprinkling the dirty mine roads and keeping the dust down.

Various colors are observed in the deposit of Aggeria, as the result of different admixtures, i.e. blue - gray color is due to sulfur compounds, such as pyrite.

The typical procedure after bentonite mining is the following: material enters crusher Shredder having breakage ability about 6000 tn/day. Bentonite being impermeable to rain, hence during its stockpiling in open areas, only the upper 10cm are affected by rain. Thus, bentonite is spread in drying fields (yards - large flat areas) initially for the first natural drying (from about 30% humidity to drop to 21%), but also for mixing

horizontally various qualities and cutting the banded flat stockpiling m vertically (each field contains a similar bentonite quality). Further material's drying is conducted in desiccators reducing humidity up to 15 - 9% depending on the rate required by the product produced. The company has the capability of 850.000 tn/year industrial drying. Finally, material is loaded onto ships using Voudia loading bridge, with a capacity of 600 tn/h.

During every stage of bentonite's industrial treatment, seven quality controls are conducted in order to determine certain properties, physical (moisture content), chemical (S, SO₄, SiO₂ quantity), physicochemical (viscosity), special ones (foundry) etc.

The certain financially exploitable reserves of Milos quarries, according to S&B Industrial Minerals calculations, are estimated as > 22 million tons, enough for more than 20 years exploitation based on current conditions. An ongoing research project, conducting drilling and geophysical surveys, is now in progress by the successor company IMERYS SA, aiming the identification of new reserves in existing holdings or totally new deposits. Bentonite exports are estimated to about 1.000.000 tons / year. Total area of bentonite mining (including Aspro Chorio in NE Milos and Zoulia) is 2.804 acres. Company owns 1676 acres, while the remaining 1128 are leased land by individuals. All mines operate under authorized licenses from competent governmental bodies with a time frame until 2015. Meanwhile, company is currently conducting abroad research for new deposits in several locations worldwide, such as India, Morocco, Turkey, Bavaria, Georgia, Sardinia.

Bentonite applications are listed below:

- In foundry industry, as binding material in molds
- In deep oil drilling, as lubricant material
- As an insulating material
- As animals litter absorbents (bentonite with 9% moisture)
- In animal feeds
- In iron ore pelletizing - Fe metallurgy on blast furnace. The valuable fine iron powder produced is collected with bentonite using "snowdrift" method and thus recycled.

Stop 3 - Voudia IMERYS Headquarters and processing plants

At Boudia, the Headquarters of IMERYS SA are located, as well as calcining mills, dryers and soda bentonite activation yards and other raw material processing devices.

Stop 4 – Junction to Sarakiniko: Plio-Pleistocene ash tuffs alternated with calcareous tuffite with terebratula and diatomite of shallow marine origin and

Stop 5 - Sarakiniko: Plio-Pleistocene ash tuffs alternated with pumice tuffs, seismicites

In Filakopi – Sarakiniko – Alimia extensive area, along the northern side of Milos Island, white diatomite rocks, identical to those existing in Adamas, as well as pumice tuffs, are observed. These diatomite rocks are occurring over a wide area and thickness, alternating with white pumiceous tuffs and calcareous layers, rich in bivalves, gastropods, etc. Burrows forms and other bio-indicator traces are present in both diatomites and the entire stratigraphic column having Plio-Pleistocene age. Diatomites, as well as pumiceous tuffs, total thickness exceeds to 100meters. Both materials have been successfully tested in laboratory as pozzolanic additives, but due to area's tourism development, further industrial exploitation is not possible. Down in the coastline of Sarakiniko, a distinct soft bed up to 1m thick representing soft fine-grained sediments is disturbed by earthquake existed before the compacting of the specific sedimentary rock. The result is the presence of a wavy bed sandwiched between non-affected beds of the same succession.



Figure 7. Alternation of white thinly laminated diatomite beds with porous pumice tuffs that externally turn to dark gray color, due to the absorption of water and the development of organic matter.



Figure 8. The occurrence of seismicites at Sarakiniko coast

In the entire Alimia-Sarakinio-Fylakopi area, each major volcanic event was succeeded by accumulation of shallow marine sediments comprising mainly laminated diatomite with local burrows and sandy limestone containing abundant brachiopods, echinoids and molluscs. Two additional sedimentary facies, i.e. cross-stratified brachiopod (*Terebratula* spp.)-rich calcareous sandstone and wave-rippled sandstone and siltstone, are both indicative of shallow depositional conditions. Silica content in the diatomaceous sediments varies from 39% to 70%, whilst $\text{SiO}_2/\text{Al}_2\text{O}_3$ ratios range from 5 to 21, which can be explained by a varied contribution of fine-grained, reworked volcanoclastic grains. Diatoms are mainly centric forms that occur usually broken and mixed with volcanoclastic grains. Alternation of lithic and biogenic laminae within the diatomite indicates that the deposit was formed as a result of dilute turbidite flows. Presence of burrow traces as well as sequential arrangement of diatomite with shore face sandy limestone deposits suggest that accumulation of the diatomaceous deposits took place in a relatively shallow marine environment.

Micropaleontological analysis, based on calcareous nannoplankton in marly horizons samples, indicated the presence of *Helicosphaera sellii*, *Calcidiscus macintyreii*, *Pseudoemiliana lacunosa*, until the third diatomaceous layer. Small sized *Gephyrocapsa* were very rare and *Discoaster* species were missing. These concentrations allow us to proceed with the biostratigraphical correlation of sediments corresponding to MNN19a biozone (1.95-1.73Ma) (Upper Pliocene). Within the 3rd diatomaceous layer, the first representatives of *Gephyrocapsa* genus, larger than 4mm, marking the Pliocene-Pleistocene boundary (1.81Ma), were successfully identified. The rest of this sequence chronostratigraphical belongs to lowest Pleistocene. Diatomite's deposition phase, based on their micropalaeontological content, reflects a quite deep marine environment.

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