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KİSECİK (HATAY) HYDROTHERMAL GOLD VEINS

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ABSTRACT .- Solutions, forming Kisecik gold veins, were derived by amphibole bearing quartz-diorite which intruded into the metadiabascs. The solutions, placed along the various fractures with different strikes and dips developed in metadiabase due to intrusion of quartz-diorite brought about the formation of vein type mineralization. Besides the vein type of mineralization, contact metamorphism and hydrothermal alteration decreasing downward in intensity developed along the contact of metadiabase with amphibole bearing quartz-diorite. Veins forming Kisecik gold deposits are seperated into two different groups; as "Kızıltepe and similar veins" and "Deliklikaya Tepe and similar veins". The former is rich in gold content with greater variety of ore minerals. The main ore minerals of this vein are arsenopyrite, pyritc, chalcopyrite, sphalerite, marcasite, loellingite, pyrotite, valleriite, cubanite, native gold, tcllurobismuthite, tellurobismuthite + hessite solid solution mineral, galenite, cinnabar, neodigenite, hematite, magnetite, rutile, anatase, sphene, chromite, ilmenite, tenorite, chalcocite, covellite, limonite, malachite, azurite, siderite, ankerite, scorodite and copper vitriol. Gangue minerals are quartz, chlorite, calcite, dolomite, clay minerals, muscovite and sericite. The ore minerals of Deliklikaya Tepe and similar veins are arsenopyrite, pyrite, sphalerite, marcasite, valleriite, pyrotite, galenite, hematite, rutile, anatase, chromite, sphene, tenorite, chalcocite, covellite, malachite, azurite, limonite, scorodite and copper vitriol. Gangue minerals of these veins are similar to those of Kızıltepe and similar veins, only with higher amount. Chalcopyrite of Kisecik mineralization bear exsolution starlets of sphalerite and show oleander leaf like twinnings. Such kind of structures indicate relatively high temperature of ore formations. The presence of cubanile and valleriite as geologic thermometers among the ore minerals points out that mineralization occurred at temperatures between 250° and 350° C. Moreover, occurrence of mushketovite in the mineralizations also indicate part of mineralization is a contact type. According to the field observations and laboratory investigations, Kızıltepe and similar veins of Kisecik gold deposits can be considered as an occurence or a small deposit from the point of reserves and grades. On the other hand, Deliklikaya Tepe and similar veins contain poor gold mineralizations with non-economic amounts.

INTRODUCTION

Kisecik hydrolhermal gold veins are located at approximately 3 km. northwest of the districts of Kızıltepe and Deliklikaya Tepe near Kisecik village of Hatay (Fig. 1).

Detailed geological studies were implemented on Kızıldağ massif, which includes hydrothermal gold veins, by Blumcnthal (1938), Dubertret (1953), Dean and Krummenacher (1961), Atan (1969), Aslaner (1973), Çoğulu (1973, 1974), Delaloyc et al. (1979, 1980a, 1980b), Selçuk (1981) and Tekeli and Erendil (1986). However, only a few geologist have been interested in the known and probable ore deposits of the Kızıldağ massif. Erickson (1940) investigated the possible petroleum deposits of the area between Hatay and İskenderun. Wijkerslooth (1942) dealt primarily with chromite and gold mineralizations and other mineral resources of the massif. Molly (1955) and Alpan (1985) searched for the possible placer gold accumulations of the above mentioned area. Additionally, Alpan pointed out that the source of placer gold could be the Kisecik gold veins. Finally, Aydal (1989) carried out some studies on the Kisecik gold occurences.

The ancient adits, called "Roman Adits", were discovered during the studies of production adits derived in Kisecik gold veins. Whether these adits were driven during Roman Period, is not clear. Moreover, which of gold and copper was produced from the ore extracted from these adits is not entirely enlightened. According to Alpan (1985), the known oldest gold production from the area dates back to 1910. Later, during the invasion of the area by french army, gold was exploited from the Kisecik gold veins and from the placer gold accumulation of Miocene basal conglomerates of Akıllıçay district.

This paper presents the field observations of the authors on the Kisecik gold mineralizations and contains the mineralogical studies and analytical result of the samples, which were collected in the mineralized area during investigations.

The studies have been realized with the invitation of concessioner of the area, Rasim Yurttaş and the approval of the General Directorate of Mineral Research and Exploration (MTA). The field studies were conducted by Ahmet Çağatay, İ.Sönmez Sayılı, Yavuz Ulutürk and M.Ziya Ateş.

The main objective of the field studies was to collect enough representative samples for mineralogical and petro graphical investigations and to carry out chemical analyses on the Kisecik gold veins and their host rocks. Thus, detailed

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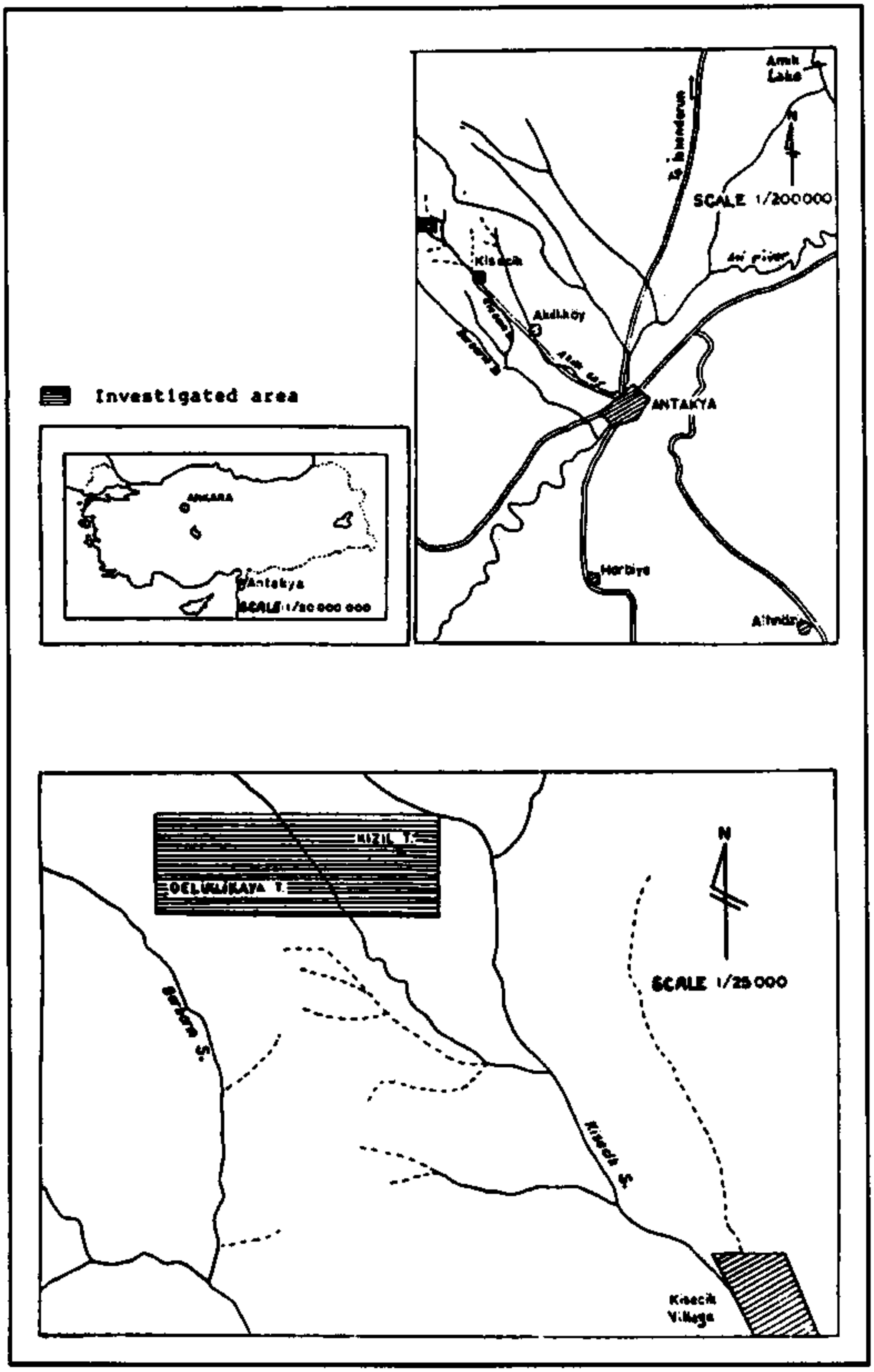

Fig. 1 - Location map of Kisecik (Hatay) hydrothermal gold veins.

mineralogical and petrographical investigations. X-ray diffraction studies and chemical analyses were done on these samples. A genetic model for the formation of Kisecik gold mineralizations was consequently tried to develop using the chemical data together with field observations.

GEOLOGY

Three different magmatic and several sedimentery rocks crop out mainly in the vicinity of the Kisecik gold occurrences (Fig. 2). Among the magmatic rocks, amphibole bearing quartz-diorite is the ore transporter or the mobilizer. Metadiabases host the ore veins. The third magmatic rock, comprised by generally rounded metagabbro, is observed in the amphibolc bearing quartz-dioritc and its contacts with metadiabases. Sedimentery rocks of Miocefie and Quaternary age occur around Kisecik village.

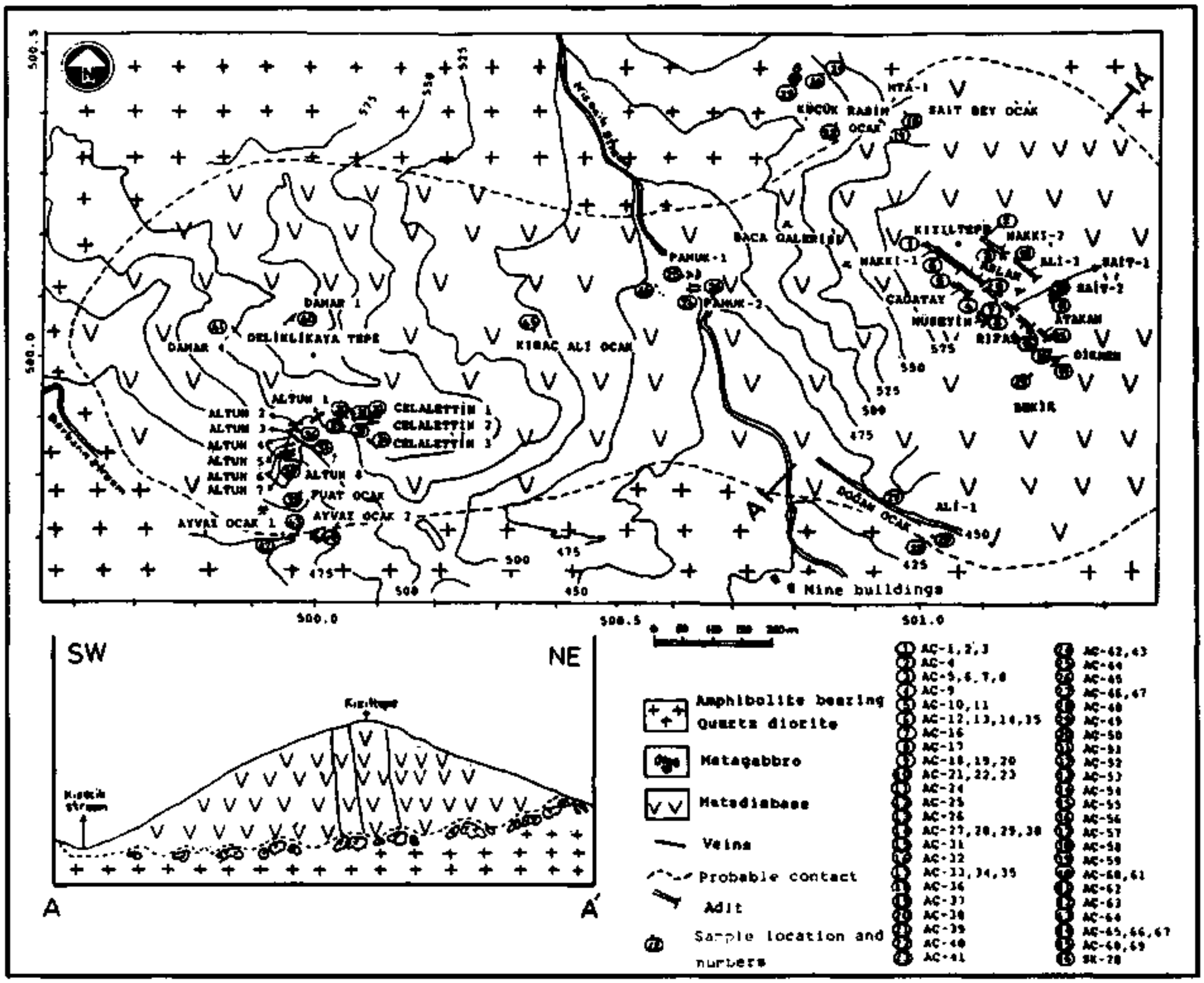

Fig. 2 - Simplified geologic and sample location map of Kisecik gold veins and their surroundings.

Amphibole bearing quartz-diorite

Amphibole bearing quartz-diorite, described as ore transporter or mobilizer rock for Kisecik gold occurrences, is exposed around the mineralizations and intrudes into metadiabases. This rock is intensively altered at the contact with metadiabases. Clinopyroxcnes of this rock are replaced by brownish hornblende and both mineral are later partly altered to actinolite-tremolite, biotite and chlorite (Plate I, fig. 1). The plagioclases of amphibole bearing quartz-diorite is saussuritized and partly occur as pseudomorphs after scapolite and sericite. The rock is cut across by mm-thick scapolite veinlets especially close to the contacts with metadiabases. The XRD analyses of the scapolite minerals showed that they are represented by dipyrc type. The hydrothermal effect decreases from the metadiabase contacts downward.

As a result of weathering, the plagioclases of amphibole-bearing quartz-diorite are highly argillized. The types of alteration minerals are defined as montmorillonite and clinozoisite by XRD. As a result of weathering, amphibole bearing quartz-diorite gained a loose structure and, hence, was casily\eroded. Preparation of thin sections and therefore, determination of plagioclase types was not possible due to pervasive argillization of these minerals in amphibole bearing quartz-diorite. Quartz crystals arc observed between altered plagioclases and amphibole minerals of the rock (Plate I, fig. 1). In addition, muscovite was rarely found in amphibole bearing quartz-diorite.

The rock, described as amphibole bearing quartz-diorite in this study, is considered within the "isotrop gabbro" unit by Tekeli and Erendil (1986). The authors point out that isotrop gabbro crops out in a large area and shows various mineral compositions, grain sizes and structures and textures. It is probably that the part of Kisecik gold veins in isotrop gabbro is suggested as a type of plagiogranite by Tekeli and Erendil (1986) representing the final differentiation solutions. Amphibole bearing quartz-diorite is an important rock unit since it forms a hot contact with older metadiabase by intruding in it and acts as an ore mobilizer. As a result of amphibole bearing quartz-diorite emplacement, this rock together with a more acidic rock and ore bearing quartz veins cut the metadiabases along its fractures.

Metadiabase

Gold bearing quartz and ore veins of Kisecik occur in metadiabases. Metadiabase forms two caplike hills with each approximately 600 meters in diameter over the amphibole bearing quartz-diorite in the districts of Kızıltepe and Deliklikaya Tepe of Kisecik gold veins. These metadiabase hills join with each other at Kisecik stream with a narrow ribbon of metadiabasc and, therefore occurs as double humps (Fig. 2). Northwest-southeast trending metadiabase ranges 1.8 to 2 km. in length along its long axis. The rest of the metadiabase, which crop out in a very small area, have already been eroded away.

Around the Kisecik gold veins, metadiabase occurs as a dyke complex composed of several parallel dykes. The dykes trending generally cast-west cut each other in a complex manner. The contact between metadiabase and amphibole bearing quartz-diorite is irregular. Metadiabase is found as enclaves in amphibole bearing quartz-diorite which replaces it.

As a result of amphibole bearing quartz-diorite intrusion into metadiabase, fractures locally parallel to each other but generally different in strikes and dips are formed in metadiabases. These fractures arc filled by quartz and ore minerals which arc transported by amphibole bearing quartz-diorites. Because it serves as host rock for ore veins, metadiabase required detailed investigations. For this reason, some samples collected from meladiabase enclaves, at various distances to the contact between amphibole bearing quartz-diorites and metadiabases and along the contact between ore veins and metadiabases are investigated.

Metadiabase dykes arc generally fine to medium grained and show intersertal textures. The texture is difficult to identifywhere locally obliterated by hydrothermal altcralions. Metadiabase is generally subjected to pervasive chloritization, silicification, carbonization and sericitization. Main constituents of metadiabase are plagioclases (labrador), clinopyroxenes (augite), magnetite and ilmeno-magnetite. Amphibolized clinopyroxenes are replaced by abundant chlorite and plagioclases by sericite, calcite and quartz Clinopyroxenes, amphiboles and plagioclases are observed as relicts in alteration minerals. Magnetite and ilmeno-magnetite are replaced by hematite in their different sections. Metadiabases also contain trace amount of ilmenite, rutile, anatase, sphene and chromite.

The invesligations carried oul on the samples taken from the contacts of amphibole bearing quartz-diorite and ore veins with metadiabases show that these samples do not comprise magnetite, ilmeno-magnetite and ilmenite. The lattice of rutile and rutile and anatas grains are locally replaced by sphene along their borders. The iron content of magnetite, ilmeno-magnetiteand ilmenite is leached from the environment (the rock) as a result of hydrothermal alteration and migrations at these specific pans of mcladiabascs. The remainder in the metadiabases are the titan bearing minerals. This iron is used mainly in the sulphide minerals of ore veins and in other iron bearing rock forming minerals.

Metadiabases are subjected to various kinds of hydrothermal alteration at its enclaves in amphibole bearing quartz-dioritcs and at the contact with the same rock, where intense epidotization, actinolitization-tremolitization and scarce prehnitizalion occur. Additionally, amphiboles are replaced by phlogopites (Plate I, fig.2) and plagioclases are saussuritized.

Metagabbro

Metagabbros are exposed especially close to the contact between amphibole bearing quartz-diorite and metadiabase in amphibole bearing quartz-diorite. They form rounded, clipsoidal or potato-like shapes around the Kisecik gold veins, and occur as thin veins cutting the amphibole bearing quartz-diorite in short distances. Elipsoidal metagabbros show well-developed exfoliation. The diameters of rounded metagabbros reach up to 1 to 1.5 m. Metagabbro occurrences, hard, strong and dark colored, arc easily recognizable in light colored, feldspar rich amphibole bearing quartz-diorite which is quite friable due to alteration.

Metagabbro contains medium grained clinopyroxenes, plagioclases and orthopyroxenes. Clinopyroxenes are amphibolized anduralitized(actinolitization-tremolization)as chessboard like (Plate I, fig.3) Orthopyroxenes, less common, are replaced by talc and serpentine along its cracks, borders and cleavages. Some phlogopite was also developed together with talc. Actinolite is partly altered to chlorite.

On the other hand, metagabbro comprises rare or trace amount of oxide and sulphide minerals. Magnetite, hematite (product ofmartitization),ilmeniteand chromite are oxide minerals. Magnetite is fine grained and idiomorph to sub idiomorph and along the borders is partly replaced by hematite. Ilmenites have small grains and lamellaes and are replaced by rutilc and sphene along its borders. Chromites occur as very fine, idiomorph grains in orthopyroxenes. Sulphide minerals are observed within or together with actinolite -tremolite and especially chlorite bearing parts of the rock. The sulphide minerals arc pyrite, chalcopyrite, millerite, pyrolite, sphalerite, chalcocite and covellite.

Fine pyrite crystals arc idiomorphic to subidiomorphic. Millerite can be identified in the stcatized and serpentinized parts of orthopyroxenes in metagabbro. Xenomorphic fine chalcopyrite crystals are replaced by chalcocite and covellite along its borders. Pyrotite occurs as intergrowths with chalcopyrite or inclusions in pyrites. Sphalerite is also fine grained and intergrowths with chalcopyrite.

Miocene deposits

Middle Miocene deposits exposed around Kisecik village rest partly either on Eocene deposits or on ophiolites by a basal conglomerate (Alpan, 1985). This unit is generally light colored but in some parts contains red to brown gravels. Most of the gravels comprised by partly or totaly serpentinized harzburgite. Conglomeratic levels grade up to sandstones, which arc in turn, overlain by sandy-marly limestones. Marls with sandstone lenses overlie the limestones and grade up into gypsifcrous levels.

Quaternary deposits

These deposits are characterized by old terraces, talus material and alluvials. There types of deposits are found at Kisecik stream. Both Miocene conglomerates and Quaternary deposits contain small amounts of detrital gold grains (Molly, 1961; Alpan. 1985).

GOLD VEINS

Primer gold deposits of Kisecik are composed of two different types of ore veins, named Kızıltepe and Deliklikaya Tepe veins. Kızıltepe ore veins arc usually enriched in ore minerals and have higher gold contents. In contrast, Deliklikaya Tepe veins are poor in ore minerals with relatively low gold contents . Therefore, the latter seems not have an economic importance.

At Kızıltepe district, the lower elevations of the most southern vein of Çağatay* and Dikmen mines and Doğan Ocak part look like Deliklikaya Tepe veins. On the other hand. Pamuk-1 and Pamuk-2 mines in Kisecik stream, Küçük Rasim and Kıraç Ali mines (veins) show some similarities to Kızıltepe veins in respect to their ore mineral contents (Fig.2).

Kızıltepe and similar veins

The most important, of the Kızıltepe veins is the one that along which are driven Hakkı-1. Aslan, Ali-1, Sait-1, Rıfat and Atakan Oğuz adits. The vein strikes N 70°W and dips 80-85° to the north. Another thin and short vein trends parallel to this vein and is located 50 m. to the north. in whicn-Hakkı-2. Ali-2 and Sait-2 adits were driven. South of this thin vein, each

The name of (Çağatay used here is taken from the mining engineer of Yurttaşlar Company Mr. Rıfat Çağatay.

50 m. away from it, two parallel short and thin veins are situated and Çağatay, Dikmen, Hüseyin and Bekir adits were driven in them. The vein located in opposite side of these veins in which Küçük Rasim mine was opened extends approximately in the same direction. The vein was intented to be intersected by MTA-1 drillhole but this aim failed. The thickness of the vein is 0.5-0.6 m. A 15 m. long adit was driven along its strike. Pamuk-1 Pamuk-2 veins, located in Kisecik stream, are close to each other and strike N 70°E and dip 75° to the NW. The thicknesses of these veins vary between 6.2 to 0.4 meters. They are rich in chlorite, calcite and pyrite.

Kıraç Ali mine is a short vein 3 to 4 m. in length with a.maximum thickness of 0.25 m. situated in a zone where faults crossing each other with different strikes. This vein extends in a large trench opened by a huge excavation activity. It strikes N 35°E and dips 50° to the NW. According to Aydal (1989) this vein, rich in hydrothermal quartz, chlorite and ore minerals, has the highest gold value among all other Kisecik gold veins. He reports that the gold content of this vein is 156 gr/t. The gold analysis of a sample taken from the same vein by the authors of this paper showed a very low gold grade (Table 1).

Table 1- Chemical analyses of Kızıltepe and Deliklikaya Tepe veins

Elements		Atomic Abs. and ICP		Optic spectrographic Semi-quantitative analyses							
Veins	Sample no	Au gr/t	Ag gr/t	% As	% Sb	% Cu	% Zn	% Ni	% Co	% Bi	% Te
Deliklikaya T. Vein -4	AÇK-1	0.46	2.2	nd	nd	0.07	0.1	0.007	0.007	nd	nd
Deliklikaya T. Vein -4	AÇK-2	0.2	nd	nd	nd	0.03	nd	nd	nd	nd	nd
Deliklikaya T. Vein -4	AÇK-3*	0.53	nd	nd	nd	0.008	nd	nd	nd	nd	nd
Altun-2	AÇK-4	0.096	nd	nd	nd	0.004	nd	nd	nd	nd	nd
Damar-1**	AÇK-5	nd	nd	nd	nd	0.007	nd	nd	nd	nd	nd
Damar-1	AÇK-6	0.252	nd	nd	nd	0.007	nd	nd	nd	nd	nd
Altun-3	AÇK-7*	0.14	nd	nd	nd	0.009	nd	nd	nd	nd	nd
Fuat Ocak (Sil. zone)	AÇK-8	nd	nd	>1	nd	0.007	nd	nd	nd	nd	nd
Fuat Ocak** (Lim. zone)	AÇK-9	4.91	22.0	>1	nd	0.1	nd	nd	nd	nd	nd
Doğan Ocak (Alt. Dia.)	AÇK-15	nd	nd	nd	nd	0.007	nd	nd	nd	nd	nd
Doğan Ocak (Quartz ve.)	AÇK-16	0.38	nd	>1	nd	0.007	nd	nd	nd	nd	nd
Doğan Ocak** (Lim. zone)	AÇK-17	0.82	nd	1	nd	0.007	nd	nd	nd	nd	nd
Celalettin-2	AÇK-18	0.21	nd	nd	nd	0.007	nd	nd	nd	nd	nd
Ayvaz-2 (from pile)	AÇK-10*	1.16	3.1	0.25	nd	0.008	nd	nd	nd	nd	nd
Ayvaz-2 (adit entrance)	AÇK-11*	1.37	0.95	0.5	nd	0.015	nd	nd	0.004	nd	nd
Kıraç Ali Ocak	AÇK-14*	0.46	nd	nd	nd	0.008	nd	nd	nd	nd	nd
SK-2B Drill (45-46 m.)	AÇK-19*	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Dedection Limits		0.040	0.5	0.4	0.02	0.0004	0.1	0.004	0.002	0.002	0.2

* Analyses are made in Canada and Saudi Arabia. The average of both analyses are shown in the table.

** The samples are collected from gold suspected places.

sil. = Silicified; lim. = Limonitized; dia. = diabase; ve. = vein; nd = not dedected

Kızıltepe ore veins show pinches and swells along their strikes and dips. Metadiabase fragments, completely silicificd, chloritized, sericitized, carbonatized and argillized occur in between mineralized stringers of the veins which locally splays out. Hydrothermal quartz and fault clays accompany to these minerals. Halloysite, illite and montmorillonite are determined as the clay minerals of fault using the XRD and DTA methods. Halloysite and illite are the most abundant clay minerals. The thicknesses of the veins which are generally very poor in ore minerals reach up to 1.5 to 2 m. The maximum total thickness of massive ore, which is important for gold, in this zone is 15 to 20 cm.

Mineralogy of Kızıltepe veins

The minerals of Kızıltepe gold bearing ore veins are arsenopyrite, pyrite, chalcopyrite, sphalerite, marcasite, pyrolite, valleriite, cubanite, native gold, tetradimite, galenite, cinnabar, neodigenite, chalcocite, covellite , malachite, azurite, siderite, ankerite, scorodite and copper vitriol. Gangue minerals arc represented by quartz chlorite, calcite, dolomite, clay minerals, muscovite, sericite and sphene.

Arsenopyrite. - This is by far the most abundant mineral in the investigated ore samples. Arsenopyrite is coarse grained and shows cataclastic structure. Pyrite, quartz, chalcopyrite and sphalerite fill cavities and cataclastic cracks of rhombic and prismatic arsenopyrite crystals. Dimension of the longest prismatic arsenopyrite grain is 3x1.2 mm. Parallel cleavages on some arsenopyrite grains arc locally clearly observed. Arsenopyrite in which pyrite and other mineral veinlets occur is the oldest sulphide mineral, and shows star (winnings. It also contains idiomorphic quartz and rutile, anatase, magnetite and hematiteinclusions.

The result of microprobe analyses, carried out on arsenopyrite crystals, arc given in Table 2. As it is easily seen from the table, arsenopyrite contains high amount of Co besides its main constituents of Fe, As and S. Those Co rich arsenopyrite crystals generally occur next to native gold or sometimes in the same part of the rock with it.

Table 2- Microprobe analyses of Kisecik arsenopyrites

Elements	*Points, % wt*				*Average*
	1	*2*	*3*	*4*	*% wt*
Fe	34.96	35.69	35.08	30.63	34.09
S	19.80	19.12	19.91	20.53	19.84
As	44.48	43.36	42.72	42.28	43.21
Sc	0.10	0.37	0.33	0.28	0.27
Cu	0.29	0.98	0.39	0.69	0.59
Co	0.04		0.30	4.44	1.20
Ni		-	-	0.25	0.06
Au		-	0.64	-	0.16
Total	99.67	99.52	99.37	99.10	99.42

Pyrite. - Pyrite is also one of the most abundant ore minerals observed. Pyrites arc characterized by different origins and ages. Primary ones arc idiomorphic to hipidiomorphic. Some of them arc corroded by later minerals and hence occur as skeletons. Primary pyrites up to 3 mm. are generally coarse grained. The interstices and cracks of the cataclastic pyrites are filled by chalcopyrite and quartz and are replaced by marcasite along their rims and cataclastic cracks. In addition, mostly xenomorphic and rarely vein type pyrites are also present as infillings in interstices and cracks of old quartz grains.

Some other main part of pyrite results as pscudomorphs alter parallel, lamellar hegzagonal pyrotite (Plate I, fig. 4). Such of pyrites increase in amount at the lower parts of the veins. They are generally observed as growths within or together with very fine grained marcasite. The pyrites, formed as pseudomorphs of hegzagonal, lamellar pyrotite show in some parts radial textures. According to Ramdohr (1975), pyrotite is replaced by a mid-product which later turns to pyrite.

A small amount of pyrite is observed as tiny gel structured forms in chalcopyrite. Beside this type of pyrite, a very young type envelopes sphalerite and chalcopyrite as thin layers and veinlets and sometimes cuts them.

Sphalerite, chalcopyrite, quartz and calcite grains intruded into pyrite and corroded rutile, anatase, sphene, magnetite, chlorite, quartz, hematite and arsenopyrite inclusions are observed in pyrites. In some idioblastic textured pyrites, quartz and chlorite are more abundant. The starlets of sphalerite in pyrites indicate that the pyrites replace chalcopyrite and include sphalerite exsolutions. Microprobe analyses were carried out on idiomorphic pyrites. It was determined that the pyrites comprise trace amounts of Co (0.09%), Ni (0.07%), As (0.08%), Sc (0.35%) and Cu (0.054%), in addition to their main Fe and S contents.

Chalcopyrite. - Chalcopyrite is also very abundant among the ore minerals. The amount of chalcopyrite increases especially towards the upper levels of ore veins. Most of them are allotriomorphic and intergrown crystal associations. A small amount of chalcopyrite occurs as exsolutions in sphalerites. In some places, excellent sphalerite exsolution starlets can be observed (Plate I, fig. 5). Ramdohr (1975) points out that sphalerite starlets in chalcopyrite arc very good indicators for high temperature formation of chalcopyrite.Chalcopyrites include inclusions of small pyrite, arsenopyrite, sphalerite, quartz, chlorite, hematite, magnetite, rutile, anatase and sphene grains. Chalcopyrites show oleander leaf-like or parallel lamellar twinning. According to Ramdohr (1975), this feature also stresses formation of chalcopyrite from high temperature hydrothermal solutions. In some places, weak cataclastic chalcopyrite replaces arsenopyrite and pyrite very clearly. Locally, chalcopyrite replaces also prismatic hegzagonal pyrotite lamellae as pseudomorphs and takes its shape and place. In some places, prismatic sphalerite grains extending in two different directions occur in chalcopyrite. Microprobe analyses of chalcopyrite show that it contains Cu (33.38%), Fe (30.84%), and S (34.42%) as main constituents and Zn (0.16%), Co (0.07%), Ni (0.02%), As (0.32%) and Sc (0.12%) in trace amounts.

Sphalerite. - Sphalerite is one of the widely observed main minerals. It is mainly coarse grained, hypidiomorphic and rarely idiomorphic reddish to brownish and sometimes yellowish internal reflections indicate high FeS contents for sphalerite. Microprobe analyses on two sphalerite grains displayed their high Fe content (Table 3). According to the analytical result, the formula of sphalerite is $(Zn_{0.81}\ Fe_{0.23})\ S_{1.03}$. Ramdohr (1975) points out that these kinds of sphalerites form from high temperature solutions. However, sufficient FeS containing solution should be present in that environment as the case for Kisecik ore veins. Some of the sphalerite crystals show well developed parallel twin lamellae and cleavages.

Table 3- Microprobe analyses of Kisecik sphalerites

Elements	Points, % wt		A Average % wt	B Atomic Weight	A/B
	1	2			
Zn	53.66	52.75	53.20	65	0.81
S	31.98	33.97	32.98	32	1.03
Fe	13.36	12.34	12.85	56	0.23
Cu	0.94	0.19	0.57	63.5	0.009
Sc	0.28	0.32	0.30	79	0.004
As	0.16	0.22	0.19	75	0.003
Total	100.38	99.79	100.09		

Sphalerite crystals are distinguished into two different types as one with chalcopyrite exsolutions and the other devoid of them. Usually, coarse grained sphalerite crystals contain mainly chalcopyrite and rarely pyrotite and valleriite exsolutions. These are located and aligned parallel to the zoning and certain crystals graphic directions of sphalerite crystals (Plate I, fig. 6). Locally, pyrotite and chalcopyrite exsolutions show myrmekitic growths in sphalerite. Sometimes, valleriite is associated with these growths.

Sphalerite replaces some parts of arsenopyrite, pyrite, quartz and fills the spaces and cataclastic cracks of them. Locally, sphalerite very clearly replaces chalcopyrite on the other hand spaces and cataclastic cracks of sphalerite are filled by younger quartz, calcite, dolomite and chalcopyrite. Besides these fillings, thin pyrite veinlets cut the sphalerite grains.

Marcasite. - Marcasite increases in amount at the lower elevations of ore veins and is formed as a result of conversion of pyrotite to semi product of marcasite-pyrite. In addition, idiomorphic and subidiomorphic pyrite crystals are locally replaced by marcasite along their rims and cataclastic fractures. Primary prismatic marcasite crystals are also observed. Some marcasite crystals show parallel lamellae-twinning.

Loellingite. - Idiomorphic and hypidiomorphic locllingite crystals are found in small amounts in polished ore sections. Locllingite appears softer in hardness and whiter in color when compared with yellowish arsenopyrite. The results of microprobe analyses from two different points in loellingite are given in Table 4. Loellingite forms a solid solution with saffiorite. The formula of loellingite is $(Fe_{0.36}\ Co_{0.13})\ (As_{0.90}\ S_{0.05}) = (Fe_{0.72}\ Co_{0.26})\ As_2$.

Table 4- Microprobe analyses of cobalt-rich loellingite

Elements	Points, % wt		A Average % wt	B Atomic Weight	A/B
		2			
Fe	20.28	20.13	20.21	56	0.36
S	1.69	1.71	1.70	32	0.05
As	67.39	67.19	67.29	75	0.90
Cu	0.70	0.81	0.76	63.5	0.01
Co	7.37	7.41	7.39	59	0.13
Ni	0.93	0.89	0.91	59	0.02
Au	0.56	0.37	0.47	197	0.002
Total	98.62	98.51	98.73		

Pyrotite. - Pyrotite is observed in very small amount within pyrite, chalcopyrite, arsenopyrite, sphalerite and quartz crystals. It occurs, additionally, together with chalcopyrite and valleriite as exsolutions in sphalerite. Hegzagonal pyrotite, which is more abundant at the lower elevations of ore veins, is completely replaced by semi-product and pyrite. Replacement to semi-product is characterized by the bird eye texture.

Valleriite. - Very small amount of valleriite, together with chalcopyrite and pyrotite are found in sphalerite as exsolutions (Plate I, fig. 7). Moreover, second generation valleriite exsolutions are observable in the exsolutions and inclusions of chalcopyrite in sphalerite. The crystals of this generation show extentions and arrangements due to the different lines in chalcopyrite. Valleriite results from the ore solutions within the temperature range of 250-300°C and is used as geothermometer mineral (Borchert, 1934).

Cubanite. - This mineral is found very rarely and in very small amounts and is observed as thin parallel exsolution lamellae in chalcopyrite (Plate I, fig. 8). Some lamellae cut each other. Cubanite also crystallizes from the ore solutions of 300-350°C and is used as geothermometer mineral like valleriite (Borchert, 1934).

Native gold. - Native gold is observed only in 8 of 57 polished sections from Kızıltepe and similar ore veins. The names of adits from which the native gold bearing samples collected, their mineral paragenesis, the minerals hosting the native gold and the number and sizes of grains measured from one polished section are given in Table 5.

Table 5- Mineral paragenesis, number and size of gold grains and associated minerals of auriferous minerals

<table>
<tr><th>Adit name and Sample no.</th><th>Paragenesis</th><th>Native gold bearing mineral or mineral contacts</th><th>Observed grain number</th><th>Grain size (m)</th></tr>
<tr><td rowspan="4">Hakkı- 2 (AÇ-5)</td><td rowspan="4">Arsenopyrite, chalcopyrite, pyrite, sphalerite, pyrotite, hematite, covellite, marcasite, gold, quartz, sericite</td><td>Chalcopyrite</td><td>7</td><td>18x13, 13x9, 6x4, 1x2, 15x2, 2x4, 3x6</td></tr>
<tr><td>Arsenopyrite</td><td>5</td><td>22x17, 28x11, 80x15, 12x11, 8x4</td></tr>
<tr><td>At contact between arsenopyrite and chalcopyrite. The latter cuts the former.</td><td>2</td><td>17x2, 18x9</td></tr>
<tr><td>Sphalerite</td><td>1</td><td>2x4</td></tr>
<tr><td>Çağatay (AÇ-9)</td><td>Chalcopyrite, pyrite, arsenopyrite, pyrotite, marcasite, limonite, neodigenite, sphalerite, covellite, malachite, scorodite, quartz</td><td>Limonite (originated from chalcopyrite)</td><td>2</td><td>6x3, 1.5x2</td></tr>
<tr><td rowspan="2">Çağatay (AÇ-10)</td><td rowspan="2">Chalcopyrite, pyrite, arsenopyrite, pyrotite, marcasite, limonite, neodigenite, covellite, chalcosite, malachite, azurite, scorodite, quartz</td><td>Limonite (originated from chalcopyrite)</td><td>1</td><td>120x4</td></tr>
<tr><td>Scorodite</td><td>1</td><td>2x12</td></tr>
<tr><td rowspan="3">Çağatay (AÇ-11)</td><td rowspan="3">Arsenopyrite, chalcoyprite, covellite, malachite, pyrite, marcasite, sphalerite, digenite, tetradimite, pyrotite, quartz</td><td>Arsenopyrite</td><td>9</td><td>17x11, 30x5, 50x45, 10x7, 62x13, 30x14, 12x9, 14x9, 16x13</td></tr>
<tr><td>In chalcopyrite veinlet cutting arsenopyrite</td><td>10</td><td>70x6, 22x6, 45x8, 11x8, 45x8, 12x7, 64x7, 4x3, 2x3, 20x12</td></tr>
<tr><td>Chalcopyrite</td><td>4</td><td>7x5, 10x10, 14x10, 13x4</td></tr>
<tr><td>Ali-1 (AÇ-18)</td><td>Arsenopyrite, chalcoyprite, sphalerite, pyrite, pyrotite quartz, calcite, sericite</td><td>Arsenopyrite</td><td>1</td><td>11x9</td></tr>
<tr><td rowspan="3">Ali-2 (AÇ-21)</td><td rowspan="3">Pyrite, sphalerite, chalcopyrite, arsenopyrite, pyrotite, hematite, limonite, quartz, calcite, chlorite, valleriite</td><td>At contact between chalcopyrite and arsenopyrite. The former cuts the latter.</td><td>1</td><td>30x4</td></tr>
<tr><td>At contact of chalcopyrite, arsenopyrite, quartz</td><td>1</td><td>32x7</td></tr>
<tr><td>Between sphalerite and chalcopyrite</td><td>1</td><td>9x6</td></tr>
<tr><td rowspan="3">Ali-2 (AÇ-22)</td><td rowspan="3">Sphalerite, chalcopyrite, arsenopyrite, pyrite, marcasite, quartz, calcite, chlorite</td><td>Inbetween quartz, arsenopyrite, chalcopyrite</td><td>1</td><td>62x45</td></tr>
<tr><td>Between quartz & chalcopy.</td><td>1</td><td>40x30</td></tr>
<tr><td>Sphalerite</td><td>1</td><td>16x12</td></tr>
<tr><td>Rıfat (AÇ-29)</td><td>Pyrite, sphalerite, chalcopyrite, arsenopyrite, pyrotite, valleriite, marcasite, calcite, ankerite, siderite, chlorite, quartz</td><td>Arsenopyrite</td><td>1</td><td>18x4</td></tr>
</table>

Native gold grains are generally very small xenomorphic, sometimes drop-like, rounded and spherulic. They are observed in chalcopyrite, arsenopyrite , sphalerite, limonite, scorodite and quartz or at the double or triple contacts of these minerals (Table 5) (Plate II, fig. 1, 2, 3, 4). Very thin and uncontinuous native gold veinlets are found at the contact of arsenopyrite and chalcopyrite, which cut across the cataclastic arsenopyrite crystals (Plate II, fig. 5, 6). Native gold is precipitated at the contact between chalcopyrite and arsenopyrite. The largest grains are found in these veinlets.

Native gold grains are usually and closely related with chalcopyrite and arsenopyrite , as it is clearly seen from Table 5. Native gold is contemporaneous with chalcopyrite but younger than arsenopyrite at the investigated samples of Kiziltepe ore veins. The ones which are rich in chalcopyrite and arsenopyrite, are also rich in native gold. However, sometimes some samples rich in these two minerals contain no native gold. The number of gold grains decrease toward the lower elevations with the abundance of pyrite, chlorite and calcite. Moreover, no native gold is observed in the polished sections rich in arsenopyrite and pyrite. Therefore, native gold grains in Kızıltepe ore veins characterize a heterogeneous distribution. This kind of distribution is also seen in the chemical analyses of the samples, which contain abundant or rare gold grains (Tables 5 and 6).

Table 6- Gold, silver and other element analyses of Kızıltepe and similar massive ore samples

Sample no.	*Adit name*	*Microscopic investigation*	*Atomic absorbsiyon and ICP*		*Optic spectrographic semi-quantitative analyses*							
			Au gr/t	*Ag gr/t*	*% As*	*% Sb*	*% Cu*	*% Zn*	*% Ni*	*% Co*	*% Bi*	*% Te*
AÇ-5	Hakkı-2	+	20.8	39.2	>1	nd	>1	1	nd	0.03	nd	nd
AÇ-7	Hakkı-2	+	17.5	21.6	>1	nd	>1	>1	nd	0.03	nd	nd
AÇ-10	Çağatay	+	19.3	56.0	1	nd	>1	0.2	nd	0.003	nd	nd
AÇ-11	Çağatay	+	96.0	34.8	>1	nd	>1	0.4	nd	0.07	nd	nd
AÇ-14	Aslan	-	3.3	15.9	>1	nd	>1	0.3	nd	0.004	nd	nd
AÇ-18	Ali-1	+	20.0	19.6	>1	0.04	>1	>1	0.004	0.04	nd	nd
AÇ-22	Ali-2	+	8.3	5.0	0.7	nd	0.3	1	nd	nd	nd	nd
AÇ-27	Rıfat	-	2.3	nd	1	nd	0.7	>1	nd	nd	nd	nd
AÇ-29	Rıfat	+	1.0	5.0	1	nd	>1	1	nd	0.003	nd	nd
AÇ-68	Kıraç Ali*		1.24	4.8	>1	nd	0.3	>1	nd	nd	nd	nd
AÇ-69	Kıraç Ali**		2.98	8.4	>1	nd	0.3	>1	0.004	nd	nd	nd
Dedection limits			0.04	0.5	0.4	0.02	0.0004	0.1	0.004	0.002	0.002	0.2

+, Present; -, Not present; nd= not dedected.
* Taken from limonitized zone.
** Taken from silicified zone.

No silver mineral except tellurobismuthite + hessite solid solution crystals are observed in the polished sections of Kızıltepe ore vein samples. Dedection of silver in the analyses and its increasing of contents parallel to gold indicate that some of silver occur in the solid solution with gold (Table 1,6). This feature is also clearly observed during the microscopic investigation. The color of native gold grains rich in silver is lighter than the ones rich in gold with their light white-yellow color. These kind of grains are generally observed in different but sometimes in the same polished section. The microprobe analyses of gold grains in the same polished section verify the microscopic observations (Table 7). The silver and trace amounts of Cu (1.53%), Pt (0.74%) and Co (0.22%) were analysed in these gold grains and are given in Table 7.

Table 7- Microprobe analyses of Kisecik golds

Elements	*Points, % wt*				*Average*
	1	*2*	*3*	*4*	*% wt*
Au	73.70	76.56	79.80	97.20	81.82
Ag	20.10	18.25	16.50	1.00	13.96
Cu	1.80	2.32	1.20	0.80	1.53
Pt	0.80	1.16	0.80	0.20	0.74
Co	0.90	-	-	-	0.22
Ni	-	-	-	-	-
Fe	2.70	1.71	1.70	0.80	1.73
Total	100.00	100.00	100.00	100.00	100.00

Tellurobismuthite. - As very fine grains and in small amounts, this mineral is found only in one sample. The largest tellurobismuthite grains are only 30-40 microns. They are rounded, drop-like and lath-like. The smallest size of tellurobismuthite grains in chalcopyrite are 2-3 microns. The unambigous determination of tellurobismuthite is quite difficult because of its fineness. The mineral considered as Te-Bi mineral resulting from the microscopic investigation is also analysed by using the microprobe method. The existence of tellurobismuthite is proven (Table 8) in that way. The formula of tellurobismuthite is as follows : $Bi_{0.23}\ Te_{0.36} = Bi_2Te_3$.

Tellurobismuthite + hessite solid solution mineral. - Trace amount tellurobismuthite + hessite solid solution minerals arc observed as small grains and intergrowths with tellurobismuthite. The results of microprobe analyses from two measurement points in this mineral are shown at Table 9. According to the analytical results, the formula of the mineral is $(Bi_{0.18}\ Ag_{0.12})\ Te_{0.35} = Bi_3Ag_2Te_{5.5} = Ag_2Te+3/2Bi_2Te_3$. This expression suggests that a solid solution mineral which has one molecule hessite and one and a half molecule oftellurobismulhite. This mineral might be a new and an unnamed mineral.

Table 8- Microprobe analyses of Kisecik tellurobismuthites

Elements	*Points, % wt*						*A Average % wt*	*B Atomic weight*	*A/B*
	1	*2*	*3*	*4*	*5*	*6*			
Bi	45.83	46.84	47.02	46.95	45.33	50.76	47.12	209	0.23
Te	45.45	47.44	47.57	46.49	44.76	43.31	45.84	128	0.36
Fe	0.88	0.88	0.86	1.21	1.18	1.18	1.03	56	0.02
S	0.27	0.23	0.14	0.13	0.27	0.15	0.20	32	0.006
As	5.86	2.92	2.93	3.08	1.58	1.38	2.96	75	0.04
Se	-	-	-	-	-	-	-	79	-
Ag	0.41	0.33	0.23	0.31	2.43	1.56	0.88	108	0.008
Cu	1.25	1.31	1.18	1.71	1.56	1.55	1.43	63.5	0.02
Ni	0.06	0.05	0.08	0.10	0.08	0.10	0.08	59	0.001
Total	100.01	100.00	100.01	99.98	97.19	99.89	99.54		

Table 9- Microprobe analyses of tellurobismuthite + hessite solid solution mineral

Elements	Points, % wt				A Average % wt	B Atomic weight	A/B
	1	2	3	4			
Te	44.99	45.58	43.93	43.06	44.39	128	0.35
Bi	38.47	40.18	38.94	36.93	38.63	209	0.18
Fe	0.82	1.05	0.74	0.79	0.85	56	0.02
S	0.10	-	-	0.13	0.06	32	0.002
As	2.25	0.92	1.60	0.93	1.43	75	0.02
Se	-	-	-	-	-	79	-
Ag	12.68	10.92	14.12	14.57	13.07	108	0.12
Cu	0.59	1.27	0.79	0.93	0.90	63.5	0.014
Ni	0.11	0.08	0.08	0.08	0.09	59	0.001
Total	100.01	100.00	100.20	97.42	99.42		

Galenite. - Galenile is very rare and is observed only in two sections including various sizes. Coarse grained galenile show cleavage fracture spaces. They locally form small idiomorph crystals in sphalerite. In addition, some xenomorph grains of galenite fill the open spaces between quartz crystals.

Cinnabar. - Cinnabar is observed in small amounts in highly chloritized, silicified and carbonitized mctadiabase due to hydrothermal alteration. It forms fine grained, xenomorph and intergrown crystal associations both in host rock and ore veins. Cinnabar is found in ankerite-siderite, pyrite and small amount of chalcopyrite disseminations bearing metadiabase.

Neodigenite. - Small amount of neodigenite is observed as veinlets cutting chalcopyrite and sphalerite. Neodigenite is replaced by covellite along its border as a result of weathering.

Chalcocite. - Trace amount of chalcocite is formed by weathering along its borders, cleavages and fractures which is later replaced by covellite. Chalcocite is associated with covellite and limonite.

Covellite. - Small amount of covellite is found as fracture and open space fillings and as thin belts around sphalerite grains. Additionally, chalcopyrite is replaced by small amount of covellite + limonite or chalcocile + covellite + limonite along its borders, cleavages and cataclastic fractures.

Hematite. - Hematite is rare and is found in different types. The most abundant type of hematite shows radial - spherulic, kidneylike or grapelike shapes and concentric textures (Plate II, fig. 7). This type of hematite is observed at the lower elevations of Kızıltepe ore veins and fills the spaces and fractures in between pyrite crystals. Sometimes, they intersect chalcopyrite grains as veinlets. Locally, observing magnetite relicts in gel textures of hematites point out that they are formed by the martitization processes of magnetites with the same textures.

In addition, some hematite occurrences arc found with rough surfaces forming small prismatic crystals or crystal associations in chalcopyrite and pyrite. Quartz crystals with concentric or kidneylike textures are colored to red by some submicroscopic hematites. Sometimes, hematite forms very thin rods and needles in concentric and radial-spherulic carbonate minerals such as ankerite and siderite.

Magnetite. - Magnetite is observed in small amounts and as relicts in gel textured hematites. They also occur as thin veinlets cutting chalcopyrite. Fine grained, radial-spherulic magnetite rods are generally found at the lower elevations of veins. These magnetite rods called as mushketovite (Plate II, fig.8) which occurs in contact type of ore deposits (Ramdohr, 1975). In addition, some magnetite is formed by intergrowings within pyrite which are occured by the replacement of pyrotite under the underground water level. According to Ramdohr (1975), the conversion of pyrotite to pyrite + magnetite can be formulated as follows:

$$6FeS + 2O_2 = 3FeS_2 + Fe_3O_4$$

Rutile + anatase. - Trace amounts of rutile + anatase are observed as fine crystals. The iron contents of the ilmenites in metadiabases has been lost by hydrothermal alteration and hence rutile and anatase are formed as ilmenite pseudomorphs. Because of the derivation from host rock, rutile and anatase, generally as skeletons, rods and xenomorph grains are located as inclusions into all other hydrothermally originated minerals. They are usually found in highly chloritized, serialized and silicified parts of host rock. The largest crystal of rutile observed in pyrite sizes 100x50 microns. The cracks of cataclastic rutilcs are generally filled by younger ore and ganguc minerals.

Some part of rutile has lattice shapes formed by hydrothermal alteration of ilmeno-magnetites. As a result of this alteration, the iron content and magnetite parts of ilmeno-magnetites are driven away from the crystal lattices and rutile lattices occur as the remaining mineral. Also, needle-like rutile crystals are observed. Rutile and anatase grains are replaced by sphene along their borders and cleavages.

İlmenite. - Trace amount of ilmenite are observed as relicts in rutile crystals. Prismatic, skeleton shaped and xenomorph ilmenite grains are determined in sections which arc replaced by trace amounts of rutile, anatase and sphene along their borders.

Chromite. - Small crystals of chromite occur in trace amounts. The largest crystal size is 40x35 micron. Chromite is also derived from diabase like ilmenite, rutile and anatase.

Tenorite. - Small amount of tenorite together with goethite are observed at the cracks and spaces of one polished section. Tenorites here are in the shapes of concentric, kidneylike and grapelike.

Limonite. - Limonites are the weathering products of iron bearing sulphidic minerals, primarily the products of chalcopyrilc and pyritc. Limonilcs are located partly as pseudomorphs of sulphidic minerals and partly as open space fillings. The former minerals sometimes contain the relicts of pyrite, chalcopyrite and arscnopyrite. The cataclastic structures of pyrites and arsenopyrites facilitate their replacement to limonite. Open space filling limonites show concentric, kidneylike and grapelikc textures. Goethite and lepidocrocite modifications of limonites are generally grown side by side or as intergrowths.

A small part of goethites are the weathering products of ankerites and siderites. Sometimes, needles of goethites occur as radial-spherulic textures. Very small amount of limonite are also observed in the cracks of hematites.

Malachite. - Some malachite is found in the cracks and open spaces of ore veins and in old production adits. Malachite is observed together with limonite and other secondary minerals. The malachite occured in the cracks and open spaces show radial and spherulic textures. They are surrounded by gocthite.

Azurite. - Very small amount of azurite is observed together with malachite and other ore minerals as intergrowihs. Azurite is occured in the cracks and open spaces similar to malachite.

Siderite + ankerite. - They are in small amounts and show gradation to each other. Because of their usual coexistence, they are investigated together. Siderite and ankerite are sorhewhat darker than the carbonates like calcite and dolomite. Locally, siderite and ankerite are colored in red by iron oxides and hydroxides. Their open spaces and cracks are filled by idiomorphic quartz and opaque minerals. Additionally, they are observed together with chlorite crystal associations especially at chlorite-rich parts of rocks. Siderite and ankerite are replaced by limonite along the borders and cleavages. During this process, some calcite are liberated. The replacement of limonites from siderites and ankerites are developed from outward to inward as radial-spherulic and concentric textures. Some siderite crystals are entirely replaced by goethite. In some places, siderite and ankerite pseudomorphically replace hegzagonal pyrotite lamellae or pseudomorph pyrites after hegzagonal pyrotite lamellae.

Scorodite. - Scorodite is observed very rarely. They sometimes pseudomorphically replace arsenopyrites along their borders, cracks and cleavages and sometimes occur as cracks and open space fillings. Some arsenopyrite relicts are observable in scorodites after arsenopyrite pseudomorphs.

Copper-vitriol. - Very small amount of copper-vitriol arc recognized especially together with clay and other secondary copper minerals. Like other secondary minerals, copper-vitriol fills the cracks and open spaces.

Quartz. - Quartz is one of most abundant gangue minerals. These hydrothermally originated quartz crystals are in different ages. Some of them are idiomorphic to subidiomorphic, zoned and coarse grained. The largest crystal size is 3-4 mm. Quartz lodes composed of small and xenomorphic crystals in different ages cut those old quartz crystals and primary ore minerals. Old quartz, crystals show generally cataclastic structures. Chlorites, sericites, ore minerals and calcites are observed in the cracks and open spaces of old quartz crystals. Zoned quartz are locally replaced by chalcopyrite corresponding to this structure. Microcrystalline quartz occurrences which are colored in red by submicroscopic hematites show kidneylike-grapelike textures, and they fill the cracks and open spaces. Those are the youngest quartz crystals.

Chlorite. - Chlorite are observed as crystal associations in between quartzs and ore minerals. Chlorites are the most abundant mineral after quartzs. The rate of chlorites increase especially at lower elevations of ore veins. Some crystal associations developed in open spaces show radial-spherulic textures. These chlorite crystal associations which form inclusions between ore minerals are intersected by quartz and carbonate veins.

Calcite + dolomite. - The abundance of these minerals increase at lower elevations of Kızıltepe ore veins and at the contacts of amphibole bearing quartz-diorite and metadiabase. Additionally, very small amounts of calcite and dolomite are observed at the upper levels of ore veins. Coarse grained calcite and dolomite are usually idiomorphic and subidiomorphic and show pressure twinnings. However, calcite and dolomites which fill the open spaces and cataclastic cracks of quartz and ore minerals are smaller and xenomorphic. Bending and folding of pressure twinnings in calcites and dolomites point out that they are faced continuous pressure after their occurrences. Between the hydrothermally originated calcite and dolomite crystals, locally concentric spheroidal shaped, fine grained calcite occurrences which are colored by limonite are observed.

Clay minerals. - Locally abundant fault clay are found together with ore veins. Some cracks and open space filling clay minerals are investigated by XRD and DTA methods. Halloysite, illite and montmorillonite are determined as clay minerals. Halloysite is the most abundant among them.

Muscovite + sericite . - These minerals arc the rarest ones among the other gangue minerals. Muscovite fills the open spaces between quartz crystals as coarse grains. The open spaces and cleavages of muscovite crystals are sometimes filled by goethite. In addition, very small amount of phlogopite crystals and crystal associations arc observed between the quartz crystals. Sericites as small crystals arc generally found in between quartz crystals.

Sphene. - Sphene is very rare and found in trace amounts. They occur generally as small grains. Sphene is formed by the replacement of titan minerals like rutile and anatase. Sphene grains sometimes contain the relicts of the above mentioned minerals.

Deliklikaya Tepe and similar veins

At Deliklikaya Tepe district veins arc poor in ore minerals and sometimes lying parallel to each other but their lengths and thicknesses generally vary by showing different strikes and dips (Fig. 2). Deliklikaya Tepe vein, belonging to this group, strikes N 80°E and dips almost vertically. The thickness of this vein at the road trench is approximately 0.4 meters. Celalettin-1, 2 and 3 veins which are parallel to Deliklikaya Tepe vein, strike N 80° E and dips 87° to the south. The die tance between Celalettin-1 and Celalettin-2 is approximately 20 meters and the distance between Celalettin-2 and Celalettin-3 is approximately 3 meters. The thicknesses of the veins at the road trench are 0.5, 0.3 and 1.0 meters, respectively. Another vein in metadiabase located nearly 40 km. northwest of Celalettin-3 vein contains disseminated pyrite, chalcopyrite, and secondary copper minerals and it strikes N 65° W. The thicknesses of eight veins, numbered from Altun-1 to Altun-8 veins vary between 1 and 1.5 meters, these parallel veins strike N 50° W. The vein in which Fuat Ocak was opened strikes N 60° W and dips 70° to the south. An alteration zone 8-10 meter in width is observed. Eight thin veins are found in this zone enriched in quartz, clay minerals and limonite and their thicknesses are about 0.2-0.3 meters.

At the west side of Deliklikaya Tepe a vein which strikes N 30° E and additional two veins in 0.7-0.8 meter thicknesses strike N 60° W and N 40° W and dip 75° to the north and 80° to the south, respectively. A 15 meter adit, called as Ayvaz Ocak is driven at the lower elevations of another vein which is close to Fuat Ocak. This vein strikes N 70° E and dips 82° to the northwest.

Additionally, some veins similar to Deliklikaya Tepe veins which are poor in are minerals outcrop at Kızıltepe district. Doğan Ocak is a big trench opened for such kind of a vein. Doğan Ocak is located in altered metadiabase zone which has 4-5 meter thicknesses. A lot of quartz veins which consist of clay minerals and limonite occur in Doğan Ocak. The strike of this vein is N 70° E and its dip is 82° to the northwest.

Quartz veins of Deliklikaya Tepe are composed of hydrothermal quartz, strongly affected fault breccia, metadiabase particules and small amount of ore minerals which are located in faults and fractures, occured during the emplacement of amphibole bearing quartz-diorite into metadiabase. Metadiabase particules in veins are silicified, chloritized, carbonitized, sericitized and kaolinized. As a result of this alteration, the intersertal textures of metadiabases have become undescribable.

The quartzs of quartz veins of Deliklikaya Tepe are derived generally from the remaining quartzs after amphibole bearing quartz-diorite occurences and partly from the hydrothermal alteration of metadiabase.

The open spaces of partly idiomorphic quartz crystals are filled by sericite, locally muscovite, phlogopite, clay minerals, chlorite and calcite. Hydrothermal quartzs are in different ages. The first generation quartzs which fill the faults are broken by later movements of faults. The open spaces and cataclastic cracks of there quartz minerals are filled by a younger generation of quartz and calcite. The spaces and cracks of some older quartz minerals are partly filled by ore minerals.

Ore minerals of Deliklikaya Tepe veins

Main ore minerals of Deliklikaya Tepe veins are arsenopyrite, pyrite, chalcopyrite, sphalerite, marcasite. galenite, pyrotite, valleriite, hematite, rutile, anatase, chromite, limonite, covellite, tenorite, malachite, scorodite and copper-vitriol.

Arsenopyrite. - Small amount of arsenopyrite forms disseminations in quartz veins. Sericite and quartz inclusions are observed in idiomorphic arsenopyrite crystals. Arsenopyrite is replaced by scorodite along its borders and cataclastic cracks. Sometimes, a thin belt of covellite is improved at the contact between scorodite and arsenopyrite. The largest arsenopyrite crystal size at Deliklikaya Tepe veins is 1.5x0.3 mm. Prismatic arsenopyrite grains are the oldest sulphide minerals. For this reason, arsenopyrite is replaced by quartz, calcite, sphalerite and chalcopyrite along its borders and cataclastic cracks.

Pyrite. - Small amount of pyrite occur as idiorpprphic and hypidiomorphic crystals in various sizes. They form disseminations and veinlets in ore bearing quartz veins. These kind of pyrites are generally fine grained. The largest grain size is 1.5x1 mm. Quartz, sericite, chlorite and rutile inclusions are observed in pyrite. Idiomorph to hypidiomorph pyrite crystals sometimes accompanied by chalcopyrite and sphalerite intersect altered metadiabase particules in ore bearing quartz veins as veinlets. Most of the pyrite is partly or totally altered to pseudomorph limonite. Limonilization is developed along the borders, cataclastic cracks and cleavages of pyrites.

Chalcopyrite. - Small amount of chalcopyrite is rarely observed. Xenomorph and fine grained chalcoyprite crystals fill the open spaces between arsenopyritc, pyrite and quartz crystals. Chalcopyrites include inclusions of quartz, chlorite and rutile grains. Sometimes, chalcopyrites envelope pyrite crystals as thin belts. Most of the chalcopyrites are replaced by chalcosite+covellite+limonite along their borders.

Sphalerite. - Small amount of sphalerite forms xenomorph to subidiomorph grains between quartz. The largest grain size is 300x250 microns. Some sphalerite grains contain chalcopyrite cxsolutions. Sphalerites reveal yellowish, reddish to brownish internal reflections. Some sphalerite grains are enveloped by covellite belt representing a thin sementation zone.

Marcasite. - Trace amount of marcasites are observed along the borders and cataclastic cracks of some idiomorph pyrites. In this case, pyrite are partly replaced by marcasite.

Valleriite. - Valleriites together with chalcopyrites form cxsolutions in some sphalerite grains. Trace amount of val-Icriitc is rarely observed.

Pyrotite. - Trace amount of pyrotile are observed as small inclusions in pyrite and arsenopyrite. Some pyrotite grains form exsolulions in sphalerites. Pyrotite is locally replaced by a semi-product.

Covellite. - Very small amount of covellite occur as fine crystal associations. Sometimes malachite accompanies covellite. Covellite is sometimes located in open spaces and cracks and sometimes envelopes chalcopyrite, arsenopyrite and sphalerite. Covellite, formed by weathering of chalcopyrite, also envelopes limonite and chalcopyrite.

Galenite. - Fine grained galenite is observed in trace amounts between quartz minerals. They are replaced by anglcsite and cerussite along their edges and cleavages.

Rutile + anatase. - Trace amounts of rutile + anatase are found as fine grains. They occur as a result of hydrothermal alteration of ilmenite grains which are located at altered metadiabase rock particules of ore bearing quartz veins. Additionally the lattices of rutile are resulted from the hydrothermal alterations of ilmeno-magnetites in metadiabases.

Iron contents of ilmenite and magnetite parts of ilmeno-magnetite are moved out from environment during hydrothermal alteration processes. Rutile rarely exhibit prisms or needles. Some rutile grains contain parallel pressure lamellae.

Chromite. - Trace amount of chromite is observed as fine and idiomorphic crystals, some chromite crystals are rarely seen in quartz bearing and altered parts of metadiabase.

Hematite. - Hematite is found in trace amounts occasionally in minute scales. A part of hematite is later generated by martitization of magnetite.

Tenorite. - Forming as cracks and open-space fillings, trace amount of tenorite occur with limonite and malachite. Partly they show concentric and kidneylike-grapelike textures. Tenorite intergrowths with goethite.

Limonite. - Rarely, two different modifications of limonite is observed together with each other. Goethite modification is much more than lepidocrosite modification. Three types of limonite are found at the veins of Deliklikaya Tepe. One of them is limonite pseudomorph of sulphidic ore mineral such as pyrite, chalcopyrite and arsenopyrite. Limonite, in addition to, forms veinlets filling cracks and open spaces. Limonite veins are generally scattered in the rock. Another kind of limonite colors the clayey and scricitic parts of ore bearing quartz veins.

Malachite. - Malachite is rarely or in trace amounts observed at the cracks and spaces of some samples. Malachite is generally associated with covellite and limonite. It forms small and partly idiomorph crystals at the spaces of rocks.

Scorodite. - Very small amount of scorodite is found partly as pseudomorph after arsenopyrite and partly as cracks and open space fillings. Some arsenopyrite relicts are observed in scorodites formed as pscudomorphs after arscnopyrites.

Copper-vitriol. - Trace amount of copper-vitriol is observed at cracks and open spaces of rocks associated with clay minerals. They form as micro crystal associations.

CHEMICAL ANALYSES

Two kinds of samples have been collected for the mineralogical investigations and chemical analyses from the ore veins of Deliklikaya Tepe. Detailed mineralogical investigations were performed on the polished sections of the samples and no gold was found. For the chemical analyses of gold, two different type of samples were taken from the ore of Deliklikaya Tepe and similar veins. Based on his experience, Ali Küpeli, the geologist of Yurttaşlar Company, compiled some samples from limonite and gold rich parts of veins. The MTA crew tried to collect the representative channel samples from the same veins. Gold and silver analyses were performed partly in MTA General Directorate Laboratory and partly in Geological Survey Laboratory in Ottawa, Canada and Dhahran University Laboratory in Saudi Arabia using the methods of AAS and ICP. At the same time, optic spectrographic semi quantitative analyses of As, Sb, Cu, Zn, Ni, Co, Bi and Te were carried out on the same samples. The analytical results are given in Table 1. As it is clearly seen from this table, apart from one sample, all samples from Deliklikaya Tepe and similar veins contain relatively low gold values. With these grades, the veins of Deliklikaya Tepe are economically unimportant.

DISCUSSION AND CONCLUSIONS

Intrusive rock provided SiO_2 rich solutions that consequently brought about gold bearing ore veins of Kisecik has the composition of amphibole bearing quartz-diorite. Tekeli and Erendil (1986), described this rock as isotropic gabbro. An intense hydrothermal alteration developed mainly in the form of silicification and chloritization as a result of intrusion amphibole bearing quartz-diorite into metadiabase. The alteration which decreases in intensity from the contact of these rocks downward is also reported by Tekeli and Erendil (1986). It is due perhaps that these researchers located a plagiogranite, resulted from solutions of last differentiation products, at the contact of amphibole bearing quartz-diorite with metadiabase in their columnar section, since they did not assume that gabbro could generate such kind of alteration. However, such a plagiogranite does not occur in the Kisecik gold field. In this case, here we favor a more acidic source rock as amphibole bearing quartz-diorite for the hydrothermal alteration rather than isotropic gabbro.

The contact of amphibole bearing quarlz-diorite, metadiabase xenoliths in amphibole bearing quartz-diorite and metagabbro concretions show various degrees of actinolitization-tremolitization, epidotization and biotitization. In addition, amphibole bearing quartz-diorite is scapolitized, metadiabase phlogopitized, and gabbro steatized and serpentinized. All these changes are the products of a contact metamorphism at epidote-amphibolite facies which caused by intrusion of amphibole bearing quartz-diorite into metadiabase. The contact metamorphism at the contact of amphibole bearing quartz-diorite with metadiabase decrease downward in intensity and grades into regional metamorphism of green schist facies characterized by silicification, chloritization, carbonatization and sericitization. Some of quartz, calcite and dolomite observed resulted from hydrothermal alteration of metadiabase and some too is highly likely formed from solution left over after crystallization of amphibole bearing quartz-diorite. Magnetite, magnetite portion of ilmeno-magnetite and Fe-compound of ilmenite were leached in the areas of intense hydrothermal alteration. This "Fe" was possibly employed in the composition of mainly sulphide minerals and rarely of Fe-bearing minerals.

Prismatic magnetites (mushketovites) are observed as hematite pseudomorphs along the lower parts of Kızıltepe ore vein. According to Ramdohr (1975), this type of magnetite occurs only in contact type mineralizations.

Three different mineral groups with respect to their origins are defined in the Kisecik gold bearing ore veins. Trace amount of ilmeno-magnetite, ilmenite, rutile, anatase, sphene and chromite were derived from diabase and were subjected to hydrothermal alterations. Arsenopyrite, pyrite, chalcopyrite, sphalerite, pyrotite loellingite, valleriite, cubanite, native gold, tellurobismuthile, tellurobismuthite-hessite solid solution mineral, galenite, cinnabar, neodigenite, magnetite, some hematite, some marcasite, quartz, calcite, dolomite, siderite, ankerite, muscovite and sericite which form the Kisecik ore are all primary minerals and arc resulted from hydrothermal solutions. The surficial weathering of these minerals brought about secondary minerals such as limonite, scorodite, chalcocite, covellite, malachite, azurite, tenorite and copper-vitriol.

Cubanite and valleriite among primary minerals arc the minerals of good geologic thermometer. According to Borchcrt (1934), cubanite exsolutions in chalcopyrite and sphalerite occur at temperatures between 300° and 350°C; valleriite, on the other hand, at 200°-300°C. Chalcopyrite and sphalerite hosting these minerals and native gold contemporaneous with chalcopyrite are formed at these temperatures. Sphalerite starlets and olcandar-leaf twinning in chalcopyrilc suggest that ore is formed by high-temperature solutions (Ramdohr. 1975). The reason that sphalerite shows dark brown-reddish internal reflection is because this mineral contains high amount of FeS in its, crystal lattice. This is only possible at higher temperatures according to Ramdohr (1975). Nevertheless, as is the case for Kisecik mineralization, adequate FeS should be available during the crystallization of sphalerite.

As is well-known, ophiolitic rocks, from the point of geochemistry, are enriched with respect to Cr, Pt, Ni, Co, Cu, Fe, Ti and V, but devoid of As (Schnciderhöhn, 1958; Turekian and Wedepohl, 1961; Turekian, 1972).Cu-mineralization is, similary, depleted in As (Çağatay, 1968; 1977; Çağatay et al., 1982). However, Kisecik ore veins are enriched in As. This, in turn, brings about arscnopyrite and its origin as a subject of discussion. On the other hand, Cu-mineralizations related to magmatic activities created by crustal meltings comprise con. iderable amount of As-minerals (Altun, 1984). Therefore, the authors consider amphibole bearing quartz-diorite which mobilized the ore as a product of crustal melting out of ophiolites and a rock which intruded in ophiolites. Amphibole bearing quartz-diorite is highly likely a product of a magmatic activity connected to the geological events developed subsequent to ophiolite emplacement.

Kisecik gold bearing ore veins arc classified into two very distinct groups in this study. These are "Kızıltepe and similar ones" and "Deliklikaya Tepe and similar ones". The most significant veins of gold deposits are the currently mined southeastern-veins (Fig. 2). Although gold content locally occurs at high amounts in the massive ores of the veins (Tables 1 and 6). The average gold content of samples collected at various elevations of the veins is generally below 5 ppm. The average gold and silver contents of a representative sample pooled from the sample loaded to a truck for ore dressing tests at the Department of Mineral Analyses and Technology of MTA arc 4.7 ppm and 8 ppm respectively (Ulu, E. personnel communications). The analytical results of selected 2300 ton massive ore, shipped to Kütahya-Gümüşköy facilities of Etibank for gold extraction tests and was also analysed for its gold content, revealed 4 ppm Au on the average (Personnel of Yurttaşlar Company and of KiUahya-Giimiis.koy facilities Personnel communications). 3 kg gold, with almost complete fineness was yielded from 2300 ton ore at Kütahya-Gümüşköy facilities (Newspapers and TV-news). This amount of gold out of 2300 ton ore corresponds to a gold grade of 1.3 ppm. Deliklikaya Tepe and similar ore veins are rather poor for gold (Table 1).

Most of the Kisecik gold bearing ore veins terminate at the contact of amphibole bearing quartz-diorite with meladiabase. Among these arc also included the most important Kızıltepe veins which arc currently being mined. Field observations do not testify any significant thicknesses and continuation for these veins. Deliklikaya Tepe veins contain ores with non economical grades at their known portions. Due to inadequate reserves and low grades Kisecik gold bearing veins are considered to form a small, insignificant deposit; even an occurrence rather than a deposit.

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PLATES

PLATE-I

Fig. 1 - Objective: 5X, Ocular: 10X, + N
Highly sericitized plagioclases (dark gray-black) of amphibole bearing quartz-diorite. Amphiboles have cleavages quartz (in the middle) is white.

Fig. 2 - Objective: 5X. Ocular: 10X, // N
Clinopyroxenes of intersertal textured diabases are replaced by phlogopite (gray). Plagioclase (labrodor) laths (white), opaque minerals (black).

Fig. 3 - Objective: 5X, Ocular: 10X.+N
Highly actinolitized-tremolitized (laths) meta gabbro.
Plagioclases (labrodor) are white.

Fig. 4 - Objective: 32X, Ocular: 10X, in oil
Hegzagonal lamellae of pyrotite are totaly replaced by pyrite (pseudomorph). Quartz as gangue mineral is black.

Fig. 5 - Objective: 32X, Ocular: 10X, in oil
Sphalerite exsolution starlets in chalcopyrite.

Fig. 6 - Objective: 32X. Ocular: 10X, in oil
Chalcopyrite (white) exsolutions in sphalerite are concordant to the zoned structure of sphalerite. Gangue minerals and spaces (black).

Fig. 7 - Objective: 32X, Ocular: 10X, in oil
Big chalcopyrite exsolutions in sphalerite contain second generation vallehite. Spaces (black).

Fig. 8 - Objective: 32X, Ocular: 10X, in oil
Cubanite (gray) lamellae in chalcopyrite (light gray).
Spaces and gangue minerals (black).

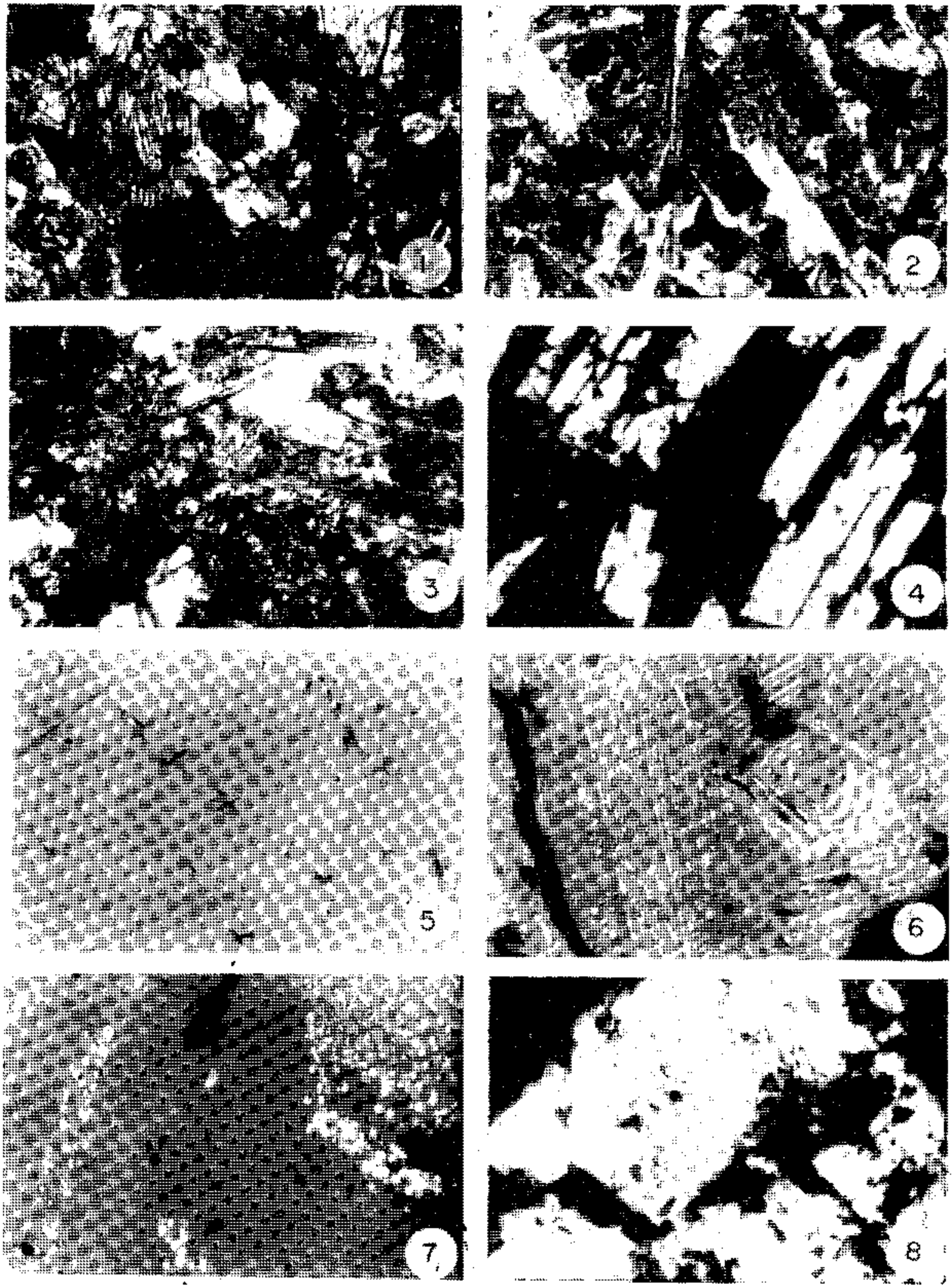
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PLATE-II

Fig. 1 - Objective: 32X, Ocular: 10X, in oil
Native gold (white and scratched); at the contact of chalcopyrite (gray) replacing arsenopyrite (light gray and high relief). Gangue minerals and spaces (black).

Fig. 2 - Objective: 32X, Ocular: 10X, in oil
Native gold (white) in cataclastic arsenopyrite. Cracks are filled by chalcopyrite. Spaces (black).

Fig. 3 - Objective: 32X, Ocular: 10X, in oil
Native gold (white) at the contact of chalcoyprite (stracthed) and quartz (black). Sphalerite (gray), spaces (black).

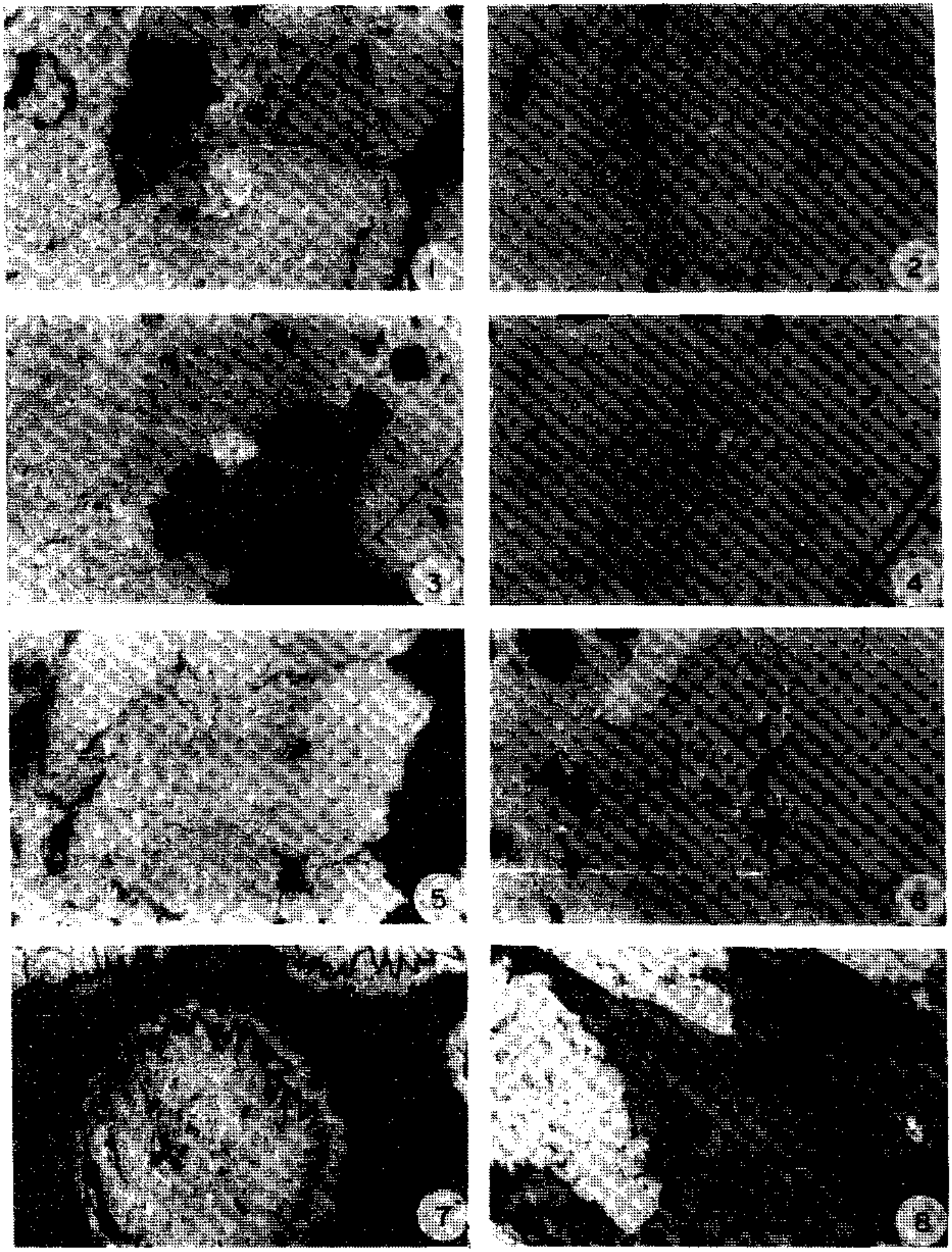
Fig. 4 - Objective: 32X, Ocular: 10X, in oil
Native gold (white) at sphalerite (dark gray) contact in chalcopyrite (stratched at one edge). Gangue minerals and spaces (black).

Fig. 5 - Objective: 32X, Ocular: 10X, in oil
Native gold (white) in chalcopyrite (gray) vein cutting arsenopyrite (light gray). Gangue minerals and spaces (black).

Fig. 6 - Objective: 32X, Ocular: 10X, in oil
Native gold (white); in chalcopyrite (gray) vein cutting arsenopyrite (light gray), at the contact between chalcopyrite-arsenopyrite and in chalcopyrite. Gangue minerals and spaces (black).

Fig. 7 - Objective: 32X, Ocular: 10X, in oil
Concentric, radial-spheluric textured hematite spheres in dolomite (black).

Fig. 8 - Objective: 32X, Ocular: 10X, in oil
Mushketovites (dark gray) are highly replaced by martitized hematite (gray). Pyrite (white), gangue minerals and spaces (black).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