GEOLOGICA CARPATHICA, 44, 2, BRATISLAVA, APRIL 1993
105 - 111

CLASTIC ADMIXTURE IN DOGGER CRINOIDAL LIMESTONES OF CZORSZTYN UNIT

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(Manuscript received February 29, 1992; accepted in revised form June 24, 1992)

Abstract: The clastic admixture in the Smolegowa and Krupianka Limestones (Czorsztyn Unit) was analysed in various localities. Heavy mineral analysis shows the predominance of garnet and zircon and smaller quantities of rutile, tourmaline and other minerals. By the method of zircon typology three various granitoid sources were distinguished, two of them unknown in the Hercynian granitoids of the Central Western Carpathians. The reconstruction of the source area shows a similarity with the core mountains of the Central Western Carpathians with granitoids intruded into a metamorphosed complex and covered with sedimentary rocks, but with differences in the chemical composition of the granitoids. This fact supports the theory about the separation of the sedimentation area of the Pienidic units from the Central Western Carpathians during Dogger.

Key words: Dogger, Pieniny Klippen Belt, Czorsztyn Unit, crinoidal limestones, heavy minerals, zircon typology.

Introduction

The problem of clastic admixture and the building of the source area of the Pienidic units has been dealt by several authors, including Lozinski (1956, 1959), Birkenmajer et al. (1960), Halajová (1981), Krawczyk & Slomka (1987) and Krawczyk et al. (1987). Lozinski (1956, 1959) analysed the associations of heavy minerals from the "flysch Aalenian", of the Lower and Middle Cretaceous of the Pieniny Klippen Belt. He found a predominance of garnet and less zircon, rutile and tourmaline during the Aalenian. This changes and the zircon becomes predominant during the time between the Aalenian and Neocomian. Halajová (1981) analysed heavy mineral associations from Dogger crinoidal limestones of the Czorsztyn Unit. Her results show primarily the predominance of zircon and less garnet, rutile and tourmaline. Other papers concerned exotic pebbles in the Bathonian lower nodular limestone (Niedzica Limestone) of the Niedzica Unit and Szlachtowa Formation (former "flysch Aalenian") of the Grajcarek Unit.

This contribution deals with the clastic admixture in Dogger crinoidal limestones of the Czorsztyn Unit (Smolegowa and Krupianka Limestones). Analysed samples were taken from 10 localities and the results from 4 localities mentioned by Halajová (1981) were also used (Fig. 1, Tab. 1).

Description of localities

1. Bolešovská dolina Valley - locality of the Czorsztyn Unit described also in Salaj (1990) as a part of the Fodorka Sequence. It occurs 4 km NW from the village Bolešov at the end of Bolešovská dolina Valley at the forest road. The sample was taken from the white sandy crinoidal limestone with small dispersed pebbles. It is marked in Salaj (l.c.), Tab. 1, Fig. 1, by letter a.

2. Vršatec - locality described in Mišík (1979) (profile II). The locality is found in the Vršatec Klippes, 1 km NE from the village Vršatecké Podhradie at the blue marked tourist route going to Červený Kameň. The sample was taken from the white sandy crinoidal limestone with small quartz pebbles in the upper slice.

3. Babiná - locality described in Halajová (1981). It is found 1.5 km NW of the village Bohunice nad Váhom. The roundness ratio of zircons was calculated from the material of Halajová; all other data were taken from her work (Halajová, l.c.).

4. Červený Kameň - locality described in Halajová (1981). It is found at Czorsztyn klippe in the saddle north of the village of Červený Kameň. All data except the roundness of zircons were taken from Halajová (l.c.).

5. Mikušovce - locality is found WSW from the village Mikušovce near the Mn occurrence described by Andrusov (1945) and Andrusov et al. (1955).

6. Mestečská skala - locality is found about 10 km NW from Púchov at the village Mestečko.

7. Dolná Mariková - two samples from the locality were analysed by Halajová (1981). All the data except the roundness of zircons were taken from this work. The locality is found West of the village of Dolná Mariková, N of Púchov.

8. Hatné - quarry found at the SE margin of the village Hatné near the main road. The sample was taken from red sandy crinoidal limestone with very small quartz pebbles.

9. Údol - the sample was taken from red crinoidal limestone of the klippe neighbouring the one drawn by Nemčok & Rakús (1988a, p. 37). It occurs NE of the village of Údol in eastern Slovakia.

10. Kyjov-Pusté Pole - locality described by Nemčok (1988, p. 35). It is a small klippe found SE from the village of Pusté Pole at the field road. The sample was taken from red sandy crinoidal limestone.

11. Kamenica - locality described by Nemčok & Rakús (1988 b, p. 32). It represents the castle hill near the village of Kamenica

in eastern Slovakia. The sample was taken from red crinoidal limestone.

12. Milpoš - locality found at the end of the village of Milpoš (Eastern Slovakia) above the left bank of the stream. The sample was taken from red sandy crinoidal limestone with abundant small pebbles.

13. Beňatina - locality described by Rakús (1990). It is found 1.5 *km* NE of the village of Beňatina (Eastern Slovakia). The sample was taken from the sandy and conglomerate layer in white crinoidal limestone.

Methods of research

The samples were dissolved in acetic acid (13 %). The heavy minerals were separated in bromophorm and studied in transmitted light. Some samples of red crinoidal limestone had to be boiled in concentrated hydrochloric acid in order to eliminate the limonitic and pyritic admixture; this enabled observations in transmitted light. By this method, unfortunately, apatite was also eliminated, thus in these samples it could not be included in the tables of results. The ratios of heavy minerals contents were then calculated statistically. The zircons were separated from the rest of the heavy fraction, especially from the diamagnetic fraction. The Pupins method of zircon typology is described in a separate chapter.

Heavy mineral associations

The main transparent heavy mineral association in the crinoidal limestones of Czorsztyn Unit is garnet, zircon and rutile, with less tourmaline and apatite (see Fig. 1, Tab. 1). A small quantity of staurolite, titanite and other minerals was also observed. All the samples contained various quantities of opaque minerals, mainly limonite and pyrite (more than 70 %), but they were not studied.

Garnet - the grains are isotropic, transparent, colourless, pink, rarely of reddish colour. They are rounded; idiomorphic grains are very rare. Often a stair-like shape occurs on the surface, caused by the partial intrastratal solution. It is very probable that a major part of the garnets has a metamorphogenic origin, because of their decreasing quantity during the Mesozoic due to erosional progress (Fig.9). Garnet is one of the dominating heavy minerals in studied samples. The lowest quantity is 14% in the Kamenica locality, the highest 54 % in the Milpoš locality.

Zircon - the grains are unisotropic with parallel extinction, and very high birefringence. They are transparent and colourless, often with liquid inclusions. Some grains have zoning structure. The ratio of rounded and idiomorphic zircons in only one sample (Mikušovce locality) was less than one (Fig. 2). That indicates a long transport or more likely the resedimentation of zircon grains from older sedimentary complexes. In the studied samples, the quantity of zircon grains is from 9 % (Údol) to 53 % (Červený Kameň). The typological analysis of zircons is described in a special chapter.

Rutile - the grains are unisotropic, with parallel extinction; they have red, brown-red to orange colouration. All the grains are rounded with well-visible cleavage cracks. Their quantity in studied samples is from 8 % (Bolešovská dolina Valley) to 47 % (Dolná Mariková 2).

Tourmaline - the grains are unisotropic with parallel extinction and very expressive pleochroism sometimes similar to extinction. They have green to brown, rarely bluish colouration, turning almost black in the direction of the highest absorption. Opaque inclusions are very frequent inside the grains. The quantity of tourmaline grains in studied samples is from 1 % (Bolešovská dolina Valley) to 29 % (Údol).

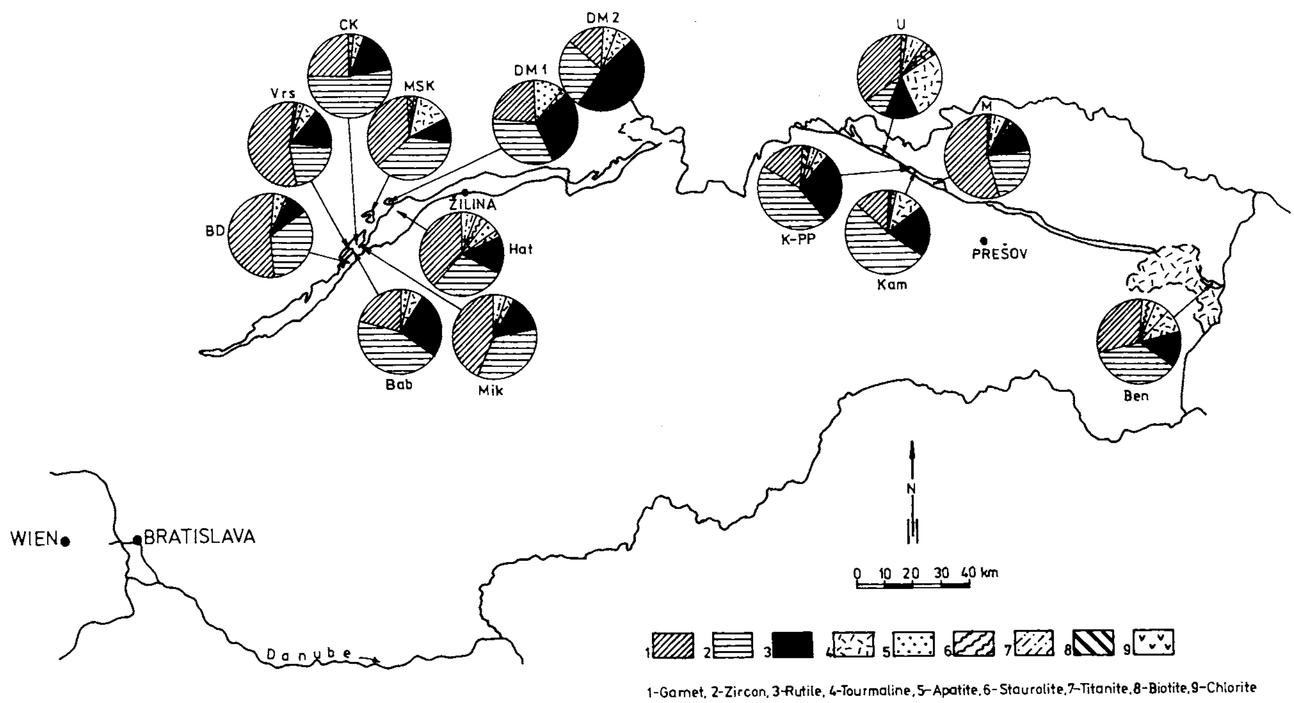


Fig. 1. Positions of the localities in Pieniny Klippen Belt and their ratios of heavy minerals.
Abbreviations: BD - Bolešovská dolina Valley, Vrs - Vršatec, Bab - Babiná, CK - Červený Kameň, Mik - Mikušovce, DM1(2) - Dolná Mariková 1(2), Hat - Hatné, U - Údol, K-PP - Kyjov-Pusté Pole, Kam - Kamenica, M - Milpoš, Ben - Beňatina.

Table 1: Heavy minerals assembledges in studied samples (in %).

Locality	Gr	Zr	Ru	Tou	Ap	St	Tit	Other	Sum
Bolešovská dolina	53	32	8	1	5	0	0	unident. 1	100
Vršatec - profil II	53	22	15	5	3	+	1	unident. 1	100
Babiná*	19	40	23	5	3	0	+	+amphib.	100
Červený* Kameň	25	53	17	4	1	0	0	0	100
Mikušovce	43	35	14	3	?	0	5	0	100
Mestečská skala	36	36	9	14	?	0	0	biot.1 chlor.3 unident. 1	100
Dolná* Mariková 1	24	33	30	2	11	0	+	+epidote +andal. +topaz	100
Dolná* Mariková 2	15	26	47	7	5	0	+	+epidote +andal. +topaz	100
Hatné	39	28	14	3	4	5	6	+biotite +chlor. +andal.	100
Údol	35	9	13	29	2	4	7	chlorite 1	100
Kyjov - Pusté Pole	18	44	28	4	?	0	4	biotite 2	100
Kamenica	14	52	20	11	?	0	2	chlorite 1	100
Milpoš	54	23	12	2	?	1	6	biotite 1	100
Beňatina	30	36	14	9	5	5	0	+biotite +chlor. +anatase	100

Note: At the underlined localities the hydrochloric acid was used at solution, so the possible apatite could not be included. Localities marked with asterisk according to Halajová (1981). + means occurrence less than 1.

Abbreviations: Gr - garnet, Zr - zircon, Ru - rutile, Tou - tourmaline, Ap - apatite, St - staurolite, Tit - titanite, unident. - unidentified minerals, amphib. - amphibole, biot. - biotite, chlor. - chlorite, andal. - andalusite.

Apatite - the grains are unisotropic with parallel extinction and with very low birefringence. Some grains have the typical shape of a hexagonal prism, but they are relatively rare. The quantity of apatite (in the samples, where they were not eliminated by boiling in HCl) is from 1 % (Červený Kameň) to 11 % (Dolná Mariková 1).

Staurolite - the grains are unisotropic, often rounded, with an expressive pleochroism of light yellow, bright yellow to almost orange colour. It occurs in only 5 of the studied localities and maximally reaches 5 % (Hatné, Beňatina). It is the most important indicator of a metamorphogenic primary source.

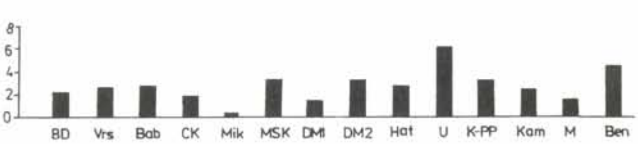


Fig. 2. Ratio of rounded and idiomorph zircon grains in studied samples. Abbreviations see Fig. 1.

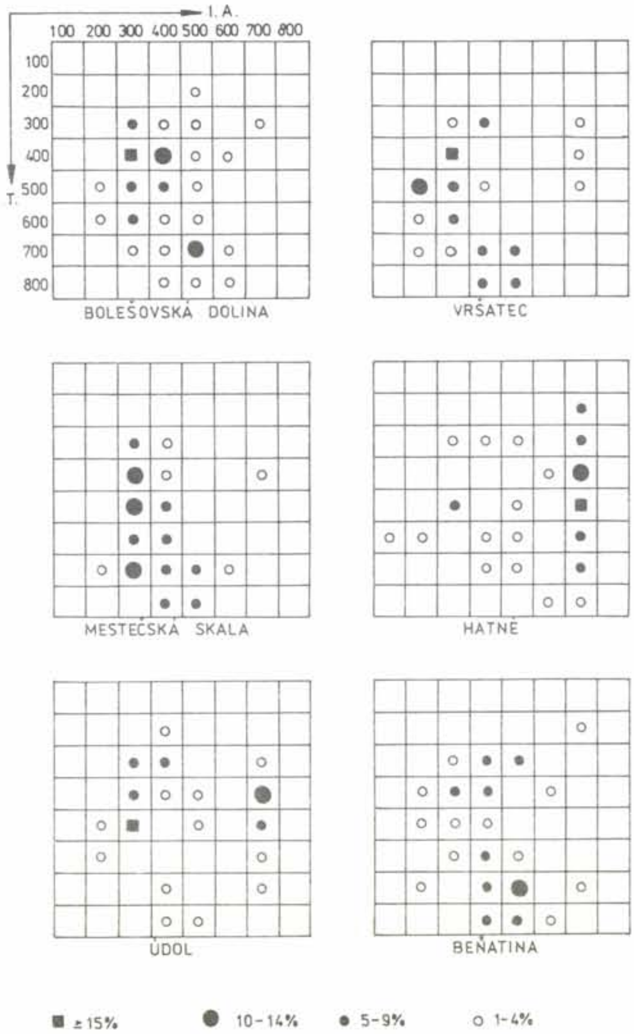


Fig. 3. Percentages of the zircon types in studied samples.

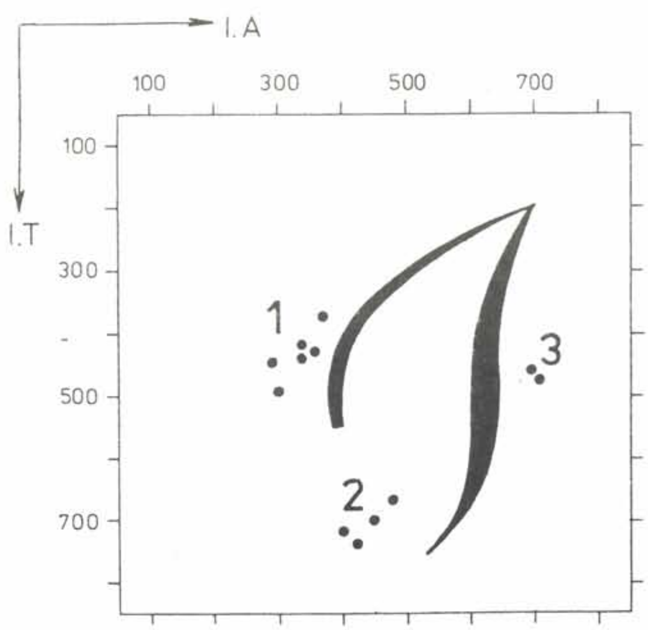
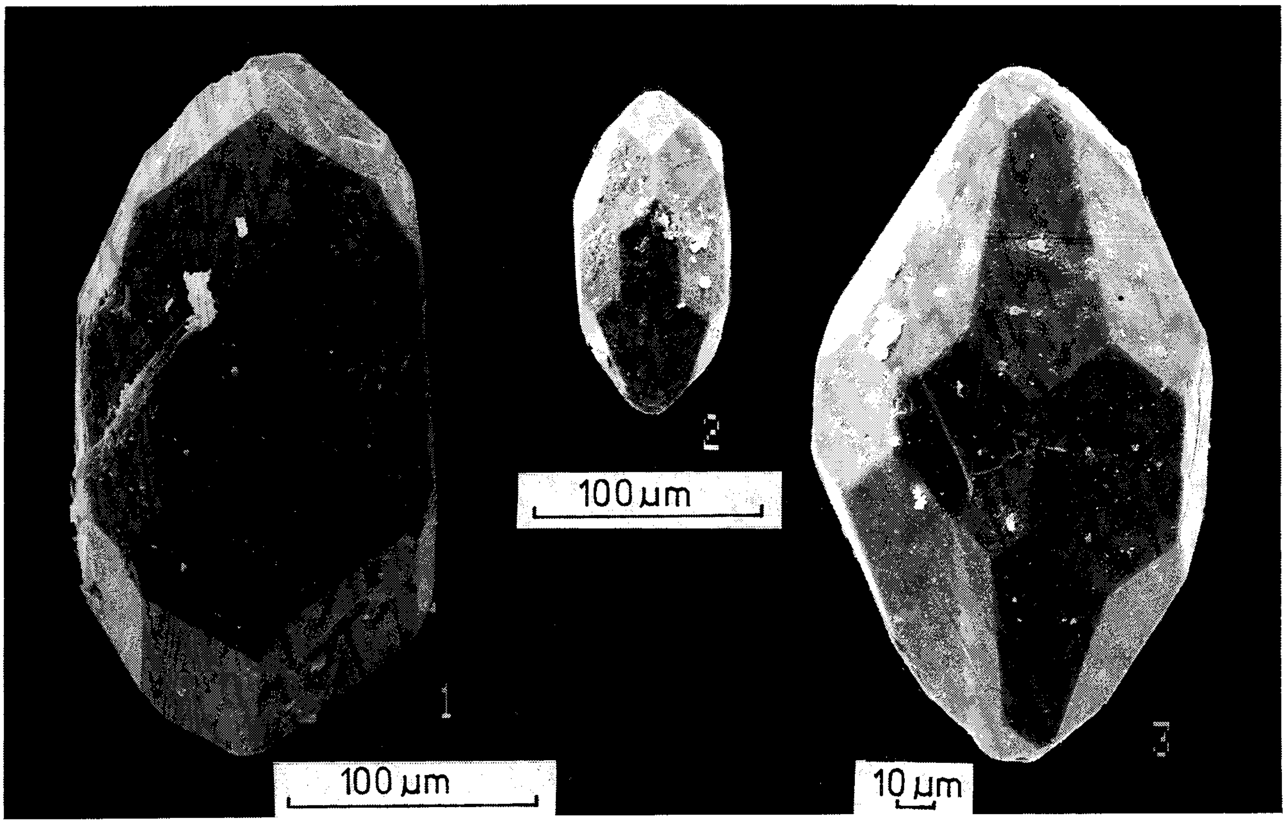
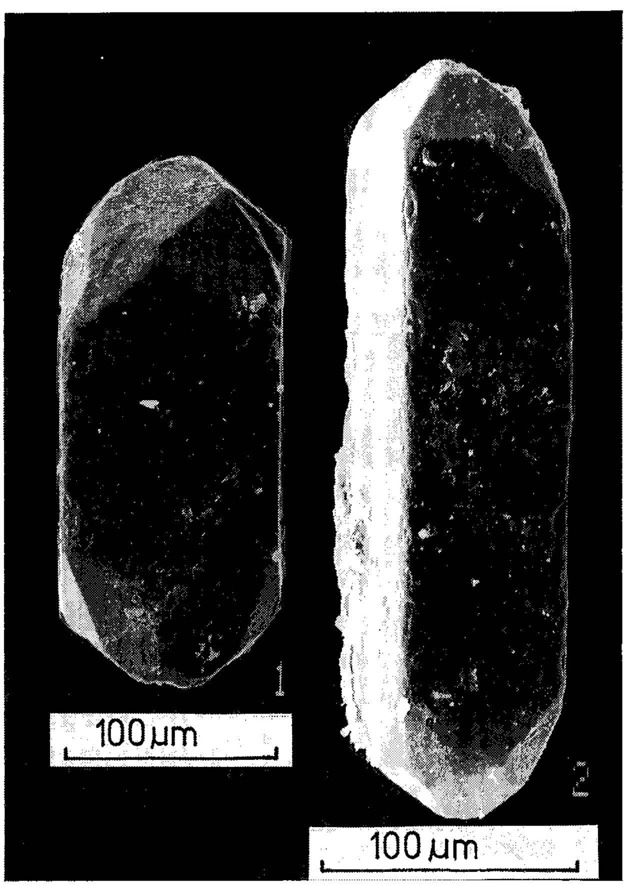


Fig. 4. The mean points of the sources of clastic zircon. Black lines are the boundary restricting the fields of the granitoids of mantle origin (right), hybrid granitoids (middle) and the granitoids of crustal origin (left), (according to Pupin 1980).





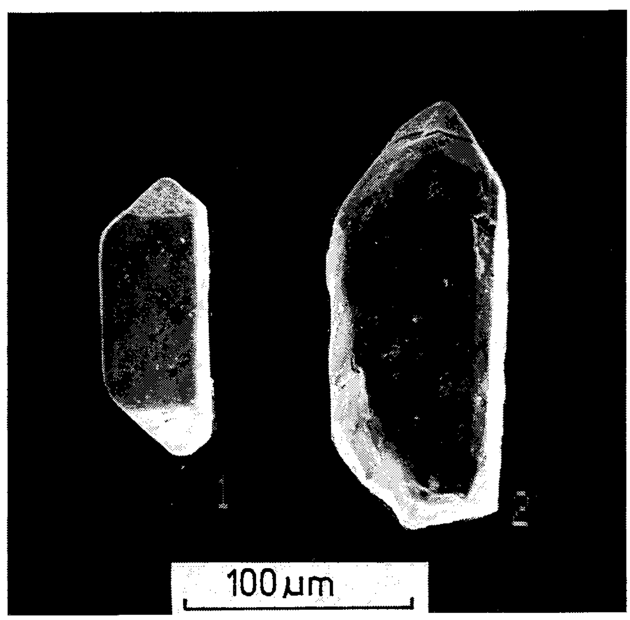


Fig. 5a. Zircon types representing the source No. 1. 1 - S_8 type, Bolešovská dolina Valley ; 2 - S_{12} type, Beňatina ; 3 - S_{11} type, Beňatina .
Fig. 5b. Zircon types representing the source No. 2. 1 - S_{23} type, Bolešovská dolina Valley; 2 - J_4 type, Mestečská skala.
Fig. 5c. 1 - P_4 type, Údol; 2 - P_2 type, Údol.

Titanite - it is unisotropic, always rounded, with very high birefringence. It has grey to pinkish colouration. It occurs in 10 of the studied localities and maximally reaches 7 % (Údol).

Other minerals i.e. epidote, anatase, andalusite, topaz and amphibole are not frequent. They reach less than 1 %. Biotite and chlorite occur in both the heavy and the light fractions. According to an oral communication of Dr. M. Sýkora, some grains of chromic spinels were found in Beňatina locality.

Zircon typology

The method of dividing the zircon types according to their origin was described by Pupin & Turco (1972), Pupin (1980). This method enables us to explain the chemical and PT conditions in which the parent rock originated. The study of zircons from clastic material in sedimentary rocks helps to determine the source material the zircons were derived from, and makes the heavy minerals analysis more exact and informative. The samples from six localities (Bolešovská dolina Valley, Vršatec, Mestečská skala, Hatné, Údol and Beňatina) were evaluated by this method. About 100 zircon grains from each sample were separated and studied with the JEOL scanning microscope (J. Stankovič, Geol. Inst. of D. Štúr - Bratislava) and under the binocular lens. The quantitities of each type were recorded in a table. Then the percentages of the types (Fig. 3) and their mean points (Fig. 4) were calculated according to Pupin (1980). By this method the three main sources of zircons were distinguished, in various proportions in each sample. The first one is determined by dominating S_7, S_8, S_{11} and S_{12} types (Fig. 5a), the second one by the types S_{23}, S_{24}, J_3 and J_4 (Fig. 5b). The third source contains mainly P-types, especially P_2 and P_3 types (Fig. 5c). The sources 1 and 2 are not sharply divided, which indicates their possible comagmatic origin. In order to calculate the mean points of the single source, the approximate boundary had to be lined between them going between S_{17} and S_{12} types and between S_{13} and S_8 types. The location of the boundary is due to the minimal contents of zircon grains in the area between the sources. The third source is sharply separated from the rest and its mean point can be calculated more exactly.

Source No. 1 - its location corresponds well with the field of the mean points calculated by Broska & Uher (1991) for the granitoids of the Central Western Carpathians, so we can suppose that the source rock had the same chemical composition and PT conditions when it originated. The zircons of this source-rock occur mainly in the samples from Bolešovská dolina Valley, Vršatec, Mestečská skala and Údol, less in Hatné and Beňatina.

Source No. 2 - is unknown in the granitoids of the Central Western Carpathians, but it corresponds well with the distribution of the mean points of the samples analysed by Uher (in Kováč et al. 1991) from the Lower Miocene of Dobrá Voda Depression in the northern part of Malé Karpaty Mts. The source of the clastic material is supposed to be derived from the teritory of the Pieniny Klippen Belt, which is supported also by this paper. The zircons from this source were recorded in the localities Bolešovská dolina Valley, Mestečská skala and Beňatina, less in Vršatec, and they were almost absent in Údol and Hatné.

Source No. 3 - is completely unknown in the Western Carpathians up to the present time. It lays in the field reserved for the high alcaline granitoids of mantle origin in its middle or lower temperature part according to Pupin (1980). A similar source, but of higher temperature, was found in the granitoids of the Velence Mts. in Hungary (Gbelský & Határ 1982). This source is the least abundant in the studied samples. It occurs in the samples from Hatné and Údol; in the other samples it is almost absent.

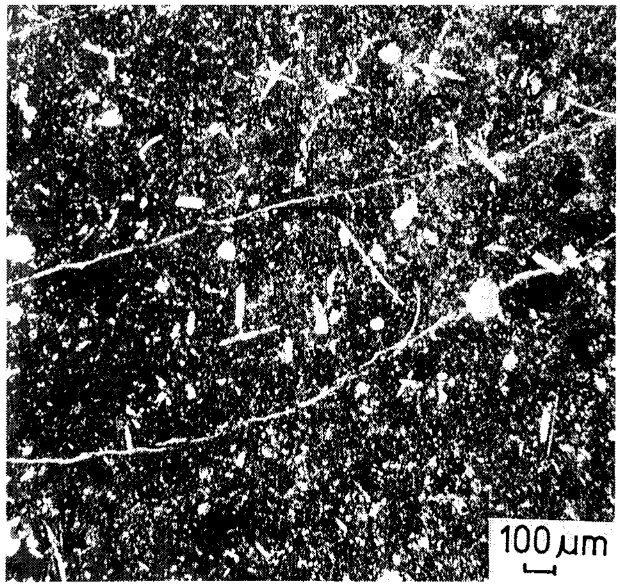


Fig. 6. Spongolite pebble from the red crinoidal limestone in the locality Milpoš. Crossed nicols. Photo: L. Osvald.

The pebble analysis

The small pebbles occurring in the insoluble remains of the samples from the localities Milpoš, Beňatina, Hatné, Vršatec and Bolešovská dolina Valey were studied in thin sections. About 95 % of the pebbles in all localities, except Milpoš, were

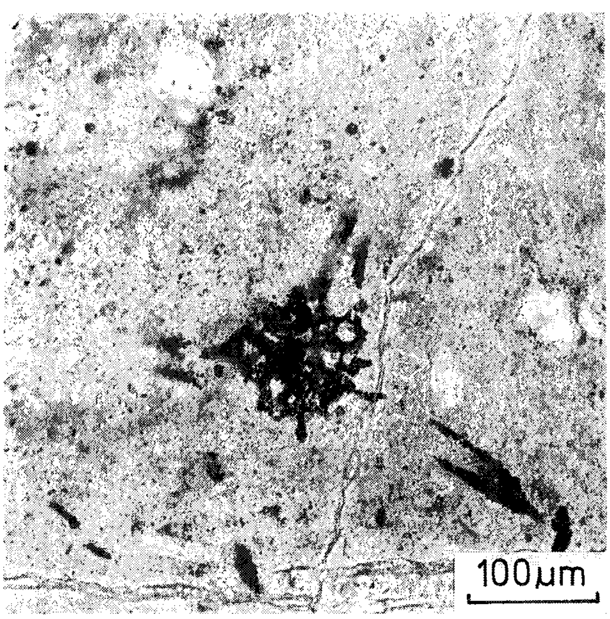


Fig. 7. Limonitized radiolaria from the radiolarite pebble from locality Milpoš. Photo: L. Osvald.

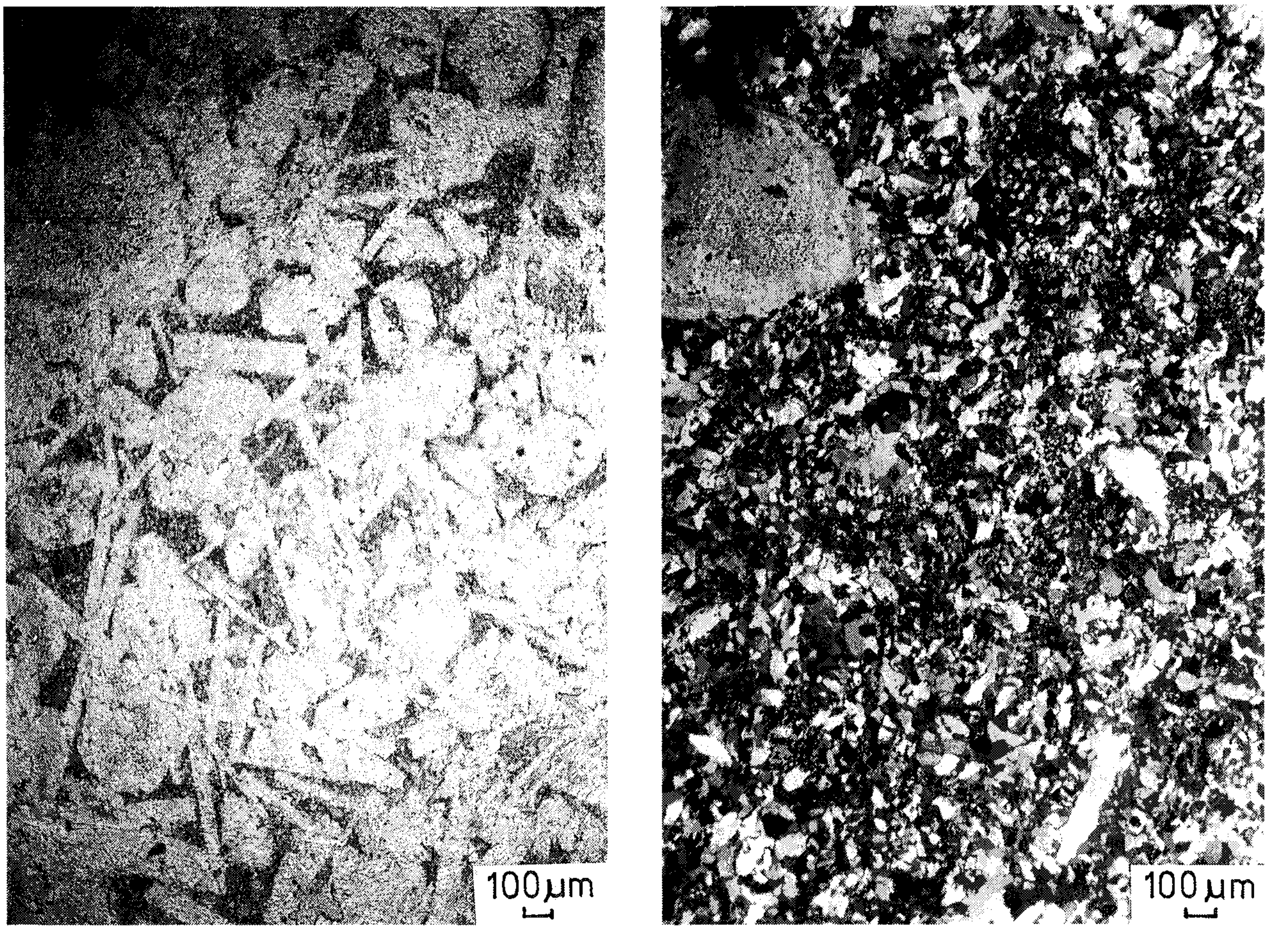


Fig. 8. Silicified volcanite. a - parallel nicols; b - crossed nicols. Photo: L. Osvald.

vein quartz clasts; the rest were quartzites, sandstones and siltstones of unknown origin (partially probably of Lower Triassic age). The limestone pebbles were eliminated by dissolving. The low quantity or lack of macroscopically identified dolomite clasts supports the opinion that most of them were affected by dedolomitization, as it is described in Mišík (1979). In addition, in the locality Milpoš, abundant pebbles of silicites were found. Most of them were spongolites, but formed by pure non recrystalized SiO_2 of opal character (totally isotropic in polarised light) (Fig. 6). Most surprising is the relatively frequent occurrence (about 5 %) of the radiolarite pebbles with chloritized, calcifcified or limonitized radiolarians (Fig. 7). Some of them were well-preserved. The radiolarites are not known in the Czorsztyn Unit so far. Also, some pebbles of silicified volcanites (Fig. 8a,b) were found.

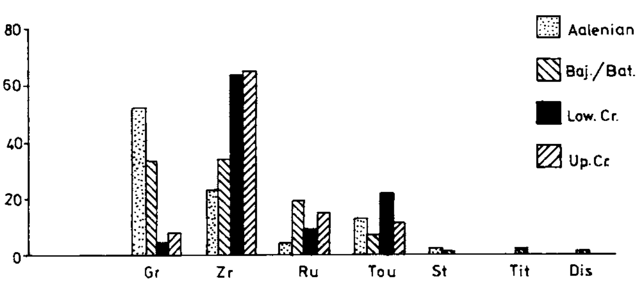


Fig. 9. Comparison of the average heavy mineral assembledges of the samples from Pienidic units of Lozinski (1956, 1959)

Conclusions

This work completes the results of Lozinski (1956, 1959), and proves that the indicated change in the heavy mineral associations was not abrupt but slow, due to the erosional progress (Fig. 9). The second, more important result is the distinguishing of three various sources of zircon in the clastic admixture. According to the absence of two of them in the granitoids of the Central Western Carpathians, we assume, that the zircons were not derived from that area. The heavy mineral associations described by Krystek (1965) from the Paleogene of the Magura Unit (Outer Carpathians) are the same as in the Jurassic of the Pieniny Klippen Belt, but we have poor information on the zircon types in the Outer Western Carpathians, thus the evaluation of the possible source from this area must be dealt with at a later time. The presence of radiolarite clasts in the locality Milpoš indicates the possible presence of a deep marine environment in the Pienidic area before Dogger. They might come from the Liassic cherts but their possible Triassic age cannot be eliminated.

Acknowledgements: My thanks belong to Prof. M. Mišík for my introduction to the study of heavy minerals, to Dr. M. Sýkora for the rendering of some samples and to Dr. P. Uher for my introduction to the study of zircon typology.

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