THE ORIGIN OF THE MILOS BENTONITE DEPOSITS

V. Dietrich*, R. Nuesch D. Ballanti***

*Institute of Mineralogy and Petrography, Swiss Federal Institute of Technology (ETH), CH-8092 Zürich, Switzerland.
** Division of Geotechnical Engineering, laboratory for Clay Mineralogy, Swiss Federal Institute of Technology (ETH), CH-8092 Zürich.

Greece is the largest producer of bentonite in Europe with a production exceeding 1 Million tpa. These bentonites are mainly exploited on the island of Milos in the Aegean Sea. In general, the Milos bentonites are primarily Ca - and Ca - Na - montmorillonites with some Mg as exchangable cation and with minor amounts of calcite, quartz, cristobalite, alkali-feldspar, sanidine, plagioclase, kaolinite, illite, baryte, gypsum, alunite, jarosite, anatase and sulfides.

The majority of the deposits occur within depressions filled with tuffitic material around Upper Pliocene dacitic to rhyodacitic plugs and flows in the northeastern and eastern part of the island.

The **protoliths of the Milos bentonites** have been recognize as **pillow lavas, pillow breccias and hyaloclastites**, which were produced during the Upper Pliocene by repeated voluminous extrusions of andesitic to latitic lava from subaqueous fissures within a E-W tending graben system in the northern part of the island. The narrow inlets and shores of **Phylakopi** along the mainroad to Apollonia are chosen as a **type locality.** There, unaltered pillow lava appears at the base of the hyaloclastites approximately at sea level and below. These lavas are overlain by reworked pillow lava and hyaloclastic flows with a poorly sorted hyaloclastic matrix, grading upward into more fine-grained, well sorted and bedded hyaloclastites. The irregular distribution of pumice in all sizes from ashes and lapilli to bombs, as well as intercalation of marls is a common feature. The outcrops of this locality also show a rapid change in lithofacies due to repeated and to rapid infill and currents within the irregularly shaped topographic depressions.

The general chemical characteristics of the pillow lavas and haloclastites are andesitic to latitic with close similarities to low Ti-shoshonites. The bulk chemical compositions follow the high-potassic calcalkaline trend (wt. %Q SiO_2 = 58 - 60, TiO_2 = 0.7 - 1.0, Al_2O_3 = 17-18, Fe_2O_3 = 4.0-5.5., MnO - 0.05 - 0.1, MgO = 2.3-2.5, CaO = 5.0 - 6.5, Na_2O = 2.7 - 3.6, K_2O = 1.9 - 2.2, P_2O_5 = 0.15 - 0.25; in ppm: Ba=650-750, Sr = 600-700, Rb = 50-70, Nb = 3-4, Y = 5-10, Ni = 5-15). Completely bentonized pillow lavas, breccias and hyaloclastites are perfectly preserved in the mine of Aggeria.

Middle to Upper Pleistocene seems to be the reasonable time for the hydrothermal activity of the **Trogalas-Aggeria-Voudia (TAV) - system.** The most important factor controlling the formation of bentonite is the andesitic to latitic composition of the protolith, especially the contents of Si, Al and Mg. Substantial transport of Mg and Al by the hydrothermal fluids during bentonitization was not required. Leaching of Si, Ca,

Na, K, Ba, Sr, Rb and LREE from the glass-rich pillow lavas, breccias and hyaloclastites at temperatures between 160 and 230^0 C were necessary, in order to achieve ideal montmorillonite compositions.

GEOLOGICAL MAP OF GREECE - AEGINA ISLAND 1:25 000

V.J. Dietrich[*], P. Gaitanakis[**], I. Mercolli[***] and R. Oberhänsli[****]

[*] Institute for Mineralogy and Petrography, Swiss Federal Institute of Technology (ETH), CH-8092 Zürich, Switzerland.
[**] IGME, 70 Messoghion Str., Athens 11527. Greece.
[***] Institute for Mineralogy and Petrography, University of Berne, CH-3012 Berne, Switzerland.
[****] Institute of Geosciences, Johannes Gutenberg University, Saarstr. 21, D-65000 Mainz, Germany.

The **new geological map of Aegina Island** in the Saronic gulf southwest of Athens, on a 1:25 000 scale, is designed as a prototype of a special map series of Greece. All legends and explanations are given in English and Greek. Two thirds of the surface of the island is covered by dacitic and andesitic lava flows, plugs and necks, and by large volcanoclastic dacitic flows. The remaining one third is covered by Neogene lacustrine and shallow marine sediments. The basement is mainly comprised of Permian to Upper Cretaceous limestones, covered by flysch and ophiolitic thrust sheets.

A **colored inferred cross section** to approx. 1000 m depth is shown below the map illustrating the polyphase deformation of the Sub-Pelagonian Paleozoic to Mesozoic platform carbonates, as well as the remnats of overthrust sheets including Upper Jurassic to Lower Cretaceous ophiolitic mélange, Upper Cretaceous to Tertiary flusch and Upper Cretaceous limestones.

The **reverse side of the map** shows the following explanation: the Neotectonic evolution in the northwestern Aegean island arc, including a tectonic map; the paleoenvironment during thw Early Pliocene; the volcanic and magmatic evolution.

The **volcanic islands of the South Aegean Sea** (Aegina, Methana, Poros, Milos, Santorini, Yali, Nisyros and Kos) are aligned along an volcanic island arc, which is regarded as a magmatic result of active subduction of the African plate beneath the Aegean plate. Subduction may have started in the Middle Miocene. The island of Aegina is dominated by tensional tectonics, which caused uplift and subsidence leading to horstgraben structures, as well as to the emplacement of magmas. Yellow to greenish marls are the dominant Pliocene sediments (nannoplankton zones: NN 14 to NN 17), with intercalations of sandy and fine grained conglomerates, rich in chlorite, epidote, serpentine minerals and Cr-spinel.

The **magmatic processes** which led to the production of dacites and andesites on