Mineralogical investigation of enclaves present in calc-silicate rocks from Novo Selo – Kriva Lakavica, Eastern Macedonia

Минераложко изследване на ксенолити в карбонатно-силикатни скали от Ново село – Крива Лакавица, Източна Македония

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This paper deals with mineralogical investigation of mafic enclaves, which are present in metamorphic calc-silicate rocks from the area of Novo Selo – Kriva Lakavica (Macedonia). The host calc-silicate rocks are situated in the Vardar zone that occupies the central part of the Republic of Macedonia. The rocks in this part of the Vardar zone suffered amphibolite facies Abukyma type regional metamorphism at medium to high temperatures and low pressures. The Abukyma type metamorphism is associated with the existence of paired metamorphic belt in the Vardar zone (Mircovski, 1997). The calc-silicate rocks are composed of calcite, diopside-hedenbergite, augite, actinolite, pargasite, K-feldspar, plagioclase, quartz, titanite, vesuvianite, clinozoisite, andradite-grossular, scapolite, prehnite (Sijakova-Ivanova, 2000; Sijakova-Ivanova at al., 2012). There are different opinions about the origin of the calc-silicate rocks, namely: carbonatites (Ivanov, 1987-88); skarns (Stojanov, Svesnikova, 1985); and regional metamorphic calc-silicate rocks (Sijakova-Ivanova, 2000; Sijakova-Ivanova et al., 1997, 2012).

Mafic enclaves of different shape and size (5 to 25 cm) are present in the calc-silicate rocks. The samples of study represent different types of enclaves according to their macroscopic appearance. Chemical, optical, and X-ray analyses were performed for identification of the enclaves rock types. The following types of enclaves were found based of the obtained results: finer granular amphibolic gabbro; medium-grained amphibolic gabbro; coarse-grained amphibolic gabbro; and serpentinic wehrlite.

Finer granular amphibolic gabbro is composed of hastingsite, diopside, and plagioclase. Accessory minerals are titanite, apatite and zircon. Hastingsite appears in nearly idiomorphic grains with size from 0.2 to 0.4 mm. All grains of hastingsite are fresh with no traces of chemical alteration. Diopside was classified using the pyroxene classification of Morimoto et al. (1988).The results from chemical investigation show that the diopside component ranges from 93.53% to 94.4%, while the hedenbergite component is from 5.6% to 6.55%. The grains of plagioclase display often completely altered central parts and crisp edges. Two generations of apatite could be distinguished by colour and crystal shapes. Some are bright-yellow, while the other are milky-white. Both are present in equal proportion. Milky-white apatite grains (probably originated from gel according to Tröger, 1969), have short-pillar shape with poorly developed (1011) faces. Zircon occurs as pale-pink and colourless grains. The latter are more abundant. It is characteristic that none of the populations have radioactive edges. This means that both populations are poor in uranium and thorium or are relatively young.

Medium-grained amphibolic gabbro comprises the following major minerals: tschermakite hornblende, diopside, K-feldspar and plagioclase. Zircon, titanite, and apatite appear as accessory minerals. For tschermakite hornblende the classification of amphiboles by Leek et al. (1997) was used. Unlike tschermakite, diopside is scarce, but it is bigger in size. Plagioclase appears in idiomorphic grains and they often show two, three or more types of twinning at the same location. K-feldspar appears in xenomorphic grains, whose size ranges from 0.2 to 0.6 mm. The relations of K-feldspar with plagioclase, amphibole, and pyroxene, as well as its size, suggest that it was formed after the crystallization of all the minerals. The origin was related to solution, most probably rich in K_2O that affected the rock immediately before the final consolidation. The epidote is the most abundant secondary mineral. It occurs exclusively in veins of different thickness.

Coarse-grained amphibolic gabbro consists of tremolite and plagioclase. Epidote, zircon, apatite and ilmenite are accessory minerals. Tremolite appears in xenomorphic grains. Cell dimensions are: a = 9859(2) Å, b = 18.134(5) Å, c = 5287(2) Å, $\alpha = \gamma = 90°$, $\beta = 104.78(3)°$, V = 913.9(3) $Å^3$. Plagioclase

occurs most frequently as xenomorphic grains, but also as hypidiomorphic ones. The results of chemical investigation show that the albite component ranges from 47.9 to 62.4%, while the anorthite varies from 36.4 to 49.4% corresponding to andesine and labradorite (Deer et al., 1962).

Serpentinic wehrlite is greenish to black in colour. The texture is porphyroblastic and the structure is massive. Based on optical and chemical examinations, the presence of the following minerals was established: serpentine, diopside, olivine, and ilmenite. Diopside appears as xenomorphic and cracked grains with sharp edges. Sometimes there is ilmenite or serpentine in the cracks. Bastite appears parallel to the cleavage plain. Olivine occurs as small islands, surrounded by serpentine, or in nests. Ilmenite was formed after the cracking of the other minerals, but also appears in small idiomorphic crystals.

On the contact between enclaves and calc silicate rocks often appear reaction zones which are cleary visible on some places, while on other places they are absent. The following assemblages are determined in the reaction zones: I) actinolite + albite; II) diopside + albite; III) diopside + prehnite; IV) diopside + prehnite + calcite; V) calc silicate rock. The zonation appears only along contacts where fluids circulation is larger and all pores are filled with CO_2–H_2O solutions. The mobility of H_2O does not depend on the composition of rocks and increases with increasing temperature, while the mobility of CO_2 increases with the increasing of the pressure.

The results of enclaves' investigation support the conclusion of our previous study that the carbonate rocks of the Novo Selo – Kriva Lakavica are regional metamorphic calc silicate rocks, rather than carbonatites or scarns.

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