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RARE EARTHS FROM URANIUM MINERALIZATION OCCURRENCES IN THE PERMIAN OF THE GEMERICUM, THE WESTERN CARPATHIANS

(12 Figs., 6 Tabs.)

Abstract: Uranium mineralization in the Permian of the Gemericum is accompanied with apatite, monazite and xenotime. Study of REE distribution is based on results of INAA and OES analyses of rocks and EDX microanalyses of minerals. Main LREE bearing mineral is monazite and HREE one — xenotime. Rocks accompanying uranium mineralization have increased REE contents. Mobilization and concentration of uranium mineralization took place during the Alpine metallogenic processes. These processes were associated also with REE mobilization, whereby total and selective enrichment in LREE and HREE was observed.

Резюме: Урановая минерализация в перми гемерикума сопровождена апатитом, монацитом и ксенотимом. Исследование распределения р. э. э. основывается на результатах INAA и OES анализов пород и EDX микроанализа минералов. Глвнаым носителем легких р. з. э. является монацит и тяжелых р. з. э. — ксенотим. Породы, сопровождающие урановую минерализацию, имеют повышенные содержания р. з. э. Мобилизация и концентрация урановой минерализации проходили во время альпийских металлогенических процессов. С этими процессами была связана и мобилизация р. з. э., причем наблюдалось общее и селективное обогащение легкими и тяжелыми р. з. э.

Increased contents of rare earth elements (including Y) in U-Mo ores near Novoveská Huta have been known for a longer time (Pelymsky, 1966; Rojkovič, 1968; Tréger, 1973; Rojkovič et al., 1981). At present, increased contents of rare earth elements (REE) have been found out in several localities in the Permian of the Gemericum in hydrothermally affected rocks accompanying uranium mineralization. Monazite, xenotime, brannerite and apatite, i.e. most of minerals considered as main REE bearing minerals of economic concentrations, have been found in these rocks. Apatite (Fig. 1) is the most frequent mineral, especially in the localities of Gočaltovo and Novoveská Huta (Rojkovič, 1981) where P_2O_5 contents reach even 12 and 13 wt. percent (Tab. 1). In spite of quite abundant occurrence, apatite is not an important REE bearing mineral in the above-mentioned localities. REE are present almost in all analyzed apatites, but their contents do not exceed 1 wt. % (Tab. 2). Ce, Nd, Sm, Yb and Y have been found out. (According to analyses

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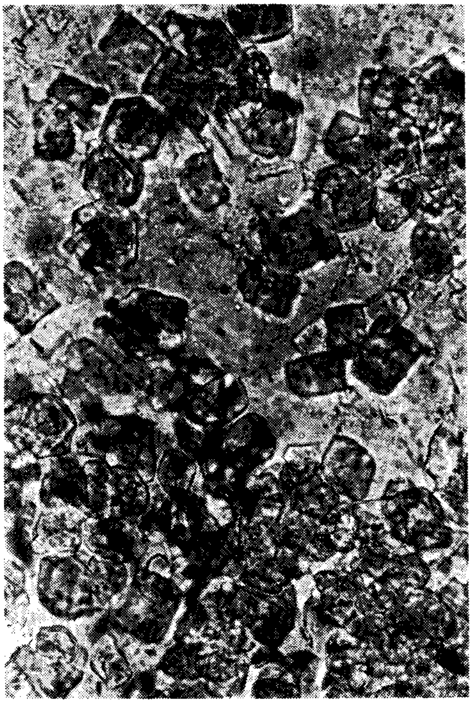


Fig. 1. Short-columnar and hexagonal sections of apatite. Novoveská Huta, transmitting light, magn. 400×, 1 nicol.

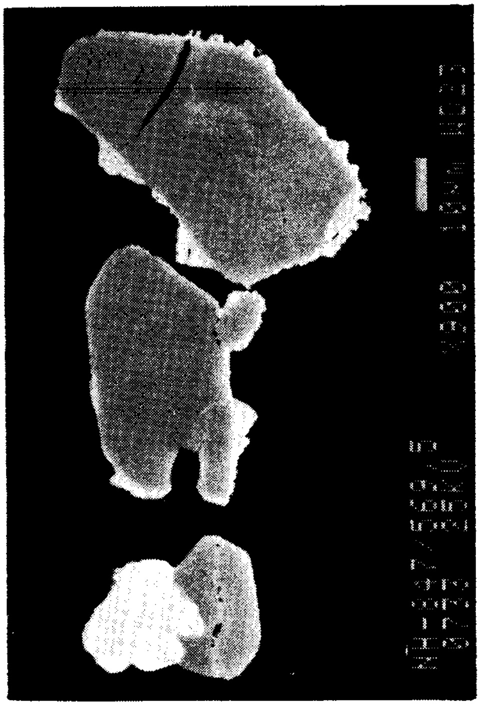


Fig. 2. Monazite (white) and zircon (grey) with rim and xenotime veinlet (light grey). Novoveská Huta, SEM.

carried out by energy-dispersive X-ray analyzers LINK in laboratories of Research and Development Institute, Czechoslovak Uranium Industry at Stráž pod Ralskem and EDAX in CLEM — Geological Institute of D. Štúr at Bratislava).

Main REE minerals in the studied rocks are monazite - (Ce) and xenotime - (Y). Monazite - (Ce) is main LREE bearing mineral. It occurs as original accessory mineral (grains of up to 0.05 mm in size) of acid volcanites, together with zircon and apatite (Figs. 2, 3). In highly altered and mineralized samples there are small (of several μm in size) grains dispersed in rocks. It occurs sporadically in veinlets together with xenotime forming there grains of up to 0.2 mm in size (Fig. 4). Dominant elements of accessory monazite are Ce, La, Nd and P, and, on the contrary, La content is decreased and dominant elements are only Ce, Nd and P in monazite veinlets accompanying uranium mineralization. Pr, Th, Sm, Gd, Tm and Ho are present in small amount (Tab. 3).

Occurrence of xenotime - (Y) suggests its later origin when compared with accessory zircon and monazite. It forms rims on zircon, clusters and veinlets

Table 1

Chemical composition of rocks (wt. percent)

Sample No.	SiO_2	Al_2O_3	MgO	Fe_2O_3	FeO	MnO	TiO_2	CaO	K_2O	Na_2O	P_2O_5	H_2O^-	H_2O^+	the rest	Sum
1.	40.12	12.68	6.02	7.95	2.76	0.07	1.33	8.03	3.94	0.23	0.29	0.10	16.34	0.05	99.91
2.	66.95	15.96	3.56	0.13	2.64	0.04	0.13	0.94	3.64	0.96	0.08	0.44	4.18	—	99.65
3.	76.64	11.49	0.46	1.75	0.69	0.02	0.14	0.97	1.50	3.88	0.11	0.28	—	—	100.11
4.	59.27	17.98	1.76	3.38	4.11	0.20	0.91	4.32	1.02	4.04	0.38	1.03	2.69	—	101.09
5.	54.33	18.24	2.94	1.79	6.94	0.05	1.58	2.24	0.75	6.00	0.46	0.14	4.01	—	99.47
6.	51.77	14.31	3.66	11.93	0.90	0.09	2.55	4.22	2.59	4.33	0.55	0.70	2.28	—	99.88
7.	55.95	18.75	2.73	6.30	1.31	0.02	0.34	0.99	5.78	0.46	0.47	0.73	6.13	—	99.96
8.	70.09	14.13	1.72	3.27	0.43	0.02	0.39	0.75	3.72	2.40	0.11	0.20	2.56	—	100.03
9.	75.46	12.15	1.51	1.70	0.49	0.02	0.11	0.76	2.72	2.24	0.23	0.34	2.02	0.24	99.75
10.	82.33	9.73	0.54	1.06	0.02	0.01	0.13	0.58	3.09	0.19	0.19	0.30	1.94	—	100.11
11.	74.66	15.21	0.54	1.50	0.02	0.01	0.16	0.58	4.40	0.28	0.16	0.02	2.48	—	100.02
12.	57.88	23.92	1.83	1.96	0.48	0.01	0.33	1.15	7.14	1.42	0.12	0.16	3.66	—	100.06
13.	37.31	2.83	5.16	0.79	2.23	0.08	0.14	23.24	0.39	0.11	13.50	0.06	12.93	1.03	99.80
14.	61.87	14.88	1.40	4.25	0.34	0.06	2.01	1.76	5.24	0.23	0.88	0.04	4.06	2.83	99.85
15.	69.59	7.45	0.46	3.37	3.44	0.05	0.85	1.61	2.76	0.16	0.69	0.38	5.14	3.87	99.81
16.	77.08	6.27	0.59	4.49	0.34	0.04	0.30	1.44	1.86	0.16	0.19	0.42	3.92	—	97.10
17.	69.60	10.57	2.35	3.05	0.63	0.12	0.63	3.86	1.62	2.07	0.27	0.14	4.90	—	99.81
18.	48.24	10.37	1.57	3.32	0.68	0.24	0.47	14.89	0.94	3.80	12.04	0.64	2.78	—	99.98

Table 2

Chemical composition of apatite (wt. percent)

Locality/ sample No.	Ca	Ce	Nd	Yb	Si	P	Cl	Fe	Y	O	Sum	EDX apparatus
Go-1	41.0	—	—	—	—	18.7	—	0.2	—	40.1	100.0	EDAX
Go-2	38.7	—	—	—	0.2	17.6	—	—	—	38.5	95.0	LINK
Go-3	39.6	—	—	—	0.2	17.7	—	—	—	38.9	96.4	LINK
H-1	40.7	—	—	0.3	—	18.1	—	0.7	—	40.1	99.6	EDAX
H-2	41.2	—	—	0.7	—	18.0	—	0.2	—	39.9	100.0	EDAX
H-3	37.9	—	—	—	—	19.2	0.3	1.1	—	40.6	99.1	EDAX
H-4	38.6	—	—	—	1.9	18.2	—	0.2	—	41.1	100.0	EDAX
H-5	38.6	—	—	—	0.2	17.7	2.9	0.4	—	38.7	98.5	LINK
H-6	38.1	—	0.5	—	0.2	17.7	2.4	0.3	—	38.4	97.6	LINK
H-7	38.2	—	—	—	0.2	17.1	3.4	0.4	0.6	37.8	97.7	LINK
H-8	37.9	—	—	—	0.3	17.0	—	0.5	0.9	37.7	94.3	LINK
H-9	37.9	—	—	—	0.2	17.3	—	0.5	—	37.9	93.8	LINK
H-10	37.2	1.0	—	—	0.5	16.6	1.9	0.3	—	37.2	94.7	LINK
H-11	38.2	0.6	—	—	0.5	17.3	2.4	0.3	—	38.3	97.6	LINK
H-12	41.5	—	—	—	—	18.2	—	0.2	—	40.1	100.0	EDAX

Locality: Go — Gočaltovo, H — Novoveská Huta.

Table 3

Chemical composition of monazite (wt. percent)

Locality/sample No.	Ce	La	Pr	Nd	Sm	Gd	Ho	Tm	Th	Ca	P	O	Sum
Kr-6/1	20.6	2.0	4.7	19.0	4.7	3.1	0.0	0.7	2.2	0.5	12.3	25.6	95.4
Kr-6/2	23.2	2.8	4.1	17.9	3.2	1.7	0.1	0.6	3.7	0.4	12.1	25.4	95.2
Kr-6/3	20.2	2.7	4.4	18.6	4.8	3.1	0.0	0.2	2.3	0.4	12.3	25.4	94.4
H-847/569.5/1	27.3	15.4	3.4	10.0	0.0	0.7	0.0	0.0	3.5	0.1	11.8	26.0	98.2
H-847/569.5/2	24.2	12.5	2.5	9.2	1.1	1.2	0.0	0.0	4.1	0.3	12.1	25.2	92.4

Locality: Kr — Krompachy, H — Novoveská Huta. Determined by EDX apparatus LINK.

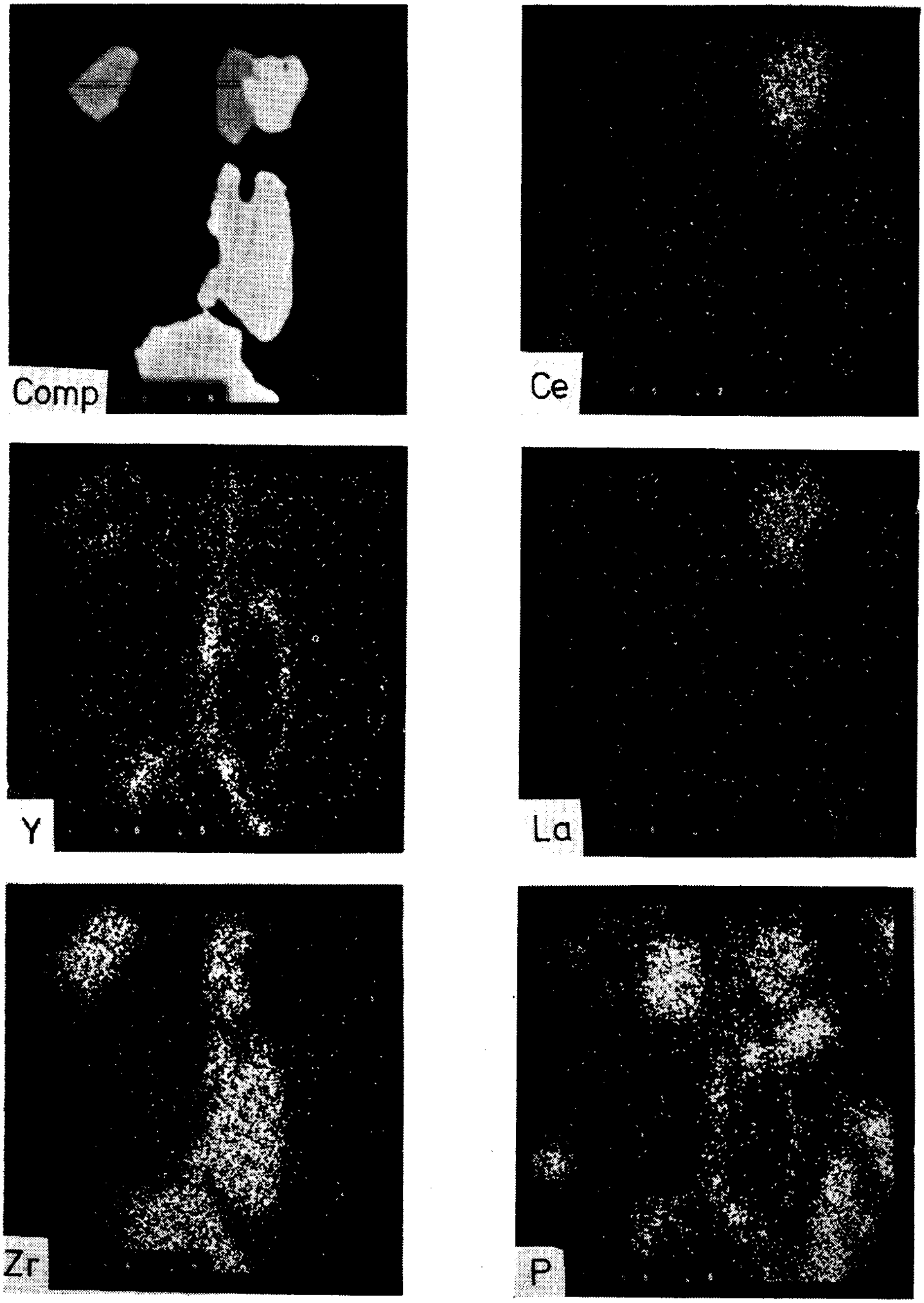


Fig. 3. Composition (Comp) and areal distribution of La, Ce, Y, P and Zr in electron microanalyzer. Monazite (Ce, La, P) and zircon (Zr) with thin rims and xenotime veinlet (Y, P) are enclosed in leucoxene which is a relic of biotite. See Fig. 2. Novoveská Huta, magn. 300×.

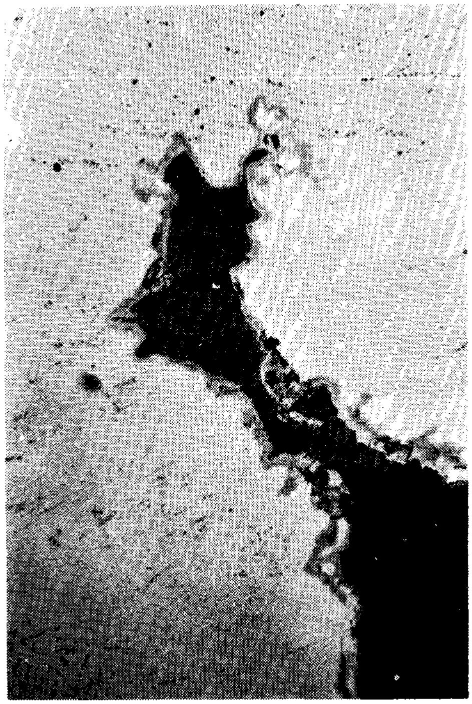


Fig. 4. Quartz veinlet (black) with xenotime and monazite (both grey) in U-Ti oxide of brannerite composition (light grey). Krompachy, reflected light, magn. 160×, 1 nicol.

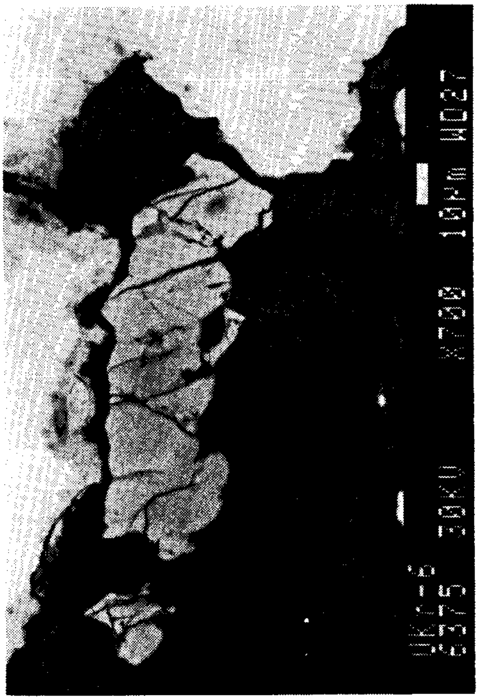


Fig. 5. Detail from Fig. 4. Monazite (light grey) and xenotime (dark grey with various shades caused by uneven Th and U distribution) in U-Ti oxide of brannerite composition (white). On the margin of U-Ti oxide of brannerite composition, products of its alteration enriched in Fe are developed. Krompachy, SEM.

in altered rocks (Figs. 2, 3, 4). Y contents in xenotime-rich rocks exceed locally 1000 ppm. Besides dominant elements Y and P, mainly HREE whose ionic radii are closest to Y, i.e. Gd, Dy, Er, Yb, Sm and Ho are represented in xenotime (Tab. 4). In contrast to monazite, from radioactive elements U occurs more frequently in xenotime than Th. Distribution of radioactive elements, as well as of REE is not homogeneous in some larger xenotime aggregates; it is manifested by their contents variation in xenotime (Fig. 5; Tab. 4).

Only low REE contents (up to 1 wt. %) were determined in uranium minerals: Ce and Nd in U-Ti oxide of brannerite composition and Y in coffinite and U-Ti oxide. However, it is probable that it is an heterogeneous additive. Low Y contents were determined by electron microanalysis in zircon too.

Rock samples from localities with Permian uranium mineralization were analyzed for radioactive elements and selected trace elements contents. U and Th were determined gamaspectrometrically and La, Yb, Y and other trace

Table 4

Chemical composition of xenotime (wt. percent)

Locality/samp. No.	Y	Sm	Gd	Dy	Ho	Er	Yb	Th	U	P	Ti	As	O	Sum
Kr-6/1	27.8	1.1	5.0	7.8	2.0	2.8	1.7	1.3	0.8	14.1	—	1.2	29.7	95.3
Kr-6/2	29.1	1.1	5.1	8.2	2.5	3.1	2.9	0.4	0.5	14.2	—	0.8	30.2	98.1
Kr-6/3	27.1	1.3	5.5	8.0	1.9	2.9	2.5	0.8	1.8	14.1	0.4	1.0	30.0	97.3
Kr-6/4	30.0	1.0	4.1	7.1	1.5	2.4	2.1	1.0	1.0	14.1	0.1	0.7	29.7	94.8
KH-6/1	34.1	—	2.8	6.1	1.2	2.3	2.6	—	1.9	15.6	—	—	32.7	99.3
KH-6/2	34.3	—	2.9	5.6	1.6	2.1	2.7	—	2.3	15.7	—	—	32.0	99.2
H 847/569.5/1	31.2	—	2.8	5.7	—	2.0	2.3	—	0.8	14.1	0.5	—	30.7	90.0
H 847/569.5/2	30.9	—	3.0	5.7	—	2.4	1.4	—	1.5	13.9	0.2	—	31.3	90.3

Locality: Kr — Krompachy, KH — Košické Hámre, H — Novoveská Huta. Determined by EDX apparatus LINK.

Table 5

REE contents in rocks (ppm)

Sample No.	La	Ce	Nd	Sm	Eu	Tb	Tm	Yb	Lu	Sum La—Eu	Sum Tb—Lu	Sum La—Lu	*Y
1.	22.7	46.5	23.6	6.3	1.45	1.2	0.62	2.9	0.31	100.55	5.03	105.58	38.0
2.	21.9	50.0	24.3	5.8	0.6	1.0	0.41	2.1	0.34	102.6	3.85	106.45	49.0
3.	64.5	146.0	58.5	12.3	9.63	1.85	1.0	5.0	0.51	290.93	8.36	299.29	35.0
4.	25.6	57.0	9.6	7.4	2.0	1.55	1.35	3.1	0.73	101.6	6.73	108.33	72.0
5.	76.5	167.0	92.5	16.6	4.2	1.85	1.15	4.4	0.73	356.8	8.13	364.93	85.0
6.	28.0	66.0	37.5	9.1	2.3	1.6	1.75	5.3	0.93	142.9	9.58	152.48	60.0
7.	9.9	54.0	52.5	3.3	0.22	0.64	0.34	0.84	0.14	119.92	1.96	121.88	9.2
8.	26.3	58.0	21.6	5.9	0.79	0.9	0.83	1.45	0.24	112.59	3.44	116.03	27.0
9.	22.3	94.0	69.5	24.5	5.4	6.3	2.75	12.9	1.35	215.7	23.3	239.0	178.0
10.	44.0	79.0	34.0	19.3	10.2	16.9	6.7	46.5	7.5	186.5	77.6	264.1	710.0
11.	29.9	64.5	39.0	27.7	21.6	31.0	15.2	85.5	14.2	182.7	145.9	328.6	1260.0
12.	108.0	230.0	78.0	19.4	1.0	2.75	1.95	6.4	1.25	436.4	12.35	448.75	54.0
13.	5.7	174.0	139.0	21.8	15.6	4.3	1.1	7.0	1.7	356.1	14.1	370.2	120.0
14.	166.0	305.0	271.0	64.5	16.9	11.9	2.75	30.0	4.9	823.4	49.55	872.95	340.0
15.	139.0	325.0	345.0	72.0	25.4	12.6	7.0	36.5	4.3	906.4	60.4	966.8	360.0
16.	174.0	470.0	560.0	6.9	25.8	8.7	1.9	21.9	3.9	1236.7	36.4	1273.1	202.0
17.	33.0	150.0	110.0	18.6	5.0	4.9	2.2	6.5	1.2	316.6	14.8	331.4	140.0
18.	57.5	177.0	46.5	30.0	3.0	7.6	5.2	42.6	6.3	314.0	61.7	375.7	260.0

* Y was determined by OES method, the rest by INAA method.

elements - by optical emission spectroscopy (OES). Samples with microscopically determined REE minerals, as well as with increased La, Yb and Y contents determined by OES method were analyzed in more detail by instrumental neutron activation (INAA) for REE and other rare elements in laboratories of Czechoslovak Uranium Industry at Stráž pod Ralskem. Set of 18 samples represents 4 groups of rocks:

1. Volcanic non-mineralized rocks (Tab. 5, sample Nos. 1—6; Fig. 6). Main representatives of the Gemeric Permian volcanites: rhyolite, dacite, andesite and basalt are ranged with this group. Basalt - typical Permian volcanite of the Choč nappe is compared with them (sample No. 6).
2. Ignimbrites and rhyolite tuffs from the region east of Krompachy, between Petrova hora hill and Košické Hámre (Tab. 5, sample Nos. 7—11; Fig. 7). In part of the samples uranium mineralization occurs.
3. Altered rocks with U-Mo mineralization affected by intensive sericitization, carbonatization and silicification from the region of Novoveská Huta and Rudňany (Tab. 5, sample Nos. 12—16; Fig. 8).
4. Sandstones from the region of Gočaltovo and Markušovská dolina valley (Tab. 5, sample Nos. 17, 18; Fig. 9). The former represent phosphate-bearing sandstones and the latter represent copper-bearing sandstones with uranium mineralization.

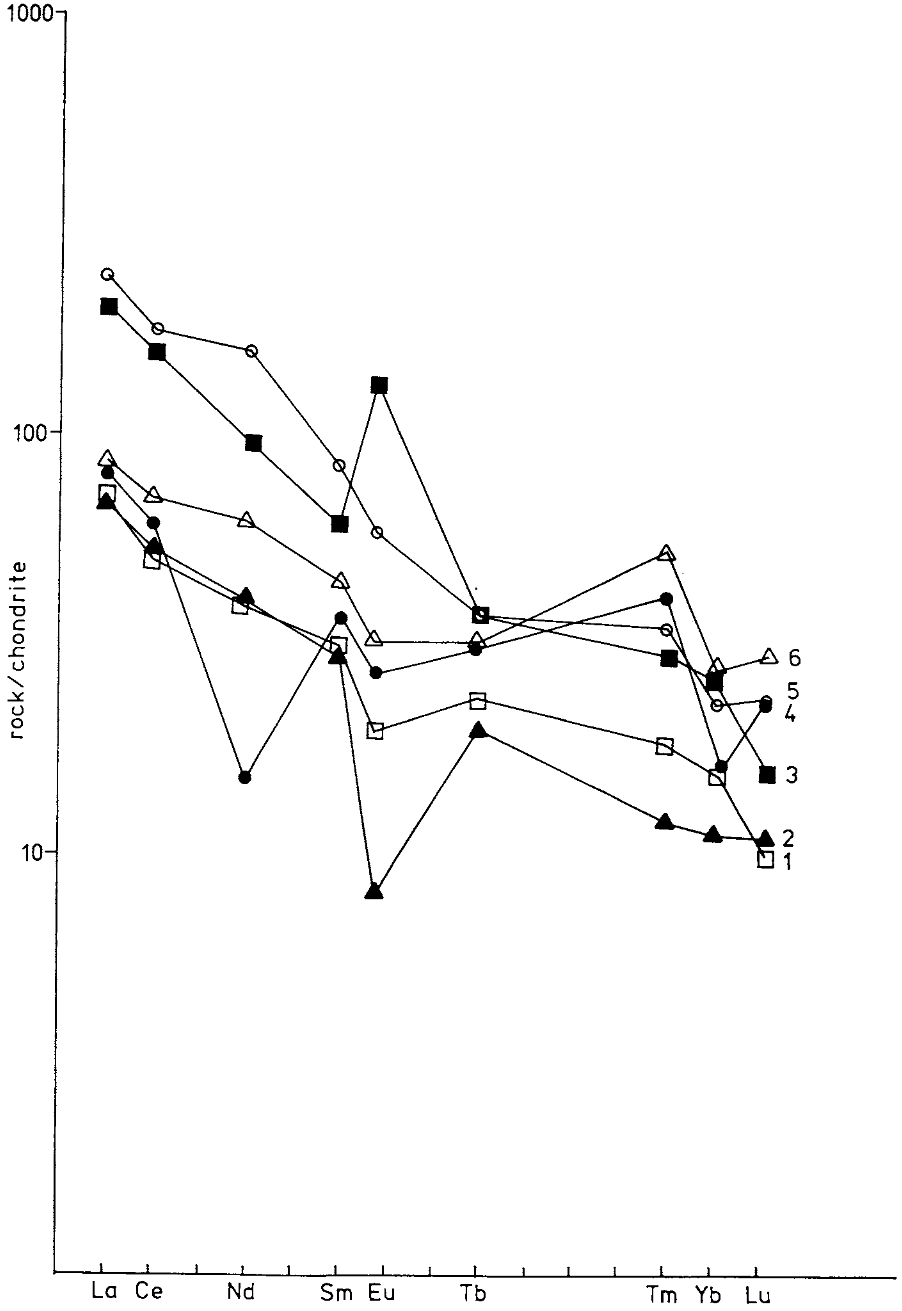
In INAA method analytical results of REE can be affected by uranium fission products. In order to establish reliability of results, control determinations of La and Yb (representing LREE and HREE, respectively) were carried out by OES method. Comparison of results of the both methods, as well as statistical evaluation are given in Tab. 6 and graphically represented in Figs. 10 and 11.

More precise analytical results and thus smaller effect of chemical composition variability were found in Yb, in contrast to La. In case of Yb, high correlation ($r = 0.99$; $w_{ort} = 1.14$) proves good agreement of obtained results (Tab. 6; Fig. 10). La shows lower correlation ($r = 0.84$; $w_{ort} = 1.40$) what supports a greater effect of chemical composition variability, especially of U, on precision of La contents determination (Tab. 6; Fig. 11). Greater dispersion of values is in INAA method what is proved by higher value of arithmetic mean standard deviation than in OES values.

On the basis of graphically represented and calculated data, it can be stated that in spite of a certain effect of chemical composition variability on La contents, the applied analytical methods provide quite reliable results of

Fig. 6. REE contents in volcanic non-mineralized rocks from the Northern Gemeric Permian (1—5).

Explanatory notes: 1 — highly carbonatized rock of amygdaloidal structure, originally probably basalt, Novoveská Huta, borehole 14, 43.4 m; 2 — rhyolite, Petrova hora hill, abandoned gallery 750 m SE of Petrova hora hill, 50 m S of elev. point 390.0; 3 — rhyolite, Novoveská Huta, borehole 847, 583 m; 4 — dacite, Vyšný Klátov, confluence of Vrbica brook 1400 m W of elev. point 559 — Kamenný hrb; 5 — andesite, Krompachy, exposures 300 m N of power station, 445 m above sea-level; 6 — basalt from the Permian of the Choč nappe, Malé Karpaty Mts. - Lošonec, Zabité valley, 400 m S of elev. point 429 - Jasanové, exposures NE of the road.


1000
100
10
rock/chondrite
La
Ce
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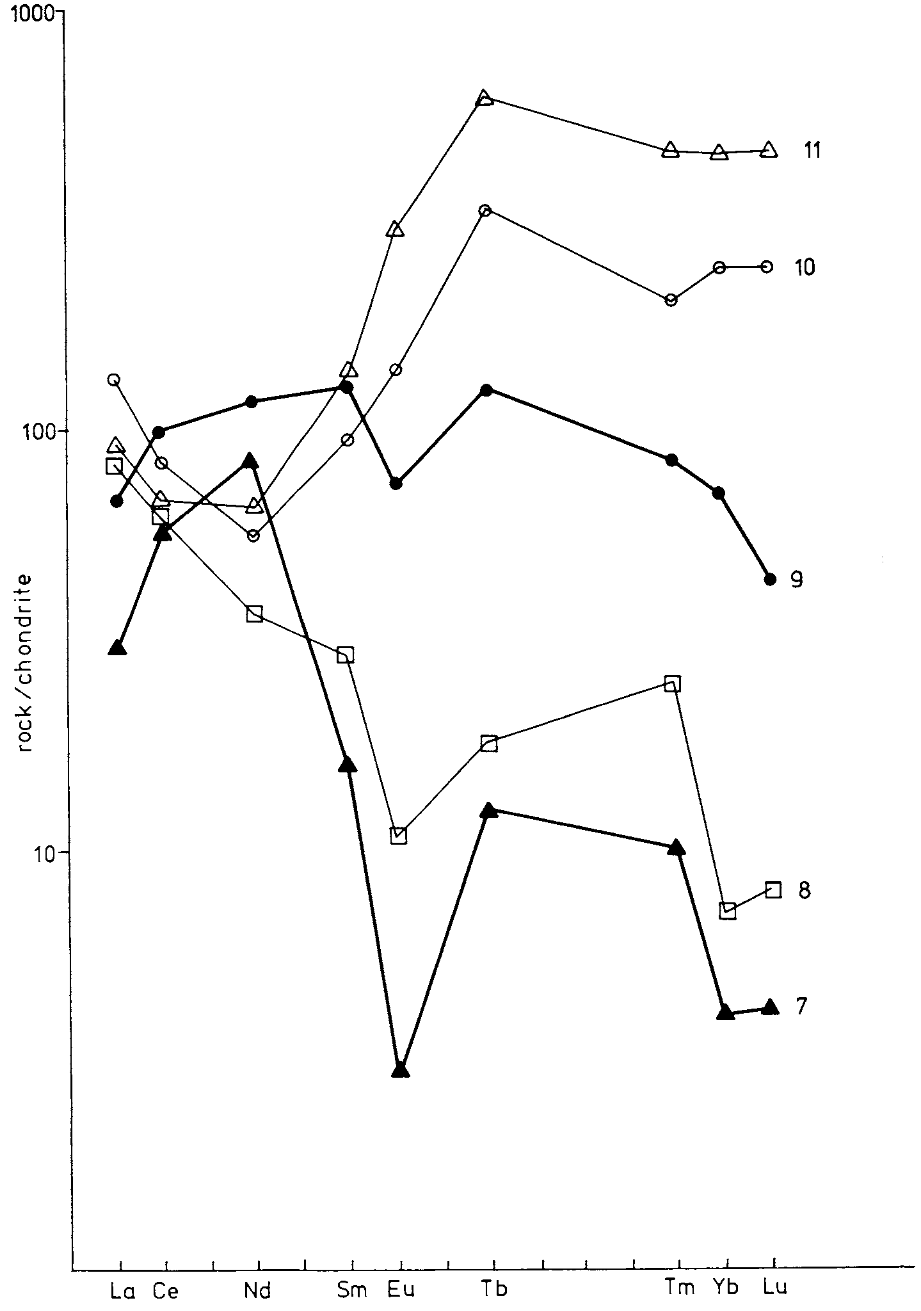

Fig. 7. REE contents in ignimbrites and rhyolites from Petrova hora hill (7, 8, 9) and from the environs of Košické Hámre (10, 11). Thicker lines denote samples with higher U contents.

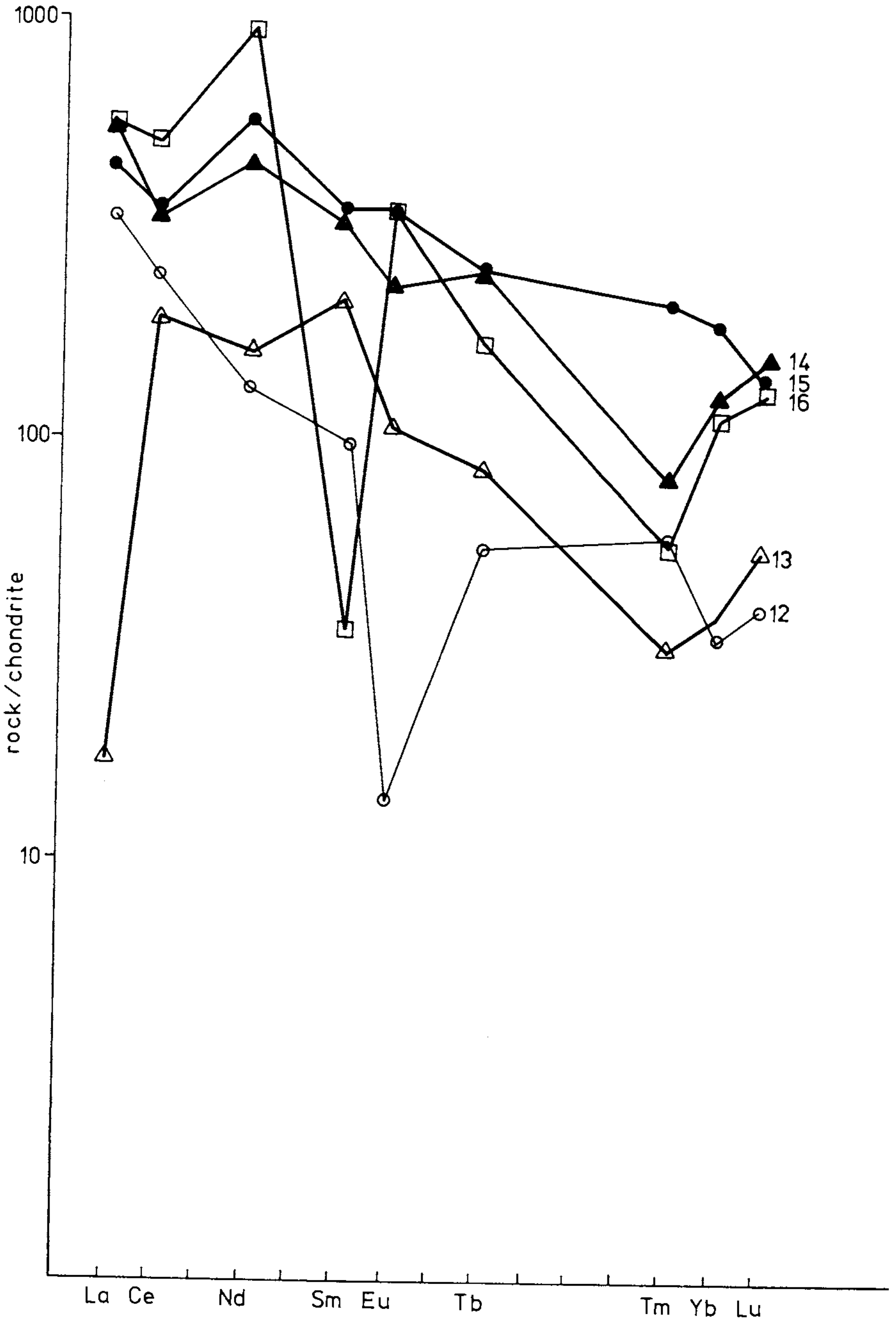

Fig. 8. REE contents from altered rocks with U-Mo mineralization from the region of Novoveská Huta (12, 13, 14, 15) and Rudňany (16). Thicker lines denote samples with higher U contents.

trace elements determination in the studied samples. Chemcal composition variability effect on contents of individual elements analyzed by various methods will be studied in more detail in a separate paper.

Relation of REE minerals and radioactive mineralization is documented not only by common occurrence of minerals, but also by rare earths and radioactive elements distribution. Uranium is dominating in radioactive mineralization of the Gemeric Permian, whereby Th is only accompanying element. Increased Th contents were determined mainly in brannerite and U-Ti oxides. From this also positive correlation of Th and U follows.

Distribution of U and REE is similar in many uranium deposits. In some of the world deposits increase of HREE and in some of them - LREE or the both is observed. Deposits Olympic Dam and Mary Kathleen in Australia are enriched in LREE (Maas et al., 1987). McLennan—Taylor (1979) observed enrichment in HREE in deposit Pine Creek Geosyncline in Australia. Other deposits in Canada and the U.S.A. show enrichment in HREE and LREE (Maas et al., 1987). Ginzburg et al. (1959) mention common occurrence of REE and radioactive elements from hydrothermal metasomatic deposit where impregnations and veinlets of radioactive and sulphide mineralization occur with monazite and xenotime in quartz-feldspar-sericitic rock. At first Ce and then Y minerals were crystallized in approximately the same amount.

Common occurrence of radioactive and REE minerals from the studied rocks is reflected also in U and REE distribution. Increased La contents determined

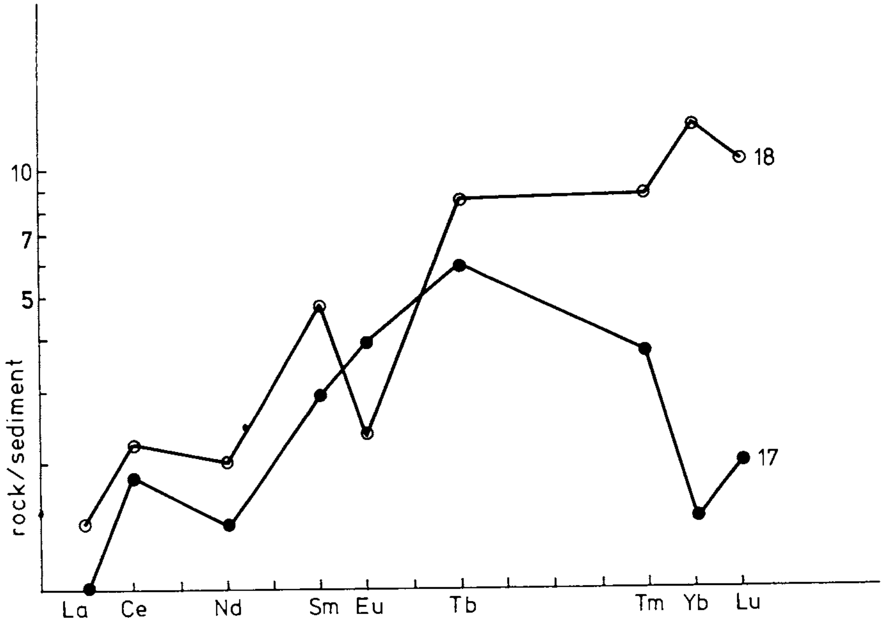

Fig. 9. REE contents in sandstones from the environs of Markušovská dolina valley (17) and Gočaltovo (18). Sediment — average sediment — b (Wedepohl, 1978).

Table 6

La and Yb contents (ppm) obtained by INAA and OES and their statistical evaluation

Sample No.	La		Yb	
	INAA	OES	INAA	OES
1.	22.7	24.5	2.9	3.9
2.	21.9	30	2.1	2.4
3.	64.5	65	5	3.2
4.	25.6	30	3.1	4.8
5.	76.5	104	4.4	5.5
6.	28	60	5.3	6.9
7.	9.9	<30	0.8	1
8.	26.3	30	1.45	1.3
9.	22.3	<30	12.9	10.5
10.	44	76.5	46.5	40.5
11.	29.9	30	85.5	76
12.	108	141	6.4	4.6
13.	5.7	<30	7.0	10.4
14.	166	83	30	23
15.	139	81	36.5	35
16.	174	148	21.9	30.4
17.	33	60	6.5	9.6
18.	57.5	93	42.6	37
statistical evaluation of results				
$\bar{x}$	58.60	63.97	17.83	17.0
s	53.14	38.74	22.59	19.89
r	0.84		0.99	
w_{ort}	1.40		1.14	

Explanatory notes: $\bar{x}$ — arithmetic mean, s — standard deviation of arithmetic mean, r — correlation coefficient, w_{ort} — regression coefficient.

in mineralized rocks from the environs of Novoveská Huta display positive U/La correlation (r = 0.54, Rojkovič et al., 1981). Similar dependence is observed also in the studied set of samples. Altered rocks with U-Mo mineralization (sample Nos. 12—16) show the highest La contents obtained by OES (Fig. 11) and the highest LREE contents obtained by INAA (Tab. 5). LREE contents reach here about 1000 ppm. In spite of the fact that phosphates are main REE bearing minerals, correlation of their contents with P is not observed. This is connected with bond of the overwhelming part of P to apatite which is not a significant REE bearing mineral in the studied region.

Common occurrence of Y and HREE in xenotime is reflected in their correlation (Fig. 12). Y and HREE do not display positive correlation with U in mineralized and non-mineralized rocks. However, distinct positive Y/Zr correlation is present in non-mineralized rocks (r = 0.59) and weaker Y/Zr correlation in mineralized rocks (r = + 0.29 to + 0.46). This is caused by association of zircon and xenotime, as well as by presence of Y in zircon (Rojkovič, 1969; Rojkovič et al., 1981).

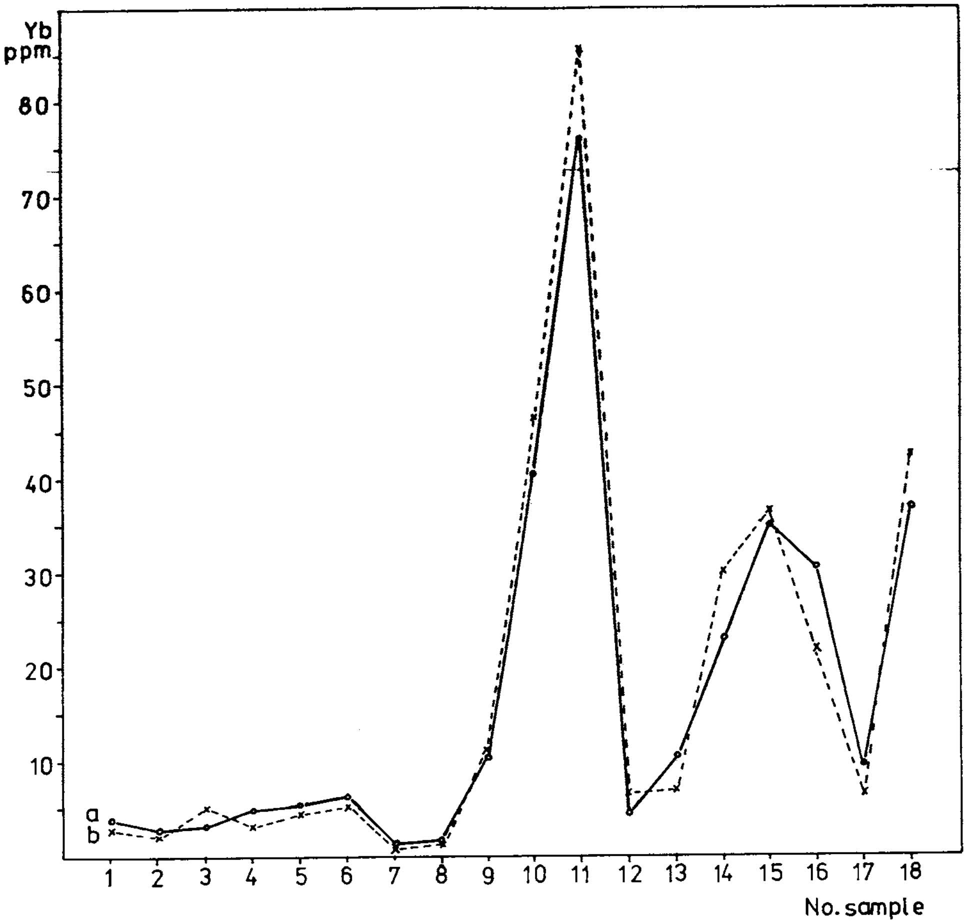

Fig. 10. Yb contents obtained by OES (a) and INAA (b).

According to McLennan — Taylor (1979), particularly HREE together with U are easily mobile in carbonate solutions. Also Vocke et al. (1987) mention easier mobility of HREE with Y which is manifested by xenotime rims on zircons in the Roffna Gneiss from Switzerland. On the basis of different interpretation of results obtained from the same area, Dickin (1988) presupposes, on the other hand, moderate loss of LREE, whereas little mobile HREE remain as rims on zircons.

From various representation of monazite and xenotime in the studied localities it may be deduced that uranium-bearing solutions transported LREE as well as HREE. According to mineralogical studies, monazite is more frequent in the rocks affected by silicification, sericitization and carbonatization, whereas xenotime occurs in silicified and serictized rocks without carbonates. Thus LREE present predominantly in monazite prefer rather carbonate environ-

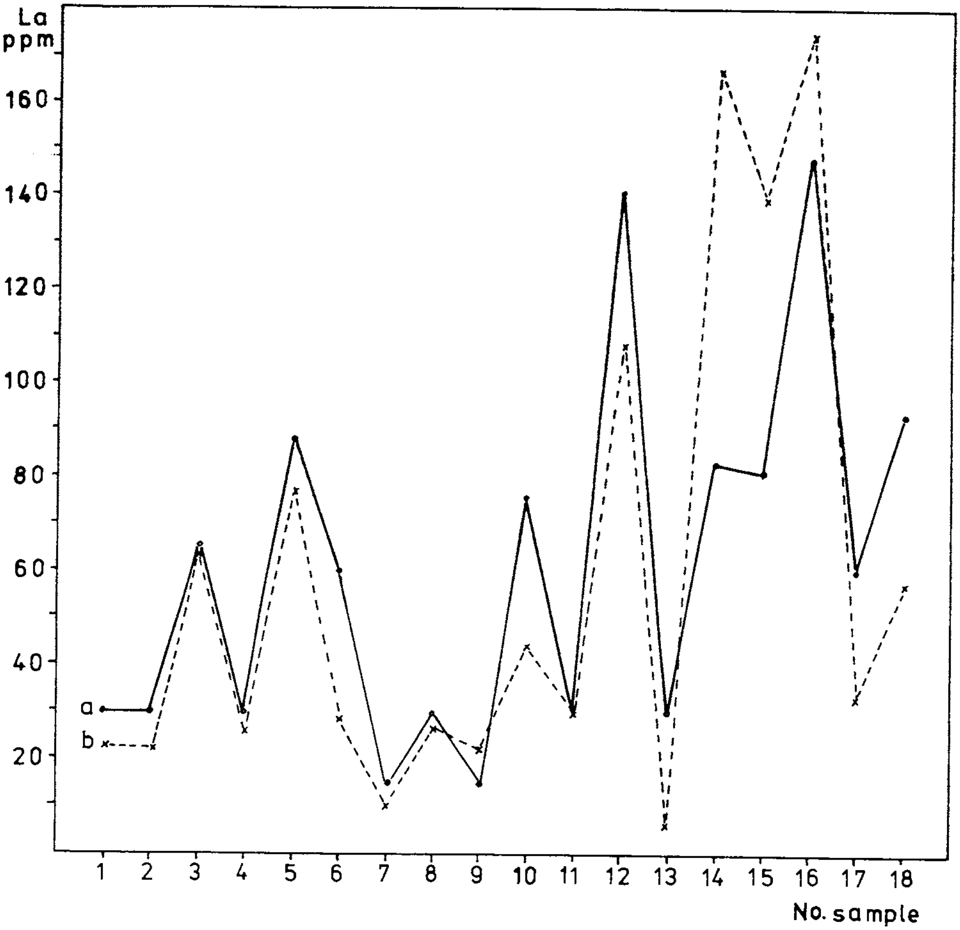

Fig. 11. La contents obtained by OES (a) and INAA (b).

ment. This is rather in accordance with experimentally established easier solubility of LREE in fluids rich in H_2O and CO_2 (Mysen, 1979; Wendtlandt — Harrison, 1979). But REE contents do not show distinct correlation with carbonate contents represented by loss on ignition in the analyses (H_2O^+). Selective enrichment or depletion in some LREE in analyzed rocks (Figs. 7, 8) reflect probably differences in their distribution in minerals (e.g. La in monazite — Tab. 3).

LREE (recalculated to chondrites) prevail in non-mineralized volcanic rocks what is in accordance with continental character of alkali-calcareous volcanism of the Gemeric Permian. Permian volcanism of the Choč nappe has transitional to tholeiitic character (Vozárová — Vozár, 1988). Basalt (sample No. 6) from the Permian of the Choč nappe displays shallower pattern of REE representation when compared with volcanites from the Gemeric Permian. Analyzed

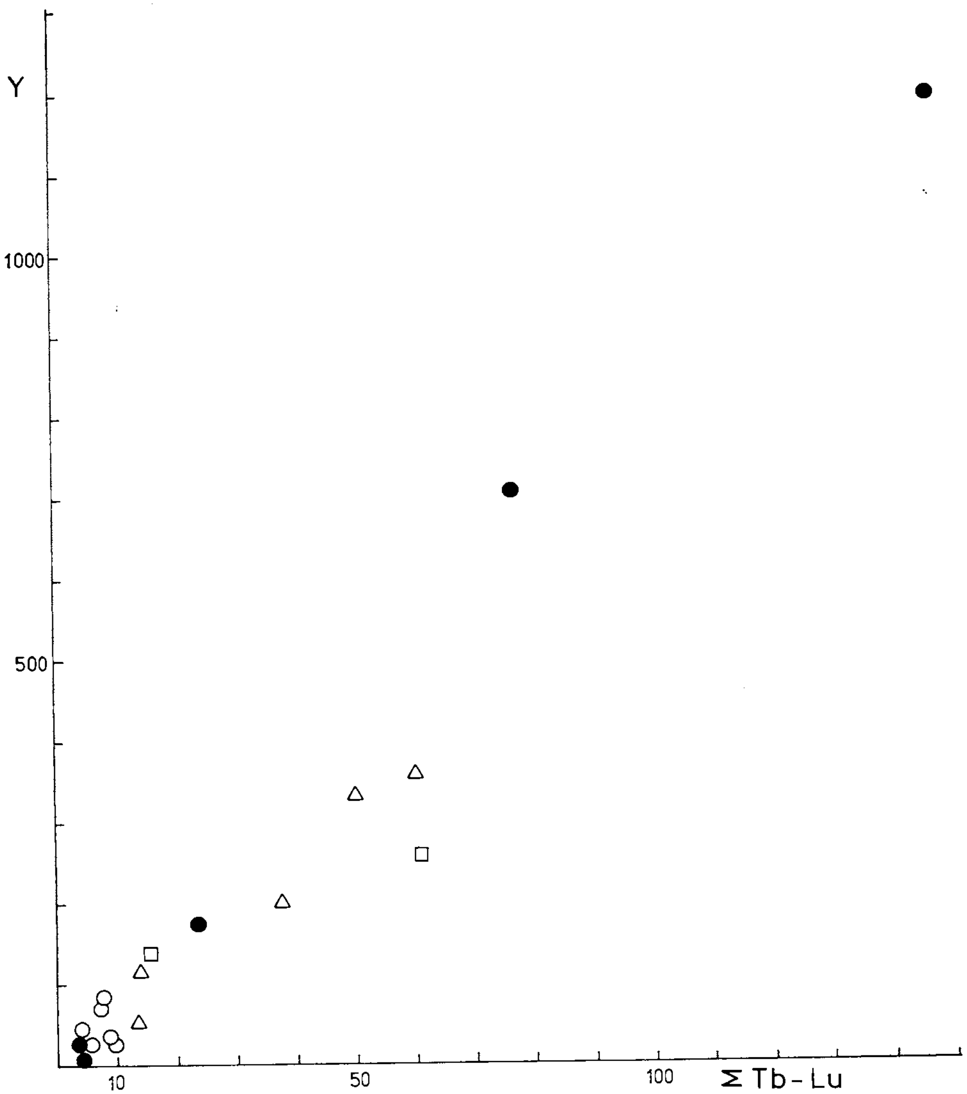

Fig. 12. Correlation Y and HREE diagram.

volcanites, excluding andesites, are typical also by negative Eu anomaly. Mobilization and concentration of uranium mineralization took place during the Alpine metallogenic processes. They were accompanied with REE mobilization followed by common and selective crystallization of LREE and HREE minerals.

Translated by O. Mišániová

REFERENCES

DICKIN, A. P., 1988: Evidence for limited REE leaching from the Roffna Gneiss, Switzerland — a discussion of the paper by Vocke et al. (1987) (CMP 95: +45——145). Contr. Mineral. Petrology (Berlin—New York), 99, pp. 273—275.

GINZBURG, A. I. — ZHURAVLEVA, L. N. — IVANOV, I. B. — SHCHERBINA, V. V., 1959: Geologiya mestorozhdeniy redkikh elementov. Redkozemeľniye elementy i ikh mestorozhdeniya. Gosgeoltekhizdat, Moscow, 3, 125 pp.

MAAS, R. — McCULLOCH, M. — CAMPBELL, I. H. — PACE, R. W., 1987: Sm-Nd isotope systematics in uranium-rare element mineralization at the Mary Kathleen uranium mine, Queensland. Econ. Geol. (Lancaster, Pa.), 82, pp. 1805—1826.

McLENNAN, S. M. — TAYLOR, S. R., 1979: Rare earth element mobility associated with uranium mineralization. Nature (London), 282, pp. 247—250.

MYSEN, B. O., 1979: Trace elements partitioning between garnet peridotite minerals and water-rich vapor: experimental data from 5 to 30 kbar. Amer. Mineralogist (Washington), pp. 274—287.

PELYMSKY, G. A., 1966: K voprosu o genezise uran-molibdenovogo orudeneniya v Zapadnykh Karpatakh. Manuscript, Arch. UP Spišská Nová Ves, 15 pp.

ROJKOVIČ, I., 1968: Mineralogical-geochemical characterization of U-Mo-Cu mineralization in the Permian of the Spišsko-gemerské rudohorie Mts. Geol. Zbor. Geol. carpath. (Bratislava), 19, 1, pp. 179—204.

ROJKOVIČ, I., 1969: Petrography and geochemistry of Permian quartz porphyries in relation to U-Mo-Cu mineralization. Geol. Zbor. Geol. carpath. (Bratislava), 20, 1, pp. 87—114.

ROJKOVIČ, I., 1981: Zvýšené koncentrácie apatitu v horninách permu pri Novoveskej Hute. Miner. slov. (Spišská N. Ves), 13, 1, pp. 75—82.

ROJKOVIČ, I. — NOVOTNÝ, L. — MEDVEĎ, J. — WALZEL, E., 1981: Geochemical characteristic of uranium-bearing horizons near Novoveská Huta (Slovenské rudohorie Mts.). Geol. Zbor. Geol. carpath. (Bratislava), 32, 6, pp. 731—744.

TRÉGER, M., 1973: Výskyty uránonosných fosfátov v Spišsko-gemerskom rudohorí. Miner. slov. (Spišská N. Ves), 5, 1, pp. 61—64.

VOCKE, R. D. — HANSON, G. N. — GRÜNENFELDER, M., 1987: Rare earth element mobility in the Roffna Gneiss, Switzerland. Contr. Mineral. Petrology (Berlin—New York), 95, pp. 145—154.

VOZÁROVÁ, A. — VOZÁR, J., 1988: Late Paleozoic in West Carpathians. GÚDŠ, Bratislava, 314 pp.

WEDEPOHL, K. H. (ed.), 1978: Handbook of geochemistry. II-5. Springer-Verlag Berlin—Heidelberg—New York), p. 57-71-K-5.

WENDLANDT, R. F. — HARRISON, W. J., 1979: Rare earth partitioning between immiscible carbonate and silicate liquids and CO_2 vapor: results and implications for the formation of light rare earth-enriched rocks. Contr. Mineral. Petrology (Berlin—New York), 69, pp. 409—419.

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