Rare-Earth Minerals within Phyllite-Quartzite Series of SE Alagonia Area (Peloponnese)

G. Economou[1], D. Tsagas[1], A. Photiades[1]
(1) EAGME, Olympic Village, Acharnae, Greece, dop@igme.gr, dirgen@igme.gr, fotiadis@igme.gr

The Rare Earth Elements (REEs) have recently moved into the spotlight since the European Commission were characterized them as critical elements. The wide use of REEs in a variety of modern applications set in motion many exploration projects for new potential REE-bearing resources. In Greece, also there are prominent locations which demonstrate REE enrichments giving the opportunity for further research. In the frame of the current research work, REE-bearing minerals where found to be present within the Phyllite-Quartzite Series of SE Alagonia Area (Peloponnese).

The study area extends to the south-eastward parts of Alagonia village, in the NW slopes of the Taygetos Mt., and geologically, consists of metamorphic nappe pile that took place during the plastic deformation of the Phyllitic-Quartzitic series and its thrusting westward on the top of the Plattenkalk series in Miocene times (Xypolias & Doutsos 2000; Jolivet et al., 2010). Furthermore, the Phyllite–Quartzite series dominated by schists and metapelites, and a lower unit of the Plattenkalk series consisting of multi-colored crystalline platy Mesozoic limestone topped by meta-flyschoidal sequence of the lower Oligocene. Due to the intercontinental subduction events in Oligocene times, both the Plattenkalk series, as the deeper metamorphic unit of the external Hellenides, and the Phyllite–Quartzite series, underwent successively HP/LT metamorphic episodes, the former during late Oligocene-lower Miocene times (Thee & Seidel 1991), and the latter in Lower Miocene 19-24 My (Panagos et al., 1979; Seidel et al., 1982, 2006).

In particular, the Phyllite–Quartzite series in the area of Alagonia, over 500 m thick, due to penetrate ductile deformation, consists of a wide range of dark-grey coloured sequence of phyllite–schist rocks (metashales and/or metamudstones) cutting by quartz veinlets (pressure dissolution). Besides, this lithological sequence is affected by stretching lineation indicating top-to-the-W and/or top-to-the-WSW sense of shear, and contains of pseudo-intercalations, boudins and shear-bands of blueschists within greenschists (chloritoid, albite), mica-schists, metaquartzite, quartz-pebble metaconglomerate, marble, serpentinite, and MORB metavolcanic rocks (Skarpelis, 1982).

Phyllite and mica-schist samples were characterized using different mineralogical techniques in order to quantify the modal mineralogy and the REE composition of REE-bearing phases. More specifically measurements were performed using polarized microscopy (Leica DMLP) under reflected and transmitted light, scanning electron microscopy (SEM) with a JEOL-JSM 5600 for semi-quantitative evaluation of minerals and finally X-ray diffraction (XRD).

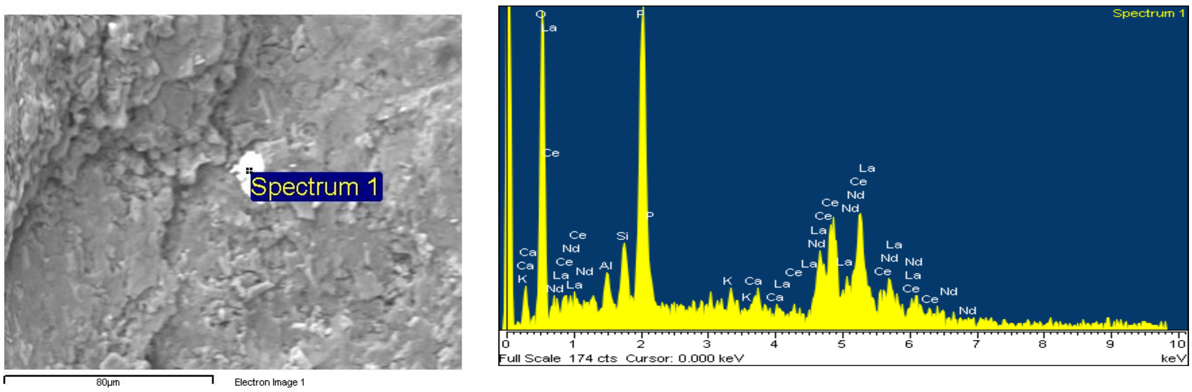
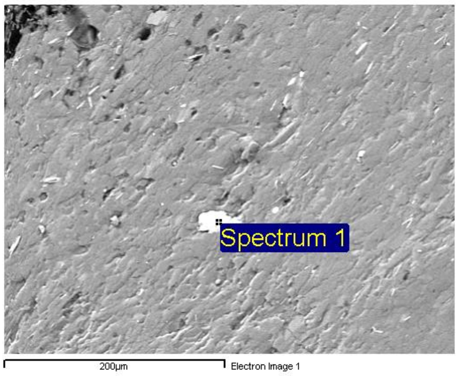


Figure 1: Semi Quantitative evaluation of monazite by SEM (I.G.M.E., Mineralogy – Petrography Lab.)
(**Al_2O_3 :** 2.50%**, SiO_2 :** 3.15%**, P_2O_5 :** 30.13%**, K_2O :** 0.95%**, CaO :** 1.73%**, La_2O_3 :** 17.42%**, Ce_2O_3 :** 31.94%**, Nd_2O_3:** 12.05%, Total: 99.87%)

The **phyllite sample,** which is black in color due to the high chlorite presence, characterized by its intense schistosity indicating metamorphic layering and by a fine-grained mineral content. In fine-layers the mineral phases are distinguished by **quartz**, in elongated recrystallized assemblages, associated with muscovite-flakes and scattered magnetite. Furthermore, it was determined by the measurements the presence of **muscovite,** micritic and microsparitic **calcite**, **rhipidolite** as Fe-rich chlorite, and **albite** as elongated hypidiomorphic crystals. Besides, the **REE-bearing phases, which** appear as gangue minerals are represented mainly by **monazite** (Fig. 1) and in lesser extend **allanite** (Fig. 2) and **apatite.** The latter contributes to the elevated phosphorus content. Zircon, magnetite, titanium-rich phases (rutile and sphene) as well are the minor mineral phases.



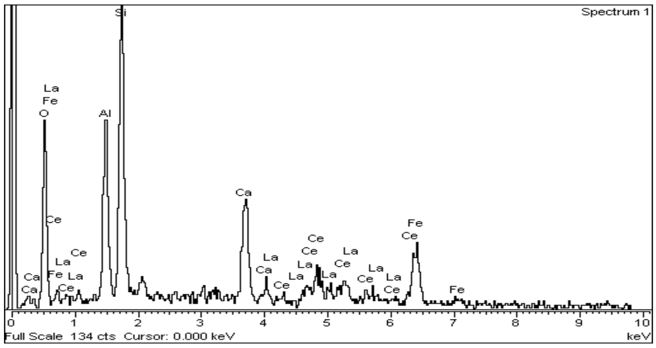


Figure 2. Semi-Quantitative evaluation of allanite by SEM (I.G.M.E., Mineralogy – Petrography Lab.)
($\mathbf{Al_2O_3}$ **:**19.85 %**,** $\mathbf{SiO_2}$ **:** 35.25%**, CaO :**12.16%**, FeO :**15.96%**, La2O**3 : 5.09**,** $\mathbf{Ce_2O_3}$:11.22 %, **Total**: 99.53)

On the other hand, the **mica-schist** sample reveals a medium-grained grayish sample with foliated texture, which is also presented in banded layers. They provided the following mineral assemblage, such as, **quartz**, in elongated recrystallized forms, associated with muscovite-flakes and scattered magnetite; mica, consisting mainly of **muscovite** related to **paragonite** components, chlorite, under compositions of **clinochlore** and **rhipidolite** (iron-rich member), and **albite** as elongated hypidiomorphic crystals. Moreover, the **rare-earth minerals** appear as gangue minerals consisting mainly of **allanite-monazite** mineral phases, **allanite** and **apatite**, and many titanium-rich minerals; monazite, zircon and magnetite are accessory minerals. We signalize that paragonite as common mineral in blueschist facies rocks along with other sodic minerals (e.g. glaucophane) retrograded to greenschist facies, where paragonite and glaucophane are transformed into chlorite and albite.

We accepted that the various types of rare-earth minerals are associated with hydrothermal mineralizations where affected metavolcanic rocks. The studied samples could be associated with the protolith of the Phyllite–Quartzite series derived from a rift sequence of Permian-Triassic age, which took place in Apulia with its progressive expansion and basalt eruptions (Seidel et al., 1982); or these rare-earth mineralizations would be related with an accreted Palaeotethyan oceanic crust (Stampfli et al., 2001).

Obviously, the presence of rare-earth minerals in Alagonia area is a promising target locality to survey of sedimentary placers in recent river gravels, such as the Neda River, that would be survived by physical and chemical weathering of a primary deposit and then transported by water to a new location and deposited.

References

Jolivet, L., Trotet, F., Monie, P., Vidal, O., Goffe, B., Labrousse, L., Agard, Ph., Ghorbal, B., 2010. Along-strike variations of *P–T* conditions in accretionary wedges and synorogenic extension, the HP–LT Phyllite–Quartzite Nappe in Crete and the Peloponnese. Tectonophysics, 480:133-148.

Panagos, A.G., Pe-Piper, G., Piper, D.J.W., Kotopouli, C. N., 1979. Age and stratigraphic subdivision of the Phyllite series Krokee region Peloponnese, Greece. N. Jb. Geol. Paläont. Monatshefte, 1979, 181–190.

Seidel, E., Kreuzer, H., Harre, W., 1982. A late Oligocene-Early Miocene high-pressure belt in the External Hellenides. Geol. Jahrb. E23:165-206.

Seidel, M., Zacher, W., Schwarz, W.H., Jaeckel, P., Reischmann, T., 2006. A Late Carboniferous age of the gneiss of Potamos (Kythira Island, Greece) and a new consideration on geodynamic interpretations of the Western Hellenides. N. Jb. Geol. Paläont. Abh., 24:325–344.

Skarpelis, N., 1982. Metallogeny of massive sulphides and petrology of the External Metamorphic Belt of the Hellenides (SE Peloponnesus). PhD thesis, University of Athens.

Stampfli, G., Mosar, J., Faure, P., Pillevuit, A., Vannay, J.-C., 2001. Permo-Mesozoic evolution of the western Tethys realm: the Neotethys East Mediterranean basin connection, in: Ziegler, P., Cavazza, W., Robertson, A.H.F., Crasquin-Soleau, S. (Eds), Peri-Tethys Memoire, 5. Peri-Tethyan Rift-Wrench Basins and Passive Margins. Memoires du Museum National d'Histoire Naturelle, 51-108.

Theye, T., Seidel, E., 1991. Petrology of low-grade high pressure metapelites from the External Hellenides (Crete Peloponnese). A case study with attention to sodic minerals. Eur. J. Mineral, 3:343-366.

Xypolias, P., Doutsos, T., 2000. Kinematics of rock flow in a crustal-scale shear zone, implication for the orogenic evolution of the southwestern Hellenides. Geol. Mag., 137/1:81–96.