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THERMOLUMINESCENCE OF BARITES ON EXAMPLE OF SOME WESTCARPATHIAN DEPOSITS

(Text figs. 1—12)

Abstract: Barites from westcarpathian deposits show wide variations in thermoluminescence intensities depending on doses of radiations received (age), the termal history of the samples and their strontium and lead contents. The possible use of natural and X-ray induced thermoluminescence in metallogenetic as well as geochemical investigations is outlined.

Since the revival of the interest for thermoluminescence investigations provoked mainly by the work of F. Daniels, Ch. Boyd, D. Saunders (1953) different rocks and minerals, mainly carbonates, fluorspars, feldspars, quartz a. s. o. have been investigated for this property. Papers dealing with other minerals are rare. Barite belongs among those minerals whose thermoluminescence (TL), although mentioned already by F. Hegemann and H. Steinmetz (1933) hasn't yet been systematically studied.

As it represents an important mineral in hydrothermal mineralisation of the West Carpathians, detailed sudies including thermoluminescence were carried out at the Dionýz Štúr Geological Institute in Bratislava. As a result regional observations as well as certain general conclusions regarding relations between thermoluminescence and crysatllochemical properties of barites could be made.

Barite Occurences in the West Carpathians

Economically most important barite deposits of the West Carpathians are concentrated in the border zones of the Spišsko-gemerské rudohorie Mts: in the NW in the surroundings of Rudňany (formerly Kotterbach) and near Krásnohorské Podhradie (E of Rožňava) in the South. In large amounts occurs barite also in the hematite-barite deposit Šankovce, where the Triassic of the Gemeridy unit is mineralized. Many other hydrothermal deposits of the Spišsko-gemerské rudohorie Mts. carry barite too, but only in mineralogical quantities.

Important barite deposits are unknown from the West Carpathian Crystalline although this mineral forms not rarely a constituent of siderite and polymetallic mineralizations or occurs in separate barite veins.

A special type of pre-Tertiary deposits is represented by barite veins genetically related to melaphyr rocks of probably Permian age. They contain high graded barite but the mineralization is usually very irregular and of small dimensions.

In connection with the Neogene metallogenesis small amounts of barite formed during the latest mineralization stages in polymetallic deposits.

Thermoluminescence of Barites

Glow curves of barites are characterised by one peak near 200 °C (180—210 °C). On samples irradiated before the running for glow curves by X-, beta- or gamma-rays, a low temperature peak (80—90 °C) appears too under normal laboratory conditions. As the corresponding trap-level depth is relatively shallow as compared with the

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temperature of the geological milieu, electrons are released by the traps during geologic time. The low temperature peak doesn't therefore appear on glow curves of natural, unirradiated barites.

A short survey of the thermoluminescence of barites from several West Carpathian ore deposits is given in this paper. The material was sampled so as to show the variability of TL in one and the same as well as between different deposits.

A. Rudňany

The main deposit of Rudňany is formed by two E—W striking veins: the Droždiak- and the Hrubá vein. The length of the first — cca 4 km, of the second 1.5 km, both varying in thikness from several to 15—20 m. The geology of the district has been recently described by J. Pecho and M. Popreňák (1962) and others, whereas detailed mineralogical and geochemical investigations were carried out by J. Bernard (1961), who gives a short review of older papers.

J. Bernard (l. c.) distinguished in the mineralization of both veins six stages:

1. Fuchsite stage. With quartz I, pyrite I und fuchsite. Strongly dependent on mobilisation of elements from the country rock.

2. Siderite stage. Quartz II, pyrite II, gersdorffite I, siderite I, pyrite III, quartz III, ankerite and ferrous dolomite occur as primary and skuterrudite-chloanthite as remobilised minerals.

3. Barite stage. Almost exclusively barite I and insignificant amounts of siderite II.

4. Tourmaline stage. Tourmaline, pyrite IV, quartz IV, ankerite II, rarely rutile.

5. Sulphide stage. Hematite, pyrite V, arsenopyrite V, quartz V, sphalerite, chalcopyrite I, pyrite VI, tetraedrite and cinnabarite are regarded as primary, whereas gersdorffite II, bornite I, chalcopyrite II, siderite III, quartz VI, barite II, pyrite VII, chalcocite, covellite, bornite II as partly mobilized.

6. Calcite stage. Calcite as well as remobilized pyrite VIII and chalcopyrite III.

Practically all the barite of the deposite (barite I) is regarded as the product of one mineralization stage, barite II occuring quite sporadically and in insignificant amounts. Barite is concentrated in the upper parts of the deposit-above the VIth level in the Droždiak- and above the IInd level in the Hrubá- vein (Fig. 1).

It occurs either in separate veins or more often in mixed siderite-barite veins. Both minerals were first regarded as contemporaneous. O. Schmidegg (1944) and later J. Bernard (l. c.) described barite as belonging to later mineralization stages forming large (up to 1 meter) metacrysts replacing older siderite.

The thermoluminescence has been systematically studied on samples from the second level of the Droždiak vein (section IV, S-III-1) which represent the wedging out of a mighty barite (+ siderite) vein intersecting permian conglomerates, sandstones, schists.

Glow curves of this 3 m long section are shown in fig. 2.

The thermoluminescence is most intense near the hanging wall, descreasing rapidly towards the central part and then rising again towards the lying wall. The intensity of TL is on the glow curves indicated in arbitrary chosen units (ordinate). Barites from this section of the unoxydized part of the deposit show a relatively low TL.

Another set of barites from the same vein system has been sampled on the locality Baniská, where a 15 meters thick barite vein is developped near the contact between the Permian and the Carboniferous. This uppermost part of the barite mineralization lies already in the oxydation zone (limonitization a. s. o.).

The natural TL of the samples is represented in fig. 3. As in the preceeding case a gradual decrease of TL from the margins to the center is observed. This tendency is interrupted by 3 samples with higher TL in the central part of the vein. Barites from this section are in general characterized by a more intense natural TL than those from the deeper parts of the deposit (compare Fig. 2, 3).

1 km N of the main veins of Rudňany is situated the Zlatník vein of ENE—WSW direction. The country rocks consist of graphite-, graphite-chlorite, to chlorite schists of Carboniferous age. This siderite-barite vein was formed during 5 mineralization stages (J. B e r n a r d l. c.):

1. Fuchsite stage with fuchsite and quartz I.
2. Siderite stage — siderite I, quartz II.
3. Barite stage — barite and small amouts of siderite.
4. Sulphide stage — specularite, pyrite I, quartz III, chalcopyrite, tetrahedrite, cinnabarite.
5. Calcite stage — calcite and some pyrite II.

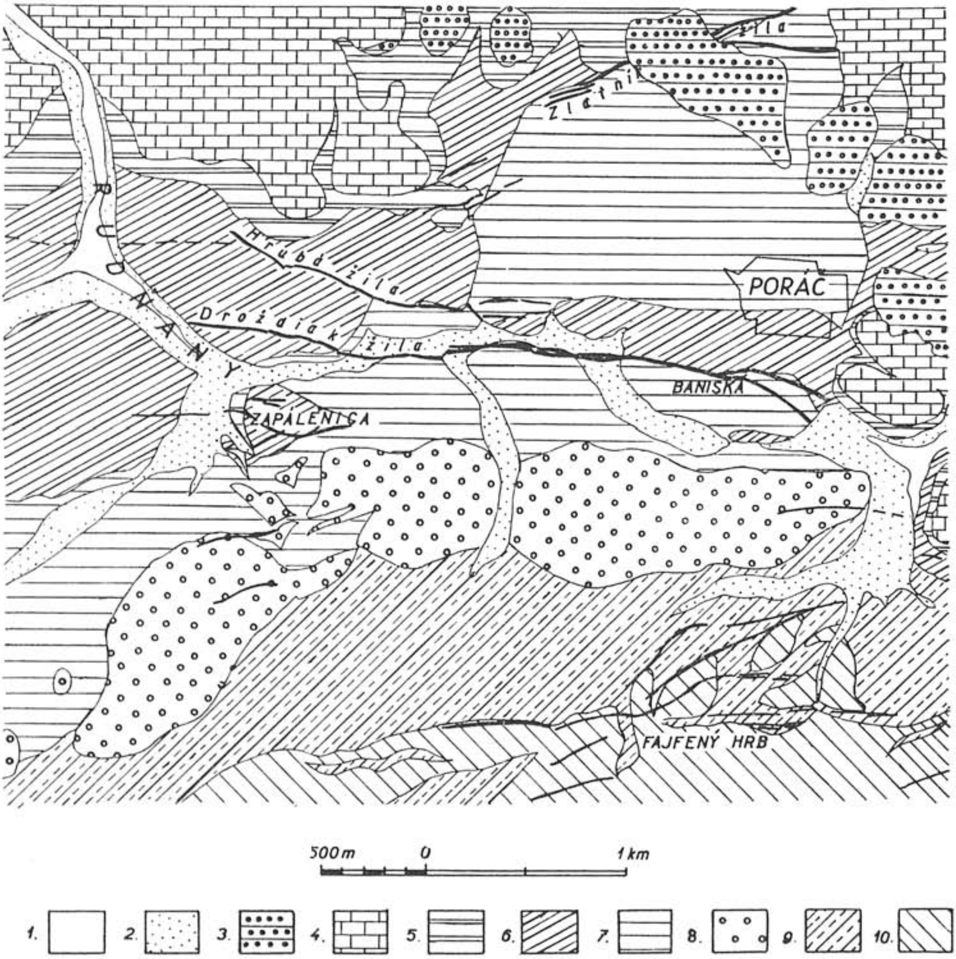

Fig. 1. Geological map of Rudňany. Schematized after J. P e c h o and M. P o p r e ň á k (1962). 1 — Alluvium; 2 — Clay, debris; 3 — Conglomerates; 4 — Limestones (Wetterstein-type); 5 — Variegated slates; 6 — Conglomerates, sandstones, slates; 7 — Graphite-, graphite-chlorite schists, sandstones, diabase tufites; 8 — Conglomerates; 9 — Chlorite-sericite phyllites; 10 — Diabases; 1-2 — Quaternary; 3 — Paleogene; 4-5 — Triassic; 6 — Permian; 7-8 — Carboniferous; 9-10 — Devonian.

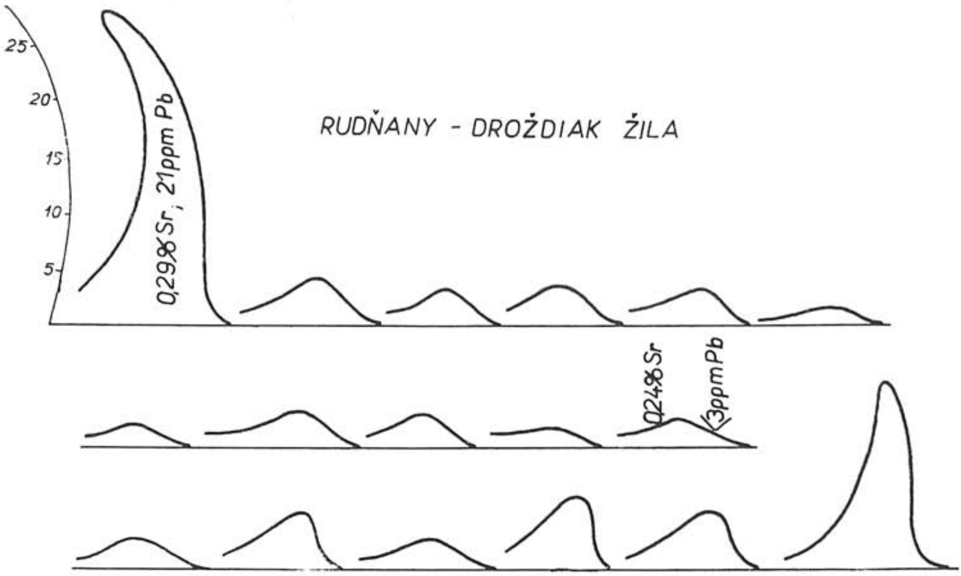

Fig. 2.

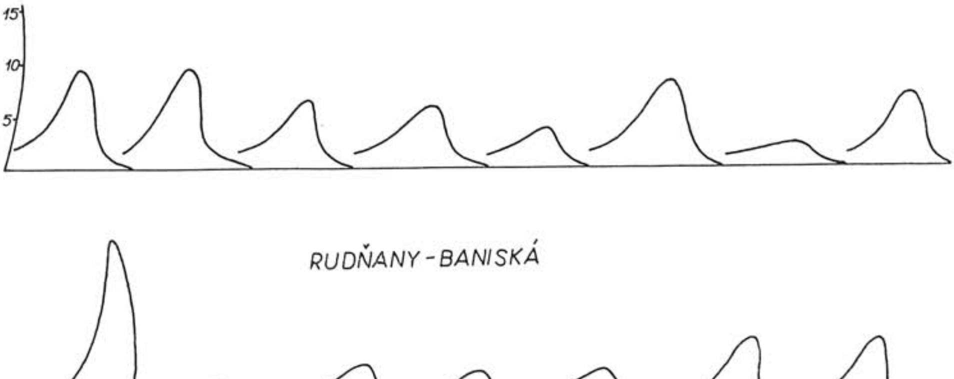

Fig. 3.

The character of the natural thermoluminescence across this 1,5 m thick vein in the Zlatník adit is shown in the upper part of fig. 4. The intensity is low in the center, increasing towards the border zones.

Barites from thin veins cutting Permian rocks at the locality Zápalenica show a markedly higher TL than all above mentioned samples. To some degree they can be considerated an analogy to the border zones of thick veins, which are usually characterized by a high TL. Differences in chemical composition, structural factors, doses of radiation received a. s. o. must be taken into account, too. In the lower vein (Fig. 5) an increase of TL near the hanging wall is observed.

B. Krásnohorské Podhradie

In the surroundings of Krásnohorské Podhradie, in the southern part of the Spišsko-

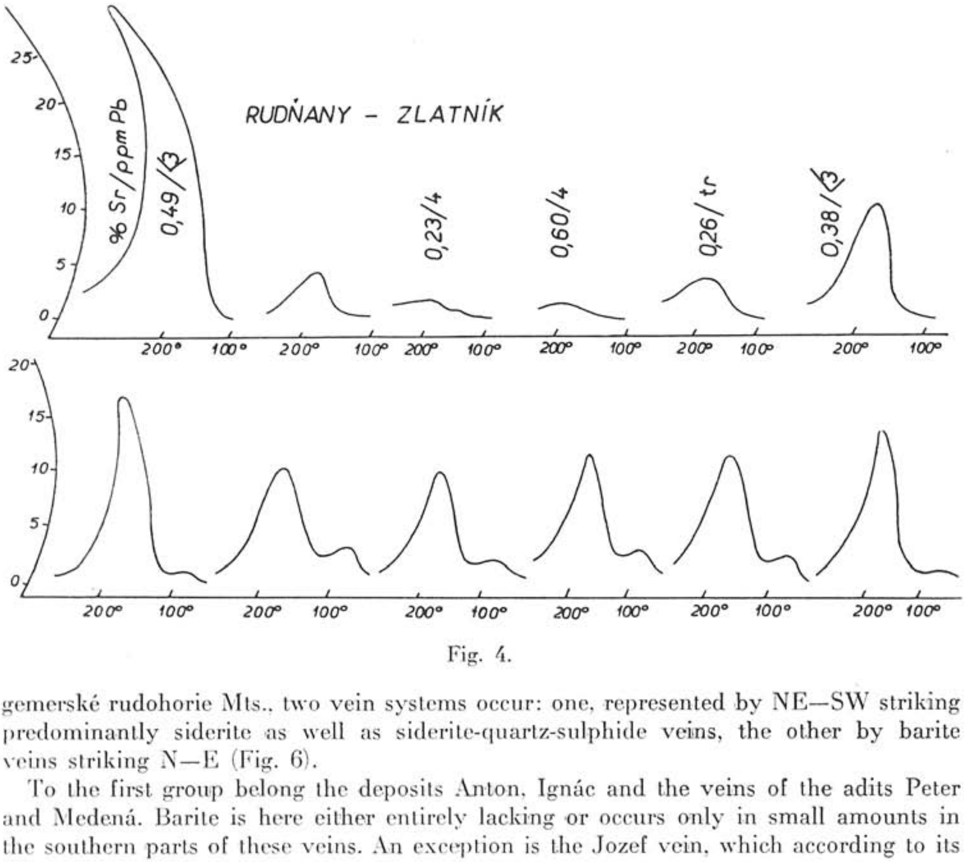

Fig. 4.

gemerské rudohorie Mts., two vein systems occur: one, represented by NE—SW striking predominantly siderite as well as siderite-quartz-sulphide veins, the other by barite veins striking N—E (Fig. 6).

To the first group belong the deposits Anton, Ignác and the veins of the adits Peter and Medená. Barite is here either entirely lacking or occurs only in small amounts in the southern parts of these veins. An exception is the Jozef vein, which according to its filling belongs to barite veins.

The barite veins differ from prevailingly siderite veins not only in the striking, but also in their occurrence South of the latter. The deposits Štefan, Pentek patak, the veins Vida, Emil as well as the so called „cross-veins" of the Anton deposit (B. Cambel 1953, J. Litavec 1955) belong to this system. Interesting is the fact that barite predominates in the southern parts of the „cross-veins", whereas towards North they change into siderite veins. The barite veins are parallel with the schistosity.

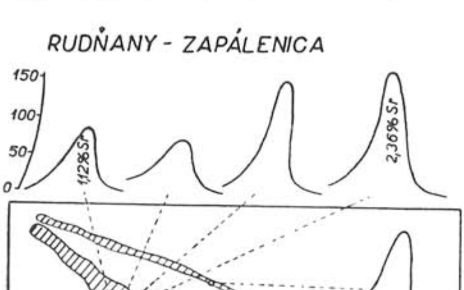

Fig. 5

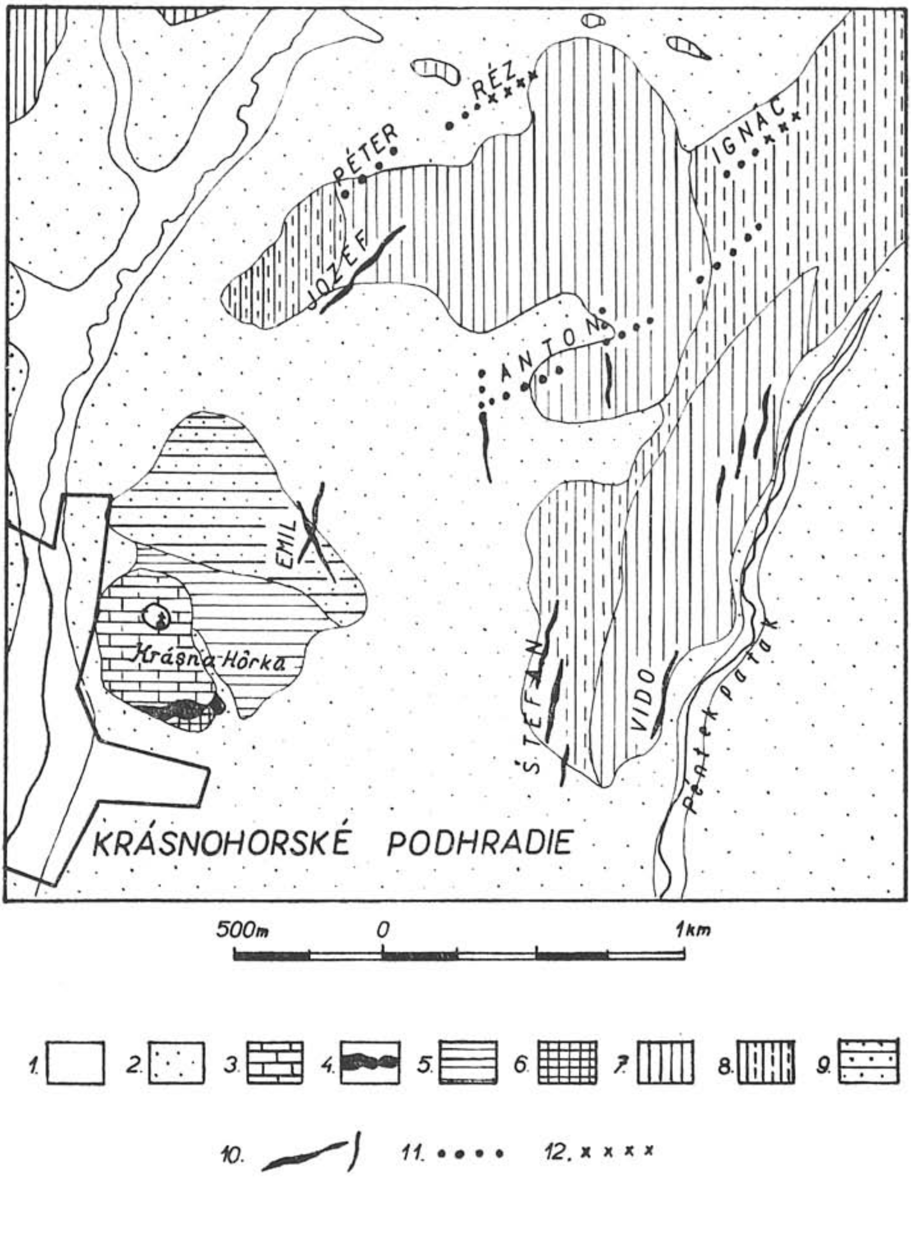

Fig. 6. Ore veins in the surroundings of Krásnohorské Podhradie. 1 — Alluvium; 2 — Clay, debris; 3 — Limestones (Wetterstein-type); 4 — Crystalline limestones; 5 — Slates, sandstones, graywaykes, phyllites; 6 — Schists with diabase tuffits; 7 — Porphyroides; 8 — Phyllites; 9 — Quartzites, sandstones, phyllites; 10 — Barite veins; 11 — Siderite veins; 12 — Siderite-quartz veins; 1-2 — Quaternary; 3, 5 — Triassic; 4, 6, 9 — Carboniferous; 7-8 — Cambro-Silurian.

The age relations between both vein systems aren't yet unequivocally determined. Detailed paragenetical studies carried out in the northern part of the Spišsko-gemerské rudohorie Mts. as well as a more intensive tectonization of the siderite Anton deposit in comparision to the Štefan deposit (J. Litavec l. c.) indicate a probably younger age of the barite mineralization.

C. Varček (1953) described from the Anton vein: siderite, barite, quartz, pyrite, hematite, chalcopyrite, tetrahedrite, ankerite, tourmaline, albite. Siderite, pyrite and quartz are present in two generations and barite formed after siderite I, pyrite I and quartz I. The hypogene minerals formed in two supply periods.

The system of barite veins of the Štefan deposit has been investigated by B. Cambel (l. c.) and J. Litavec (l. c.). The vein filling consists of barite, siderite, quartz, specularite, tetrahedrite, pyrite, chalcopyrite. B. Cambel supposed that all minerals are the product of one portion of hydrothermal solutions without a greater lag between the deposition of siderite, barite, quartz and the sulphides. According o J. Litavec the following succession can be observed: siderite I — quartz I, barite — specularite, specularite, siderite II — quartz II, tetrahedrite — chalcopyrite.

High grade barite occurs always in thick veins and lenses, whereas in thinner ones its quality is lowered by higher contents of siderite.

The Štefan deposit is formed by 3 barite veins cutting porphyroids of the Cambro-Silurian Series near their contacts with sandstones and quartzite beds. In the uppermost, oxydized part of the deposit a thick lenseshaped body of barite and limonite occurs, too. Barite veins were interpreted either as the continuation to depth of the limonite-barite lense (B. Cambel), or as a younger mineralization, cutting an older lense-shaped siderite vein (J. Litavec).

The deposit Pentek patak consists of 3 barite veins. The geologic setting and paragenesis are similar. J. Guľa (1955 manuscript) distinguished three mineralization stages: quartz I — siderite I — pyrite I, barite — siderite II — specularite I, quartz — tourmaline — specularite II — pyrite II — chalcopyrite — tetrahedrite — albite — ankerite — calcite.

The distribution of natural TL across a 2 m thick vein from the Magdaléna adit of the Pentek patak deposit is given in the upper part of fig. 7. The intensity of TL is

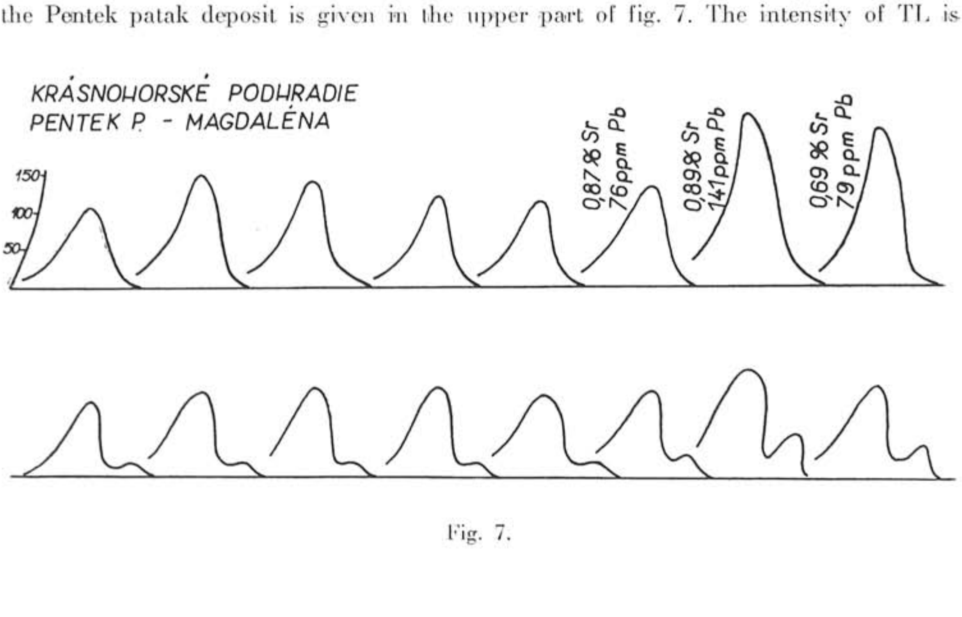

Fig. 7.

here considerably higher than in barites from the main veins of the Rudňany deposit.

Barites from the 70 m deeper lying profile of the Pentek patak deposit (Zero-level) show a lower natural thermoluminescence. A very regular decreasing of TL from the outer to the inner parts of the vein can be observed (Fig. 8, upper part).

C. N i ž n á M a t e j k o v á S. of Ružomberok

A NNE—SSW striking barite vein cuts leucocratic granitoids of the Veľká Fatra Mts. The mineralization penetrates even Lower Triassic quartzites and is regarded of Cretaceous age (J. T u r a n 1959).

Besides barite small amounts of quartz and quite subordinate galena, sphalerite, chalcopyrite, pyrite and tetrahedrite occur. Succession: quartz — barite — sulphides.

The natural TL of barite from the outcrop (oxydation zone) of a 1,5 m mighty vein has been studied. Great variations in the intensity of TL are observed in this section (Fig. 9).

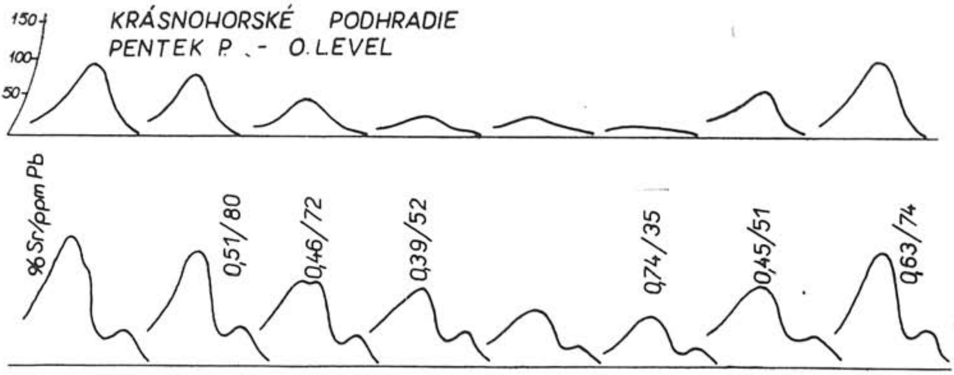

Fig. 8.

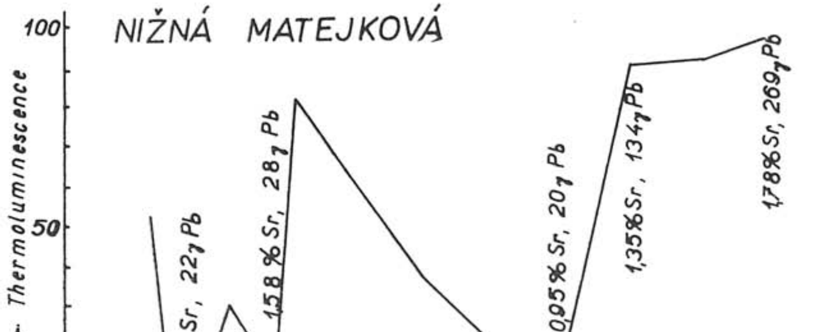

Fig. 9.

Chemical Composition of Barites

The chemical composition of barites, especially their minor elements were investigated by quantitative and qualitative spectrochemical analyses kindly carried out by G. K u p-č o at the Dionýz Štúr Geological Institute in Bratislava (Table 1 — qualitative analyses).

From qualitative spectrochemical analyses follows:

Sr: Usually present in amounts 0,1—1,0 %. Higher contents observed in barites from lokalities: Nižná Matejková, Jaklovce, Košické Hámre, Šankovce, Čuntava and Zapálenica (Rudňany).

Pb: In barites from siderite-barite veins in Rudňany present in traces. Highest contents in Nižná Matejková and Banská Štiavnica i. e. in material from lokalities where galena occurs, too. Lower amounts of lead showed samples from Jaklovce and Košické Hámre.

Ca: Relatively monotonous. Between 0.01 and 1.0 %.

Al: Mostly as Ca. Only samples from Nižná Matejková characterised by higher contents (supergene enrichment?).

Mg: Similar to Al.

Mn: Always present in barite from siderite-barite veins in Rudňany, to lesser extent in Krásnohorské Podhradie. In polymetallic deposits only sporadically observed.

Cu: Present in all samples in amounts ranging from traces to 0.1 %.

Ag: Found in samples from Banská Štiavnica, Hodruša, Nižná Matejková, Jaklovce i. e. in material where Pb is present in higher concentrations, too.

Na, Fe are usually present, whereas other elements occur quite sporadically.

The results of quantitative spectrochemical analyses for Pb, Sr, Ca, Cu, Mg and Mn are shown in table 2.

Relations between Thermoluminescence and Chemical Composition of Barites

The study of natural thermoluminescence in barites revealed the following cases: The intensity changes according to certain laws-decreases from the border zones towards the center of the vein (Fig. 2, 4 and 8) eventually is higher near the hanging wall than in other parts of the vein (Fig. 5, 7).

Sometimes the tendency to a gradual decrease is interrupted by the presence of higher thermoluminescent barites in central parts of the veins (Fig. 3) or the intensity is very irregularly distributed (Fig. 9).

Certain differences were also observed in barites from different levels of the same deposit (Fig. 2, 3) and still more pronounced in fig. 7 and 8.

Striking is sometimes the difference in TL of barites belonging to the same ore formation (for example siderite-barite formation): barites from the Droždiak and Zlatník veins in Rudňany are characterized by a much lower TL than barites from Pentek patak near Krásnohorské Podhradie as well as barites from other veins in the vicinity of Rudňany (Zapálenica, Fajfený hrb a. s. o.).

Low thermoluminescent barites from Rudňany (Droždiak-, Zlatník vein) are characterized by low strontium and very low lead contents in contrast to Krásnohorské Podhradie, where higher concentrations of strontium an markedly higher lead contents are observed.

The influence of Pb and Sr is in this case evident notwithstanding the fact that the natural thermoluminescence depends on many other factors including the age of the

Table 1

	No. TL	Sr	Ca	Pb	Si	Al	Mg	Na	Fe	Mn	Cr	Ni	Cu	Ag	Li	Zn
Rudňany:	337	5	3	—	3	3	2	2	2	—	—	—	1	—	—	—
Zlatník	339	4	4	—	—	2	2	2	2	2	—	—	1	—	—	—
Droždiak	220	4	3	—	4	2	2	—	3	2	—	—	2	—	—	—
IInd hor.	229	4	4	—	2	2	2	—	3	2	2	—	1	—	—	—
	205	4	3	—	4	2	2	—	3	2	—	—	1	—	—	—
	204	4	3	—	4	2	2	—	3	2	—	—	2	—	—	—
	233	4	4	—	4	2	2	—	3	2	—	—	1	—	—	—
	209	4	4	—	4	3	2	—	3	2	2	—	2	—	—	—
Rochus	267	4	4	—	4	2	2	—	2	2	—	—	1	—	—	—
	268	4	4	—	4	3	—	—	2	2	—	—	1	—	—	—
Baniská	262	4	3	—	2	3	2	2	2	2	1	—	1	—	—	—
	264	4	3	—	2	3	2	2	2	2	—	—	1	—	—	—
	266	4	3	—	2	2	2	2	2	—	—	—	1	—	—	—
Zapálenica	383	5	4	—	2	2	2	2	2	—	—	—	1	—	—	—
Krásnohorské Podhradie:																
Pentek p. O h.	317	4	4	1	2	2	2	2	2	2	2	1	1	—	—	—
	318	4	4	1	2	3	2	2	3	3	—	—	1	—	—	—
	322	4	4	—	2	2	2	2	2	2	2	1	2	—	—	—
	323	4	4	1	2	2	2	2	2	2	—	—	—	—	—	—
	279	4	4	—	—	2	2	2	1	—	—	—	1	—	—	—
Magdaléna adit	307	4	4	1	3	2	2	2	2	2	2	2	1	—	—	—
	310	4	4	—	3	2	2	2	2	2	—	—	1	—	—	—
	312	4	4	—	4	2	2	2	2	2	—	—	1	—	—	—
Štefan dep.	283	4	4	1	2	2	2	2	1	—	—	—	1	—	—	—
	284	4	3	1	2	2	2	2	1	—	—	—	1	—	—	—
Jozef vein	326	4	3	—	4	2	2	2	2	—	—	—	1	—	—	—
	327	4	3	1	3	2	2	2	2	—	—	—	1	—	—	—
Jaklovce:	295	5	4	2	3	3	3	2	3	—	—	—	1	—	—	—
	296	5	4	2	3	4	3	2	3	—	—	—	1	1	—	—
	305	5	4	—	2	3	3	2	3	—	—	—	2	1	—	—
Košické	288	5	4	1	4	3	3	2	3	1	1	—	2	—	—	—
Hámre:	291	4	3	—	3	2	2	2	2	2	—	—	1	—	—	—
	292	5	4	1	5	3	3	2	3	1	1	—	2	—	—	—
	303	4	3	—	4	3	2	2	2	2	—	—	2	—	—	—
	304	4	4	—	5	3	3	2	2	2	1	—	2	—	—	—
Nižná	195	5	4	3	4	4	2	2	4	1	1	—	3	1	1	—
Matejková:	198	5	4	3	4	4	2	2	3	—	—	—	2	—	—	—
	199	5	4	3	5	4	2	2	3	—	—	—	1	—	—	—
	218	5	4	1	4	3	2	2	2	—	—	—	1	—	—	—
	221	5	4	3	5	4	3	2	3	—	—	—	3	2	1	—
Banská Štiavnica:																
Terézia vein 3th hor.	238	4	3	2	4	3	1	1	2	—	—	—	1	—	—	—
Bieber vein	245	5	4	3	5	4	2	2	1	—	—	—	2	1	2	2
Hodruša:																
Rozália vein	242	4	4	—	3	3	2	2	4	—	—	—	1	—	—	—
Baia Sprie:	257	4	3	—	2	3	2	2	4	4	1	—	2	—	—	—

10—1 %	1—0,1 %	0,1—0,01 %	0,01—0,001 %	0,001—0,0001 %
5	4	3	2	1

Table 2

Locality	No. TL	Pb (γ)	Sr %	Ca %	Cu %	Mg %	Mn %
Rudňany:							
Droždiak vein	200	21	0,29	<0,01	0,0017	0,022	0,0054
	206	23	0,42	0,01	0,0030	0,018	0,0042
	233	<3	0,24	<0,01		0,010	0,0016
Zlatník vein	337	<3	0,49	0,018		0,039	<0,0010
	339	4	0,23	0,031	<0,0010	0,033	<0,0010
	340	4	0,60	0,040	<0,0010	0,031	<0,0010
	341	tr.	0,26	<0,01	0,0014	0,011	<0,001
	342	<3	0,38	<0,01	0,0015	0,006	<0,0010
Krásnohorské Podhradie:							
Magdaléna adit	314	76	0,87	0,02	<0,0010	0,016	0,0016
	315	141	0,89	0,025	<0,001	0,030	0,0012
	316	79	0,69	0,01		0,030	0,0037
O-level	319	80	0,51	0,021	<0,0010	0,014	0,0020
	320	72	0,46	0,018	<0,0010	0,024	0,0027
	321	52	0,39	0,018		0,013	<0,0010
	323	35	0,74	0,021	<0,0010	0,020	<0,0010
	324	51	0,45	0,061		>0,03	0,0061
	325	74	0,63	0,044		>0,03	0,0043
Nižná Matejková:	197	20	0,95	<0,01	0,0012	0,0025	<0,0010
	199	269	1,78	<0,01	<0,001	0,0037	tr.
	218	22	1,10	<0,01	<0,001	0,0044	<0,0010
	220	28	1,58	0,014		0,004	<0,0010
	223	134	1,35	0,010	0,0013	0,002	<0,0010
Banská Štiavnica:	177	6	0,50	tr.		0,008	0,0014
	238	24	2,20	0,035		0,029	<0,0010
	239	8	0,68	0,014	<0,0010	0,0066	0,0013
Jaklovce:	296	89	1.04	0,017		0.008	<0,0010

mineralization, the thermal history of the sample. different contents of radiogenetic elements, deformation and damage of the lattice a. s. o.

Many of these factors can be eliminated by the study of artificially irradiated samples. In our experiments the natural thermoluminescence was annealed by heating of the samples to 450 °C. Afterwards they were irradiated by equal doses of X-rays and investigated for their thermoluminescence.

The difference between the thermoluminiscence of natural and artificially irradiated samples is evident for example from fig. 4 (upper part — natural TL, lower part same samples, X-ray irradiated). Whereas the natural TL gradually decreasses from the margins to the center of the vein. the irradiated samples, with the exception of both outermost ones, are characterised by almost equal TL indicating similar chemism and structural factors.

Great differences in natural TL are in this case evidently the result of unequal doses of radiation received-decrease of radioactive elements to the center of vein. To lesser degree they depend on variation of strontium contents. A similar case is represented in fig. 7.

A regular distribution of TL intensity was also observed in barites from the Zero-level of the Pentek patak deposit (upper part of Fig. 8.). But the intensity of X-ray induced TL (lower part of Fig. 8) shows in this case a similar trend as the natural one. The decrease of thermoluminescence, both natural and induced, towards the central part of the vein is here due to lower contents of Pb and Sr in later portions of hydrothermal solutions with a rather uniform distribution of radioactive elements across the vein.

Barites from Nižná Matejková may also represent an example, where close relations between chemical composition and natural TL exist (Fig. 9). Samples poor in lead and strontium exhibit a low thermoluminescence and conversely. These relations may be, mainly in barites with high lead contents, partly veiled by the presence of heterogenous lead not incorporated in the lattice of barites. Further variations are probably the result of secondary, supergene processes (leaching out of certain elements — Sr, Ca, Pb, enrichment in other, recrystallisation a. s. o.). Barites from the oxydation zone are usually characterized by less regular thermoluminescence than those from primary zones.

An example of primary vertical zoning, revealed by the study of natural TL in the Pentek patak deposit is given in the upper parts of fig. 7 and 8. The mean values of Pb and Sr in barites of the Magdalena adit are 90 ppm Pb and 0,80 % Sr, whereas on the 70 m deeper Zero-level they decrease to 60 ppm Pb and 0,50 % Sr.

Striking is the difference in TL intensity of barites from the Droždiak and Zlatník veins (Fig. 2 and 4) as compared with some other occurrences in the vicinity of Rudňany (Fajfený hrb. Zapálenica; Fig. 5). The Pb and Sr contents are — in accordance with the TL — low in the first case and high in the second.

Glow curves of barites from the siderite-barite formation of the Spišsko-gemerské rudohorie Mts, after irradiation by equal doses of X-rays, are shown in fig. 10. The lead content in ppm is indicated on each glow curve.

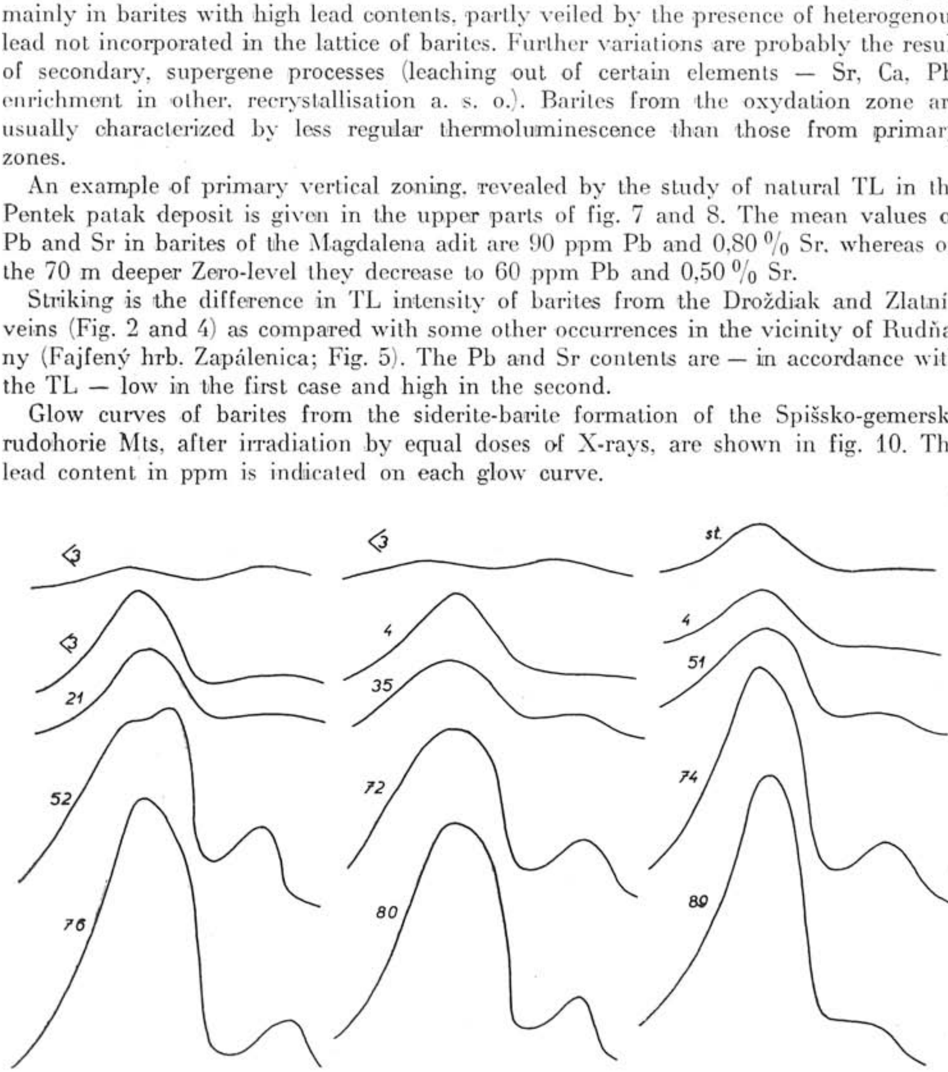

Fig. 10.

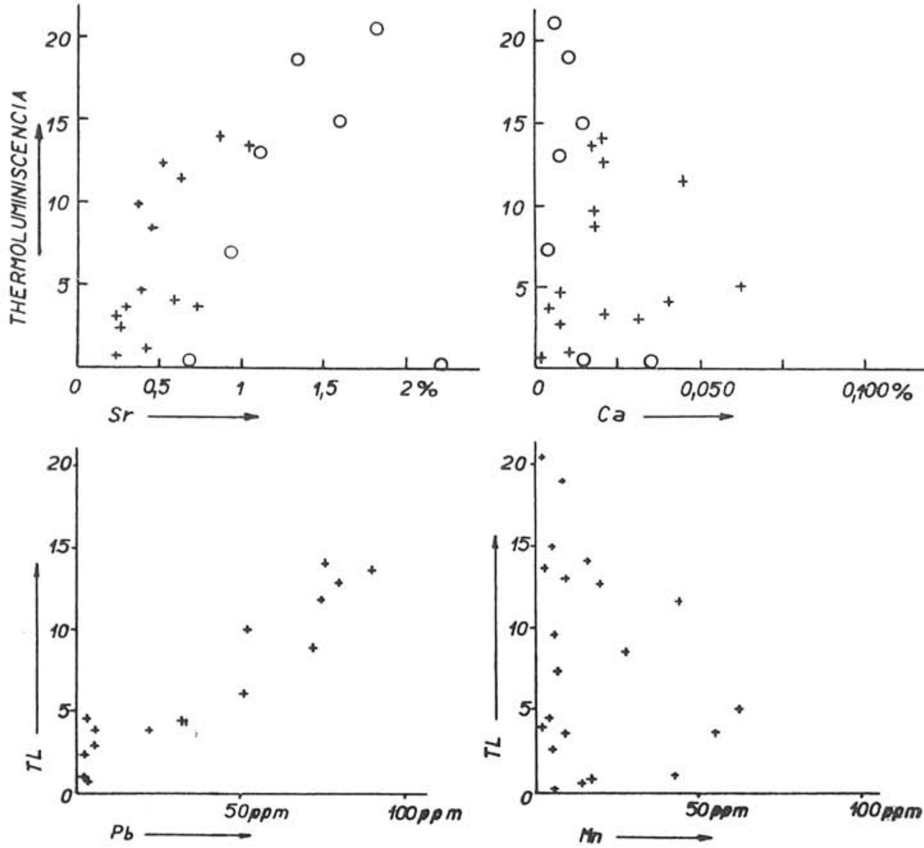

Fig. 11.

A graphical presentation of relations between artificially induced TL of barites and their Sr, Ca, Pb, Mn contents is given in fig. 11 (siderite-barite veins-crosses; polymetallic veins-circles). A direct proportionality between thermoluminescence and lead and strontium is evident (ionic radii: Ba — 1,38; Pb — 1,26; Sr — 1,20 Å). Calcium in very small amounts (O,OX %) is present partly bounded by secondary diadochy to the more abundant Sr^{++}, possibly as isomorfous substantion of $CaSO_4$—$BaSO_4$, and may be also as heterogenous admixture. Owing to its very low contents no influence of Ca on the thermoluminescence is observed.

Of Neogene age are polymetallic deposits of Banská Štiavnica, Hodruša in Czechoslovakia and Baia Sprie in Roumania, whereas Trangoška, Jasenie, Nižná Matejková are pre-Tertiary. There is a marked difference between both groups in the TL of natural as well as activated samples (Fig. 12). A very low TL is typical for Neogene barites. The high X-ray induced TL of older samples reflects besides other factors lattices with more defects, partly produced by higher doses of radioactive radiations received, probably also by a more intensive tectonization.

Conclusions

The thermoluminescence of barites depends besides other factors on isomorfous substitution of lead and strontium in the lattice. In artificially irradiated samples an approximative picture about the contents of these elements can be got.

From a comparision of glow curves of natural and irradiated samples an idea can be made about the distribution of radioactive elements in barite veins.

Thermoluminescence investigations allow to follow primary, lateral and vertical changes, variations in Pb and Sr contents occuring during one stage of mineralization, as well as those between barites belonging to different generations. In cases, where a direct relation between thermality of hydrothermal solutions and Sr and Pb contents of barites exists, thermoluminescence can serve as a usefull tool in paleothermometric studies.

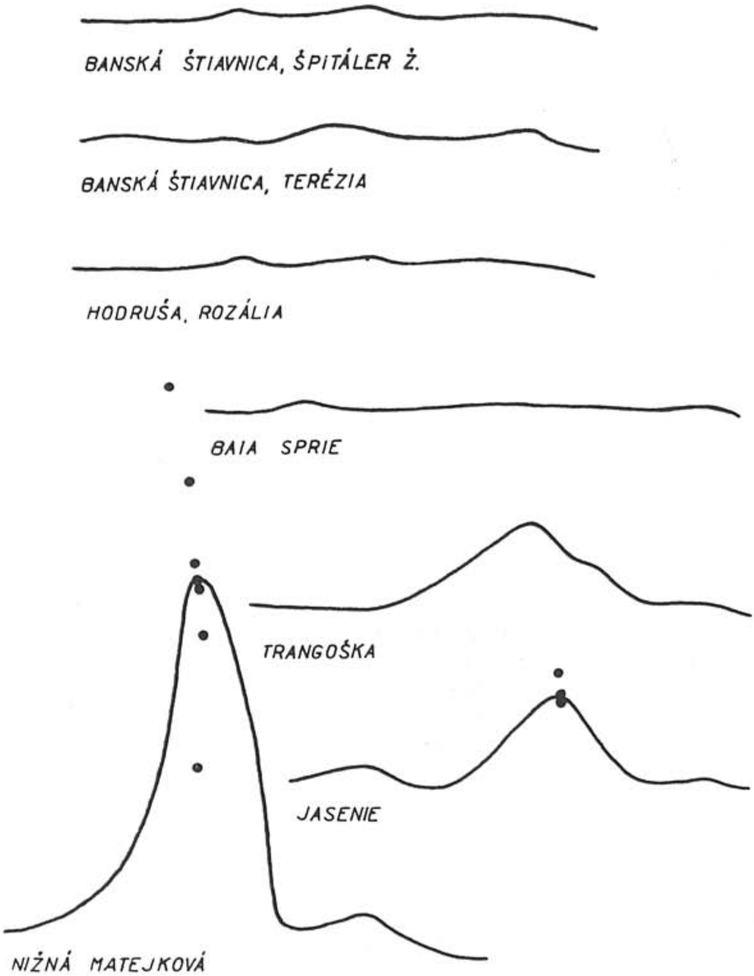

Fig. 12.

Conclusions about relative ages can be sometimes obtained directly from glow-curves. For approximative datings a quantitative determination of radioactive elements is necessary.

Unsystematically sampled material for geochemical investigations of barites and other minerals is only of limited value. Thermoluminescence represents a very quick method allowing to select the most suitable material for detailed geochemical investigations.

Thermoluminescence is therefore to be regarded a perspective method in metallogenetical as well as mineralogical and geochemical investigations.

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Review by B. Cambel.

B. CAMBEL, G. KUPČO: PETROCHEMIE UND GEOCHEMIE DER METAMORHEN HORNBLENDGESTEINE IN DER KLEINKARPATENREGION. Edited in the German language by the institutes of the Scientific Advisory Board for Geology and Geography of the Slovak Academy of Science, 1965, Bratislava, pp. 108, 20 tables, 42 diagrams.

In the first number of the 1965 year's volume of the edition Science of the Earth — Geologica — the work by B. Cambel and G. Kupčo,[1] dealing with petrography, geochemistry and petrochemistry of metamorphites of the ophiolitic volcanism in the crystalline of the Small Carpathians, has been published.

Since it represents the first work in our literature dealing in such a detailed manner with the composition of the ophiolitic magma, it is necessary to inform our readers about its contents.

71 samples of amphibolitic rocks have been taken for the estimation, 31 of them having been put to silicate, planimetrical and quantitative-spectrochemical analyses; the rest were subject just to the quantitative-spectrochemical analysis complemented with microscopical observations. The results of the analyses have been carefully and easy-to-survey arranged in tables and diagrams.

There are p. p. m. values of macroelements and of the following microelements: Ga, Cr, V, Ni, Co, Cu, Zr, Sc, Y, Sr, Ba, and Rb, and the quantitative values for Li, Sn, Pb, Mo, Yb, La, and Ag.

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In the first part of the work, B. Cambel presents the opinion that ophiolites from the crystalline of the Small Carpathians belong in the majority to the Niggli's gabbroid and leucogabbroid magmatic group. Ophiolites were first regionally epimetamorphosed, then periplutonically contact meso- to katametamorphosed. Locally the metamorphites were diaphtorized under the influence of the alpine tectonometamorphism.

In the second part of the work, both authors deal with the geochemistry of ophiolites. Quantitative spectrochemical analyses were carried through by G. Kupčo by means of his own method described in detail in Acta Geologica et Geographica Universitatis Comenianae No. 6 (1963). Nevertheless, in the work reviewed the decisive circumstances of the carrying-on of the analyses have been presented, too.

The authors arrange the samples studied into natural groups, viz. according to two aspects. In the first case they take in consideration geological outcropping and basic character of the ophiolites (differentiation row) with groups: gabbros, gabbroamphibolites, amphibolites and melanocratic amphibolites. These are complemented by stratigraphically defined group — ophiolites of the Harmonia series (the only series of the West-Carpathian crystalline with known stratigraphical position) and by the group of the most melanocratic types from among all groups. To this group amphibolstones belong first of all. In the second case the authors take in account the degree and character of the metamorphism with the groups of epi-, meso-, kata- and retrogrademetamorphosed ophiolites.

In the present work, the mean quantitative values of the elements studied (in p. p. m.) in separate groups are stressed; and the relations of microelements to macroelements which are the isomorphic agents of the former ones, are being followed as well. The distribution of elements is graphically worked-up by means of the graphs of dispersion and histograms. The dependence of element concentration upon the amount of Mg in the rock, upon the basic character of the rock expressed by the Zavaricki's value Q or upon modificated Larsen's value $[^1/_3\ Si + K - (Ca + Mg)]$ has been followed, too. In each element studied its portion is compared with dates presented in literature.

As to the evaluation, the authors state that clarks of the elements in question deviate only in Ga from the usual intervals. In this element its portion does not reach even the half value of the clark determined by Vinogradov (1962). The metamorphism does not cause any observable migration of elements with the exception of Ba in ophiolites from the contact with granitoids, which is connected with the enrichment of the rock with Kalium. Sulphur ore mineralization in the Small Carpathians is not copperbearing, since its cause — the ophiolitic magmatism — shows just very low portion of Cu at all; and vice versa — high portion of Ni in amphibolitic rocks is shown in the high fone of Ni in pyrites. In stratigraphically defined ophiolites of the Harmonia series, the specificity of magma in comparison with the rest of ophiolites may bee seen, too.

In the conclusion it is necessary to point out the systematic working-up of the theme and the amount of the analytical material suitable for the comparative study, which is continued by the authors in the work with ophiolites of other West-Carpathian areas.

Doubtlessly, it will contribute to the knowledge of the magma of the ophiolites from this area. The work just testifies to the fact, that by means of geochemistry of microelements in amphibolic rocks of the Small Carpathians it has been possible to solve successfully the problems of the ophiolitic magmatism, metamorphism, stratigraphy and of the relation of metallogenesis to magmatism. It has been affirmed that by means of geochemistry of microelements of rocks it is possible to solve important geological and genetical problems.

Translated by E. Jassingerová.

Ladislav Kamenický