THE KÖPRÜBAŞI ORE OCCURRENCE (NE TURKEY)

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The occurrence is located about 4 km ENE from the center of the Tirebolu town, on the left bank of the Harşit River, on the Harşit road cut. The visible length of this occurrence is about 100 m. Several outcrops as well as two tunnels and a big number of shafts are visible at the west side of this mine. There is a number of indications which suggest the presence of a dropped open pit, too. All of the described works have been carried out in an area of about 300 m in diameter.

GEOLOGICAL SITUATION

In the prospected area occurs a rhyodacitic volcanic breccia which is overlaid by trachytic tuffs, lavas and tuffaceous sandstones. All these rocks are penetrated by trachyandesitic dykes. The great part of the described formation is covered by terrace material.

The rhyodacite volcanic breccia is cut by numerous faults, fissures and cracks, which were mostly discovered on the Harşit road cut and inside the tunnels running from this road cut. The faults and fissures show different strikes, dips and angles of dip.

MODE OF ORE OCCURRENCE IN THE KÖPRÜBAŞI MINE

The Köprübaşı mine is located on the left bank of the Harşit River, and the tunnels were run generally in the western direction from the Harşit road cut. There are three main and several short tunnels over here, all of them run in rhyodacitic volcanic breccia. These tunnels were located on the Harşit road cut. The distance between the first and last tunnel is about 50 m. A tunnel was also run through the contact between rhyodacite pyroclasts (volcanic breccia) and the overlying volcanic-sedimentary formation (tuffs, lavas, tuffaceous sandstones, etc.). This tunnel was run on the Harşit road cut too, but in the direct vicinity of the Samsun-Trabzon road.

Two ancient tunnels have also been run in this formation, but the mineralization is not visible in these tunnels. The adit no. 5 was run through the contact of the said volcanic breccia and overlying tuffs. A vein or lense of barite was observed in this adit, but the ore minerals appear to be completely lacking here. Two of the three main tunnels, which were run in the volcanic breccia (G-2 and G-3), are in a collapsed state. The visible portion of G-3 is an inclined shaft, 10 m of which are accessible. According to the owner of the mine, this shaft traced the ore vein for about 20 m downward, then the mining had to be sloped at the level of the Harşit River. The tunnel no. 1, which is about 20 m in length, is now only a slope. From this slope (according to the owner) a lunnel was run in the NW direction, which is about 50 m in length, but it is collapsed now. According to the owner, this lunnel traced a very rich ore vein, about 1 m in thickness.

There is a number of faults and fissures in the above-mentioned stope, filled by ore veins 0.5 to 1.5 m in thickness, striking in NNW-SSE and WNW-ESE directions; some of them almost in N-S and E-W directions. Their dips and angles of dip are varying, the last ones ranging from 12° to 85°. Actually, a brecciated fault zone exists over here. The ore occurs as veins, as drag ore and as impregnations in the host rock. The above data show that the case is of an ore body the size of which is unknown. This ore body belongs to the stockwerk type.

During the mining operations only high-graded ore was excavated, but not completely. From the non-excavated parts of the ore body we carried out systematic sampling, taking specimens at distances of one meter along the lines of the two directions. The collected specimens were chemically analyzed and microscopically examined. The average contents of metals were as follows:

Cu	0.80 %
Zn	2.83 %
Pb	5.40 %
Total :	9.03 %

During our mapping of this area several short tunnels were made on the Harşit road cut, practically between the main tunnels. All of these new headings cut a fault which is striking almost in N-S direction. It is filled by ore vein about 1 m in thickness. This vein is almost parallel to the Harşit road cut. After cutting the vein and excavating the ore the mining was sloped. On the village road cut, about 200 m west of the mine, two ore outcrops were also found. During the mapping of this area, several tons of ore were seen by us. This ore was excavated from a tunnel that is now in a collapsed state. This is the same sort of ore as in the Köprübaşı mine. There are fragments and blocks of barite near the described outcrops and the tunnel.

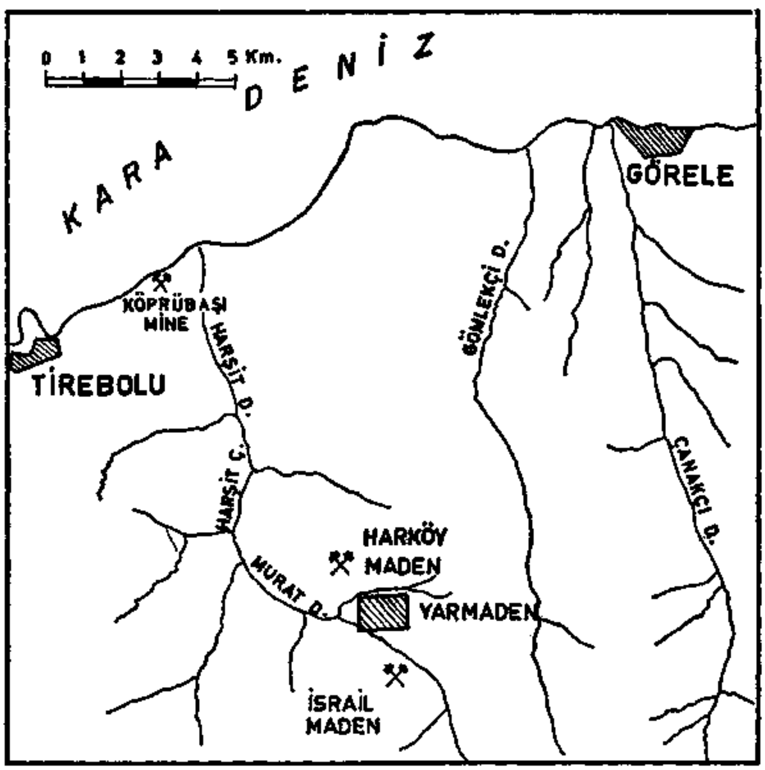

Fig. 1 - Location map of the Köprübaşı mine.

THE ORE-MICROSCOPIC EXAMINATIONS

As the result of the examinations the following minerals were determined: *sphalerite, pyrite, galena, tetrahedrite, chalcopyrite, bournonite, bornite, realgar, chalcocite, covellite, malachite, azurite, cerussite,* and *limonite.* Gangue minerals are mainly *quartz* and *barite.* Some *clay-sericite* veinlets in the rock have also been seen.

Sphalerite is the most abundant mineral and it occurs in the rock in almost all of the polished sections. Sphalerite is predominant (up to 30 %) in a number of sections. It occurs in the form of grains of very various sizes (even megascopic), it mostly replaces the rock metasomatically. Sphalerite also replaces, cements and encloses the grains and crystals of quartz andpyrite. Sphalerite is one of the oldest minerals, thus it is often replaced by galena, tetrahedrite, chalcopyrite and bournonite, as well as by secondary copper minerals. The veinlets of galena and bournonite in sphalerite are rare, as the later minerals replaced sphalerite mostly along its grain contacts. Sphalerite is partly fractured and cemented by later minerals, especially by secondary copper minerals. The chalcopyrite exsolutions in sphalerite are quite rare, and they occur in the form of inclusions in the host mineral. The pyrrhotite exsolutions in sphalerite are extremely rare. Pyrrhotite occurs as thin needles, in some places they become massive and orientated. Sphalerite very often has massive internal reflexions.

Pyrite is present in all of the polished sections. Mostly it is very frequent, but in some polished sections it is very scarce. Pyrite appears as grains of different sizes and crystals, mainly in the rock which is replacing it metasomatically. Also it has often been seen in quartz, which replaced and enclosed it. In other sulphides pyrite is also frequent and it is enclosed in them. In some p.s. pyrite is disseminated only exclusively in the rock. Sometimes it is cemented by later sulphides; in places pyrite is cemented by quartz too.

The fine-grained pyrite is rather frequent, rounded and ring-like pyrite grains were also observed. Pyrite, which is showing these structures, is mostly enclosed in tetrahedrite and bournonite, and sometimes in galena. However, approx. 90 % of the described pyrite is enclosed in tetrahedrite and bournonite. Some ring-like pyrite grains are rimmed by pyrite crystals, and filled by tetrahedrite. The fine-grained intergrowths of the described pyrite with bournonite and host rock are also visible. In such cases the host rock contains numerous rounded rock-forming minerals. Pyrite in the form of "mineralized bacteriae" is very scarce.

Galena is mostly present but its content is very variable. In general, it is very frequent, but it is abundant only in places. Massive galena is not very frequent. Galena occurs as grains of very various sizes. It occurs in the rock, replacing it metasomatically, or it appears with sphalerite and pyrite, replacing them in the same way. In the galena groundmass pyrite, sphalerite and rock grains are often visible. Galena occurs also with tetrahedrite (replacing it), chalcopyrite and bournonite. The galena veinlets in sphalerite are rare. Sometimes galena cemented pyrite. All replacings of galena are of metasomatical character. Galena is rarely converted into cerussite. In the excavated portions of the ore body (tunnel G-l) galena was very abundant.

Tetrahedrite is quite frequent, but it is abundant only in some places. It occurs as grains of different sizes in the rock, replacing it along its grain contacts, or it occurs with chalcopyrite, galena, sphalerite, pyrite and bournonite. Tetrahedrite appears later than sphalerite and pyrite, and replaced and enclosed them, especially pyrite. Often numerous small pyrite grains and inclusions are observed in tetrahedrite. Sometimes rounded and ring-like pyrite grains are also visible in tetrahedrite.

Chalcopyrite is not frequent and it is concentrated only in some places. This mineral mostly replaced the rock along its grain contacts, but it is encountered also with tetrahedrite and sphalerite, replacing them. The small chalcopyrite grains in sphalerite are often visible, the veinlets are rare. Chalcopyrite also replaced and enclosed pyrite, or it occurs with galena and bournonite.

Bournonite is visible only in some places and it occurs as grains of very variable sizes. It is encountered in the rock, but also with sphalerite, pyrite, galena and tetrahedrite, and sometimes with chalcopyrite. Bournonite replaced the rock, pyrite, galena and tetrahedrite; sometimes it occurs also with chalcopyrite. Bournonite replaced the rock, pyrite, sphalerite and tetrahedrite metasomatically. Numerous small pyrite grains are enclosed in bournonite.

Bornite is scarce and mostly transformed into secondary copper minerals. It is visible only in chalcocite and covellite, as small grains.

Realgar is rarely visible, and it is encountered in the rock with pyrite and quartz.

Chalcocite and covellite: Although the sampling was not carried out in strongly oxidized parts of the ore body, chalcocite and covellite are quite frequent in the examined polished sections. Covellite is more frequent than chalcocite. Both minerals are almost always intergrowing. Chalcocite is grained, but covellite occurs mostly as thin needles. In places, covellite is very abundant. In some sections covellite is in the form of gel (rhythmical and other structures). Chalcocite belongs to the blue variety, but mostly it is isotropic. These minerals replaced the rock along its grain contacts and cemented fractured sphalerite or replaced galena and other minerals. Some sphalerite, tetrahedrite and galena grains are with covellite and chalcocite haloes.

Malachite and azurite are mostly rare, but in some places very abundant, especially malachite. In some sections malachite occurs as large grains and patches, replacing the rock. In general azurite is scarce.

Quartz is quite frequent and in places very abundant. It occurs as grains of various sizes and crystals and it replaces the rock and pyrite metasomatically, often enclosing their grains. Quartz is often fractured and cemented or replaced by sulphides, such as galena, sphalerite, tetrahedrite and chalcopyrite.

Barite is frequent and it mostly replaced the rock metasomatically. Barite is very often crystalline. In some sections the content of barite in the rock is up to 40 %. Sometimes barite occurs in the rock as «phenocrysts», or replaced the rock's matrix.

GENESIS

Two phases may be recognized in the formation of this deposit: 1) Volcanic-sedimentary and 2) Hydrothermal.

1. Volcanic-sedimentary phase

A part of pyrite, sphalerite, tetrahedrite, galena, chalcopyrite, bournonite and barite were formed during the first phase. Pyrite formed in this phase is usually fine-grained, although it may also have rounded or concentrical form. Pyrite has been rarely observed in the form of the «mineralized bacteriae». The other minerals are usually in the form of irregular grains inside the rock and, rarely, have oval or other shapes. The volcanic-sedimentary tetrahedrite and bournonite (sometimes galena as well) contain numerous inclusions and small pyrite grains of the same origin.

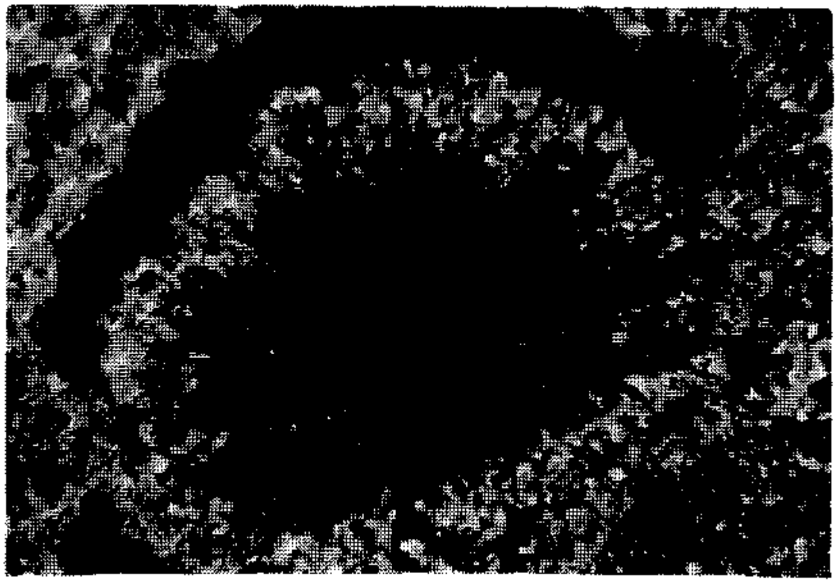

Photo 1 - Köprübaşı mine. Volcanic-sedimentary paragenesis.
Concentrically distributed pyrite grains in the rhyodacite pyroclast (black).
Right: minute tetrahedrite inclusions (dark gray) between pyrite grains. Oil imm. 180 ×.

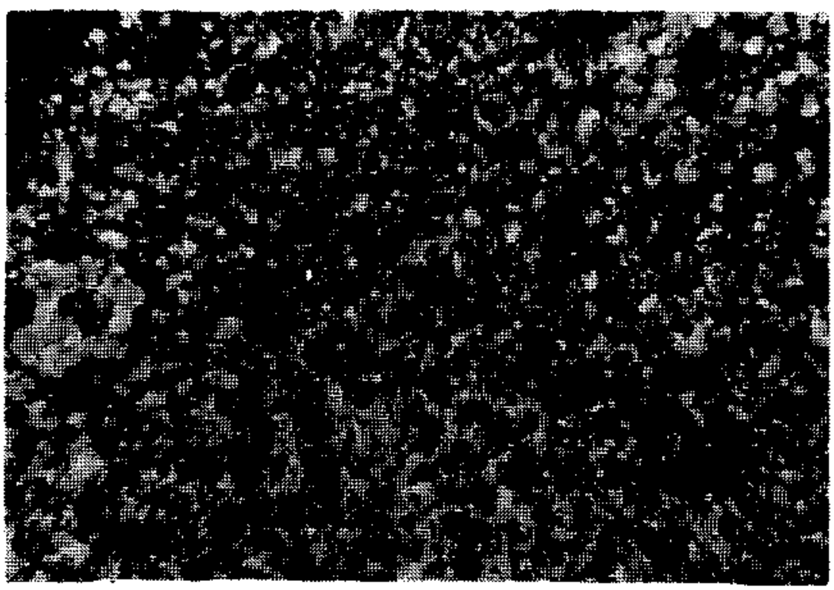

Photo 2 - Köprübaşı mine. Volcanic-sedimentary paragenesis.
Fine-grained mixture of pyrite (almost white) and tetrahedrite (dark gray) in the rhyodacite pyroclast (black). Oil imm. 220 ×.

Photo 3 - Köprübaşı mine. Hydrothermal paragenesis.

Pyrite (white, high relief) enclosed in coarse galena (almost white) and tetrahedrite (gray). The latter is intergrown with bournonite (light gray) and sphalerite (almost black). Black: quartz. Below: the residues of volcanic-sedimentary paragenesis-tetrahedrite (gray) enclosed numerous small grains and inclusions of pyrite (white, rather high relief). Oil imm. 180 ×.

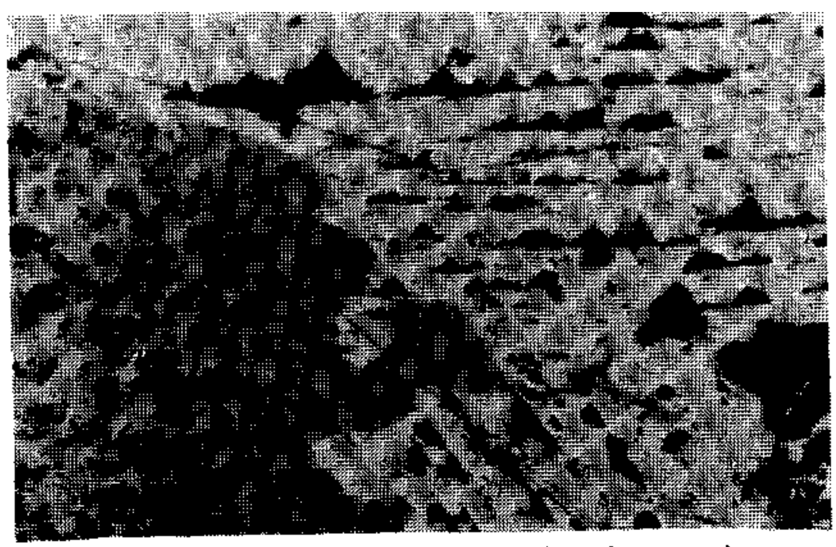

Photo 4 - Köprübaşı mine. Typical hydrothermal paragenesis.

Very coarse sphalerite (gray) replaced by a galena patch (almost white, showing characteristic triangular cleavage). Both of the said minerals replaced quartz (black) 60 ×.

All volcanic-sedimentary minerals are intimately intergrown with the host rock (volcanic breccia) with the replacement structures completely lacking, either relative to the rock or between the different minerals.

2. Hydrothermal phase

The same mineral assemblages were formed in the hydrothermal phase as well, with the addition of bornite, realgar and quartz. The hydrothermal pyrite is usually coarse-grained or crystalline, and other minerals are generally coarse-grained as well. The hydrothermal sphalerite contains the chalcopyrite exsolutions locally, and sometimes pyrrhotite as well, that points out to the fact that higher temperature has prevailed during this paragenesis. The replacements in hydrothermal minerals are clearly visible, both in respect to the host rock and among the minerals, but they are mainly of metasomatic type and the veinlets are relatively infrequent. The hydrothermal minerals replace also those of volcanic-sedimentary phase, frequently including them into their grains. The hydrothermal paragenesis was formed mostly at moderate temperatures; this opinion is further supported by the fact that, both the contact and other high temperature minerals, as well as the more frequent pyrrhotite exsolutions, inside the hydrothermal sphalerite, are lacking.

Origin of hydrothermal paragenesis: There are two possible hypotheses regarding the origin of the hydrothermal paragenesis at the Köprübaşı deposit, namely:

a. by the new hydrothermal influx of the same metals and minerals that have formed the volcanic-sedimentary phase, and

b. by remobilization of volcanic-sedimentary paragenesis by the subsequent thermal waters, that have circulated along the faults, fissures and void spaces inside the primary deposit and by redeposition—this time hydrothermal—of dissolved material inside the existing deposit.

Due to the fact that in the Black-Sea coastal region both mechanisms—the juvenile hydrothermal introduction and the regeneration of the existing volcanic-sedimentary deposits—were observed, it will be very difficult, at the present time and level of investigations, to give final conclusion in the given case. It might be possible that the subsequent hydrothermal solutions have, on the one hand, introduced the juvenile metallic influx, and, on the other hand,—when they have reached the volcanic-sedimentary paragenesis—have regenerated it in a higher or lesser degree.

The solution of this problem may be considered as highly important for the evaluation of the Köprübaşı deposit, mainly due to the following two factors:

a. If the main ore concentrations are of juvenile hydrothermal paragenesis, the deposit may extend to appreciable depth;

b. If the remobilization of the existing volcanic-sedimentary deposit, genetically and spacially related to the rhyolite-dacite volcanic breccia, is the case, then the extension of the ore body toward the appreciable depth is highly improbable.

Naturally, this problem shall be best solved by the additional explorations that are presently under way at this deposit.

As far as the relalgar and the appreciable quantities of quartz are considered, it is beyond doubt that they are the typical hydrothermal products; anyhow, for the present, realgar is of mineralogical importance only.

Manuscript received May 77, 7972