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COPPER AND ZINC OCCURRENCES AT KILISE TEPE, MURGUL AREA, NE TURKEY

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ABSTRACT.- The copper occurrences in the Murgul area had been known in ancient times, but their systematic exploration and exploitation began at the end of nineteenth century, and later in twentieth century they had been continued and intensified. The Kilise Tepe showings argue, on the basis of slag material, show that there had been provided a primitive exploitation, judging from high copper (even 4%) contents. Otherwise, the Kilise Tepe district is built up mostly of volcanic and volcanic-sedimentary rocks units, chiefly of rhyolitic composition. These formations are injected along faults by minor quartzdiorite bodies, commonly in from of sills. In this field 12 copper and zinc-copper occurrences have been registered. The most important copper mineralizations occur in lower stratigraphic level, generally related to the argillized breccious zone with chalcopyrite fragments ("oreclasts"), dropping from the loose rock material with copper contents up to 20%. This situation is characteristical for the source part of the Kopitvan dere stream. On the other side, a stratiform ore body consisting around 2% copper takes place in the source part of Skutari Dere. It is supposed that these occurrences are continuation of the Anayatak - Çakmakkaya mineralization zone. In the same zone the mineralized rhyolite volcanic breccia appears as well, grading over 0,2% copper, where ore reserves of 10-20 million tons of the low grade copper ore are to be expected. The next occurrences are represented by mineralized quartzdiorite sills where zinc is predominant, grading from 1% to 10% and with copper as accompanying metal, showing contents from 0.1% to 0.5%. Finally, on the Kilise tepe - Kopuk zone, a belt of molybdenum geochemical anomalies is distinguished, with Mo contents ranging from 200 -1000 ppm. The potential of Kilise tepe area, taken as a whole, is considerable: 1- KiliseTepe mineralization could to be a continuation of the Anayatak - Çakmakkaya ore zone, and 2- in deeper levels quartz diorite sills, a mineralized quartz diorite could be expected maybe related to the porphyry type of the zinc and copper sulfide ore.

Key words: Copper, zinc, ore occurrences, volcanite, quartzdiorite, Kilise Tepe, Kopitvan Dere, Skutari Dere, Murgul, Turkey.

INTRODUCTION

The copper ores at Minor Caucasus and so in the Murgul district are known in times before Christ (being known in ancient times), but the oldest systematic mining activity had dated from the medieval age. However, explorations and mass exploitation began near the end of nineteenth century and continuously (lesser breaks) have lasted till the present days. At the beginning of twentieth century as smelter was erected in Murgul, being operative till the middle of seventies.

If the Anayatak - Çakmakkaya localities are considered as two separete ore deposits (500 m apart from each other) it could be said that in the nearest surroundings of Murgul there are four copper deposits which have been subject of exploitation, (Fig. 1) and more than 30 occurrences with low level of research workings. Limited studies among these are 12 occurrences in a larger Kilise tepe area, or more exactly, in the space between Kurtumele önü and Yeşil Tepe. .

According to available information, indication for the first mineralizations were registered by Buser (1970) in the Kopitvan Dere valley and then Stern (1971), Popovic (1972) and Pejatovic (1979). Buser (1970) observed a very intensive silicification and pyritization in the source part of the Kopitvan Dere stream,

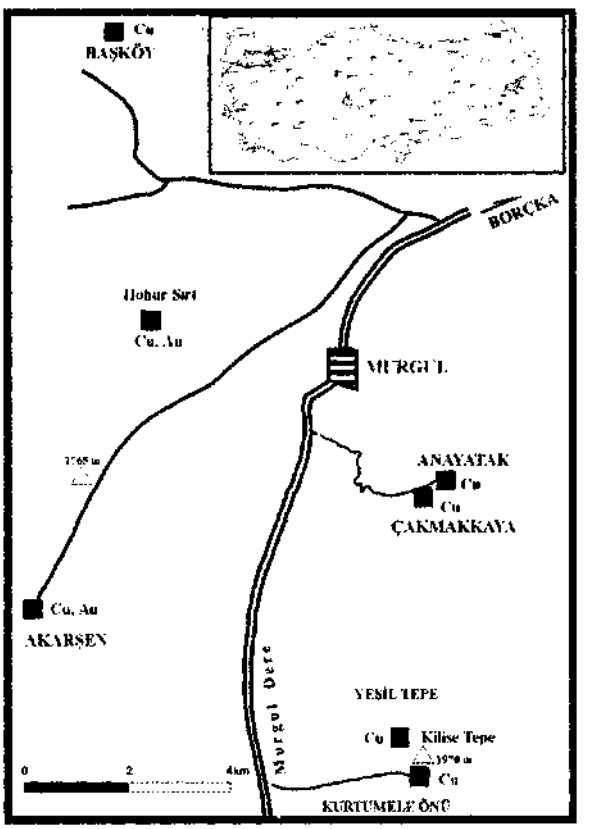

Fig. 1- Location map of the sulfid deposits in Murgul region (NE Turkey).

and in the torrential material of the stream itself they found numerous chalcopyrite fragments and pebbles with pyrite, later named as oreclasts. Although the terrain was covered by a detailed prospecting, including trenching (these workings were hindered by very steep slopes and practically impassable rhododendron vegetation without cutting), the search for the real source of chalcopyrite-pyrite fragments was not successful, except local augmentation of copper content and individual oreclasts in argilized zones. However, by prospecting and geochemical investigations, 10 copper and 2 zinc-copper occurrences as well as a zone with high molybdenum were discovered.

Descriptions about mineralizations mentioned above have not been published, except some basic informations, but taking into consideration a high potential of sulfide as a whole, it is of interest to attract attention of the broader public for further explorations.

Fig. 2- View to the southern slopes of Kilise tepe (dense intertwined rhododendron Trees with individual conifer trees are visible).

PRINCIPAL GEOLOGICAL FEATURES

The Kilise Tepe surrounding is restricted to the spacious volcanic-sedimentary and volcanic complexes of the Murgul district. The oldest rocks are sandstones and tuffaceous sandstones, appearing in the southwestern sector, being, confined to a formation of the possible Upper Jurassic and Lower Cretaceous age, occurring in the Murgul Dere (Iskalka köprü) valley. Although they bear pyrite and weaker chalcopyrite mineralization, these are not of greater importance. Other formations are volcanic-sedimentary and volcanic in origin, whereas the intrusive rocks are quartzdiorites; the volcanites are mixed and difficult to be distinguished, especially in presence of submarine activity, followed at times by subaerial extrusions. These formations are of major importance, nevertheless if they are represented by rhyodacite, dacite and most commonly rhyolite flows, tuffs, agglomerates, breccias or redeposited, volcanic rocks, alternating with tuffaceous sandstones, conglomerates, quartzose sandstones and cherts (with Radiolaria - radiolarites and other microfossils). The mylonitization zones and tectonic breccias, as well as talus cones, covering large areas, appear as distinct geological bodies. Volcanites are generally Upper Cretaceous and Tertiary in age, and talus cones are practically contemporaneous. In the cones occur fragments and blocks of various sizes from the first size to blocks measuring twenty or more cubic meters. In the first moment one could have impression that, except talus cones, other rocks constitute an unique volcanic complex representing volcanic activity of variable intensity. These are, from one side, products of vigorous and explosive volcanism represented by flows, tuffs, breccias, alternating - from the other side with calm stages, producing deposition of sandstone and conglomerate beds and redeposited volcanic material. These stages are featured by radiolarites (cherts, Fig. 3).

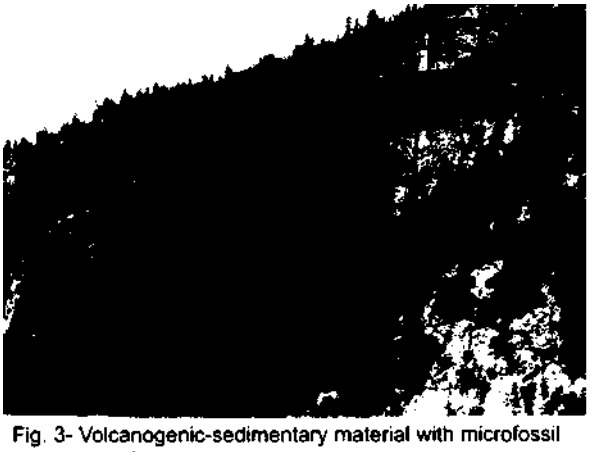

Fig. 3- Volcanogenic-sedimentary material with microfossil remains.

In later magmatic phases the volcanic and volcanic-sedimentary formations were faulted and cut by minor or major sills, dikes and other quartzdiorite bodies, generally of limited size, commonly injected along the fracturing structures. Above all, these intrusives represent only apical parts of a larger intrusive mass, directly related to the Tiryal Dağ - Tatos Dağları pluton

(batholith). It is of an importance to be noticed that among these rocks there is a younger differentiation product, determined as granite. Otherwise, all varieties, from diorites to granodiorites and quartzdiorites have been determined.

When the presence of individual formations is discussed, it should be stressed that in this terrain the both volcanic-sedimentary and sedimentary rocks are subordinated, compared with other volcanics. Rhyolitic rocks are the most abundant, followed by rhyodacites, and the least abundant are dacites and andesites.

It should be particularly stressed that te field as a whole had supported strong tectonical deformations, manifested as manifold fracturing of variable intensity, even accompanied by limited folding. Numerous ruptures are synchronous with volcanism, and some of them originated during relaxing stages of volcanism or after finishing that activity. The fact that in the redeposied (sedimentary) formations numerous folds are visible, testifies in favor of tectonics, probably having been occurred in Later Paleogene or in Neogene time.

It is necessary to notice that in a larger Kilise Tepe area the contact metamorphism is less well defined, although relatively numerous small quartzdiorite bodies are present. Only locally a weak cornitization and partial pyritization and silicification are observable, and some Cu-Zn mineralizations could be also restricted to the contact metamorphism, rapidly disappearing when drifted apart from the contact itself. Fractured structures often accompanied by intrusives, the size of intrusive bodies, degree of contact metamorphism, indicates a partly rather cooled magma, but the accompanied hydrothermal solutions could have an important role in formation of sulfide mineralizations. This has also been confirmed by the fact that volcanites were affected by repeated hydrothermal alterations, manifested by silicification and pyritisation as the most prominent ones, then by argillization, carbonatization (calcification), sericitization, epidotization and other. To those are to be added numerous Cu and Zn occurrences, following the mentioned alterations.

In frames of volcanic-sedimentary complexes the genuine cherts and quartzose sandstones, although are hard to be observed, have been still distinguished, representing - along with other rock types, an original petrogenic feature of this field. As an important charac-. teristic of this terrain, reflecting intensive disintegration of rocks, appear the erosional pyramids, rising up to 5 m and more above the botton covered by dense rhododendron forest, as visible in Figure 4.

Fig. 4- Erosional pyramid built up of silicified rhyolitic volcanites (source part of the Kopitvan Dere stream).

Observing the Kilise Tepe geological map (Fig. 5.) it is remarkable at the first sight that showings of copper and zinc mineralizations occur mostly along the faults, in higher parts of the relief. Some of these, however, appear as impregnation in rocks, but in such cases the fracturing structures generally control the mineralized areas. It should be mentioned too, as visible on the map as well (Fig. 5.), that a horizon - or better - a conglomerate formation composed of volcanite pebbles (being not agglomerate) has been distinguished, beneath it any occurrence of copper and zinc sulfides having not been registered to date. By that feature in a certain case the relative age of the Cu and Zn mineralization has been determined in the larger Kilise Tepe tract of land, including corresponding magmatism.

All copper and zinc ore occurrences could generally be divided into two groups: copper and zinc-copper mineralizations. It should be noted that all these occurrences are numbered, because in this area there are very little toponyms (these are Kurtumele önü, Kopuk, Kilise Tepe, Yeşil Tepe, Kopitvan Dere, Skutari Dere).

Going from the southeast to the northwest, i.e. from the Kurtumele önü peak, across the Kilise tepe - Kopuk ridge to Yeşil Tepe there are 12 Cu and Zn mineralizations, as well as three molybdenum geochemical anomalies. Some of them are grouped under the same number, so that all together they bear numbers from 1-9.

According to knowledge to date, as it has already been mentioned in part, all these showings are restricted to tectonic zones and porous rocks, such as pyroclastic material or volcanic flows, but also to the intrusive rocks, such as quartzdiorites. It is interesting that in samples from dacites copper and zinc concentrations have not been registered.

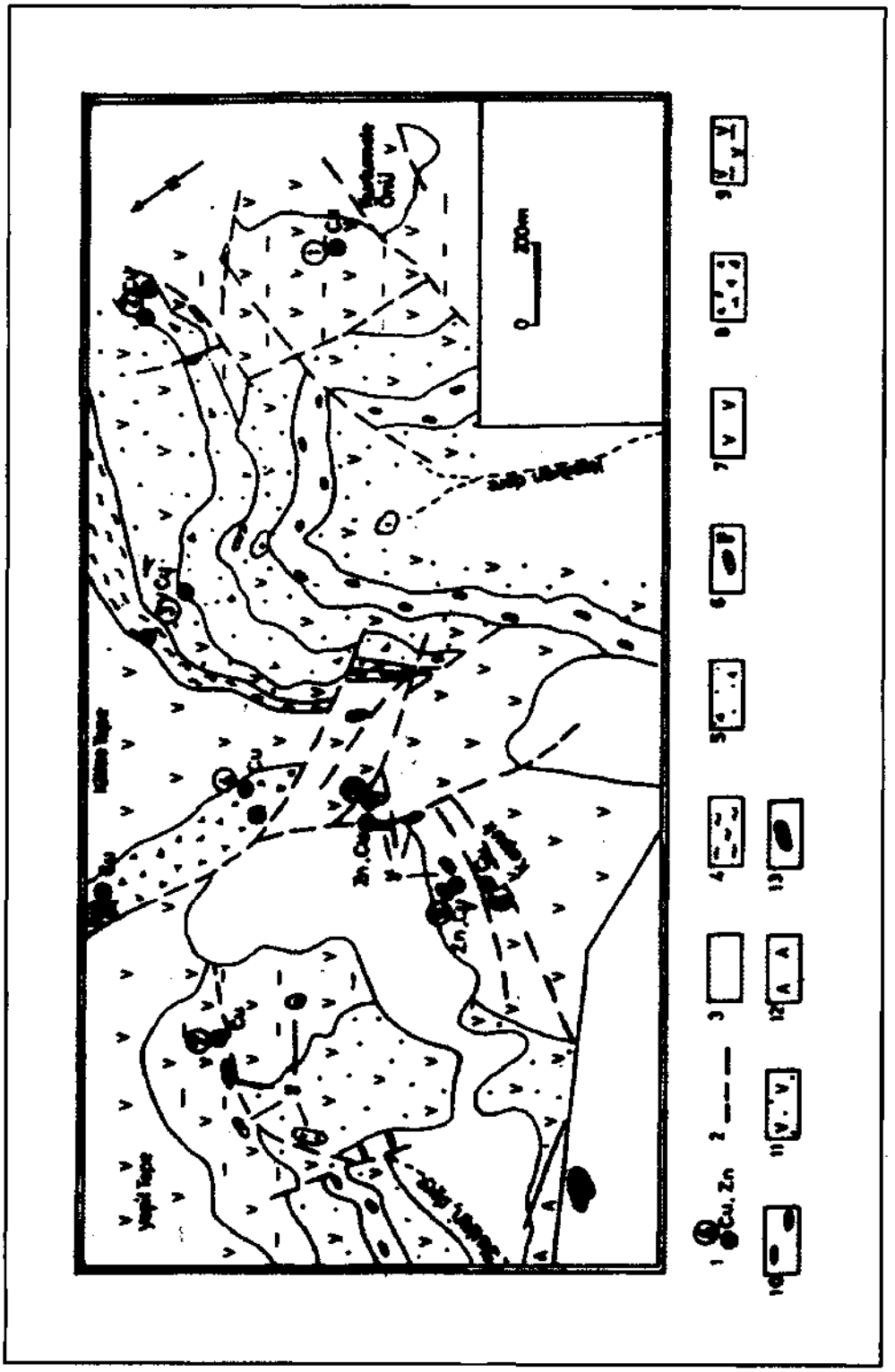

Fig. 5- Geological map of Kilise tepe. 1- Cu, Zn - ore occurrence, 2- fault, 3- rubble, 4- mylonitic zone kaolinized and pyritized, 5.- strongly alterated tectonic brccia, 6- quartzdiorite, 7- rhyolite and rhyolitic breccia, 8- strongly silicified and mineralized rhyolite volcanic breccia, 9- rhyodacite, rhyodacitic tuff, breccia and tuffaceous sandstone with chert and fossil remains, 10- tuffaceous sandstone and conglomerate, 11- rhyodacite, rhyodacitic tuffs, breccia and tuffaceous sandstone, 12- epidotized sandstone and tuffaceous sandstones, 13- sleg dump.

Copper mineralizations

Occurrence No. 1.- It is located on northwestern slopes of Kurtumele önü, at around 200 m from trigonometrical point, 1962 m of altitude. The minerali-zation occurs along a fault, observed at about 200 m, represented by pyrite and subordinated chalcopyrite, accompanied by limonite, mostly produced by pyrite oxidation. This is a vein 5 cm thick, visible along the mentioned fault for about 100 m. Chalcopyrite is irregu-larly distributed, judging from high variability of copper contents from 0,07% to 2%. In contrast to chalcopyrite, the pyritization is spread over the country rocks at 20 m in both fault sides. This is a nearly N - S trending fault, cutting the rhyolitic tuff.

At around 250 m easterly of this occurrence there is an outcrop of altered rhyolite with Cu-mineralization, showing grades of 0,3% Cu and 0,05% Zn.

Occurrence No. 2.- To the north-northeast from the occurence No. 1 extend rhyolitic coarse grained tuffs, with local appearences of cherts with Radiolaria (determined by D. Pesic, in Popovic, 1972). These tuffs are more or less silicified and pyritized. The occurrence No. 2 is at 400 - 500 m from the occurrence No. 1. These are actually two mineralized localities at a distance of around 80 m, being of similar features, thus being marked under a common number. This segment of the field is strongly technically fractured, and in a relatively limited area the six faults with various directions, cutting an old brecciated zone (probably tectonic in origin), highly silicified, kaolinized and pyritized, have been observed. Both outcrops of the Cu-mineralization are linked with this zone. At the northern contact of this zone is quartzose sandstone. From the other side, in the tectonic zone itself the appearences of contact metamorphism is visible, produced by quartzdiorite intrusions found in the surrounding of these mineralizations. For that reason mineralizations seem to be in direct genetic relation with mentioned minor quartzdiorite bodies. It is interesting to stress that the main ore mineral is chalcopyrite, whereas pyrite is subordinate and in that occasion chalcopyrite replaces pyrite, being younger of it. Beside these two minerals the paragenesis includes hematite (specularite) too, as well as rare sphalerite grains. Among secondary minerals chalcocite and rare malachite have been detected.Pyrite grains are commonly fractured, indicating their relative time of origin, compared with chalcopyrite, but the tectonic events as well, producig these breccia zones.

The Cu-mineralization is exposed over an area of about 10 m^2. Two channel samples both 0,2 m in length exhibited copper grades from 0,28% to 1% and zinc contents from 0,02% to 0,12%. With regard to general (vein-impregnation) feature, environment (tectonical breccia), geochemical limit (primary dispersion halo was investigated), this occurrence would not be interesting in particular, but being found in the same breccia zone as the occurrence. No. 3, it is considered that the zone as a whole should be systematically studied, cosidering the large dimensions of tectonic zone and that it includes quartzdiorite bodies, to which these mineralizations are generally related.

Occurrence No. 3.- Resembling to the previous one, three mineralizations are present here as well, one being represented only by chalcopyrite fragments as ore clasts. All of three mineralizations are located in the source part of the Kopitvan Dere stream. This is actually a highly silicified and pyritized zone, affected by intensive oxidation, related to the same tectonic zone as the occurrence No. 2. It should be stressed in particular, as visible on the map as well (Fig. 5), that at southern and southeastern slopes of Kilise Tepe two tectonic zones have been distinguished: one represented by mylonite and the other by silicified breccia. These arbitrarily estimated two zones are separated by the Rhyolite Volcanic-Sedimentary Formation, being reduced in southeastern parts by joining of both zones into a single zone. On the basis of such a statement it has been adopted opinion that this is the same single zone of considerable dimensions in all directions. In its upper part have been registered one and in the lower part two copper mineralizations. However, the geochemical anomalies of primary dispersion haloes are to be focussed, in which the copper grade is over 500 ppm; in such a way five to six or probably more Cu-mineralizations could be considered.

At 300 m to the southeast of Kilise Tepe an occurrence of Cu - mineralization was found in mylonite. The sampling was done by partial trenching and in a 1 m long channel sample a copper grade 0,43% was registered; in another sample at about 15 m to the south from the trench the copper content in a 0,5 m long sample was 0,23%. In both samples the zinc contents were less then 100 ppm. Otherwise, in this mineralization pyrite is principal and almost unique mineral, beside some subordinate chalcopyrite. The lower part of the tectonic zone, accompanied by strong silicification, pyritization and oxidation, was also trenched, but only individual fragments of the chalcopyrite ore were

found, showing 17,90% Cu. These are fragments of chalcopyrite-pyrite mineralization with zinc and lead grades less than 100 ppm. Unfortunately, we could not find the source of these fragments (oreclasts), thus cosidering that in the tectonic zone a larger orebody was fractured, and by motions along the zone the fragments (oreclasts) were brought into the contemporaneous erosional level. This assumption could further envisioned the Volcanic-sedimentary formation as well, taking place in the footwall part of tectonic zone, considering that it has existed a stratiform orebody, which is tectonically cut, providing the mentioned ore fragments. But this is only an assumption. It should be also added that at 300 m to the west a weak copper mineralization grading 0,08% Cu, and about 100 ppm or lesser zinc and lead, had been detected. It is of an importance to be noticed that this tract of land (easterly from the Kilise Tepe - Kopuk ridge) is depleted in zinc, and copper is practically the only metal (excluding iron) showing increased contents. Investigation of mineral composition of Cu - mineralizations in the source part of the Kopitvan Dere stream have indicated that chalcopyrite and pyrite are the most abundant ore minerals, concerning chalcopyrite as dominating in oreclasts, and in all other cases pyrite is leading ore mineral. It is interesting to be noticed that in cases when pyrite is chief mineral, chalcopyrite occurs in it along fissures and in some cases hematite is observable as well. Covelite and limonite as secondary minerals are constantly present. The size of pyrite grains are very variable, ranging from microscopic dimensions to 0,5 cm in diameter, exhibiting octahedron and pentagonal dodekahedron as the most common forms.

Occurrences Nos. 4 and 5.- Both of these occurrences are related to the same silicified rhyolitic volcanic breccia, gray-violet in color, occurring on western slopes of Kilise Tepe. This mineralized breccia zone of northern trending is more than 600 m long and around 140 m wide (real thickness is not known). From the western side it is bound by a fault zone and it grades easterly into Formation of rhyolite and rhyolitic breccia.

In view of exceptionally inaccessible and impassable terrain, in the breccia only three outcrops of Cu mineralizations have been registered (two exposures in the southern part are assigned as occurrence No. 4 and the No. 5 is located in the northern part). This breccia is subdivided as an individual geological body or formation, with regard to the strong silicification, pyritization and Cu - mineralization, compared with the other part of Formation of rhyolites and rhyolitic breccia.

Estimation of metal contents had been done at place assigned as occurrence No. 4 by spot sampling (samples are 0.2 m in length), being not possible to make a systematic sampling of such a large mass of the mineralized rhyolitic volcanic breccia. The eastern mineralization exhibited 0.2% Cu and the western one, situated at 150 m far from the first one 0.1% Cu. It is interesting to be emphasized the molybdenum anomaly for 500 ppm Mo, discovered by geochemical investigations, which could be characterized as Mo - mineralization, but molybdenite has not been detected by explorations to date. In-that way, molybdenum would not be taken into consideration, nevertheless that such anomalies even of higher metal contents had been registered in other parts of western slopes of the Kilise Tepe - Kopuk ridge.

The Cu - mineralization itself is situated along a fault zone, occurring near the contact of this rhyolitic breccia with the principal Formation (Fig. 5). The dominating ore mineral is pyrite, accompanied by rather subordinated chalcopyrite!. The most abundant nonmetallic mineral is quartz, which is younger tham pyrite and chalcopyrite.

On the northern slopes of Kilise Tepe an exposure denoted as occurrence No. 5 is located at 500 m north of outcrops marked under No. 4. This is, however, the same silicified rhyolitic volcanic breccia where the showing No. 4 has been registered. This zone continues to the north, but unfortunately it was impossible to follow it to its very end because of rough topography and missing of corresponding topographic maps. The mineralized exposure 5 x 3 m in size was sampled by trenching, forming a 0.5 m deep and 3 m long cut by blasting, where an 1.5 m channel sample (supposing the homogenity of mineralization) was taken, exhibiting copper content 0.21% and zinc 0.1%, with only traces of lead (70 ppm).

The ore paragenesis constitute pyrite (the most abundant), then chalcopyrite, sphalerite and sporadic galena. The crystallographic form of pyrite is here also cube and pentagonal dodekahedron as in the Anayatak orebody.

If taken into consideration the lithological environment appearence figure of Cu - mineralization (stockwork-impregnational), ore paragenesis, crystallographic form of pyrite, it could be concluded that there is a cosiderable similarity between Cu - occurrences in this volcanic breccia and roof parts of the Anayatak deposit.

From the other side one has impression that these mineralizations and silicified (rhyolitic) breccia are related to the same zone in which the Anayatak and Çakmakkaya deposits are present.

As far as concerned dimensions of these volcanic breccias (more than 600 m in length and 150 m in width), despite the relatively low copper grades (from 0.1% to 0.21%), they still represent a certain potential, confirmed by the fact that beneath this ore zone occurs a massive Cu - orebody, marked as Occurrence No. 7.

Occurrence No. 6.- Is situated at northern flanks of the Kopuk hill (the peak altitude 1795 m). One part of it is linked with the fault zone, and the other occurs as impregnations in the space between this zone and another fault parallel to the first one, at a distance of about 60 m. (Fig. 6).

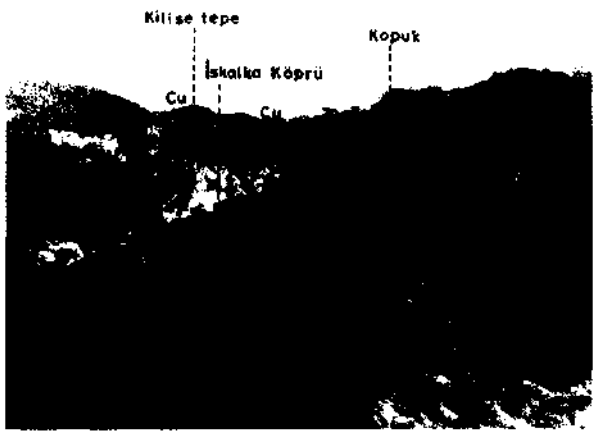

Fig. 6- Cu - Zn ore occurrences on the Kilise tepe - Kopuk ridge.

The mineralized fault zone is 1 m thick, whereas the ore vein, embedded in. it is 0.5 m in thickness, including pyrite and chalcopyrite as chief minerals, in some parts with traces of sphalerite and galena. The ore vein has been traced at only 10m, because of very steep slopes in the relief. In a 0.5 m long sample the contents of 0.3% Cu, 24 ppm Zn and 100 ppm Pb were found.

Occurrence No. 7.- Is located in the source part of the Skutari Dere stream, at about 700 - 800 m to the west of Kilise Tepe (altitude 1970 m). It occurs in "the. Volcanic-sedimentary Formation, composed of coarse grained rhyolitic and rhyodacitic tuffs, breccias and tuffaceous sandstones with radiolarian cherts. This is one of the most widespread formation, locally with higher pyrite impregnations (especially near the fault zones).

Here discussed occurrence of Cu-mineralization, occupies approximately the space between two nearly parallel faults. This is an evidently stratiform orebody showing thickness 2 m and length 5 m. The Cu-mineralization, appearing as impregnation grading into country rock, occurs within coarse-grained rhyolite, which is silicified, sericitized, chloritized and weakly argillized.

Two samples exhibited copper contents 1.8% and 2%, wheres zinc and lead grades were extremely low (less than 150 ppm Zn and 10 ppm Pb). The most abundant ore mineral is pyrite, accompanied by chalopyrite, covellite and limonite, these two of them as secondary minerals.

Zinc and copper mineralizations

Occurrence No. 8.- Is situated on western flanks of the Kilise Tepe - Kopuk ridge, forming with the occurrence No. 9 an unique zone, embedded in quartzdiorite, but they are distinguished as two localities being distanced at more than 200 m.

Volcanites of rhyolitic composition (rhyolite and corresponding breccia) are the main formation in this segment of the field, beside minor intrusions of mineralized quartzdiorites injecting rhyolites.

The mineralized zone trends parallel with the Kilise Tepe - Kopuk ridge, including the richer or weaker zinc mineralizations. The increased zinc contents occur not only in quartzdiorite, but also in volcanites. Taking into cosideration the zinc mineralization with Zn contents over 500 ppm, it constitutes a zone more than 400 m in length; the highest content in volcanites are to 0.1% Zn, whereas in quartzdiorite intrusions they range from 1% to 10%, usually accompanied by increased copper content, varying from 500 ppm to 0.5%. The occurrence No. 8 is characterized by mineralization of yellow sphalerite occurring chiefly in a sill, exhibiting thickness 0.5 - 2 m (Fig. 7) observed at 20 m in length. The zinc content is 1% and copper 0.5%; here are also remarkable secondary copper minerals, such as malachite, covellite and chalcopyrite. At about 40 m farther to the east occurs another quartzdiorite sill, also injected into a volcanite of rhyolitic composition, with an intensive pyrite-chalcopyrite mineralization, exhibiting grades of 1% Cu and 0.025% Zn (in a 0.2 m long sample). This mineralization is situated at the contact of quartzdiorite and rhyolite, represented by pyrite and chalcopyrite, with malachite and covellite as secondary minerals.

Fig. 7- Mineralized quartzdioritic sill (Y) in rhyolitic volcanites.

Occurrence No. 9.- Is located on the northern flanks of the Kopuk hill at 140 m from the peak or about 100 m northerly from the copper occurrence No. 6. This is also a mineralized quartzdiorite body, observed at about 4 m in length and 1 m in thickness. The quartzdiorite, being injected into rhyolite, as the previous ore occurrence, is simply soaked by sphalerite. This is metasomatic coarse grained sphalerite (grains are 3 mm in size) with little chalcopyrite of finer grains, replacing sphalerite. Only one sample was gathered from this locality, exhibiting 10% Zn, 0.05% Cu and 0.03% Pb.

This rock is microscopically determined as biotite microdiorite, affected by vigorous chloritization, calcification, sericitization, argillization and weaker silicification.

Observed as a whole, the space or zone respectively between occurrences Nos. 8 and 9 is focussed as an interesting zinc mineralization, accompanied by copper, being in direct association with quartzdiorite or with fracturing structures injected by small quartzdiorite bodies, probably forming channelways for posterior hydrothermal solutions bringing the described mineralization. These structures are generally of north - south to east - west trending.

All presented data may suggest an assumption on existence of a larger diorite to granodiorite mass as a possible bearer of the porphyry type copper and zinc mineralization.

THE POTENTIAL ESTIMATION

According to available data, it could be considered that the tract of land between Kopuk to the southeast and Yeşil tepe to the northwest represents an area composed chiefly of volcanic and volcanic-sedimentary complexes, with subordinated minor quartzdioritic intrusive bodies, observed as:,exposures. On the basis of the appearance figure of quartzdiorite, lithological environment and mode occurrence of mineralization, four types of ore occurrences are to be distinguished (Fig. 8).

The first is vein type of Cu-mineralization with minor zinc and lead. These veins in all cases coincide with fault zones, exhibiting relatively high copper contents (to 2%).

The second type is represented by rich copper mineralization in from of "oreclasts" registered in the Kopitvan dere stream, as well as the occurrence No. 9, which could be supposed, according to preliminary information, to be stratiform mineralization. The both occurrences are embedded in volcanic-sedimentary complex, and from that reason it is logical the discovery of a stratiform copper mineralization to be expected.

The third type, considered as volcanogenic in origin, is placed in large masses of rhyolitic volcanic breccia. Two outcrops exhibited relatively low copper contents, but in deeper parts the more favorable contents, as for example over 0.5% Cu, could be expected, forming ore reserves at least 10 -20 million tons of arbitrary poor copper ore. Here it should be added that chalcopyrite-pyrite oreclasts in Kopitvan dere probably derive from the same zone in which the Anayatak - Çakmakkaya ore deposits are situated.

The fourth type is represented by zinc mineralizations accompanied by copper, occurring in minor quartzdiorite masses, injected along fault zones, bearing relatively high zinc grades (to 10% Zn). On the basis of such statement, as well as of copper and zinc contents in quartzdiorites (diorites/granodiorites) in other localities (for instance, on the Borçka - Artvin road, in granodiorites the contents of 0.25 Zn, 0.1% pb and 0.02% Cu have been found; on the road to Melo in the same rock the chalcopyrite and malachite have been observed) it could be supposed that in the deeper parts of Kilise tepe area exist larger granodiorite masses, the more so that to the south from this terrain occurs the large Tiryal Dağ - Tatos Dağları granodioritic pluton. In such a geologic situation the existence of the porphyry type of zinc and copper mineralization could be further supposed. In such a case the mineralized quartzdiorite bodies would represent only apical parts of a larger mineralized granodiorite mass.

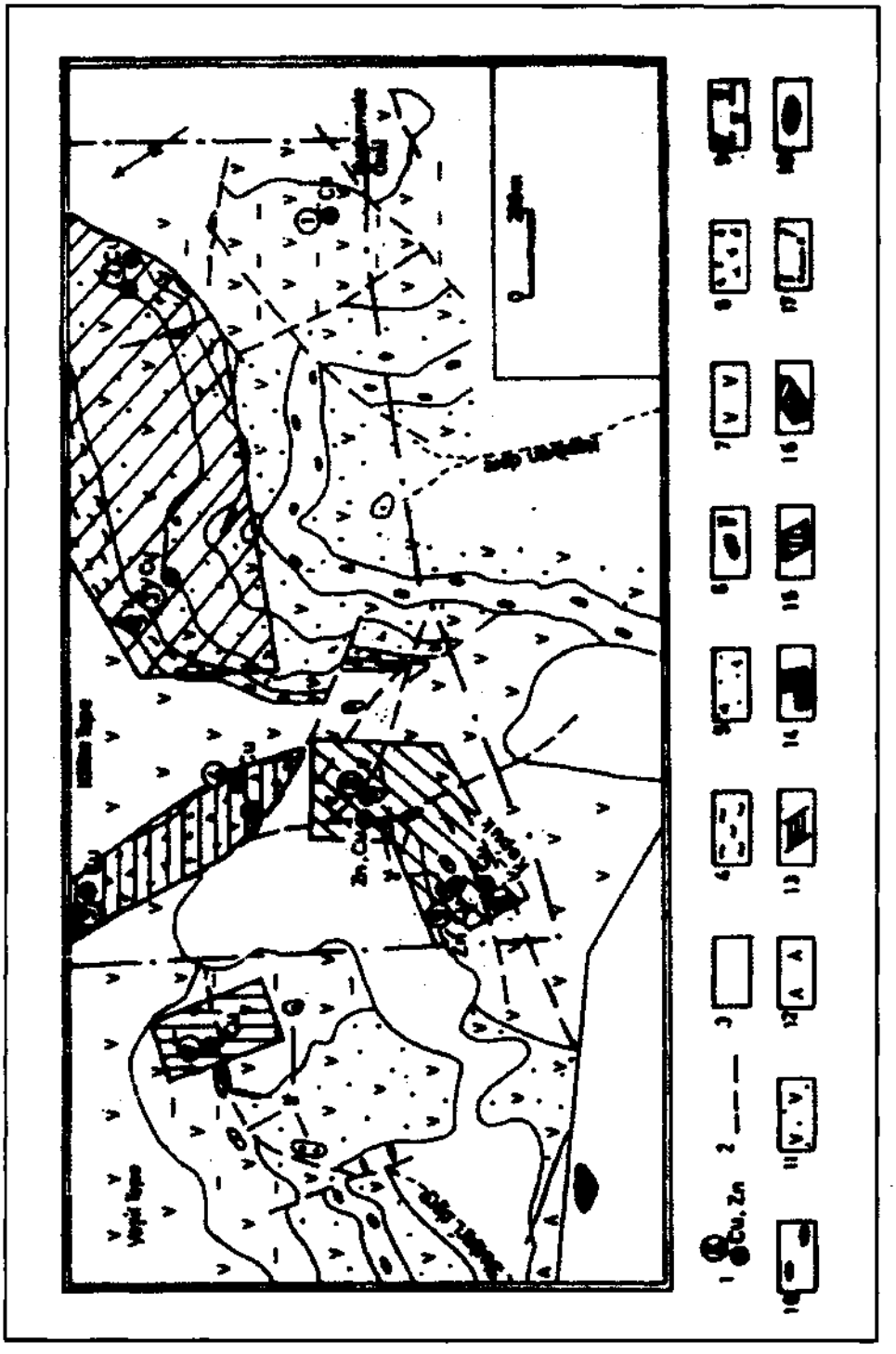

Fig. 8- Geological map of Kilise tepe and surrounding area showing potential mineralizations. 1- Cu, Zn - ore occurrence, 2- fault, 3- rubble, 4- mylonitic zone, 5- strongly alterated tectonic breccia, 6- quartzdiorite, 7- rhyolite and rhyolitic breccia, 8- strongly silicified and mineralized rhyolite volcanic breccia, 9- rhyodacite, rhyodacitic tuffs, breccia, and tuffaceous sandstone with chert and fossil remains, 10- tuffaceous sandstone and conglomerate, 11- rhyodacitic tuff, breccia and tuffaceous sandstone, 12- epidotized sandstone and tuffaceous sandstone, 13- volcanogenic type of Cu-mineralization, 14- vein type of Zn-Cu-Mo - mineralization, 15- stratiform type of Cu mineralization, 16- chalcopyrite oreclasts in tectonic zone, 17- area where is expected porphyryc type of Cu, Zn sulfide mineralizations, 18- sleg dump.

This (Zn-Cu) type mineralization is younger than Cu - minaralizations in the Kopitvan Dere stream and in the source part of the Skutari Dere stream, which are linked with older volcanic activity.

Beside the aforementioned, it should be noticed that along the western part of the Kilise Tepe - Kopuk ridge a prominent zone of molybdenum geochemical anomaly has been distinguished, reflecting primary dispersion haloes, exhibiting molybdenum contents to 1000 ppm. This zone is running along with zinc and copper occurrences, thus it could be related to the quartzdiorite bodies. However, if molybdenite or any other molybdenum mineral has not been detected so far, it cannot be more seriously discussed as a Mo-mineralization, although content of 1000 ppm are of economical importance.

Finally, in favor of considerable Cu and Zn potential of this district a slag dump has been found at 600 - 800 m to the west of Kopuk, covering an area of about 200 m^2, with visible thickness more than 1 m the slag fragments are stained with malachite and covellite. The chemical analysis of this slag exhibited following contents: 4% Cu, 0.6% Zn and 0.04% Pb. According to these records, first of all the high copper grades, as well as the visible secondary copper minerals, it is evident that the very rich ore was treated by primitive method, leaving much copper in the slag. It is not known the origin of ore and who exploited it, but discovery of rhyolite fragments in the slag points out the same lithological medium as in source part of the Skutari Dere stream. Beside these facts, it is evident that the ore was not transported uphill from the lower parts of the field even that there exists a deposit, neither from the tract of land easterly of the Kilise Tepe - Kopuk mountain ridge. It is logical that the smelted ore derived from the field sector west of the Kilise Tepe - Kopuk ridge.

CONCLUSION

From the aforementioned, it is evident that the source part of the Kopitvan Dere and the field sectors trending westerly of the Kilise Tepe - Kopuk mountain ridge are considerable promising for discovery higher copper and zinc concentrations. For that reason the continuance of systematic investigations and explorations is suggested, taking into account the fact that this district represents a continuation of the Anayatak - Çakmakkaya zone, even more so that between these two deposits from one side and Kilise tepe ore occurrences from the other side, occur mineralizations in the Lebiskur dere valley as well, actually cutting the Anayatak - Çakmakkaya - Kilise Tepe ore-bearing zone. The unique character of this zone is proved by numerous identity features of ore deposits and occurrences along it.

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ABSTRACTS OF THE PAPERS PUBLISHED ONLY IN THE TURKISH EDITION OF THIS BULLETIN

LITHOSTRATIGRAPHY AND SEDIMENTOLOGY OF THE MIOCENE BASIN BETWEEN MUT-KARAMAN, (CENTRAL TAURIDS)

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ABSTRACT.- The study area includes Mut-Karaman part of the Mut Miocene Basin. Lowermost lithostratigraphic unit of Miocene is Göcekler formation which is represented by mudstone and conglomerate of Aquatian age. This formation is unconforably overlies the late Cretaceous basement. The Göcekler formation gradually pass both laterally and vertically into the Aquatian-alt Burdigalian The Fakırca formation which is characterized by clayey limestone/sandstone and coal bearing shale. Clayey limestone part of the Fakirca formation is recognized as the Kestelkapızı member. Marine rock units in the region can be grouped into five formation: The Mut formation, the Köselerli formation, the Dağpazarı formation, the Tirtar formation and the Ballı formation. The Mut formation, the Köselerli formation and the Dağpazarı formation is form the lower part of the sequence. At the upper part of sequence there are the Tirtar formation and the Ballı formations. The Mut formation and the Köselerli formation are represented by limestones, clayey limestone and marl, whereas the Dağpazarı formation consist of calcarenite, limestone, claystone, mudstone. Mut formation and Köselerli formation are laterally transitional and are of Upper Burdigalian-Langian-Serravalian (?Lower Serravalian) age. The Dağpazarı formation was deposited in Langian-Serravalian (?Lower Serravalian) time interval. The Tirtar formation is represented by limestone and unconformably overlies the Dağpazarın formation. The Tirtar formation is represented by limestones. The age of the Tirtar formation is Serravalian (?Upper Serravalian)- Tortonian. The lateral equivalent unit of the Tirtar formation is the Ballı formation and is composed of clayey limestone and marl. At the top, Pliocene continental elastics and lacustrine limestones unconformably overlies the Miocene sequence.

GEODYNAMIC PHASES OF THE ARAÇ MASSIF, WESTERN PONTIDS, KASTAMONU, TURKEY

Doğan AYDAL*****

ABSTRACT- This paper is concerned with the geological, mineralogical and geochemical properties of Araç massif. The Araç massif is mainly composed of ophiolites and metamorphic rocks. The age of the metamorphic rocks, which are dominant rock group in the study area, are ranging from Pre-Malm to Upper Cretaceous. K-Ar age determination were performed in hornblendes derived from amphibolites, which are previously thought to be Precambriam age in the study area. According to the K-Ar age results, which gives 130-146 ma, suggests that the amphibolites were affected by retrograde metamorphism, which took place in Berriasian (Lower Cretaceous). These ages are believed to represent the metamorphism age, not the occurence age of the formation. Because of this, the occurence of the Bekirçay formation should have taken place before this retrograde metamorphism. Some very intensely altered metaophiolitic bloks were found as xenolits in Bekirçay metamorphic units. Therefore the age of the metaophiolites shoud have been older than the Bekirçay formation. Mercimekdere metaophiolites were overlain, not only by Bekirçay formation, but also by Kavacık formation, which is represented by graphite-garnet micaschist in the study area. The Bekirçay formation and the other above mentioned formation is overlayed discordantly by Palaeozoic metasediments, namely the Dumantepe formation, which consists of various low grade schists and phyllites. The Mesozoic is represented by Yongalıdağ formation, Pelitveren ophiolitic melange and serpentinized, carbonatized and sillicified rocks, so called listwaenites of the Gemiköy formation. Finally, this Mesozoic formations were transgresively superseded by biosparite and biomicrite units of the Araç formation. The area and surroundings were then affected by post Eocene faulting. According to the geochemical investigations, it can easily be said that ultramafic rocks occured as mantle fractionates and all mafic rocks were originated from subalcaline tholeiitic magma. Amphibolites are found as metaluminous, while garnet-micaschist are peraluminous and epidote-amphibolites show both character in different places. Carbonaceous rocks in the study area are found to be rich in calcite rather than dolomite and other minerals.

MINERALOGY-PETROGRAPHY AND GEOCHEMISTRY OF KONYA MIOCENE VOLCANIC UNITS AND GENERAL DETERMINATION OF NEOFORMED CLAY MINERALS

Selahattin KADİR* and Zehra KARAKAŞ**

ABSTRACT.-Volcanic, sedimentary and volcano-sedimentary units are wide spreaded in south and southwest of Konya. Mineralogy and micromorphology of ignimbrite and nuee ardentes as well as domes exhibit characteristic of rhiyolite, dacite, andesite, basalt and tuff. Tuffs are classified as vitric, lithic and crystal tuffs, based on the volcanic glass, rock fragments and crystal properties while Argillisation and limonitisation are common in tuff, these alteration products are less or not present in the other volcanic rocks. Generally, argillisation and limonitisation are dominant in the fracture of volcanic glasses, which is the main component of tuffaceous units. In addition, argillisation is observed in feldspar and opacitazat and chloritisation in biotite and hornblende. As a result of XRD studies in the tuffaceous units Halloysite, kaolinite, smectite, palygorskite and illite type clay minerals and opal-CT, feldspar, quartz, amphibole, serpentine, minamiite and jarosite type non-clay minerals are determined SEM studies indicate that halloysite, kaolinite and smectite are generally developed in the dissolution voids and fractures of volcanic glasses. Chemical analyses reveal that halloysite, kaolinite and smectite units and adjacent volcanic rocks are similar. Formation of clay minerals in the study area are controlled by the movement of water as well as the mobility of the ions of volcanic glass and feldspar. The field observation, mineralogical, chemical, and micromorphological determinations indicate that halloysite, kaolinite and smectite could be formed diagenetically following the period of depositions of tuffaceous materials by the effect of ground and meteoric water.

GEOCHEMiCAL PROPERTIES THOSE IDENTIFYING THE ENVIRONENT OF MANGANESE OXIDE MINERALIZATION OF KASIMAĞA (KESKİN - KIRIKKALE)

Şükrü KOÇ**, Öner ÖZMEN*** and Nursel ÖKSÜZ****

ABSTRACT- Kasımağa Mn- oxide ore deposit is found in basalt, radiolarite and marl of pelagic deposits of ophiolitic series of Kırşehir massif in the form of scattered, banded or bedded structures of varying thinckness. Paragenesis of ore mineralization is formed by braunite, pyrolusite, ramsdellite, geothite, hematite, and magnetite. Based upon the findings from the analysis of samples such as low-and variable Fe/Mn ratios; low trace ele ment contents and negative anomaly of Ce (a rare earth element) suggest that ore mineralization took place under submarine hydrothermal condition. Two major different clusters determined from the major and trace elements were attributed to the rigorous fractionation developed mainly from the same solution.

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