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GEOLOGY, PETROGRAPHY AND PRECIOUS METAL MINERALIZATIONS OF ALTINTEPE AND ÇİLEKTEPE SECTORS OF KARŞIYAKA ORE OCCURRENCES, IZMIR, TURKEY

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ABSTRACT.- As result of geologic studies on the field and microscopic studies of the samples from Altıntepe and Çilektepe areas located southwest of Sancaklı village, Karşıyaka-İzmir, dacitic tuffs and lavas and their silicified types, biotite-hornblend-dacite. andesitic lava, tuff and agglomeras in addition to andesitic dykes are determined and mapped. Investigations indicate two different type of mineralizations, First type is gold and silver mineralizations in quartz veins emplaced in tension fractures of silicified dacitic lavas at Altıntepe (Arapdağ) sector. The other kind of mineralizations is related to hydrothermal alterations in dacitic tuffs at Çilektepe (Çerkeskayası or Pilavtepe) sector. Gold mineralizations are developed as stockworks and disseminations in those kind of rocks because uprising channels are tapped by silica gels. The age of volcanism based on regional geological data is between Late Oligocene and Middle Miocene. Biotite-hornblende-dacites (14.7+0.5 Ma) contain no precious metal mineralizations and are believed to occur after ore mineralizations. According to these findings, the mineralizations should be Middle Miocene in age.

INTRODUCTION

World known gold reserves decreased gradually in recent years. In contrast, gold prices increased sharply between 1980 and 1990. New technologies have been developed for the production of gold and silver from low grade deposits. All these changes increased the exploration efforts for precious metal deposits. Preconditions for the commence of and an exploration can be summarized as follows: Heat source, faults and fractures on regional and local scale, hydrothermal springs, especially Tertiary volcanics convenient as host rocks. They provide suitable tectonic environments for emplacement of mineralizations. Models developed upon all these conditions brought certain areas of the world and also Turkey as prospect and important areas to search. So, known old gold deposits and occurrences became target areas for new investigations at West Anatolia. Therefore gold bearing quartz veins and its surroundings at Arapdağ-İzmir which is mined at the end of 1900 th's investigated by detail geologic and mineralogic studies and tried to be interpreted for model of formation.

This paper, based on the field studies carried on by MTA General Directorate in 1990, aims presentation of the geological, petrographical and mineralogical data collected from surface and drill core samples of gold bearing quartz veins at Altıntepe and Çilektepe Sectors close to Altıntepe.

Study area is located at southwest of Sancaklı village of Karşıyaka town of İzmir and in İzmir K 18 d3 sheet in 1/25 000 scale. Mineralizations are found around Ilıcadere, Kocadere and Eski Sekiköy dere and Altıntepe (Arapdağ) and Çilektepe (Çerkestepe or Pilavtepe) 5 to 6 km north of Karsıyaka (Fig. 1).

With the studies carried on volcanics and their relationships in stratigraphic sequence including age data in the study area and its close vicinity are tried to be explained by various authors (Dora, 1964; Borsi et al., 1972; Düzbastılar, 1976; Akyürek and Sosyal, 1978; Kaya and Savaşcın, 1981; Kozan et al., 1982; Ercan et al., 1983; 1984a and 1984b Akdeniz et al., 1986; Ejima et al., 1987; Kissel et al., 1987; Eşder et al., 1991, Turkish-Italian Joint Venture Project, 1991; Ercan et al., 1997; Seyitoğlu et al., 1997; Dönmez et al., 1998; Kaya, 1999). In addition, precious metal mineralizations in Yamanlar volcanics cropping out around Karşıyaka, İzmir have also been the subject of many studies including mineralogical and petrographical investigations, geochemical studies, of

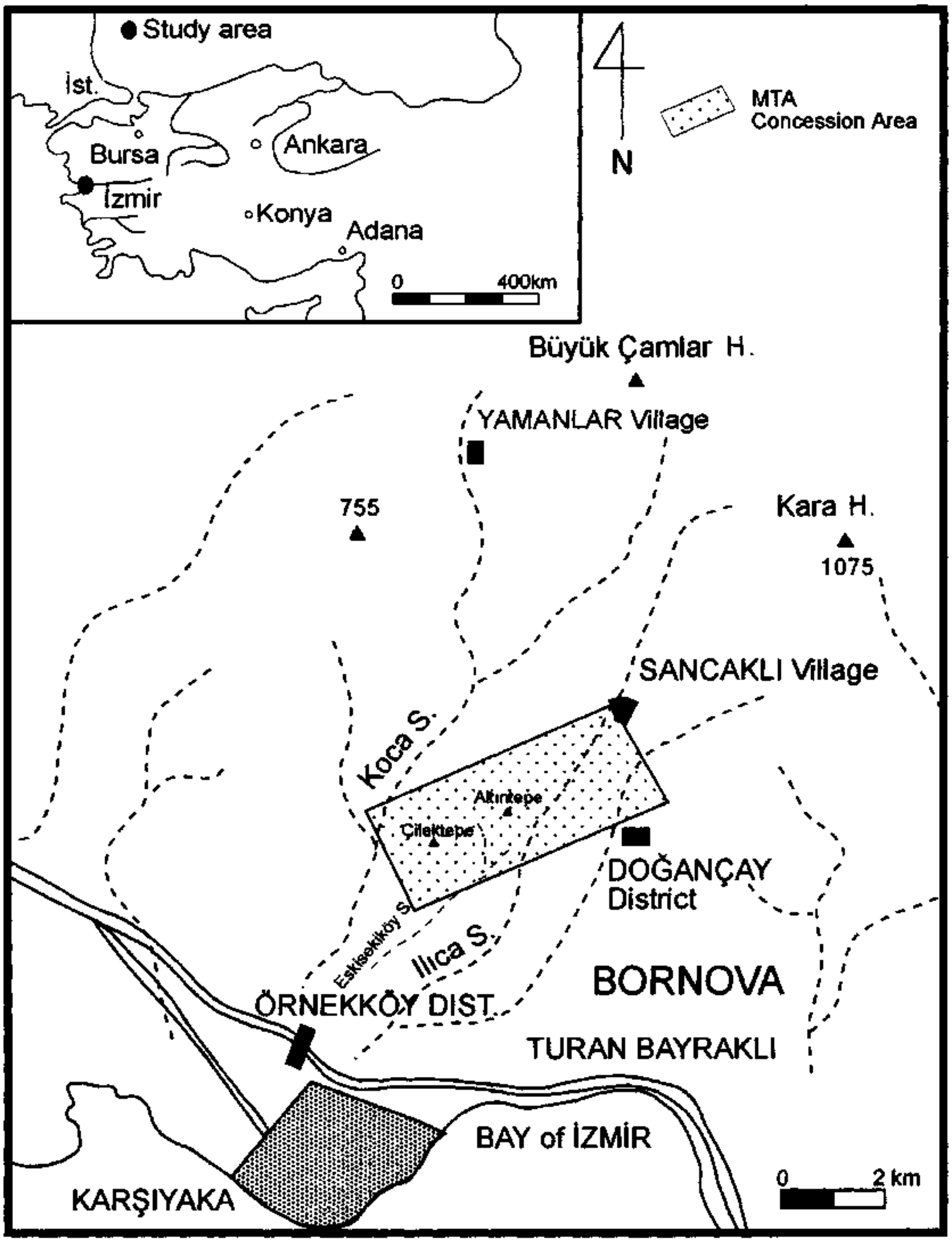

Fig. 1- Location map on the study area.

formation types and for grade/tonnage estimations (Weiss, 1895; Atabek, 1944; Molly, 1956; Vural, 1962; Higgs, 1962; İzdar, 1962; Dora, 1964; Dora, 1970; Çelik and Dayal, 1976; Alpan, 1986; Gonca, 1990; Sayılı et al., 1990 and Turkish-Italian Joint Venture Project; 1991).

REGIONAL GEOLOGY

Study area is regionally located in İzmir-Ankara suture zone (Brinkmann, 1966) lying between Sakarya continent to the north and Menderes massif to the east and southeast.

Volcanic rocks containing mineralizations in the study area divided into three types as dacites, andesites and andesitic dykes by Dora (1964). These volcanics are accepted as "Yamanlar volcanites" by Akdeniz et al. (1986), while the ore bearing volcanites named as "Altıntepe volcanites" by Dönmez et al. (1998). Volcanites overlie İzmir flysch (Öngür, 1972) in near vicinity of the study area. İzmir flysh is named for the first time as "Crystalline schists" by Dora (1964) and mapped as phylitte, clay bearing schists and low grade metamorphosed quartzite, greywacke and very low grade metamorphosed arkose alternating with schists and phyllites. The age of crystalline schists is Paleozoic. Lateron, this unit is described as "flysch association" of Upper Cretaceous age according to regional correlations made by Oğuz (1966). This unit is made up of chlorite schists, phyllite, metasandstone, albit-epidote schists, actinolite schists spilite, cherty limestone, meta-conglomerate, bituminous schists and other kind of schists which metamorphosed under greenschist facies. Limestones and serpantinite exotic blocks of Permian, Triassic, Jurassic and Lower Cretaceous age occur in this unit. This unit is called as "Bornova complex" of Maastrichtian-Danien age by Dönmez et al. (1998).

At the east of Bornova, Yamanlar volcanites. unconformably overlie Belkahve formation or Dededağ formation which are both described by Akdeniz et al. (1986), Belkahve formation consists of clastic rocks of flysch character in which lime stone blocks occur. Clastic sediments contain conglomerate-sandstone, shale-marl, clay bearing limestone alternations and blocks of limestone, radiolarite, greywacke, tuff, spilite and small serpantinites. The age of this unit is Campanian-Paleocene (Akdeniz et al. 1986). At the north of Bornova and near Karaçam region, Yamanlar volcanites horizontally and vertically grade into Vişneli formations. This formation consists of conglomerate, sandstone, claystone and clay bearing limestone and accepted as Middle to Upper Miocene according to its regional counterparts. Vişneli formation is equivalent of "Soma formation" (Akyürek and Sosyal, 1978) at Soma Basin. Near Menemen, upper levels of Soma formation which overlie İzmir flysch contain some sequences of tuff and tuffite of the Yamanlar volcanism (Nebert, 1978). Alluvium and talus of Quaternary age generally unconformably overlie Yamanlar volcanites according to Akdeniz et al. (1986). Dönmez et al. (1998) believe that Altıntepe volcanites which are equivalent of Hallaçlar formation at northwest Anatolia, overlie unconformably over Bornova complex. The authors suppose that the age of Altıntepe volcanites is Oligocene to Early Miocene. Soma formation (or Group according to Dönmez et al. 1998) overlie Early Miocene aged Aydınlar volcanites with angular unconformity which is overlied again by Altıntepe volcanites. At the northeast of Bornova, partly silicified limnic limestone of Lower Pliocene Yaka formation (Akdeniz et al. 1986) overlie all the rocks mentioned above. This means that silica transporting volcanism is not far from the sedimentation environment.

GEOLOGY AND PETROGRAPHY

Geological map (1/5000) of the study area is prepared by using 1/5000 and 1/2000 topographic maps. The adits of Nr.2, Nr.4 and Nr.6 (G-2, G-4 and G-6) and all others are geologically mapped at 1/500 and 1/200 scales. Thin and polis-hed sections of rock samples collected from surface and adits are investigated.

The stratigraphically lowest unit of the region is a flysch formation called as "İzmir flysch" outcrops outside of our mapping area. Dacitic tuffs and silica gel (hydrothermal breccia) contemparenous with tuffs overlie the flysch unit. Dacitic lava and their silicified, sericitized, chloritized, actinolitized, turmalinized and brecciated equivalents called as silicified dacitic lava overlie all units. These volcanism becoming more, basic created andesitic tuffs and agglomeras and young andesitic dykes with intermediate character (Fig. 2 and 3). This sequence is in very concordance with the sequence given by Dora (1964). Age determinations carried on samples by using whole rock K/Ar method during Turkish-Italian joint venture project revealed that biotite-hornblend dacites and andesites are 14.7 ± 0.5 Ma and young andesitic dykes has the age of 18.9 ± 0.4 Ma. According to the explanations of italian experts, the reason why the dykes are older than dacites and andesites is related with "argon absorption". Thus, the age of volcanism can be given as Middle Miocene.

Rocks of flysch unit are observed in the channel samples collected from F.VII vein exposed at Ilıcadere. Rock fragments of bituminous materials bearing quartz-sericite-chlorite schists and bituminous schists are found during microscopic studies. These kind of rock fragments hard to find out at the field because of their small sizes. However, the rock pieces of flysch unit can easily be seen at drill cores.

Dacitic tuff.- The unit (crystalline tuff of Dora, 1964), crops out at Çilektepe sector that takes place at the western part of study area and Eski Sekiköy dere. The color of the unit is dirty white, beige and light yellow because of hydrothermal alterations, however fresh samples are light grey and grey in color. Dacitic tuffs generally comprise fine grained and angular primary quartz crystals, silicified rock fragments, hydrothermal quartz particles, sandstone fragments and phyllosilicate phenocrystals effected from tectonism. The groundmass of rock is composed by very fine grained sericite, biotite, chlorite and clay minerals. Mica minerals are replaced by opaque minerals and the groundmass became darker at the portions where mineralization is affected the rock. In additions, brecciated parts are also observed in tuffs. Fine and medium grained quartz phenocrystals of primary origin and silicified volcanic rock fragments, hydrothermal and recrystallized quartz grains take place in a micro to criptocrystalline quartz and opaque enriched groundmass.

Dacitic lava and silicified dacitic lava.- These rocks can be observed at the upper levels of Altıntepe and Çilektepe sectors of the study area and are light grey and light purple colored. Silica saturated, viscous lavas serve as tapping domes as short and thick lava flows (Dora, 1964 and Gonca, 1990). Hematite, limonite and kaolinized feldspars are generally observed at the cracks of rocks. The rock has an appearance of mixed colors consisting of grey, brown, red, dirty white and purple. Coarse grained quartz, oligoclase-andezine type plagioclase in addition to chloritized, carbonatized biotite and hornblende which are also replaced by opaque minerals. Therefore, the porphyric texture of the rock is easily recognizable. Tectonism creates thin and discontinious cracks and fractures in phenocrystals and groundmass which are filled by opaque minerals.

As a result of hydrothermal activity, advance silicification, carbonatization, sericitization, chloritization, actinolitization, prehnitization and turmalinization occurred at Altıntepe where the center of dacitic volcanism is. Because of these features of lavas and pervasive silicification observed at macroscopic scale and on hand specimens, the parts of rock which reveal such kind of characteristics are called as silicified dacitic lava. This kind of rock is in grey-green and bluish colors and glassy breakdown feature. In addition to minerals described at other lavas determined by thin section investigations, these rocks comprise the sections of hydrothermal quartz enrichments and very small turmaline needles and suns (Dora, 1964).

Biotite-Hornblende dacite.- This unit crops out to the northeastern and southeastern parts of investigation area and named as biotite-hornblende dacite both by modal analyses executed by Dora (1964) and our microscopic investigations. The final period of dacitic volcanism became more basic at this stage. Fresh parts are generally in greenish brown color. Milky brown colors are developed at

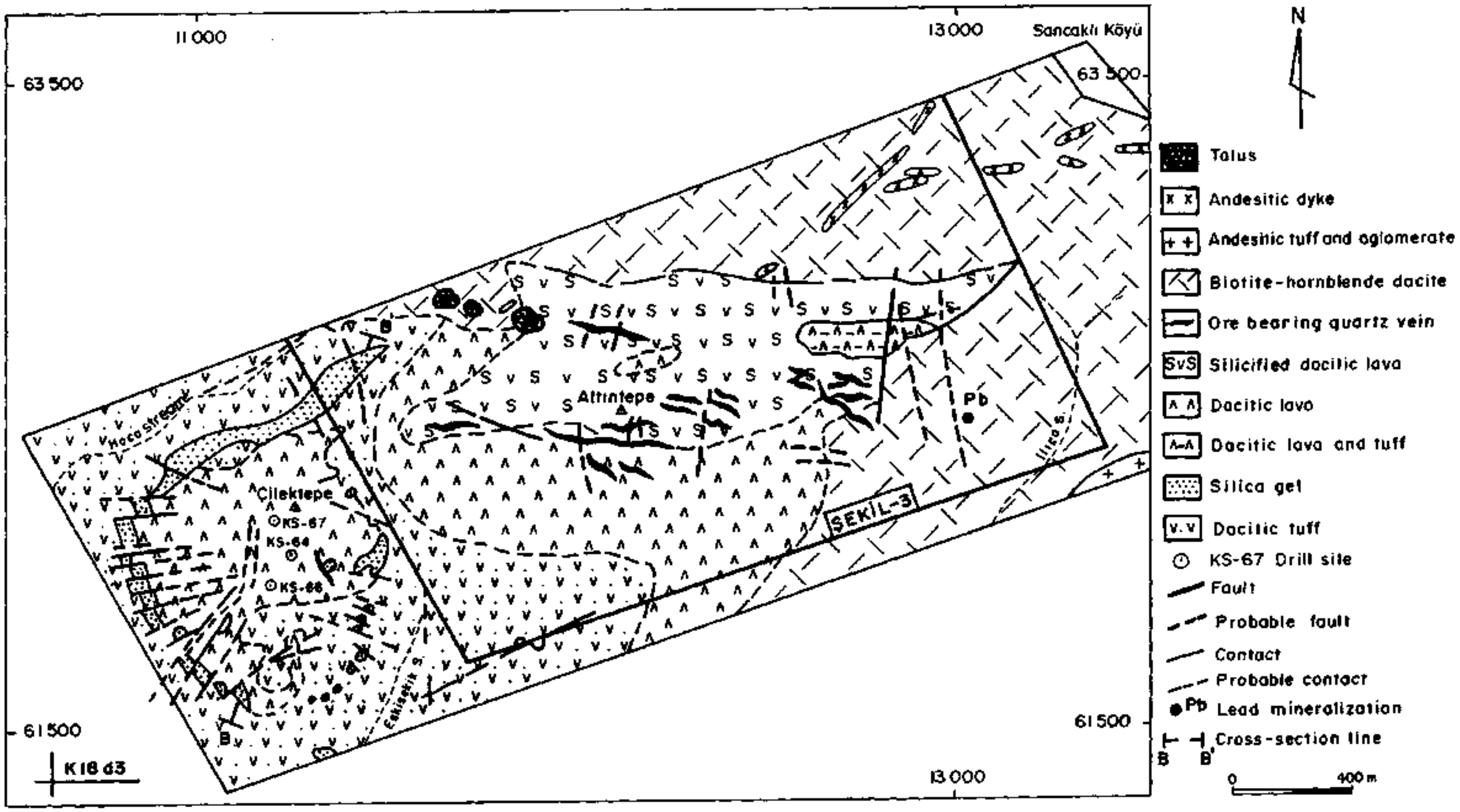

Fig. 2- Geological map and mineralizations of Altıntepe and Çilektepe sectors, Karşıyaka-İzmir (Modified from Gonca, 1990). Ore bearing quartz veins are exaggerated.

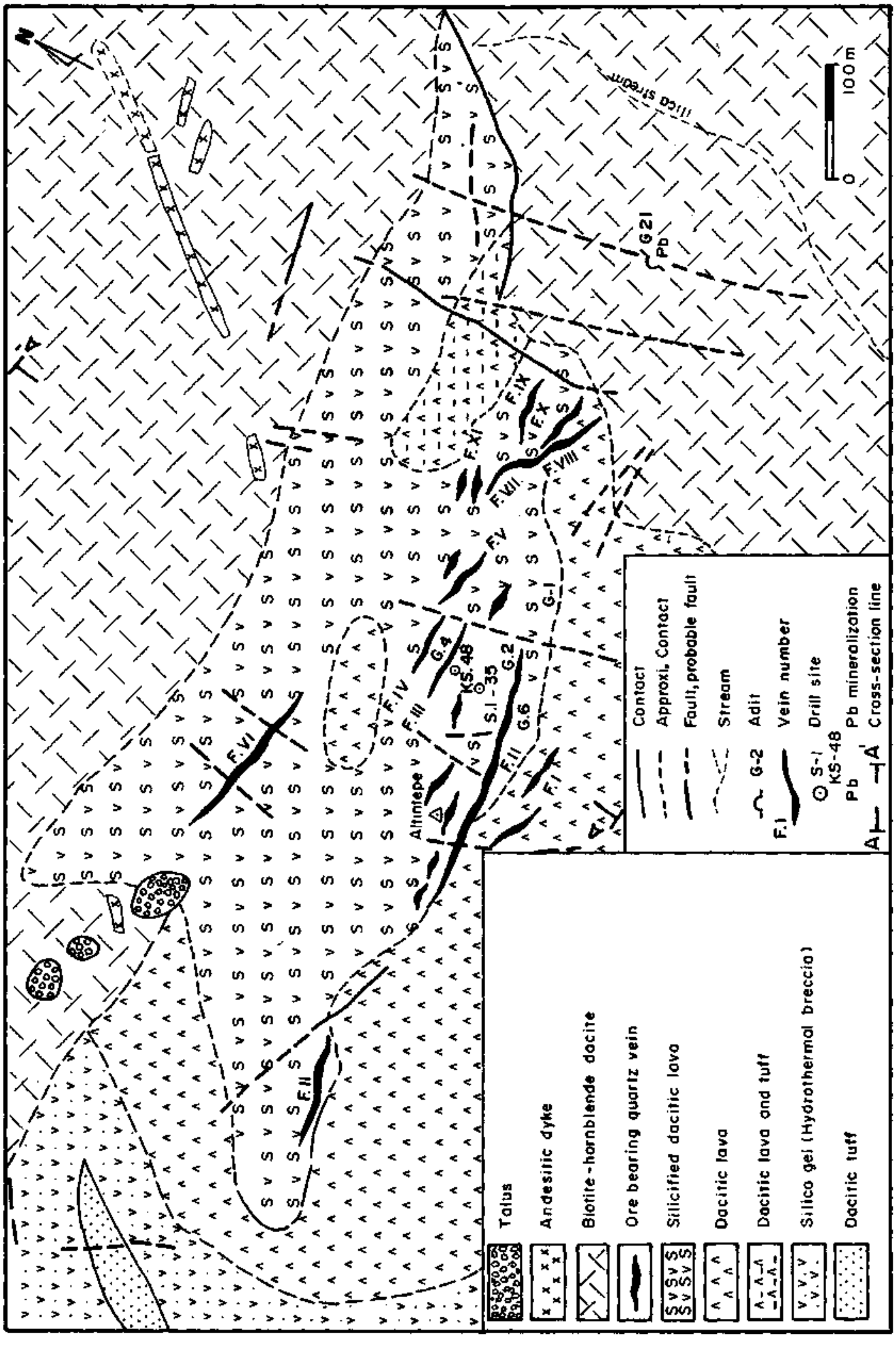

Fig. 3- Geological map and mineralizations of Altıntepe sector. Ore bearing quartz veins are exaggerated.

the parts where weathering dominantly occurred and gave a soft character to the rock. Porphyric texture can easily be seen. Phenocrystals of quartz, feldspar, biotite and amphibole scattered in glassy and microlitic groundmass at fresh rocks. Plagioclases are generally in andesine composition an exhibit zoned textures. Carbonate fillings are seen at the cracks of rocks. Amphiboles are replaced by quartz, carbonate and opaque minerals, biotites enriched in opaques and chloritized and feldspars are argillized at the altered rocks. Groundmass is kaolinized, chloritized, sericitized and silicified.

Andesitic tuff and agglomerate.- This type of rocks are observed at the eastern part of the study area. Tuffs are banded agglomerates. Lavas generally have vesiculated or scoriaceous forms. Blocky andesites contain sometimes schist and dacite fragments. Andesitic lavas exhibit clearly recognizable flow textures. Coarse and medium grained plagioclase and medium to fine grained pyroxene, biotite and amphibole phenocrystals are dispersed in both microlitic and glassy groundmass. Labradorite and andesine type of plagioclases show zoned textures. Pyroxenes are also observed in the groundmass and replaced by epidotes and amphiboles which are replaced again by epidotes and opaque minerals.

Young andesitic dykes.- These dykes frequently occur at the northeast of the study area. The thickest one is 5 meter and found between the northwest of Sancaklı village and Altıntepe. Phenocrystals consisting of coarse grained plagioclases, abundant medium grained pyroxenes and less amount of biotites occur in a groundmass of plagioclases, pyroxenes, biotites and chlorites in addition to opaque minerals. Piagioclases are andesine in composition and are kaolinized and sericitized. Pyroxenes are uralitized and chloritized.

Five fresh samples were taken and analysed by Eşder 1990 (in Gonca 1990), another five samples were collected and analysed during Turkish-Italian Joint Venture project and seven samples were taken and analysed by Dönmez et al., 1998. Petrological studies carried on all these 17 samples revealed that the rocks are dacites and andesites with high-K calcalkaline character.

E-W trending veins at Altıntepe are dipping to north or south with an angle greater than 50°. All the veins occur along the tension fractures, which served channels and open spaces for hydrothermal solutions. These fractures are intersected by young faults with N-S direction. Because of young tectonicsm, tension fractures are dislocated and therefore fluids ascending along these new open spaces created later on impermeable zones. Solutions circulating beneath these tapped zones caused explotion due to increase at temperatue and thus the veins gained brecciated structures.

MINERALIZATION AND MINERALOGICAL INVESTIGATIONS

Lead, antimony and gold-silver mineralizations occur in both sectors of the study area.

Lead mineralization is found at a probable fault with N-S direction near the fountain of Sancaklı village, east of Ilıcadere (Fig. 2). Mineralization occur in biotite-hornblende-dacite and has a strike of N 45-70 E and dip with 50-60° to northwest. Veinlets have 25 m lengths and 3-8 cm thicknesses. Galena, pyrite, anglesite and cerussite are ore minerals while quartz and baryte gangue. Some silver is detected in the samples taken from the veinlets (Dora, 1964 and Gonca, 1990).

Antimony mineralizations take place at around Çilektepe. Antimony veins are 5cm to 2m in thicknesses and arrive up to 50 m length and strike with changing directions, namely NE-SW and NW-SE. Ore minerals such as stibnite, pyrite, cinnabar and senarmontite occur together with ganque minerals of quartz and baryte. The mineralizations are believed to occur related with young tectonism.

Two different types of gold and silver bearing mineralizations are found in the study area. The general features of these types can be summarized as follows:

First type is represented by gold and silver mineralizations and occur in quartz veins which take place at tension fractures in the silicified dacitic lava (Fig. 2, 3 and 4). Three dimensional studies based on surface and underground geological maps. Drill cores showed that the wall rock alteration of quartz veins are developed as carbonatizations, sericitization, chloritization, actinolitization, prehnitization and tourmalinization in addition to advanced silicification.

Second type is represented by lode type gold and silver mineralizations found in the hydrothermally altered dacitic tuffs at Ilıcadere and Çilektepe. These mineralizations are not well concentrated and therefore can only be regarded as occurrences.

Detailed descriptions for two type of mineralizations are as follows:

Mineralizations at Altıntepe sector

Eleven quartz veins are determined in dacitic lavas and silicified dacitic lavas at Altıntepe. Most of them strike E-W and only a few ones NW-SE (Fig. 2 and 3).

Vein F. I.- The vein occur in silicified, chloritized and turmalinized dacitic lava at southeast of Altıntepe. It strikes N 80 W and dips with 65° to NE and has a lenght of 20 m and thicknesses varying between 4 cm and 10 m. Microscopic studies revealed that pyrite, limonite and native gold grains are ore minerals in milky quartz. According to the analyses carried on three samples indicate low grade precious metal contents with less than 0.2 ppm Au and 2 ppm Ag.

Vein F. II.- It trends in E-W direction just below Altıntepe and takes place as two lenses. Silicification, chloritization and argillization represented by quartz, sericite, epidote, chlorite and kaolinite form the alteration pattern in dacitic lavas close to the vein. First lens has a strike of N 85° E with a dip of 50-72° to NW. The thicknesses of this lens change between 2 cm and 3 m with a length of 350 m. Milky quarti, tooth like quartz, limonite, baryte and silicified dacitic lava fragments occur in the lens. An adit (G-2) is driven at the eastern end

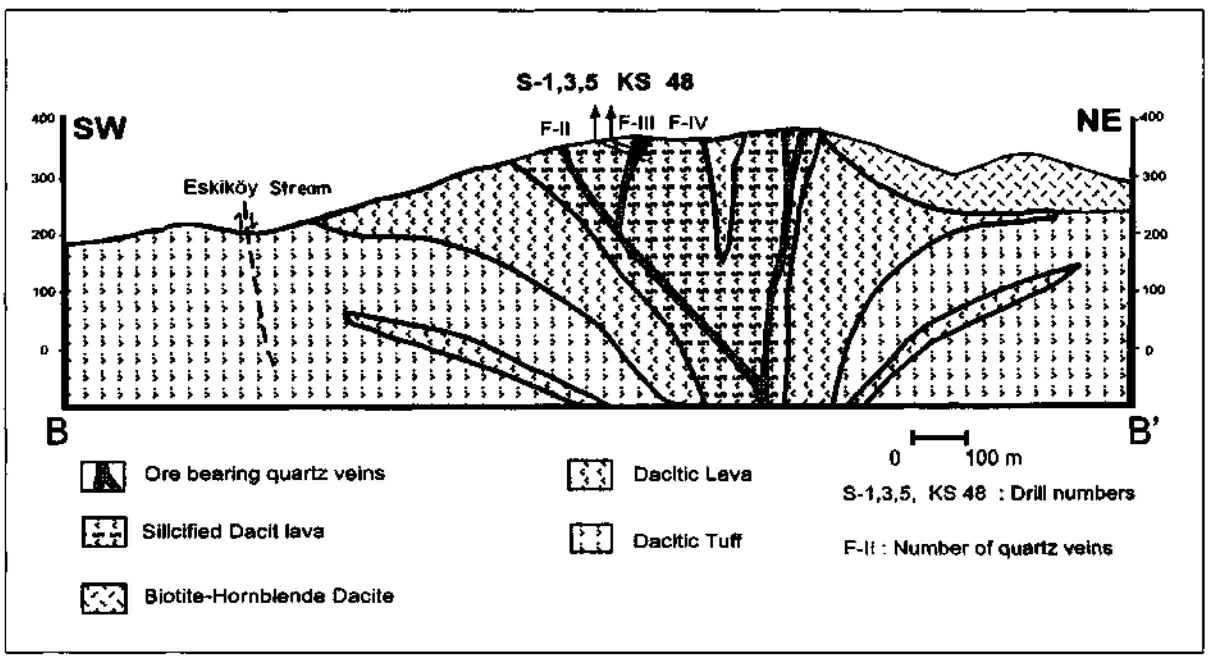

Fig. 4- A cross section from ore bearing quartz veins of Altıntepe.

of it. Due to ore microscopic studies, anglesite, galena, pyrite, chalcocite, covelline goethite, native gold, fahlore, smitsonite and baryte are determined Channel samples taken from the lens and the samples collected from G-2 and G-6 adits an drill cores aimed to intersect this lens indicate that the lens has an average thickness of 1 meter and grades of 4.65 g/t for gold and 60 g/t for silver. Second lens (N 63-84 E, 40-74 NW) takes place at the west to southwest of Altıntepe. It lies in silicified dacitic lava with a length of 150 m and thickness varying between 50-70 cm. Channel samples taken from the lens and samples from drill cores show an average thickness of 70 cm and average grades of 5.4 g/t Au and 70 g/t Ag. Gold and silver values continue to the outside of the vein.

Vein F. III.- The vein strikes N 77-88 E and dips to SE with 60-80° and occurs in silicified dacitic lava at the east to northeast of Altıntepe with a length of 80 m and thicknesses between 5-45 cm (Fig. 4). Mineralization is characterized by milky quartz, toothlike quartz, baryte as ganques and native gold, sphalerite, galena, pyrite, chalcopyrite and limonite. The contact between host rock and veins is not sharp. The vein reachs an average thickness of 140 cm along the drills to the depth (58m). Numerous analyses were carried on the samples taken from G-4 adit, drill cores and the vein as channel samples. The results gave 10.5 g/t Au and 90 g/t Ag grades for an average thickness of 78 cm.

Vein F. IV.- The vein is located ENE of Altıntepe and has a length of 80 m with thicknesses between 20-30 cm. It occurs in silicified dacitic lava and has a strike of N 78-88 E and dips to SE with 72-75° (Fig. 4). The wallrock of the vein is silicified, sericitized and chloritized. Milky quartz, abundant pyrite, limonite, galena, sphalerite, chalcopyrite and a few grains of native gold are observed during microscopic studies. Analyses based on the samples collected from G-4 and G-8 adits, drill cores and as channel samples from the vein revealed a 24 cm average thickness and 13.8 g/t Au and 160 g/t Ag average grades..

Vein F. V.- The vein with a length of 80 m and thicknesses varying between 3-10 cm lies at the east to northeast of Altıntepe and occur in silicified dacitic lavas. It strikes N 88 E and dips with 82o to SE. The vein contains milky quartz, limonite and brecciated fragments of dacitic lava. According to the data from an old drill, the vein reachs a thickness of 67 cm at 64 meter depth. A channel sample from the vein indicate the grades of 14.3 g/t Au and 70 g/t Ag.

Vein F. VI.- This is not an individual vein but a zone of veins lying at E-W direction and dipping to N with 82-87° at the north of Altıntepe. The length of the vein zone is 150 m and the thicknesses vary betwen 160 and 530 cm . They occur in silicified dacitic lava which is characterized by alterations of sericitization, chloritization, actinolitization, epidotization and pyritization. Ilmenomagnetite and rutile are observed in the host rock, while the veins are rich in pyrite, hematite, limonite and a few grains of native gold with 10-20 micron sizes. Sulphide mineralizations are abundant in some parts of veins. Mineralogical investigations revealed that silicification, actinolitization, chloritization and sericitization together with pyrite, ilmenomagnetite, rutile-anatase and galena crystals occur at these parts. Twelve new trenches are digged out and G-10 and G-11 adits were driven at this zone. The grades of precious metals are so scarce that 2 g/t Au and up to 10 g/t Ag could be detected at only one trench. The analyses of the samples taken from drill cores indicated even less amount of gold and silver.

Vein F. VII.- The vein is found in a tributary of Ilicadere east of Altıntepe. It lies in silicified dacitic lava. The vein strikes N 60-85 W and dips to SW with 50-82° and is intersected by the vein F.VIII. The length of the vein is around 200 m with thicknesses of 20 to 50 cm. Bituminous schist fragments are also found at this part of the field. These fragments are believed to represent Belkahve formation. Gold grains with 5-30 micron sizes are observed together with pyrite in the schists. The vein consists mainly of quartz but small and thin ankerite veinlets are also found in it. One of the four channel samples taken from the vein gave 19 g/t Au and 100 g/t Ag in addition to 2.4 % Pb grades.

Vein F. VIII.- The vein (N 37-87 W, 50-73 SW) is located at the tributary of Ilıcadere like vein F VII at the east of Altıntepe and occur in dacitic and silicified dacitic lava. The length of the vein is 270 m and thicknesses range between 10-50 cm. Grey colored quartz, baryte are ganque minerals and sphalerite, galena, pyrite, hematite and limonite are that of ores. A few gold grains up to 20 micron are also determined. The vein is followed until the depth of 14 meter. Grades of 1.5 g/t Au and 30 g/t Ag are estimated from channel samples of the veins.

Vein F. IX and F. X.- These veins are located to the north of vein F.VIII and stockwork type mineralizations occur in silicified dacitic lava and have E-W, 82 SE strike and dip. Their length are around 40 m and thicknesses vary between 30-40 cm. Quartzs with various sizes and forms seem to represent different generations. Pyrite, sphalerite, galena, covelline, chalcocite, neodigenite, fahlore (tetraedrite), limonite, bournonite, boulangerite, marcasite, native gold (10-20 microns), chalcopyrite, anatase-rutile and hematite in addition to rare amount of ankerite and gypsum are determined. Analyses made on the samples taken from the vein F. IX as channel sample method revealed that an average thickness of vein is estimated as 45 cm and the vein has 12.5 g/t Au and 172 g/t Ag grades. However, surface channel and drill core samples have only trace amount of gold and silver.

Vein F.XI.- This vein (N 56 E, 80 SE) is again in silicified dacitic lava to the north of Vein F.VII. It is rather short and thin one with 5 m length and 25 cm thickness. Ore minerals consist of pyrite, limonite and a few native gold grains between 5 and 20 microns dispersed in a matrix of milky quartz in the vein. A channel sample taken from the vein showed 3.1 g/t Au and 3 g/t Ag.

Although alterations in veins and host rocks close to veins at Altıntepe are mentioned, alteration pattern of the whole area will be presented in another publication (Gevrek and Sayılı, in preparation). Therefore, more details will not be given here. Comb structures and crustifications are the main features that are observed on the veins.

Mineral paragenesis of ore bearing quartz veins

Before starting detailed description of the ore minerals, ganque minerals will be shortly summarized. Main ganque minerals are toothlike quartzs and milky quartzs (Dora, 1964). Initially baryte crystals are replaced by siliceous solutions sometimes leaving some baryte relicts in them are called as toothlike quartzs. Another type of generation occurred from post silica generation which formed dull and pinkish white, white milky quartzs. Limonites accompany to milky quartzs. Gold is found in both type of quartzs, however toothlike ones richer than milky quartzs. Chalcedony occur at the surface while quartz characterize deeper zones at Altıntepe. Young and old baryte laths also accompany to the quartzs as ganque minerals. Gold free calcite and siderite minerals are reported by Dora (1964) at the outside of the study area.

Ore microscopic studies on the samples of the study area are in very good concordance with the studies of Dora (1964, 1970) and of Italian mineralogists performed during Turkish-Italian Joint Venture project. The findings of ore microscopic studies and important features of ores from older to younger are mentioned below respectively:

Rutile-Anatase.- They are observed in both host rocks and as transportations to the veins.

Pyrite and Arsenopyrite.- The dominant sulphide mineral is pyrite and some arsenopyrites which are replaced by other sulphide minerals. Thus, they are accepted as the oldest ore minerals. They are especially grown with baryte neddles and laths. Electrum grains (around 10 micron sizes) are found at the cracks of pyrites and arsenopyrites. Pyrites are often limonitized. Gel like textured pyrites are contemparenous with or younger than other sulphide minerals.

Marcasite.- Radial and fibrous marcasites form aggregates. They are subhedral and sometimes very abundant. They sometimes replace pyrites.

Hematite.- As stainings and small and thin needles and laths occur in the cracks of quartzs.

They are also observed as inclusions in pyrites and are grown together with them.

Sphalerite.- Anhedral sphalerites are found as irregular grains up to 2 cm in quartz matrix and are the second abundant sulphide minerals following pyrites. They are associated with galena and chalcopyrites and show cataclastic texture in some grains. Sphalerites are replaced by chalcopyrite, fahlore and galena and by secondary minerals like chalcocite, covelline and neodigenite as well. Gold can be observed at their cracks.

Galena.- Anhedrel galena crystals occur as generally small but sometimes up to 1 cm sized grains at the open spaces or cracks of quartzs together with sphalerite and chalcopyrite. Some grains are dominantly replaced by anglesite. It is the most important mineral for the deposition of electrum.

Chalcopyrite.- Rather small and anhedral grain of chalcopyrites are mainly enveloped by sphalerite, fahlore and galena and fill the cracks of quartzs or as inclusions in them. They are replaced by fahlore especially at rims or cleavages. Chalcopyrite and their oxidation products contain electrum.

Fahlore.-Trace amount of fahlore minerals are found as very small grains in anglesites and are sometimes replaced by covelline and antimony ochers. Chalcopyrites are replaced by fahlore beginning from their rims.

Bournonite - Boulangerite - Zinkenite.- Bournonites and boulangerites are formed as a result of replacement along the rims and cracks of galena. Additionally, these minerals are also found in trace amounts as reaction minerals between galena and fahlore. Very small laths of boulangerites and zinkenites occur in and at the cracks of quartzs.

Electrum.- Electrums occur mainly as isolated grains in quartz crystals or enveloped by sphalerite, galena, chalcopyrite and pyrite or together with limonite and covelline masses and crusts. Grain sizes vary between 5 and 60 microns. Dora (1964) is the first geologist Who reported their silver contents. Later on, by the studies of italians, two samples were analysed by electron microprobe method which gave the results of up to 23.86% Ag content of the old grains. Thus, they can be called as electrum.

Secondary ore minerals.- The most abundant secondary ore mineral is limonit which is formed in two different types. First type can be described as concentric textured limonite fillings in fractures and open spaces and the other types occur as pyrite pseudomorphs. Limonites are sometimes as geothite in forms and are observed at the cracks and open spaces and also in the outer zones of anglesites. Other secondary minerals are chalcocite, covelline, neodigenite and smitsonite.

Mineralizations at Çilektepe sector

The geological map and cross-section of Çilektepe sector demonstrate (Fig. 2 and 5) that the stratigraphically lower parts are represented by dacitic tuffs and upper parts by dacitic lavas, while tuffs are pervasively silicified. They contain silica gels (hydrothermal breccia), which consist of amorphous and silica oversaturated hydrothermal solutions. Because of tectonic activities, along the main tectonic line represented by N 18 E strike, silica bands are formed from siliceous hydrothermal solutions which were rised along the openings in some levels of tuffs and along the contacts between tuffs and lavas. The thicknesses of silica bands including tuffs arrive up to 20 meter. Flow textures can be recognized in the field and contain metamorphic and silicified volcanic rock fragments. Because of these angular fragments in silica gels, they are also called as hydrothermal breccia.

Argillization, sericitization, chloritization and opaque mineral developments are the alteration types accompanying to silicification at Çilektepe. According to the geological features and antimony adits driven in silicifed tuffs, an epithermal type of mineralization can be postulated for this sector (see Henley 1985, 1990). Therefore seven holes were drilled at Çilektepe. Five of them intersected silica gels besides dacitic lavas and dacitic tuffs as expected (Fig. 5). 1 to 23 meter mineralized zones are cut beneath and sometimes over the silica gel levels which contain gold varying between 40 ppb and 4.37 g/t in every drill holes. Thus, the levels of silica gels should serve as taps for the uprising of weakly ore bearing hydrothermal solutions. At the levels where gold detected, the contents of Cu increase to 1000 ppm, Pb to 700 ppm, Sb to between 70 ppm and 1 % and Ag generally around a few ppm but sometimes up to 200 ppm could not be arranged to any systematic. It has been determined that gold occur in pyrite rich stockworks and thin veinlets.

Antimony mineralizations observed at Çilektepe contain pyrite, cinnabar and senarmontite besides stibnite and quartz and baryte as ganque minerals. Analyses of sample of quartz bearing stibnite veins indicated the contents of 81.29% Si, 7.3% Sb, 2.0% Ba, 0.68% Pb and 617.3 ppm As (Turkish-Italian Joint Venture Project, 1991). Upon all these data, epithermal type of formation model could be advocated basing on host rock and structures in it, alteration pattern, fluid inclusion studies (details will be published at Sayılı, in preparation).

Mineralization stages

All the data from the field observations and mineralogical investigations of gold bearing quartz veins at Altıntepe demonstrate three mineralization stages. The first stage is characterized by the oldest sulphide minerals of pyrite and arsenopyrite. Hydrothermal solutions at this stage caused silicification, actinolitization, chloritization, argillization and turmalinization alterations at Altıntepe which are typically observed at Vein F.VI. This stage is sterile for gold and silver. Second stage is represented by gold, silver and sulphide mineral associations. Pyrite, sphalerite, galena, chalcopyrite, fahlore, bournonite, boulangerite, zinkenite, marcasite, hematite and according to Dora (1964) proustite, pyrargyrite, polybasite, freibergite ve pet-

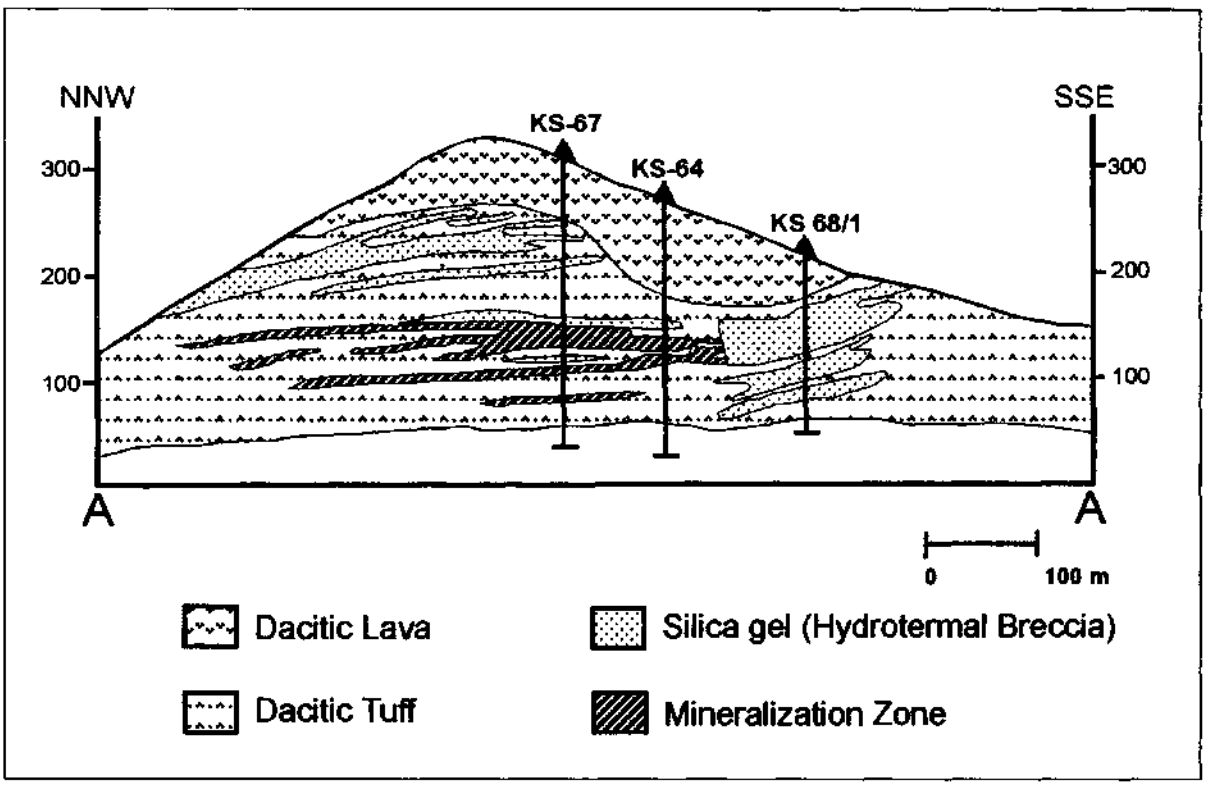

Fig. 5- A cross section showing the mineralizations of Çilektepe sector.

zite(?) as silver bearing minerals occurred at this stage. Dora (1964) pointed out that jamesonite, native silver minerals, slyvanite and electrum minerals are detected. Secondary ore minerals of this stage are limonite, goethite, chalcocite, covelline, anglesite, neodigenite and smithsonite. Gangue mineral are represented by toothlike and milky quartz, baryte, gypsum in addition to some chlorite, actinolite, epidote, sericite and chalcedony. The ore minerals of third stage are galena, pyrite and stibnite (see Mineralization at Çilektepe sector section). In addition to stibnite, cinnabar is found both by us and Dora (1964). Analyses show that gold occurrences as stockwork type and in veinlets developed especially below the silica gel (hydrothermal breccia) levels at Çilektepe have low gold contents. Dora (1964) believe that this stage contains also silver. Anglesite, cerussite and young quartz and barytes from the secondary ore and gangue minerals.

INTERPRETATION AND DISCUSSION

Numerous investigations carried on both host rocks and mineralizations at the study area exhibit different views. At this point, views about host rocks, tectonic lines in which mineralizations emplaced and mineralizations will be discussed and interpreted.

The host rocks around mineralizations are tuffs and lavas which are the products of andesitic volcanism (Dora, 1964, 1970; Gonca, 1990; Sayılı et al., 1990 and Turkish-Italian Joint Venture project, 1991). On the other hand, Dönmez et al: 1998 named the unit of dacitic tuff as Yamanlar tuff. It is believed that Dönmez et al. 1998 could not determine other volcanic products because of detailed lack of knowledge about the mineralized area. Petrological studies carried on 17 rock samples taken from the study area revealed that these rocks are dacite, andesite with high-K calcalkaline character. The age of volcanism is determined by K/Ar method as 14.7±0.5 Ma for biotite-hornblende dacite and andesite and as 18.9±0.4 Ma for young andesitic dykes performed during Turkish-Italian, Joint Venture Project (1991).

At first, some findings should be mentioned in order to make interpretations about the relationships between tectonism and mineralization. These are as follows:

Dora (1964) suggests that the region is affected by Laramian orogenesis. Doming at E-W directions occurred and the center of volcanism used these domes as uprising channels. He also defended the view that giant faults with 1000 to 1500 meter offsets on the characteristic graben zones of West Anatolia caused fractures arriving below to the Moho discontinuity at beginning of Miocene. Magma rising from these fractures which arrive to Sima and spreading into large areas formed recent volcanic rocks. Generally, intermediate to asidic character of volcanic rocks is related with chemical composition of the crustal material which is assimilated during the rising (Dora, 1964; Eşder, 1990 in Gonca 1990).

An interpretation about the age determination of the region indicated that Vişneli formation represented by claystone, clay bearing limestone and tuffs and tuffites alternating with the formers at the upper parts of the sequence overlie Yamanlar volcanites. Due to this stratigraphic relationship, it has been suggested that the region began uprising before the sediments of Vişneli formation of Middle to Upper Miocene age were deposited (Gonca, 1990).

Seyitoğlu et al., (1997, Fig.2) summarise the different views regarding the relationship between tectonic style and volcanic character in western Anatolia. Some studies suggest a close relationship between calcalkaline volcanism and compressional tectonic regime during Oligocene and Early Miocene. However, the other studies proposed that Oligocene-Early Miocene calcalkaline volcanism occurred under extensional regime which continues until Pleistocene.

Dönmez et al., (1998) mapped northern part of İzmir. They divided the main tectonic elements as faults, thrusts and discordances. Faults follow three main lines on NE-SW directions which are observed as big and small faults. The same trends are determined in the mineralization area around Doğançay-Sancaklı villages.

Kaya (1999) examined the important phases of compressional-extentional tectonics and related trends of fautt and fractures during Late Cretaceous to Late Pleistocene in western Turkey. He pointed out that NE-SW trending faults progressively developed from west to east and high-K calcalkaline volcanic centers occurred on the same tectonic lines between latest Oligocene to Early Miocene. During Early Miocene-Middle Miocene period, an E-W trending regional doming is proposed (Kaya, 1999).

Under the light of findings and data given in the Geology and Petrography section, it can be accepted that high-K calcalkaline volcanism in the study area was active at the beginning of latest Oligocene and E-W doming occurred during Early to Middle Miocene.

Views about mineralizations can be summarized as follows: Molly (1956) believed that gold mineralizations at Arapdağ are not directly related with dacites and andesites, but rather with hydrothermal (mesothermal) mineralizations originated from an asidic magma chamber. İzdar (1962) suggested that ore formation is related with quartz rich juvenile hydrothermal solutions which ascended into fault zones. These zones occurred by tectonic activity which is affected dacite, dacite breccia and tuff complex. Dora (1964, 1970) postulated that gold bearing quartz veins at Arapdağ were hydrothermal solutions of gold rich meso- to epithermal character which ascended along the E-W tension fractures and occurred between dacitic and andesitic volcanism. He pointed also out the formation temperatures for quartz veins as 100-200°C. Gonca (1990) suggested that quartz veins filled E-W trending fractures in dacitic lavas at Altıntepe and silicified and thus altered the lavas. The mineralizations occurred in these veins. On the other hand, silica gels tapped dacitic tuffs at Çilektepe. Therefore, tapped tuffs caused gold enrichments. Similar findings with Gonca (1990) are expressed at the report written by Turkish-Italian Joint Venture Project (1991). They found the homogefiezation temperatures of the quartz veins between 130-290°C and low salinities with maximum 1% NaCl equivalent. Homogenezation temperatures are in good concordance with Ayan (1990) (in Gonca 1990).

According to the investigations carried on the study area, gold and silver bearing quartz veins associated with sulphide minerals and barytes trend approximately at E-W direction and occur in silicified dacitic lavas at Altıntepe. Trace amount of gold and silver contents (Gonca, 1990 vol.2 about the results of analyses) at dacitic lavas highly support that the formation of lavas and quartz veins are contemperaneous. Under these conditions, the age estimations made from Vişneli formation and age determination from the sample of biotite-hornblende dacite as 14.7±0.5 Ma during Turkish-Italian project (1991.) suggests an age of Middle Miocene for the mineralizations.

Because of silica gels (hydrothermal breccia) which crop out at Çilektepe, it is believed that dacitic tuffs and/or dacitic lava graduations are tapped by siliceous solutions. Stibnite and cinnabar mineralizations are recognizable at the surface and thin mineralized zones with low grade gold contents are determined by drills. All these data suggest epithermal type of mineralizations at this sector (Sayılı, in preparation). Mineralizations at this sector contain stibnite and cinnabar type of ore minerals and exhibit some mineralogical differences. Additionally, mineralizations occur beneath the silica gel levels and the trends of faults at Çilektepe sector suggest somewhat different type of mineralizations than Altıntepe and they are probably formed at the end of Middle Miocene.

CONCLUSIONS

Asidic volcanic rocks including dacitic tuff and lava, silicified dacitic lava, biotite-hornblende-dacite and andesitic lava, tuff and agglomerate and also andesitic dykes are determined at the study area. During the formation of dacitic tuffs, silica gels occurred arriving up to 23 meter thicknesses which are gained breccia appearances caused by hydrothermal activities.

As result of detailed petrographic, mineralogic and ore microscopic studies, two different types of mineralizations have been determined. First type is as Dora (1964, 1970) mentioned gold and silver mineralizations associated with quartz veins which took place in tension fractures in the silicified dacitic lava at Altıntepe (Arapdağ) sector. Eleven quartz veins not more than 3 meter thicknesses and associations with limonites are determined in the field and their continuations are detected by drill holes. Second type is described for the first time with this study and represented by gold mineralizations of epithermal type (?) related to hydrothermal alterations developed in dacitic tuffs of Ilıcadere and Çilektepe (Çerkeskayası or Pilavtepe). Mineralizations occurred as disseminations and in veinlets representing a stockwork type of formation.

It was reported that Late Oligocene and Middle Miocene high-K calcalkaline volcanism is developed at Western Anatolia. Based on this finding and other data collected, mineralizations should occur in and to the end of Middle Miocene.

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