PROVENANCE OF HEAVY MINERALS OF THE JARMUTA AND SZCZAWNICA FORMATIONS (POLISH FLYSH CARPATHIANS)

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Abstract: Heavy mineral fractions of the Jarmuta Fm and the Szczawnica Fm have been analysed. They consist mainly of ultra-stable zircon, tourmaline and rutile. Besides, garnet, apatite and a significant number of chromian spinels are present. The investigated heavy fractions represent mixtures of minerals deriving from different rocks deposited in one sedimentary basin. They comprise low to medium grade metamorphic rocks, sedimentary as well as granitoides and ultramafic ones.

Key words: Jarmuta Fm, Szczawnica Fm, heavy minerals, provenance.

The area of investigations

Samples for investigations were taken in the Szczawnica Formation in Krościenko-Zawodzie and Krościenko Łąkcica and in the Jarmuta Formation in Krościenko-Zawiasy, Szczawnica Zabaniszcze, Sielski stream and in Black Water stream.

The Szczawnica Fm (Palaeocene-Lower Eocene) in the Krościenko-Zawodzie and Krościenko Łąkcica sections are parts of Krynica Subunit of the Magura nappe (Birkenmajer & Oszczypko, 1989). The Jarmuta Fm (Maastrichtian-Palaeocene) in the Krościenko Zawiasy section belongs to the Branisko succession of the Pieniny Klippen Belt, while sediments of the Krościenko Zabaniszcze, Sielski stream and Back Water stream belong to the Magura succession of the Pieniny Klippen Belt (Birkenmajer, 1977, 1986).

The clastic material of the formations was delivered from the southeast.

Analytical methods

During microscopic observations, only transparent minerals were counted.

The chemical composition of minerals was analysed in polished grain mounts using scanning electron microscopy (SEM) JEOL 5410 equipped with an energy

dispersive spectrometer (EDS) Voyager 3100 (NORAN). The data were normalised according to “standardless” procedure i.e. (using standards from the software library supplied by the manufacturer).

An internal zoning in zircons was analysed using hot cathode equipment HC2-LM, Simon Neuser, Bochum.

Composition of heavy fractions

Heavy mineral assemblages of the Jarmuta and Szczawnica formations consist mainly of ultra stable assemblages of tourmaline, zircon and rutile. Besides, in heavy fractions garnet and chromian spinels as well as small number of apatites, and touches of epidote, brookite and chloritoide are present. The number of garnet and chromian spinels in the Jarmuta Fm varies significantly between samples. The percentages of heavy minerals are shown in the Table 1. Characteristic features of the most important members of the investigated heavy fractions are described below.

Tourmalines are characterised by dark-greenish brown to brownish yellow pleochroic colour. The majority of grains are zoneless. Zoning, if present, is visible as a faint change in colour intensity. The best part of tourmalines are present in the form of strongly rounded grains. Chemical composition of tourmalines allowed to classify them as members of the schörl-dravite series. Points reflecting their chemistry in discrimination diagrams for provenance of tourmalines locate generally in fields corresponding to different kinds of granitoides and metasediments (Henry & Guidotti, 1985).

The population of zircons is varied. Differences are especially noticeable in terms of colour. There are colourless or pinkish or slightly yellow grains. In the pink coloured zircons, internal zoning is particularly visible. Like for tourmalines, most of the zircon grains display a high degree of roundness. The cathodoluminescence analyses have revealed that internal zoning of zircons is mainly of magmatic origin. Regarding zoning six types of zircons were distinguished: 1) the most frequent one - regular oscillatory zoned, 2) two-stage with brightly luminescent oscillatory core and dark oscillatory zoned margins, 3) displaying patchy zoning, 4) with a very complex internal pattern. Apart from zoning, the following varieties of zircon grains were noticed: a) containing inclusion of a non-luminescent mineral in the central part of a grain, b) zircons with a magmatic zoning which show embayments due to partial resorption, 6) grains with bright yellow, probably xenotime, rim, 8) non- luminescent (Salata & Leichmann, 2002).

Garnet is present in the form of irregular pinkish fragments. Because of a very small number of garnets in sediments of the Szczawnica Fm, the required analyses could have been so far carried out for the Jarmuta Fm only. The dominating molecule of garnets occurring there is almandine, which comprises up to 80 % of end-members. Other constituents are: pyrope (4-25 %), andradite (4-10 %), grossular (1-15 %) and spessartine (2-25 %). Compositional variability within single grains has not been detected.

Chromian spinels are characteristic components of the investigated heavy fractions. They are present as reddish-brown angular fragments. Their characteristic colour is visible only in thin grains. They comprise up to 9 % and 6 % of the transparent heavy mineral assemblages in the Jarmuta and the Szczawnica formations respectively (for further information see the abstract entitled *"Provenance of Chromian Spinels of the Szczawnica (Magura Nappe) and the Jarmuta (Pieniny Klippen Belt) Formations in the Light of Their Chemical Composition"* by Dorota Salata in the Congress Proceedings Book).

Rutile is present in the form of rounded or hipidiomorphic brown or brownish-yellow grains. It comprises a considerable number of the investigated heavy fractions, but due to its little usefulness as an indicator of source rocks, chemical analyses of it have not been carried out.

Apatite grains are colourless and very often strongly rounded. They contain many inclusions.

Apart from zircon, monazite and xenotime grains were noticed. Monazite grains are often rounded. They displayed blue colour in cathodoluminescence. Xenotime occurs as single grains or as overgrowths on zircon ones (Salata & Leichmann, 2002). The latter feature is probably the effect of diagenetic processes in sediments. Since it is very difficult to distinguish zircon, xenotime and monazite, particularly if grains are strongly rounded or partly altered, all these minerals were counted together (table 1).

Provenance of the clastic material

Because the investigated heavy fractions consist mainly of ultra stable minerals, the determination of source rocks may be very difficult. However, chemical composition and internal structure may well provide some clues.

The chemistry of tourmalines, as already mentioned, leads to the conclusion that they derive from different kinds of metasediments as well as granitoides. Planar oscillatory zoning of the majority of zircons suggests that they crystallised in magmatic conditions. Only a relatively small number of zircons displayed features (inner embayments) of partial resorption. Nevertheless, the fact does not exclude the possibility that zircons with undisturbed magmatic zoning could just survive metamorphic stage in low-grade metamorphic conditions. Almandine is the type of garnet, which can be found in metamorphic rocks as well as granitoide ones so it is not a good tool for determining a type of the source rock.

The presence of strongly rounded grains (tourmalines and zircons) suggests that that they could derive from a source areas located at a great distance from the sedimentary basin or from older eroded and reworked sedimentary rocks. They could have been mixed with fresh sediment, which is supported by the fact that in the investigated fractions strongly rounded grains occur together with idiomorphic or hipidiomorphic ones.

The relatively large number of chromian spinels in the Jarmuta Fm suggests the presence of a source region built of mafic or ultramafic rocks to the South of the Pieniny Klippen Belt. Their

chemistry points to Cr-rich cumulates as well as lherzolites and harzburgites, which could have been parts of an ophiolite sequence. Such an area, which is a subduction zone, has already been postulated by Birkenmajer (1986) and others.

To sum up, it seems that the investigated heavy fractions represent mixtures of minerals deriving from different rocks deposited in one sedimentary basin. They comprise low to medium - grade metamorphic rocks, sedimentary as well as granitoides and ultramafic ones.

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Table 1: Heavy minerals of the Jarmuta and Szczawnica formations (volume %)

locality	Zrn/Mnz/ Xe	Tur	Rt	Grt	Ap	Cr-Spl	Ep	St	Brk	Cld
Jarmuta Fm Krościenko Zawiasy	35,3	36,3	17,4	3,8	0,9	2,3	4,1	0,0	0,0	0,0
	26,0	60,7	9,2	0,6	0,9	2,7	0,0	0,0	0,0	0,0
	38,0	47,0	21,2	2,2	0,6	3,8	0,2	0,0	0,0	0,0
Jarmuta Fm Sielski stream	45,7	25,7	13,6	10,5	2,4	1,6	0,0	0,0	0,5	0,0
Jarmuta Fm Szczawnica Zabaniszcze	48,4	25,1	14,8	0,9	1,7	9,1	0,0	0,0	0,0	0,0
	20,6	41,6	6,8	23,5	5,6	1,5	0,0	0,0	0,1	0,3
Jarmuta Fm Black Water	44,2	18,0	13,8	14,9	0,5	8,2	0,0	0,2	0,0	0,3
Szczawnica Fm Krościenko Łąkcica	31,4	52,2	9,4	1,5	2,1	4,7	0,0	0,0	0,3	0,0
Szczawnica Fm Krościenko Zawodzie	43,4	32,2	16,6	0,2	0,1	5,9	1,4	0,0	0,2	0,0