GEOLOGICKÝ ZBORNÍK — GEOLOGICA CARPATHICA, 40, 3, BRATISLAVA, JUNE 1989,
Pp. 323—332

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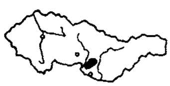
Rb—Sr GEOCHRONOLOGY OF LEUCOCRATIC GRANITOID ROCKS FROM THE SPIŠSKO-GEMERSKÉ RUDOHORIE MTS. AND VEPORICUM

(3 Figs., 4 Tabs.)



Abstract: Information on new Rb—Sr data from leucocratic types of rocks occurring in the Gemericum and Veporicum is given in the paper. On the basis of isochron geochronological data, mutual geochronological and geochemical relations, as well as relations to the rocks of environment where they occur are discussed.

Резюме: В статье приведены информации о новых Rb-Sr данных, полученных из лейкократовых типов пород, находящихся в гемерикуме и вепорикуме. На основе изохронных возрастных данных обсуждаются взаимные геохронологические и геохимические отношения, а также отношения к породам среды, в которой они находятся.

Introduction

Views on the Mesozoic age of Gemeric granites were expressed since long ago in geological literature, e. g. Kantor (1957) determined age of Betliar Gemeric granite to 98 m. y. by means of K—Ar method; this fact considerably affected the views of Carpathian geologists. Kordiuk (1941) pointed out their slight tectonic affection from which he deduced their younger Alpine age. Schönenberg (1947), on the other hand, pointed out their genetic relation to ore mineralization in the Spišsko-gemerské rudohorie Mts. Since the period when radiometric dating started, majority of geologists using mainly results of K—Ar geochronological method and of tectonic study considered metallogeny and contact metamorphism in the Gemericum and partly in the Veporicum connected with the Alpine granitoid plutonism. It should be noted that Ilavský (1957) tried to prove the Upper Permian to the Lower Triassic age of the Gemeric granites. These granites were formerly considered to be of the Variscan age. Grecula (1982) has lately derived metallogeny in the Spišsko-gemerské rudohorie Mts. from the Variscan metamorphic processes of the Lower Palaeozoic intervening even in the Permian when mineralization manifestations were fading away in veiny indices and altered zones.

Turn in views on age of granitoids appeared when Grecula in cooperation with Hungarian geologists (Kovách et al., 1979, 1986) proved by Rb—Sr

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isochron methods that a part of the Gemeric granitoids is of the Late Variscan till Permian age and when Kantor — Rybár (1979) on the basis of K—Ar method of muscovites study obtained data supporting the earlier Late Variscan age of the Gemeric granitoids. At the same time, they consider polyphase character of the Gemeric granitoids determined radiometrically till the Cretaceous as a possible, but they leave it open. They accept that the determined Neoide model age may be caused also by rejuvenation, i. e. by additional younger geological processes. This is stressed also in the work of Kovách et al. (1986). Later Burchart et al. (1987) established from the existing K—Ar analyses of amphiboles on the basis of $^{40}Ar/^{40}K$ isochron method that slope of this isochron corresponds to an age of 265 m. y. It is probable that this age is bound to influence of the Gemeric granites. According to Grecula (1982), also formation of schistosity s_2 appeared in this period. At the same time it must be admitted that these originally older rocks may be rejuvenated in the period of the Variscan orogene.

In order to prove verity of isochron (Rb—Sr) determination results of rocks age published in the work of Kovách et al. (1986), some analyses of the Gemeric granitoids were carried out also by G. P. Bagdasaryan and R. Kh. Gukasyan at Erevan. Part of samples denoted by symbols GGG taken by I. Matula from Geological Survey, Spišská Nová Ves was provided by J. Veselský and sent for Rb—Sr analyses to Erevan. Analyses, in fact, prove an agreement in results obtained by the both laborotories. Isochron of Hnilec granitoids giving an age of 282 ± 2 m. y. is of special importance. This age is closest to an original age of the Gemeric granitoids and it is in accord with age determination made by G. P. Bagdasaryan and R. Kh. Gukasyan, as well as with that made by Kovách et al. (1986) (290 ± 40 m. y.). Substantial differences are, however, in determination of initial ratio $(^{87}Sr/^{86}Sr)_0$, whereby in the work of Kovách et al. also standard deviation of this value is great. It is evident that the studied bodies were isotopically inhomogeneous. In order to compare the results of the both laboratories, the conclusions of A. Kovách's team (Kovách et al., 1986) must be presented.

This work brings significant isochron determinations of granitoids from the following localities: Hnilec (290 ± 40 m.y.), Zlatá Idka (251 ± 16 m.y.), Zlatá Idka—Poproč (223 ± 32 m.y.), Humel (270 ± 64 and 246 ± 6 m.y.) carried out by Rb—Sr method. The authors state that age of granitoid body at Betliar cannot be determined on the basis of isochron, but the obtained data indicate the Palaeozoic age of formation of this granite, since it was intensively metamorphically affected. Isochron ages of coarse-grained granitoids from the locality Podsúľová (142 ± 6 m.y.) and from the Dlhá dolina valley (151 ± 14 m.y. and 146 ± 6 m.y.) refer to an important period of thermal and tectonic activation in the Upper Jurassic. They state that formation of granitic melt took place during the Upper Carboniferous orogene-metamorphic events, simultaneously with development of ore mineralization. In their opinion, granite plutonism continued even in the Permian and local granite intrusions were formed mainly in the Middle and Upper Permian. Alteration of rocks, postmagmatic changes, cataclastic deformations, mylonitization and retrograde metamorphism took place in this period. The authors presuppose local rejuvenation and hydrothermal activity in tectonically active zones in the Upper Jurassic. Tectonic activity and low-grade metamorphism manifestations (below 300 °C) on the Lower/Upper Cretaceous boundary are presumed only on the basis of data obtained by dating of biotite from granites. They stress that magmatic-metamorphic development in the Upper Cretaceous may be taken into consideration only on the basis of

K—Ar dating. But now we know that model ages of K—Ar dating may be affected by various geological events and they are not decisive from the point of view of age determination of the studied objects.

In the meantime one of the authors (B. Cambel) collected samples of leucocratic rocks from the Veporicum which were analyzed by Rb—Sr method by R. Kh. Gukasyan from Institute of Geological Sciences at Erevan. Thus new and interesting results related to leucocratic abyssal or hypabyssal, mostly veiny and apophysal granitoid rocks penetrating the basic Sihla or younger Vepor types of granitoids and metamorphosing the Veporic or Gemeric crystalline schists with a various intensity and in a different way were obtained.

When the Lower Devonian age of granitoids from the Kohút zone of the southern Veporicum was proved (Cambel et al., 1988), whereby the Sinec (Rimavica) type of granitoids was concerned, the existing views that these granitoids are of the Alpine age had to be changed. However, if the correctness of Rb—Sr analyses is accepted, the mentioned granitoids are approximately of the same age as granitoids of the Sihla type (Bagdasaryan et al., 1986). From this a question arises of what age are leucocratic granitoid bodies usually of smaller dimensions intruding as younger ones into the main rock types (Sihla, Rimavica, or Vepor) or into metamorphites of different character in the Veporicum. One of the authors (B. Cambel) collected the samples from the most significant occurrences of such rocks and sent them to Erevan for analyses. The results of analyses of these samples obtained by Rb—Sr isochron method give new interesting information.

Methods

Rb and Sr contents were determined by standard method of isotopic dilution. Isotopic ratios in the mixture (samples + tracer) were measured on masspectrometer MI-1309. Variation coefficient of the measured $^{87}Rb/^{86}Sr$ ratio is about $\pm$ 2 %. Isotopic ratios were measured on masspectrometer MI-1201 with programme control of measurements. Variation coeffificient of $^{87}Sr/^{86}Sr$ ratio varies from 0.03 to 0.05 % (with normalization of measured ratios to $^{86}Sr/^{88}Sr$ = 0.1194). In calculation of ages, ^{87}Rb decay constant equaling to $1.42 . 10^{-11}$ $year^{-1}$ was used.

Discussion

From graphic representation of isotopic data from the Gemeric Hnilec granitoids (Tab. 2, Fig. 2) it is evident that analysis of Rochovce granite (ZK-112) falls on Rb—Sr isochron of Hnilec granitoids too. According to model K—Ar and Rb—Sr mineral isochrons, Rochovce granite is of the Cretaceous age. Isochron of Hnilec granitoids has initial ratio of Sr isotopes 0.70528 $\pm$ 0.00224 (2 σ). Determined initial ratio is lower than that given by Kovách et al. (1986). This extremely low initial ratio is very close to that of granitoids of the Sihla type. This fact might suggest:

a) differences caused by isotopic inhomogeneity of $^{87}Sr/^{86}Sr$ isotopic ratios in the granitoid massif,

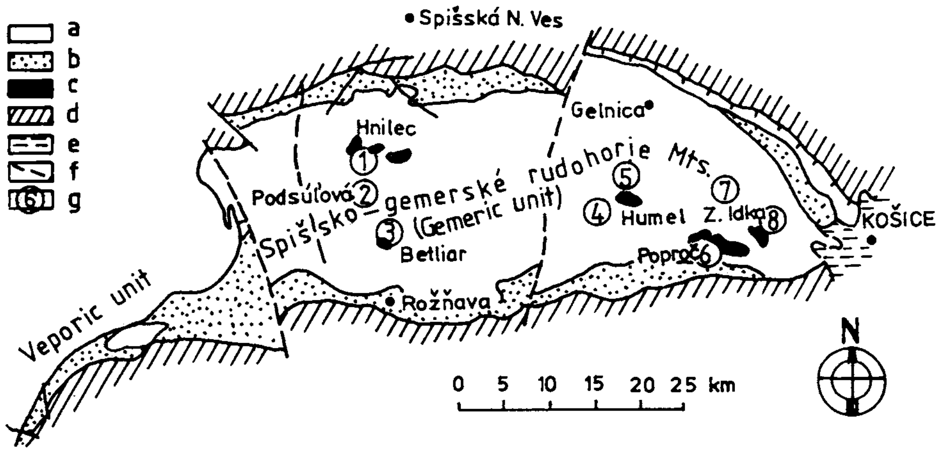

Fig. 1. Simplified geological map of the Spišsko-gemerské rudohorie Mts. with sampling localities.

Legend: 1 — Hnilec—Medvedí potok brook, 1 km SWW of the village; 2 — Podsúľová, borehole PSS-1 in the Krátka dolina valley 9 km N of Gemerská Poloma, outcrop in the Dlhá dolina valley 7 km N of Gemerská Poloma village; 3 — Betliar, brook valley, 4 km N of the village; 4 — Humel, borehole SG-1, 5 km N of Medzev village; 5 — Humel, outcrops, Humel valley; 6 — Poproč; 7 — Zlatá Idka, borehole ID-1, 3 km NW of the village, 8 — Zlatá Idka, outcrop, 5 km SE of the village. a — Lower Palaeozoic; b — Upper Palaeozoic; c — granitoids; d — Mesozoic (Triassic); e — Neogene; f — faults; g — sampling localities. Taken over from the work of Kovách et al. (1986), p. 3.

Table 1

Rb—Sr whole rock isochron data

Locality	Initial $^{87}Sr/^{86}Sr$ ratio	Whole rock isochron age (m.y.)
Hnilec	0.7119 ± 0.0181	290 ± 40
Betliar	0.7112 ± 0.0200	272 ± 47
Humel (borehole SG-1)	0.7193 ± 0.0076	246 ± 25
Zlatá Idka (borehole ID-2)	0.7133 ± 0.0040	251 ± 16
Zlatá Idka-Poproč (borehole ID-1)	0.7279 ± 0.0103	223 ± 32
Dlhá dolina valley	0.7330 ± 0.0123	151 ± 14
	0.7204 ± 0.0053	146 ± 6
Podsúľová	0.7339 ± 0.0040	142 ± 6

Taken over from the work of Kovách et al. (1986), p. 12.

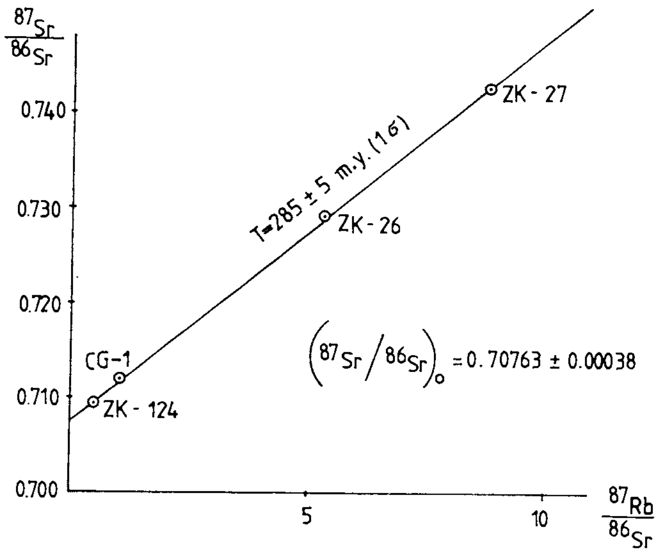

Fig. 2. Rb—Sr isochron constructed from the samples of the Gemeric granites.

Table 2

Isotopic analytical data on granitoids from Hnilec and Rochovce

Sample number	Rb ppm	Sr ppm	$^{87}Rb/^{86}Sr$ at. ratios	$^{87}Sr/^{86}Sr$ at. ratios
ZK-35	502.54	12.19	120.24 ± 2.40	1.1874 ± 0.0007
		11.99		
GGG-28-Hn	424.96	12.71	93.59 ± 1.87	1.0800 ± 0.0004
	397.46	12.71		
GGG-7-Hn	652.40	33.17	54.41 ± 1.09	0.8908 ± 0.0005
	621.72	35.65		
	639.34	34.00		
ZK-34	310.70	48.36	18.55 ± 0.37	0.7797 ± 0.0002
	315.36	49.29		
ZK-112	137.71	469.67	0.848 ± 0.017	0.7093 ± 0.0035

ZK-35 — muscovite leucogranite; borehole HG-1, Hnilec;
GGG-28-Hn — Hnilec—Medvedí potok brook, borehole HG-1/509 m, coarse-grained two-mica granite;
GGG-7-Hn — Hnilec—Medvedí potok brook, gallery No. 1, muscovite—quartz—albite—microcline apogranite;
ZK-34 — borehole No. 1, Hnilec, muscovite—biotite autometamorphic granite, depth 900 m;
ZK-112 — Rochovce, borehole, Hladomorná Formation, biotite granite.

b) that source of these Gemeric granitoids of the so-called northern zone is sometimes different or sometimes similar as that of the Veporic granitoids when compared with other leucocratic granitoids from the Veporicum and the certain parts of the Gemericum. However, it should be pointed out that isochrons from the Hnilec granitoids analyzed by K o v á c h et al. (1986) and in Erevan do not differ in ages, but they differ in initial ratios. It can be seen from the Table 1 taken over from the work of K o v á c h et al. (1986) for comparison. Isochrons presented in this work (Fig. 2) were constructed on the basis of data given in Tab. 2.

For the reasons of isotopic inhomogeneity, our view that one or two samples from each body of the Gemeric granites will be sufficient for determination of age of all granites from the Spišsko-gemerské rudohorie Mts. was not correct. P. G r e c u l a's approach to age determination of the Gemeric granites was more correct, because it turned out that it was better to take larger num-

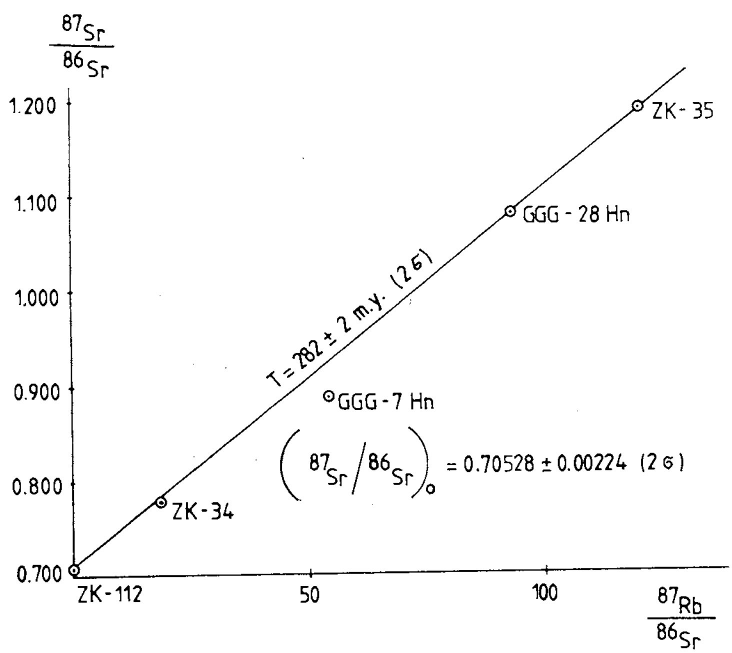

Fig. 3. Rb—Sr isochron constructed from leucocratic varieties of the Veporic granitoid rocks.

ber of samples from individual granitoid bodies and to make a separate isochron for each of them. This is the only way to dating of the Gemeric granites, since these rocks are genetically variable, isotopically inhomogeneous and additionally affected by various geological events in the course of geological history of the region.

What has been said about the Gemeric granites is valid also for the leucocratic granitoids occurring as smaller bodies in the Veporicum. Several samples have to be collected from each occurrence for a separate isochron analysis in order to determine its age more accurately. If even numerous samples are taken from various veins and apophyses of the leucocratic granitoids from the Veporic zone, it is evident that all data cannot be used for construction of isochrons. Only determination of model age of rocks can be applied what gives also a certain preliminary information. These hitherto obtained data presented in Tab. 4 can be applied in further geochronological dating in the future.

Table 3

Rb—Sr analyses of granitoids of the Hrončok, Skorušina (Rástočná) and Budinná types

Sample number	Rb ppm	Sr ppm	$^{87}Rb/^{86}Sr$ at. ratios	$^{87}Sr/^{86}Sr$ at. ratios
ZK-27	179.38	51.01	8.794 ± 0.176	0.74306 ± 0.00028
ZK-26	187.71	102.30	5.31 ± 0.106	0.72983 ± 0.00007
	187.66			0.72906 ± 0.00028
CG-1	115.96	328.92	1.02 ± 0.0204	0.71226 ± 0.00069
				0.71162 ± 0.00015
ZK-124	69.24	453.46	0.460 ± 0.009	0.70937 ± 0.00060

ZK-27 — Kamenistá dolina valley, muscovite leucogranite, aplite vein in the Hrončok granite, Slovenské rudohorie Mts.;
ZK-26 — Kamenistá dolina valley below gamekeeper's lodge of Čierny potok brook, muscovite—biotite granite with feldspar phenocrysts, typical granite of the Hrončok type, Veporicum—Kráľova hoľa zone;
CG-1 — Skorušina near the road Klenovec—Rástočná, granitoids of the Vepor type;
ZK-124 — Budinná, near monument of resistance, leucogranodiorite, Slovenské rudohorie Mts.

Isochron constructed from data presented in Tab. 3 concerns granites of the Hrončok type which were considered in the past as the Alpine by several authors. As it is seen from the graph (Fig. 3), these granitoids are of the Late Variscan age. Also other types of the leucocratic granitoids occurring in the Kráľova hoľa Veporic zone fall on isochron of the Hrončok granitoids. This proves the fact that the Late Hercynian intrusions penetrating the main types of the Veporic granitoids (Sihla, granitoids of the Kohút zone, Cambel et al., 1988) as the younger ones occur in the Veporicum as well as in the Gemericum. It becomes evident that the Variscan Devonian and Lower Carboniferous granitoids underwent the effects of repeated phases of younger Late Variscan plutonogene process as early as after cooling of granitoids of the Sihla, Rimavica, Vepor and Ipeľ types (Bagdasaryan et al., 1986). Leucocratic granitoids from the region of Čierny Balog village, Vydrovo valley (samples ZK-69 and ZK-122) are similar geochronologically and isotopically to the Hrončok granite.

Table 4

Rb—Sr analyses of the samples of leucocratic granitoids from the Gemericum and Veporicum which cannot be evaluated by isochron method

Sample number	Rb ppm	Sr ppm	$^{87}Rb/^{86}Sr$ at. ratios	$^{87}Sr/^{86}Sr$ at. ratios
GGG-16-ZI	267.62	41.54	18.64	0.7745 ± 0.0003
GGG-24-Po	364.02	20.25	51.99	0.8606 ± 0.0019
GGG-12-B	334.18	19.32	49.85	0.8561 ± 0.0002
	331.82			
ZK-122	264.72	16.29	47.09 ± 0.942	0.87507 ± 0.0036
	268.64	14.36		
		17.88		
		17.05		
ZK-69	244.53	13.54	52.62 ± 1.05	0.89626 ± 0.00038
	241.81	13.22		
	243.82			
CG-2	98.34	111.71	2.55 ± 0.051	0.72426 ± 0.00012
CG-5	60.77	78.74	2.21 ± 0.044	0.72202 ± 0.00030
				0.72359 ± 0.00050

GGG-16-ZI — Zlatá Idka, borehole ID-1/350 m, medium-grained biotite (leucocratic) granite;
GGG-24-Po — Poproč, exposure in old quarry, medium-grained to coarse-grained biotite granite;
GGG-12-B — Betliar, exposure in nature reserve, fine-grained granite aplite;
ZK-122 — Čierny Balog, Vydrovo — the first valley near gamekeeper's lodge, before the end of asphalt road, in road-cut, muscovite leucogranodiorite, various textures and structures — aplitic and pegmatitic;
ZK-69 — Vydrovo valley 1 km of the road Čierny Balog—Hriňová, right slope, Kráľova hoľa zone of the Veporicum, Slovenské rudohorie Mts., leucogranite, granitoids situated in migmatite zone containing acid metatuffs of leptites;
CG-2 — Chorepa, quarry on the road between Klenovec and Kokava, hybrid granite;
CG-5 — Hnúšťa, near bridge in railway-cut at the station, vein of aplitic granite.

Even these few data indicate that plutonic activity in the Veporicum and Gemericum during the Upper Carboniferous to Permian period took place in the both geological units. Further geochronological research will show which rocks can be grouped together in common phases of granitoid plutonism. It should be noted that checking of the results by U—Pb method from zircons from individual granitoid occurrences will be inevitable and will complete our hitherto insufficient knowledge.

Conclusions

a) Results of Kovách et al. (1986) about the Late Palaeozoic Variscan—Upper Carboniferous to Permian age of the Gemeric granitoids are proved. Granitoid rocks similar in age occur also in the Veporicum.

b) Rochovce granite, granites of the Hrončok type and other leucocratic intrusive bodies in the main Sihla and Rimavica types of the Veporic granitoids belong also to this age category of the Upper Carboniferous to Permian Variscan granitoids.

c) The source of the mentioned magmas heterogeneous in age did not form a homogeneous substratum. Even the conditions of magmatic melt genesis were not the same. Substratum from which magma was formed probably by anatexis consisted of different protolithic material, whereby corresponding homogenization of Sr isotopes did not take place in individual parts of granite magma. This situation is similar not only in the case of typical Gemeric granitoids, but also in leucocratic intrusive bodies of the Veporicum. It should be noted that initial ratio of Sr isotopes of the Gemeric granitoids is higher than that of the Veporic leucocratic rocks. Hnilec granitoids whose initial ratio of Sr isotopes is close to that of the Veporic granitoids form an exception (Fig. 2). However, it should be stated that according to the work of Kovách et al. (1986), initial ratio of Sr isotopes is considerably higher. Rochovce granite with medium initial ratio of Sr isotopes coinciding in age with the Hnilec Gemeric granitoids (282 m. y.) falls on isochron of the Hnilec granitoids.

d) In the authors's opinion, isochrons giving lower values than the Late Palaeozoic in determination of the Gemeric granites age can be considered as "false" isochrons. Their values obtained by calculations are influenced probably by various secondary phenomena affecting the rocks during geological history of the territory which cannot be, for the time being, univocally explained. This view should be hitherto considered as preliminary, but more probable than an assumption of polyphase and polycycle character of the Gemeric granitoids whose age interval finished in the Upper Cretaceous according to data of K—Ar or some data of Rb—Sr dating.

e) Statement that also the so-called Vepor type of granitoids (including the Ipeľ one with red phenocrysts) belongs to younger Late Variscan types of the Veporic granitoids is important.

f) Main reason of differences in initial isotopic ratio of strontium must be seen in conditions of magma genesis with variable composition of protolithic material and in the way of magma outcrop to higher parts of the Earth's crust under changing tectonic, thermodynamic and magma differentiation conditions with features of greisenization and hydrothermal-pneumatolytic effects. Very important effect is represented by superposed younger tectonic and thermodynamic conditions which were, in a various degree, applied in the Alpine orogene.

Translated by O. Mišániová

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Manuscript received January 11, 1989.