Geophysical Research Abstracts, Vol. 8, 00150, 2006
SRef-ID: 1607-7962/gra/EGU06-A-00150
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Low temperature metamorphic event recorded in the gneiss and granulite pebbles from the Silesian Unit (Western Outer Carpathians, S Poland)

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Outer Carpathians flysch rocks comprise numerous extrabasinal clasts (so-called “exotics”), which represent source areas of clastic material. Three main source areas that supplied Carpathian basins with sediments might be distinguished: northern source (external to the Western Outer Carpathians) related to the Brunovistulicum and/or Malopolska Massifs, the Silesian Ridge, and the Southern Magura Ridge. Two latter ones represent internal source areas, so-called “cordilleras” (e.g. Wieser 1949, Książkiewicz 1965, Sikora 1976). Constraints on alterations that resulted in REE mobilization in metamorphic rocks from the Silesian Ridge are reported below.

The metamorphic rocks pebbles (gneisses and granulites) from the Silesian Unit (Western Outer Carpathians, SE Poland) collected in four localities (Gorlice, Krzeslawice, Siekierczyna and Skrzydlna regions) were investigated. Fifteen relatively non-altered samples of gneisses and three samples of granulites were chosen to analyses. Chemical compositions of minerals were determined using SEM-EDS method.

Gneisses are composed of plagioclase ($An_{<35}$), quartz, biotite, muscovite, K-feldspar, with accessory rutile, apatite, zircon, monazite, xenotime, uraninite, thorianite, garnet (spessartine, almandine), barite, iron and titanium oxides, as well as iron, zinc, copper and lead sulphides. REE concentrations above EDS detection limit were determined in the following minerals: monazite, xenotime, uraninite, thorianite and zircon. Temperatures of the metamorphic peak, up to ca. 660˚C, were roughly determined with use of Ti-in-biotite geothermometer (Henry *et al.* 2005).

Monazite from gneisses contains 3.24 wt.% of ThO_2 and 0.66 wt.% of UO_2 on average (up to ca. 17 wt. % of ThO_2). Average Nd_2O_3/Ce_2O_3 ratio is ca. 0.35. Monazite in gneiss sample from Krzeslawice region contains euhedral inclusions of thorianite (86.29 wt.% of ThO_2, 7.33 wt.% of UO_2 and 1.18 wt.% of PbO_2). Moreover, gneiss sample from the Gorlice region contains uraninite (92.67 wt.% of UO_2 and 3.00 wt.% of PbO_2). Rare xenotime grains are present in three of four samples from Skrzydlna region. Xenotime contains ca. 16.5 wt.% of REE and ca. 1.7 wt.% of UO_2 and ThO_2 (with UO_2 content up to 3.64 wt.%).

Granulites are mainly composed of plagioclase ($An_{<34}$), garnet (almandine), alkali feldspar (microperthite) and quartz, with minor amounts of biotite. Kyanite, apatite, monazite, zircon, rutile, iron and titanium oxides, iron and zinc sulphides occur as accessory minerals. High degree of sericitization of plagioclase is common. Iron sulphides between lamellae of biotite are present. Monazite contains up to 3.96 wt.% of ThO_2 and up to 0.90 wt.% of UO_2. Average Nd_2O_3/Ce_2O_3 ratio is ca. 0.38. Temperature conditions of the metamorphic peak (up to ca. 780˚C) were roughly determined with use of Ti-in-biotite geothermometer (Henry *et al.* 2005).

Increase of ThO_2 content in monazite might be related to solubility of Th-phase end-members in the structure. Enrichment of xenotime in UO_2 might be a result of substitution $2(REE, Y)^{3+} \Leftrightarrow (U, Th)^{4+} + Ca^{2+}$ (van Emden *et al.* 1997). These might be related to low temperature hydrothermal alterations. Chloritization and sericitization, associated with barite, iron oxides, as well as iron, zinc, copper and lead sulphides also suggest low temperature alterations. REE mobilization, enrichment of monazite in Th and formation of thorianite and uraninite might occur during the late Carboniferous-early Permian metamorphic episode dated in other "exotics" (e.g. Michalik *et al.* 2004; Poprawa *et al.* 2004). Similar age (300-260 Ma) was roughly determined using chemical method based on thorianite composition occurring in gneiss from the Krzeslawice region.

Acknowledgements: This study was supported by MEiN research grant 2 P04D 041 29 (to B.B.) and the Jagiellonian University research fund.

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