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ORE MINERALS FROM THE KEY SECTION OF THE BAKSA COMPLEX (W BARANYA HILLS, HUNGARY)

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ABSTRACT

This paper is a documentation-like presentation of the study and description of ore minerals found in the geological key borehole Baksa 2. The ore minerals can be divided into two genetic groups by the studies. The lateral secretion phase can be regarded to be monophase represented by ilmenite. The other phase is formed by ore minerals coming from hydrothermal activity. These minerals are partly disseminated, and partly occur in veins. According to ore microscopic studies, the ore mineral paragenesis of the hydrothermal phase are the following: pyrite, marcasite, pyrrhotine, sphalerite, chalcopyrite, galena, pentlandite, hematite, covellite. The most significant ore indication of the borehole can be found at the depth of 186.4 m. It is a massive sulphide vein of 7 cm thickness with an independent mineral paragenesis formed by pyrite, marcasite, sphalerite, pyrrhotine, chalcopyrite and galena. On the basis of the exposed ore mineral paragenesis and the performed studies, the possibility of a perspective ore exploration can seriously arise.

INTRODUCTION

In 1978/79 a geological key borehole was drilled near Baksa village in the frame Hungarian Palaeozoic Key Section Research program organised by the Hungarian Geological Survey (Fig. 1). The borehole, which produced core sample along its total length, reached 1200 m depth, and exposed the metamorphic formations of the Baksa Complex forming the basement of the West Baranya Hills in a thickness of 1143 m. Complex geological and geochemical study of the obtained rock samples was performed by leadership of the Attila József University in 1979 (SZEDERKÉNYI, 1979). This borehole is regarded as the key section of the Baksa Complex.

Metamorphic rocks are dominant in the exposed formations. Major part of the borehole is represented by mica-schist and gneiss, while a minor part is formed by metamorphic carbonates, hornblende-schist, amphibolite and aplitic rocks. The pre-metamorphic sequence of the rock column is dominated by pelitic-psammitic (argillite-greywacke) rocks which suffered polymetamorphism (SZEDERKÉNYI, 1977). Preliminary ore microscopic study on the core samples of the borehole Baksa 2 showed that the exposed formations contained ore indications formed by hydrothermal activity (GRASSELLY, 1979). Their detailed mineralogical and genetic study was performed by the author in the Department of Mineralogy, Geochemistry and Petrology of the Attila József University in 1995/96 (TARNAI, 1996).

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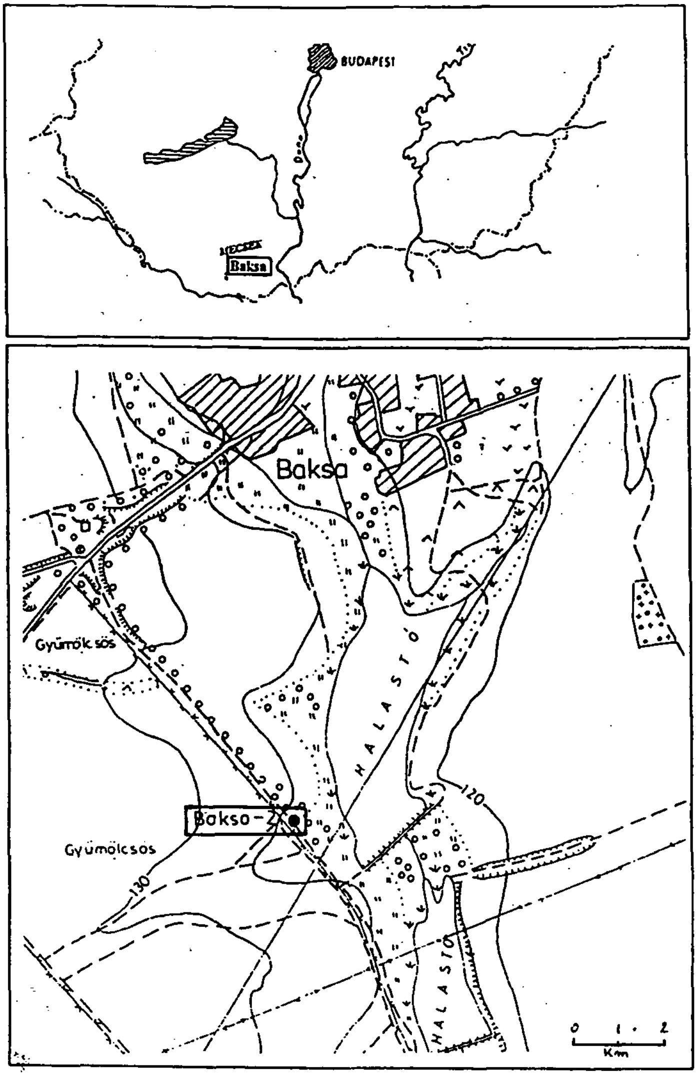

Figure 1: Location map of the borehole Baksa 2.

CHARACTERISATION OF THE BAKSA COMPLEX

The Baksa Complex – Görcsöny Crystalline-schist Formation (FÜLÖP, 1994) – is situated in the central part of the western third of the Tisza Unit (Tisia Composite Terrane) extending to south of the Central Hungarian Lineament, between the Mecsek and the Villány Subunits (Fig. 2). Information on its situation, subsurface extension, facies of its uppermost part as well as on the overlying formations comes from geophysical measurements, water prospect holes and geophysical control drillings (VADÁSZ, 1960;

JÁMBOR, 1962; BARABÁS et al., 1964; RAVASZNÉ BARANYAI, 1969; SZEDERKÉNYI, 1974, 1976, 1977, 1983; VÁRSZEGI, 1978; JANTSKY, 1974, 1979; ÁRKAI, 1984; SZEDERKÉNYI et al., 1991; KOVÁCS et al., 1996). According to the above mentioned studies the overlying beds are formed by Tertiary (mainly Upper Pannonian), Pleistocene and Holocene sediments. In general, their thickness ranges from 50 to 150 m, and they superposed on the basement by sharp erosional discordance. South of Rózsafa-Pécs, west of Pécs-Szalánta, north of Szalánta-Kisdér and north-east of Kisdér-Rózsafa line, the Palaeozoic basement is formed by the tectonically elevated formations of the Baksa Complex (Fig. 3). Surface outcrop of the rocks of the Complex has not been known anywhere. Morphologically and genetically, it has close relation to the Babócsa Complex (situated south-west of it) built up mainly gneiss and schist, however, there are differences, too, regarding the elevated position and the more varied geological setting of the Baksa Complex. The Baksa Complex is dominantly built up by polymetamorphic rocks, mainly mica-schist and gneiss interbedded by marble, metamorphic lime-silicate, amphibolite and eclogite formations. An interesting geological object of the area is the Gyód Serpentinite Formation situated in the above mentioned rocks. According to Szederkényi (1976) the metamorphic rocks of the Baksa Complex form a Barrovian facies sequence. Line of strike of the formations is NW-SE, they have steep (almost perpendicular) dip, and from south-west to north-east they form complete progressive metamorphic facies series from the chlorite to the sillimanite zone and the granitization.

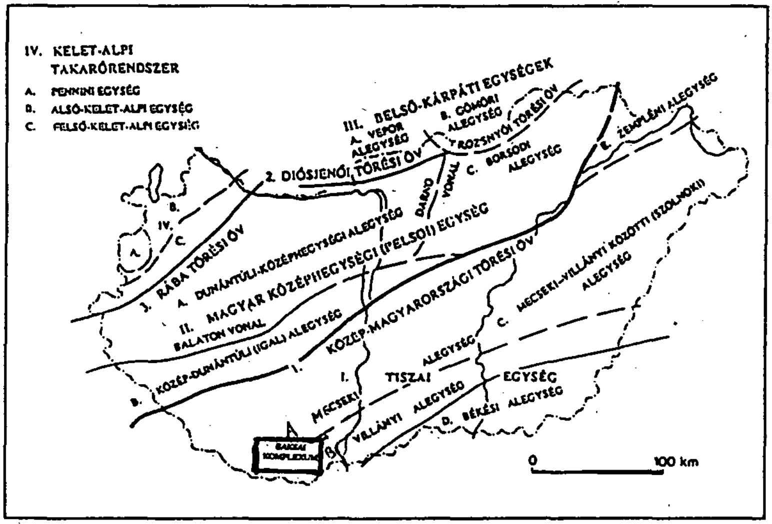

Figure 2: Tectonic units of Hungary (J. FÜLÖP, K. BREZSNYÁNSZKY, J. HAAS, 1989)

DESCRIPTION OF ORE MINERALS OF THE GEOLOGICAL PROSPECT BOREHOLE BAKSA 2

Basis of the research was represented by macroscopic, polarised microscopic and ore microscopic studies which were completed by inclusion, ICP and preliminary RFA analyses, and by re-evaluation of the former chemical analyses. As a result of these studies, these ore minerals can be grouped described by the following way.

Ore minerals of the key borehole Baksa 2 can be divided into two genetic groups. One group is represented by lateral secretional ore minerals, the other is formed by hydrothermal ones. The hydrothermal ore minerals can be disseminated and can occur in veins, too.

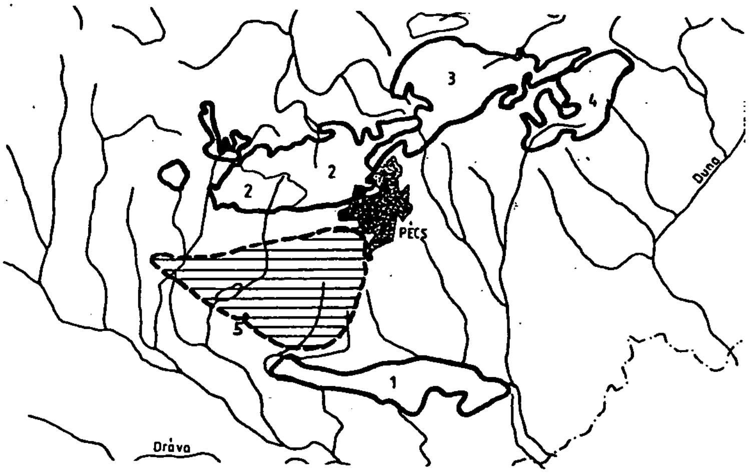

Figure 3: Subsurface extension of the Baksa Complex in the SE Transdanubia.
1. Surface extension of Mesozoic formations of the Villány Mountains; 2. Surface extension of Palaeozoic and Mesozoic formation of the W Mecsek Mountains; 3. Surface extension of Mesozoic formations of the E Mecsek Mountains; 4. Surface extension of the Mórágy Block; 5. Geological key borehole Baksa 2.
Formations of the Baksa Complex covered by Tertiary and Quaternary beds are shown by the shaded area.

THE LATERAL SECRETIONAL ORE PHASE

This phase is a monophase represented by ilmenite. (It can be noted that, regarding the whole rock column, metamorphic segregation could play a role in origin of the disseminated pyrite which can be found in many places. On the basis of the features observed by the studies, however, pyrite can rather be connected to the hydrothermal activity.)

Quantity of the ilmenite is very variable in the exposed rock column. It can be found in the whole borehole but it mainly associates with amphibolite, amphibolite-schist or any amphibolitic rock: in these cases its quantity can be as high as 3–5 %. It also occurs in mica-schist and gneiss, although in a subordinate amount. It is not characteristic, however, in carbonate rocks. In the studied thin sections, orientation of the ilmenite is always parallel to the cleavage planes, and it has elongated shape. Ilmenite is closely packed with the metamorphic minerals, and it never passes or breaks through them (TABLE I/1). Shape of its grains is always xenomorphic, and their size ranges from 150 to 300 μm. In the ore microscope its surface is always smooth and even, and it is grey. It has characteristic and uncommon pleochroism which is similar to that of pyrrhotine to a certain extent. In the 50 % of the samples, ilmenite shows the features of regressive metamorphism, i. e., leucoxenism and titanitization. In many cases, these secondary products surround ilmenite as a cover (TABLE I/2).

HYDROTHERMAL ORE PHASE

The other group of ore minerals of the exposed formations is represented by the hydrothermal phase. These minerals are disseminated or occur in veins (TABLE II/1). In general, thickness of the veins ranges from 0.1 to 1 mm, however, there is a 7 cm thick massive sulphide veins at the depth of 186.4 m. Their occurrence does not relate to characteristic rock, however, there are more veins near the surface. Their ore mineral paragenesis is the following: pyrite, marcasite, sphalerite, chalcopyrite, pyrrhotine, galena, hematite, pentlandite, covellite.

The disseminated pyrite can be found in a lower amount in the formations, however, it is one the major minerals in the veins. Pyrite in veins is mainly characteristic near the surface (TABLE II/2). It occurs together with chalcopyrite in many cases. Its shape can be xenomorphic, hypidiomorphic and idiomorphic, too. Pyrite crystals are bigger in veins (200–600 μm), while the disseminated pyrite grains are smaller (20–50 μm). In general, the pyrite crystals are fresh, their marcasitization is subordinate. The only one exception is the vein at the depth of 186.4 m, where marcasite originating from pyrite and pyrrhotine is one of the major ore mineral constituents (TABLE VIII/2).

Out of the above mentioned vein, marcasite (TABLE III/1) is very rarely. Here and there, it can be found as small grain. In the 7 cm thick vein, however, its amount is 10–15 %. It should be regarded as a secondary mineral because pyrite and pyrrhotine could turn into marcasite.

The disseminated sphalerite can be found very rarely, and it has a lower quantity even in the veins (TABLE III/2). In general, it is inclusion-free and xenomorphic (there is only one sample in which sphalerite is hypidiomorphic). It is associated with chalcopyrite (TABLE IV/1) and hematite (TABLE IV/2). In the ore vein at the depth of 186.4 m, however, its quantity is 24 %, and it contains chalcopyrite-pyrrhotine inclusions of 2–2.5 % (TABLE V/1). Chalcopyrite and pyrrhotine in sphalerite can be regarded as partly demixing, partly epitaxial inclusions (TABLE V/2). In the major part of the vein pyrite is its accompanying ore mineral but in the outer part it is accompanied by chalcopyrite and galena.

Excepting two samples, chalcopyrite is subordinated in the veins. It is associated with sphalerite and galena in the outer phase, mainly in the 7 cm thick vein at 186.4 m (TABLES IV/1 and VI/1). The disseminated chalcopyrite occurs in the form of small rags. Together with pyrrhotine, it can be found very often as inclusion in sphalerite. Displacing each other, its disseminated grains also occur together with pyrrhotine. Chalcopyrite is always xenomorphic, and its characteristic size ranges from 50 to 100 μm.

Galena (TABLES VI/1 and VI/2) occurs only in the 7 cm thick vein, and only in the external ore phase. It is always xenomorphic and disseminated. It is associated with chalcopyrite, sphalerite and pyrite. Its observed maximum size is about 2 mm.

Pyrrhotine can be disseminated ore mineral – in the vein at the depth of 186.4 m it occurs as inclusion of pyrite (TABLE VII/1) and sphalerite (TABLE V/1) –, and forms massive monomineralic ore veinlets (TABLES VII/2 and II/1) in the deeper part of the borehole. Thickness of the biggest veinlet is 1 mm. Pyrrhotine is always xenomorphic. In ore microscope, its surface is uneven and porous. Pentlandite inclusions in pyrrhotine can well be observed at high magnifying (TABLE VIII/1). The disseminated pyrrhotine is frequently associated with chalcopyrite.

Hematite is quite subordinated in the studied samples. It occurs only in two samples from the near surface region. It is the only one non-sulphide, hydrothermal ore mineral in the rock column. It forms thin veins, and lamellar join structure is characteristic for it. Size of a lamella is 15–30 μm. At crossed polars its red reflection is excellently visible. Generally, it is associated with sphalerite (TABLE IV/2).

Pentlandite can be found in pyrrhotine veins at the depth of 900 m of the exposed rock column. It forms small (1–2 μm wide and 20–50 μm long) exsolution spindles and flames of similar size (TABLE VIII/1).

In one sample two covellite grains of 20 μm was found as alteration product of chalcopyrite.

CONCLUSION

Ore minerals exposed in the borehole Baksa 2 was formed by a significant hydrothermal activity affecting the Baksa Complex, with the exception of ilmenite coming from lateral secretional process. Hydrothermal origin of the ore minerals is indicated by the ore mineral paragenesis as well as their morphological and textural features. The frequent chalcopyrite-pyrrhotine exsolution, the double (pyrrhotine-chalcopyrite) inclusions of the sphalerite, and pentlandite inclusions of the pyrrhotine veins in the deeper region of the borehole suggest high temperature of fluids forming the ores. The two-phase-structure of the 7 cm thick vein at the depth of 186.4 m proves that the hydrothermal activity could happen in two phases at least. The mainly sulphide mineralisation characterised by Fe, Zn, Cu, Pb, (Ni) shows that fluids were in connection with real magmatic activity and not from mobilisation of a metamorphic fluid in a wider sense. Beside the varied ore mineral paragenesis, this assumption is also supported by compositional, textural and morphological features of non-ore minerals in the veins.

Accurate geological dating of the hydrothermal activity is quite difficult because of the available data and features of the samples. It can be stated, however, the hydrothermal activity affected the Baksa Complex after the progressive metamorphic effects of the Variscian tectonometamorphic cycle since the veins always cross the schistosity, sometimes they are pressed amongst the cleavage planes, and metamorphic phenomena can not be observed in the ore-bearing veins.

Determination of the regional connections is also difficult. On the basis of geological closeness and analogy of the mineralisational features it is possible hydrothermal processes found in borehole Baksa 2 are related to the Lower Permian rhyolitic volcanism (Gyürüfű Rhyolite Formation) or the subsequent post-volcanic activities because centre of the above mentioned volcanism lies as near as 20 km to the east of the key borehole (boreholes Vokány 2 and Egerág 7). Moreover, hydrothermal ore indication related to the rhyolitic volcanism was found in the borehole Szava 1 which is 10–15 km to the east of the borehole Baksa 2 (FAZEKAS AND VINCE, 1991). It is also possible, however, that hydrothermal ore mineralisation of the Baksa Complex is totally independent of the Lower Permian volcanism. It could be interpreted as a product of the Lower Cretaceous or Miocene volcanism of the Mecsek Mountains, or product of a still unknown volcanic activity. This assumption is supported by a 7 cm thick andesite dike at 469.4 m of the borehole Baksa 2.

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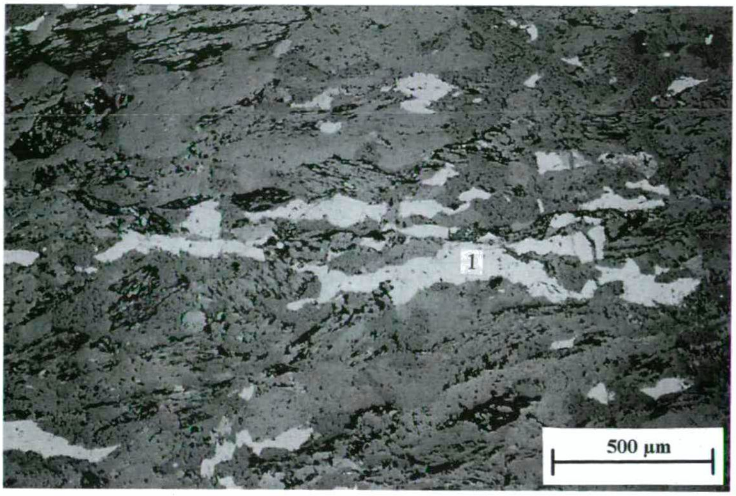

TABLE I/1: Polished section. Key borehole Baksa 2. Lateral secretional ilmenite orientating to schistosity (x40, ordinary light). Legend: 1. ilmenite.

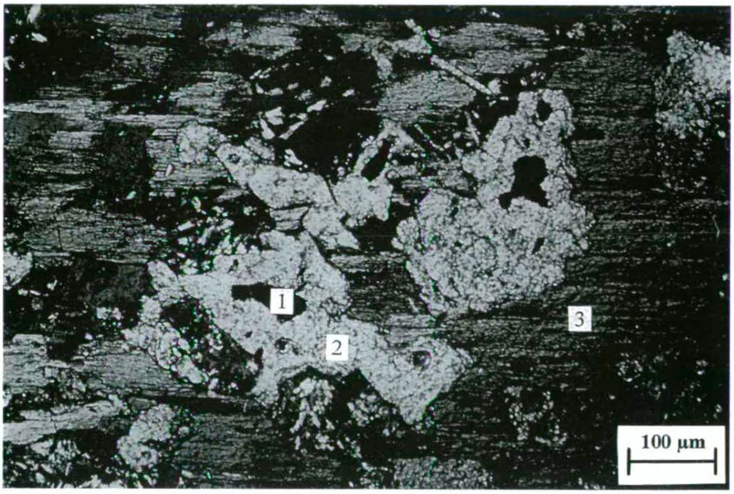

TABLE I/2: Thin section. Key borehole Baksa 2. Ilmenite surrounded by titanite (x200, crossed polars). Legend: 1. opaque mineral, 2. titanite, 3. amphibole.

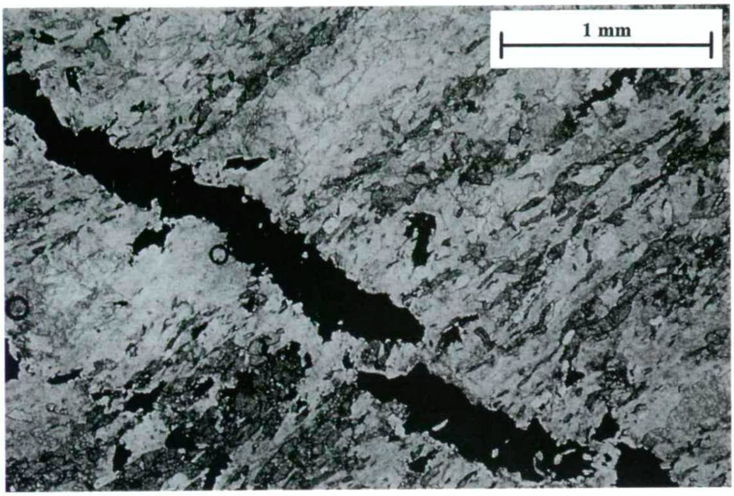

TABLE II/1: Thin section. Key borehole Baksa 2. Vein filled with ore minerals. The ore minerals penetrated amongst the cleavage planes, too (x50, ordinary light).

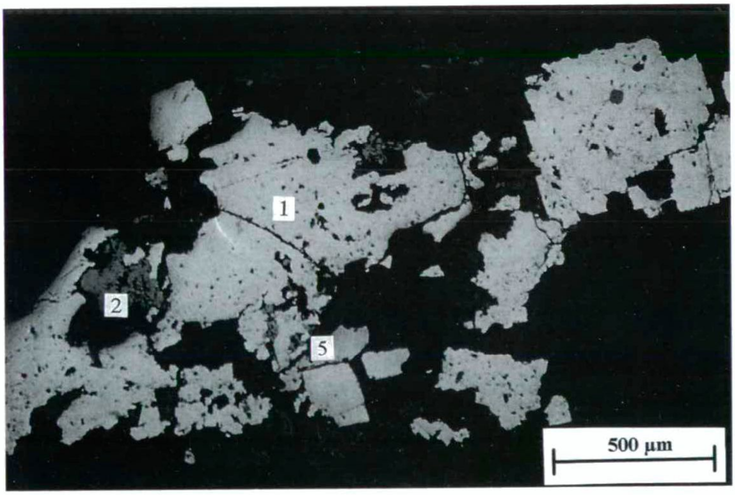

TABLE II/2: Polished section. Key borehole Baksa 2. Hypidiomorphic-xenomorphic pyrite grains in a vein (x40, ordinary light). Legend: 1. pyrite, 5. chalcopyrite, 2. sphalerite.

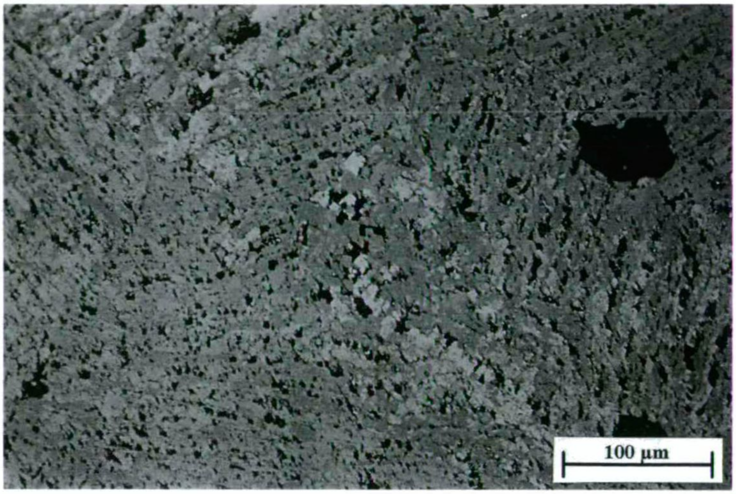

TABLE III/1: Polished section. Key borehole Baksa 2. Typical marcasite (x200, crossed polars)

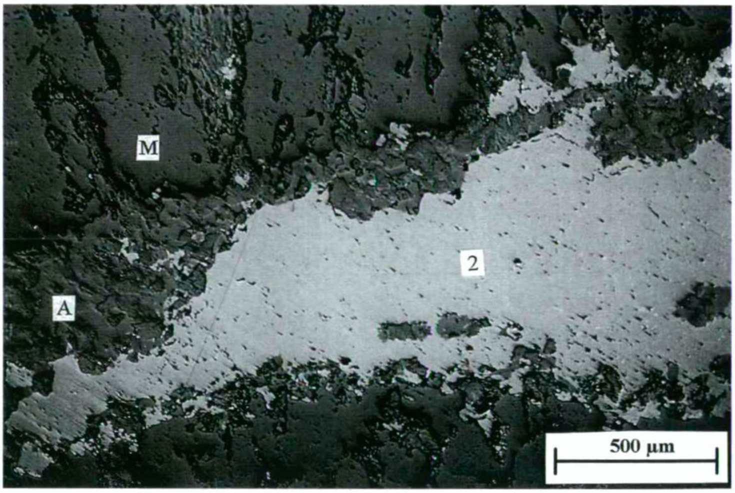

TABLE III/2: Polished section. Key borehole Baksa 2. Sphalerite with chalcopyrite inclusions (x40, ordinary light). Legend: 2. sphalerite, A. barren apophysis, M. wall rock.

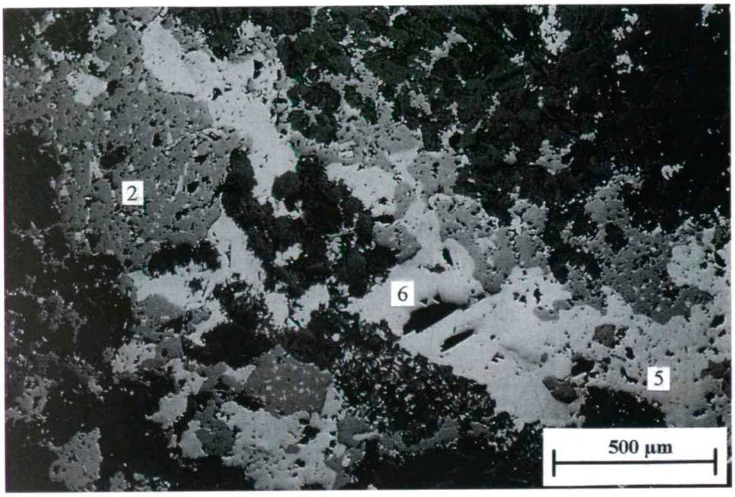

TABLE IV/1: Polished section. Key borehole Baksa 2. Ore minerals of a hydrothermal vein (x40, ordinary light). Legend: 2. sphalerite, 5. chalcopyrite, 6. galena.

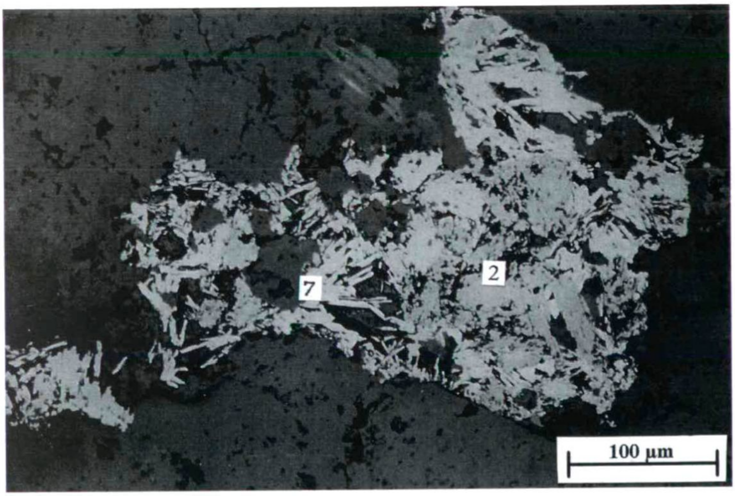

TABLE IV/2: Polished section. Key borehole Baksa 2. Hematite lamellae in sphalerite (x200, crossed polars). Legend: 7. hematite, 2. sphalerite.

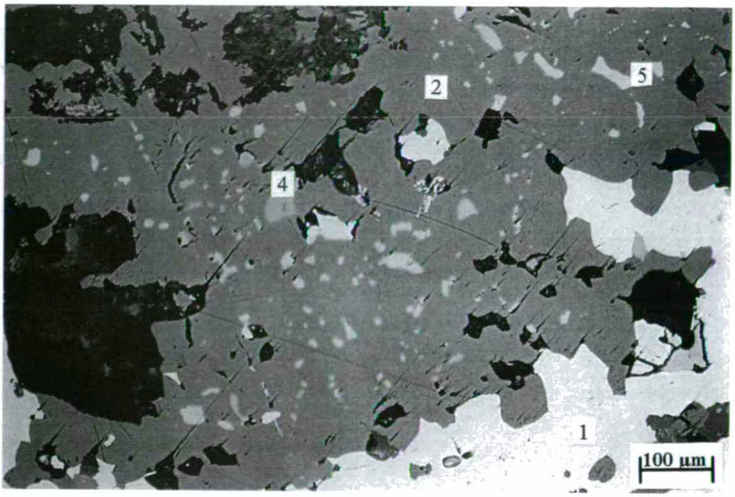

TABLE V/1: Polished section. Key borehole Baksa 2. Interlocking of pyrite and sphalerite containing chalcopyrite and pyrrhotine inclusions (x100, crossed polars).
Legend: 1. pyrite, 2. sphalerite, 4. pyrrhotine, 5. chalcopyrite.

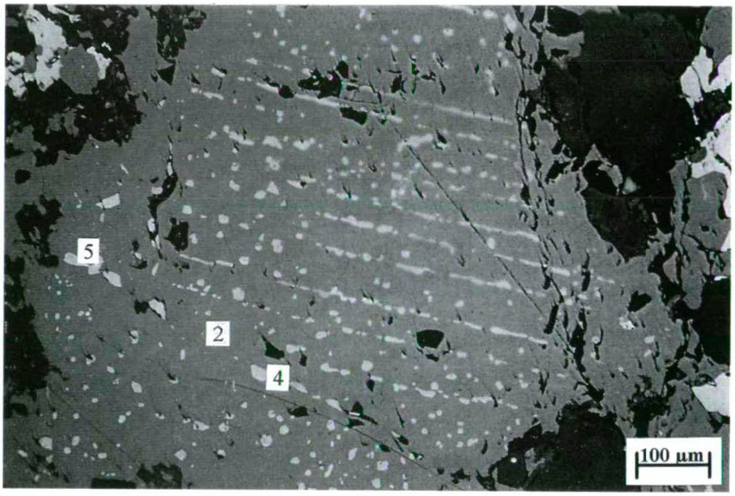

TABLE V/2: Polished section. Key borehole Baksa 2. Oriented inclusion of sphalerite (x100, crossed polars).
Legend: 2. sphalerite, 4. pyrrhotine, 5. chalcopyrite.

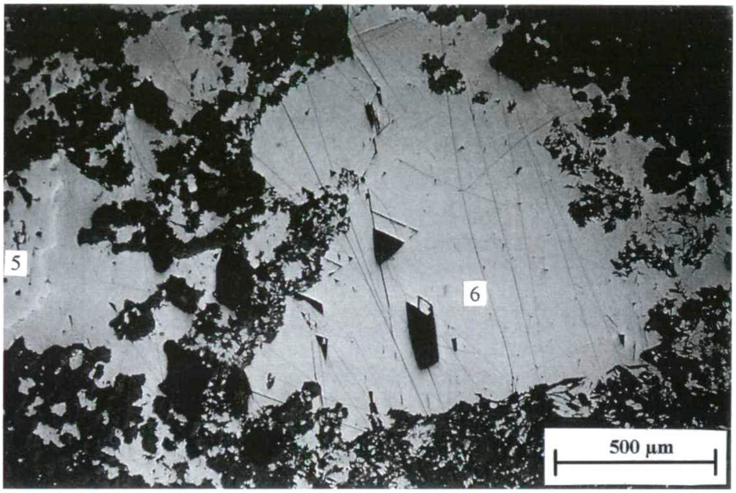

TABLE VI/1: Polished section. Key borehole Baksa 2. Galena and chalcopyrite (x40, ordinary light).
Legend: 5. chalcopyrite, 6. galena.

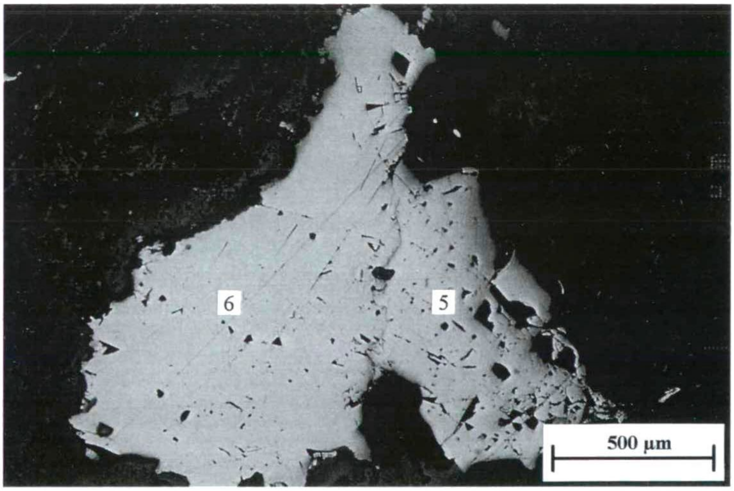

TABLE VI/2: Polished section. Key borehole Baksa 2. Galena (x40, crossed polars).
Legend: 5. chalcopyrite, 6. galena.

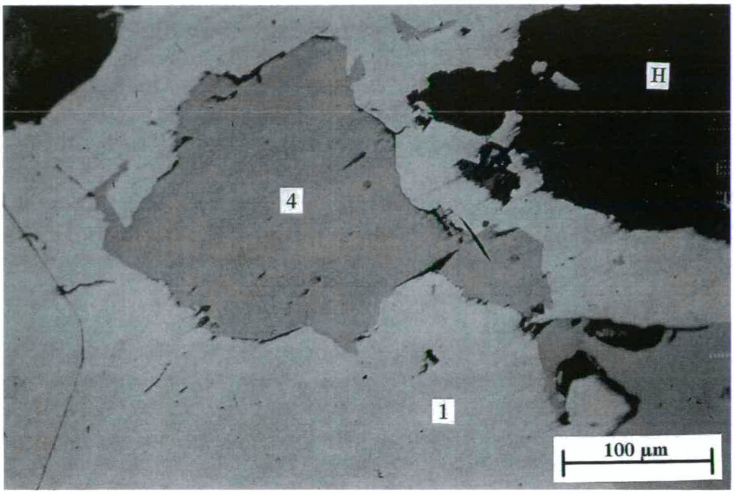

TABLE VII/1: Polished section. Key borehole Baksa 2. Pyrrhotine inclusion in pyrite (x200, ordinary light).
Legend: 1. pyrite, 4. pyrrhotine, H. gap.

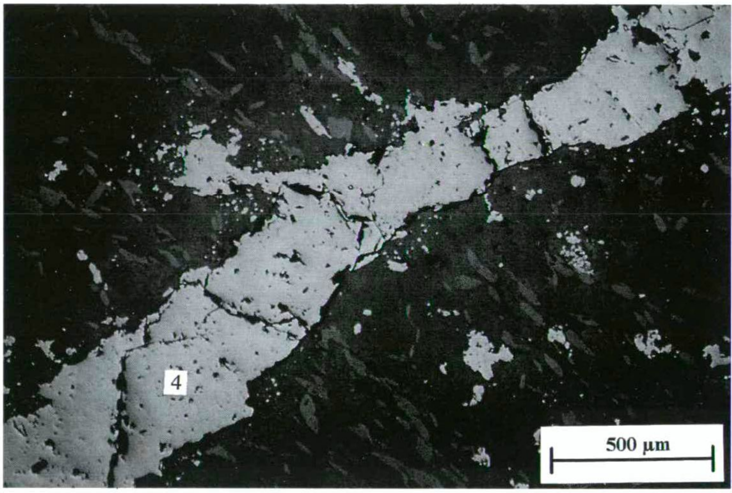

TABLE VII/2: Polished section. Key borehole Baksa 2. Pyrrhotine vein (x40, ordinary light).
Legend: 4. pyrrhotine.

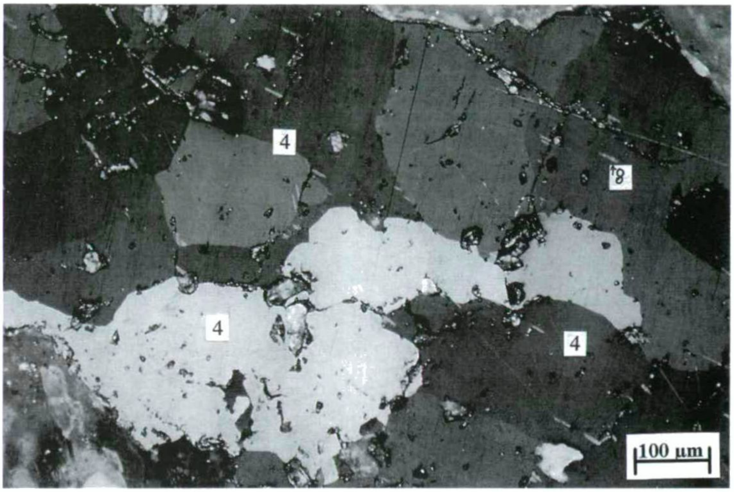

TABLE VIII/1: Polished section. Key borehole Baksa 2. Pleochroism of pyrrhotine. Pentlandite inclusions can also be observed (x100, parallel polars). Legend: 4. pyrrhotine, 8. pentlandite.

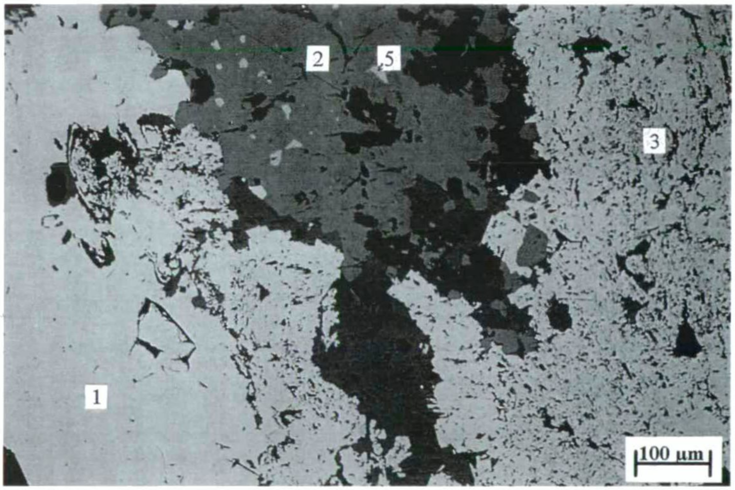

TABLE VIII/2: Polished section. Key borehole Baksa 2. Fresh and marcasitizing pyrite with sphalerite (x100, ordinary light). Legend: 1. pyrite, 2. sphalerite, 3. marcasite, 5. chalcopyrite (inclusion).