

Borate and Sulphate Salt Deposits of the Late Miocene Basin of Karlovasi, Samos Greece

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The present graduate study refers to the research of the borate and the sulphate deposits of the Late Miocene basin of Karlovassi, west Samos Island, Greece.

Borates, which are the main objective of the research, are the most important economic source of boron. This happens due to the fact, that boron is extremely dispersed in nature, averaging 10ppm in earth's crust (Anovitz and Grew, 1996). As a result, there are relatively few occurrences where the element is sufficiently concentrated to be economic.

Samos Island is located in the eastern part of the Aegean Sea and neighbors with the coast of Asia Minor-Turkey.

The Karlovassi basin which is the main area of the research, is one of the two biggest sedimentary basins of Samos and has a North-South direction. Furthermore, the basement rocks of the basin are mainly marbles and limestones (Papanikolaou 1979). To be more specific, the basin was filled with basalt conglomerates, evaporites, marls, claystones and limestones. The Karlovasi basin has been predominated by hot and dry conditions during Late Miocene. These conditions led to the formation of a saline and alkaline lake (Stamatakis, 1986, 1989b). As it is known, borate salts and boric acid enrichments of supergene type occur mostly within recent playas-saline flats associated with volcanic emanations and hot springs (Helvacı, 2015). This criteria, along with older field and laboratory data on the occurrence of borates and celestine in the lake (Stamatakis and Economou, 1996), lead us to investigate in detail the Karlovassi basin, to locate any considerable amount of borate deposits that may be economically exploitable.

For that reason, the aim of this study was to determine the borate deposits of this basin and draw the conclusions on the genesis and possible importance of the borates existed in that area.

The borate mineral that has been found the most, is colemanite- $\text{Ca}_2\text{B}_6\text{O}_{11} \cdot 5(\text{H}_2\text{O})$ (Figure 1). Furthermore, ulexite is also present in some cases in smaller amounts with the form of needle-like crystals, with approximately 0.2mm size. Additional, celestine and barite crystals were found in the form of fissure fillings crossing the colemanite groundmass. Barite occurs rarely, covering celestine, as a fine-grained thin film of a few microns in thickness. Secondary calcite occurs replacing colemanite in micro and macro scale.



Figure 1. Characteristic colemanite crystals (purple circle) and laminated layer of clay (yellow lines)

In the context of the present study, several depositional information, fieldwork observations and analytical lab results are presented. The field work included the sampling and investigation of the relationship of the borates with the host rocks. Moreover the analytical lab tests that have been carried out on the geological samples from the basin of Karlovasi were:

- X-ray diffraction (XRD), which helped the identification of the mineral phases
- Scanning Electron Microscope (SEM), which yields flexibility in the analysis of the geometry and composition of the microstructure of the individual mineral phases and their relationship

- Optical Microscope Analysis (LM), which helped the identification of minerals in each rock sample through observation under magnification using both crossed and uncrossed nicols
- Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES), which is predominant in the analysis of major and trace elements
- Stereoscopic microscope analysis, which helped to capture characteristic photographs providing very important information about the macro-structure of the mineral assemblages of the specimens

All of the above tests were necessary in order to identify the presence of the borate and the sulphate minerals and the related minerals as well.

Afterwards, conclusions about the studied area and the depositional model are presented. Some of them are:

- The Karlovasi basin is continental type and during Late Miocene it was a playa lake like environment similar to that of the Neogene basins of western Anatolia, Turkey.
- The borate and sulphate deposits relate with the hydrothermal activity due to volcanism which took place in Late Miocene
- The host rocks of the deposits are the tuffaceous rocks rich in Authigenic K-feldspar and zeolites and dolomitic claystone
- The intense weathering of borate minerals in the basin of Karlovasi was reinforced by large-scale tectonic events that caused fractures in the sedimentary rocks of Upper Miocene and thus to the host rocks of the boron deposits. These data, combined with the rare occurrences of boron-bearing bodies found in this study, lead us to the conclusion that the probability of maintaining large borate mining bodies is limited
- The only part of the basin which may have prosperity of further research by performing a drilling project is its NE part, where the Upper Miocene siliceous limestone-porcelanite cap rock is still preserved and may protect the borates from strong weathering that occurs in the rest of the basin.

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