THE RELATIONSHIPS BETWEEN Cu-Pb-Zn MINERALIZATIONS AND CERTAIN STRUCTURES IDENTIFIED ON LANDSAT IMAGES IN THE EASTERN BLACK SEA REGION

Bahri YILDIZ*

ABSTRACT. — Number of circular, semicircular and elliptical structures, which have close relationships with the Cu-Pb-Zn mineralizations, have been identified on Landsat images. It is probable that the circular and semicircular structures are the centers of volcanism of Late Cretaceous, and elliptical structures are the eroded calderas. Drainage patterns which have developed on circular and semicircular features, forms on distinct patterns.

INTRODUCTION

The Eastern Black Sea Region contains a wide range of Cu-Pb-Zn mineralizations (Fig. 1). Hence many geological studies have been undertaken since 1912 and some of which still continue (Kovenko, 1943; Zankle, 1959; Schultz - Westrum, 1958, 1961; Pollak, 1961; Turkish and Yugoslavian team, 1968, 1970; Şarman, 1975; Popovic, 1975; Akıncı, 1975, 1982 etc.). In these studies many different approaches have been suggested regarding mineralization and its relation to fracture systems, fold axes, granitic intrusions and volcanism.

It is well known that Landsat images are very useful tools for geological studies (mineralizations, lineaments, rock types, hydrology etc.) because they save time and cover extensive areas. During this study, Landsat-2 images, dated 16 April 1975, 20 Agust 1975, 21 August 1975 and 29 September 1975, identificatWnumbers; 2084-07170, 2210-07153, 2211-07214 and 2248-07271, were used respectively. The scale of images were (1 :1.000.000, 1:500.000 and 1:250.000) and they were analysed in black and white and false colours. Moreover, the scale of 1:60.000 of air photographs were also examined. Because the study area was covered by dense vegetation, it was not possible to make a lithological map.

GEOLOGY OF THE REGION

The Eastern Black Sea Region is situated within the Pontid tectonic zone and developed between Jurassic-Pliocene as a part of Pontid-Elbruz volcanic island are chain (Dixon and Pereira, 1974). This region is effected by Caledonian, Hercynian and Alpine orogenesis (Hamamcıoğlu and Sawa, 1971). The Alpine volcanism started in the Jurassic and became intense and widely distributed during the period of Cretaceous-Eocene time. At the begining of the Jurassic, south of the Eastern Pontids, opening up of the North Anatolian Tethys started. There is strong evidence indicating that at the begining of Early Cretaceous, the oceanic crust of the North Anatolian Tethys began to subduct beneath the Pontids (Şengör and Yılmaz, 1983). In the Late Cretaceous, volcanism expanded as the result of this subduction. According to Şengör and Yılmaz (1983), the northern branch of the Tethys closed between Paleocerte-Lutesian, on the other hand, Tokel (1977) claimed that the closure occured in the Oligocene time. During Early Paleocene (?) - Early Eocene the Anatolid-Torid platform collided with the Pontids (Şengör and Yılmaz, 1983) As a result of this collision a new stage of magmatizm developed in the area.

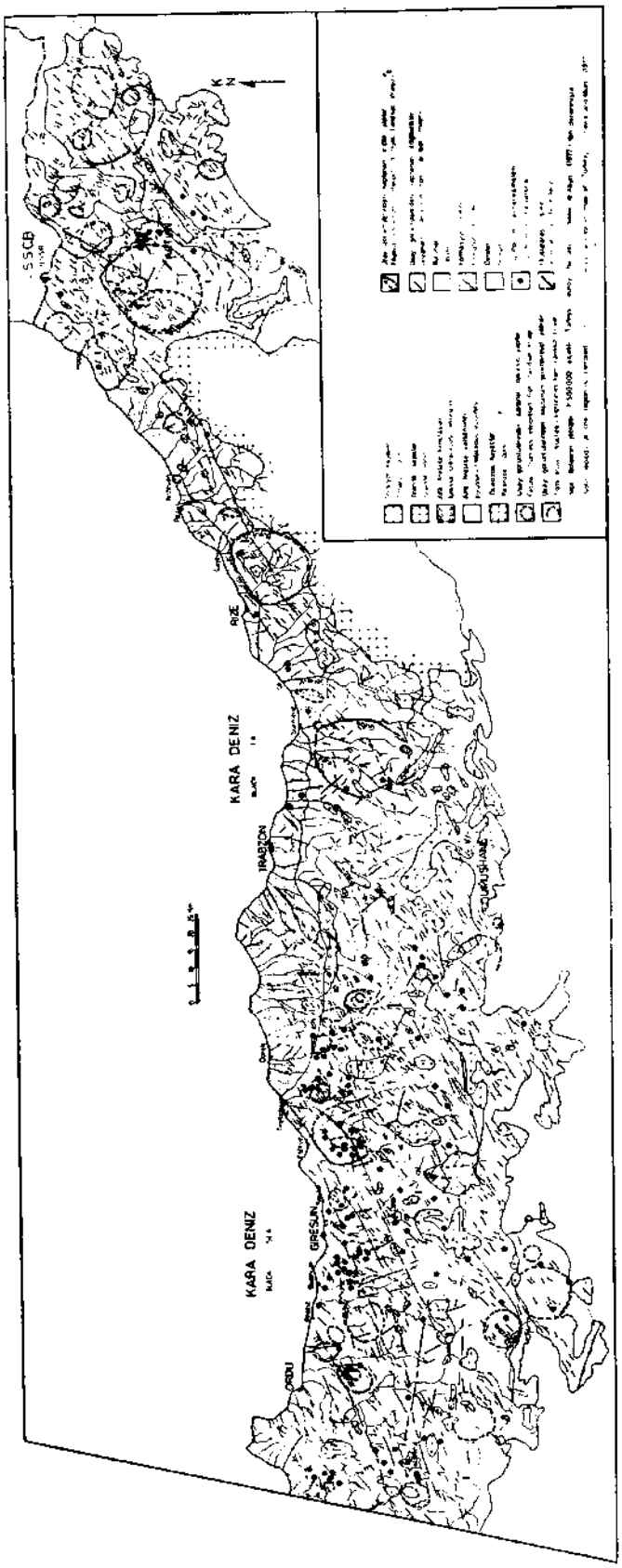

Fig. 1 - The relationships between Cu-Pb-Zn mineralization and certain structures (circular, semicircular, cliptical and fracture) and drainage pattern in the Eastern Black Sea Region.

From older to younger, the major stratigraphic units of the region are as follows; (Schultz -Westrum, 1958, 1960, 1961; Turkish and Yugoslavian teams, 1968; Sawa and Altun, 1971):

1. The basement rocks within this region, are of the Paleozoic age, metamorphic cristalline schists and granits.

2. Jurassic (Lias) conglomerates which are covered by sandstone, marl and spillites.

3. Lower basic series: This series, is the first volcanic unit of the region, consisting of spillites, basalts, andesites, lavas, aglomerates and their pyroclastics. The age of this unit is Late Jurassic-Early Cretaceous. These series were partly intercalated with marl, limestone with marl, siltstone and sandstone.

4. Lower dacitic series: This series which is Senomanian embraces dacites, riodacite lavas, aglomerates and their pyroclastics. It shows calcalcaline characteristics (Tugal, 1969). This series is named as «minerallized dacite» in the region, because it is the host rock for the stockwork, massive and vein types of mineralizations.

5. Upper basic series: This comprizes of basalt and andesitic lavas and their sills with pyroclastics intercalated with marn and limestones of the Senonian-Eocene age.

6. Granitic rocks of the Tertiary age.

7. Young volcanism which is seen in the Oligocene-Pliocene age contains basalts, andesitic breccias and volcanic pebbles with marl and limestone.

TECTONICS

The Eastern Black Sea region can be devided into two distinct region according to tectonic setting; fracture systems dominated within the volcanic rocks which occur in the northern part of the study area (Kovenko, 1943; Schultz - Westrum, 1958;Pollak, 1961; Turkish and Yugoslavian team, 1968, 1970; Simonovic, 1972; Göksu et al., 1974; Çağatay, 1979), and folding, dominated within the sedimentary rocks which occur south of the volcanics (Gattinger et al., 1962; Erentöz and Ketin, 1974; Göksu et al., 1974).

As a result of the study of Landsat images, it is believed that most of the lineaments coincide with the fracture patterns. Two main directions of lineaments are developed in NE-SW and/or NW-SE in the area. N-S and E-W lineaments are also observed, but they are less common (Fig. 1). The most important folds are Pulur-Artvin anticline, Maden-Ovacık syncline, Çorum and Kelkit synclines and Kopdağı-Akbabadağı anticline. The oldest fracture systems are considered to be NW-SE direction which developed parallel to the same direction of the fold axes which occur in the southern part of the study area. As-it is expressed, on the lineament map of the region (Fig. 1), NW-SE fracture system cuts NE-SW fracture system. It is determined that Tertiary granitic rocks occurred mainly along the NE-SW striking system with the exception of east of Gölköy where granitic rocks developed along the E-W striking fracture system and south of Trabzon where granitic rocks developed along NW-SE striking fracture system (Fig. 1). It is more likely that the NE-SW striking fracture system may have developed before Late Cretaceous because it is thought that this system gave rise to an upheaval of magma which yielded Late Cretaceous volcanism (Fig. 1, 2) (lineaments L1, L2, L3, L4, L5, L6). NE-SW striking fracture system is characterized mainly by a series of normal faults and/or horst-graben structures which are parallel to each other. Within the area between this fracture system, many fractures normal to this system and various directions of fractures developed and NW-SE, E-W and N-S striking fractures may have been created as a result of later tectonic and magmatic activities. This conclusion has also been arrived at by many other scientists who have done detailed studies of the region (Kovenko; 1943; Schultz-Westrum, 1958; Kraeff, 1963; Sawa et al., 1930).

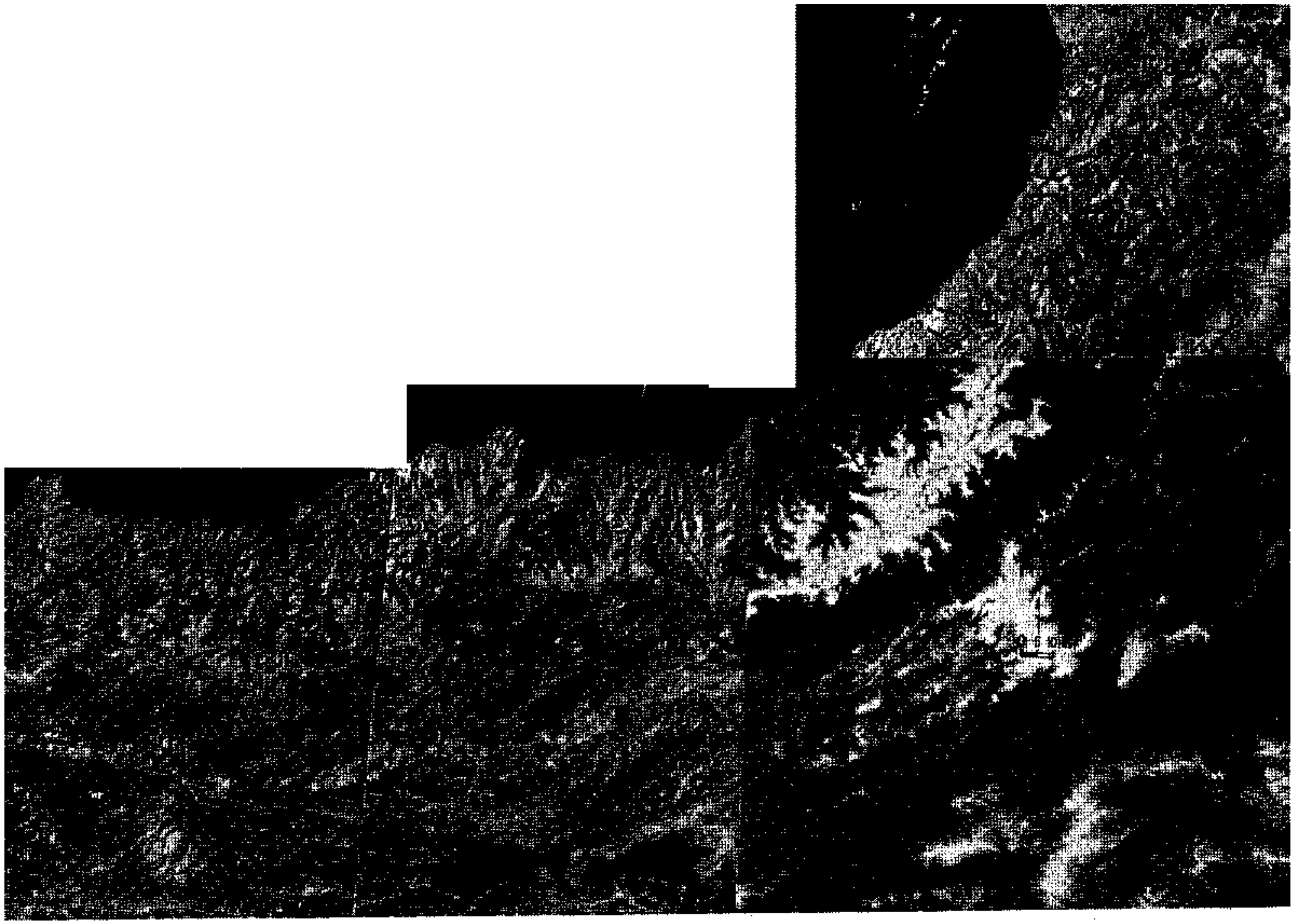

Fig. 2 - Landsat imagery mosaic of the Eastern Black Sea Region.

D - Circular and semicircular structures; DS - The boundary of dome identified by Sawa and others (1970); E - Elliptical structures (circular, semicircular and elliptical structures are show by dotted pattern. The important structures are shown by numbers).

RELATIONSHIP BETWEEN VARIOUS STRUCTURES AND Cu-Pb-Zn MINERALIZATIONS

Cu-Pb-Zn deposits in the Eastern Black Sea region, can be divided into four groups

1. Massive deposits
2. Stockwork type deposits
3. Vein type deposits
4. Skarn type deposits

It is considered that there is a strong relationship between circular, semicircular, eliptical structures, fracture patterns and drainage systems which were controlled by the above mentioned structures, and massive, stockwork and vein types of Cu-Pb-Zn mineralizations. Mineralizations take place in or around these structures (Fig. 1,2; Table 1). Apart from the structures related to known mineralizations, new structures have been discovered that may be associated with mineralizations. These circular and semicircular structures show dome-shaped morphology. These stuructures are the centre of volcanism (especially Late Cretaceous volcanism) which have yeilded complex volcanic rocks. The circular and semicircular structures occurring along the NE-SW striking lineaments support the idea that Late Cretaceous volcanism took place also along these lineaments. (Fig. 1,2) (lineaments L1,L2,L3,L4,L5,L6). According to Pejatovic, the volcanism developed as stratovolcano domes. Later magmatic activities initiated a new series of volcanos and its associated dykes and sills around the domes of the stratovolcano which formed volcanic complexes within the areas of circular and semicircular structures.

Table 1 - The important Cu-Pb-Zn mineralization in the Eastern Black Sea Region

Ore number (Fig. 1)	*Ore name*	*Type*
1	Murgul	Stockwork
2	Kuvarshan	Massive
3	Akarşen	Massive
4	Pironit	Massive
5	Tunca	Massive
6	Çaycli-Madenköy	Massive
7	Kutlular	Massive
8	Harkköy	Stockwork
9	İsrail	Massive
10	Lahanos	Massive
11	Kızılkaya	Stockwork
12	Harşit-Köprübaşı	Stockwork
13	Akköy (Bulancak)	Massive

Since volcanic activities took place within the area of circular and semicircular structures, these localities have become morphologicaly higher. Furthermore the resistance of the volcanic rocks are found to be high against erosion because the volcanism mainly of an asidic origin. Hence, the morphology of circular and semicircular structures expressed in the drainage patterns. Semicircular and circular drainage typically developed (Fig. 1,2), For example around Murgul (D1), Çayeli-Madenköy (D2), İsrail (D3), Lahanos-Kızılkaya (D4), Kabadüz (D6) and Manka (D7) mineralizations (Fig. 2). It is easy to observe typical drainage around the circular and semicircular structures. Thus the relationship between the type of drainage and structures is used as the clue to define the target areas of mineralization.

The elliptical structures in the region, are considered to represent volcanic calderas, which developed as a result of collapse of the crater at the last stage of volcanism (Fig. 1,2).

Volcanism in the region, shows calcalcaline characteristics (Tuğal, 1969; Leitch, 1981). Mineralizations occured mostly at the last stage of dacitic volcanism. Massive mineralization developed around. the wings of the dacitic lava domes as a consequence of exhalative hydrothermal reactions. Stockwork type of mineralizations occurred as the filling of fractures by hydrothermal mineral solutions of subvolcanics around the neck of the dacitic volcanos and lastly vein type mineralization evolved in the tectonic fractures which were filled by mineral solution, which coincided with the wings of andesitic and dacitic volcanic domes (Hamamcıoğlu and Sawa, 1971). Skarn type of mineralization took place at the contact with Tertiary age granitic rocks and limestone of the lower basic series. Stockwork and massive types of Cu-Pb-Zn mineralization are quite similar to the Kuroko type mineralizations which occur in Japan (Tuğal,-1969; Leitch, 1981).

In recent years, the view of the Japanese and Yugoslavian geologists who have worked in the Black Sea Region, supports the above conclusions related to circular, semicircular and elliptical structures. For example Sawa et al. (1970) explained the Murgul mineralization as being a dome structure which was identified during field observations (Fig. 2, DS). It was also pointed out that the domes does not have simple structures, but consist of many smaller domes. They emphasized that the Murgul mine spongey tuffs are the badrock which are the product of large scale volcanic activity and the Caldera developed at the last stage of these volcanic activities. This locality coinsides with the E2 elliptical structure which was identified on the Landsat images. Morever, the centre of volcanism, which was indicated by the same group of geologists, created dacitic lavas around the Murgul mine, which is emplaced on the edge of the El elliptical structure (Fig. 2). Kawada and Engin (1972) and Bora and Roncevic(1970) related Çayeli Madenköy mineralization (Fig. 1,2, D2) and Karaerik and Ağalık mineralization (Fig. 1,2,D4) respectively to dome structures. Turkish and Yugoslavian teams (1968) pointed out that the Kızılkaya mineralization which is emplaced on the edge of elliptical structure must have been deposites should in a major volcanic channel way (Fig. 1,2, E3). The same team as a result of their study around Kabadüz in 1970, related the vein type of mineralization of this region to unexposed young monzonitic intrusions which produced batolites under the volcanic series (Fig. 1,2, D6). Takashima et al. (1974), after working in the vicinity of the Menka mine (Acıdere), concluded that there was a relationship between the vein type of mineralization, andasitic and dacitic volcanism which was reactivated during the formation of the Caldera (Fig. 1,2, D7). All the above informaion emphasizes the importance of more detailed research on the relationships between circular, semicircular, elliptical structures, types of drainage and mineralizations.

Areas in and around the circular and semicircular structures which have not been explored in detail as in Figure 2 (D1,D2,D3,D4,D5,D6,D7,E1,E2 and E3) the circular and other areas of similar structures, are the targetareas for the exploration of the Cu-Pb-Zn mineralizations (Fig. 1,2). These are, in order of importance; the circular structures, to the west of Foldere (Gökçeköy) with circular structures in the vicinity of Karabörk, and Tutak mountain (Şebinkarahisar) and secondly, circular, semicircular and elliptical structures which are defined on or in the vicinity of L1,L2,L4,L5,L6 lineaments.

CONCLUSIONS AND RECOMENDATIONS

1. In the Eastern Black Sea Region, there is a close relationship between Cu-Pb-Zn mineralizations and circular, semicircular and elliptical structures which are defined on the Landsat images.

2. Drainage systems, which have developed on circular and semicircular structures are related to the mineralization, they form distinct patterns.

3. It is likely that the NE-SW fracture systems, which occurred before Late Crretaceous, gave rise to the Late Cretaceous magmatism.

4. Hence it is emphasized that it would be most beneficial to undertake detailed geoloigical and geophysical studies within those areas which are chosen as the target of exploration for Cu-Pb-Zn mineralization.

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REFERENCES

Akıncı, Ö.T., 1975, Görele güneyindeki Koyunhamza ve Çömlekçi dereleri arasında kalan sahanın (Çanakçı nahiyesi civarı) jeolojisi ve maden zuhurları: MTA Rep., 4875 (unpublished), Ankara.

———, 1982, The mineralogy and crystallization processes of the Bulancak sulfide veins: MTA Bull., 93/94,8-19, Ankara.

Bora, E. and Roncevic, G., 1970, Ağalık, Karılar, Karaerik maden sahaları civarının 1:5.000 ölçekli jeolojik raporu: MTA Rep., 4589 (unpublished), Ankara.

Çağatay, N., 1979, Yeni gelişmeler ışığında Türkiye'nin volkanik kökenli masif sülfid yatakları. 1. st Scien. Tech. Con. Geol. Eng. Turkey, 35-56.

Dixon, C.J. and Pereira, J., 1974, Plate Tectonics and Mineralization in the Tethyan Region: Mineral Deposita, 9, 185-198.

Erentöz, C. and Ketin, İ, 1974, 1:500 000 ölçekli, Türkiye jeoloji haritası (Kars): MTA Publ., Ankara.

Gattinger, T.E.; Erentöz, C. and Ketin, İ, 1962, 1:500 000 ölçekli Türkiye jeoloji haritası (Trabzon): MTA Publ., Ankara.

Göksu, E.; Pamir, H.N. and Erentöz, C. 1974, 1:500 000 ölçekli Türkiye jeoloji haritası (Samsun): MTA Publ., Ankara.

Hamamcıoğlu, A. and Sawa, T., 1971, Gelişen yeni görüşler ışığında Doğu Karadeniz bölgesi Cu-Pb-Zn yatakları: II. Scien. Tech. Cong. Mine., Turkey, 64-73.

Kawada, K. and Engin, A., 1972, Çayeli bölgesinin Rize (Turkiye) jeolojisi ve jeolojik yapısı: MTA Rep., 4991 (unpublished), Ankara.

Kovenko, V., 1943, Bakırlı pirit madenleri bölgesi Giresun vilayetinde Esbiye ve Görele dolaylarındaki Karaerik, Ağalık, İsrail madenleri: MTA Bull., 192-209, Ankara.

Kraeff, A., 1963, Geology and mineral deposits of the Hopa-Murgul region: MTA. Bull., 60, 45-61, Ankara.

Leitch, C.H.B., 1981, Mineralogy and textures of the Lahanos and Kızılkaya massive sulphide deposits, Northeastern Turkey and their similarity to Kuroho Ores: Mineral Deposita, 16, 241-257.

Mado, H., 1972, Kuzeydoğu Türkiye'de bulunan Murgul madenindeki Cu cevheri yataklarının jeolojisi ve mineralizasyonu: MTA Rep., 4883 (unpublished), Ankara.

Pejatovic, S., 1977, Complex volcanic arc. evolution and related sulfide metallogeny in the eastern Pontids: Jankovic, S., ed., Metallogeny and plate tectonics in the northeastern Meditarranean da., Faculty of Mining and Geology University Press., Belgrade, 505-521.

Pollak, A., 1961, Die Lagerstatte Lahanos im Vilayet Giresun an der Türkischen Schwarzmeerküste: MTA Bull., 56, 26-40, Ankara.

Popovic, R., 1975, Some of the structural and genetic characteristics and the zonal distribution of nonferrous metals deposits in Eastern Pontides: MTA Bull., 85, 1-17, Ankara.

Sawa, T.; Sawamura, K. and Teşrekli, M., 1970, Murgul madeni ve civarındaki bakır yatakları hakkında rapor: MTA Rep., 4790 (unpublished), Ankara.

———and Altun, Y., 1971, Doğu Karadeniz Bölgesindeki tabakalı ve stockwork tip bakır, kurşun, çinko yatakları: MTA Rep., 1510 (unpublished), Ankara.

Schultz-Westrum, H.H., 1958, Giresun vilayeti Esbiye sahasının jeolojik ve yatakbilimi bakımından etüdü: MTA Rep., 3090 (unpublished), Ankara.

———, 1960, Karagöl yanı ile Eseli yataklarını detaylı tetkik hakkında rapor. Görele kazası, Giresun: MTA Rep., 2922 (unpublished), Ankara.

———, 1961, Das geologische Profil des Aksudere bei Giresun-Ein Beitrag zur Geologie und Lagerstaettenkunde der Ostpontischen Erz-und Mineral provinz, NE-Anatolien: MTA Bull., 57, 65-75, Ankara.

Simonovic, R., 1972, Artvin bölgesinde (Kuarshan, Zinkot, Ursa, Seyitli-Umasen) 1:10 000 ölçekli jeolojik harita alma ve prospeksiyon çalışmaları hakkında rapor: MTA Rep., 5091 (unpublished), Ankara.

Şarman, E., 1975, İsrail ve Eseli güneyindeki G41-bl, b2, b3, b4 ve G42-al, a4 paftalarına ait sahanın 1:10 000 ölçekli jeolojik etüt raporu: MTA Rep., 5447 (unpublished), Ankara.

Şengör, A.M.C. and Yılmaz, Y., 1983, Türkiye'de Tetisin evrimi levha tektoniği açısından bir yaklaşım: Geo. Soc. Turk. Earth. Scien. Spe Publ. 1.

Takashima, K.; Kawada, K.; Hakari, N.; Kılıç, M. and İşler, F., 1974, Menka madeni etrafındaki sahanın jeolojisi ve mineralizasyon Koyulhisar, Sivas ili kuzey kısmı. MTA Rep., 5148 (unpublished), Ankara.

Tokel, S., 1977, Doğu Karadeniz Bölgesinde Eosen yaşlı kalk-alkalen andezitler ve jeotektonizma: TJK Bull., 20, 49-54.

Tuğal, H.T., 1969, Pyritic sulphide deposits of the Lahanos mine area, Eastern Black Sea Region, Turkey: Ph. D thesis Durham Univ. England (unpublished).

Turk-Yugoslav Ekibi, 1968, Espiye-Bulancak bölgesinin 1:10 000 lik jeolojik raporu: MTA Rep., 4602 (unpublished), Ankara.

———, 1970, Ordu, Kabadüz sahası 1:25000 ölçekli jeoloji etüdü ve prospeksiyon raporu: MTA Rep., 4596 (unpublished), Ankara.

Zankle, H., 1959, Harşit vadisi bölgesinde yapılan maden yatakları ile ilgili jeolojik etüd hakkında rapor: MTA Rep., 2751 (unpublished), Ankara.