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MYSTERIOUS HIGH-PYROPE DETRITIC GARNETS IN THE MIDDLE JURASSIC CLASTICS OF THE CRACOW REGION

Zagadkowy, wysokopiropowy detrytyczny granat w środkowojurajskich utworach klastycznych regionu krakowskiego

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Treść: W celu rozpoznania składu minerałów ciężkich środkowojurajskich piasków i piaskowców, analizie poddano utwory tego wieku z kilku odsłonięć okolic Krakowa (Dębnik, Dębnik-Czatkowice, Racławice, Paczółtowice). Wykazano w ich obrębie wysoki udział minerałów z grupy granatu, wskazując na duże podobieństwo do minerałów tego typu znanych z zewnętrznych Karpat Zachodnich. Tym niemniej bezpośrednie wskazanie obszaru źródłowego tych minerałów nie jest możliwe, a stwierdzić można jedynie, że ten enigmatyczny region obfitował w granulity, eklogity i perydotyty.

Słowa kluczowe: minerały ciężkie, jura, monoklina śląsko-krakowska, analiza proweniencji, granat

Key words: heavy minerals, Jurassic, Polish platform, provenance analysis, garnet

INTRODUCTION

Detritic heavy mineral analysis of the Middle Jurassic sands and sandstones in the southern part of the Kraków-Wieluń Upland was performed to compare the heavy-mineral assemblages with those published from the Tethyan Jurassic of the Western Carpathians

(Łoziński 1956, 1957, 1966, Aubrecht 1993, 2001), Eastern Alps (Faupl 1975) or from the Tethyan margin of the Bohemian Massif (Štelcl *et al.* 1972, 1977). The results from the Tethyan regions show big differences in the heavy mineral spectra between the internides and externides. The externides are dominated by garnet, accompanied by zircon, rutile and tourmaline, with subordinate amounts of other minerals. The internides are characterized by predominance of tourmaline and apatite, accompanied with zircon and rutile. The results from the margin of the Bohemian Massif correlate well with the results from the externides. Analyses of detritic garnet in the samples from the externides (Jurassic to Paleogene of the Pieniny Klippen Belt and Flysch Zone) display big portion of pyrope-almandine garnets coming from granulites and eclogites (Otava *et al.* 1997, 1998, Aubrecht & Méres 1999, 2000, Salata 2004, Grzebyk & Leszczyński 2006). Wieser (1985) reports about rich granulitic pebble material from the Silesian Unit of the Flysch Zone. Exotic, pyrope-almandinic garnets were also reported from the Carboniferous of the Moravo-Silesian Culm basin (Čopjaková *et al.* 2001, Hartley & Otava 2001). Most of the authors derived this exotic garnet material from Moldanubian zone of the Bohemian Massif. Except of this zone, there are only two other known occurrences of granulites and eclogites – Góry Sowie Block and the Śnieżnik area complex in the Western Sudetes (Smulikowski 1967, Oberc 1972, Kryza *et al.* 1996). These are, however, too small to be a regionally important source of clastic material.

GEOLOGICAL SETTING

Middle Jurassic deposits of the Kraków region (Kraków-Wieluń Upland, Poland) represent the transgressive sequence. They were laid down on the erosional surface, which is developed on the older, Palaeozoic and Mesozoic rocks. In some places the lower or early Middle Jurassic continental clays (mainly lacustrine) are preserved. The sequence of Middle Jurassic deposits commences with quartz sand and sandstone, which comprises conglomeratic horizons. These deposits are devoid of any fossils excluding silicified fragments of tree trunks. They are of shallow marine origin, however their basal part might be deposited in fluvial environment. They gradually pass upwards into sandy limestone of Calloviense zone. The transgression caused the filling of the uneven basement topography. It is reflected by variable thickness of clastic deposits, which varies from zero up to 10 m while the sandy limestone is about 3 m in thickness. The latter belongs to Calloviense Zone whereas the underlying clastics are of uppermost Bathonian and lowermost Callovian age. Percentual ratios of heavy minerals in this formation were previously published by Krysowska (1960, 1962). She reported about the heavy mineral spectra dominated by garnet, accompanied by zircon and rutile, with subordinate amount of turmaline and staurolite. We studied the following localities: quarry at the road between Dębnik and Czatkowice

(N 50°13'16.5", E 19°47'41.3"), Dębnik Quarry (N 50°09'52.1", E 19°40'17.4"), Paczółtowice (N 50°10'33", E 19°39'22.9") and Racławice (N 50°11'7.8", E 19°40'34.5").

METHODS USED

The heavy minerals were separated from the sands in heavy liquids (bromoform, density ca 2.8). The fraction 0.08–0.25 mm was studied in transmitting light, the whole fraction was examined also by binocular lense. Percentual ratios of the heavy mineral assemblages were determined by ribbon point counting. The opaque minerals in all samples were dominated by limonite and pyrite, that are insignificant from the point of view of clastic provenance. Therefore, the results presented in this paper are exclusively from translucent heavy minerals. The composition of garnets was determined using a CAMECA SX-100 electron microprobe at the State Geological Institute of Dionýz Štúr in Bratislava. The analytical conditions were 15 kV accelerating voltage and 20 nA beam current, with a peak counting time of 20 seconds and a beam diameter of 2–10 μm. Raw counts were corrected using a PAP routine.

RESULTS AND INTERPETATIONS

The studied heavy mineral spectra were slightly dominated by garnet but the contents of zircon, rutile and turmaline were also high which is in contradiction with previous results of Krysowska (1960, 1962). These four minerals were accompanied by lesser amounts of staurolite and apatite. The microprobe analyses of detrital garnet grains show that they can be divided into 5 groups, according to their composition (Fig. 1):

1) Garnets coming from garnet peridotites. These have high contents of pyrope molecule (~70 mol %), relatively low contents of almandine (~15 mol %), grossular (~12 mol %) and very low spessartine molecule (< 1 mol %).
2) Garnets coming from granulites. They have relatively lower contents of pyrope (30–50 mol %) than the previous ones, but have higher contents of almandine (50–60 mol %), low proportion of grossular (~5 mol %) and very low contents of spessartine (~2 mol %).
3) Garnets coming from eclogites. These have pyrope contents about 30–56 mol %, almandine contents of 35–45 mol % and that of spessartine less than 1 mol %. They differ from the group No. 2 by higher proportion of the grossular molecule (20–30 mol %).
4) Garnets coming from gneisses. They have high almandine contents (~60 mol %), low pyrope contents (~10 mol %) and higher contents of spessartine (10–27 mol %) than granulitic garnets. Contents of grossular were less than 6 mol %.
5) Garnets coming from amphibolites. They are characteristic by pyrope contents of about 15–25 mol %, low spessartine contents (< 10 mol%), gigher grossular contents (20–30 mol %) and relatively high contents of almandine (~75 mol %).

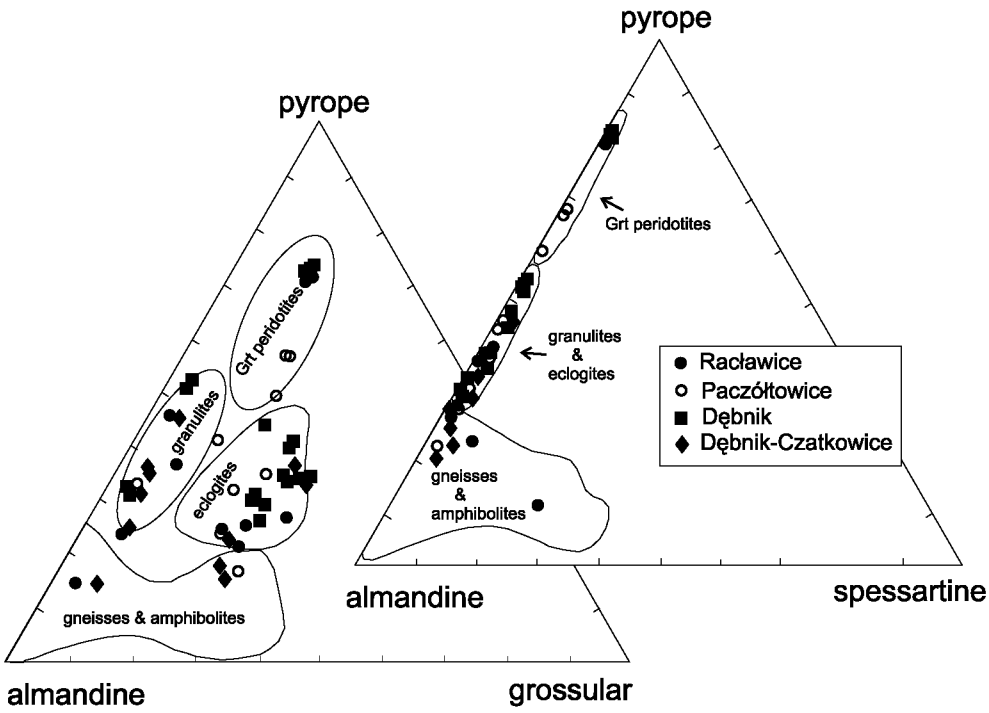

Fig. 1. Composition of the detrital garnets from the Bathonian-Callovian sands from the Cracow Region and their source rocks

Fig. 1. Skład detrytycznych granatów z batońsko-kelowejskich piaskach z obszaru krakowskiego i ich skały źródłowe

All the garnets from the **Dębnik** locality are characterized by high pyrope contents (> 30 mol %). Such garnets are typical for high-grade metamorphics. According to chemical variability, they represent garnets from garnet peridotites, granulites and eclogites. In the quarry **between Dębnik and Czatkowice**, garnets from garnet peridotites, granulites and eclogites were distinguished. Garnets from gneisses were in minority. The source rocks of the garnets from **Racławice** locality were granulites, eclogite, gneisses and amphibolites. **Paczółtowice** locality contains ganets from garnet peridotites, granulites and eclogites.

DISCUSSION AND CONCLUSIONS

All the examined samples yielded surprisingly high portion of pyrope-almandine to pyrope garnets. The heavy mineral percentages and the garnet chemistry are very similar to the data from the West Carpathian externides. In this part of the Hercynides, however, it is difficult to estimate the source area. As mentioned in the introduction, there are only small

terrains with granulites and eclogites in Poland (Góry Sowie and Śnieżnik). Granulitic rocks are generally considered as exotic in the area of Cracow. Some granulitic pebbles were found in the Carboniferous sediments of the Upper Silesia Coal Basin (Paszkowski *et al.* 1995). In the Carboniferous clastics of the Moravo-Silesian Zone, the authors invariably derive the clastic material from the Moldanubian Zone of the Bohemian Massif (Paszkowski *et al.* 1995, Hartley & Otava 2001). Similarly, the crustal segments of the Pieniny Klippen Belt were interpreted to be derived from the Moldanubian Zone (Aubrecht & Méres 1999, 2000). However, the new data presented in this paper indicate that the source area should be more proximal to the recent Polish Platform. The detrital garnet chemistry shows that the source area was predominantly formed by granulites, eclogites and peridotites. Any river draining recently known crystalline areas in the Moravo-Silesian Zone would bring a big portion of almandine-rich garnets coming from phyllites, mica-schists and gneisses, because they form majority of these terrains. Góry Sowie and Śnieżnik cannot solely represent a source area. The only possible interpretation is to admit an existence of yet unknown terrane with granulites, eclogites and peridotites that was situated near the Moravian-Silesian area before the Jurassic rifting.

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