

*Epididymite and milarite—alteration products of
beryl from Věžná, Czechoslovakia.*

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Summary. Epididymite, determined by means of its optical properties, X-ray powder pattern, and spectrographic analysis, was found in a desilicated pegmatite near Věžná, Western Moravia, Czechoslovakia. It was formed contemporaneously with minor amounts of milarite in a late hydrothermal stage by the action of sodium-rich solutions on beryl. This is the first occurrence of epididymite and milarite as alteration products of beryl and the first findings of epididymite in any other paragenesis than that of alkaline pegmatites. The optical properties of epididymite are re-examined and older data rejected.

SINCE 1957 pegmatite bodies in serpentinite quarries near Věžná, Western Moravia, Czechoslovakia, have yielded many interesting and rare minerals. In a complex pegmatite body with marked potash and soda phases, the following minerals were formed during a late replacement: niobian rutile (Černý and Čech, 1962), monazite, oyamalite (Černý, 1959), beryllium-bearing cordierite, apatite, tourmaline, micro-lite, milarite (Černý, 1960), bavenite, etc. Another desilicated pegmatite body, a quartz-oligoclasite composed chiefly of albite-oligoclase and quartz with wide contact zones of anthophyllite, biotite, and actinolite, contains apatite, sillimanite, tourmaline, monazite, tantalian rutile, and columbite; it is characterized by extensive late hydrothermal alterations, which gave rise to abundant prehnite, thomsonite, calcite, aragonite, wellsite (Černý, 1960), natrolite, etc. Despite their differences in bulk composition and successive development, both pegmatites have a very similar association of accessory elements: P, B, Ti, Nb, Ta, Ln, Be, Zr.

In the first pegmatite mentioned, there are relatively abundant beryllium minerals: beryllian cordierite, milarite, bavenite. In the second pegmatite, no primary beryllium minerals have been found, although beryllium was detected by spectrographic analyses in amounts as much as 0.0 x % in many samples of prehnite, palygorskite-like

mineral, and kaolinized feldspar. Recently beryl was discovered in this pegmatite—a greenish variety with rather low alkali content. Beryl is often altered to a chalky-looking substance, which is sometimes accompanied by radiating aggregates of a white fibrous mineral, located on the surface or in the closest neighbourhood of altered beryl crystals. Both chalky substance and white fibres were identified as epididymite, $\text{Na}[\text{BeSi}_3\text{O}_7\text{OH}]$. Thin fissures adjacent to altered beryl are often filled with fibrous milarite $(\text{K},\text{Na})\text{Ca}_2\text{AlBe}_2[\text{Si}_{12}\text{O}_{30}]\cdot 0.5 \text{H}_2\text{O}$.

Epididymite.

The microcrystalline, chalky epididymite, replacing beryl, is nearly isotropic with medium $n = 1.544$; it occurs as irregular grains with maximum dimension 0.01 mm.

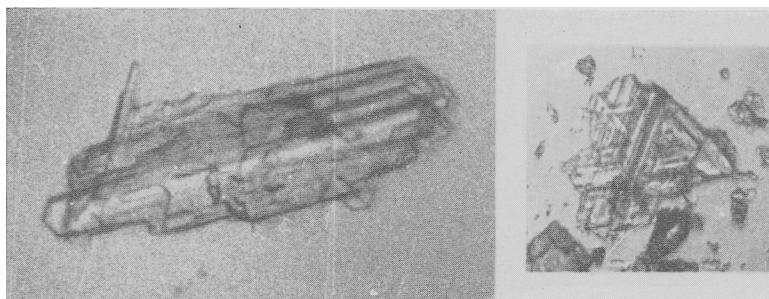


FIG. 1.

FIG. 2

FIG. 1 (*left*). Group of subparallel epididymite crystals, lying on (001), with minute twinned laths. $\times 230$. FIG. 2 (*right*). Fragment of a net of twinned epididymite crystals. $\times 95$.

Fibrous epididymite usually forms laths elongated parallel to the b -axis and flattened on {001}, with small faces of {110} in termination (fig. 1). Individuals with predominant macrodomatic forms are less usual. (In this study, the orientation adopted by Strunz, 1957, is used: $a = 12.77 \text{ \AA}$, $b = 7.34 \text{ \AA}$, $c = 13.65 \text{ \AA}$, $a:b:c = 1.734:1:1.860$; this setting corresponds to that of Flink, 1894, with the c -axis doubled, or to that of Goldschmidt, 1897; Gossner and Kraus, 1929; Ito, 1934; and Zachariasen, 1929.) Two cleavages are developed, the one parallel to (001) being much better than that parallel to (100). Crystals of epididymite are in most instances characteristically twinned in triangular skeletons, sagenite-like in appearance, aragonite-type in symmetry relations (fig. 2).

Optical properties determined on epididymite from Věžná and Narsarsuk, Greenland, in the present study, differ considerably from the previous data (table I and fig. 3). Since 1893 much misunderstanding

TABLE I. Optical properties of epididymite.

	1.	2.	3.	4.	5.
α	1.5645	1.5440	1.540	1.544-1.548	1.541
β	1.5685	1.5441		$\cong \gamma$	$\cong \gamma$
γ	1.5688	1.5464	1.543	1.547-1.552	1.545
$\gamma - \alpha$	0.0043	0.0024	0.003	0.003-0.004	0.004
$2V$	(-) $31^\circ 4'$ *	(+) $22^\circ 38'$ *	(-) $2^\circ - 3^\circ$	(-) $\leq 10^\circ \dagger$	(-) $\leq 10^\circ \dagger$
disp.	$r > v$		distinct	$r > v$	$r > v$
optical orientation ...	$\alpha = a, \gamma = b$	$\alpha = a, \gamma = b$		$\alpha = a, \gamma = b$	$\alpha = a, \gamma = b$

1. Narsarsuk, Flink (1894); $a : b : c = 1.7367 : 1 : 0.9274$.

2. Narsarsuk, Flink (1898, 1901); $a : b : c = 1.7274 : 1 : 1.0680$ (in comparison with original setting, a - and b -axes interchanged and the new a -axis tripled, the new c -axis doubled).

3. Narsarsuk, Christophe-Michel-Lévy (1961).

4. Věžná, fibrous variety, new data; $a : b : c = 1.734 : 1 : 1.860$ (as accepted by Strunz, 1957).

5. Narsarsuk, new data (Coll. Dr. Ed. Burkart, Dept. of Mineralogy and Petrology, Moravian Museum, no. 9381); $a : b : c = 1.734 : 1 : 1.860$ (as accepted by Strunz, 1957).

* Calculated.

† Estimated.

ing accumulated regarding optical properties of this mineral. The original data of Flink (1893, 1894) and Nordenskiöld (1894) were corrected by Flink in 1898 and 1901, but even these latter determinations were not free of mistakes, as indicated by the present investigations. Up to 1957 all notes on optical properties of epididymite had been only citations of Flink's erroneous data. Some authors quoted Flink's corrected values (Bøggild, 1905; Winchell, 1951), others accepted his older data, not being familiar with his re-examination (Hintze, 1897; Ito, 1947; Beus, 1960); Bøggild (1953) quotes a mixture of both determinations. Furthermore, many changes of crystallographic setting have been made without corresponding changes of the optical orientation as recorded by Flink. The a - and b -axes have been often interchanged and axial parameters multiplied or divided to show the polymorphic relations of orthorhombic epididymite and monoclinic eudidymite (Hintze, 1897; Flink, 1901; Goldschmidt, 1916; Gossner and Mussgnug, 1928; Gossner and Kraus, 1929; Zachariasen, 1929; Winchell, 1951).

New determinations of optical properties by Shilin and Semenov (1957) and Vlasov, Kuzmenko, and Eskova (1959) are unacceptable, as

these authors did not respect the difference between eudidymite and epididymite in their optical investigation. A short note on the optics of epididymite in a morphological study by Labuntsov (1957) is insufficient and probably erroneous in determining the optical character. Only the results of Christophe-Michel-Lévy (1961) agree with the optical properties determined in the present study (table I).

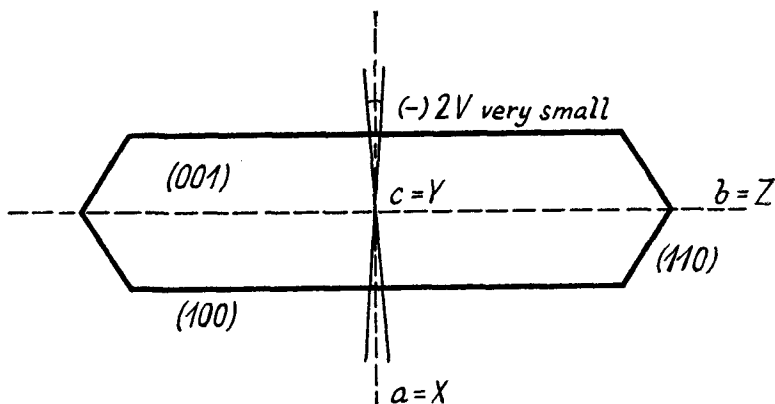


FIG. 3. Optical orientation of epididymite from Věžná, Czechoslovakia, and Narsarsuk, Greenland.

It is evident that all older optical data must be discarded and substituted by those of Christophe-Michel-Lévy and this paper, based on material from Narsarsuk and Věžná.

From the data of these new studies it is evident that the refractive indices of epididymite vary considerably. Chemical analyses in the literature show only minor deviations from theoretical composition and are unfortunately accompanied by confusing descriptions of optical properties (Shilin and Semenov, 1957; Vlasov, Kuzmenko, and Eskova, 1959). Unfortunately, the chemical analysis of the Věžná epididymite is not possible because of lack of material. So the variations of refractive indices cannot be correlated with chemical data at present. It can be only suggested that diadochie substitutions NaSi/CaAl , BeSi/AlAl and particularly F/OH may cause them; fluorine was detected in epididymite from Lovozero massif in quantities as much as 0.5 % (Vlasov, Kuzmenko, and Eskova, 1959).

X-ray powder data of both chalky and fibrous epididymite from Věžná are set out in table II, compared with patterns available in the

TABLE II. X-ray powder data for epididymite.

1.		2.		3.		4.		5.		6.	
<i>d</i> , Å.	<i>I</i> .	<i>d</i> , Å.	<i>I</i> .	<i>d</i> , Å.	<i>I</i> .	<i>d</i> , Å.	<i>I</i> .	<i>d</i> , Å.	<i>I</i> .	<i>d</i> , Å.	<i>I</i> .
7.97	3										
6.97	1			6.8	tf						
6.37	6	6.43	3	6.3	m	6.36	6	6.43	8	6.39	5
5.79	4	5.80	2	5.78	> f	5.80	3	5.80	5		
4.64	5b	4.62	3b	4.64	> f	4.61	5	4.61	6	4.65	5
4.02	1	4.00	3							4.07	1
3.663	5	3.663	7	3.65	m	3.69	6	3.71	9	3.65	7
3.414	7	3.401	7	3.40	i	3.38	8	3.39	10	3.40	8
3.220	2			3.22	tf						
		3.186	5	3.17	f						
3.100	10	3.083	6	3.09	i	3.09	10	3.10	10	3.10	10
2.998	7	2.993	5	2.99	i	2.97	10	3.00	9	2.98	10
2.875	1	2.870	1	2.88	tf					2.88	1
						2.75	1	2.76	1	2.75	1
2.607	4	2.599	3	2.60	f	2.60	5	2.61	7	2.60	6
2.494	4	2.488	3	2.49	m	2.49	5	2.51	8	2.48	7
2.398	1	2.398	0.5	2.40	f	2.41	3	2.42	4	2.41	3
2.270	3	2.268	1	2.26	f	2.27	3	2.28	7	2.26	5
2.131	5	2.127	1	2.13	m	2.13	5	2.13	8	2.13	8
2.071	0.5			2.07	tf						
2.027	0.5			2.023	tf	2.02	1	2.04	1	2.04	1
1.961	0.5			1.965	tf	1.973	1	1.976	1	1.976	2
						1.937	1	1.940	1	1.931	1
1.834	4			1.836	f	1.856	7	1.856	9	1.835	7
1.800	6	1.814	3b	1.799	> m	1.807	7	1.804	9	1.797	9
1.746	2	1.749	1	1.747	tf	1.757	2	1.759	5	1.750	4
1.704	1	1.697	1	1.703	tf	1.707	2	1.709	5	1.700	3
1.642	3	1.643	1	1.641	> f	1.651	5	1.651	8	1.643	8
1.587	1			1.589	tf	1.594	3	1.594	4	1.590	1
1.546	5			1.545	> f	1.548	5	1.553	8	1.542	8
1.523	2b										
1.479	0.5			1.475	tf	1.484	1	1.490	2	1.480	2
1.452	1			1.451	tf	1.455	1	1.449	2	1.451	2
1.431	1										
1.389	4			1.390	f	1.392	4	1.397	7	1.391	7
1.364	4			1.361	f	1.367	4	1.366	6	1.363	7
1.329	4			1.326	f	1.332	4	1.330	7	1.328	7
1.307	0.5									1.306	1
1.284	5			1.284	> m	1.287	7	1.286	9	1.280	9

1. Věžna, fibrous variety, Cu/Ni radiation, $\lambda = 1.5418$ Å, 114.59 mm-diameter camera.

2. Věžná, chalky variety, Cu/Ni radiation, $\lambda = 1.5418$ Å, 114.59 mm-diameter camera.

3. Narsarsuk, Christophe-Michel-Lévy (1961).

4. Lovozero massif, Shilin and Semenov (1957), Fe radiation, 57.9 mm-diameter camera.

5. Khibina massif, Shilin and Semenov (1957), Fe radiation, 57.9 mm-diameter camera.

6. Lovozero massif, Vlasov, Kuzmenko, and Eskova (1959), Fe radiation, 57.9 mm-diameter camera.

literature. The pattern of fibrous epididymite shows close similarity to those of Kola peninsula and Narsarsuk minerals, whereas the chalky variety gave an incomplete pattern with only strongest

lines present and with certain changes in their relative intensities. The X-ray powder photograph of fibrous epididymite also corresponds closely to the diagrammatic picture of a powder pattern of epididymite from Narsarsuk, Greenland, given by Neumann, Sverdrup, and Saebo (1957).

The differences in grain size and X-ray powder patterns of chalky and fibrous epididymite from Věžná indicate that the former type is probably less ordered or incompletely crystallized. This may be another factor influencing the optical properties of epididymite.

Spectrographic analysis of the Věžná epididymite established the presence of Na, Si, Be as major elements in this mineral, besides minor contents of Mg (x %), Al, Ba, Ca ($0.0x$ %), B, Sn ($0.0x$ %) and traces of Cu, Ga, Mn, Pb, Cr, Fe, Ni, Ti, Zr, As ($< 0.0x$ %).

Milarite.

Milarite is disseminated in fissures of feldspar adjacent to altered beryl crystals as randomly oriented tiny needles or radiating bunches. Six-sided prisms $\{10\bar{1}0\}$ are often terminated by $\{10\bar{1}2\}$; the basal plane was not observed. Indistinct cleavage is developed parallel to the c -axis, its orientation cannot be determined on the fine fibrous material. Optical properties are: parallel extinction, negative elongation, ϵ 1.549, ω 1.553, $\epsilon - \omega$ 0.004; no optical anomalies were observed.

An X-ray rotation photograph of a minute needle showed spots corresponding to the strongest reflections of milarite. Unit-cell dimensions, as computed from this photograph, are a 10.42 Å, c 13.72 Å, $c:a$ 1.3166. Spectrographic analysis showed the presence of Si, Al, Be, Ca, K, Na, as most important elements.

The crystal habit and optical properties differ considerably from those of Swiss milarites and of milarite from Kola peninsula (Sosedko, 1960), but are very similar to the morphology and optics of milarite from another Věžná pegmatite, mentioned in the introduction of this paper. This milarite was described in detail by the present author (Černý, 1960) and an attempt was made to explain its properties by different water and alkali contents. Unfortunately, lack of material of the milarite under present investigation prevents its further detailed study.

Origin of epididymite and milarite.

Epididymite in the Věžná quartz-oligoclase originated by low hydrothermal alteration of beryl, partly directly replacing it, partly crystallizing in closely adjacent cavities and fissures of albite-oligoclase. There

is no sharp boundary between chalky epididymite and replaced beryl. Epididymite penetrates into relicts of beryl as clouds of fine flakes. Milarite is the second product of this decomposition of beryl, being less abundant and not so intimately associated with beryl as epididymite. It crystallized in fissures of albite-oligoclase in a broader neighbourhood of altered beryl crystals. No other minerals are genetically associated with epididymite and milarite. A palygorskite-like mineral, which sometimes transects epididymite aggregates, is evidently of later origin.

Paragenetic and geochemical relations of the pegmatite evolution indicate that this alteration of beryl took place under the influence of hydrothermal solutions rich in sodium, which were accumulated during the alteration of large masses of albite-oligoclase and their replacement by prehnite and calcium-rich thomsonite.

This is the first occurrence of epididymite and milarite as alteration products of beryl. Particular conditions of beryl decomposition gave rise to these silicates instead of bertrandite, phenakite, euclase, bavenite, or bityite, which have been known in this connexion up to the present. It is noteworthy that epididymite in Věžná is not accompanied by any of the aluminosilicates that are usually associated with the above-mentioned beryllium minerals, pseudomorphous after beryl—adularia, albite, muscovite, gilbertite, kaolinite, stilbite. There was undoubtedly nearly complete removal of aluminium during decomposition of beryl; a part of it was fixed after short migration with small amounts of beryllium in milarite.

Since 1893, epididymite and eudidymite have been found only in pegmatites of alkaline syenitic magmas at Narsarsuk, Greenland, at Langesundfjord, Norway, and in the Lovozero and Khibina massifs, Kola peninsula, USSR. They have been considered to be typical minerals of this paragenesis, formed in the final stage of alkaline pegmatite development, which is characterized by intensive sodic metasomatism and crystallization of small amounts of beryllium and lithium minerals (Vlasov, Kuzmenko, and Eskova, 1959; Beus, 1960). At Věžná epididymite is found for the first time in another paragenesis than that of alkaline pegmatites. But maybe this occurrence is not exceptional, as extensive hydrothermal decomposition of feldspar is quite common in plagioclastic desilicated pegmatites, penetrating serpentinites, and the conditions that gave rise to epididymite in the Věžná quartz-oligoclase could be developed also in other localities of these pegmatite types.

A detailed study of pegmatites from Věžná and their mineral

paragenesis is being carried out by the author; its results will be given in a separate paper.

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References.

- BELOV (N. V.), 1961. *Min. Mag. Geol. Soc. of Lvov*, vol. 15, p. 5.
 — and TARKHOVA (T. N.), 1951. *Trans. Inst. Cryst. Acad. Sci. U.S.S.R.*, no. 6, p. 83.
 BEUS (A. A.), 1960. *Geochemistry of beryllium and genetic types of beryllium deposits*. Publ. Acad. Sci. U.S.S.R., Moscow.
 BØGGILD (O. B.), 1905. *Mineralogia Groenlandica*. Kjøbenhavn.
 — 1953. *The mineralogy of Greenland*. København.
 CHRISTOPHE-MICHEL-LÉVY (M.), 1961. *Bull. Soc. franç. Minér. Crist.*, vol. 74, p. 320.
 ČERNÝ (P.), 1959. *Čas. Morav. musea v Brně*, vol. 44, p. 57.
 — 1960. *Práce Brněnské základny ČSAV*, vol. 32, fasc. 1, op. 399, p. 1.
 — and ČECH (F.), 1962. *Čas. Morav. musea v Brně*, vol. 47, p. 13.
 FLINK (G.), 1893. *Geol. Fören. Förh.*, vol. 15, pp. 195, 467.
 — 1894. *Zeits. Kryst. Min.*, vol. 23, p. 344.
 — 1898. *Meddels. om Grönland*, vol. 14, p. 230.
 — 1901. *Zeits. Kryst. Min.*, vol. 34, p. 639.
 GOLDSCHMIDT (V.), 1897. *Kristallographische Winkeltabellen*. Berlin.
 — 1916. *Atlas der Kristallformen*. III. Heidelberg.
 GOSSNER (B.) and MUSSGUG (F.), 1928. *Festschrift V. Goldschmidt, Heidelberg*, p. 117.
 GOSSNER (B.) and KRAUS (O.), 1929. *Centr. Miner., Abt. A*, p. 257.
 HINTZE (C.), 1897. *Handbuch der Mineralogie II*. Leipzig.
 ITO (T.), 1934. *Zeits. Krist.*, vol. 88, p. 142.
 — 1947. *Amer. Min.*, vol. 32, p. 442.
 LABUNTSOV (A. N.), 1957. *Trans. Min. Mus. Acad. Sci. U.S.S.R.*, vol. 8, p. 164.
 LARSEN (E. S.) and BERMAN (H.), 1934. *U.S. Geol. Survey Bull.*, 848.
 NEUMANN (H.), SVERDRUP (Th.), and SÆBØ (P. Chr.), 1957. *Avhand. Norske Vidensk.-Akad. Oslo, I. Mat.-Naturv. Kl.*, no. 6.
 NORDENSKIÖLD (G.), 1894. *Geol. Fören. Förh. Stockholm*, vol. 16, pp. 336, 345.
 SHILIN (L. L.) and SEMENOV (E. I.), 1957. *Compt. Rend. Acad. Sci. U.S.S.R.*, vol. 112, p. 156.
 SOSEDKO (T. A.), 1960. *Compt. Rend. Acad. Sci. U.S.S.R.*, vol. 131, p. 643.
 TENNYSON (Ch.), 1960. *Neues Jahrb. Min., Abh.*, vol. 94, p. 1253.
 VLASOV (K. A.), KUZMENKO (M. V.), and ESKOVA (E. M.), 1959. *The Lovozero alkaline massif (rocks, pegmatites, mineralogy, geochemistry, and genesis)*. Publ. Acad. Sci. U.S.S.R., Moscow.
 WINCHELL (A. N.) and WINCHELL (H.), 1951. *Elements of optical mineralogy*, New York.
 ZACHARIASEN (W. H.), 1929. *Norsk. Geol. Tidsskr.*, Oslo, vol. 10, p. 449.

Further references on studied minerals, which are not essential to the present paper, are quoted in Belov (1961), Bøggild (1905, 1953), Černý (1960), Ito (1947), and other studies.