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DETERMINATION OF ANCIENT EROSION BY ZIRCON MORPHOLOGY AND INVESTIGATIONS ON ZONED TOURMALINE IN KŐSZEG-RECHNITZ WINDOW (WESTERN HUNAGRY)

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ABSTRACT

The rocks exposed in the Kőszeg-Rechnitz Window in Western Hungary and Austria belong to the Penninic unit of the Alps. The investigated rocks are of sedimentary origin, mostly graphitic chlorite-muscovite phyllites and quartzphyllites. The latter contains significant amounts of detrital zircon and tourmaline. Morphology of zircon grains has been preserved during metamorphism and indicates alkaline granite, plagiogranite, monzogranite and garnodiorite source rocks. Electron microprobe investigation on tourmaline grains indicates formation in Ca-poor metapelites and metapsammites without Al-saturated phases. These rocks have shed part of the sediments deposited in the Penninic ocean.

Keywords: low-grade metamorphism, Penninic unit, Kőszeg-Rechnitz Window, zircon morphology, tourmaline compositions.

INTRODUCTION*

The Kőszeg-Rechnitz sequence is formed of a lower and an upper tectonic unit. Both of them contain metamorphic rocks of igneous and sedimentary origin (JUGOVICS, 1917, BANDAT, 1928, 1932, VARRÓK, 1963, KOTSIS, 1965. NAGY, 1972, KISHÁZI and IVANCSICS, 1976, 1984, KOLLER and PAHR, 1980, KUBOVICS, 1983, KOLLER, 1985). The sedimentary sequence of the upper scale studied in the present work is made of rocks of psephitic-psammitic origin, turning more and more pelitic upwards. The gradual increase of the carbonate content is indicated by calcereous phyllite and calc-schist at the top. This trend is similar to that described by SZEBÉNYI *et al.* (1948).

SCHMIDT, (1956) was the first among the Austrian authors to suggest a Penninic position and the Mesozoic age of the Kőszeg-Rechnitz series. SCHÖNLAUB, (1973) recognised Middle Cretaceous sponge spicules in the calcareous phyllites.

We intended to study the composition of tourmaline and the morphology of zircon grains by electron microprobe and optical investigations, respectively.

The investigated samples have been collected from a quartzphyllite portion of the Velem Calcareous Phyllite Formation of the Kőszeg Hills.

RESULTS

1. *Tourmaline*

Tourmaline is one of the heavy minerals in the most significant quantities in the samples collected from the Kőszeg Hills. Some quartzphyllite samples from the Terv Road profile at Velem contain up to 0.5% tourmaline. The largest specimens

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can be found here in this series up to 0.2 mm in diameter. The average diameter of the grains along the profile is about 0.02—0.03 mm.

Three tourmaline types have been recognised: an uncoloured, a brownish yellow and another with greenish blue pleochroism.

The uncoloured tourmaline is a rare type, forming the core of large (0.1—0.2 mm) grains with compound zonality (see *Fig. 2*). The uncoloured core is anhedral. Rarely a continuous transition can be observed between the brownish yellow zone and the core *(Fig. 2)*.

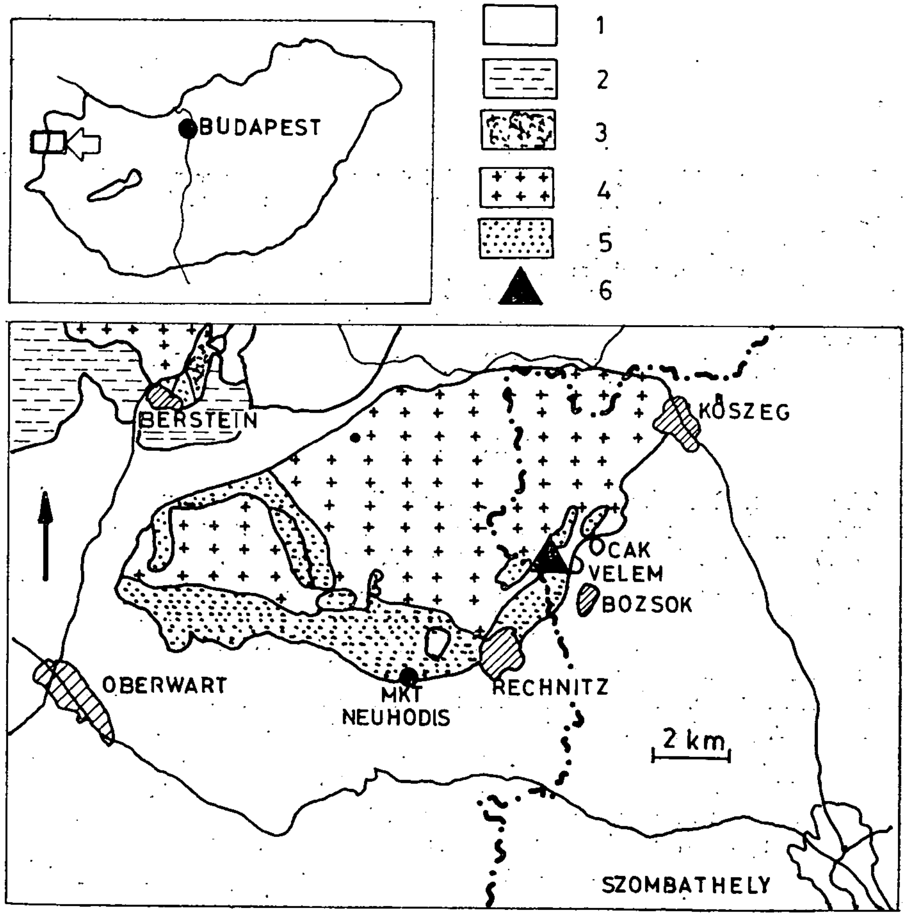

Fig. 1. The map of the Kőszeg Hills (Western Hungary—Eastern Austria). 1. Tercier, 2. Lower East-Alpine, 3. Serpentinite, 4. Metasediment, 5. Greenschist-metagabbro, 6. Samples

Most of the brownish yellow tourmaline grains are anhedral, rarely strongly resorbed *(Fig. 3)*. Oriented graphite inclusions were found in a grain *(Fig. 4)*, unparallel with the cleavage of the host rock. It indicates the detrital origin of the grain.

Some tiny (0.01 mm) euhedral yellow grains occur, too; these might have been formed after the main, syntectonic metamorphism of the rock (see later).

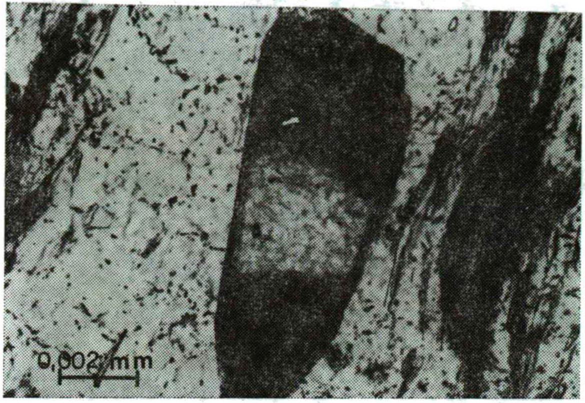

Fig. 2. Tourmaline grain with complex zonation (whitebrownish yellow-greenish blue). 1N

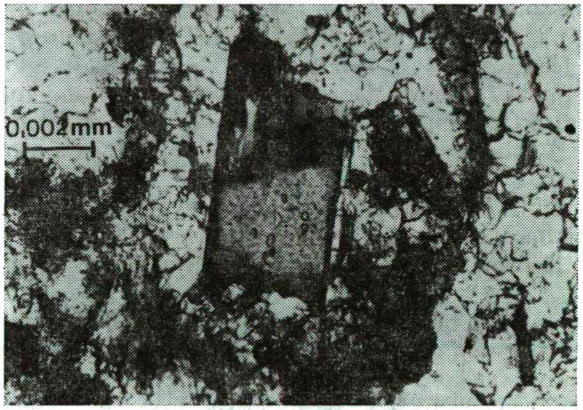

Fig. 3. Tourmaline grain with resorbed brownish yellow core and greenish blue overgrowth. 1N

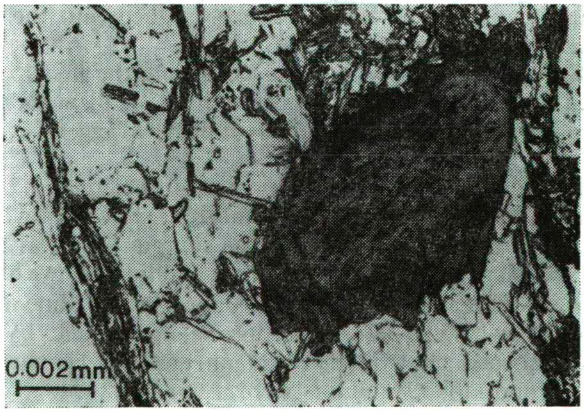

Fig. 4. Zoned tourmaline grain in quartzphyllite. Notice the oriented inclusions in the brownish yellow core. 1N

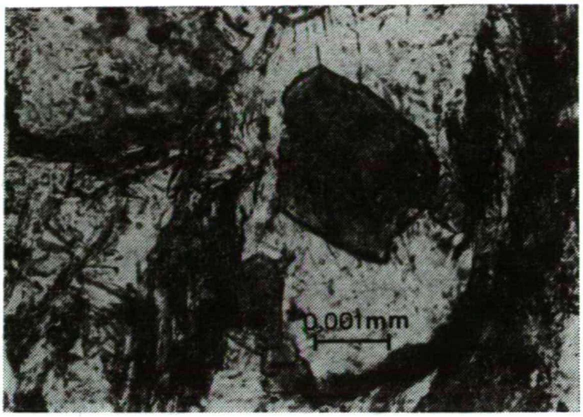

Fig. 5. Tourmaline grain with reverse zonation in quartzphyllite. 1N

Greenish blue tourmaline occurs in two forms: overgrowth on brownish yellow grains or a group of tiny (0.01 mm) euhedral grains. The overgrowth is characterized by the following features:

a) Sharp boundary towards the brownish yellow core and zone.

b) It contains great number of inclusions, mostly in oriented positions parallel with the cleavage of the host rock *(Fig. 3)*. The inclusions are mostly quartz and muscovite.

c) Rarely terminal forms of the crystalls can be observed *(Fig. 2);* the presence of intact prismatic faces characterize euhedral forms *(Fig. 3)*.

d) Frequent resorption phenomena can be observed on the greenish blue overgrowth.

The euhedral greenish blue grains bear no inclusions and rarely show resoprtion. Sometimes a thin yellowish green zone surrounds the grain *(Fig. 5)*. The difference between the greenish blue core and the yellowish green margins is less conspicuous.

The following conclusions have been derived from the results of the investigations:

— Brownish yellow tourmaline grains, rarely with uncoloured cores, originating from graphitic metamorphic rocks, have been shed into the sediments of the Velem Calcareous Phyllite Formation.

— Part of these grains has been dissolved during the first metamorphic phase and recrystallized as a greenish blue overgrowth or small euhedral crystalls. This process happened during the folding that caused the cleavage, i.e. it was a syntectonic process.

— During the second, posttectonic phase part of the greenish blue and brownish yellow tourmalines was dissolved and recrystallized, showing reverse zonality. The colour of the above mentioned yellowish green margin indicates the mixing of the two substances and that the margin wasn't in equilibrium with its environment.

Composition of the zones of three tourmaline grains shown on *Figs. 2, 3, 4* has been determined by a JXA—50 A microprobe, applying 15 kV acceleration voltage, 3×10^{-8} Å absorbed electron flux and an electron beam 1 μm is diameter. Biotite, barkevikite and albite standards were used.

Tables 1a and 1b show concentration values, cation numbers and end-member ratios. Boron data were calculated postulating three boron atoms. The zonality of

Table 1a

Concentration values for zones of tourmaline grains shown on Figs. 2, 3, 4

	Fig. 3		*Fig. 4*		*Fig. 2*		
	core	rim	core	rim	core	zone	rim
B_2O_3	10.98	10.54	10.75	10.53	10.94	10.73	10.45
SiO_2	37.40	37.30	37.50	37.60	37.40	36.40	37.00
Al_2O_3	32.90	30.90	33.30	30.20	32.00	33.10	29.10
TiO_2	0.53	0.25	0.60	0.38	0.50	0.80	1.20
Cr_2O_3	nd	nd	nd	nd	—	—	—
FeO_t	3.20	10.00	6.00	9.90	0.30	3.90	9.30
MgO	10.10	5.40	6.31	5.57	12.00	8.00	6.20
CaO	1.02	nd	0.31	nd	1.70	1.60	0.10
Na_2O	2.40	2.80	2.24	2.94	2.30	2.10	3.10
K_2O	nd	nd	nd	nd	nd	nd	nd
Total:	98.53	97.19	97.01	97.12	97.14	96.63	96.45

nd = non detectable

Table 1b

Cation numbers and end-member ratios for zones of tourmaline grains shown on Figs. 2, 3, 4

	Fig. 3		*Fig. 4*		*Fig. 2*		
	core	rim	core	rim	core	zone	rim
B	3	3	3	3	3	3	3
Si	5.9144	6.1440	6.0650	6.1989	5.9394	5.8897	6.1527
Al	6.1341	6.000	6.3396	5.8697	5.9858	6.3092	5.6999
Ti	0.0627	0.0307	0.0728	0.0470	0.0590	0.0972	0.1498
Fe	0.4229	1.3777	0.8103	1.3652	0.0400	0.5269	1.2908
Mg	2.3806	1.3253	1.5187	1.3681	2.8409	1.9297	1.5365
Ca	0.1720	—	0.0533	—	0.2890	0.2770	0.0179
Na	0.7355	0.4474	0.3503	0.4696	0.7059	0.6572	0.9990
sörl	15.25	54.95	36.68	49.95	1.34	18.80	42.31
dravite	62.30	45.05	56.08	50.02	56.46	29.32	48.02
uvite	18.90	—	7.24	—	29.03	29.65	1.76
elbaite	3.55	—	—	—	13.17	22.23	7.90

the grain shown on *Fig. 3* easily recognisable by the optical microscope, is clearly indicated by analytical data and by the linear measurement of element compositions *(Figs. 6, 7)*. The zonality is caused by concentration variations of FeO_{tot} and MgO. The discontinuous boundary indicates that the grains weren't produced by a single, progressive metamorphic phase, also shown by thin section investigations (see above).

The end-member calculations resulted Al and Si in surplus. Since we had no possibility to determine the concentrations of all elements (i.g. Li) constituting the tourmaline, it is supposed that the surplus is due to compositional causes, to be cleared during subsequent investigations.

Analytical data were plotted in Al-Fe_{tot}-Mg and Ca-Fe_{tot}-Mg diagrams *(Figs. 8. 9)*. These plots illustrate the interrelationships among rock types and compositions of tourmalines formed in them. Arrows show the core to margin trends.

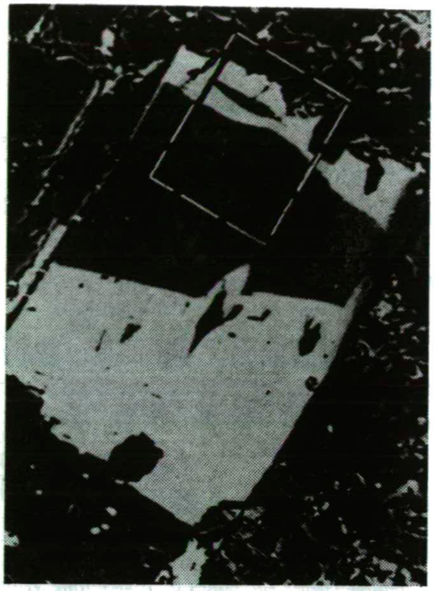

Fig. 6. Back scattered electron image of the tourmaline grain of *Fig. 3.* The marked area is shown on *Fig. 7.*

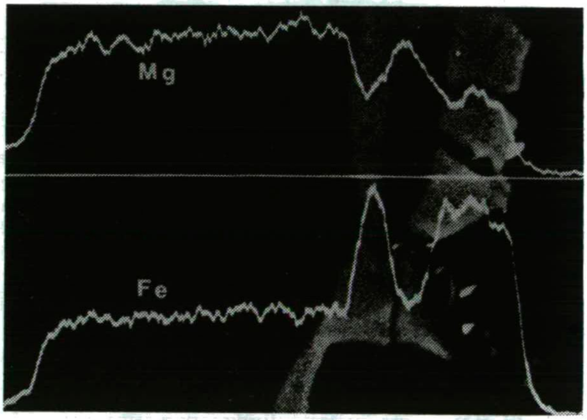

Fig. 7. A microprobe traverse in the area shown on *Fig. 6.*

One analysis has been made on the uncoloured core found in the thin-sections. The dot representing the composition of this core lies in the 5th or 7th field of the Al-Fe_{tot}-Mg diagram *(Fig. 8)*, due to the overlap of the two fields.

If the 7th field is correct, we have to decide, that the uncoloured tourmaline cores have been formed in a Cr, V-rich metasediment or in an ultramafic rock (*Fig. 8,* legend). To make the choice easier, point of a typical Cr, V-rich metasediment (Foit and Rosenberg, 1979) has been plotted. The two points lie in the same field of the diagram, but relatively far from each other. This divergence may indicate differences in the conditions of formation. The high Mg-content is characteristic for

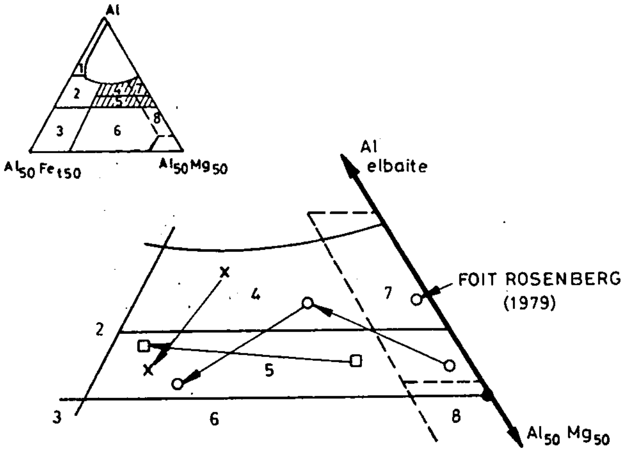

Fig. 8. Al-Fe$_{tot}$-Mg diagram (in molecular proportions) for tourmalines from various rock types. Fe$_{tot}$ total Fe in the tourmaline; the rock types *represented* are:

(1) Li-rich granitoid pegmatites and aplites.
(2) Li-poor granitoids and associated pegmatites and aplites
(3) Fe^{3+}-rich quartz-tourmaline rocks
(4) Metapelites and metapsammites coexisting with an Al-saturated phase
(5) Metapelites and metapsammites not coexisting with an Al-saturated phase
(6) Fe^{3+}-rich quartz-tourmaline rocks, calcsilicate rocks and metapelites
(7) Low Ca metaultramafics and Cr, V-rich metasediments
(8) Metacarbonates and metapyroxenites (after HENRY and GUIDOTTI, 1985)

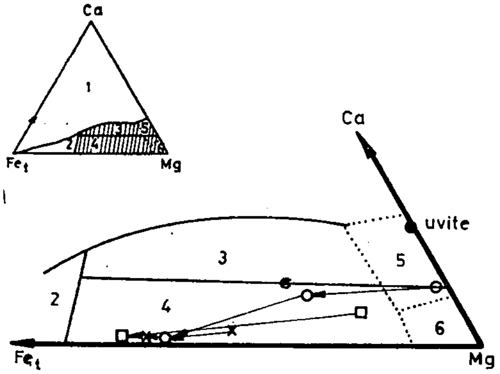

Fig. 9. Ca-Fe$_{tot}$Mg diagram (in molecular proportions) for tourmalines from various rock types. The fields are:

(1) Li-rich granitoid pegmatites and aplites
(2) Li-poor granitoids and their associated pegmatites and aplites
(3) Ca-rich metapsammites and metapelites; calcsilicate rocks.
(4) Ca-poor metapelites and metapsammites and quartz-tourmaline rocks.
(5) Metacarbonates
(6) Metaultramafics
(after HENRY and GUIDOTTI, 1985)

ultramafic rocks. Having a point in the Mg-rich part of the field indicates ultramafic origin. Accepting this result, the continuos transition from the uncoloured core to the yellow margin may be effect of metamorphic homogeneization, being characteristic for high-grade metamorphic rocks.

We cannot exclude the possibility that the uncoloured core belongs to the 5th field. Then it has been formed in a metapelite or metapsammite lacking an Al-saturated phase. Since the point lies in the Mg-rich part of this field, the source rock may have been a Mg-rich one.

Plotting the data in a Ca-Fe_{tot}-Mg diagram, interpretation of the uncoloured core leads to more problems. Here the point lies on the common boundary of three fields *(Fig. 9)*. Tourmaline of metacarbonates lies close to uvite, while analytical data of Henry and Guidotti (1985) from metaultramafites show higher dispersion. It means that the latter field is more close to the source rock. Overlap of the 4th and 6th fields means, that we cannot exclude from the source rocks a Ca-poor metapelite or metapsammite.

The three analytical results of the brownish yellow tourmaline show high dispersion in both kind of plots. It means different source rocks. Two points fall in the field of metapelites-metapsammites with Al-saturated phases, while one falls in the field without Al-saturated phases *(Fig. 8)*. This fact indicates the former origin; however, more analytical data are needed.

All three points fall in the field of the Ca-poor metapelites-metapsammites of the Ca-Fe_{tot}-Mg plot, with high dispersion. The three analytical data of the greenish blue margin fall almost to the same place in both plots. It means formation in the same rock under the same processes. These grains derived from quartzphyllite samples. It fulfils the requirements of metapelites-metapsammites without Al-saturated phases and it is Ca-poor (see *Figs. 8, 9*).

By these measurements we have calibrated the method for our rock, proving that tourmalines formed in a known rock fall in the field of the respective rock in the plots of Henry and Guidotti, (1985).

2. *Morphology of zircon grains*

Thin-section investigations show that while the zircon grains are of detrital origin, these are bordered by intact faces and edges, preserving the original morphology during transportation and metamorphism.

Zircon grains were separated by grinding of the rock, then applying bromophorme heavy liquid and magnetic separator.

Three hundred zircon grains from quartzphyllite have been analysed for morphological features following the method of Pupin, (1980, 1985). The material was selected under binocular microscope.

Morphological types were determined after the diagram of Pupin, (1980) *(Fig. 14)* and under binocular microscope, because usually the grains are slightly rounded. The results are shown on *Fig. 15.* The rock contains a large variety of zircons, with some types showing extramely large values (types G_1, D, Q_3, S_{25}, *Fig. 14*). The dominant forms are shown on *Figs. 10, 11, 12, 13.* The results are shown in a suggestive graphic form on *Fig. 16.*

Uncoloured, clear zircon grains dominate the investigated material; it is present in all kinds of morphological groups. Light pink, translucent crystalls are present among forms belonging to the S_{16}-S_{20} fields. However, this group also contains uncoloured grains. A third group is formed by uncolured crystalls with much inclu-

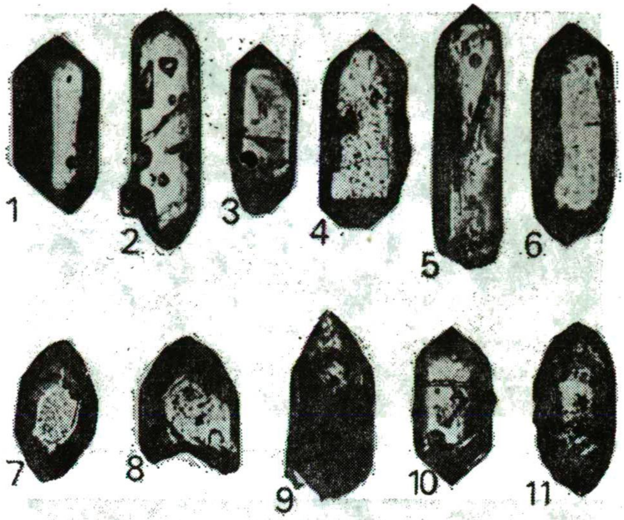

Fig. 10. Optical microscope pictures of the dominant types derived from quartzphyllite of the Kőszeg-Rechnitz series. 1. G_1, 2. P_2, 3. P_4, 4. P_5, 5. D, 6. D, 7. S_2, 8. S_7, 9. S_{11}, 10. S_{24}, 11. rounded grain with complex zonation. Some of the represented grains (4, 5, 8, 9) are cracked.

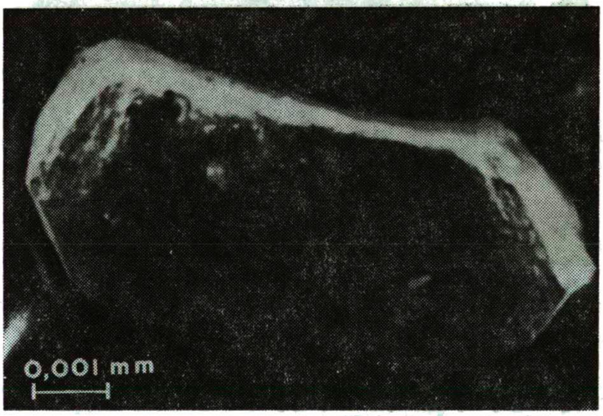

Fig. 11. Elongated S_4-type zircon grain from quartzphyllite. SEM picture.

sions. The inclusions are probably ore minerals, although lots of grains have obviously fluid inclusions *(Fig. 10—2.5)*. The high inclusion content makes some crystalls opaque. This type is characteristic for the group positioned along the J_4-S_{14}-P_1 line.

It may be important for subsequent studies that VOGGENREITER, (1986) also mentions similar types of inclusions found in zircon in Penninic quartzphyllites of Tauern Window.

Appearence of these groups with different colours indicates different source rocks.

The distribution curve shown on *Fig. 17* has been drawn from the data *Figs. 15* and *16*.

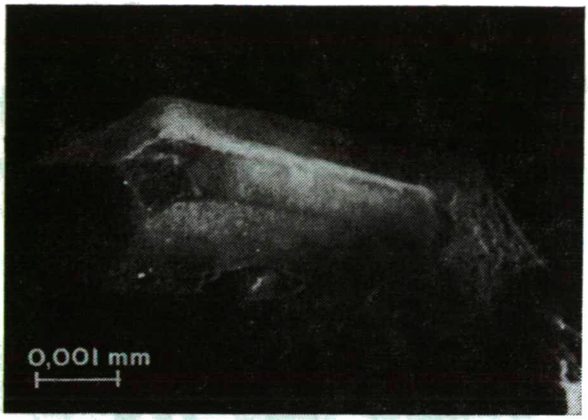

Fig. 12. S_{19}-type zircon grain from quartzphyllite. SEM picture.

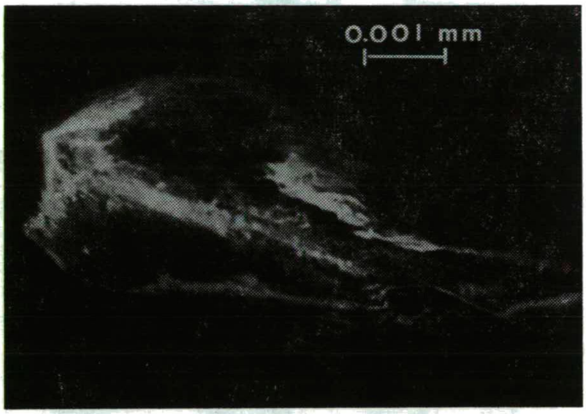

Fig. 13. D-type zircon grain from quartzphyllite, SEM picture.

Following the method of PUPIN, (1980), field I means alkaline granites and alkaline basalts. The large number of zircon grains in the investigated quartzphyllite makes derivation from the latter improbable.

Field II means porphiroidic granodiorite-monzogranite of anatectic origin, but the distribution maximum has moved towards form Q_3. This kind of shift hasn't been mentioned by PUPIN, (1980, 1985).

Field III, indicating type D grains on *Fig. 14,* corresponds to plagiogranites of tholeiitic suites and alkaline rhyolite. A conspicuously high distribution maximum has been found here, indicating either the erosion of a very large amount of alkaline rhyolite or a significant amount of plagiogranite.

From the above mentioned data we can conclude that the source rocks might have belonged to two different series. One of them was of crustal origin (field II), while the other derived from the mantle T (fields I and III).

Similar detrital material has been discussed by WEISSERT and BERNOULLI, (1985), proving a common erosion process of ophiolite and granite bodies for the formation of breccias between radiolarite beds of Tethian sedimentary sequences. POLINO and

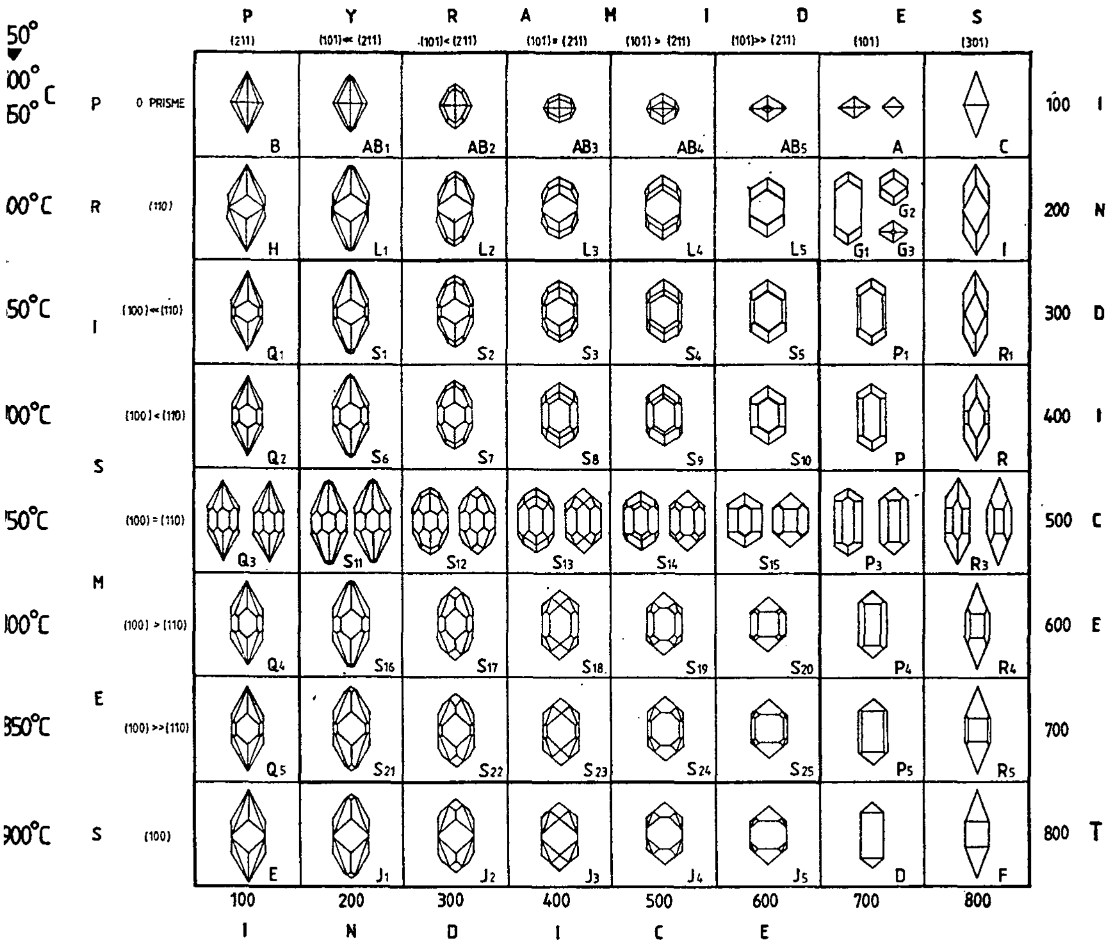

Fig. 14. Morphological types of zircon (by Pupin, 1980).

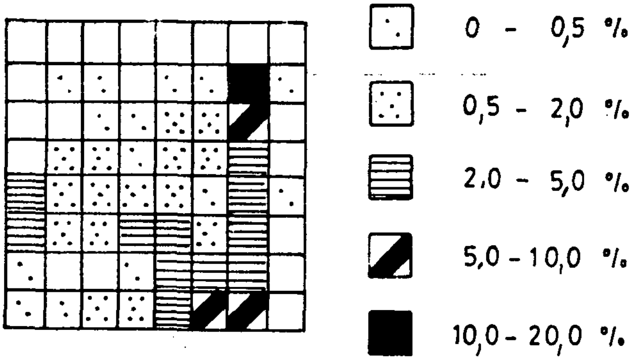

Fig. 15. Percentage of types shown on *Fig. 14* in our samples.

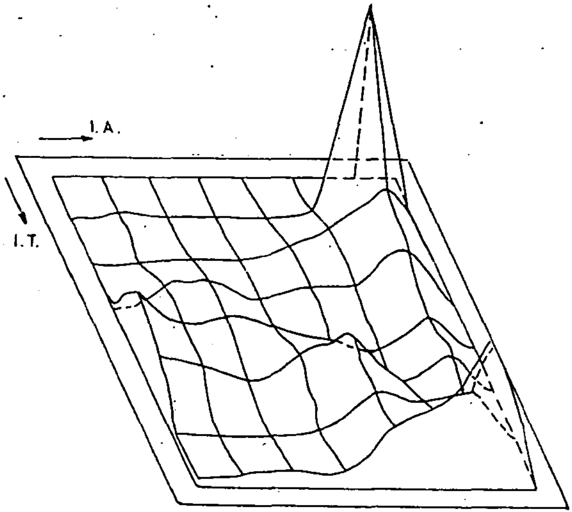

Fig. 16. Distribution of morphological types of zircon grains. Crossing points of the lines indicate the morphological forms, while distance from the base level is proportional with the quantity of the grains.

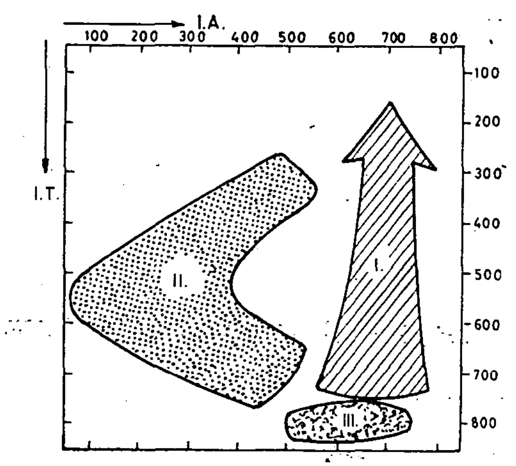

Fig. 17. Distribution fields of zircon grains in the quartzphyllite samples.

Lemoine, (1984) described the mixing of continental and ophiolitic detritus in the Penninic sediments of the Lago Nero seies of the Western Alps. Among others the material of continental origin contains biotite granite.

Plagiogranite as source rocks has been mentioned by Pupin (1980) for the Inzecca ophiolitic suite of Corsica. Also, Caron and Delcey (1979) have proven significant amount of rhyolite material shed into the East Corsican "schistes lustres" (a similar problem has been discussed in connection with field III of *Fig. 17*).

We can conclude, that in several Penninic regions the erosion of this kind of rock suites has occured.

In the Austrian part of the Kőszeg and Rechnitz window there are radiolarites (Koller Pahr, 1980), but these authors don't mention such detrital material.

CONCLUSIONS

Sedimentary rocks of the Kőszeg-Rechnitz series have been deposited in the Tethys ocean during the Jurassic and Cretaceous. Several kinds of metamorphic rocks and granites have been eroded contemporaneously with the sedimentation.

The former rocks might have belonged to medium or high metamorphic grade, and were Ca-poor metapelites-metapsammites with Al-saturated phases. These rocks contained a relatively large amount of tourmaline. Beside the parametamorphic rocks large amount of monzogranite-granodiorite (derived from the crust), alkaline granite and mantle-derived plagiogranite have been eroded. The metamorphic rocks belonging to an older tectogenesis indicate continental erosion, therefore the granitoids might be considered as relatively old, probably Variscan ones.

Literature data and our results indicate, that the sedimentation might have been fairly uniform in the Tethys ocean. Mostly zircon investigation results lead to this statement, since these ones agree well with data obtained from other parts of the Alps.

Similarly of detrital material in Tethyan rocks of different Alpine areas indicate, that the rocks affected by subaerial erosion were similar in large areas.

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