The Problem of Garnet Composition in Eclogite-Bearing Gneisses from the Śnieżnik Metamorphic Complex (Western Sudetes)

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In the Śnieżnik Metamorphic Complex (ŚMC) – the eastern part of the Orlica-Śnieżnik Dome, Western Sudetes, there are numerous bodies of eclogites. They outcrop as small, usually several tens of meters long, lensoidal bodies inside gneisses. Mostly they are surrounded by two-feldspar orthogneisses, rarely they also contact with plagioclase paragneisses. Discovery of possible pseudomorphs after coesite in omphacites resulted in conclusion, that the eclogites experienced ultra-high pressure metamorphism (UHPM) (Bakun-Czubarow 1992). During retrogression the (U)HP metabasites were extensively amphibolitised, especially the outer parts of the bodies.

The orthogneisses surrounding the eclogites frequently contain accessory grains of garnets. Some of the garnets display unusual composition. They are almandines with a high content of grossular mole fraction, reaching up to 50 %. Simultaneously they are poor in pyrope component (1–7 %). These Ca-Fe garnets have been interpreted as indicators of ultra-high pressure metamorphism of the migmatic orthogneisses directly contacting with the eclogites (Bröcker and Klemd 1996). They were recognized together with rutile as remnants after UHP mineral assemblage. The clinozoisite and sphene, also present in the gneisses, were interpreted as the products of retrogressive reaction *Grt(Grs30−50)+Coe+Rt → Zo+Spn*. Garnets with high grossular content were also observed in the ultra-high pressure gneisses from the classical UHP terrane: Dabie-Sulu in China (e.g. Carswell et al. 2000), what strengthens the above-mentioned interpretation. The recognition of the Grs-Alm garnets as UHP mineral relics in gneisses is a good support for generalized interpretation of the whole Śnieżnik Metamorphic Complex as an ultra-high pressure terrane (Gordon et al. 2005).

The high-grossular garnets have been reported by Bröcker and Klemd (1996) in only one part of the ŚMC, so called the Międzygórze unit (MU). The garnets occurring in eclogite-bearing gneisses outside the MU normally do not have a high-Ca composition. They are typical almandines (*Alm 60–87.5, Sps 2.5–20.5, Grs 1.5–18 (mostly<12), Prp 0.2–10.5, And 0–1.5*). The diversity of mole fraction ranges in the almandines is strongly connected with a whole rock chemistry of the gneisses, in which they occur. Regardless of Grs-Alm or typical Alm composition, the garnets usually have anhedral shape, sometimes they form skeletal or atoll grains. All the garnets often display strong effects of resorption, what gives them a relic look. Mostly the blasts have small size: from tens to hundreds of micrometers. Occasionally they are being replaced by biotite and chlorite. No inclusions of high pressure minerals (Jd, Ky, Zo, Rt) or quartz pseudomorphs after coesite have been observed inside the garnets.

The studies of the present author have revealed rare cases of Ca-Fe garnets in the localities outside the Międzygórze Unit, in the Gierałtów (GU) and Śnieżnik Units (ŚU) (Stawikowski 2005). Borkowska et al. (2003) also mentioned about the find of high-Ca garnets in the orthogneisses from the Gierałtów Unit. The granite gneisses from the GU and ŚU containing the Ca-rich garnets, like in case of the MU, either show the direct evidence of migmatisation or, if not, gradually pass into migmatites. Usually the Grs-Alm garnets were found in them in the nearest neighbourhood of eclogites, more precisely, close to their amphibolitised outer shells. They were sampled at distances of milimeters or centimeters from post-eclogitic amphibolites. Also in the MU, the biggest number of garnets was observed in the rocks situated very close to the metabasites. Such a regularity led the author to the hypothesis about the growth of high-Ca garnets in upper-amphibolite facies conditions, due to migration of Ca ions from metabasites to gneisses during eclogite retrogression (Stawikowski 2005).

Recently, the high-grossular garnets have been discovered near Strachocin in the Gierałtów Unit, about 50 meters from the large body of post-eclogitic amphibolites. The garnets occur in the migmatic orthogneisses, displaying partially pegmatitic appearance. The migmatites are composed of an assemblage *Qtz+Pl+Kfs+Bt+Grt+Spn+Ap*+Zr. The rocks comprise numerous newly-grown porphyroblasts of antiperthitic plagioclases, reaching up to 30 mm. The size of the garnet blasts is also bigger than in majority of eclogite-bearing gneisses from the ŚMC. They form crystals up to 5 mm in diameter. Their composition is *Alm 59.5–71.5; Grs 21–34.5; Prp 2–6; Sps 1–3; And 0–2*. The diversity of garnet chemistry is caused by retrogression. The crystals are heavily fractured and show bigger amount of Fe and Mg, whereas smaller content of Ca, in the areas situated close to chloritised biotites. They do not contain the inclusions of HP mineral relics. Frequently, garnet grains have subhedral to anhedral shapes and are in equilibrium with the big neoblasts of feldspars. The Ca-Fe garnets are accompanied here by sphene, usually absent in the granite gneisses outside the Międzygórze Unit. The textural relationships between the minerals building the migmatised metagranites indicate common growth of the feldspar porphyroblasts and garnets, as well as the sphene. One can deduce, that they build together the mineral assemblage connected with a migmatic event. As the migmatisation must have been induced either by temperature rise or drop of pressure (decompression), both these explanations do not fit well to the conception of blastesis of the Ca-rich garnets within the investigated gneisses in UHPM conditions.

The ambiguity of the UHPM genesis of Grs-Alm garnets in the orthogneisses is emphasized by different composition of garnets appearing in ultra-high pressure granulites from the ŚMC. The bimodal granulites build here several km long belt called the Stary Gierałtów Granulitic Complex. The garnets in the felsic granulites display significantly higher amount of magnesium, typical for HP metamorphism (*Alm 48–53, Prp 19–23, Grs 25.5–29.5, Sps 0.5–1, And 0–0.5*). On the other hand, the whole rock chemical composition of the orthogneisses and felsic granulites is analogous. Also the garnets from thin intercalations of felsic high-pressure rocks in the ŚMC eclogites contain more Mg than the ones from eclogite-bearing gneisses (*Alm 37–62.5, Prp 8–35, Grs 4.3–37.5, Sps 0.5–13.5, And 0–2*).

In conclusion, the high-Ca composition of garnets occurring in part of the eclogite-bearing gneisses may not be a sufficient evidence for common, in situ (ultra-)high pressure metamorphism of the eclogites and their host orthogneisses in the Śnieżnik Metamorphic Complex. Origin of these Grs-Alm garnets can be connected not with the burial to the mantle depths, but with migmatisation, possibly in the upper amphibolite-facies conditions.

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The Basement of Eastern Part of the Polish Carpathians in the Light of Geophysical Data Interpretation

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The study area is located in the eastern part of the Polish Carpathians, east of the Wisłoka River valley, and includes a transition zone between the Western and Eastern Carpathians. The structural rebuilding of the Carpathian orogen and its basement characteristic of that zone reflects in changes of geophysical fields, e.g. in the distribution of gravity anomalies (Bojdys and Lemberger 1986). Specific 3-D deformations of the flysch cover observed in the area suggest strike-slip faults in the basement. In the western part of the area, there probably occur a major tectonic zone in the basement that separates zones of different tectonics (Żytko 1997).

The recognition of the basement in that zone is not complete, generally because of the complex structure of the Carpathian overthrust and lack of deep boreholes, making interpretation of geophysical data difficult. As only a few boreholes located in the marginal zone of the overthrust reached the sub-Paleogene basement, its recognition is based on surface geophysical investigations. As a result of the complex structure of the orogen, the efficiency of the reflection seismic method is lesser. Hence, magnetotellurics, gravity method, geomagnetic soundings and refraction seismics are of greatest importance to investigations in that area.

Deep geomagnetic and magnetotelluric suondings have been made in Polish Carpathians since 1960s (Jankowski et al. 1991). Since then, wide regional surveys applying equipment of two different technological generations were made and different geological interpretations were presented (Woźnicki 1985, Ryłko, Tomaś 1995, Żytko 1997, Stefaniuk 2001). During the period of 1997–2002, a regional survey with the use of high-frequency MT system was made in the framework of "The project of magnetotelluric survey in Carpathians" (Stefaniuk 2003). Seven profiles crossing transversally the orogen and two profiles paralell to the general strike of Carpathian outocrops were located in the eastern part of the Polish Carpathians. Results of MT data interpretation enabled the structural map of the top of high-resistivity basement and maps of horizontal resistivity distribution for selected depths to be constructed. Resistivity cross-sections including elements of geological interpretation were made along measurement lines.