

## ELBAITES FROM ŘEČICE, WESTERN MORAVIA

ELBAITY Z ŘEČICE NA ZÁPADNÍ MORAVĚ

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### *Abstract*

Elbaite from the pegmatite near Řečice (western Moravia) are described in this paper. Their morphology, optical data, chemical analysis, unite cell dimensions, origin and comparison with other occurrences of elbaite in the Bohemian-Moravian pegmatites are given.

In the spring of 1984, B. Ubr found a crystal of elbaite in amelioration ditches near Řečice, south of Nové Město na Moravě. He reported his find to the local collector P. Blažek who shortly afterwards succeeded in discovering primary pegmatite with beautiful crystals of elbaite, so far the biggest ever found in the territory of the Bohemian Massif.

Pegmatite with the occurrence of elbaite is situated about 1 km to the south of Řečice on a slight landscape wave above the immediate surroundings, in the Moldanubicum of Strážek, about 3 km to the south of the fault of Křídla. In its immediate neighbourhood migmatitic kyanite-biotitic gneisses crop out as well as fine-grained granoblastic paragneisses, somewhat farther away minor bodies of amphibolites and serpentinites (Stárková, Zrůstek 1973).

In 1985, the pegmatite was thoroughly opened by several ditches dug by the Mineralogical and Petrographical Department of the Moravian Museum in Brno. It was found that it was constituted by a body of most probably dike shape, of a probably north-south direction, about 15 m long, with maximum thickness of 1 m, near the surface steeply sloping to the east, in the depth almost vertical, sending numerous veins into the neighbourhood on the border of nongranitized and granitized paragneisses. But a more complicated situation can by no means be excluded, namely that it can be a small dike of a much bigger body not found so far. This possibility would be indicated by a relatively simple composition of the pegmatite as it is known now, its inconspicuous zonation and an altogether unusual, very simple paragenesis of the minerals.

The pegmatite accessible for observation was constituted mainly by fine-grained aggregate of granitic to pegmatoid texture, more rarely by small nests of potassium feldspar grown through graphically by quartz, by nests

of bigger measuring centimetres to decimetres individuals of reddish pink K-feldspar and grey to brownish grey quartz, both often in cavities developed in the crystals. In those cavities there appeared crystals of elbaïtes, most frequently dark red or zonally coloured rubellites. All parts of the pegmatite body are richly penetrated by albite, younger albitization having played a major part in them. The albitization need not always be macroscopically perceptible, sometimes it can only be found in thin sections and it can be stated that albite is accompanied by tiny crystals of rubellite, and that considerable portions of pegmatite are so to speak also rubellitized.

Pegmatite of granitic to pegmatoid texture, constituting the greater part of the body, consists of 0.3 to 3 cm large, reddish or greyish white grains of orthoclase ( $\Delta = 0.0-0.4$ ), mosaic-like, extinguishing greyish grains of quartz and white grains of albite-oligoclase ( $n_\alpha = 1.535$ ,  $n_\gamma = 1.545$ ). Frequently there occurs schorl forming aggregations of irregular grains or of small columns. It is strongly pleochroic, O = grey blue, E = weakly violet pink,  $n_\omega = 1.658$ ,  $n_\varepsilon = 1.635$ . Muscovite and biotite are rare. This pegmatite aggregate is frequently penetrated by younger fine-grained albite ( $n_\alpha = 1.525$ ,  $n_\gamma = 1.536$ ) and by small crystals of clear rubellite.

The nests with graphic texture are rare. They are represented by small potassium feldspar blocks, several cm<sup>3</sup> in size, white or greyish white in colour. K-feldspar belongs to orthoclase ( $\Delta = 0.0-0.3$ ). It is penetrated by metasomatic perthite veins. With orthoclase intergrow ichthyoglyphs of quartz, only several individuals as a rule.

K-feldspar blocks from the vicinity of the cavities or crystals of this mineral from the cavities are up to 1 dm<sup>3</sup> in volume. They are always represented by reddish pink orthoclase. On crystals the following forms were observed: {001}, {010}, {110}, {110}, and {101}. They are frequently penetrated by albite which also forms yellow-white crusts on their surfaces, up to 1 mm thick. Some crystals, even if it is not at all perceptible macroscopically on them, are albitized almost to a half. Many of them are, besides, covered by tiny crystals of rubellite, about 1 mm in size. In thin section this orthoclase is partly quenched, it extinguishes mosaic-like and is penetrated by albite; its  $\Delta = 0.0-0.1$ .

Quartz forms imperfectly or perfectly developed crystals in the cavities. The crystals are terminated by the usual forms — {1010}, {1011}, {0111} — grey or grey brown, sometimes coated with white younger quartz. Rubellites often occur together with quartz.

Metasomatic albite penetrates in tiny grains about 0.2–1 mm in size along the outside of older minerals or it forms either fine crystalline crusts in the cavities on the surface of potassium feldspars or perfectly developed crystals of as much as 2 mm in size, limited tubularly according to {010}, with narrow faces {110}, {110}, {001}, often parallel compound. According to optical data belong they both to pure albite Ab<sub>100</sub> ( $n_\alpha = 1.525$ ,  $n_\gamma = 1.536$ ) and Ab<sub>98-97</sub> ( $n_\alpha = 1.527$ ,  $n_\gamma = 1.539$ ). In the cavities of albite there are pinkish crystals of K-feldspar, 1–2 mm in size, representing older relics. Together with fine-grained albite there often occur tiny crystals of rubellite, also of metasomatic character. Often rubellite grows about older black schorl, forming on it continuous crusts or coats of isolated small crystals.

In the whole body of pegmatite further minerals occur only rarely. Relatively rare are also micas — biotite and muscovite. Biotite is sporadically represented in contact parts, in slabs up to 2 cm in size. Muscovite forms fine scales accumulating in small nests less 1 cm<sup>3</sup> in size in some cavities in the

centres of the dike or veins. It does not contain lithium, not even in trace amounts.

Garnet was found in several red-brown grains, 1–2 mm in size, grown in block-like feldspars or quartz. It was somewhat more frequent in fine-grained parts, resembling the neighbouring granitized gneisses. According to the refractive index  $n = 1.811$  it belongs most probably to spessartine-almandine.

Zircon forms dark brown dipyrarnidal crystals, up to 2 mm in size, quite isotropized. It was only found in two samples.

Cassiterite forms irregularly black-brown grains or crystals of 1.5 cm in size, with  $\{101\}$ ,  $\{011\}$ , and  $\{001\}$  forms, grown in albite or developed freely into cavities. Spectral analysis has proved in it the main amount of Sn, in 0.X % Fe, Mg, Mn, Nb, Ta, in 0.OX % Al, Ti, Zn, Zr, in amounts < 0.OX % Be, Ca, Cu, Mo, Ni, and Pb.

Löllingite was found in slab-like aggregates 1–2 mm thick and as much as 2 cm large, silver grey, often contorted. It is mostly altered, in its neighbourhood are light green-grey coats of scorodite, in cavities after löllingite there appear green to green-brown cubes of pharmacosiderite, the size of which is 0.X mm. In a cavity with rubellite, quartz, orthoclase and albite M. Novák found coating of fine spherulitic brown arseniosiderite.

Elbaïtes are represented by verdelite, indicolite, achroite and rubellite. Whereas the former three were only found in several specimens, rubellite is, besides feldspars and quartz, the most common mineral.

Verdelite forms imperfectly developed dark green columns up to 7 mm long and 3 mm wide, in coarsely flanged albite. It is strongly pleochroic, O = green, E = weakly green-yellow,  $n_{\omega} = 1.645$ ,  $n_{\epsilon} = 1.627$ . Indicolite and achroite were found in cavities. Indicolite is light blue, fine-grained, pleochroic, O = blue, E = weakly yellow,  $n_{\omega} = 1.647$ ,  $n_{\epsilon} = 1.626$ , achroite is clear, without pleochroism,  $n_{\omega} = 1.636$ ,  $n_{\epsilon} = 1.619$ .

Rubellite exhibits greater variability both in colour and in crystals. The colour depends above all on the size of the crystals. The smallest crystals, 1–2 mm in size, are practically of one colour, light pink. Rubellites of somewhat bigger sizes are usually zonally coloured, at one end they are light pink, at the other red to brownish red; they are the "Turkish heads", exhibiting visually distinct dichroism. Crystals over 1 cm in size are always zonally coloured, the core being brown-grey to grey-black, the outer parts intensely red to brown-red. Often rubellite grows on black schorl. The biggest rubellites can be as much as 13 cm long and 8 cm thick.

Rubellite crystals can be classified into two types according to size.

Crystals of type I, with sizes up to 0.5 cm, are rarely developed on both sides. The antilogous pole is terminated by lustrous faces of a trigonal pyramid  $r \{10\bar{1}\}$ , the analogous pole by dull faces of the trigonal pyramid  $g \{01\bar{1}2\}$  and base  $c \{000\bar{1}\}$ . The faces on the analogous pole are very rare, the crystals are on this pole mostly without termination. In the prismatic zone prisms  $a \{11\bar{2}0\}$ ,  $m \{01\bar{1}0\}$  are present; they are straight, lustrous, practically non-striated. Often the prisms and pyramids are almost of the same size, the crystals having isometric development. Altogether 8 crystals were measured with a two-circle reflecting goniometer, the results are given in Tab. 1. An idealized crystal of type I is represented in Fig. 1.

Crystals of type II, sized more than 1 cm, are, as a rule, terminated on one end only, both by an antilogous and by an analogous pole. The crystals could be measured only with a contact goniometer. The antilogous pole, more rare in the crystals, is terminated by the trigonal pyramid  $r \{10\bar{1}\}$ , the analogous

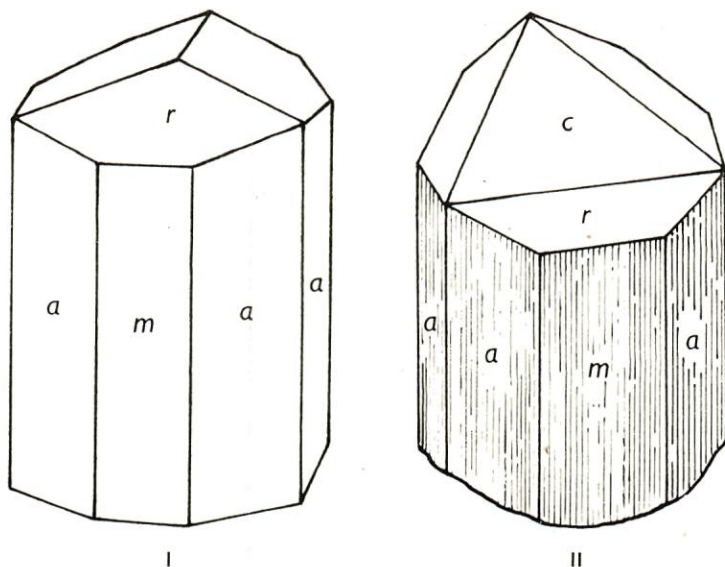


Fig. 1. Crystals of rubellite from Řečice.

one above all by the large surface of base  $c$   $\{000\bar{1}\}$  and three narrow faces of the trigonal pyramid  $r'$   $\{01\bar{1}\bar{1}\}$ . In the prismatic zone prisms  $a$   $\{11\bar{2}0\}$  and  $m$   $\{01\bar{1}0\}$  were found, strongly vertically striated. An idealized crystal of rubellite of type II is shown in Fig. 1.

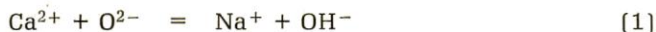
Tab. 1. Results of goniometric measurement of rubellite.

Letter	Symbol	Measured		Goldschmidt 1897		Number of faces measured
		$\varphi$	$\rho$	$\varphi$	$\rho$	
a	$\{11\bar{2}0\}$	30°18'	90°06'	30°—	90°—	39
m	$\{01\bar{1}0\}$	0°11'	90°04'	0°—	90°—	14
c	$\{000\bar{1}\}$	0°—	0°03'	0°—	0°—	1
r	$\{10\bar{1}\bar{1}\}$	30°21'	27°25'	30°—	27°33'	24
g	$\{01\bar{1}\bar{2}\}$	30°13'	14°39'	30°—	14°29'	6

Refractive indices of weakly coloured rubellites vary from  $n_o = 1.639$ — $1.643$ ,  $n_e = 1.622$ — $1.626$ , there being no major differences. The situation is different in zonally coloured bigger crystals, in which refractive indices change very much. The lowest values are those of the pink-coloured parts  $n_o = 1.642$ — $1.643$ ,  $n_e = 1.624$ — $1.626$ , the grey-pink parts nearer the centre exhibit substantially higher values,  $n_o = 1.649$ ,  $n_e = 1.627$ , greyish coloured parts still nearer the centre again somewhat higher values  $n_o = 1.651$ — $1.652$ ,  $n_e = 1.627$ — $1.628$ . If a grey-black core is present then the indices are still higher,  $n_o = 1.656$ ,  $n_e = 1.636$ , and if the core is almost black, the values are highest,  $n_o = 1.663$ ,  $n_e = 1.637$ . It follows that the refractive indices vary in the crystal from place to place, they drop from the centre towards the outer parts. The grey-black and almost black cores exhibit — unlike peripheral zones — conspicuous pleochroism, grey-green — weakly green-yellow in the black-green, grey-blue — pink-violet in almost black-coloured tourmaline.

A fragment of a large crystal was chosen for chemical study. With a diamond saw its outer part was cut off. Then the two parts were crushed and from fractions — 1—0.5 mm visually homogeneous material for chemical

analysis was chosen by hand. The result of the overall analysis of the core and the comparison of the chromophore content in the outer zone of tourmaline are given in Tab. 2, together with the calculation of the crystallochemical formula for Z 31 O, OH, F. As indicated by the result of the calculation, the elbaite from Řečice does not differ from other elbaite from the pegmatites of the Bohemian Massif. It can be said that the contents of chromophores, Mn and Fe, are relatively low, as compared with the content of those elements in red elbaite from Pikárec and other localities (Povondra, Čech, Staněk, 1985). The crystallochemical formula of the elbaite from Řečice shows that, as in other tourmalines, also this mineral has fully occupied tetrahedra  $\text{SiO}_4$ , the planar configuration  $\text{BO}_3$ , and outer octahedra  $\text{AlO}_6$ . Like further elbaite studied by us, also this one exhibits a considerable deficit (and/or excess) in the number of  $\text{Li}^+$  and  $\text{Al}^{3+}$  ions in the inner octahedra. Notable is also the increased content of the liddicoatite component of our elbaite. If we consider the substitution  $\text{Ca}/\text{Na}$  according to Equation (1)

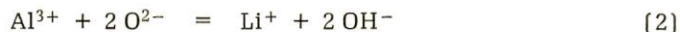


Tab. 2. Chemical analysis of the Řečice elbaite and its recalculation to 31 O, OH, F.

	Core	Outer part		
$\text{SiO}_2$	36.59 %		Si	5.979
$\text{B}_2\text{O}_3$	10.60		B	2.990
$\text{Al}_2\text{O}_3$	39.75	38.26%	Al	7.657
$\text{TiO}_2$	traces	traces	Ti	0.000
$\text{Fe}_2\text{O}_3$	traces	traces	$\text{Fe}^{3+}$	0.000
FeO	0.99	0.30	$\text{Fe}^{2+}$	0.135
MnO	1.81	0.70	Mn	0.250
MgO	0.025		Mg	0.006
$\text{Li}_2\text{O}$	1.94		Li	1.275
CaO	1.75		Ca	0.306
$\text{Na}_2\text{O}$	2.14		Na	0.677
$\text{K}_2\text{O}$	0.074		K	0.016
$\text{H}_2\text{O}$	2.55		OH	2.781
$\text{F}_2$	1.32		F	0.682
dehum.	0.07		O	27.537
$-\text{O} = 2\text{F}$	-0.566		$\Sigma_{\text{oct.}}$	9.324
Total	99.053 %			
			a = 1.5857 nm	
			c = 0.7071 nm	

Analyst: P. Povondra

(see Povondra 1981), it can be assumed that the exchange  $\text{Al}/\text{Li}$  is given by Equation (2)



This type of substitution has not yet been described in natural phases nor has it been experimentally studied. From among further crystallochemical dependencies the elbaite from Řečice, like other elbaite, exhibits a considerably low content of  $\text{Mg}^{2+}$  and  $\text{Ti}^{4+}$ .

In accordance with the change in the refractive indices from the dark core to the lighter shades of the external parts also the content of chromogens, i. e. FeO and MnO, of the outer zone drops. The determination of elbaite was completed by the determination of lattice parameters of the outer part of the crystal (a powder sample, diffractometer DRON 2, without interior standard,

step record  $2\theta = 0.05^\circ/3$  seconds within the limits of  $20-60^\circ$ ). The calculated values are given in Tab. 2. The parameters of the core of elbaite could not be determined owing to the considerable heterogeneity of the mineral fraction studied.

In the pegmatite of Řečice, elbaites are the only bearers of lithium; such a common lithium mineral as lepidolite has not been found there although it almost invariably accompanies elbaites in the other lithium pegmatites of the Bohemian Massif (Čech, Staněk 1958, Staněk 1963, 1965, 1973, Povondra, Čech, Staněk 1985). In those pegmatites, elbaites and lepidolite originated in the late metasomatic Li-phase (according to Ginzburg 1955 II Li-phase). We are of the opinion that also in the pegmatite of Řečice, elbaites originated in an independent II Li-phase and that they are younger than the albite of the metasomatic Na-phase. The occurrence at Řečice is exceptional among the hitherto known lithium pegmatites; all lithium — not much — concentrated in it only into elbaites. In this it is somewhat similar to Li-pegmatite near Rudolec, SW of Žďár nad Sáz., which, according to Němec (1983), is also very poor in lithium.

The elbaites from Řečice, with their chemism and physical properties, do not differ much from other elbaites of the Bohemian Massif. Unlike the elbaites from Rožná (Sekanina 1928), Ctídužice (Čech 1958), Dobrá Voda (Staněk 1963), they are crystallographically simple, poor in forms, most similar to the elbaites from Strážek.

#### SOUHRN

U Řečice jižně od Nového Města na Moravě ve strážeckém moldanubiku byl objeven pegmatit s elbaity, zatím největšími, jaké kdy byly na území Českého masívu nalezeny.

Pegmatit s výskytem elbaítů vytváří těleso nejspíše žilného tvaru, přibližně severojižního směru, asi 15 m dlouhé, maximálně 1 m mocné, uklánějící se k východu či v hloubce téměř svislé, na rozhraní negranitizované a granitizované pararuly.

Pozorování přístupný pegmatit byl tvořen hlavně drobně zrnitým agregátem granitické až pegmatoidní struktury, ojedinělými malými hnízdy draselného živce prorostlými graficky křemenem, a konečně hnízdy větších individuál červenavě růžového K-zivce a křemene, často vyvinutých do menších dutin ve formě krystalů. V těchto dutinách se pak objevovaly krystaly elbaítů, nejčastěji tmavě červené nebo zonálně zbarvené rubelity. Všechny části pegmatitového tělesa jsou proniknuty albitem, uplatnila se v nich silně mladší albitizace. Albit pak doprovází velké množství drobných krystalů rubelitu, značné části pegmatitu jsou silně rubelitizovány.

Pegmatit je chudý na vzácné minerály, poměrně řídké jsou v něm i slídy — biotit a muskovit. Běžný je jedině skoryl. Z dalších minerálů byl zjištěn granát, zirkon, kasiterit, löllingit, farmakosiderit, skorodit a arzeniosiderit.

Elbaity jsou zastoupeny verdelitem, indigolitem, achroitem a rubelitem. Zatímco první tři byly zjištěny jen v několika exemplářích, rubelit je po živcích a křemeni nejběžnějším minerálem.

Verdelit tvoří až 7 mm dlouhé, 3 mm široké tmavozelené sloupečky v albitu. Indigolit a achroit byly zjištěny v malých nedokonalých krystalech v dutinách.

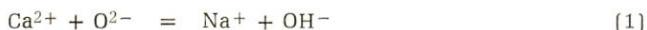
Rubelit vykazuje velkou variabilitu jak v barvě, tak v krystalech. Barva je závislá od velikosti krystalů. Nejmenší krystaly, 1–2 mm velké, jsou jednobarevné, světle růžové. Rubelity poněkud větších rozměrů bývají slabě zonálně zbarvené, někdy jsou to tzv. „turecké hlavičky“. Krystaly s rozměry nad 1 cm jsou vždy zonálně zbarveny, jádro je šedohnědé až téměř šedočerné, okraje sytě červené až hnědočervené. Největší rubelity jsou až 13 cm dlouhé a 8 cm silné.

Krystaly rubelitu jsou dvojího typu. Typ I, u krystalů do 0,5 cm velkých, je zpravidla omezen antilogním pólem, a to trigonální pyramidou  $r\{10\bar{1}1\}$ ; analogní pól je

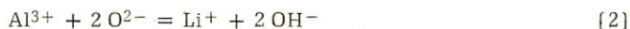
vzácný, zakončen matnými plochami trigonální pyramidy  $g \{01\bar{1}2\}$ , vzácně bazí  $c \{000\bar{1}\}$ . V prizmatickém pásmu zcela převládá hexagonální prizma  $a \{11\bar{2}0\}$ ; trigonální prizma  $m \{01\bar{1}0\}$  je mnohem vzácnější. Prizmatické plochy jsou lesklé, téměř nerýhované. Idealizovaný krystal rubelitu I. typu je uveden na obr. 1. Výsledky goniometrického měření podává tab. 1. Krystaly rubelitu II. typu jsou vždy větších rozměrů, omezené jen na jednom konci, a to jak antilogním, tak analogním pólem. Antilogní pól, na krystalech vzácnější, je omezen trigonální pyramidou  $r \{10\bar{1}1\}$ , analogní pól velkou bazí  $c \{000\bar{1}\}$  a třemi úzkými plochami trigonální pyramidy  $r' \{01\bar{1}1\}$ . Prizmata  $a \{11\bar{2}0\}$ ,  $m \{01\bar{1}0\}$  jsou silně vertikálně rýhovaná. Idealizovaný krystal II. typu ukazuje obr. 1.

Indexy lomu jednobarevných rubelitů menších rozměrů kolísají v rozmezí  $n_o = 1,639-1,643$ ,  $n_e = 1,622-1,626$ , není mezi nimi velkých rozdílů. U větších, zonálně zbarvených krystalů se indexy dosti mění. Nejnížší hodnoty vykazují vnější růžově zbarvené části  $n_o = 1,642-1,643$ ,  $n_e = 1,624-1,626$ , šedorůžové části ke středu krystalu  $n_o = 1,649$ ,  $n_e = 1,627$ , šedavě zbarvené části ještě více k centrální části  $n_o = 1,651$  až  $1,652$ ,  $n_e = 1,627-1,628$ . Je-li přítomno šedočerné jádro, pak jsou jeho indexy lomu ještě vyšší,  $n_o = 1,656$ ,  $n_e = 1,636$ , a u téměř zcela černého nejvyšší  $n_o = 1,663$ ,  $n_e = 1,637$ . Z toho vyplývá že indexy lomu v krystalu klesají od centra k okrajům. Stejně je tomu s pleochroismem, téměř černé či černošedé jádro vykazuje silný pleochroismus — šedozelená—slabě žlutozelená v prvním, šedavě modrá—růžově fialová ve druhém případě, světleji zbarvené části k okrajům a okraje jsou bez pleochroismu.

Výsledky chemické analýzy jádra zonálního elbaitu a porovnání obsahu chromoforů ve vnější zóně turmalínu jsou uvedeny v tab. 2 současně s rozpočtem krystalochemického vzorce na  $Z \ 31 \ O, OH, F$ . Jak výsledek rozpočtu ukazuje, neliší se elbait z Řečice od jiných elbaitů ze pegmatitů Českého masívu. Obsahy obou chromoforů,  $Mn$  a  $Fe$  jsou relativně nízké, krystalochemický vzorec ukazuje, že jako u jiných turmalínů má i řečický plně obsazený tetraedry  $SiO_4$ , planární konfiguraci  $BO_3$  a vnější oktaedry  $AlO_6$ . Podobně jako další námi studované elbaity i tento vykazuje poměrně značný deficit resp. přebytek v počtu  $Li^+$  a  $Al^{3+}$  iontů ve vnitřních oktaedrech. Pozoruhodný je i zvýšený podíl liddicoatitové složky studovaného elbaitu. Pokud budeme uvažovat substituci  $Ca/Na$  podle rovnice (1)



(viz Povondra 1981), lze předpokládat, že záměna  $Al/Li$  je dána rovnicí (2)



Tento typ substituce nebyl dosud u přírodních fází popsán, ani nebyl experimentálně studován. Dále vykazuje elbait z Řečice, stejně jako jiné elbaity, značně nízký obsah  $Mg^{2+}$  a  $Ti^{4+}$ . V souhlase se změnou indexů lomu od tmavého jádra ke světlejším okrajům poklesá podstatně i obsah chromogenů, tj.  $FeO$  a  $MnO$  okrajové zóny. Určení elbaitu bylo doplněno i stanovením mřížkových parametrů vnějšího lemu krystalu, viz tab. 2.

Elbaity v pegmatitu u Řečice jsou jedinými nositeli lithia, nebyl zde nalezen ani tak běžný lithný minerál jako lepidolit. Elbaity vznikly v metasomatické II  $Li$ -fázi, jsou mladší než albit metasomatické  $Na$ -fáze. Řečický výskyt zaujímá výjimečné postavení mezi dosud známými lithnými pegmatity; veškeré lithium, jehož nebylo mnoho, se v něm zkoncentrovalo pouze do elbaitů. Tím je poněkud podobný  $Li$ -pegmatitu od Rudolce, jenž je podle Němce (1983) rovněž chudý lithiem.

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