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GEOLOGY, MINERALOGY AND GEOCHEMISTRY OF SULPHITE MINERALIZATION IN THE ISPENDERE REGION (MALATYA)

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ABSTRACT.- In this study, the geology, mineralogy, petrography, geochemistry, wallrock alteration, ore-wallrock relations, micro structural and textural relations in the copper-pyrite mineralization in Kızmehmet site (Ispendere-Malatya) and its vicinity were investigated. Ispendere Ophiolite (Jurassic-Lower Cretaceous), Yüksekova complex (Upper Cretaceous) and Kırkgeçit formation (Middle Eocene) crop out in the study area, which is located in Malatya-Elazığ region of the Eastern Taurus orogenic belt. Yüksekova complex is formed by Kuluşağı magmatites, Kapıkaya volcanics, Şişman magmatites and Harabe hill magmatites. Harabe hill magmatites cut all of the mentioned rocks in the complex and caused to form all of alteration types and different mineralizations in the study area. When the mineralogical, petrological and geochemical data are taken into consideration, the ore minerals bearing Harabe hill magmatites and the other type magmatites in Yüksekova complex were determined as product of I-type calcalcaline magmatism.The copper-pyrite mineralization is generally located in the Harabe hill magmatites and its contacts with the surrounding rocks. Four types of alterations related with the mineralization processes were determined in the study area, namely; weak potassic, phyllic, argillic and prophylitic. The ore mineralization is generally surrounded by phyliic-prophylitic alteration and/or phyllic alteration halous. The ore minerals are found within quartz-carbonate veins, as coatings in joints and faults and as well as disseminated ore minerals in the host rock. The main ore minerals are pyrite, chalcopyrite and magnetite, while sphalerite, galenite, pyrotite. bornite. rutile-anatase and ilmenite is less amount. Limonite, hematite, marcasite. chalcocite and covellite are found as secondary ore minerals. Prophyry copper-pyrite and/or stokwork type mineralization were detected in the study area according to the studies based on geotectonic environment, ore mineralogy, ore type host rock-ore relation and host rock alteration.

Key words: Granitoid, porphyry, alteration, dacite, Kızmehmet Site (Malatya).

INTRODUCTION

Study area is located 20 km east of Malatya city and comprises Karakaya dam lake at norh and an area of about 70 km^2 on Malatya-Elazığ highway at south of 1:25.000 scaled Malatya L41-a1 and a4 quadrangles (Fig. 1). Upper Cretaceous Yüksekova complex within the Eastern Taurus orogenic belt is widely exposed along the belt extending from Hakkari to Elbistan. Kızmehmet site pyrite-copper mineralization of study interest (İspendere-Malatya) is found within the Yüksekova complex.

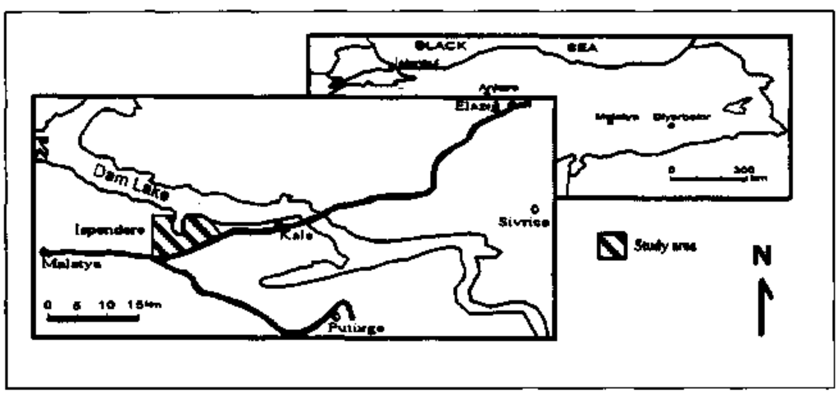

Fig. 1- Location map of study area.

Studies on mineralization within the Yüksekova complex were started in 1991 with general geochemical prospection works in stream sediments conducted by General Directorate of MTA. In Kızmehmet site copper-pyrite field, which is one of the anomalies found during these studies, metal concentrations in vertical-horizontal directions and total reserve were determined by drilling works with a total length of 1958 m carried out in 11 different locations (Tüfekçi and Dumanlılar,1994).

The study area where detailed drilling works were conducted, in the first pyrite-copper mineralization. In the study area, type of mineralization, formation conditions, country rock relations, ore geometry and geotectonics setting were examined in detail to construct a model for the other occurences within belt.

Several studies were conducted in the study area and its vicinity by means of geology, tectonsm, petrography and petrology (Baykal,1966; Yazgan,1981; Yazgan and Asutay, 1981; Asutay, 1985,1986; Yazgan and Chessex, 1991; Turan et al., 1995; Dumanlılar, 1993).

REGIONAL GEOLOGY

Study area located in Malatya-Elazığ section of Eastern Taurus orogenic belt has gained its geological structure through the following stages. During Upper Triassic, an ocean started to open between Eurasia and Arabian platform in the region and it was continued to evolve to the end of Lower Cretaceous (Yazgan et al., 1987). In the region arc magmatism products (Yüksekova complex) were formed in association with a northerly dipping subduction zone which was started to evolve by the beginning of Upper Cretaceous (Cenomanian-Turonian). At the beginning, arc magmatism had an ensimatic character (Hempton and Savcı, 1982) while it gained an ensialic character (in areas where it was developed under the Keban continent) in further stages (Yazgan et al., 1987). During this stage, ophiolitic masses were placed to the passive southern margin (ispendere and Guleman ophiolites). This phase was followed by Upper Maastrichtian transgression which resulted in deposition of Harami limestones. As a result of completely receding of the sea after Upper Maastrichtian, a terrestrial regime was prevailed in the region during Lower Paleocene and, thus, foldings and uplifts were formed (Poyraz, 1988).

At the beginning of Tertiary, a north-west trending compressional stress was dominated in the region and volcanite-bearing Maden complex was formed in a deep basin (Yazgan et al., 1987; Turan et al., 1995).

In Middle Miocene as a result of compressional stress following a continent-continent collision in the region, formation of tectonic structures such as Southeast Anatolian thrust zone and East Anatolian fault belt had shaped the present structure of the region (Turan et al.,1995).

GENERAL GEOLOGY AND MINERALOGY

In the study area, Yüksekova complex has a tectonic contact with ispendere ophiolite at south, while it is unconformably overlain by Eocene Kırkgeçit formation at north (Fig.2).

ISPENDERE OPHIOLITE

This unit, which is described by Yazgan et al., (1987) at first, is differentiated as nonmetamorphic ispendere and metamorphic Kömürhan units. Jurassic - Lower Cretaceous aged ispendere ophiolite is observed as a tectonic slice, which is northerly dipping between Yüksekova complex at north and Maden complex at south, and exposed in a wide area on Malatya L41-a4 quadrangle.

Ultramafic cumulates consisting of moderately thick dunite and wehrlites are found at the basement of ispendere ophiolite. They are overlain by a zone composing of cumulate gabbros. These two units are transitional and often cut by wehrlitic intrusions. Cumulates are overlain by a transition zone consisting of thinly bedded gabbros followed by isotropic gabbros. Plagiogranites are found between thinly bedded gabbros and isotropic gabbros. Dike complex in the upper part comprises the thickest unit of ispendere ophiolite. Pillow lavas in east of study area make up the upper most part of ispendere ophiolite.

YÜKSEKOVA COMPLEX

This unit is extending from Hakkari city in Eastern Taurus belt to Elbistan town and was first described around Hakkari Yüksekova town by Perinçek (1979). Some workers studied in Eastern Taurus (Perinçek, 1979; Bingöl, 1984; Turan, 1984) use the name of Yüksekova complex for the unit, while Asutay (1985) who studied in Baskil and Yazgan et al., (1987) who made the geological map of Şişman village named this unit as Baskil magmatites and pointed out that unit is represented with magmatic, volcanic and subvolcanic rocks. Based on K/Ar isotopic determinations the age of these rocks is 75 my to 86 my (Upper Cretaceous). Calc-alkaline Baskil magmatites are completely defined as I type granitoid and cut the Keban metamorphites thus caused contact metamorphism (Tüfekçi et al., 1979; Asutay, 1985).

In tne region, Yüksekova complex is com-

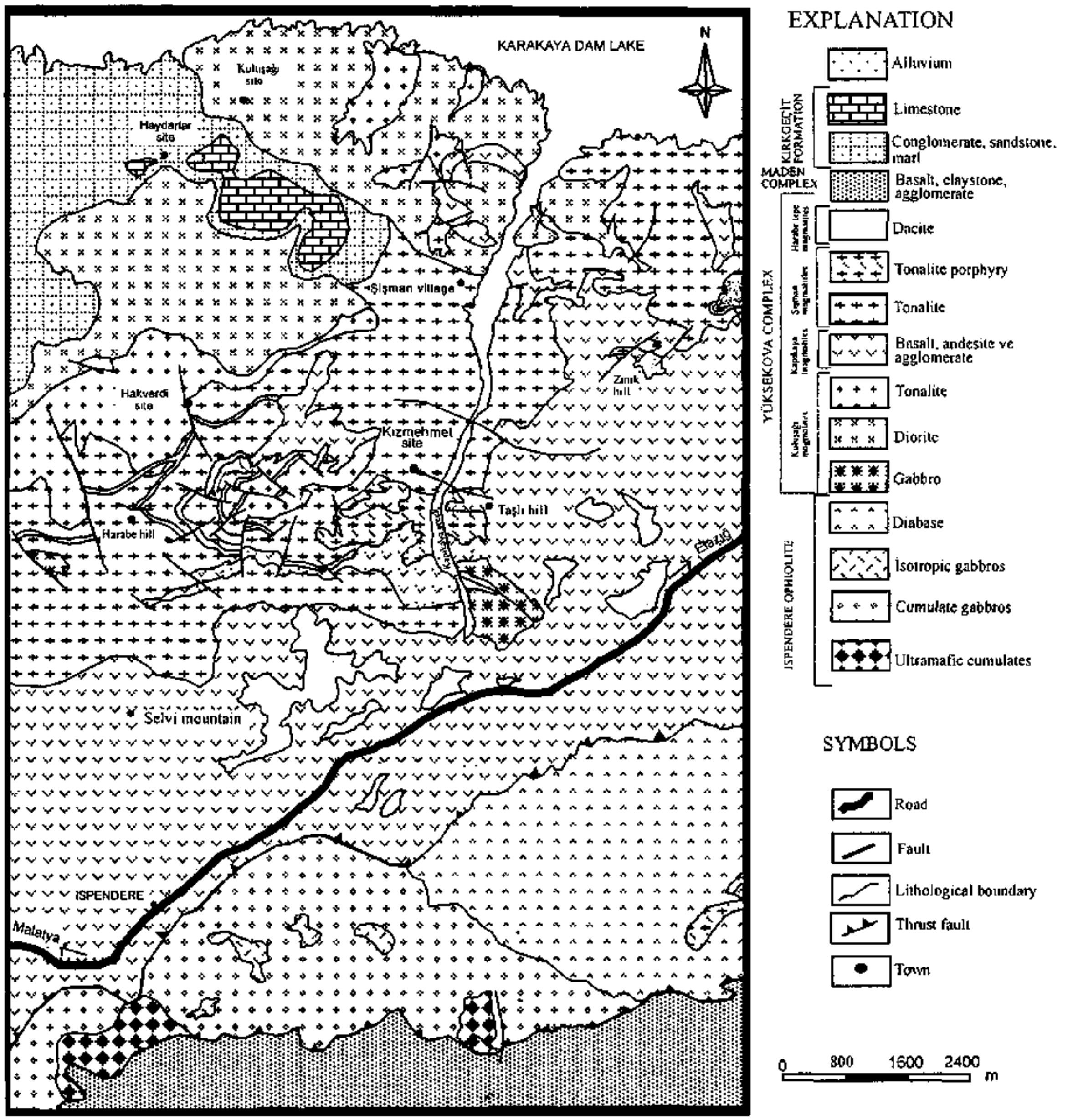

Fig. 2- Generalized geology map of İspendere (Malatya) region.

posed of Kuluşağı magmatites, overlying Kapıkaya volcani-tes and Şişman magmatites cutting former two units, and Harabe hill magmatites which have an intrusive contact with all above units and facilitate alteration and mineralization.

Kuluşağı magmatites.- As a result of modal mineralogic analysis and chemical-mineralogical examinations, Kuluşağı magmatites were determined as gabbro, quartz diorite and tonalite (Figs. 3 and 4) (Table 1).

Gabbro: Gabbros those are found in outer zones of batholith, microscopically show two different textures. The Gabbros, where they are exposed in mappable sizes, display holocrystalline grain texture, while they are exposed in small areas in quartz diorites, gabbros show holocrystalline porphyritic texture. Andesine-labradorite type of plagioclase (49.1%) and clinopyroxene (42.1%) are the main constituents of the rock. In addition, some amount of opaque minerals (7.3%) and quartz(1.5%)are also found in gabbros.

The Pyroxenes are altered to tremolite and actinolite along their edges, while plagioclases do not seem to be subjected to an intense alteration,but are sericitized and argillitized in places.

Quartz diorite and tonalite: Quartz diorite and tonalite have a holocrystalline grain texture. Quartz diorite contains 56.6% plagioclase, 35.1% amphibole, .6.8% quartz and 1.50% orthoclase. Quartz content in tonalite is increased up to 20.8% while amphibole and plagioclase amounts are reduced to 30.2% and 43.1%, respectively. In addition, tonalite contains 3.7% orthoclase and 2.2% opaque minerals.

Plagioclases are of andesine composition and subjected to sericite and lesser amount of epidote alteration.

Table 1- Macro-micro properties of rocks of Şişman and Kuluşağı magmatites.

Rock name		Color	Texture	Modal Mineralogic Composition (%)	Accessory Minerals	Grain size
KULUŞAĞI MAG	Gabbro	Dark green-black	Holocrystalline grain texture	Plagioclase (49,1%) Pyroxene (42.1%) Quartz (1.5 %) Opaque Minetal (7,.3%)	-	0,5-3 mm.
	Quartz diorite	Dark green-gray	Holocrystalline grain texture	Plagioclase (56,6%) Amphibole (35,1 %) Quartz (6,8%) Alkali Feld. (1.5%)	-	1-2 mm.
	Tonalite	Light green	Holorcrystalline grain texture	Plagioclase (43,1%) Amphibole (30,2%) Quartz (20,8%) Alkali Feld. (3,7%) Opaque Mineral (2,2%)	-	1-2 mm.
ŞIŞMAN MAG	Tonalite	Grayish-white	Holocrystalline grain texture	Plagioclase (49,9%) Quartz (37,2%) Chloritized mafic minerals (11.3%) Alkali Feld. (1 6%)	Sphene, apatite	l-5 mm.
	Tonalite porphyry	Light pink-white	Holocrystallin porphyry texture	Plagioclase, quartz, Ortochlase and chloritized mafic minerals	-	

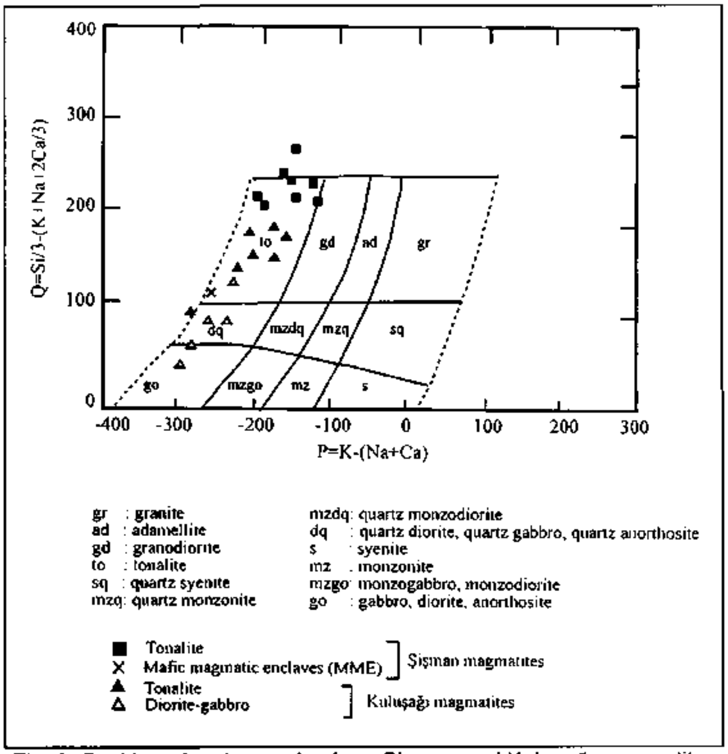

Fig. 3- Position of rock samples from Şişman and Kuluşağı magmatites on Q-P nomenclature diagram, (Debon and Le Ford, 1983).

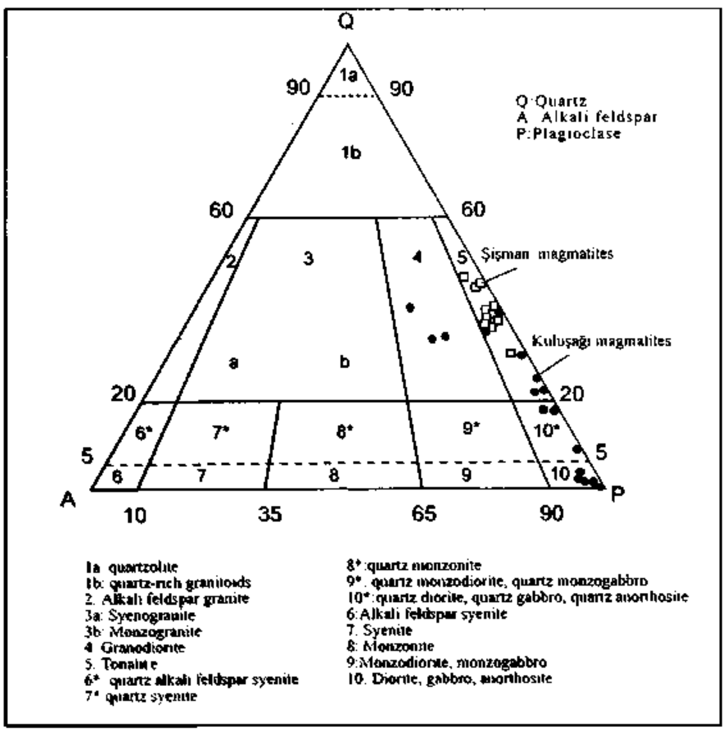

Fig. 4- Distribution of Şişman and Kuluşağı magmatites on QAP diagram of Streckisen (1976)

Amphiboles of green hornblende type are observed as euhedral or subhedral crystals and, platy and bar-like shapes. Chloritization and opaque minerals are rarely observed in hornblendes. Hornblendes which contain plagioclase inclusions show a poikilitic texture.

Quartz has generally fractures and observed as anhedral crystals.

Quartz diorite and tonalite contains less amount of K-feldspar which is rarely subjected to sericitic alteration. K-feldspar is not detected in some thin sections.

Kapıkaya volcanites.- Kapıkaya volcanites are composed of pyroclastics, and lava flows those compositions change from andesite to basalt.

Lava flows with hyalopilitic and porphyritic texture consist of volcanic glass and pyroxene and plagioclase minerals in phenocrysts and microlite forms. Rarely observed vesicules are filled with calcite and zeolite minerals. Alteration is very common in basalts, and in all thin sections epidotization and Chloritization are encountered. Some carbonatization and opaque minerals are also detected.

Andesitic lava flows have a pilotaxitic texture and composed of intensely altered plagioclase and amphiboles. Amphiboles are observed to have been altered to chlorite and opaque minerals, while plagioclases are subjected to intense argillization and epidotization.

Andesitic pyroclastics consist of agglomerate and volcanic breccia and are composed of grains of 0.5 cm. to 20 cm.

Şişman magmatites.- Şişman magmatites are composed of tonalite and tonalite porphyry. As a result of modal mineralogic and chemical-mineralogic examinations, samples of Şişman magmatites are determined as tonalite (Fig.3 and 4).

Tonalite: Tonalites of Şişman magmatites are distinguished from those of Kuluşağı magmatites with their appearance in the field and mineralogic features in thin sections. Their quartz content and grain size are larger than, but mafic mineral content is less than those of Kuluşağı magmatites (Table 1).

Main minerals of tonalites are plagioclase (49.9%) and quartz (37.2%) and they contain minor amount of K-feldspar (1.6%) together with mafic minerals (11.3%) that are completely altered to epidote and chlorite. Quartz minerals in tonalites are anhedral and their size changes 1mm. to 5mm. In addition, quartz grains also fill the spaces between other minerals. Symplectite texture is one of the distinct features of quartz and plagioclase grains in tonalites. This texture is an distinctive feature of tonalites of Kuluşağı and Şişman magmatites. The size of subhedral and platy plagioclases ranges from 1 mm. to 1.5mm. Although plagioclases display typical albite twinning, some of them are observed to have a zoning structure. Needle-like apatite inclusions are rarely found in plagioclases.

Besides argillization, epidotization is also common in plagioclases. The fact that, epidotization is formed in inner part of the zonned plagioclases, which indicates that anorthite content of inner zones is higher than that of outer zones.

Tonalite porphyry: Tonalite porphyries are determined to be a sub-intrusive rock and have a porphyry texture. Microscopic examinations reveal that rock is composed of plagioclase, quartz, orthoclase and chlorite. In general, plagioclases show polysynthetic twinnings and are detected as euhedral phenocrysts or anhedral grains in the matrix. They are extremely argillaceous and carbonaceous and rarely altered to epidote and opaque minerals. In comparison to plagioclases, quartz phenocrysts show little amount of anhedral forms. In addition to quartz and plagioclases, some amount of orthoclase are also observed as the rockforming mineral. Orthoclases are commonly subjected to sericitization and argillization. Mafic minerals are completely chloritized. The matrix contains micro crystalline quartz and orthoclase minerals.

Mafic magmatic enclaves (MME): Mafic magmatic enclaves are observed in tonalite and porphyries of Şişman magmatites. They generally have and ellipsoidal shape with a diameter of 2 to 20 cm, but some cases, they may also show irregular shapes.

Mafic magmatic enclaves have a fine-grained texture and are composed of plagioclase, quartz, hornblende, chlorite, apatite, sphene and opaque minerals. Oligoclase-andesine type of plagioclases are observed as microlites and in general, quartz minerals are detected as microcrystals. Hornblends parth are chloritized. Opaque minerals besides needle-like apatites and sphenes are also seen in the rock.

Harabe hill magmatites.- Harabe hill magmatites comprising the last stage of Yüksekova complex, that hosts mineralization and alteration, is composed of dacite and granodiorite porphyrites which were cut by drill holes.

Dacite: Thickness of the dacite around Germik stream changes from 10m. to 70m. On the other hand, the thickness of the dacite were found changing from 20cm. to 6m. in drill holes. Strike and dips of units in the study area are N80E/35°NW and EW/35°N to a lesser extend. They easily recognized with their pink colored alteration. In hand specimens, it could be easily distincted by quartz crystals scattered in a pink matrix. They are irregularly, but widely exposed around Selvi mountain. Microscopically, rock has a holocrystalline hypidiomorph porphyritic texture. Plagioclase and quartz are the main components of the rock. Plagioclase phenocrysts have euhedral and subhedral forms and on the basis of extinction angles, they are of oligoclase and andesine composition. Plagioclases are intensely subjected to carbonation and sericitiation besides lesser clay alterations. Quartz phenocryst are corroded by the matrix along their edges.

Dacites contain vast amount of enclaves of the units which they cut, along the boundaries.

Granodiorite porphyry: They are typical with their pink colored alteration on the surface and their grain size is increased with increasing depth. Therefore, rock is named as granodiorite porphyry.

Examinations on thin sections reveal that rock is completely undergone to sericite and carbonate alteration. For this reason, it is difficult to get information on primary texture and composition of the rock.

ALTERATION

BIOTITE+QUARTZ ALTERATION (POTASSIC ALTERATION)

An alteration assemblage composing of biotite and quartz was encountered at depths 0-45 m. in well no KS-5. This alteration was observed only in andesites. Biotite, quartz and opaque minerals are detected as veinlets and matrix material.

In addition, it was also determined that hornblendes are altered to an aggregate consisting of biotite and quartz. There are also little amount of sericite and chlorite. This type of alteration as observed together with andesites in well no KS-5 and described as quartz-biotite alteration, resembles to potassic alteration which consists of biotite, K-feldspar, sericite, and albite minerals and described by Lowell and Guilbert (1970).

CHLORITE+CARBONATE+EPİDOTE ALTERATION (PROPYLITIC ALTERATION)

Alteration consisting of chlorite, carbonate and epidote minerals is widely, exposed in the field. Propyllitic alteration, observed on the surface and in drill holes together with all rocks belonging to Yüksekova complex, is characteristic with its gray-green color in hand specimens and on the exposures.

Under microscope, except for quartz, all other minerals are observed to alter to chlorite+carbonate+epidote+sericite+clay. Intense propyllitic alteration are observed around Germik stream and cut by pyrite-chalcopyrite bearing carbonate and quartz veinlets. Based on the results of XRD analysis, type of carbonatization was determined to be dolomite, calcite and aragonite.

The plagioclases were subjected to completely carbonate, clay, partially epidote and a lesser degree of sericite alteration. Based on the XRD data clay type was found to be kaolinite. In general, mafic minerals are intensly altered to an aggregate consisting of chlorite and opaque minerals.

Chlorite-epidote-carbonate-sericite-kaolinite alteration described in the field is similar to propyllitic alteration that is characterized by chlorite-calcite-epidote-adularia-albite mineral paragenesis and described by Lowell and Guilbert (1970).

QUARTZ+SERICITE+PYRITE ALTERATION (PHYLITIC ALTERATION)

In the study area, quartz + sericite + pyrite consisting phyllitic alteration is found around Germik stream as surrounded by propyllitic alteration. Additionally, this alteration is also observed as narrow zones around dacites of Harabe hill magmatites. Phyllitic alteration exposing in a wide area is surrounded by propyllitic zone around Kara stream and Selvi mountain in south of the region.

In the intensly altered areas, all minerals except quartz were altered to sericite, thus primary texture of the rock is completely destroyed and primary quartz minerals are recaytallized and in larged. Based on the results of XRD analysis, in intensely altered areas (quartz + sericite + pyrite alteration), pyrophyllite also participates into the alteration paragenesis. Quartz + sericite alteration in the area is similar to phyllitic alteration described by Lowell and Guilbert (1970).

In sericitic alteration, carbonatization also appears with the participation of chlorite into the paragenesis (weak sericitic zone). In this zone, feldspar minerals are completely sericitized, while mafic minerals are partly sericitized and altered to opaque minerals and partly to chlorite-opaque mineral. With the existence of chlorite, carbonatization and carbonate veins are also increased. Due to chloritization of primary mafic minerals (biotite), sagenitic structures are often observed that are formed by lattice-shaped rutile needles. Ashley et al., (1978) state that sagenitic structures are formed in chlorite-carbonate zone.

In the study area, weak phyllitic alteration consisting of sericite + carbonate + clay + chlorite minerals are observed in dacites and granodiorite porphyries encountered in drill holes. Primary quartzs are corroded and grown. It was determined that matrix is completely transformed to sericite, carbonate and clay, feldspars are commonly changed to sericite + carbonate while mafic minerals are transformed to chlorite and sericite.

XRD analysis revealed that clay type is kaolinite. Argillization is observed in feldspars and matrix. Dominant carbonate minerals in this alteration type are dolomite and calcite in lesser amount.

CLAY + CHLORITE + QUARTZ ALTERATION (ARGILLIC ALTERATION)

Argillization observed within tonalitic rocks around Delav hill at north of Kızmehmet site and between Deve stream and Kavak stream gives a yellowish color to these areas.

During the clay alteration, plagioclases are completely altered to clay and sericite while mafic minerals are altered to chlorite. XRD analysis yield that clay mineral in this alteration is kaolinite. Partly limonitized, disseminated or veinlet type pyrite is the ore mineral.

The mineral paragenesis of this alteration is similar to argillic alteration belt of Lowell and Guilbert (1970), that is composed of quartz, kaolinite, montmorillonite, and lesser amounts of sericite and leucoxene minerals.

PETROGENETIC AND TECTONOGENETIC EXAMINATIONS

In order to determine tectonic setting of Şişman and Kuluşağı magmatites, Y-SiO_2, Yb-SiO_2, Nb-Y, Rb-SiO_2, and Rb-(Y+Nb) diagrams (Pearce et al., 1984) were used. In Y-SiO_2 and Yb-SiO_2 diagrams (Pearce et al., 1984), rock samples plot in volcanic arc granitoids (VAG)+collision granitoids (COLG) + ocean ridge granitoids (ORG) fields (Fig. 5).

On Nb-Y stable elements diagram (Pearce et al., 1984), all the samples plot in (VAG)+syn-COLG fields (Fig.6). Exact tectonic position of Şişman and Kuluşağı magmatites were determined with the use of Rb-(Y+Nb) and Rb-SiO_2 diagrams, and this magmatites are found to represent a set of volcanic arc granitoids (VAG) (Fig. 7).

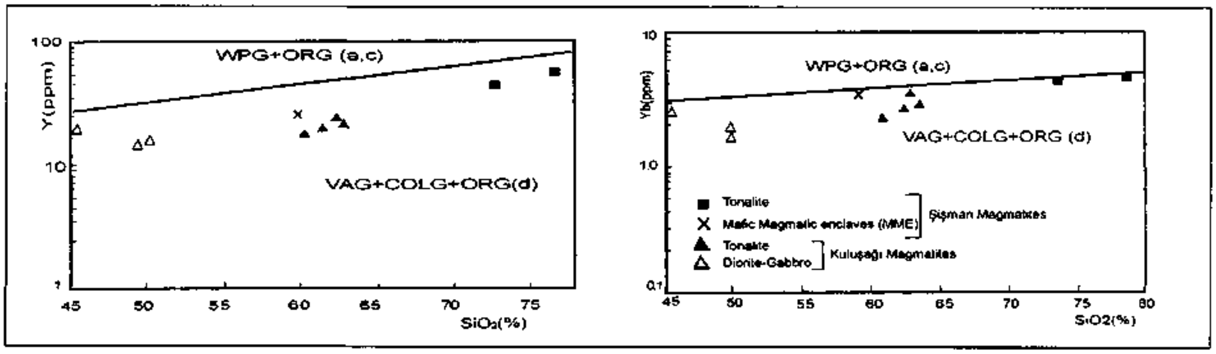

Fig. 5- Position of rock samples from Şişman and Kuluşağı magmatites on Y-SiO_2 and Yb-SiO_2 diagrams (Pearce et al., 1984). WPG: Within plate granitoids, ORG: Ocean ridge granitoids, VAG: Volcanic arc granitoids, syn-COLG: Syn-collision granitoids.

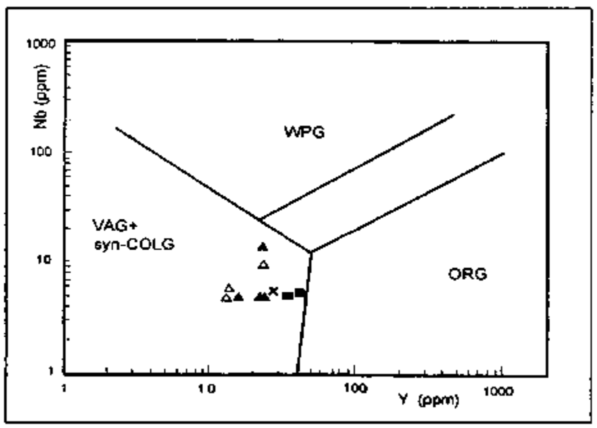

Fig. 6- Position of rock samples from Şişman and Kuluşağı magmatites on Nb-Y diagram (Pearce et al., 1984) (See Fig. 5 for other explanations).

GEOCHEMISTRY OF KULUŞAĞI AND ŞİŞMAN MAGMATITES

Major and trace element contents of 21 samples collected from intrusive rocks of Yüksekova complex were determined with ICP method while their rare earth element contents were found with ICP-MS method.

Results of chemical analysis of major and trace elements and CIPW norms and some ratios are given in Table 2 and 3.

Examination of changes of major oxides with respect to SiO_2 contents reveals that CaO, Fe_2O_3, Al_2O_3, MgO and TiO_2 values are decreased, with respect to the increasing in SiO_2 content, and there is a weak positive correlation in Na_2O values. K_2O concentration in Kuluşağı magmatites increases

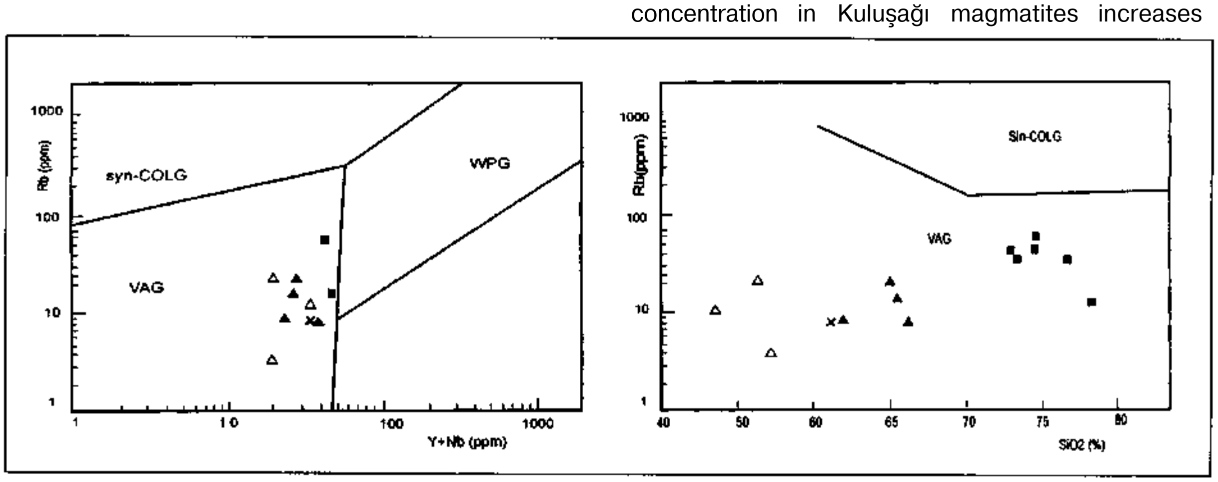

Fig. 7- Positoin of rock samples from Şişman and Kuluşağı magmatites on Rb-(Y+Nb) and Rb-SiO_2 diagrams (Pearce et al., 1984) (See Fig 5 for other explanations).

Table 2- Major element percents (%), trace element concentration (ppm), A/CNK=Al_2O_3/CaO+Na_2O+K_2O molecular ratios and CIPW norms of Kuluşağı magmatites.

Sample No	KS1-P3	KS1-P28	KS2-P18	HD-24	ÖD-K4	ÖD-K6	ÖD-K9	HD-27	HD-50	HD-51	ÖD-K7	ÖD-K11
Symbol	▲	▲	▲	▲	▲	▲	▲	Δ	Δ	Δ	Δ	Δ
Results of major element analysis												
SiO_2	63,01	60,49	63,5	62,81	63	63,5	64,48	44,16	49,88	49,63	54,06	47,35
TiO_2	0,65	0,54	0,74	0,41	0,4	0,7	0,6	0,78	0,61	0,65	0,7	0,5
Al_2O_3	13,9	14,62	14,43	17,09	14,5	15,6	14,6	16,04	13,85	14,5	10,47	11,72
Fe_2O_3	8.00	7,48	7,77	2,41	7,2	6,6	6	12,54	9,55	11,87	11,18	11,98
MnO	0,15	0,13	0,12	0,04	0,1	0,1	0,1	0,21	0,21	0,28	0,1	0,1
MgO	3,39	5,09	3,02	0,94	3,6	1,9	2,34	4,78	9,55	8,02	10,38	13,41
CaO	4,66	6,44	4,68	4,86	4,2	5,6	3,55	10,69	9,31	11,03	10,35	13,55
Na_2O	3,11	3,04	3,26	6,06	3,9	3,4	5,2	2,72	3,29	1,55	1,5	0,6
K_2O	1,12	0,49	0,57	0,42	1,19	0,21	0,56	0,38	0,22	0,69	0,31	0,12
P_2O_5	0,09	0,07	0,1	0,12	0,1	0,1	0,1	0,12	0,14	0,12	0,1	0,1
Cr_2O_3	0.048	0,075	0,051	0,35				0,018	0,092	0,078	-	
L.O.I.	1,9	1,5	1,7	4,8	1,45	0,81		7,4	3,2	1,6	-	
Total	100.02	99.96	99.94	100,3	99.64	98.53	97.53	99.83	99.90	100.02	99,15	99.43
Results of trace element analysis												
Rb	20,05	8,6	15	8,06				10,43	4,28	21,23		
Sr	131,6	166,2	130,6	414,0				452,5	167,5	189,7		
Nb	<10	<10	<10	13				10	<10	<10		
Zr	74	55	70	157				64	44	67		
Y	26,3	18,6	25	23,4				22,7	16,5	16,4		
Hf	3,44	2,27	3,31	5,26				2,42	1,79	1,75		
Ta	<,1	<,1	<,1	1,0				2,9	0,2	0,4		
Th	3,25	1,12	1,13	20,85				7,06	3,43	2,47		
U	0,4	0,2	0,4	3,6				1,2	0,6	0,5		
Ba	118	58	64	55				45	33	143		
Ni	176	258	195	141				82	254	215		
Sc	21	25	21	<10				18	26	28		
CIPW - Norms												
Q	21,13	16,19	23,27	17,74	17,26	24,67	18,14	0	0	0	5,34	0
Or	6,81	2,97	3,46	2,62	7,22	1,28	3,41	2,47	1,36	4,21	1,87	0,72
Ab	27,05	26,34	28,32	54,02	33,85	26,94	45,39	21,73	29,1	13,5	12,95	5,17
An	21,25	25,41	23,23	19,19	19,03	27,5	15,32	33,41	23,4	31,48	21,34	29,49
C	0	0	0,17	0	0	0	0	0	0	0	0	0
Di	1,67	5,72	0	4,66	1,4	0,38	1,83	20,29	19,58	19,96	24,81	31,72
Ap	0,22	0,17	0,24	0,30	0,24	0,24	0,24	0,31	0,35	0,29	0,24	0
Il	1,27	1,05	1,44	0,82	0,78	1,37	1,18	1,62	1,21	1,27	1,36	0,97
Ol	0	0	0	0	0	0	0	18,34	16,54	2,76	0	16,49
Hpr	20,65	22,21	19,92	3,73	20,22	14,92	14,49	0	8,52	26,6	32,09	15,44
A / CNK = Al_2O_3 / CaO + Na_2O + K_2O Molecular ratios												
A/CNK	0.95	0,86	0,99	0,89	0,94	0,97	0,82	0.46	0,62	0.43	0,48	0.45

Table 3- Major element percents (%), trace element concentrations (ppm), A/CNK=Al_2O_3/CaO+Na_2O+K_2O molecular ratios and CIPW norms of Şişman magmatites.

Sample No	KS4-24	HD-106	HD-180	ÖD-K1	ÖD-K2	ÖD-K3	ÖD-K5	ÖD-K8	ÖD-K10
Symbol	■	■		■	■	■	■	■	■
Results of major element analysis									
SiO_2	73.07	77,28	58,3	74,9	71	72,27	70,5	71,69	71,92
TiO_2	0,53	0,22	0,76	0,3	0,5	0,3	0,3	0,5	0,35
Al_2O_3	13,05	12,14	15,21	12,5	13,5	13,6	13,7	13,66	12,95
Fe_2O_3	2,37	1,78	8,29	2	2,9	2,8	3,2	4,79	4
MnO	0,06	0,03	0,11	0,1	0,1	0,1	0,1	0,1	0,1
MgO	1,59	0,44	2,15	0,6	1,2	0,5	1	1,52	0,72
CaO	2,3	0,98	6,58	1,56	2,8	1,8	2,33	1,8	2,2
Na_2O	3,57	5,07	3,83	5,5	4,6	4,4	3,6	4,2	3,4
K_2O	1,5	0,65	0,37	0,32	0,4	1,16	1,8	0,3	1,5
P_2O_5	0,09	0,03	0,11	0,1	0,1	0,1	0,1	0,1	0,1
Cr_2O_3	0,041	0,062	0,023						
L.O.I.	1,8	1,5	4,2	1,81	1,81	1,1	2,7		
Total	99,97	100,18	99,9	99,69	98,92	98,13	99,34	98,67	97,24
Results of trace element analysis									
Rb	52,59	14,19	8,7	40	40	70	50		
Sr	61,9	51,9	154,8						
Nb	<10	<10	<10						
Zr	126	139	125						
Y	37	42,9	28,6						
Hf	5,38	6,06	4,51						
Ta	<,1	<,1	<,1						
Th	2,71	1,44	1,11						
U	0,8	0,7	0,2						
Ba	97	84	46						
Ni	162	233	93						
Sc	10	<10	19						
CIPW - Norms									
Q	38,85	42,04	14,44	37,23	34,41	37,78	35,51	37,64	39,31
Or	9,08	3,91	2,31	1,94	2,44	7,1	11,05	1,81	9,16
Ab	30,86	43,58	34,15	47,64	40,2	38,57	31,63	36,19	29,71
An	11,11	4,78	24,48	7,25	13,67	7,34	11,32	8,43	10,6
C	1,6	1,4	0	0,52	0,67	2,6	1,9	3,46	2,04
Di	0	0	7,87	0	0	0	0	0	0
Ap	0,22	0,07	0,27	0,24	0,24	0,25	0,25	0,24	0,24
Il	1,03	0,42	1,52	0,58	0,98	0,59	0,59	0,97	0,69
Ol	0	0	0	0	0	0	0	0	0
Hpr	7,3	3,84	14,99	4,6	7,38	5,76	7,75	11,26	8,27
		A / CNK = Al_2O_3 / CaO + Na_2O + K_2O Molecular ratios							
A/CNK	1,13	1,14	0,82	1.02	1.03	1.15	1.13	1.3	1.15

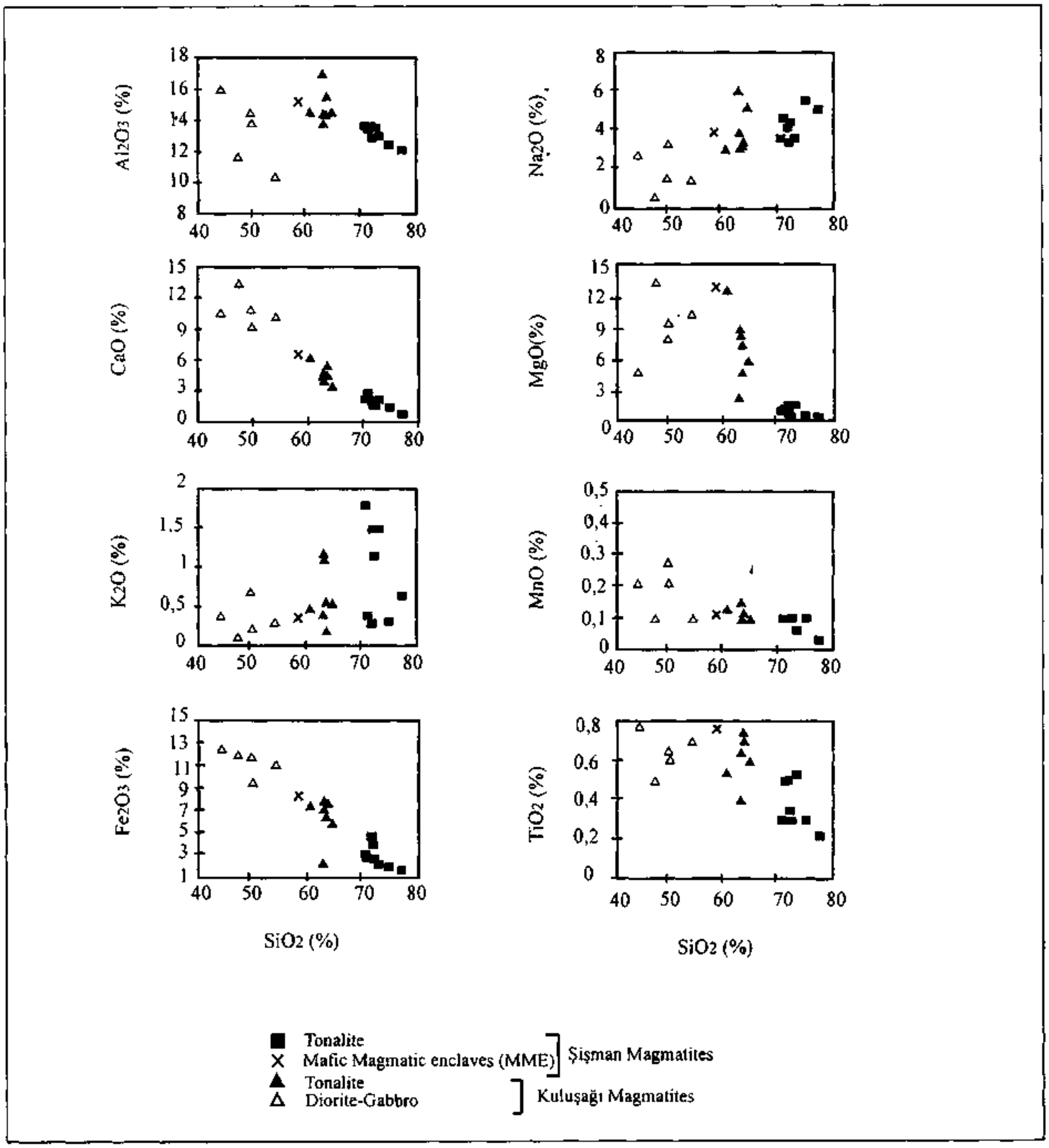

Fig. 8- Variation diagrams of major oxides of Şisman and Kuluşağı magmatites.

with increasing SiO_2 contents, while there is a weak negative correlation in SiO_2-K_2O variation diagram of Şişman magmatites. There is no significant correlation in MnO-SiO_2 variation diagram (Fig. 8).

SiO_2 values in rock samples of Kuluşağı magmatites are ranges from 44.16 to 64.48% while those in Şişman magmatites are changes from 71 to 77.28%. This difference SiO_2 values cause two different clusters to occur in Marker diagrams (Figs. 8 and 9).

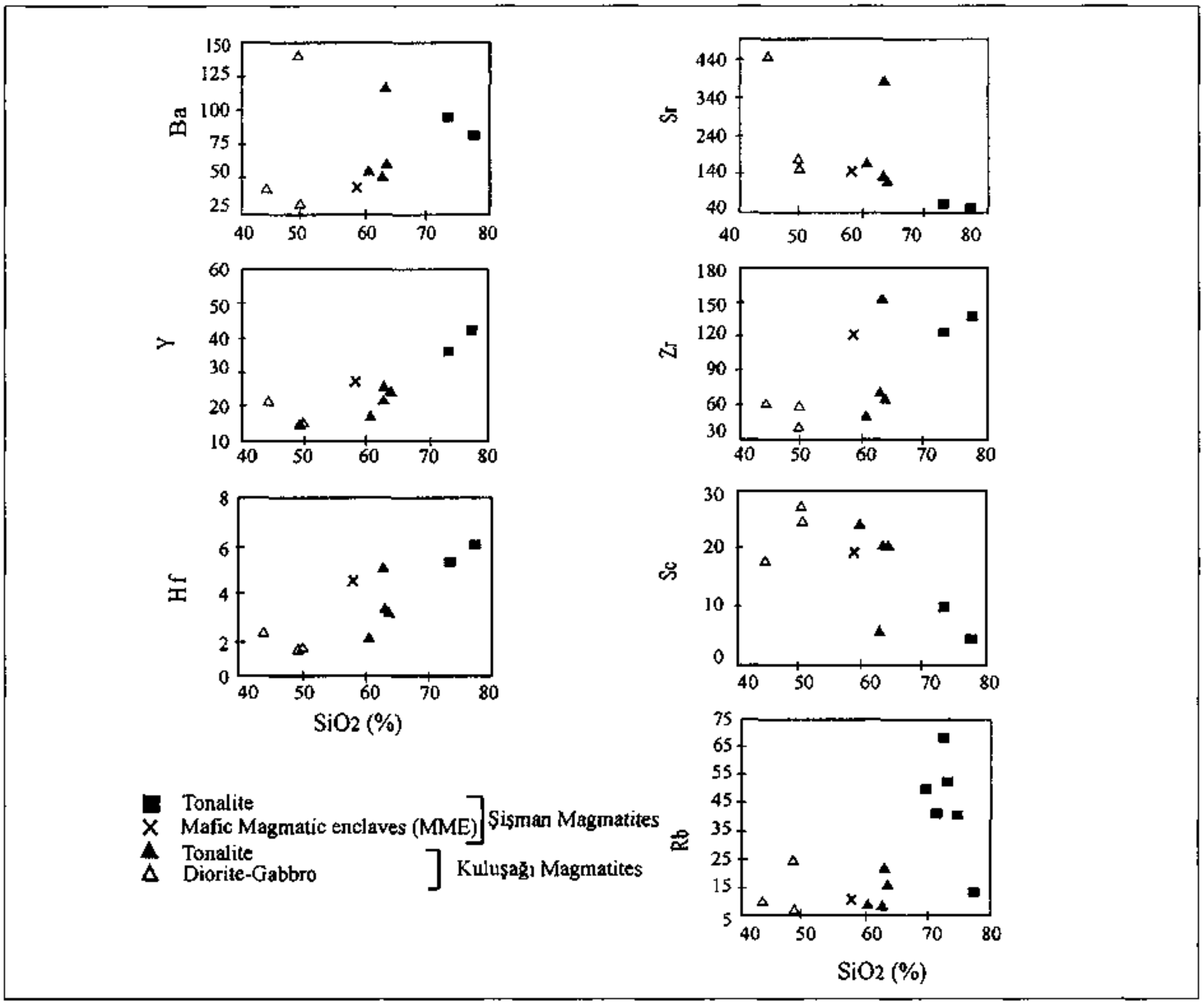

Fig. 9- Variation diagrams of trace elements of Şişman and Kuluşağı magmatites.

Examination of variations of trace elements in rock samples from Şişman and Kuluşağı magmatites reveals that Sc, Y, Zr and Hf contents increase with increasing SiO_2 values while Sr content decreases.

Concentrations of Ba, Rb and Sr, which are known as large ions, are consistent with those of CaO and K_2O. As known, Ba and Rb are retained in K-bearing minerals, while Sr in Ca- bearing minerals (particularly plagioclase). Like CaO, Sr contents are also decreased with respect to increase of SiO_2 concentrations. Observed different correlations in K_2O contents of Şişman and Kuluşağı magmatites are also detected for Ba and Rb contents. Ba and Rb contents of Kuluşağı magmatites increase with increasing SiO_2 concentrations, while they are decreased in samples from Şişman Magmatites (Fig. 9).

Among high-charged cations, Zr has a concentration ranges from 55 to 74, ppm in Kuluşağı magmatites (except for sample HD-24), while 125 to 139 ppm in Şişman magmatites. Hf, Th, U and Nb also results groupings similar to that of Zr.

Concentration of Y changes from 16.4 to 25 ppm in Kuluşağı magmatites, while it is from 37 to 42.9 ppm in Şişman magmatites.

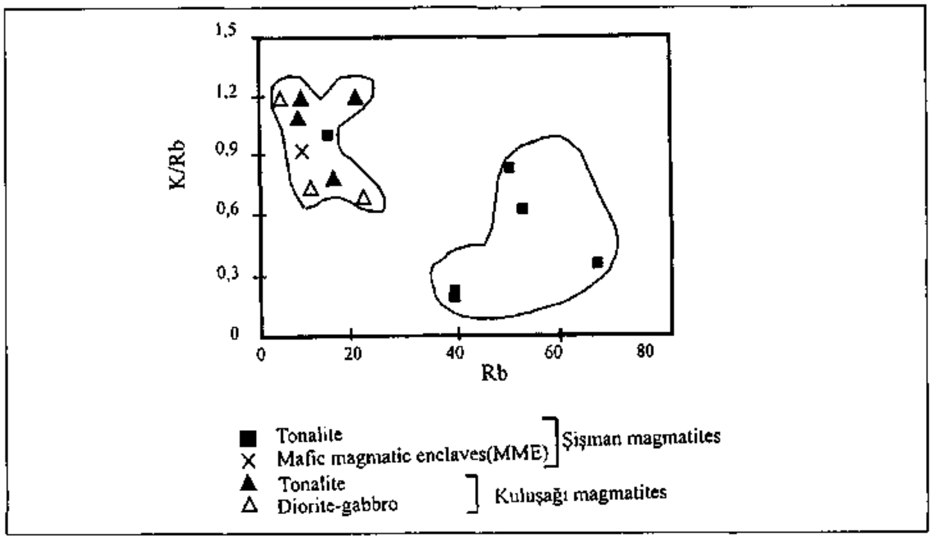

Fig. 10- K/Rb-Rb variation diagram of rock samples from Şişman and Kuluşağı magmatites.

A linear trend is expected in K/Rb-Rb variation diagrams for rock types formed as a result of solidification of a homogeneous magma (Jakes and White, 1970). Whereas, Şişman and Kuluşağı magmatites tend to show different correlations on K/Rb-Rb variation diagrams (Fig. 10). Petrogenetic and trace element studies indicate that these two magmatites are of same magma origin but formed in different stages.

Rock samples from Yüksekova complex plot in sub-alkaline field on alkali-silica diagram (Fig. 11). In AFM diagram used, for determining sub-magma type, diorite and gabbros of Kuluşağı magmatites plot in tholeitic field while tonalitic rocks plot on the boundary between tholeitic and calc-alkaline (Fig. 12). Rocks of Şişman magmatites are located in calc-alkaline field. In A-B diagram of Debon and Le Fort (1982), rock samples of Kuluşağı magmatites show a negative slope in IV and V sectors of metaaluminous area. As shown in the same diagram, such a trend has a similar extend with main cafemic (CAFEM) trend (Fig. 13).

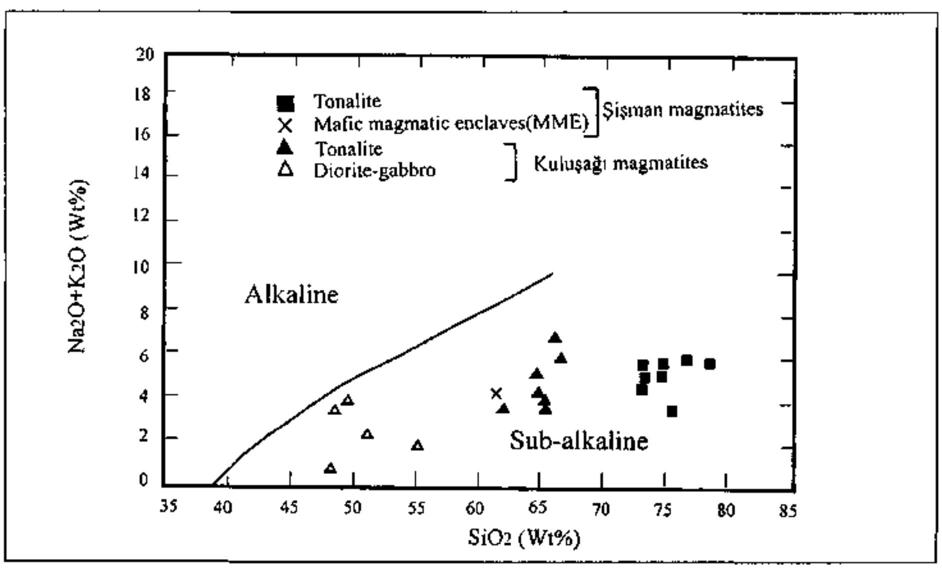

Fig. 11- Position of rock samples from Şişman and Kuluşağı magmatites on total alkali-silica diagram (Irvine and Baragar, 1971).

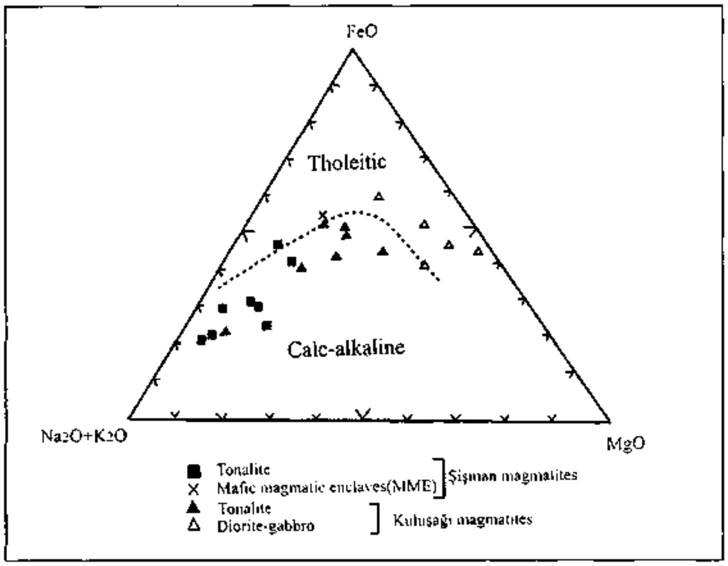

Fig. 12- Position of rocks samples from Şişman and Kuluşağı magmatites on AFM triangular diagram (Irvine and Baragar, 1971).

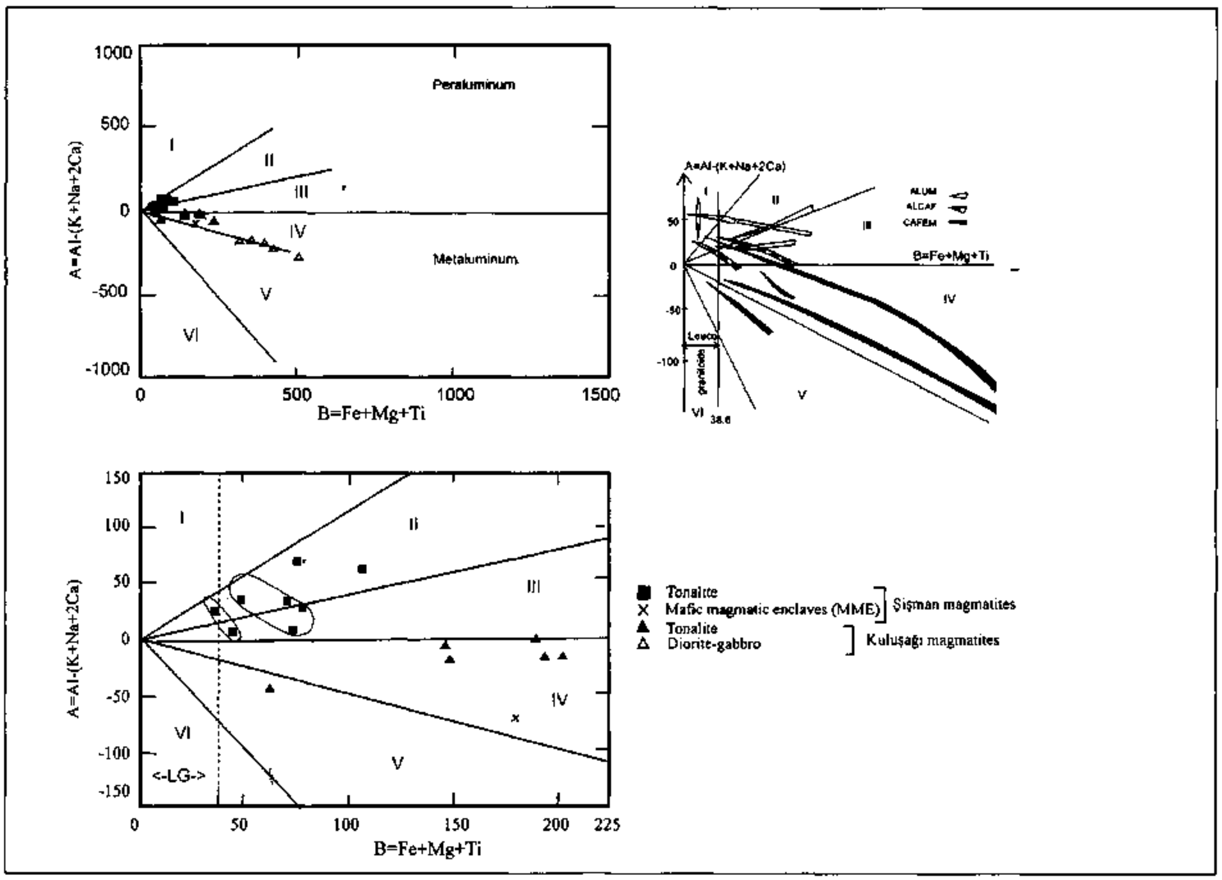

Fig. 13- Distribution of rock samples from Şişman and Kuluşağı magmatites on A-B characteristic mineral (Debon and Le Fort, 1983)

Table 4- Comparison of described features of Şişman and Kuluşağı magmatites to I-S type granitoid classification (Chappel and White, 1974).

Kuluşağı and Şişman magmatites	I-TYPE	S-TYPE
A large SiO_2 range Composition changes from granodiorite to gabbro	A large SiO_2 range Composition changes from granite to diorite	SiO_2 range is limited Composition is not changeable. (In general, leucocratic monzogranites are dominant)
It has volcanic equivalents (Kapıkaya volcanites)	It is found with its volcanic equivalents	No volcanic equivalent
Dark colored minerals are hornblende and biotite	Dark colored minerals: hornblende for mafic types and bitotite for felsic types	No hornblende. Biotite and muscovite are dominant
Magnetite is more common than ilmenite	Magnetite is dominant ore mineral	Ilmenite is dominant ore mineral
Secondary minerals are sphene and apatite	Orthite, sphene, needle-like apatite are secondary minerals	Monazite, cordierite, garnet, andaluKızmehmet Mahallesi, sillimanite and coarse apatite are secondary minerals
Enclave in tonalite is diorite	Enclaves are hornblende-bearing diorite	Enclaves are of meta sedimentary rock character
Element variation diagrams are generally regular	Element variation diagrams are regular. They are linear or close to linear.	Element variation diagrams are not regular
Na_2O is>3.2%-felsic (8 tonalite samples from Şişman magmatites and 2 granodiorite samples from Kuluşağı magmatites)	Na_2O in felsic types is>3.2% while Na_2O in mafic types is>2.2%	Na_2O is<3.2% in rocks with about 5% K_2O content while Na_2O is <2.2% in rocks with about 2% K_2O content
Mol (Al_2O_3) / $((CaO)+(Na_2O)+(K_2O))$ is>1.1 for Şişman magmatites while Mol$(Al_2O_3)/((CaO)+(Na_2O)+(K_2O))$ is<1.1 for Kuluşağı magmatites	Mol (Al_2O_3) / $((CaO)+(Na_2O)+(K_2O))$<1.1	Mol $(Al_2O_3)/((CaO)+(Na_2O)+(K_2O))$ is>1.1%
CIPW-normative corundum s 0.52 3.46% in Şişman magmatites while it yields no value in Kuluşağı magmatites	CIPW-normative diopsite or<1% normative corundum	CIPW-normative corundum>1%

In A-B diagram of Debon and Le Fort (1982), tonalites of Şişman magmatites show two different negative slopes in II and III sectors of peraluminous area and yield similar trends with main trends of alumino cafemic (CAFEM) assemblages (Fig. 13). This assemblage is derived from a hybrid source formed by mixing of mantle and sialic materials. On the basis of criteria suggested by Chappel and White (1974), except for the findings that Şişman magmatites are peraluminous and contain corundum normatively, all other features of these magmatites are in accordance with I type granitoids. As shown from Table 4, intrusive rocks of Yüksekova complex completely resemble to I type granitoids, excluding differences of Şişman magmatites.

Based on Shand index (Maniar and Piccoli, 1983) computed using major oxide data, Kuluşağı magmatites have a metaaluminous character, while Şişman magmatites are in peraluminous character (Fig. 14). This feature is consistent with the results of A-B diagram of Debon and Le Fort (1982).

GEOCHEMISTRY OF RARE EARTH ELEMENTS (REE)

Data on rare earth elements of rock samples from Şişman and Kuluşağı magmatites were normalized on the basis of condrite values described

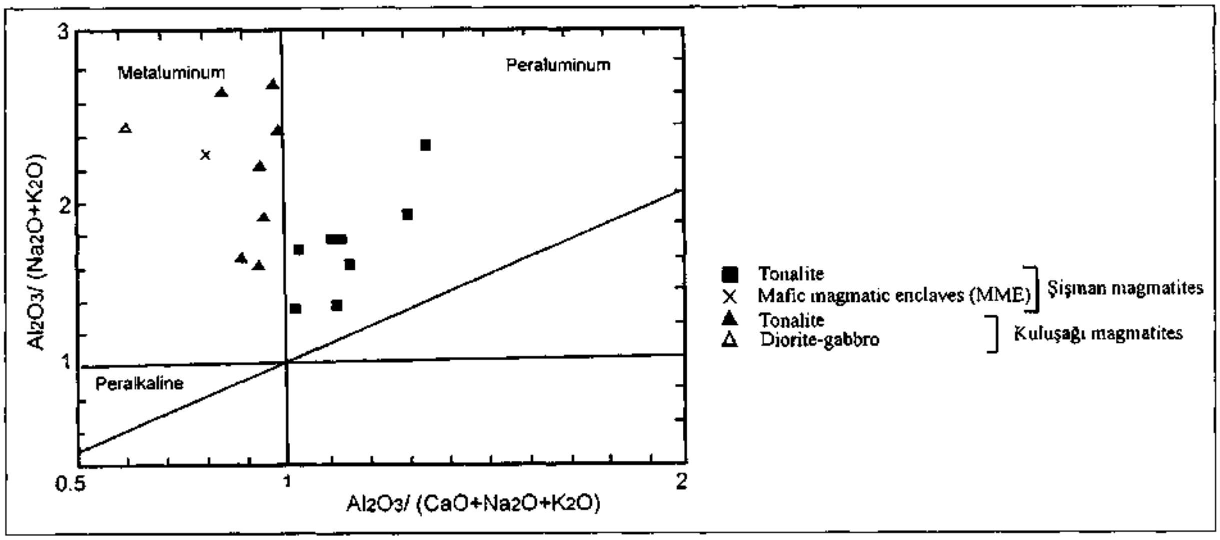

Fig. 14- Position of rock samples from Şişman and Kuluşağı magmatites on Shand index diagram (Maniar and Piccoli, 1983).

by Evensen et al., (1978) (Table 5). Enrichment coefficient of La ($(La/Sm)_{CN}$), which is one of light rare earth elements, with respect to that of Sm, which is one of intermediate rare earth elements, and enrichment coefficient of La ($(La/Yb)_{CN}$) with respect to that of Yb, which is one of heavy rare earth elements, were examined separately for each rock group of Şişman and Kuluşağı magmatites (Table 6). As shown in Table 6, Kuluşağı magmatites are less enriched in heavy rare earth elements in comparison to Şişman magmatites. If they were products of fractional crystallization, gabbroic and dioritic rocks of Kuluşağı magmatites would consume heavy rare earth elements and would be more enriched than Şişman magmatites. This difference between such rock groups is also shown in distribution diagram of normalized rare earth elements (Fig. 15).

Table 5- Normalized values (Evensen et al., 1978) of rare earth element (RRE) contents of rock samples from Şişman and Kuluşağı magmatites.

	SAMPLES	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Er	Tm	Yb	Lu	Ho
KULUŞAĞI MAG	KS1-P28	12,2	12	1.25	11,8	11,6	8,7	11.2	15	12.7	13.9	13.6	14.4	13.3	12
	KS2-P18	15,9	15,9	1,6	14,9	15,9	12,2	14.0	19	16.6	18.6	17.5	18.5	17.3	17
	HD-24	130,8	109,8	7.24	48,9	26.9	14,3	19.6	21	15.9	16.3	16.0	16.7	15.7	15
	KS1-P3	24,9	17,5	1,79	16,7	17	14,1	16.0	21	17.5	19.9	19.5	19.5	18.5	18
	HD-27	44,5	41	3,45	27,7	20.5	15,8	17.2	20	16.0	16.2	14.4	14.9	13.7	15
	HD-50	34,7	30,7	2,41	19.2	14,9	12	12.9	15	12.0	12.3	11.7	11.8	11.0	11
	HD-51	29,8	30,4	2,32	19,2	14,8	12,5	12.1	15	12.1	11.8	10.9	11.0	1.2	11
ŞİŞMAN MAG	KS4-24	20,8	23,5	2,35	22.8	22	12.4	20.6	28	23.8	27.7	27.3	29.0	28.3	24
	HD-180	17,1	22,4	2,1	19.9	19.4	14,9	17,2	22	18.2	20,5	19,9	21.1	2,0	18
	HD-106	22,4	26	2.57	25,1	27,4	11	27.2	36	33.1	38.9	38.6	40.5	39.7	34

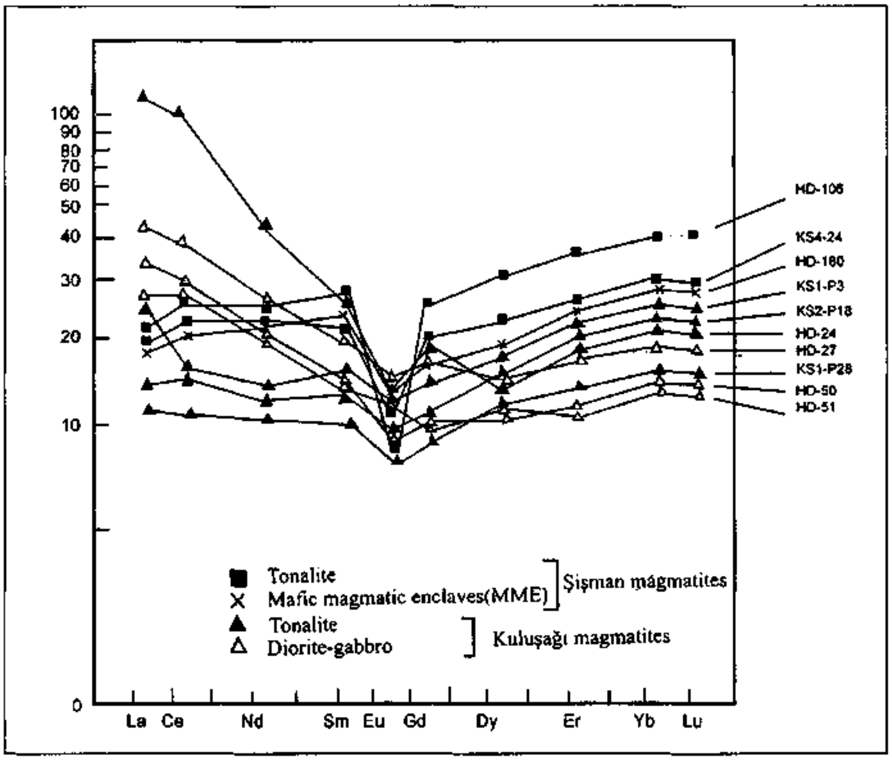

Fig. 15- Distribution of condrite-normalized values of NTE contents of şişman and Kuluşağı magmatites.

Table 6- $(La/Sm)_{CN}$ and $(La/Yb)_{CN}$ values of rock samples from Şişman and Kuluşağı magmatites.

	Sample No	Rock name	(La/Sm)CN	Average	(La/Yb)CN	Average
KULUŞAĞI MAG	KS1-P28	Tonalite	1.05	1.02	0.85	0.85
	KS2-P18		1		0.85	
	HD-24		4.86		7.83	
	KS1-P3	Gabbro-Diorite	1.46	1.98	1.28	2.49
	HD-27		2.17		2.99	
	HD-50		2.32		2.99	
	HD-51		2		2.70	
ŞİŞMAN MAG	KS4-24	Tonalite	0.94	0.88	0.71	0.63
	HD-106		0.82		0.55	
	HD-180	MME (mafic magmatic enclave)	0.88		0.81	

The fact that curves drawn for rock groups of Şişman and Kuluşağı magmatites are consistent with each other but not internally consistent indicates that Şişman and Kuluşağı magmatites belong to different formation stages.

RELATION BETWEEN MINERALIZATION AND ALTERATION

DISTRIBUTION OF MINERALIZATION

East-west extending Kızmehmet site copper mineralization is observed along two parallel structural lines with a length of about 6 km. and a width of 1 km. The one in north begans from eastern part of Kızmehmet site and extends towards Mişmiş hill. The one in south extends from the Taşlı hill ridge at east to Ziyaret hill - Harabe hill ridges at west. These lines belong to old fractures and are filled with acidic dikes of Harabe hill magmatites. In connection with N60°E and N60°W trending tension fractures, these lines give rise to formation of large ore and alteration packets (Fig. 16).

MINERALIZATION TYPES

Based on mode of occurrence observed within the magmatic suite, mineralization in the study area may be categorized into three main groups; namely vein type, coating in fracture and fissures, and disseminated type mineralizations. Mineralization types and relation between ore minerals and alteration are summarized in Table 7.

Vein type mineralizations

Iron mineralizations.- Black colored iron mineralizations are generally observed as veins on the boundary between tonalites of Şişman magmatites and dacites of Harabe hill magmatites. They are well exposed around Harabe hill. They have a thickness of 5 cm. to 50 cm. and an extension of 10 m. to 100 m. Dominant strike and dips of iron veins are N80°E/35°NW and N10°W/35°SW.

In this mineralization, macroscopically observed ore minerals are hematite, magnetite, and lesser amounts of malachite. Chloritization and silicification are detected as the main alteration types in massive magnetite veins.

Mineralizations in association with barite vein. - Barite vein which is exposed only 400 m. southeast of Taşlı hill in the study area has a position of N70°E/45°NW. This vein with a thickness of 0.5 to 2 m. continues 100 m. Stockwork zones, that are cut by quartz veins and consist of galena, pyrite and chalcopyrite minerals with a thickness of 1.5 m. are found at lower and upper parts of barite veins within andesites which are subjected to epidote-chlorite-carbonate alteration.

Table 7- Mineralization types of ore minerals and their distribution in alteration assemblages.

Ore Mineral	Alteration Type			Mineralization Type	
	Potassic	Propyllitic	Phyllitic	Disseminated	Veinlet/Vein
Pyrrhotite	X	X		X	
Magnetite	X	X		X	X
Rutile		X	X		
Pyrite	X	X	X		X
Chalcopyrite	X	X	X		X
Sphalerite		X			X
Bornit		X			X
Galena		X			X

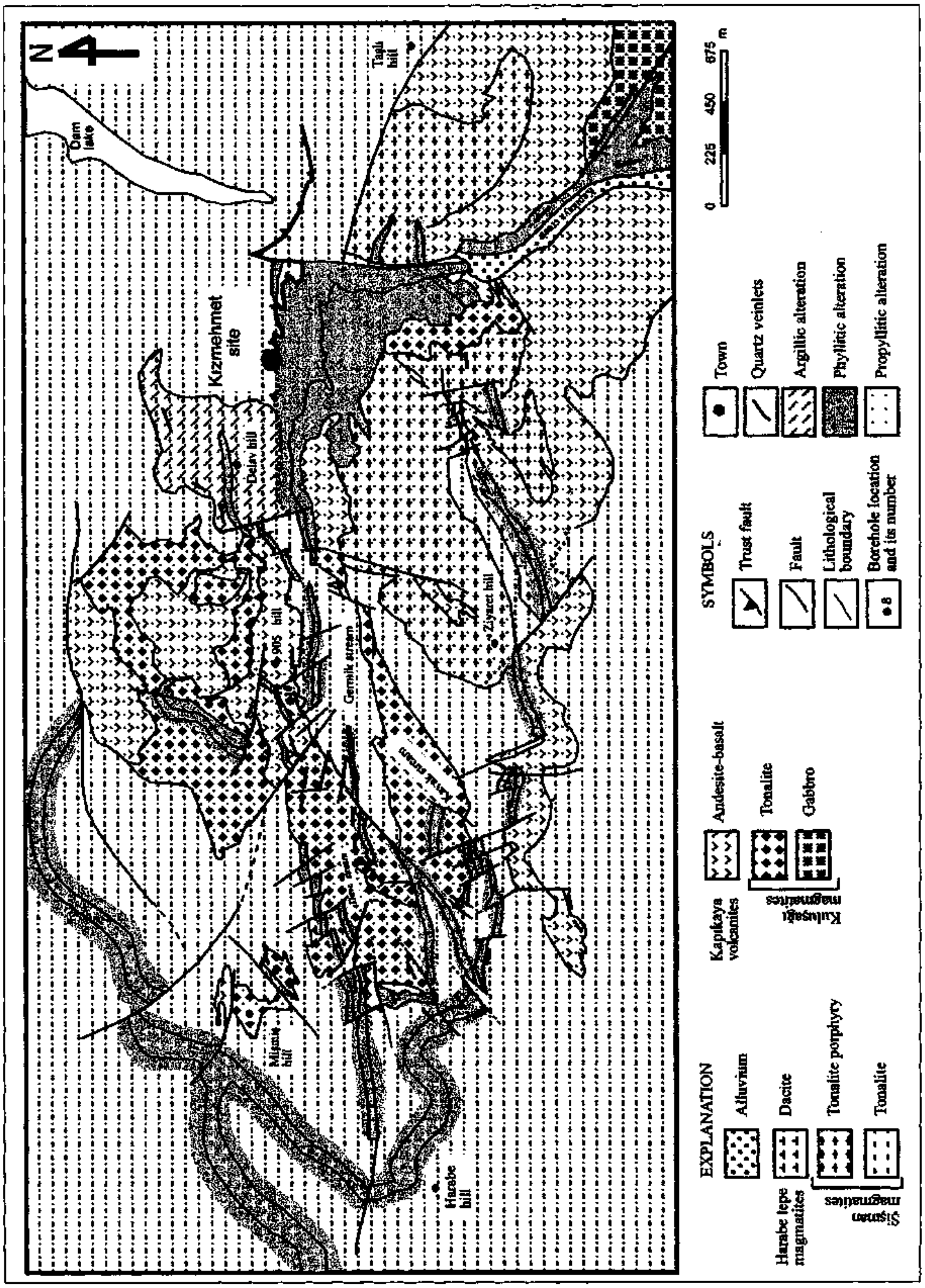

Fig. 16- Structure and lithology map of Kizmehmet site.

Mineralizations in association with quartz-carbonate vein and veinlets.- Quartz and carbonate veins are observed together with propyllitic alteration locating between Ziyaret hill, Taşlı hill and Deve hill. Their thickness changes from a few cm. to 1 m. The dominant strike and dip of quartz and carbonate veins in N60°E/65°NW. In addition, capillary quartz and carbonate veinlets in intense propyllitic and sericitic belts show a stockwork appearance.

Chalcopyrite, magnetite, hematite and bornite are observed in quartz and carbonate vein/veinlets within the propyllitic zone, while Chalcopyrite and pyrite are absent in quartz and carbonate vein/veinlets of phyllitic zone.

Coating type mineralization in fissure and fractures.- This type of mineralization is detected variously trending fissure and fractures of the rocks. The main minerals of coating type mineralization, that is widely exposed in all units of the study area, are pyrite and Chalcopyrite. These minerals are completely altered on the surface, If coating type mineralization is existed in propyllitic zone, chloritization is very intense at the contact with country rock. If it is found in phyllitic zone, secondary quartz and an intense sericitization are observed at the contact.

Disseminated type mineralization.- Disseminated type mineralization in chlorite-epidote zone is composed of fine grained Chalcopyrite, pyrite, magnetite, and a lesser amount of pyrrhotite, while that in quartz-sericite alteration zone consists of pyrite and Chalcopyrite. Ore minerals of biotite-quartz zone are disseminated magnetite, pyrite, pyrrhotite and a lesser amount of Chalcopyrite.

MINERALOGY, STRUCTURE AND TEXTURE OF MINERALIZATION

Main ore minerals of Kızmehmet site pyrite-copper mineralization are pyrite, Chalcopyrite and magnetite. In addition to these minerals, pyrrhotite, galena, sphalerite, bornite, rutile-anatase and ilmenite were determined as the accessory minerals. Moreover, secondary limonite, hematite, maroasite, chalcosite and covellite were also observed.

Due to mineralogic relations explained below, mode of occurrence was determined from older to younger as follows: (I) pyrrhotite, magnetite, rutile and ilmenite, (II) pyrite, (III) Chalcopyrite and sphalerite, (IV) bornite and (V) galena.

Pyrrhotite.- Disseminated pyrrhotite is found in propyllitic and potassic alteration zones. In general, pyrrhotite with euhedral and subhedral forms is found in pyrite as inclusions and in some cases, it occurs on the boundary with Chalcopyrite.

Magnetite.- Magnetite is existed in veins and also it disseminates in propyllitic and potassic alteration zones. Magnetites in massive veins are subhedral and euhedral and changed to hematite in places. Magnetites in propyllitic and potassic zones are observed in two types. First is euhedral, coarse grained magnetites and the second is anhedral magnetites which are formed by oxidation of iron originated during alteration of the mafic minerals to chlorite and decomposition of them along the cleavages.

While first type of magnetites change to hematite, second type of magnetites do not show any sign of decomposition. Magnetites have an intermediate reflection strength and brown and grayish colors.

Rutile.- Rutile is commonly observed in phyllitic zone and it has a needle-like shape.

Ilmenite.- Under microscope, ilmenite appears in pink-brown and gray-white colors. It has a certain reflection pleochroism and anisotropy.

Pyrite.- Pyrite often observed together with Chalcopyrite, is commonly found in three types of mineralization. It is detected in all types of determined alterations in the study field.

Pyrites in rock samples in which oxidation is intensely observed are partly or completely changed to limonite. Due to cataclasis effect, pyrites gain a brecciated appearance and are changed to limonite along fracture and fissures. In addition, fracture and fissures of pyrites, that are undergone to a cataclasis, are filled with chalcopyrite in places.

Inclusions detected in pyrite are pyrrhotite, magnetite and rutile. Distribution of inclusions in pyrite crystals is irregular. Pyrite itself is observed as inclusions in chalcopyrite and galena.

Scanning-Electron Microscope (SEM) studies performed on element content of pyrite yielded 46% Fe and 53% S.

Chalcopyrite.- In general, chalcopyrite is found as anhedral grains. Scanning Electron Microscope (SEM) studies performed on element contens of chalcopyrite yielded 34.5% Cu, 31.66% Fe and 33.82% S.

In addition, as a result of SEM studies, unknown mineral inclusions of 5 micron in size with two different compositions were determined in chalcopyrite. Elemental composition of one of these inclusions is 33.71% Co, 29.21% Mg, 27.28% S, 6.33% Fe and 3.46% Cu, while second inclusion has a composition of 25.45% Cu, 0.01% Al, 14.4% Ca, 25.49% Fe and 34.90% S.

It was observed that chalcopyrite was changed to malachite and limonite in oxidation zone, while it was altered to chalcosite and covellite in cementation zone. SEM quantitative point analysis conducted on covellites yield a composition of 69.50% Cu, 18.89% Fe, 9.65% S and 1.96% Si. SEM quantitative point analysis conducted on chalcosites yield a composition of 79.17% Cu, 18.34% Fe, 1.19% S and 1.31% Si.

Sphalerite.- Sphalerite With anhedral grains contain chalcopyrite and pyrite inclusions.

Bornite.- Bornite is seldom detected in quartz veins within the propyllitic zone. Bornites of anhedral grains are associated with chalcopyrite and hematite and contain chalcopyrite inclusions in places.

Galena.- Galena is generally found with pyrite and sphalerite and they contain pyrite inclusions in some places. Galena in association with sphalerite is observed in sutures.

Marcasite.- Marcasite is detected as anhedral grains or bar-like shapes. It is generally developed in association with sphalerite, chalcopyrite and galena.

RELATION OF ALTERATION TO MINERALIZATION

Radial dikes of dacitic composition of the Harabe hill magmatites and granodiorite porphyries at depth (cut in drill holes) are rocks which facilitate Kızmehmet site copper mineralization (Fig. 17).

It is observed that units of Harabe hill magmatites and surrounding rocks are subjected to phyllitic alteration. Phyllitic belt is cut by quartz

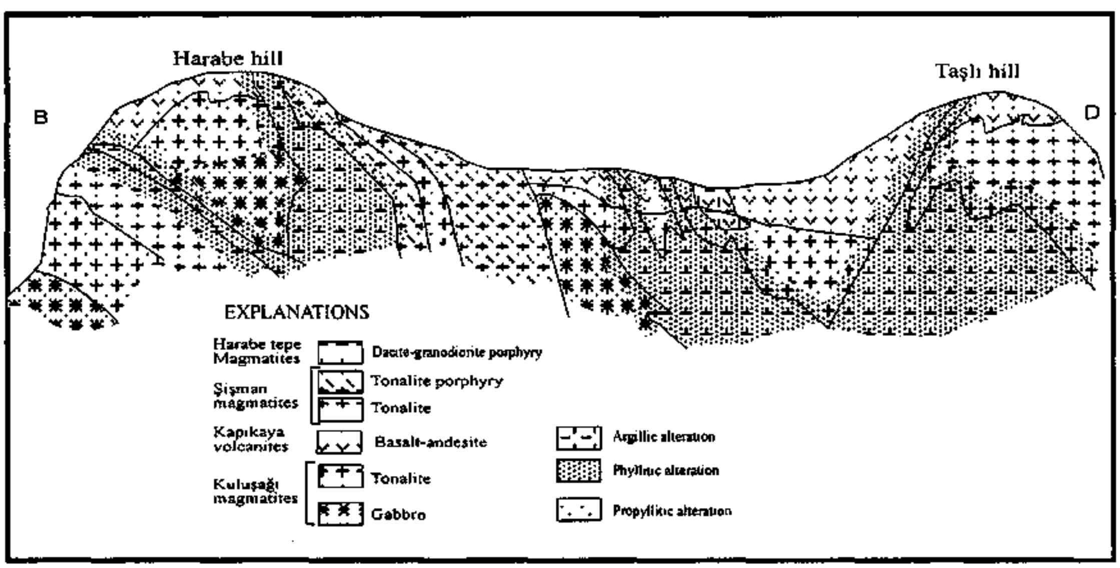

Fig. 17- A schematic section showing relation among rock assemblages within the Yüksekova complex (no scale).

veins which contains pyrite-chalcopyrite zone of 1 cm to 0.5 m thicknesses. Cu, Pb, Zn, As and Ag contents of rock samples collected from these Kızmehmet site are 1.07%, 80 ppm, 296 ppm, 56 ppm and 3.3 ppm, respectively (Tüfekçi and Dumanlılar, 1994).

Consistent phyllitic alteration in dacites of Harabe hill magmatites is surrounded by propyllitic alteration, that is widely exposed in the area. Between these two halos, argillic alteration is observed in south of Kızmehmet site and in Kavak stream. Quartz, carbonate and barite veins associated with pyrite, magnetite, chalcopyrite and galena minerals are present in N70E/45°NW propyllitic zone. Average Cu, Pb, Zn, As and Ag element concentrations of samples collected from this zone are 0.015%, 0.7%, <0.1%, <0.4% and 2.5 ppm (Tüfekçi and Dumanlılar, 1994). In comparison with phyllitic hole, Cu concentrations are decreased, while Pb values are increased.

Coating type sulfite mineralization and ore-bearing quartz capillary vein as well as disseminated pyrite are observed on intensely altered at the 905 hill and in the area between Kavak and Deve stream. Cu concentrations in this area changes from 0.04% to 4.44% in the studied samples (Tüfekçi and Dumanlılar, 1994).

Like on the surface, well developed phyllitic alteration zones in drill zones are also detected around dacite and granodiorites of Harabe hill magmatites.

A potassic alteration and a copper anomaly were determined at depths between 0 and 50 m in KS-5 well drilled along Kapıkaya creek.

Although no Au anomaly was found at the surface within Kızmehmet site copper mineralization, gold concentrations of 0.14-2.62 ppm were determined at depths between 80 and 130 meters in KS-3 well. In addition, a gold concentration of 1 ppm was also detected at depths between 97 and 100 m in KS-7 well. Chemically determined gold in samples was not clearly seen during polished section determination. During limited SEM studies conduct ed on these samples no visible gold grain was observed. Also propyllitic alteration is dominant alteration type in levels where gold concentrations are chemically determined, which is surrounded by phyllitic alteration. However, the presence of Cl, P and S determined in these samples by SEM studies, indicates that magma is saturated with aqueous fluids and forms a suitable environment for gold transportation. Aydal (1989) and Aydal et al., (1992) who studied gold-bearing quartz veins in Hatay-Kisecik, stated that As, Zn, Cu, S and P_2O_5 concentrations are increased in gold-bearing hydrothermal vein contacts.

If any gold presence detected in porphyry copper mineralizations, it is generally found as disseminated grains in sulphite minerals or veins, and in quartz. Highest gold concentration is observed in potassic zone. In addition, small but high-grade gold-silver-chalcopyrite veins are found in propyllitic belt, while gold disseminations raising due to highly acidic fluids are detected in the argillic zone (Sillitoe, 1981). Intrusive rocks of Yüksekova complex associated with Kızmehmet site porphyry copper mineralization show some similarities to country rocks of similar mineralizations given in the literature. Porphyry Cu-Mo or Cu-Au deposits are generally a part of ore zoning of main arc granitoids (Sillitoe, 1981).

Granitoids hosting porphyry copper enrichments are generally classified as I type granitoids (Chappel and White, 1974). As known, this type of granitoids are originated from areas very close to magma and are closely associated with subduction processes (Sawking, 1984). Composition of intrusives related to porphyry copper mineralizations is from diorite to granite. Intrusives in porphyry copper mineralization areas generally cut each other and are settled as multi-phase intrusions (Erler, 1981).

The difference of gold-bearing porphyry copper deposits from other Cu-Mo systems may be explained as follows: (a) Known gold-rich porphyry copper deposits are poor in Mo, (b) 80% of deposits are rich in hydrothermal magnetite and (c) They may be found in volcano-plutonic island arc and continental margins (Sillitoe, 1981). These features are consistent with those of Kızmehmet copper mineralization.

RESULTS

Results of geologic, petrographic and geochemical studies conducted in the study area may be summarized as follows:

Three main units were differentiated around İspendere. Jurassic-Lower Cretaceous İspendere ophiolite is located at south of the study area and it has a tectonic contact with Upper Cretaceous aged Yüksekova complex. At north, Yüksekova complex is unconformably covered by Eocene aged Kırkgeçit formation.

Yüksekova complex, which is related to mineralization around Kızmehmet site was differentiated as Kuluşağı magmatites (gabbro, quartz diorite and tonalite), Kapıkaya volcanites (andesitic and basaltic volcanic rocks), Şişman magmatites (tonalite and tonalite porphyry) and Harabe hill magmatites (dacite and granodiorite), and all were mapped.

Based on total alkaline-silica and AFM diagrams for Kuluşağı and Şişman magmatites, gabbro and quartz diorite type rocks are product of a tholeitic character, while other rock groups are product of a calc-alkaline type magma. According to Debon and Le Fort (1982) and based on Shand index criteria, Kuluşağı magmatites exhibit a cafemic (CAFEM) assemblage character in which Metaaluminous type mantle material is dominated, while Şişman magmatites exhibit an alumino-cafemic assemblage type in which sialic origin of peraluminum character is dominated.

Harker diagrams constructed on the basis of rare earth elements and trace element geochemistry, indicate that Kuluşağı and Şişman magmatites are formed at different stages by subduction processes, and it is also approved by petrogenetic and tectonogenetic data. Based on these data, Kuluşağı and Şişman magmatites are I type volcanic arc granitoids (VAG) of a calc-alkaline character (except for the character that $(Al_2O_3)/(CaO)+(Na_2O)+(K_2O)$ ratio of Şişman mag matites is >1,1).

Mineralization is related to Harabe hill magmatites and it is observed within these magmatites or rocks having contact with them (Kuluşağı magmatites, Kapıkaya volcanites and Şişman magmatites). Mineralization is detected as disseminated grains in quartz-carbonate veins and fracture-fissures, while as coating within the rock.

Main ore minerals in the order of abundances are pyrite, chalcoprite, and magnetite. In addition to these minerals, pyrrhotite, sphalerite, bornite, galena, rutile-anatase, ilmenite and gold-silver (chemically) were also determined. Moreover, limonite, hematite, marcasite, chalcosite and covellite were observed as secondray alteration products.

Ore paragenesis in the order of occurrence, from older to younger was determined as follows: (I) pyrrhotite, magnetite and rutile, (II) pyrite, (III) chalcopyrite and sphalerije, (IV) bornite and (V) galena.

Four different alteration types are recognized in association with mineralization. Alteration types described are potassic, propyllitic, phyllitic and argillic. Mineralization is generally associated with quartz veinlets and sulfite coatings in phyllitic and propyllitic alterations.

On the basis of geometric features, mineral paragenesis and alteration types determined in Kızmehmet site pyrite-copper mineralization, mineralization can be thought of a porphyry or stockwork pyrite-copper type mineralization.

Kızmehmet site copper mineralization is similar to pyrite-copper mineralizations in the literature by means of origin and tectonic setting and is found in multistage I type granitic rocks associated with volcanic island arc granitoids.

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