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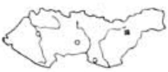
JÁN ILAVSKÝ — JÁN KANTOR — CONSTANTIN KOUKOUZAS*

STRATIFORM BARITES IN THE DEVONIAN OF THE NÍZKE TATRY MTS. WEST CARPATHIANS, CZECHOSLOVAKIA

(Figs 15, Tab. 3)



Abstract. In the Nízke Tatry Mts. (West Carpathians) a new type of stratiform mineralization with tourmalinitites and barite has recently been discovered in the Devonian crystalline schists (O. Miko — D. Hovorka, 1978). We have examined in detail the structures, textures and chemistry of the barites as well as their contents of Sr and other trace elements, microfossils and the isotopic composition of sulphur.

For comparison, several barite samples from Bulgaria (the Kremikovci deposite of Fe-Ba type located in the Triassic rock complex, and from Milos Island in Greece — a volcanic type deposit in the Upper Pliocene complex — have been studied.

Резюме: В кристаллических сланцах Низких Татр (Западные Карпаты), возраст которых был доказан как девон, в последние годы был открыт новый тип слоеобразном минерализации с турмалинититами и баритом (О. Мико — Д. Ховорка, 1977). Мы изучали бариты более подробно с точки зрения структуры, текстуры, химии, следовых элементов, содержания микрсскопических ископаемых, изотопового состава серы и. т. д.

Для сравнения мы изучали ориентировочно несколько образцов баритов из Болгарии (месторождение Кремиковци типа Fe-Ba, которое лежит в триасе) и из острова Милос в Греции (вулканогенный тип в верхнем плиоцене).

Introduction

In the recent years the crystalline area of the Nízke Tatry Mts. has been the object of intensive geological studies. On their basis new geological maps have been prepared and new information on the geology and technics of the Veporicum Crystalline (Klinec, A., 1966, 1973; Klinec A. — Miko O. — Planderová E., 1975) and in the field of petrography and metalogenesis has been gathered (Klinec A. — Kantor J. — Rybár M., 1971; Miko O. — Hovorka D., 1978).

In the course of petrographic and petrogenetic studies, stratiform layers of tourmalinic rocks have been discovered in Hron Complex which are associated with the porphyry volcanism (O. Miko — D. Hovorka, 1978). O. Miko called our attention to the barite layers of stratiform character, which occur in the tourmalinitites.

This contribution deals with the results of a detailed field investigation of barite outcrops and their laboratory analyses. The barites represent a new type of stratiform, volcano-sedimentary mineralizations in the Lower Paleozoic of the West Carpathians, which has not been so far described from this area.

* RNDr. Ján Ilavský, DrSc., RNDr. Ing. Ján Kantor, CSc., Dionýz Štúr Institute of Geology, Mlynská dolina 1, Bratislava, Dr. Constantin Koukouzas, Institute for Geological and Subsurface Research, 608-Athenes, 70-Messeghion str., Greece.

Geological setting of the Bacúch

Geographically, the area of the Bacúch locality and it environs belongs to the Nízke Tatry (Low Tatra) Mts. in central Slovakia. It is situated north of the river Hron, in the proximity of the meridian 20° E long (Fig. 1).

Geologically, the area is a part of the Veporicum tectonic unit, of its Hron Complex, which has been defined by A. Klinec (1966, 1973) and Klinec A. — Miko O. — Planderová E. (1975) as a Paleozoic complex, in places up to mesozonally metamorphosed.

In the area studied the Hron Complex is composed of two lithologically different units:

— 1. a varied volcanogenic series, and

— 2. a monotonous sedimentary series.

The varied series of the Hron Complex consist of acid volcanic rocks of the porphyroid type, which form recurrent lava flows separated from one another by the original sediments, shales, sandstones to quartzites. The quart-tourmaline rocks interlayered in the porphyroids have been studien in detail by O. Miko — D. Hovorka (1978).

Barite mineralization at Bacúch

The barite occurrence at Bacúch are situated 3,5 km north of the village, in the eastern sides of the Hutky valley, near the place where the main valley Bacúšska dolina branches into the Stará dolina, Ramžová dolina and Sokolová dolina (some 200 m from elevation point 798 m). They lie ca 810 m.s.1. and can be reached by a forest-road, which ascens from elev. point 798 southwards along the slopes of Babina towards the Sparistá dolinka valley, where from it turns to the north and than eastwards above the Nemcová and Sokolová dolina (Fig. 1).

The varied series crops out in the cutting of the forest road over a distance of several hundred meters, where strongly schistose porphyroids with layers of dark shalles and tourmalinic-quartzose rocks are visible (Fig. 2). The beds strike SW—NE nad dip ca 40—50° S.

The barite layers contained in the varied porphyroid complex are situated about 200 m south of elev. point 798 m. Two of them are in the quartz-tourmalinic rock and third in overlying porphyroids (Fig. 3).

The shape of barite bands is on the whole regular and continuous, but the bands of other minerals (Fe-oxides, quartz) are impersistent and have often the form of lenses or irregular beds, which give the impression of cross- or convolute bedding (Fig. 4, 5).

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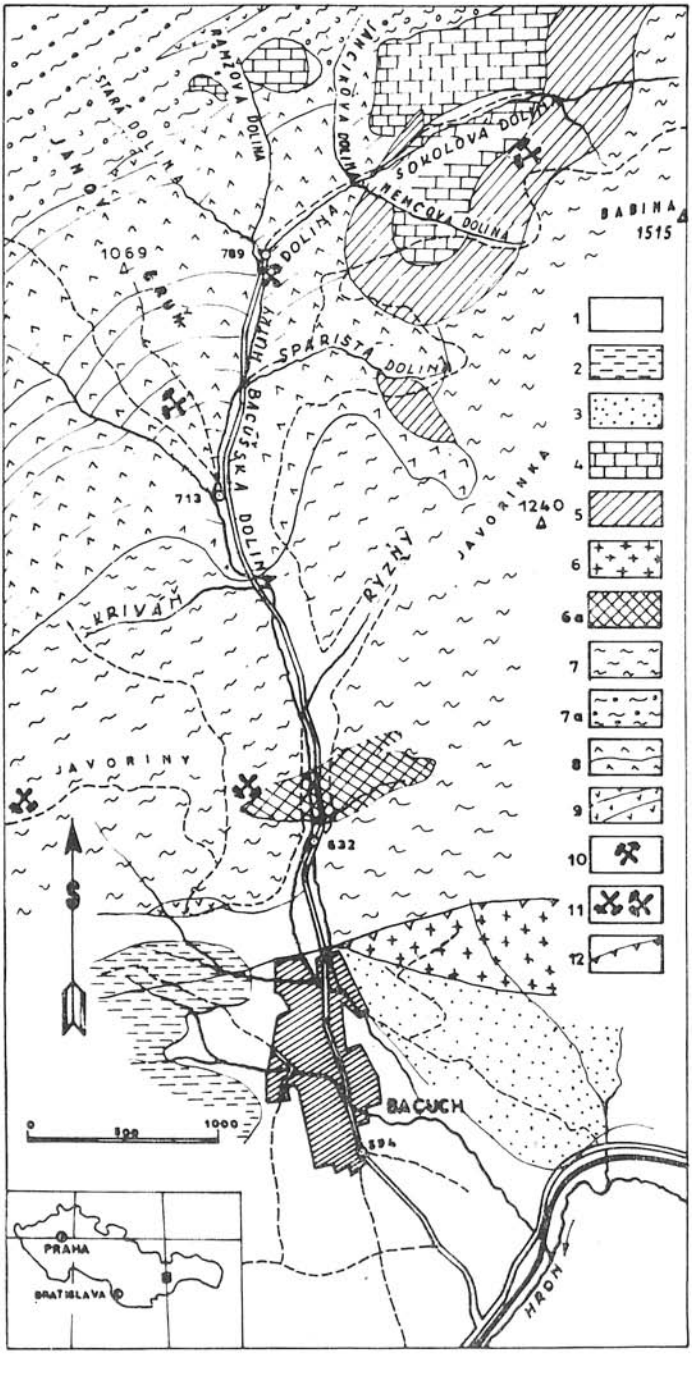
Fig. 1. Geological map of the Hron Complex in the environ of Bacúch in the Nízke Tatry Mts. After A. Klinec, 1975. 1 — alluvium, 2 — talus cônes (Quaternary), 3 — Pliocene, 4 — Paleogene, 5 — Mesozoic (Triassic), 6 — Variscan granitoids, 7 — pegmatites and aplites of Variscan plutonism, 8 — mica-schists to paragneisses, 9 — amphibolites, 10 — porphyroides, 11 — stratiform barites, 12 — Cu and Fe mineralization (old mining works).


STARÁ DOLINA
RAMŽOVÁ DOLINA
JANČIKOVÁ DOLINA
SOKOLOVÁ DOLINA
NEMCOVÁ DOLINA
JANOV
BABINA
1515
1069
GRÚŇ
789
DOLINA
HUTKY
SPÁRISTÁ DOLINA
BACÚŠSKA DOLINA
713
JAVORINKA
1240
RYŽNÝ
KRIVÁŇ
JAVORINY
632
S
BACÚCH
594
0
500
1000
HRON
PRAHA
BRATISLAVA
1
2
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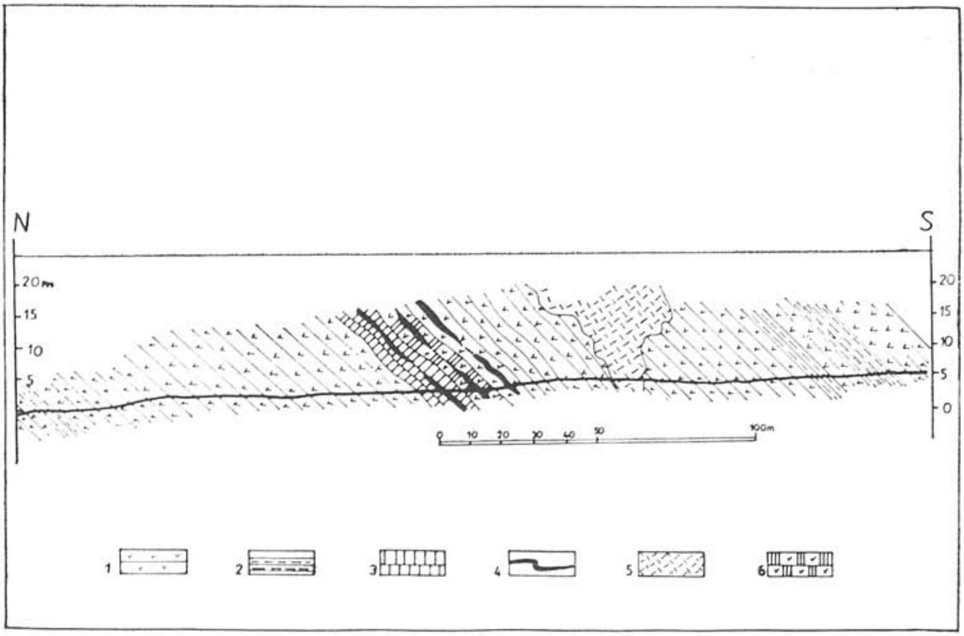

Fig. 2. Bacúch — Hutky valley. Outcrops of the Hron Complex of the Varied series with barite layers. Ján I l a v s k ý. 1 — schistose porphyroids, 2 — dark schists (biotite mica-schist), 3 — black tourmaline-bearing rocks, 4 — barite layers, 5 — Quaternary deposits (debris), 6 — tourmaline-quartzose rocks.

The barite layers display a rhythmic structure of mm to cm order, which is emphasized by different colouring of the mineral: withe, pink, beige, brown to black. These stripes change facially within very small distances.

Indications of graded bedding are seen in the marginal parts of the barite stripes (at their lower side), where the quartz admixture is increased and the grain-size of quartz greater (0,1—0,2 mm). Inwards the barite layers the quartz admixture decreases and the grain size of barite is finer (0,05—0,1 mm).

The changes in barite colour in the fine- rhytmic stripes, are caused by its different grain-size, and by the different admixtures in the matrix, particularly of Fe-minerals (siderite, limonite), quartz and micas.

The barite is very fine-grained (,0,01—0,1 mm) to fine-grained (0,1—0,2 mm) (Fig. 6). Barite crystalloblasts (0,2—0,5 mm) appear occasionnally in the fine-grained barite mass (Fig. 7).

The microscopic examination suggests that the grain-size of barite is controlled by the amount and character of the biotite, quartz and pyrite admixtures.

The essential minerals of the barite layers are barite, quartz, Fe carbonates altered to limonite). Biotite, muscovite and tourmaline are subordinate admixtures, and sphene, rutile, amphibole, arsenopyrite, pyrite, chalcopyrite, tetrahedrite, sphalerite and covellite, chalcocite are accessories.

Barite is the principal and most widespared mineral of the ore beds. It occurs in granoblastic to porphyroblastic textures (Fig. 6) and rarely forms large metacrysts in a fine-grained granoblastic mass (Fig. 7). The grains are usually euhedral, isometric or elongated in the direction of the rock schistosity (Fig. 6). The stratified character of barite grains is prominent even at the high magnification on the scannig electron microscope (Fig. 8). The minerals occasionally occurs in mosaic textures as isometric and euhedral grains, whose shape recalls a pentagonal dodecahedron (Fig. 9). Under the microscope, the barite is white to greyish in colour. In many cases pores and pits of oval, rounded, irregular, lenticular and other shapes are seen on the grain surfaces. Such pores on crystal faces of barite are also observable on the scanning microscope micrographs (Fig. 10). The pores are either empty (Fig. 11) or filled with minute barite crystals (Fig. 12) or with dendritic crystals resembling aragonite (Fig. 13). These pores may be caused either by the defects in the crystal lattice or by washing away of the easily soluble mineral inclusions during recrystallization and metamorphism (calcite, gypsum, halite and others).

The barite grains are aligned in the direction of schistosity, which is due to metamorphic recrystallization. The crystals show a uniform optical orientation and a uniform extinction and many grains, especially metacrysts, several directions of undulosity (Fig. 7). Scanning microscopic examination at higher magnification has revealed fossilized spores of Dictyotriletes sp. (Richardson J. B., 1969) in the barite crystals (Fig. 14, 15). According to E. Planderová (personal communication) this Devonian form is iden-

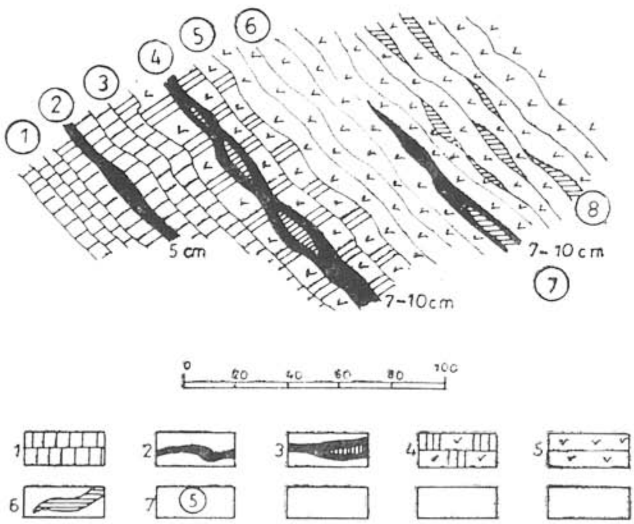

Fig. 3. Bacúch— Hutky valley. Detailed sketch of the Hron Complex and its Varied series, with layers of tourmalinic rocks and barites. The sampling localities are shown schematically. Ján Ilavský. 1 — black tourmalinic rocks, 2 — -barite layers, 3 — limonite seam in barite, 4 — quartz-tourmalinic rocks, 5 — porphyroids, 6 — quartz lenses in barite or porphyroids, 7 — number of samples.

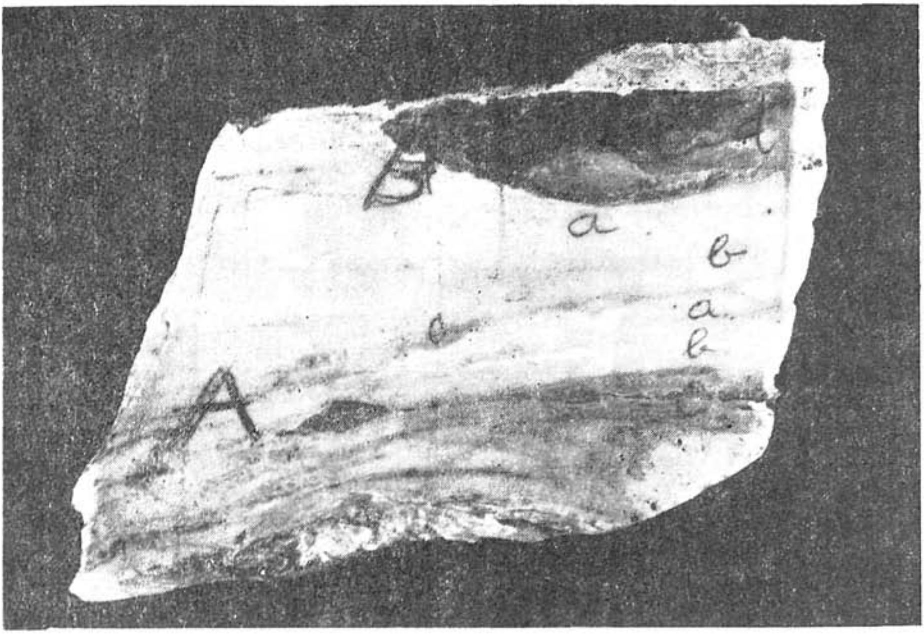

Fig. 4. Bacúch — Hutky valley. Macrostructures of barite layers. A — barite layers with limonite admixture, B — quartz-tourmalinic layers, a — white: fine-grained barite, b — fine-grained pinkish-violet barite, c — brown granular barite with abundant limonite admixture, d. -quartz layer limonite and sulphides.

tical with those found in the tourmaline-quartzose rocks of the monotonous and varied series of the Hron Complex in this area (A. Klinec — O. Miko E. Planderová, 1975).

This find confirms a syngenetic, i. e. sedimentary mode of barite origin and its association with the Hron Complex, in which Dictyotriletes occurs fairly abundantly both in the tourmaline-quartzose and mica-schist-phyllitic rocks.

Barites of the Kremikovci

Barite is widely distributed on the Bulgarian deposit Kremikovci, which is situated in the West Balkan structural-metallogenic zone. The Kremikovci deposit is the most important iron-ore in Bulgaria. After R. Dokov — M. Stajkov — G. Kanurov (1977) it is of the hydrothermal-metasomatic type. Mangano-siderite, hematite, barite and ankerite are essential minerals, pyrite and galena are subsidiary components. The oxidation zone consists of limonite, which represent 70 % of the total deposit content.

For detailed information about geology, mineralogy, chemistry and petrography of the country rocks see the paper of I. Iovčev (1961) and V. Panajotov (1974).

The stratiform deposit is located in a Triassic carbonate series thrust as a mappe over the Upper Jurassic complex. At the base of the ore bearing

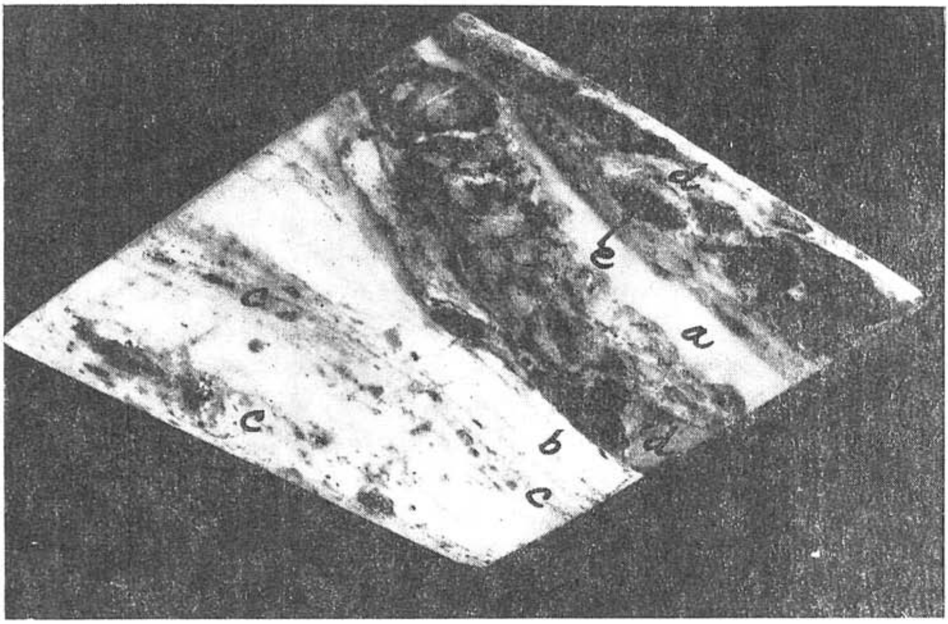

Fig. 5. Bacúch — Hutky valley. Macrostructures of barite-quartz leyers. a — withe: massive barite, b — beige-violet barite, c — bands of brown barite with limonite stripes, d — quartz bands with seams and lenses of tourmaline and limonite, e — tourmaline lenses in quartz bands.

formation there is siderite containing thin barite layers which is overlain by several hematite layers and these in turn by barites with thin siderite beds. The ores are banded or massive and their grain size changes from bed to bed, showing a rhythmic character. The ore are coarse-grained of massive, occasionnally even brecciated with ore aggregates scattered in the gangue.

In the siderite mass, which is highly limonitized in the surficial layers, barites form irregular aggregates, nests and lenses parallel to the stratification of the deposit. The barite parts of the deposit show a porphyritic structure, with barite forming the matrix and limonite with pyrite the galls.

In samples studied two barites generations have been distinguished. Barite I forms elongated or isometric grains in limonite. Barite II constitutes a coarse-grained mass (grain-size 2 mm and more). The grain are tabular, highly undulatory, usually in two directions trending diagonally to each other, one of which is parallel to the longer dimension of crystals. A number of barite crystals show a fanwise type of extinction and undulosity.

Micas of sericite-muscovite type form minute grains and aggregates in barite. They are present in accessory amounts.

Barites from Milos Island

The barite deposits on the Greek Island Milos in the Aegean Sea are of volconogenic type. They are located in a complex of Upper Pliocene dacites

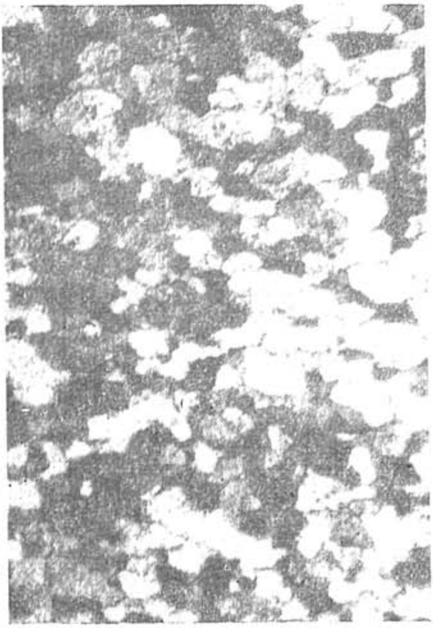

Fig. 6. Bacúch — Hutky valley. Thin section 1746/76. Isometric or elongated grains of granoblastic barite (white to grey). Their shapes and extinction indicate blastesis in two diagonal directions. Crossed nicols, X 25.

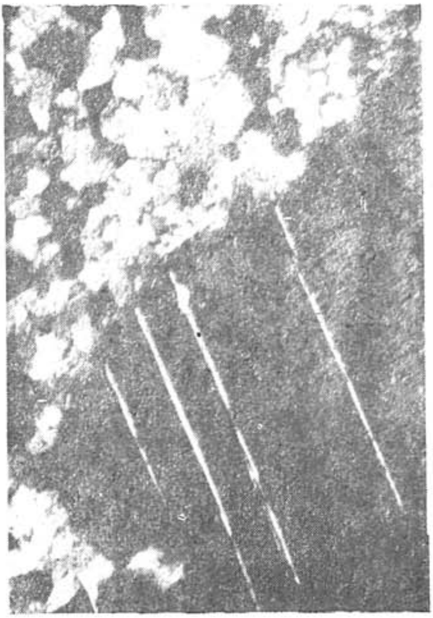

Fig. 7. Bacúch — Hutky valley. Thin section 1746/76. Barite crystaloblasts in the mass of fine-grained granoblastic barite. Large crystallobalasts extinct in two diagonal directions. Fine-grained barite shows a different direction of extinction. Crossed nicols, X 25.

and andesits, forming concordant bodies 10 to 30 m thick. In places beds of manganese ore form the base of the barite bodies (Ktenas C. 1911; Sonder R., 1962).

Barites are usually fine-grained, grey to dark-coloured. The lighter coloured barites are coarser-grained. In the vicinity of barites, the volcanic rocks contain frequent vein of coarse-grained barite (Cordellas A. 1892).

The barite bodies show a bedded structure. At the base, the barite is fine--grained, grey to dark-coloured, strangly siliceous, locally brecciated. The mineral of this type has 50 to 80 % $BaSO_4$. The barite layers are generally underlain by volcanic tuffs with abundant crystals of barite of a dimensionation character (Stiotis G., 1936). In the upward direction barite preserves its fine grain size but it becomes white, porous and the $BaSO_4$ content rise to 95 %.

Barite and the volcanic country rocks contain finely dispersed sulphidic minerals with silver, and especially galena contents (Voreadis G. — Mourabas T., 1935). Other mienerals comprise opat, spahlerite, pyrite, chalcopyrite, argentite, in places cerargyrite and native sulphur.

The underlying tuffites underwent the most intensive alternation of all rocks, particularly kaolinization, argillization and silicification. The genesis

Fig. 8. Bacúch — Hutky valley. Scanning electron micrograph of a cleavage plane of pure barite with a prominent parallel stratification. X 15.000.

Fig. 9. Bacúch — Hutky valley. Monomineral white barite in scanning electron microscope. The euhedral character of barites is marked X 15.000.

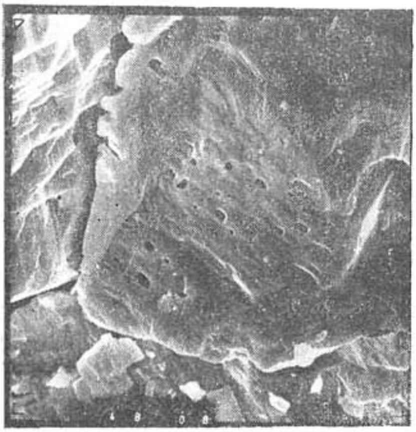

Fig. 10. Bacúch — Hutky valley. Scanning electron micrograph of a barite crystal lattice, to metamorphism of to the solution of some chemical compounds. Pressure grooves seen on the crystal face. X. 1.250.

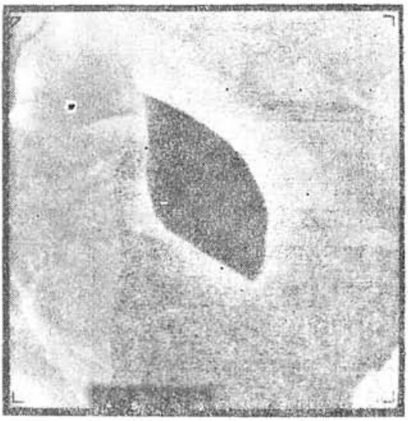

Fig. 11. Bacúch — Hutky valley. A hollow pore on the barite crystal face, magnified 15.000 x̄.

of barites is thought to be associated with the hydrothermal phase of volcanic activity, and the metasomatism played doubtless a great role in the formation of the deposit (Liatsikas N., 1955).

The analytical results show that all barites contain quartz as a most common admixtures. The analyses of Bacúch barite have revealed that the quartz amount increase upwards from the basal layers, which corresponds with macroscopic observation. In the contrast, barite is more abudant where quartz is of least amount.

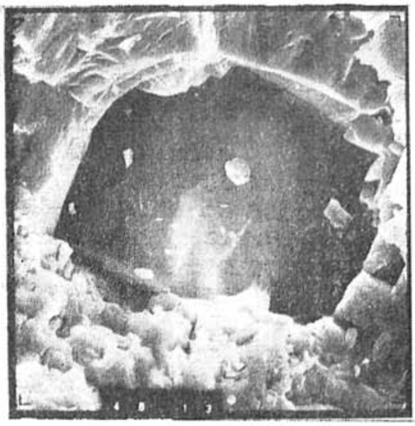

Fig. 12. Bacúch — Hutky valley. Some pores in barite are filled with sporadic crystals of the younger barite II. Scanning electron micrograph. X 25.000.

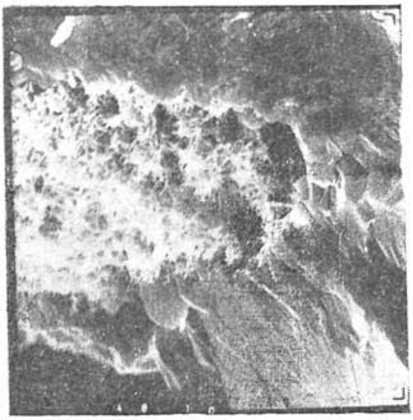

Fig. 13. Bacúch — Hutky valley. Some pores on the crystal face of barite are filled with fine-grained acicular-fibrous mineral of aragonite or stroncianite(?) type. X 15.000.

Fig. 14. Bacúch — Hutky valley. Microcrystalline barite contains a colony of five oval egg-shaped forms of Devonian spore Cf. Dictyotriletes (Richardson, 1969). X 1.250.

Fig. 15. Bacúch — Hutky valley. The same image as in fig. 16 at magnification X 4.500. The spores of Dictyotriletes sp. on the surface are tuberculate or to spiny, and the interor structure ist not homogenous.

The Fe contents coincide to a certain degree with quartz. At Bacúch they also increase upwards from the base. They are linked up with the sulphidic and carbonate minerals, which were identified also in the polished sections.

A certain parallelism of Mn contents with Fe contents indicate that Mn is associated with iron-carbonates. The same is valid for Ca contents.

Contents of Al, Mg, Na and K are obviously associated with the admixtures of rock-forming minerals such as biotite, muscovite or amphibole. The Cr,

Table 1
Chemical composition of barites

Compound	1	2	3	4	5	6
SiO_2	0,78%	0,97	5.19	23.16	0.95	0
Ba	56,73	49,34	41,37	40.40	51.87	56.03
Fe	0,36	0,40	2.15	1.68	0.03	0.03
Mn	0,09	0,09	0.37	0.15	0.0016	0.027
Ca	0,06	0,05	0.12	—	0.005	0.01
Cu	0,003	0,004	0.022	0.003	0.0006	0.316
Pb	0,002	0,003	0.003	—	0.035	0.123
Zn	0,001	0,004	0.003	0.006	0.014	0.002
Sb	—	—	—	—	0.003	—
Hg	—	—	—	—	—	0.02
Ag	—	—	—	—	0.005	0.005
Ni	—	0.05	—	—	—	—
Sr	0,56	0,84	2.10	0.68	0.88	1.02
SO_4	40,42	39,85	31.85	28.35	40.71	40.80

All samples contain same amounts of Al,K,Na,Mg,Cr and Ti too.

Samples and their localizations: 1 — Bacúch Nr. 2, 2 — Bacúch, Nr. 4, 3 — Bacúch Nr. 7, 4 — Bacúch (O. Miko), 5 — Bulgaria—Kremikovci, 6 — Greece—Milos.

Table 2

Number of sample	Author	Departure in per mill	Locality
1600	O. Miko	+ 24.4	Bacúch — Hutky valley
1643	J. Ilavský-4	+ 25.6	Bacúch — lower layer
1644	J. Ilavský-7	+ 25.5	Bacúch — upper layer

Table 3

Number of sample	Author	Departure per mill	Mineral
942/ S	Anastopoulos	+ 21.4 to 21.76	barite
942 a/S	Koukouzas	— 18.26—22.63	galena

Ti and Ni may be also placed in this group. They are likewise associated with micas, amphiboles etc..

The contents of metallic elements: Pb, Zn and Cu reach only several thousandths to hundredths of one % in all samples. Higher contents are only in barite from Milos Island ,where sulphides of these elements occur in larger amounts, as well as the contents of Ag, which was mined on the island. in the past. Silver is present even on Kremikovci deposit in Bulgaria, but it has not been identified on the Bacúch deposit.

The strontium contents in barites vary between 0,5 % and 2,1 %. At the Bacúch locality they increase from the base upwards from 0,56 to 3,1 %.

The average Sr amount in this deposit range about 1,04 %. On the Kremikovci deposit the strontium amount is 0,88 % and on Milos Islands about 1,02 %.

The strontium contents in barites from Bacúch (of Paleozoic age), from Kremikovci (of Mesozoic age) and from Milos (of Tertiary age) show that they are of the same order of magnitude although the mineralizations differ greatly in age. The scheme proposed by C.. D. Werner (1958) is not valid in this case for all three localities, but it is valid for one locality only (see Bacúch, table 1.).

The elements of antimony and mercury have not been determined (or fined) at the Bacúch locality. Although antimony occurs at Kremikovci and mercury on the Milos Islands. It may be inferred from this finding that Sb and Hg are absent from the old metamorphised deposits, but occur on the young-or metamorphosed- ones.

Isotopes of sulphur from the barites

The sulphur from the barites whose mineralogical and geochemical composition have been studied, was examined as to its isotopic composition. The results of isotopic analyses of three samples from the Bacúch locality are listed below in per-mill departures from the standards (tables 2, 3).

As is seen, that the isotopic composition of sulphur from the Bacúch barites is homogenous. It is characterized by the enrichement in the isotopes of heavy sulphur, which is encountred in many mineralizations in the western part of the Nízke Tatry Mts. (localities of Staré Hory, Baláže, Ráztočno, Nová Maša etc.). The influence of the synchronous porphyric volcanism is evident, particularly as concerns the origin of barium and sulphur.

Thermoluminiscences has been studied on two barites. It is of medium (the peak area 43 cm^2) to extremely high intensity (221 cm^2). The latter value is a result of barite contact with a higher-radioactive environment. The higher radioactivity was likely caused by the effusions of porphyric and tourmalinic rocks.

The sulphur isotopes have been studied also in the barites and galenas samples from Milos Island (Greece). The number of analyses is small (only one analyse of each sample) and the results should therefore be regarded only as informative (table 3).

As seen, the sulphur from the Milos Islands barites is also of homogenous isotopic composition, which approaches that determined in Bacúch barites. This is obviously due to a related genetic type of the two minerals. The two localities represent a type of volcanogenic barites, depending on the synchronous acid to intermediate volcanism.

On the contrary, the isotopic composition of sulphur from the galena of Milos is essentially different, most probably because of a different paragenetic and chronological position of galena relative to barite. The predominance of light sulphur isotopes in galena may be due, e.g. to the fractionation and enrichement of solutions in light sulphur from the sea-water, or of the contamination by biological sulphur, which is a frequent phenomenon in ore forming processes.

Isotopic analyses have not been made on the barite samples from the Kremikovci locality (Bulgaria), since they are so intensitely intergrown with the carbonates, sulphides and oxides of Fe.

Genetic conditions of barite origine

The studies performed on the barites from Bacúch, from Bulgarian deposit Kremikovci and from Greek deposit on Milos Island allow the following general conclusions to be drawn:

— Barites of all these localities are stratiform and make up concordant bedded bodies in the country rocks of different age.
— The barite from Bacúch yielded *Dictiotriletes* spores (Richardson J. B., 1969) of Devonian age, i.e. synchronous with the country rocks. This age also corresponds to that of Pb isotopes of galenas from some sulphidic deposits in the Nízke Tatry Mts. (Kantor J. — Rybár M., 1964).

The fossil finds of similar type have been described from the Meggen deposit of stratiform barite in the Federal Republic of Germany by Zimmermann R. A. — Amstutz G. C. (1971) and by Plumer L. N. (1971) from the U.S.A.

The Devonian age of stratiform barites from Bacúch coincide with the most important barite-bearing epoch in Europe and North America. Major deposits of this type are known from Arkansas, Nevada, Mississippi States, from Rammelsberg and Meggen in Germany, from Ireland etc.

— The interior structure of barite layers at the Bacúch locality is distinguished by rhythmic alteration of sulphide, carbonate, sulphate and oxidic bands. A similar structure with bands analogous composition has been most recently described by R. A. Zimmermann (1969, 1976), J. V. Mills et al. (1971) and many others from the stratiform barite deposits or occurrences in the USA, Canada and Europe.
— The rhythmicity of the barite layers shows facial changes in the horizontal direction and indications of graded bedding of the same types as was described from many stratiform deposits by R. A. Zimmermann, G. C. Amstutz et al. (1964, 1971).
— The sulphide-sulphate rhythmites are distinguished by an asymetric vertical zoning. At the base precipiated as the oldest mineral pyrite, higher up chalcopyrite, which was followed by sphalerite and still higher by galena. The youngest and spatially uppermost is barite, which makes up separate rhythmites. R. A. Zimmermann (1969) described a similar pattern from the barite deposits in the USA and Europe, and P. Gilmour (1976) from Canada, Germany and Ireland.
— The mineral composition of the barite layers from Bacúch and other localities studied is the same, irrespective of their age. The essential mineral is invariably barite, and limonite, quartz, pyrite, carbonates are admixtures. Galena, sphalerite, chalcopyrite and tetrahedrite are accessory minerals. Rare or accessory minerals are biotite, arsenopyrite, amphibole and sphene-rutile. Native sulphur occur only at the Milos Island.
— The barite localities described by the authors cited above have an analogous chemical composition. The chemistry of the barites examined is roughly identical, with strontium contents within the 0,5—2,1 % range. Other components are the same at all localities, being represented

only by hundredths to thousandths of one per cent, which corresponds to the microscopic image of the samples.

The small thickness of barite layers did not allow to study the changes in Sr contents in more detail, as it was examined by R. A. Zimmerman (1976) on many North American deposits. At the Bacúch deposit, the increase of strontium towards the higher lying barites layers has been observed, consistently with the observations of R. A. Zimmerman (1976), R. Starke (1964), P. V. Čuchrov — L. P. Jermilova (1970) etc.

In the sense of Zimmermann (1976) the Sr contents in the barites, which was studied, may be denoted as medium. This author believes the main cause of the different Sr contents in barites to be the velocity of its precipitation from the solution: the longer they were precipitated, the smaller are their contents, and vice versa.

Another factor controlling the Sr amounts in barites is the salinity of sea water (Turekian K. K. — Wedepohl K. H., 1961; Wedepohl K. H., 1969; R. Starke, 1964; G. Strübel, 1967; Church T. M., 1970, Plumer L. N., 1971; K. Fisher — H. Puchelt, 1969, 1972; Boström K. et al., 1973; Renfro A, R., 1974, and others.). At the high salinity of sea water the Sr contents in barites are low, whilst they are high where the salt contents was low (e.g. under estuarian conditions).

At the Bacúch locality, the contents of SiO_2, Fe, Mn, Ca also increase in upward direction, which is in agreement with the microscopic image of barites. The elements Sb, Hg, Cu and Ag increase in barite layers towards the younger deposit types. R. A. Zimmermann (1976) revealed the same relations at the deposits of the USA and Canada.

— At all the localities studied the barites are located in the volcanogenic-sedimentary formations containing porphyroids and tourmalinities (Bacúch), or diabases (Kremikovci), or andesites to dacites (Milos). A. C. Dunham — J. S. Hanor (1967) pointed out the importance of the relationship between Ba and K (orthoclase, microcline etc) under these circumstances.

— At the localities that were affected by metamorphism (Bacúch, Kremikovci) the barites shows a prominent undulosity and extinction in two or even three directions. In some cases it is possible to recognize the time sequences and intensity of the individual planes of extinction, which according to F. M. Vokes (1968) and A. M. Mookerjee (1976) makes it possible to assess the progressive or retrograde type of the successive metamorphic phases.

Barites that suffered metamorphism do not contain antimony and mercury. These, however, occur in the barites of the younger formations (Kremikovci, Milos).

— The sulphur isotopes in barites of various regions show identical values in the stratiform deposits and in the epigenetic veins as well in case they occur in these region. In such cases the genesis of epigenetic barite veins is accounted for by the remobilization from the older stratiform mineralizations. These instance have been registered by G. Anger et al. (1960) from Rammelsberg and by A. C. Dunham —

J. S. Hanor (1967) from the barite deposits of Nevada, Idaho, Washington and elsewhere.

From this point of view it is remarkable that the sulphur isotopes from the barites of different types in the Nízke Tatry Mts. (J. Kantor — J. Ďurkovičová, 1977) show the same composition regardless of their occurrences in barites of the siderite, siderite-polymetallic, polymetalic or antimonite veins.

From the above it may be concluded that in all barite types described from Nízke Tatry Mts. the origin of barite could be common. The primary occurrences were the stratiform, sedimentary-volcanogenic barites in Lower Paleozoic (Devonian). Through metamorphism and mobilization and or remobilization repeated in several epochs barite was removed from stratiform deposite into hydrothermal veins associated with different ore formations.

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REFERENCES

ANASTOPOULOS, J. — KOUKOUZAS, C., 1970: Metallogeny of Greece. Manuscript. Institut for Geological and Subsurface Research, Athenes, p. 175.

ANGER, G. — NIELSEN, H. — PUCHELT, H. — RICKE, W., 1966: Sulphur isotopes in the Rammelsberg ore deposit (Germany) Econom. Geology (Lancaster), 61, p. 159—174.

BOSTRÖM, K. — JOENSUU, O. — MOORE, C. — BOSTRÖM, B. — DALZIEL, M. — HOROWITZ, A., 1973: Geochemistry of baryum in pelagic sediments. Lithos, (Oslo), 6, p. 159—174.

CHURCH, T. M., 1970: Marine barites. Ph.Dr. Thesis, University of Caligor. San Diego.

CORDELLAS, A., 1892: On the Silver ores of Milos and their metallurgy. (in greek). Athenes.

ČUCHROV, F. V. — JERMILOVA, L. P., 1970: Zur Schwefel-Isotopen-Zusammensetzung in Konkretionen. Berliner Deutsch. Gesell. Geol., Reihe B. (Berlin), 15, p. 255—267.

DOKOV, R. —STAIKOV, M. — KANURKOV, G., 1976: Apèeçu sur les formations ferriféres en Bulgarie. Iron Ore Deposits of Europe, Tom I, Hannover, p. 101—105.

DUNHAM, A. C. — HANOR, J. S., 1967: Controls on barite mineralization in the Western United States. Econ. Geol. (Lancaster), 62, p. 82—94.

FISCHER, K. — PUCHELT, H., 1969—1972: Barium. Handbook of Geochemistry, Springer, Berlin—Heidelberg—New York, II/4, p. 56.A—56.0

GILMOUR, P., 1976: Some transitional types of mineral deposits in volcanic and sedimentary rocks. Handbook of strata-bound and stratif. ore deposits, I., p. 111—160.

IOVČEV, I., 1961: Poľezni iskopajemi na Narodne Respublike Bulgarii. Černi metali (bulg., engl., russ.) Technika, (Sofija), p. 146.

KANTOR, J. — RYBÁR, M., 1964: Isotopes of ore lead from several deposits of west-carpathian Cristalline. Geol. Zbor. SAV, (Bratislava), Nr. 2, p. 285—298.

KANTOR, J. — ĎURKOVIČOVÁ, J., 1977: Izotopy síry v barytoch rudných ložísk a výskytov Západných Karpát. (Sulphur isotopes in barites from some ore deposits and occurrences of West Carpathians) ,Manuscript-Rapport final, GUDŠ, Bratislava.

KLINEC, A., 1966: K problému stavby a vzniku veporského kryštalinika. (Zum Problem des Baues und der Entstehung des Vepor-Krystallins). Sbor. geolog. vied Západné Karpaty, (Bratislava), Sv. 6, p. 7—28.

KLINEC, A., 1973: Je vo veporskom kryštaliniku zastúpené paleozoikum? (Ist im Veporikum-Krystallin auch das Paläozoikum verträttet?) Geol. Práce, Zprávy, (Bratislava), 60, p. 121—128.

KLINEC, A. — MIKO, O. — PLANDEROVÁ, E., 1975: Staropaleozický vek hronského komplexu veporíd (Altpaläozoisches Alter des Hron-Komplexes in den Veporiden). Geologické práce, Správy (Bratislava), 63, p. 95—104.

KANTOR, J. — KLINEC, A. — RYBÁR, M., 1971: Sulphur isotopes of the metamorphosed Pyrrhotite-Pyrite Deposit of Heľpa, Nízke Tatry Mts., Czechoslovakia. Geol. Zbor. — Geol. carpath. (Bratislava), 22, 2, p. 261—280.
KTENAS, C., 1911: The barytes of Milos Island. (in greek). Archimidis, Athénes, 12, p. 124—126.
LIATSIKAS, N., 1955: Geology of some useful minerals of Milos Island (in greek). Geolog. Recoon. IGSR, Athénes, 20, p. 30.
MIKO, O. — HOVORKA, D., 1978: Krenito-turmalinické horniny veporidného kryštalinika Nízkych Tatier (Quartz-tourmalinic rocks of the Veporide Crystalline Complexe in the Nízke Tatry Mts. Západné Karpaty, séria Min. Petr. Geoch. Metalogen (Bratislava), 5, p. 7—28.)
MILLS, J. W. — CARLSON, C. L. — FEWKES, R. H. — HANDLEN, L. N. — JAYPRIKAS, G. P. — JOHN, M. A. — MORGANTI, J. M. — NEITZEL, T. W. — REAM, L. R. — SANFORD, S. S. — TODD, S. G., 1971: Bedded barite deposits of Steven County, Washington. Econ. Geol. (Lancaster), 66, 8, p. 1157—1163.
MOOKERJEE, A., 1976: Ores and metamorphism: temporal and genetic relationship. Handbook of strata-bound and stratiform ore deposits. Elsevier, Amsterdam, 4, 5, p. 203—260.
PANAJOTOV, V., 1974: The Kremikovci iron deposit. 4. Sympos. IAGOD, Varna. Tvelve ore depos. of Bulgaria, Sofia, p. 257—266.
PLUMER, L. N., 1971: Barite deposition in Central Kentucky. Econ. Geol. (Lancaster), 66, p. 252—258.
RENFRO, A. R., 1974: Genesis of evaporite-associated stratiform metalliferous deposits Sabkha process. Econ. Geol. (Lancaster), 69, p. 33—45.
RICHARDSON, J. B. — Lister, T. R., 1969: Upper Silurian and Lower Devonian spore assemblages from the Wels Borderland and South Wales. Paleontology (London), 12, 2, p. 37—43.
SONDER, R., 1925: Zur Geologie und Petrographie der Inselgruppe von Milos. Zeitschr. f. Vulkanologie, Berlin, T.S.H.4, p. 181—229.
STARKE, R., 1964: Die Strontiumgehalte der Baryte. Freiberger Forschungshefte, (Freiberg), 150, p. 86.
STIOTIS, G. I., 1936: The barite deposits of Greece. Sands, Clays and Minerals (Oxunits of the Earth Crust. Geolog. Soc. Amer. Bull. (New York), 72, p. 175.
VOKES, F. M., 1968: Regional metamorphism of the paleozoic geosinclinal sulphide ore deposits of Norway. Transl. Inst. Mineral. Metallurg. (London), 77, B.53—B.59.
VOREADIS, G., — MOURBAS, Th., 1935: The silver ores of Milos (in greek), Publ. of Geol. Surv. of Greece, (Athenes), 22, p. 54.
WEDEPOHL, K. H., 1969: Composition and abundance of common igneous rocks. Handbook of geochemistry, Springer, Berlin—Heidelberg, I. p. 227—249.
WEDEPOHL, K. H., 1969: Composition and abundance of common sedimentary rocks. Handbook of Geochem., Springer, Berlin—Heidelber, I, p. 250—271.
WERNER, C. D., 1958: Geochemie und Paragenese der saxonischen Schwerspat-Flussspat-Gänge in Schmalkaldenen Revier. Freiberg Forschungshefte, (Freiberg), 47.
ZIMMERMANN, R. A. — AMSTUTZ, G. C. ,1964: Small scale sedimentary features in the Arkansas barite district. Develop. in Sedimentology, Sedimentation and Ore genesis, Elsevier, Amsterdam—New York, 2.
ZIMMERMANN, R. A., 1969: Stratabound barite deposits in Nevada. Mineralium Deposita, (Berlin—Heidelberg, 4, p. 401—409.
ZIMMERMANN, R. A. — AMSTUTZ, G. C., 1971: The Meggen Pyrite—Barite-Deposit, VIII. Internat. Sedimentol. Congr., Heidelberg, p. 254—261.
ZIMMERMAN, R. A., 1976: Rhythmicity of barite-schales and of Sr in stratabound deposits of Arkansas. Handbook of strata-bound and stratif. ore deposits, Elsevier, 8, p. 339—353.

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