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# Mineralogical and Geochemical Investigation of the Alteration of Ultramafic Magnesite-Hosting Rocks from Gerakini (Chalkidiki, Northern Greece)

A. Papadopoulos[1], E. Tzamos[1,2], E. Pagona[3], G. Grieco[4], A. Kasinos[5], E. Tziritis[2,6], M. Mitrakas[3], A. Zouboulis[1]

(1) Laboratory of Chemical and Environmental Technology, Section of Chemical Technology and Industrial Chemistry, School of Chemistry, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece, argpapad@geo.auth.gr
(2) North Aegean Slops SA, Thessaloniki Greece
(3) Chemical Engineering Department, School of of Engineering, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece
(4) Department of Earth Sciences, Università degli Studi di Milano, via Botticelli n.23, 20133, Milano Italy
(5) Grecian Magnesite SA, Gerakini, Greece
(6) Hellenic Agricultural Organization "Demeter", Soil and Water Resources Institute, Sindos, Greece

## Background

Magnesite is closely associated with ophiolitic ultramafic rocks, more specifically dunites and chartzburgites, which can be altered at several extents due to different alteration episodes (e.g. serpentinization, carbonitization-silicification). In Northern Greece, the main magnesite ore deposits are located at Chalkidki area, more specifically, at Vavdos, Gerakini, Ormilia, Poligiros and Agia Paraskevi. Currently, magnesite is being mined at Gerakini and Ormilia sites by “Grecian Magnesite SA’ mining company. The study area of Gerakini hosts the ophiolitic sequence of Western Chalkidiki.

## Objective

Previous researchers have already provided mineralogical and geochemical data about ultramafic host rock-types, as well as magnesite (e.g. Papadopoulos, 2007, Skliros, 2013). In this study, the main objectives are to provide additional mineralogical and geochemical information, aiming to elucidate the mineralogical and geochemical differences of the different ultramafic lithological host rock-types, reveal their alteration history and thus to contribute to the understanding of magnesite formation.

## Methods

For the present study, seven (7) rock samples were taken from the Rachoni open pit mining site located at the Gerakini mining district. Thin-polished sections were mounted from each sample and were examined both in optical microscope and by means of scanning electron microscopy (SEM). Mineralogical composition of the collected samples was determined by X-Ray Diffraction (XRD) whereas supplementary information on the composition was received by Thermo-Gravimetric and Differential Thermal Analysis (TG-DTA) and Fourier-Transformed Infrared Spectroscopy (FT-IR). The chemical composition of the samples was determined by FUS-ICP-MS.

## Results

The studied samples can be divided into three different categories based on the degree and type of alteration they have undergone.

The mineral assemblages of quartz+carbonates(dolomite+calcite)+spinels+chlorite, as well as the enrichment in $SiO_2$ and CaO (Table 1) content of samples W1 and W2 are typical of listwanites. Listwanites are silica-carbonate-rich products of low-grade metasomatic processes after mafic and ultramafic rocks (Tsikouras *et al.,* 2006 and references therein). More specifically, hydrothermal circulation of a $CO_2$-rich fluid phase in a high water/rock ratio (Koutsovitis and Magganas, 2013) favor the formation of listwanites. The silification-carbonization reactions may well be responsible for the liberation of MgO from serpentine, suggesting an alternative source of Mg responsible for the magnesite formation.

Sample W3 is consisted of vermiculite+quartz+serpentine+talc+amphibole+plagioclase+chlorite+magnesite. Notably, also small grains of zircon and monazite were observed with SEM. The extended presence of vermiculite indicate that this sample has undergone clay alteration apart from serpentinization (Serelis *et al.*, 2004).

Samples W4, W5, W6 and W7 mainly consist of olivine+serpentine+pyroxenes+spinels+magnetites+carbonates (magnesite+dolomite+calcite). These rocks are all typical magnesite-hosting serpentinites having undergone various degrees of serpentinization with their protoliths being dunites and hartzburgites.

The chemical analyses of the studied samples are in agreement with the mineralogical investigation and the classification of these rocks in three different categories.

**Table 1. Chemical composition of major and minor oxides in studied samples.**

| Sample | | W1 | W2 | W3 | W4 | W5 | W6 | W7 |
|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | (wt.%) | 64.92 | 65.31 | 40.63 | 41.8 | 37.22 | 35.02 | 36.63 |
| $Al_2O_3$ | (wt.%) | 10.74 | 1.23 | 2.68 | 0.55 | 0.32 | 0.24 | 0.34 |
| $Fe_2O_{3(t)}$ | (wt.%) | 1.88 | 7.23 | 5.76 | 8.34 | 8.5 | 7.9 | 8.18 |
| MnO | (wt.%) | 0.035 | 0.106 | 0.107 | 0.117 | 0.147 | 0.112 | 0.119 |
| MgO | (wt.%) | 8.42 | 5.82 | 33.32 | 45.16 | 43.86 | 41.91 | 42.21 |
| CaO | (wt.%) | 3.95 | 7.44 | 1.52 | 0.54 | 0.47 | 0.3 | 0.47 |
| $Na_2O$ | (wt.%) | 2.95 | 0.05 | 0.1 | < 0.01 | < 0.01 | < 0.01 | < 0.01 |
| $K_2O$ | (wt.%) | 0.38 | 0.06 | 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.01 |
| $TiO_2$ | (wt.%) | 0.078 | 0.051 | 0.045 | 0.007 | 0.004 | 0.003 | 0.004 |
| $P_2O_5$ | (wt.%) | 0.02 | 0.04 | 0.02 | 0.01 | 0.01 | < 0.01 | < 0.01 |
| LOI | (wt.%) | 6.87 | 12.47 | 15.96 | 3.5 | 9.49 | 14.43 | 12.35 |

Regarding the content of the samples in rare earth elements (REE), samples W4, W5, W6 and W7 contain very low REE concentrations, which is a typical characteristic of serpentinized ultramafic rock. On the contrary, the chondrite-normalized patterns of samples W1, W2 and W3 reveal higher REE concentrations, especially LREE.

## Conclusions

Considering the mineralogical and geochemical composition of the rock-types, serpentinization, carbonitization-silicification and clay alteration can be distinguished. Carbonatization-silicification suggests additional Mg source for the formation of magnesite. Ongoing research aims to the better understanding of the geologic history of the ultramafic rocks of the broader Gerakini-Ormilia area along with the magnesite ore formation at these localities.


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## References


Koutsovitis, P., Magganas, A., 2013. Mineralogy and geochemistry of listwanite occurrences from the Othris ophiolite, Greece. EGU General Assembly, Vienna, Austria., Geophysical Research Abstracts, 15, EGU2013-12712.

Papadopoulos, A., 2007. Production and applications of commercial types of Klisoura bauxite and Gerakini magnesite. M.Sc. Thesis, Aristotle University of Thessaloniki, 130p. (in Greek)

Serelis, K., Gartzos, E., Tsaousidou, P., 2004. Investigation of the alterations of the ultramafic rocks hosting magnesite ores at N. Evia. Proceedings of the 10th International Congress, Thessaloniki, Greece, Bulletin of the Geological Society of Greece, XXXVI, 377-386. (in Greek)

Skliros, V., 2013. Investigation of the formation conditions of Vavdos and Gerakini (Central Chalkidiki) magnesite occurences and environmental applications utilization study. M.Sc. Thesis, University of Patras, 186 p. (in Greek).

Tsikouras, B., Karipi, S., Grammatikopoulos, T., Hatzipanagiotou, K., 2006. Listwaenite evolution in the ophiolite melange of Iti Mountain (continental Central Greece). European Journal of Mineralogy, 18, 243-255.