Subduction related mafic rocks from the Sideronero-Mesta unit, Western Rhodopes – geochemistry and preliminary isotope data

Субдукционни мафични скали от Сидеронеро-Местенската единица, Западни Родопи – геохимия и предварителни изотопни данни

Antoaneta Marinova, Maria Stankova
Антоанета Маринова, Мария Станкова

Sofia University, 15 Tzar Osvoboditel Blvd., 1504 Sofia; E-mail: marinova_a@dir.bg

Key words: amphibolites, tholeiite, subduction, magmatism.

Introduction and general settings

Metamafic rocks are common components in the metamorphic section of the Western Rhodopes. This study represents geochemical and isotope data for amphibolites from few localities in the vicinity of Satovcha village. Present data ascertain the protoliths origin and age, considering possible geodynamic setting of their formation.

Amphibolites belong to the metamorphic section in the Western Rhodopes, where the most abundant rocks are orthogneisses of Jurassic protoliths ages (von Quadt at al., 2008). These rocks are components of the Late Alpine regional-scale Sideronero-Mesta unit (Georgiev et al., 2010), intruded by Paleocene and Eocene granite plutons.

The amphibolites in the studied area crop out as an isolated massive body (in the area of the village of Pletena) or as thin layers characterized by samples from few localities NE of Pletena, SW of Dolno Dryanovo, Oreshe, and Kochan villages. Typically, the rocks from the massive body present banded amphibolite rarely preserving primary "pillow" structure and including lenses of ultramafic rocks. Within the Mesta shear zone (Sarov et al., 2008) they are strongly mylonitized. Rare felsic dikes (metatonalite), banded with the host rocks cut the south section of the body. Generally the amphibolites from other outcrops are thin layered, well foliated, fine grained and dark, in alternation with biotite gneisses and metacarbonate rocks. Felsic dikes (metatonalite?) are observed in vicinity of Kochan village. Mafic xenoliths included in a felsic dike at Kochan locality also attend in this study.

The equilibrium mineral assemblage of studied amphibolites is: amphibole (tchermakite) + plagioclase (oligoclase–andesine) + quartz ± epidote. It refers to the peak of a prograde regional metamorphic event at low-temperature amphibolite facies conditions (5–6 kbar and 570–600 °C) (Marinova, Machev, 2011).

Geochemistry

The major element contents of studied amphibolites show considerable variation and negative linear trends of MgO (9.8–3.2 wt.%), CaO (15.9–6 wt.%) and Al_2O_3 (20.9–13.2 wt.%) versus SiO_2 (45 to 62 wt.%). Broadly positive trends are characteristic of Na_2O (0.6–4.5 wt.%), TiO_2 (0.14–1.2 wt.%), FeO_{tot} (5.7–10.8 wt.%) and P_2O_5 (0.01–0.19 wt.%) distribution. K_2O contents vary in small range (0.1–0.61 wt.%) except for the sample with the highest SiO_2 content (K_2O 1.1 wt.%). According to major elements contents the rocks are classified as high-magnesium tholeiite basalts to calk-alkaline basalts and andesites and overlap the same rock species according to immobile elements diagram Nb/Y-Zr/TiO_2 (Winchester, Floyd, 1977). The mafic xenolith included in metatonalite vein show boninite-like features – high MgO (17.02 wt.%), low TiO_2 (0.21 wt.%), high Ni (114 ppm) and Cr (828 ppm) contents. All studied rocks form a stable tholeiitic trend. They belong to a transitional low-K tholeiitic – calc-alkaline series, but only single samples have calk-alkaline features. CaO correlates positively with MgO, indicating CPx fractionation, and insignificant role of Ol in protolith modal composition that is a distinctive feature of evolved melts. The mafic xenolith only could be considered representative of more primitive magma composition.

The studied amphibolites display similar REE patterns but differ significantly in absolute contents (ΣREE = 6.6–172.7 ppm). The few specific features of their REE distribution allow defining two distinctive groups.The first group comprises metaophiolite body samples (Pletena) and layered amphibolites, exposed NE of Pletena and SW of Dolno Dryanovo localities, whose chondrite normalized REE patterns are almost identical and nearly flat (La_N/Yb_N 0.62–1.78). Eu-anomalies are small (Eu/Eu* 0.84–1.76). The second group includes rocks from Kochan and Oreshe localities that differ with higher REE contents (due to enriched in REE source?) LREE enrichment (La_N/Yb_N 2.93–7.96) more pronounced negative Eu-anomalies (Eu/Eu* 0.52–1.01) and similar flat HREE patterns. The mafic xenolith is depleted in LREE and Eu (La_N/Yb_N 0.79; Eu/Eu* 0.46).

NMORB normalized multi-element diagrams show LILE/HFSE enrichment that is slight for group I rocks (Ba_N/Yb_N 3.2–79.1), and more significant for group II metabasites (Ba_N/Yb_N 26.9–168.1). All metamafic rocks are characterized by Nb trough, very deep for group I amphibolites (Fig. 1).

Plotting on tectonic discrimination diagrams involved immobile elements correspond to island arc tholeiitic basalts (IAT), to calc-alkaline basalts (CAB) from continental volcanic arcs, and often overlap with the MORB fields. The subduction related geodynamic setting is further revealed by significant trace element fingerprints, namely: high Th contents, deep negative Nb anomalies, lower absolute abundances of Ti, Zr and Y compared to NMORB. Low Ti/V ratio corresponds to high fO_2 typical for melts enriched in fluids. It seems probable low contents of LILE reflect very high mobility caused by followed metamorphic process, but REE patterns strongly suggest garnet-free peridotite mantle source. Differences in Nb/Yb and Nb/Ta ratios (lower for Pletena and higher for Kochan group) refer to a depleted mantle source for rocks with IAT features and another more enriched peridotite mantle for metabasites with CAB characteristics. The rocks from the II group also present more evolved and fractionated melts with higher LILE, HFSE and LREE. A mafic cumulate (clinopyroxene-rich and plagioclase-poor) with trace element contents similar to the I group metabasites is the most likely protolith for the xenoliths in the felsic dike, grabbed from the lower crust.

Geochronology

Zircon grains of different morphology and CL characteristics from the massive metaophiolitic body (Pletena) are analyzed by LA-ICP-MS. U-Pb isotope data forms two maximums in ages. The first one at 440 Ma corresponds to zircon xenocrysts. The second maximum at 170–160 Ma (calculated concordant age 158.1 ± 3.0 Ma) is marked by oscillatory zoned grains mostly and probably reflects the age of protolith crystallization.

Conclusion

The main geochemical characteristics of metamorphic rocks well present the features of their protoliths, namely: basic magmatic rocks (mostly extrusive), formed during the subduction of an oceanic lithosphere and involving partial melting of variably metasomatized hydrated mantle wedge.

We assume that the protoliths of studied amphibolites appear to be genetically related and very likely reflect a temporal and/or spatial evolution of island arc-continental arc magmatism contributed to persistent melting of a heterogenic mantle source. Future detail isotope research could specify the age of magmatism, subsequent metamorphic event and continental crust contamination effects. Widespread Jurassic calc-alkaline metagranitoids in the metamorphic section support an idea of a subduction related association including entire metamorphic section in the studied area.

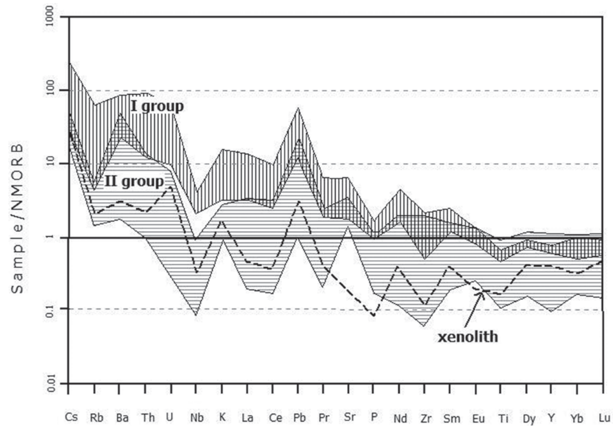

Fig. 1. NMORB-normalized trace elements diagram for the rocks studied (NMORB values from Sun, McDonough, 1989)

Acknowledgments: The investigations were financially supported by Scientific Found of "St. Kliment Ohridski" University, Grand 83/2010 and ДО02-76 (National Found of Scientific Researches).

References

Georgiev, N., J. Pleuger, N. Froitzheim, S. Sarov, S. Jahn-Awe, T. Nagel. 2010. Separate Eocene-Early Oligocene and Miocene stages of extension and core complex formation in the Western Rhodopes, and Pirin Mountains (Bulgaria). – *Tectonophysics*, *487*, 59–84.

Marinova, A., Ph. Machev. 2011. Mineral indicators of high-grade Alpine metamorphism in Mesta and Slashten lithotectonic units, Western Rhodopes. – In: *Proceedings of National conference "Geosciences 2011"*. Sofia, BGS, 23–24.

Sarov, S., N. Georgiev, K. Naydenov, E. Voinova, K. Kolcheva. 2008. Lithotectonic subdivision of the Western Rhodopes and parts of Eastern Pirin. – In: *Proceedings of National conference "Geosciences 2008"*. Sofia, BGS, 89–90.

Sun, S.-s., W. F. McDonough. 1989. Chemical and isotope systematics of oceanic basalts: implications for mantle composition and processes. – *Geol. Soc. London, Spec. Publ.*, *42*, 313–345.

Von Quadt, A., I. Peytcheva, S. Sarov, K. Naydenov, N. Georgiev. 2008. Metamorphic rocks from Dospat area of Western Rhodopes – conventional and in situ UPb zircon dating, isotope tracing and correlations. – In: *Proceedings of National conference "Geosciences 2008"*. Sofia, BGS, 33–34.

Winchester, J. A., P. A. Floyd. 1977. Geochemical discrimination of different magma series and their differentiation products using immobile elements. – *Chem. Geol.*, *20*, 325–343.