MINERALOGIA POLONICA – SPECIAL PAPERS
Volume 31, 2007

Roman AUBRECHT[1], Štefan MÉRES[2], Michał GRADZINSKI[3], Milan SÝKORA[1]

PROVENANCE OF DETRITIC GARNETS IN THE MIDDLE JURASSIC CLASTIC SEDIMENTS OF THE CRACOW REGION.

Abstract: Detritic garnets from the Upper Bathonian/Lower Callovian sands of the Cracow-Wieluń Upland show high proportion of the almandine-pyrope and even pyrope garnets. Their source rocks were most likely granulites, eclogites and ultrabasics. Their source area is unknown. Similar compositions of the detrital garnets were also recorded in the Outer Western Carpathians (Flysch Zone, Pieniny Klippen Belt), i.e. the crustal segments which formed Silesian and Magura cordilleras and the Czorsztyn Swell were not necessarily derived from Moldanubian Zone of the Hercynides as was thought before.
Keywords: heavy minerals, Jurassic, Kraków-Wieluń Upland, 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 numerous granulitic pebbles from the Silesian Unit of the Flysch Zone. Pyrope-almandine 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

[1] *Department of Geology and Paleontology, Faculty of Natural Sciences, Comenius University, Mlynská dolina - G, 842 15 Bratislava, Slovakia*
[2] *Department of Geochemistry, Faculty of Natural Sciences, Comenius University, Mlynská dolina - G, 842 15 Bratislava, Slovakia*
[3] *Institute of Geological Sciences, Jagiellonian University, Oleandry 2a, PL-30-063 Kraków, Poland*

Śnieźnik area complex in the Western Sudetes (Oberc 1972; Smulikowski 1967; 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. 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. The sands gradually pass upwards into sandy limestone of Calloviense zone which is about 3 m in thickness. The underlying clastics are then of uppermost Bathonian and lowermost Callovian age. Percentual amounts 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 heavy minerals at 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 cca 2.8 g/cm^3). To check the ratios of various heavy minerals in the samples, the fraction 0.08-0.25 mm was studied in transmitting polarized light. The amounts of heavy minerals were determined by ribbon point counting. Detrital garnets were separated manually under binocular lens. 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 INTERPRETATIONS

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 (for better overview, in the diagram they are grouped together with garnets from gneisses). They are characteristic by pyrope contents of about 15-25 mol %, low spessartine contents (< 10 mol%), higher grossular contents (20-30 mol %) and relatively high contents of almandine (~ 75 mol %).

All the garnets from the **Dębnik** locality are characterized by high pyrope contents (> 30 mol %). Such garnets are typical for granulites, eclogites and garnet peridotites. In the samples from 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, eclogites, gneisses and amphibolites. Garnets from the **Paczółtowice Locality** were derived from garnet peridotites, granulites and eclogites.

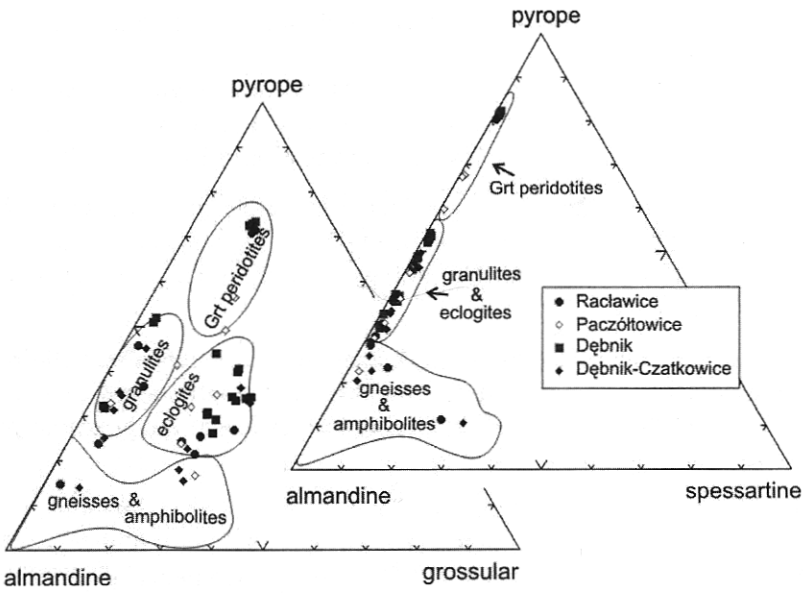

Fig.1. Composition of the detrital garnets from the Bathonian-Callovian sands from the Cracow Region and their source rocks (for source rocks - see Aubrecht and Méres, 2000).

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 Śnieźnik). 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 Śnieźnik 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.

Acknowledgements: The authors are thankful to the APVV grant agency for grants No. 0571-06, 0465-06 and VEGA grant agency for grant No. 1/2031/05 and No. 1/4035/07.

REFERENCES

AUBRECHT R., 1993: Clastic admixture in Dogger crinoidal limestones of Czorsztyn Unit. Geologica Carpathica 44, 2: 105-111.

AUBRECHT R., 2001: Jurassic heavy mineral distribution provinces of the Western Carpathians. Mineralia Slovaca 33, 5: 473-486.

AUBRECHT R., MÉRES Š., 1999: Possible Moldanubic provenance of the Pieniny Klippen Belt crystalline basement deduced from detrital garnets. Carpathian Geology 2000 symposium, Geologica. Carpathica 50, spec. issue, 13-14, Smolenice, Slovakia.

AUBRECHT R., MÉRES Š., 2000: Exotic detrital almandine-pyrope garnets in the Jurassic sediments of the Pieniny Klippen Belt and Tatric Zone: where did they come from? Mineralia Slovaca 32, 1: 17-28.

ČOPJAKOVÁ R., SULOVSKÝ P., OTAVA J., 2001: Utilization of detrital garnet chemistry for determination of the provenance and lithostratigraphy of the Culm of Drahany Upland. Mineralia Slovaca 33, 5: 509-511 (in Czech).

FAUPL P., 1975: Kristallinvorkommen und terrigene Sedimentgesteine in der Grestener Klippenzone (Lias-Neokom) von Ober und Niederösterreich. Ein Beitrage zur Herkunft und Genese. Jahrbuch der Geologischen Bundesanstalt 118, 1-74.

GRZEBYK J., LESZCZYŃSKI S., 2006: New data on heavy minerals from the Upper Cretaceous-Paleogene flysch of the Beskid Śląski Mts. (Polish Carpathians). Geological Quarterly 50, 2: 265-280.

HARTLEY A.J., OTAVA J., 2001: Sediment provenance in a deep marine foreland basin: the Lower Carboniferous Culm Basin, Czech Republic. Journal of Geological Society, London 158, 137-150.

KRYSOWSKA M., 1960: Zespoły minerałów ciężkich w osadach jury brunatnej okolic Krzeszowic. Biuletyn Institutu Geologicznego 152, 289-320.

KRYSOWSKA M., 1962: Analiza petrograficzna utworów środkowo-jurajskich z Rzeszotar. Rocznik PTG 32, 4: 565-578.

KRYZA R., PIN C., VIELZEUF D. 1996: High-pressure granulites from the Sudetes (south-west Poland): evidence of crustal subduction and collisional thickening in the Variscan Belt. Journal of Metamorphic Geology 14: 531-546.

OBERC J., 1972: Budowa geologiczna Polski. Tektonika - 2. Wydaw. Geologiczne, Warszawa, 307 pp.

OTAVA J., KREJČÍ O., SULOVSKÝ P., 1997: The first results of study of garnet chemisty from the sandstones of the Rača Unit of the Magura Flysch. Geologický výzkum Moravy a Slezska v r.1996 39-42 (in Czech).

OTAVA J., SULOVSKÝ P., KREJČÍ O., 1998: The results of chemistry of detrital garnets from the Cretaceous sediments of the Rača Unit, Magura Group. Geologický výzkum Moravy a Slezska v r.1997 10-12 (in Czech).

PASZKOWSKI M., JACHOWICZ M., MICHALIK M., TELLER L., UCHMAN A., URBANEK Z., 1995: Composition, age and provenance of gravel-sized clasts from the Upper Carboniferous of the Upper Silesia Coal Basin (Poland). Studia Geologica Polonica 108: 45-127.

SALATA D., 2004: Detrital garnets from the Upper Cretaceous-Paleogene sandstones of the Polish part of the Magura Nappe and the Pieniny Klippen Belt: chemical constraints. Annales Societatis Geologorum Poloniae 74, 3: 351-364.

SMULIKOWSKI K., 1967: Eclogites of the Śnieźnik Mts. in the Sudetes. Geologia Sudetica 3: 7-180.

ŠTELCL J., SCHMIDT J., SVOBODA L., NOVOTNÝ M., 1972: Notes to the petrography of autochtonous Paleozoic, Mesozoic and Paleogene in the basement of the Carpathian Foredeep and Flysch Belt in southern Moravia. Folia Facultatis Scientiarum Naturalium Universitatis Purkynianae Brunensis13, Geologia 23, 2: 3-106 (in Czech).

ŠTELCL J., SVOBODA L., SCHMIDT J., ZÁDRAPA K., 1977: Notes to the petrography of autochtonous Paleozoic and Mesozoic in the platform basement of the Carpathian Foredeep and Flysch Belt (sections "SOUTH" and "CENTRE"). Folia Facultatis Scientiarum Naturalium Universitatis Purkynianae Brunensis 18, Geologia 29, 14: 5-120 (in Czech).

WIESER T., 1985: Some remarks on the sedimentation, composition and provenance of exotics-bearing conglomerates in the Western Polish Carpathians flysch formations. In: Wieser, T. (ed.): Fundamental researches in the western part of the Polish Carpathians. Guide to excursion 1. XIII CBGA Congress, 57-68, Cracow, Poland.