4) The comparision with geochemical anomalies : Copper anomaly zones over 200 ppm lies in the zone of high PFE which formed the horseshoe shape shell. Molybdenum anomaly zones of more than 75 ppm were located inside the shell.

5) Conclusive remarks : The horseshoe shape zone of PFE higher than 8% is correlative with the pyrite shell in the phyllic zone, and a target area for exploration is assumed to exist in this shell through to the zone of potassic alteration.

Chapter 5 Drilling Survey

5-1 Outline of the Diamond Drilling

As a result of geological and geochemical surveys carried out in the initial phase of the project, a porphyry copper type ore deposit was found as a promising target for future exploration in the Güzelyayla area. In the second and third phases, a drilling survey consisting of eight holes was planned and subsequently carried out in order to explore underground emplacement of the porphyry-copper type ore deposit, and to investigate and unravel the relationship between the emplacement conditions of the ore deposit and the results of geological and geochemical surveys. The purpose of these cores are as follows;

- MJT-1: exploration of copper and molybdenum mineralized area discovered on the surface
- MJT-2: exploration of copper and molybdenum mineralized area and copper anomalous area as found by soil geochemical survey on the surface.
- MJT-3: exploration on molybdenum anomalous area found by soil geochemical survey
- MJT-4: exploration in the center of the potassic zone
- MJT-5: exploration of the phyllic zone in south-eastern Güzelyayla
- MJT-6: exploration of the molybdenum anomalous area found by soil geochemical survey
- MJT-7: exploration of the IP anomaly area
- MJT-8: exploration of the SIP anomaly area

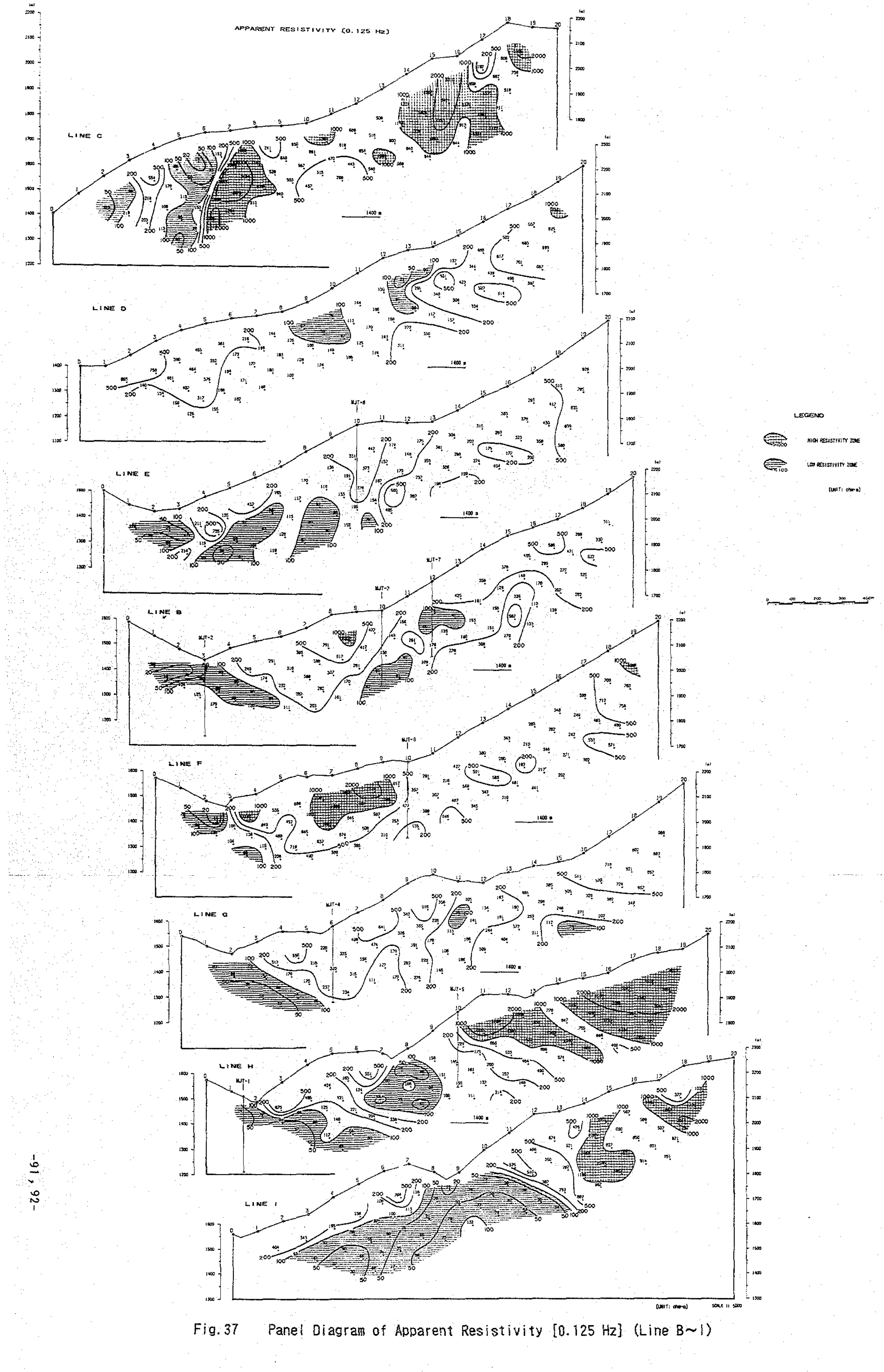

Fig.37 Panel Diagram of Apparent Resistivity [0.125 Hz] (Line B~I)

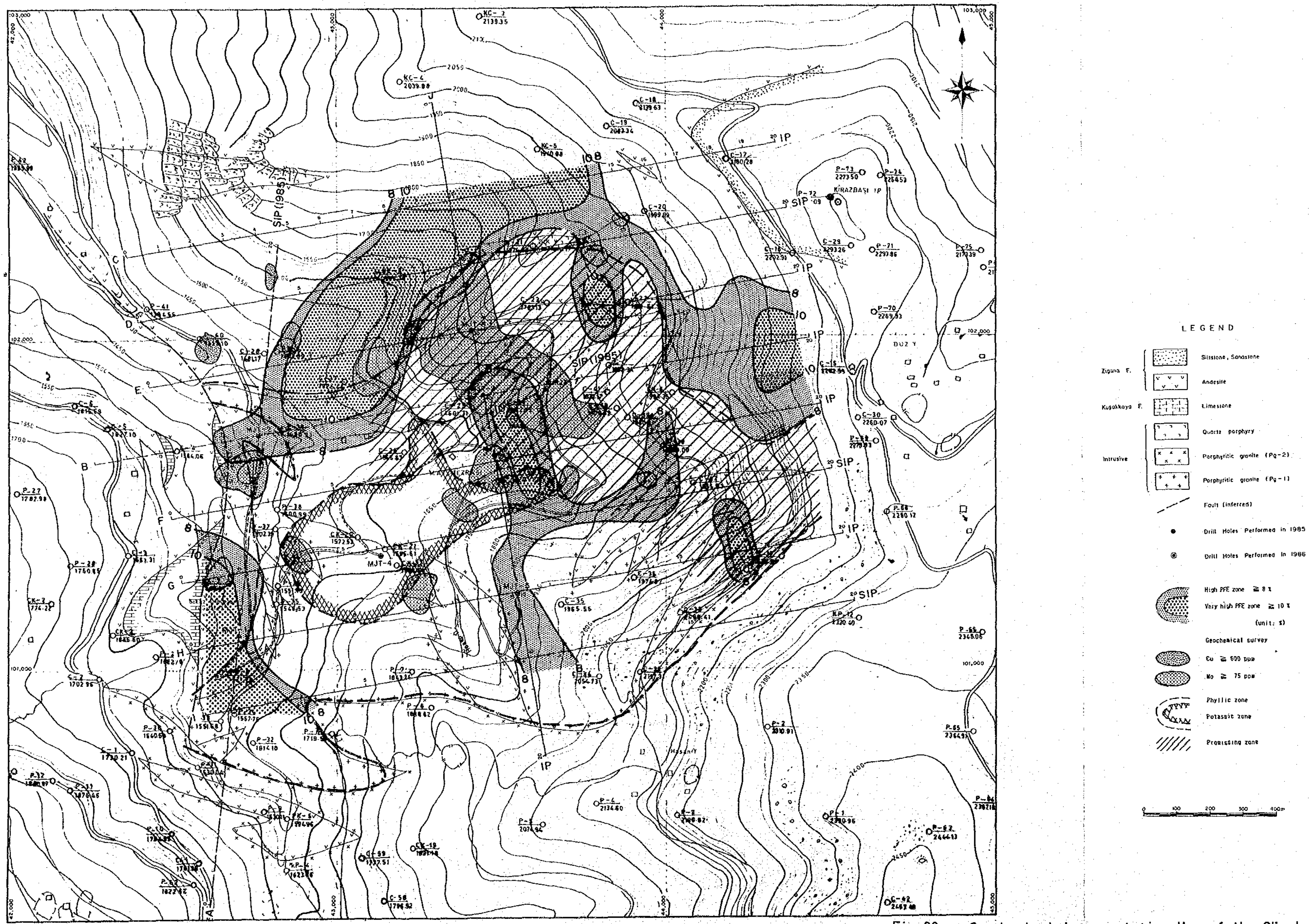

Fig. 39 Geophysical Interpretation Map of the Güzelyayla Area

Location of drill holes

No	Y	X	Z [m sea level]
MJT-1	42 705	01 098	1,518
MJT-2	42 762	01 708	1,438
MJT-3	43 444	01 825	1,635
MJT-4	43 131	01 338	1,578
MJT-5	43 550	01 227	1,857
MJT-6	43 482	01 640	1,635
MJT-7	43 639	01 860	1,752
MJT-8	43 409	02 023	1,761

5-2 Duration and Amount of Work

Drilling No.	Drill length planned	Drill length performed	Dip (°)	Surface soil	Core length	Core recovery	Period (Second phase)
MJT-1	300m	301.00m	-90	9.9m	290.40m	96%	Sep.12-Oct 1
MJI-2	300m	301.00m	-90	9.5m	276.40m	91%	Sep.12-Oct.8
MJT-3	300m	401.00m	-90	0.0m	398.85m	99%	Oct.8-Oct.30
Total	900m	1,003.00m		19.4m	965.65m	96%	

Drilling No.	Drill length planned	Drill length performed	Dip (°)	Surface soil	Core length	Core recovery	Period (Third phase)
MJT-4	300m	301.00m	-90	0.00m	300.70m	99%	June 24-July 10
MJI-5	300m	01.00m	-90	0.00m	297.20m	99%	Sep. 10-Sep. 23
MJT-6	300m	301.00m	-90	0.00m	301.00m	100%	June 24-July 12
MJI-7	300m	301.00m	-90	0.00m	300.80m	99%	July 25-Aug. 10
MJT-8	300m	301.00m	-90	0.00m	298.90m	99%	July 25-Aug. 12
Total	1,500m	1,505.00m		0.00m	1,498.60m	99%	

5-3 Alteration and Mineralization of Drill Hole

MIT-1 :【Alteration】 Under general observation, the shallow sections of andesite and quartz porphyry, and Pgl near the surface have predominantly undergone sericitization(phyllic zone from 0.9m to 195m), but chlorite increases towards the deep section, and epidote is also recognizable with the apperrance of chlorite(propylitic zone from 195m to 301m).

【Mineralization】 Mineralization accompanying pyrite, chalcopyrite and molybdenite is observed throughout from surface to 301m, but generally is weak mineralization. Chalcopyrites and molybdenites are embedded in quartz veins and along fissures, while pyrites are disseminated in the rock and also in the quartz veins and fissures. Comparatively strong mineralization occurs from 200m to 250m.

MJT-2 :【Alteration】 Andesite has mostly undergone chloritization and weak epidotization. Contrarily, small intrusions of porphyry granite have undergone sericitization. Thus the alteration zone is classified into the propylitic zone.

【Mineralization】 Mineralization with chalcopyrite and molybdenite is emplaced in quartz veins and fissures. A strong part of the mineralization of chalcopyrite and molybdenite is located especially in quartz veins and fissures within chloritized andesite accompanied by magnetite around 10 ~ 80 m and 180 ~ 300 m. Results of the chemical assay of ores at the strongly mineralized sections indicate (199~ 222m Wd:3m) 0.92% Cu and 0.043% Mo. Mineralization of MJT-2 is better and stronger than mineralization in MJT-1 because a greater number of finer, irregularly directioned fractures are developed and chalcopyrite and molybdenite are emplaced along these fine fissures, in comparison with the case of MJT-1.

MJT-3 :【Alteration】 The rock has undergone silicification and sericitization throughout the hole from surface to 401m. Small amounts of chlorite are also evenly contained. Potassic feldspar begins to appear from around 130m in depth, anhydrite from around 150m in depth and biotite from around 190 m in depth. Judging by this evidence, the alteration of the hole is divided into two zones, namely the potassic zone from 150m to depth and the phyllic zone from 150m to surface.

【Mineralization】 Thereis an oxidized and limonitized zone from surface to 2.2m, thus sulpide minerals are not recognizable. The range from 2.2m to 16m, is regarded as the secondary enrichment zone because of the existance of native copper and chalcocite. Below 16m, content of sulphide minerals increase, associated the disseminations of chalcopyrite and molybdenite. Mineralization of chalcopyrite and molybdenite continues to 401m.

MJT-4 :【Alteration】 Pg1 has undergone biotitization and sericitization throughout the hole from surface to hole bottom(301m). Small amounts of chlorite are also evenly contained. It is considered the center of the potassic zone as a result of the geological survey. The drilling survey indicated the same zone, but anhydrite was not observed in this hole as it was in the potassic zone of MJT-3.

【Mineralization】 Mineralization accompanying pyrite, chalcopyrite and molybdenite is observed throughout from surface to hole bottom, but generally it is weak mineralization. The range from 5m to 30m is regarded as the secondary enrichment zone because of the exsistance of chalcocite. Chalcopyrites and molybdenites are embedded in quartz veins and along fissures, while pyrites are disseminated in the rock and also in the quartz veins and along fissures. Comparatively strong mineralization occurs from 200m to 280.00m

MJT-5 :【Alteration】 Pg1 has undergone sericitization, and small amounts of chlorite are also contained. Contrarily, basaltic andesite has undergone mostly chloritization and weak epidotization. Thus the alteration zone is classified into the phyllic and propylitic zones.
【Mineralization】 Mineralization with pyrite, chalcopyrite and molybdenite is emplaced in quartz veins and fissures. It also occures as disseminations in the rocks, but generally is weak. The range from 10m to 112m is regarded as the secondary enrichment zone because of the existance of chalcocite and native copper.

MJT-6 :【Alteration】 The rock has undergone mainly sericitization from surface to hole bottom except for the intrusive rocks of Pg2 and basalt. Small amounts of chlorite are also evenly contained. Potassic feldspar begins to appear from around 244m in depth, anhydrite from around 248m in depth. Judging by this evidence, the alteration of the hole is divided into two zones, namely the phyllic zone from surface to 150m and the potassic zone from 150m to depth.
【Mineralization】 There is an oxidized and limonitized zone from surface to 1m. Thus sulphide minerals are not recognizable. The range from 1m to 23m, is regarded as the secondary enrichment zone because of the existance of chalcocite, but there are minor amounts of chalcopyrite and molybdenite disseminated in Pg1. Mineralization of chalcopyrite and molybdenite continues to 299.9m, but it tends to weaken toward the deep part. The mineralization is mostly emplaced as disseminations along fissures and quartz veins.

MJT-7 :【Alteration】 Pg1 has undergone silicification and sericitization throughout the hole from surface to 301m. Small amounts of chlorite are also evenly contained. Biotite-anhydrite-gypsum begins to appear from around 254m in depth. Judging by this evidence, the alteration of the hole is divided into two zones, namely the phyllic zone from surface to 254m and the potassic zone below 254 m.

【Mineralization】 Mineralizations of pyrite, chalcopyrite and molybdenite are observed from surface to hole bottom, but generally are weak. The range of 5m to 42m is regarded as the secondary enrichment zone because of the exsistance of chalcocite. Below 42m, pyrites are disseminated in the rock and also in quartz veins and fissures, but minor amounts of chalcopyrite and molybdenite are embedded in quartz veins and along fissures. Comparatively strong mineralization occurs from 160m to 240m.

MJT-8 :【Alteration】 The rocks consist of pale green and dark green Pgl and andesite throughout the hole from surface to 301m. The alteration of the hole is divided into five zones as follows;

0.00~ 40.75m	Pale green Pgl	Phyllic zone
40.75~169.00m	Dark green Pgl	Propylitic zone
169.00~233.40m	Dark green andesite	Propylitic zone
233.40~283.00m	Dark brown Pgl	Potassic zone
283.00~301.00m	Pale green Pgl	Phyllic zone

【Mineralization】 Mineralizations of pyrite, chalcopyrite and molybdenite are observed from surface to hole bottom, but generally is weak mineralization. The range from 9m to 84m is regarded as the secondary enrichment zone because of the existance of chalcocite and covelline. Below 84m, pyrites are disseminated in the rock and also in quartz veins and fissures, but minor amount of chalcopyrites and molybdenites are embedded in quartz veins and along fissures. Comperatively strong mineralization occurs from 230m to 300m.

5-4 Assay Result of Core

Drilling survey of the third phase resulted in eight holes, totalling 2,508m in length. Whole core (2,482.2m) was split, and half of the split core was subjected to chemical analysis for two elements (Cu and Mo).

Taking into consideration that the ore deposit is porphyry copper type, the cores assayed were grouped and pulverized at each three meters. These samples (840 samples) were analyzed for Cu and Mo. Thirty seven samples which contained many sulphide ore minerals such as pyrite, chalcocite and covelline, had undergone strong biotitization and were regarded as scheelite by minerallight, were selected to be analyzed for Au, Ag, Sn and W. Average grades of these drill holes are as follows ;

Drill hole	Assayed range	Average grade		
		Cu%	Mo%	Equivalent Cu% *
MJT-1	9.9~301.0m	0.066	0.002	0.091
MJT-2	9.5~301.0m	0.172	0.009	0.257
MJT-3	0.0~401.0m	0.237	0.011	0.345
MJT-4	0.0~301.0m	0.075	0.003	0.105
MJT-5	0.0~301.0m	0.067	-	0.071
MJT-6	0.0~301.0m	0.157	0.007	0.231
MJT-7	0.0~301.0m	0.120	0.013	0.247
MJT-8	0.0~301.0m	0.160	0.010	0.264

* Equivalent Cu% = Cu% + 10 X Mo%

Histograms of assayed results of each drill hole are presented in Fig.41.

Only a few amounts of Sn and W are detected through this assay, and only ppb unit grades of Au was recognizable, similar to other porphyry copper type ore deposits accompanied by Cu and Mo.

The average ore grades of the secondary enrichment zone are as follows;

Drill hole	Assayed range	Average grade		
		Cu%	Mo%	Equivalent Cu% *
MJT-4	0.00~ 21.00m	0.198	0.002	0.218
MJT-5	9.00~105.00m	0.066	-	0.066
MJT-6	0.00~ 24.00m	0.404	0.032	0.724
MJT-7	6.00~ 57.00m	0.157	0.013	0.287
MJT-8	9.00~ 54.00m	0.264	0.007	0.314

* Equivalent Cu% = Cu% + 10 × Mo%

Chapter 6 Consideration

6-1 Altered porphyritic granite (Pg1)

Porphyritic granodiorite is classified into Pg1 and Pg2 by differences in mode of alteration. Porphyry copper type mineralization is embedded in Pg1 in the Güzelyayla Area. The intrusion was inferred to be vertical in form, since it could not be unravelled by the initial phase geological survey. The drilling survey of the second and third phases revealed that Pg1 had intruded into andesite of the Zigana Formation. It dips 60° to 70° south-east. Alteration zoning indicates that the center of mineralization is situated slightly east of the intrusion. Investigation of fluid inclusions also reveals that the homogenization temperature of the inclusions is higher and

MJT−1

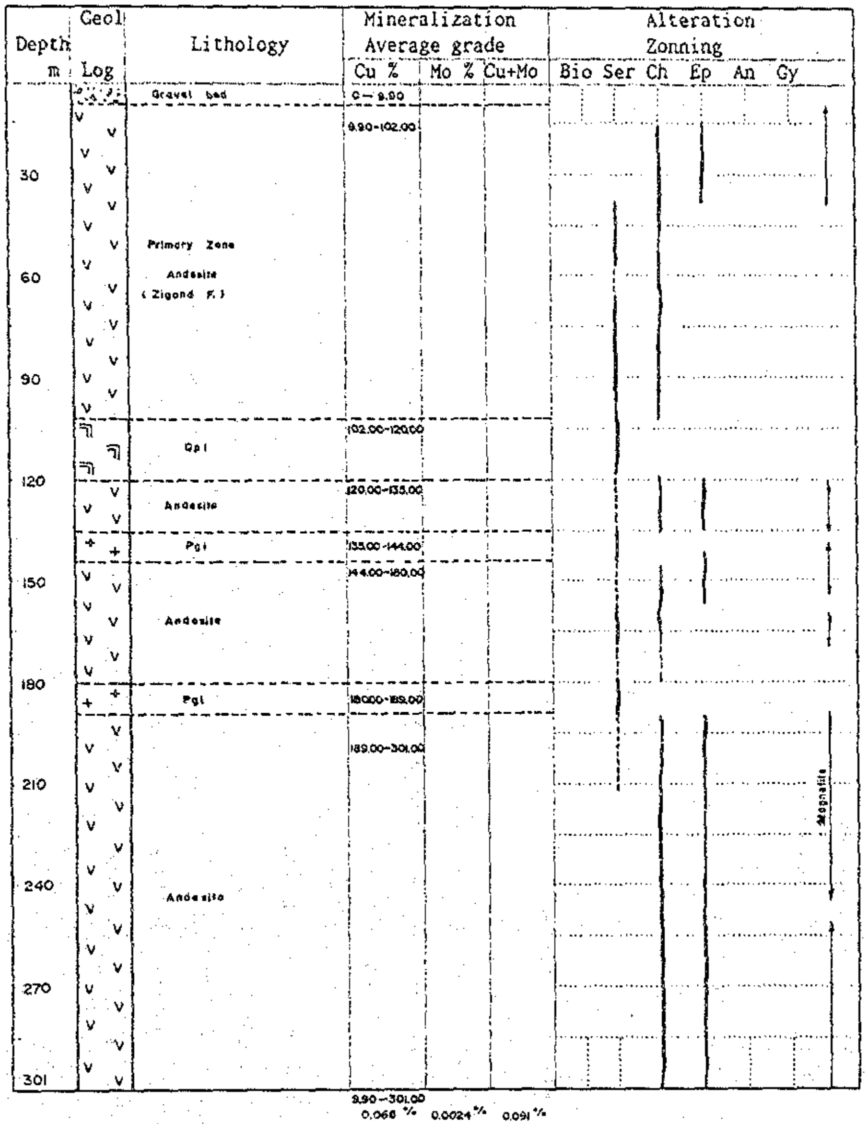

Fig. 40 Geological Log of MJT-1

MJT−2

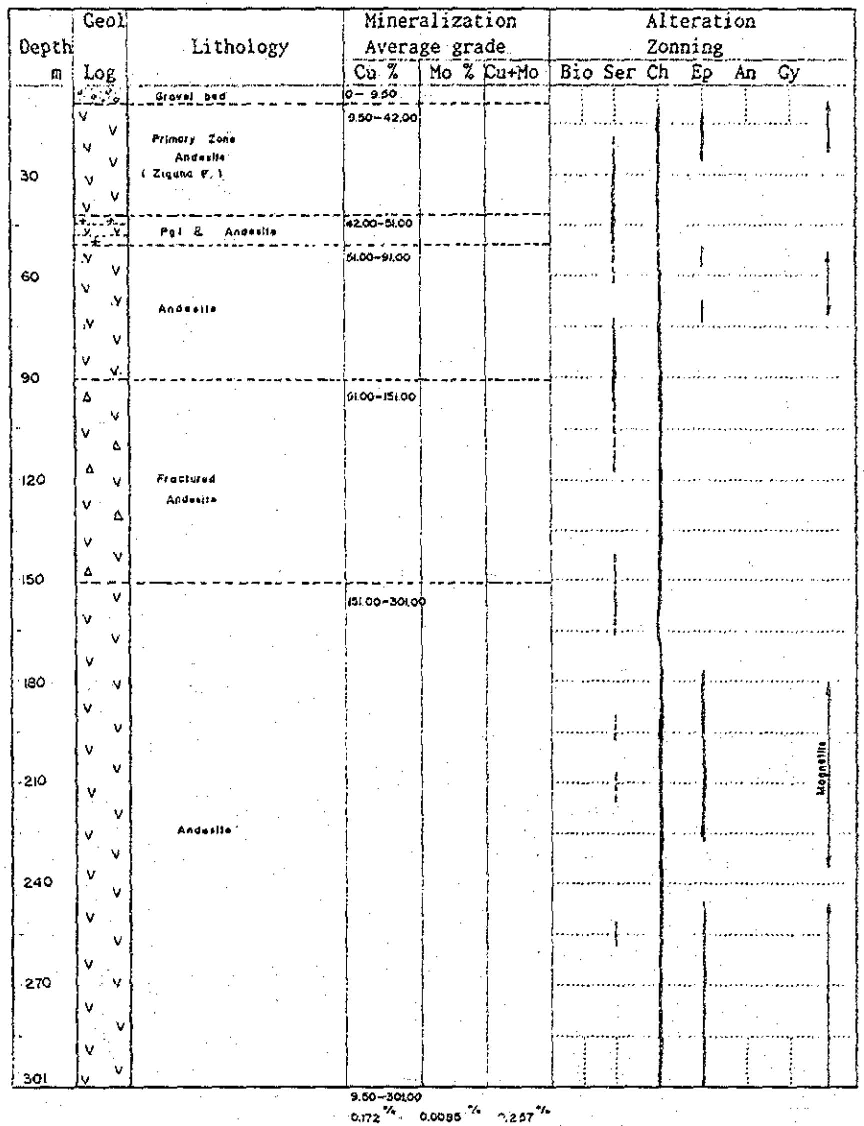

Fig. 40 Geological Log of MJT-2

MJT-3

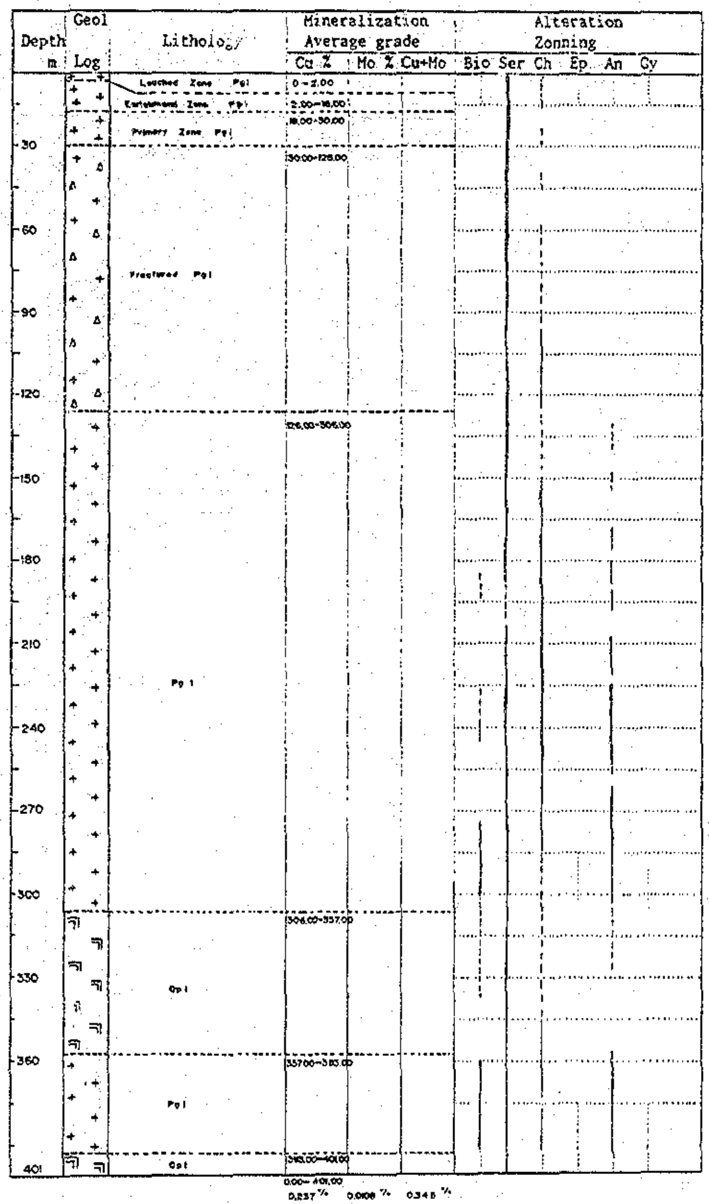

Fig. 40 Geological Log of MJT-3

MJT-4

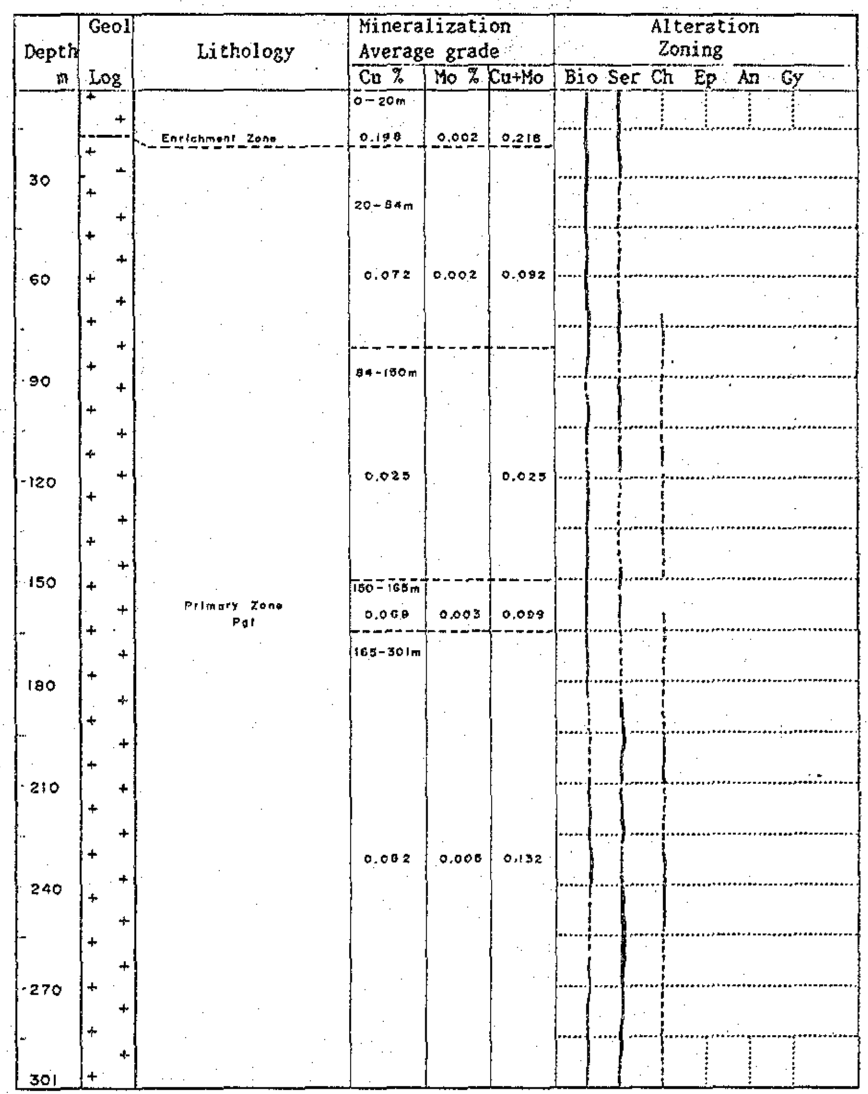

Fig. 40 Geological Log of MJT-4

MJT－5

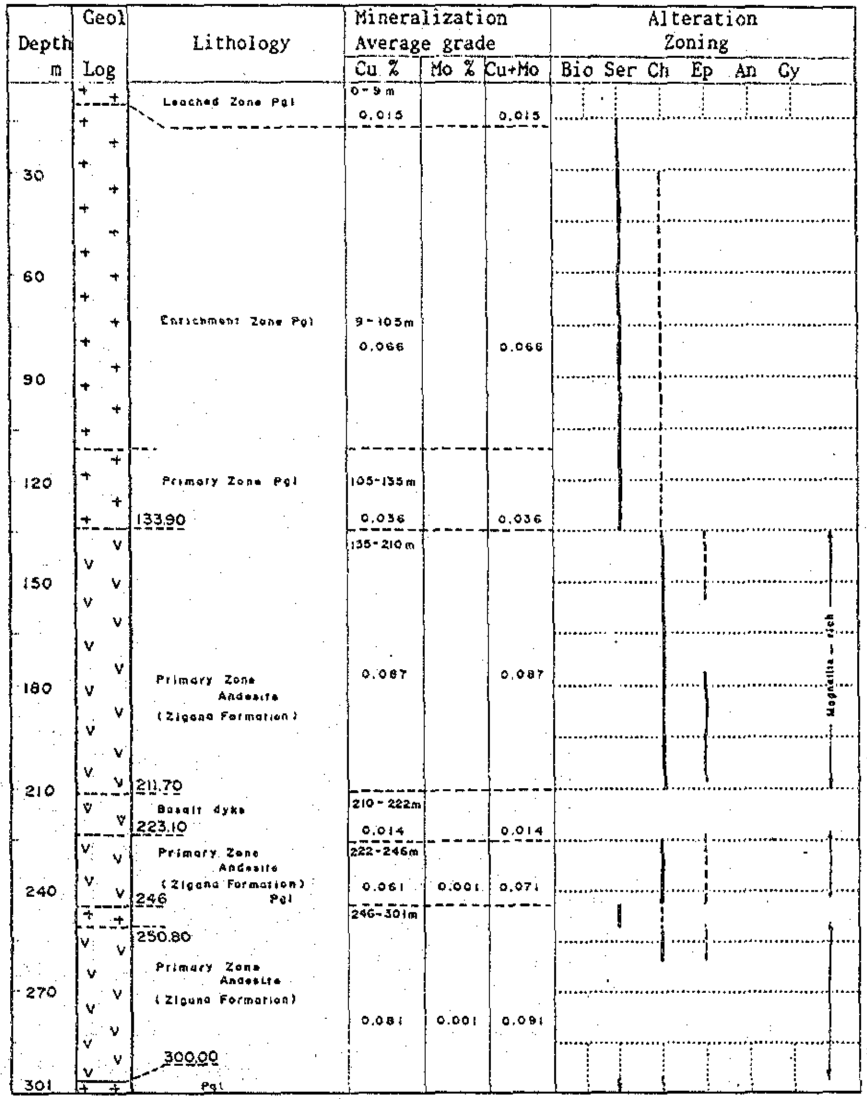

Fig. 40 Geological Log of MJT-5

MJT－6

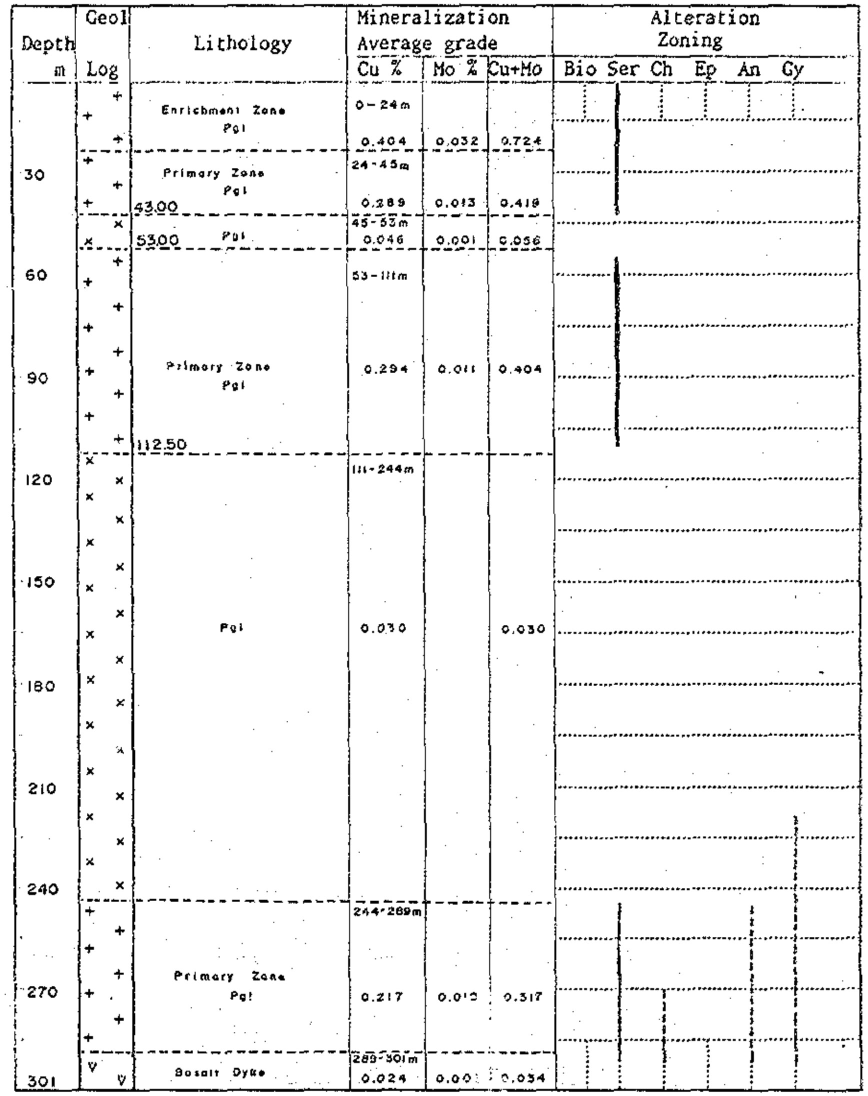

Fig. 40 Geological Log of MJT-6

MJT-7

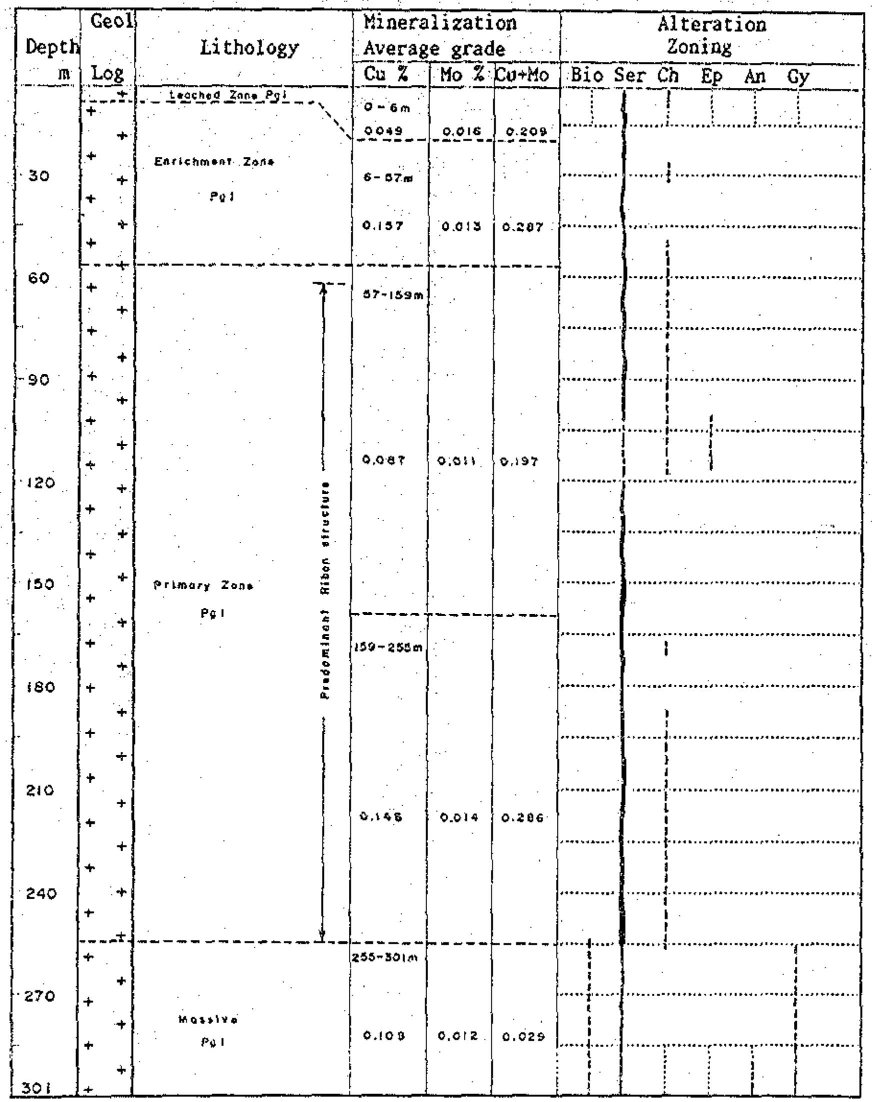

Fig.40 Geological Log of MJT-7

MJT-8

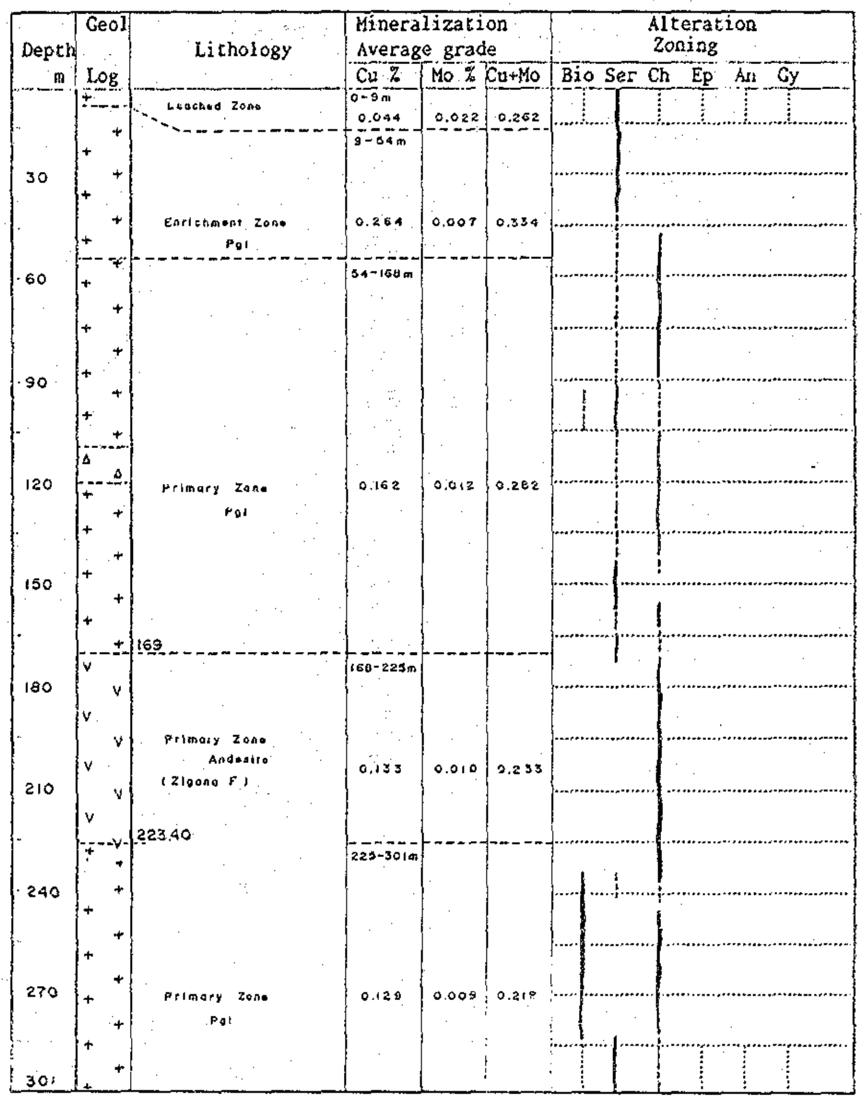

Fig.40 Geological Log of MJT-8

MJT-1

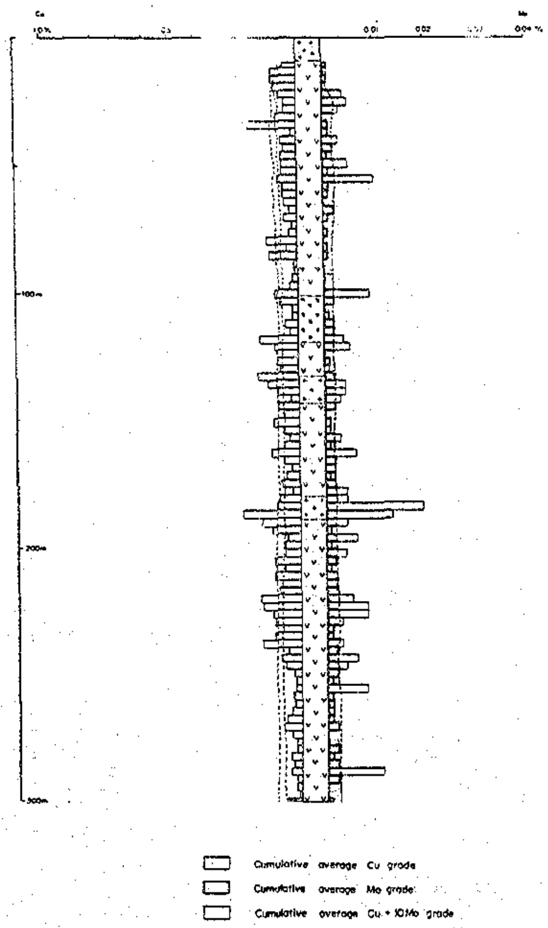

Fig. 41　Chemical Analysis Map of Copper and Molybdenum of MJT-1

MJT-2

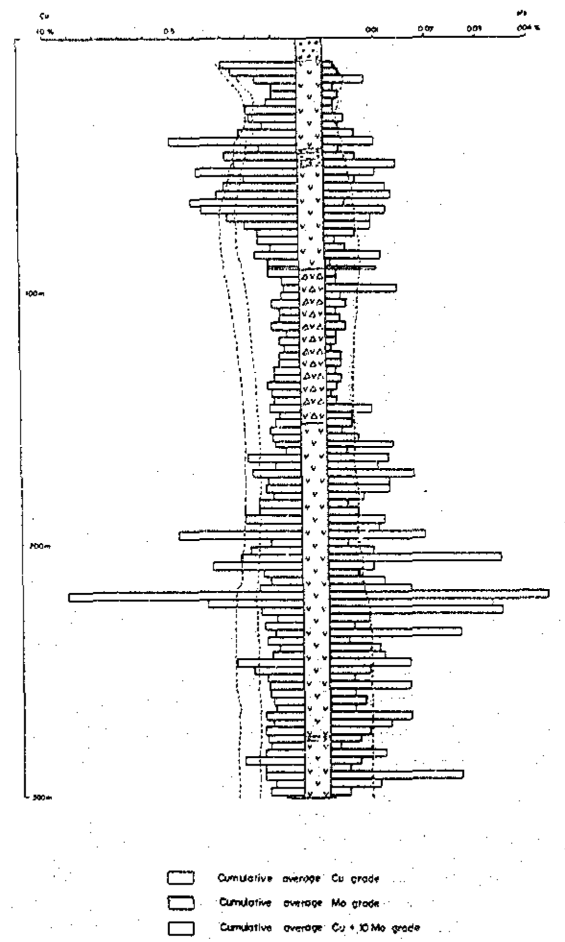

Fig. 41　Chemical Analysis Map of Copper and Molybdenum of MJT-2

MJT-3

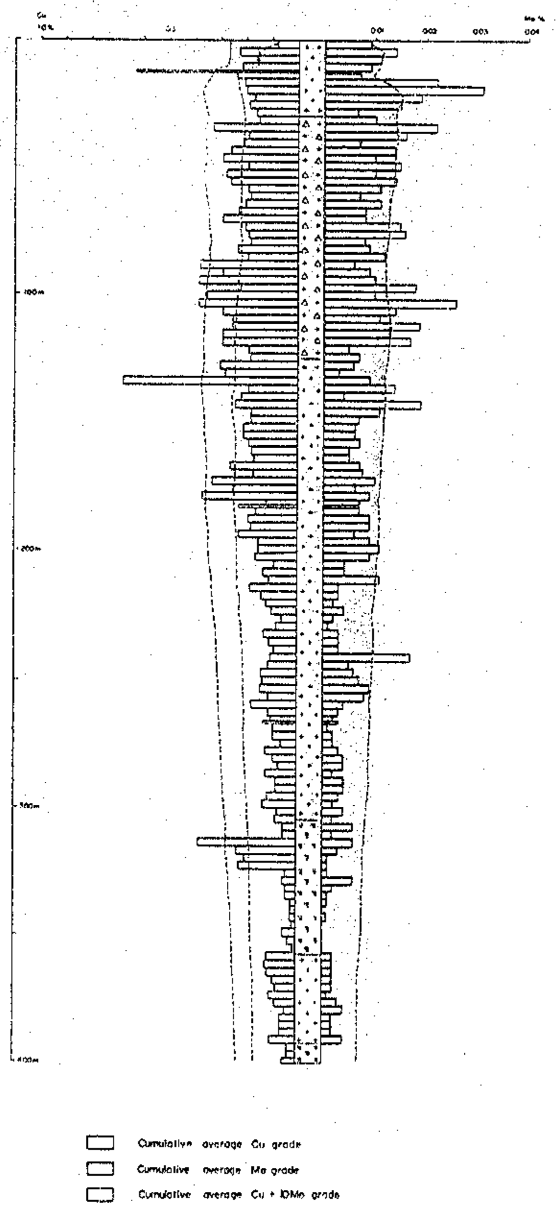

Fig. 41 Chemical Analysis Map of Copper and Molybdenum of MJT-3

MJT-4

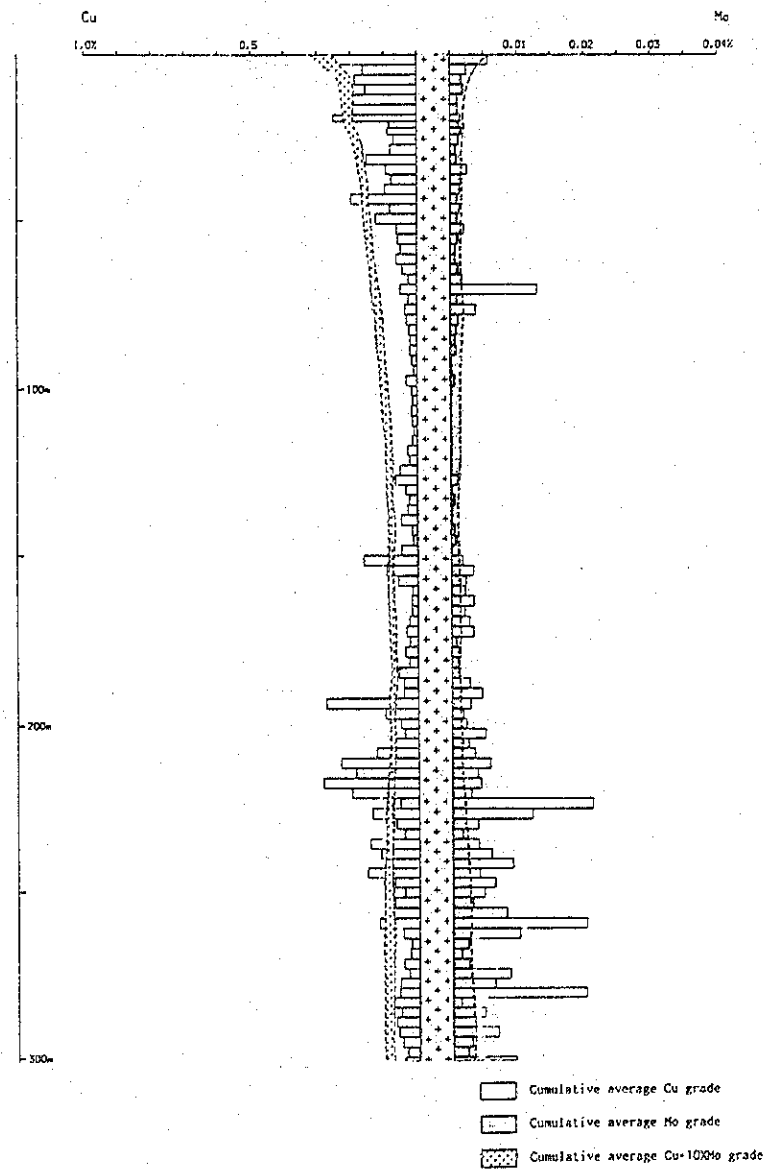

Fig. 41 Chemical Analysis Map of Copper and Molybdenum of MJT-4

MJT-5

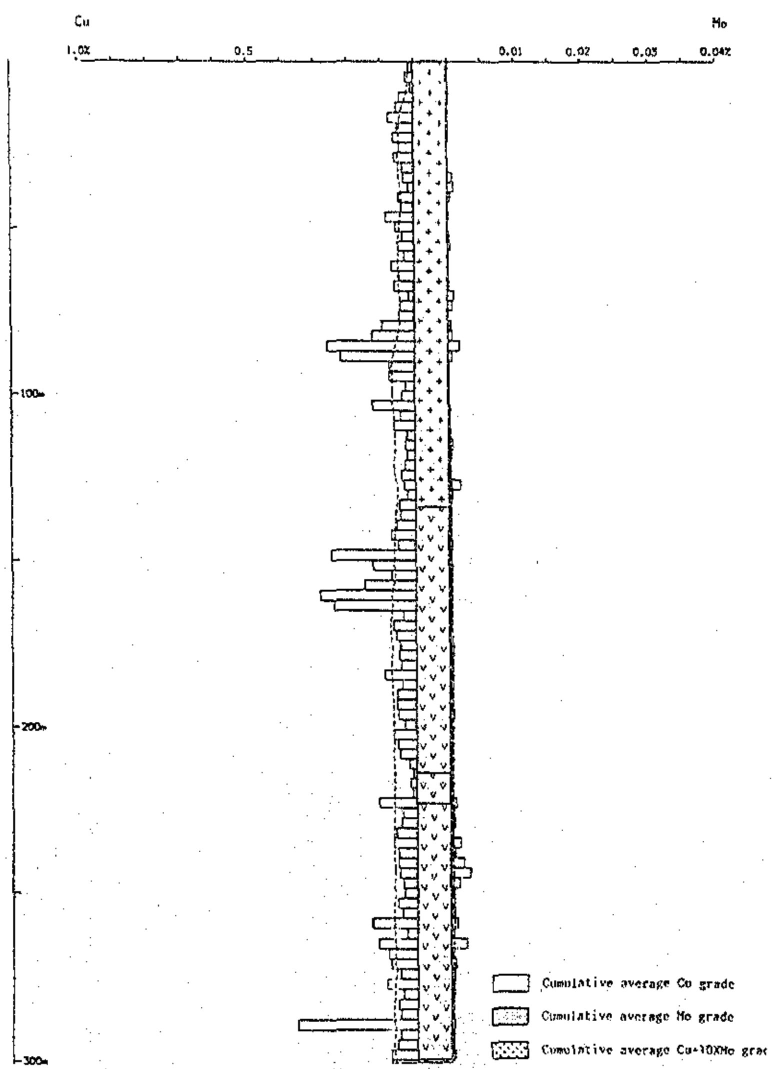

Fig. 41 Chemical Analysis Map of Copper and Molybdenum of MJT-5

MJT-6

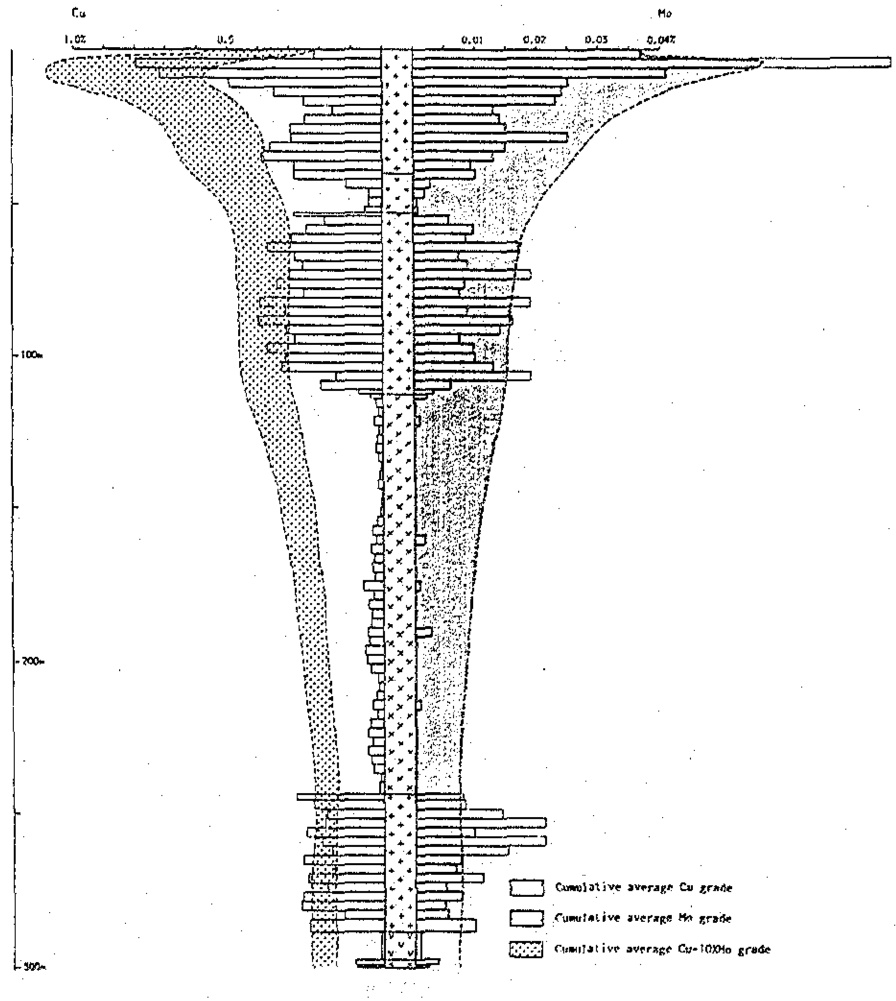

Fig. 41 Chemical Analysis Map of Copper and Molybdenum of MJT-6

MJT-7

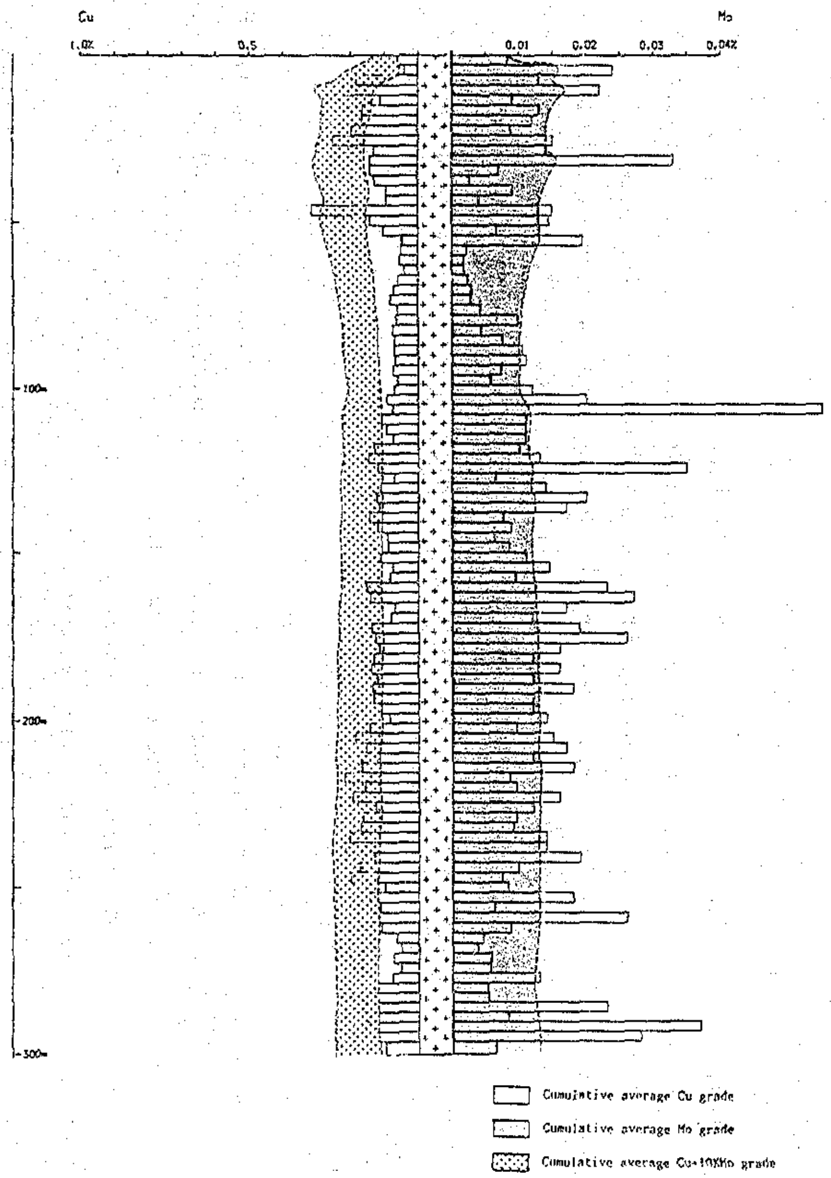

Fig. 41 Chemical Analysis Map of Copper and Molybdenum of MJT-7

MJT-8

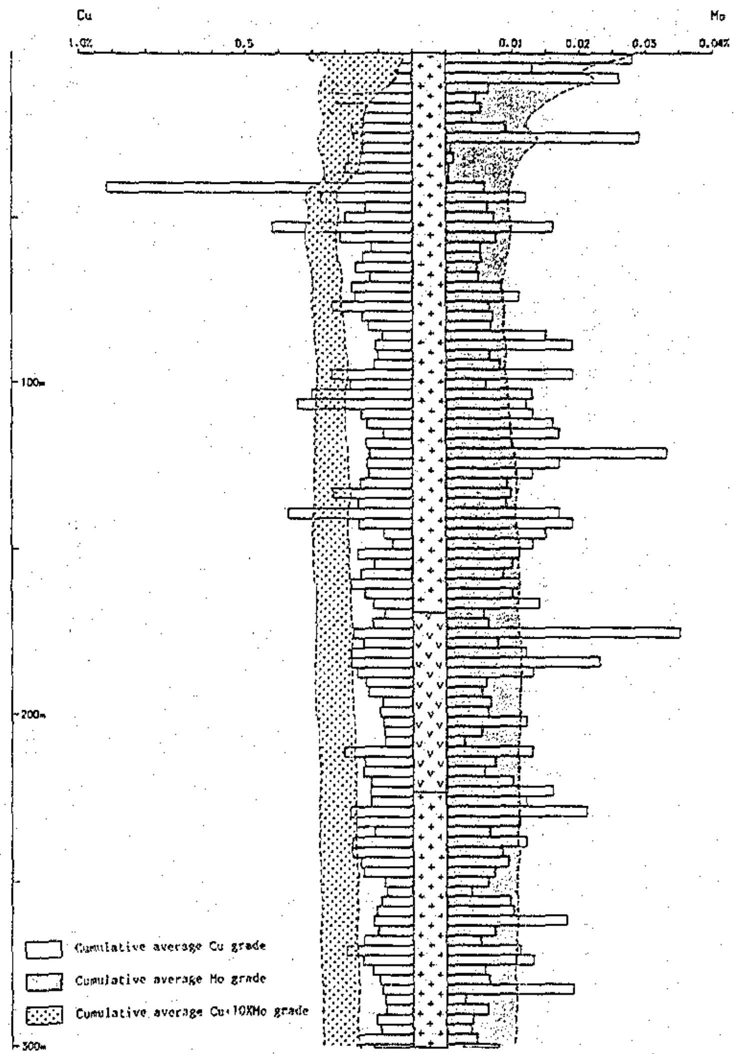

Fig. 41 Chemical Analysis Map of Copper and Molybdenum of MJT-8

boiling phenomena of the inclusions is observed in samples collected from the Mat Dere to Hasan Dere area.

As mentioned earlier, ore minerals in the high ridge area were almost completely leached. Only unleached molybdenites remained. Drilling results of MJT-3, 7 and 8 indicate that Cu ore minerals were leached from the surface of the projected ridge in the altered porphyritic granite area, but the zone below remains the primary ore zone. A secondary enrichment ore zone is intercalated between the leached and primary zones.

6-2 Zigana Formation

In the andesite of the Zigana Formation-distributed in an area from MJT-1 and MJT-2 sites to the MJT-8 site upstream of Mat Dere and surrounding Pgl- a magnetite-pyrite bearing zone (chalcopyrite may be leached) is observed. Andesites of MJT-1, 2 and 8 contain as much magnetite as the surface rock and surrounding Pgl.

The part having extensive distribution of the propylitic zone (chlorite-magnetite-pyrite) is regaded as the marginal part of mineralization, regardless of strong or weak mineralization. On the basis of this fact, the prospectable area is 1.8 km × 1.8 km covering the andesite and Pgl areas.

6-3 Ore Minerals

Sulphide ore minerals occur in the following areas:

① Magnetite: It is distributed as veins and disseminations in the propylitic zone,and is accompanied by a small amount of hematite.

② Pyrite: It occurs along fissures in quartz veins and as disseminations throughout the mineralized area, but especially in the propylitic to the phyllic zone.

③ Chalcopyrite: Distribution extends from the potassic zone to the propylitic zone. The mineral assemblage is mainly chalcopyrite-pyrite in fissures, and chalcopyrite-pyrite-quartz in quartz veins. Chalcopyrite content increases toward the center of the mineralization.

④ Molybdenite: It is distributed over the potassic zone to the propylitic zone. Molybdenite assemblies are mostly quartz-molybdenite, and quartz-pyrite-molybdenite.

⑤ Sphalerite: Some sphalerite is observed in the potassic zone of MJT-3.

⑥ Chalcocite, covelline and native copper:

They are present in the secondary enrichment zone of the phyllic zones of MJT-3, 5, 7 and 8.

6-4 Mineralization

Mineralization is in the form of disseminations, veinlets and fissures. In the center of the potassic zone, chalcopyrites and molybdenites are mainly embedded along fissures, but mineralization is weak. In the phyllic zone of the periphery of the core (potassic zone), chalcopyrites and molybdenites occur not only in fissures and quartz veins but also as disseminations in Pg1, so mineralization becomes strong. This is also the case for the phyllic zone of MJT-3, which is close to the core. Mineralization in MJT-1, 2 and 8 mainly is accompanied with quartz veins in the propylitic zone. Characteristics of mineralization in each hole are as follows;

Drilling No.	Dissemination	Quartz veins	Fissures
MJT-4	△	△	△
MJT-5	△	□	□
MJT-6	□	△	○
MJT-7	△	○	△
MJT-8	□	○	□

○:commom □:few △:rare

6-5 Alteration Zoning

Zoning of alteration in this surveyed area is characterized by X-ray diffraction analysis as follows:

① Potassic zone: The zone is usually in the core of the porphyry copper type ore deposit, and biotite and potassic feldspar indicate the alteration mode. The zone of the surveyed area is characterized by the existence of a small amount of biotite and potassic feldspar, and additionally contains quartz and anhydrite.

② Phyllic zone: This zone consists of quartz and sericite with a small amount of chlorite as the altered mineral, and surrounds the potassic zone.

③ Argillic zone: This zone is usually distributed at the periphery of the phyllic zone of the porphyry copper type ore deposit, and is represented by kaolinite and montmorillonite minerals, but this zone is absent in the surveyed area.

④ Propylitic zone: The zone containing chlorite, epidote and magnetite is located in the marginal section of alteration in the area.

6-6 Fractures in the Mineralized Area

According to the drilling results from MJT-1 to MJT-8, most fractures and shatter cracks have been formed in irregular directions with less than 60° dip. Vertical dip is extremely rare. Detailed survey could not determine a predominant or special direction among the fissures. Furthermore, core collected from 91.2m to 152 m of MJT-1, from 30m to 125m of MJT-3 and from 25m to 254m of MJT-8 were broken into thin plate fragments owing to ribbon structure. Chalcopyrites and pyrites were found along these fractures. Although core recovery was quite low, ore grade of this section generally was good.

5-7 Potentiality of Mineralized Zone

As a result of the drilling surveys in the second and third phases (8 holes 2,508m in total length), the promising mineralized zones were intercepted by drill holes MJT-3, 6 and 8. Geological ore reserves calculated as more than 0.200% cumulative copper grade are as follows:

	Depth(m)	Cu %	Mo %	Cu+10xMo%	Reserves(10^6 tones)
MJT-3	0~ 285	0.200	0.009	0.290	200mx200mx2.5x285m=28.8
MJT-6	156	0.277	0.021	0.487	200mx200mx2.5x156m=15.6
MJT-8	0~ 54	0.228	0.010	0.328	200mx200mx2.5x 54m= 5.4
Average grade		0.227	0.013	0.356	Total 49.8

The following conditions were applied for calculation:

① Ore reserves included the leached zone from surface to 12m of MJT-3, intrusive rock (Pg2) from 45m to 53m of MJT-6, and theleached zone accompanied by molybdenum from surface to 9m of MJT-8.

② Intrusive rock (Pg2) from 111m to 244m was excepted from calculation.

③ Size of the polygon of the area was 200m x 200m because the intervals between the drill holes were 200m.

④ Gravity equals 2.5.

Geological ore reserves included the predominantly molybdenum mineralized zones of MJT-7 and the lower part of MJT-8 as follows;

	Depth(m)	Cu %	Mo %	Cu+10xMo%	Reserves(10^6 tones)
MJT-3	0~ 285	0.200	0.009	0.290	200mx200mx2.5x285m=28.8
MJT-6	156	0.277	0.021	0.487	200mx200mx2.5x156m=15.6
MJT-7	0~ 300	0.120	0.013	0.247	200mx200mx2.5x300m=30.0
MJT-8	0~ 300	0.160	0.010	0.264	200mx200mx2.5x300m=30.0
計		0.177	0.012	0.300	104.4

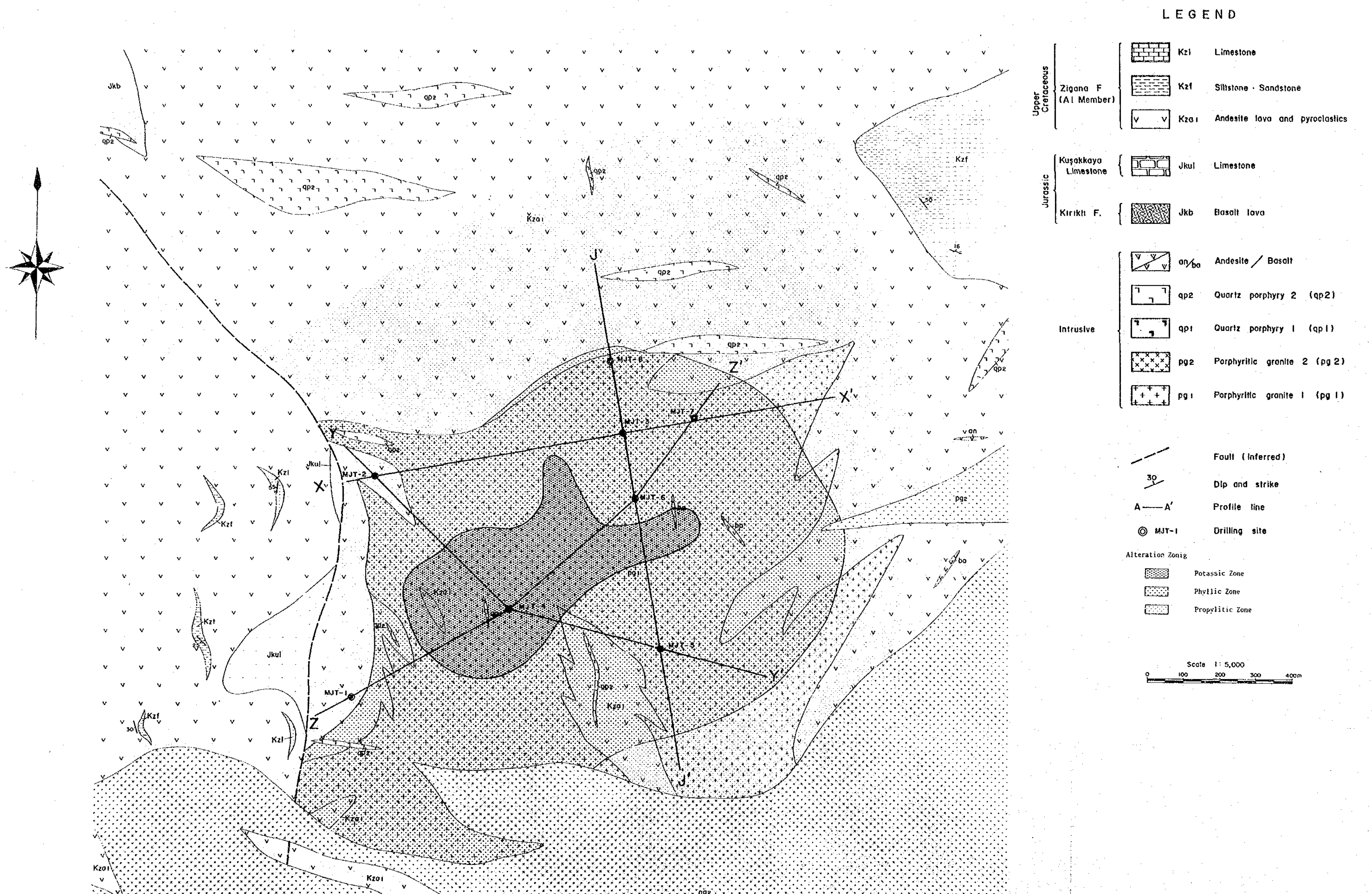

Fig.29 Alteration Zone Map of the Güzelyayla Area

GEOLOGICAL PROFILES OF GÜZELYAYLA MINERALIZED ZONE

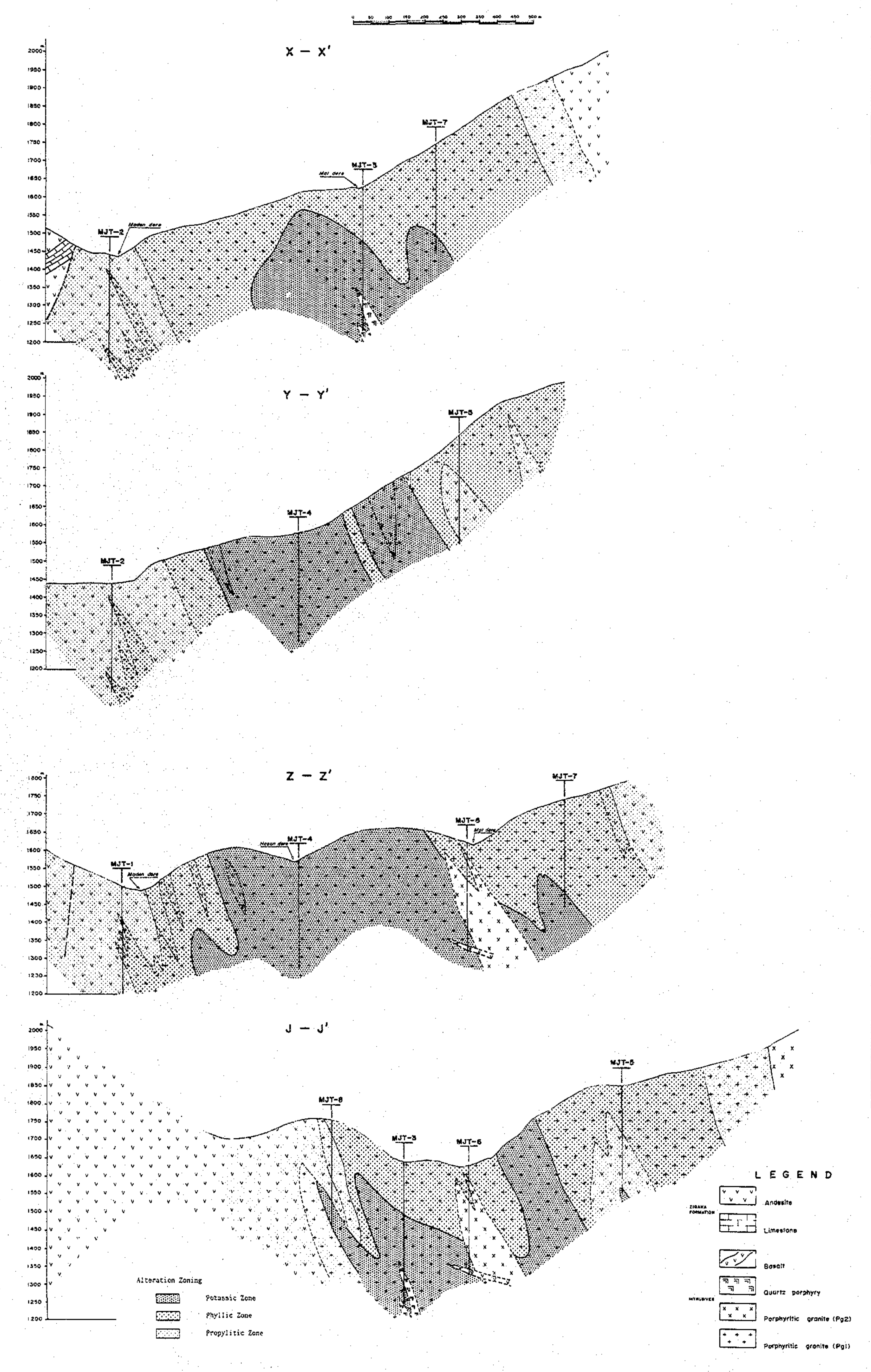

Fig. 30 Alteration Zone Profile Map of the Güzelyayla Area

6-8 Relationship between Geophysical Anomaly and Mineralization

Results of the drilling survey and geophysical survey (IP and SIP methods) revealed their relation as follows:

Results of SIP method (second phase)

① A zone consisting of high PFE and high phase values was found on survey Line A connecting MJT-1 and MJT-2 holes along Mat Dere. By the SIP survey on the survey Line connecting MJT-2 and MJT-3 holes, the western side of the inferred fault striking north-south has low PFE and low phase value. The part between MJT-2 and MJT-3 sites has a somewhat high PFE and phase value. These values fall slightly east of the MJT-3 site.

② Among SIP responses obtained from laboratory tests of cores and rock samples, PFE and phase values are in proportional correlation, while both values and resistivity values have inversely proportional correlation. The relation between copper or molybdenum grades and SIP response is that there is no correlation. Phase spectra of the higher copper grade section is similar to spectra type of the non mineralized area(general type spectra).

The above mentioned SIP survey results indicate that the high PFE value (phase value) anomaly is caused by pyrite emplacement. Determination of a pyrite rich zone by geophysical survey and by consideration of geological and alteration conditions is very useful for finding copper rich zones which may surround the pyrite.

Results of IP and SIP methods (third phase)

A zone consisting of high PFE and high phase values was found on the periphery of the altered porphyritic granite (Pg1). The zone forms an arc of a circle because of the distribution area of the unaltered porphyritic granite. A north-south direction of another zone of high PFE and high phase was disclosed in the central portion within the arc.

The results of the geophysical surveys in the second and third phases indicate that the high PFE value (phase value) anomaly is caused by pyrite emplacement. Drilling sites in the third phase were determined on the basis of the geophysical data. MJT-7 and MJT-8 were drilled inside the arc. The relations between drilling and geophysical survey results are as follows:

	Geophysical survey(PFE)	Results of drilling
MJT-4	0~300m > 8% 300m~ < 8%	5~150m :Weak mineralization 150m~ :Mo-Cu mineralized zone
MJT-5	100~300m > 8% 300m~ < 8%	10~100m :Secondary enrichment zone 100m~ :Pyrite-rich zone
MJT-6	100~250m > 8%	1~112m :Cu-Mo mineralized zone 112~244m:unaltered porphyritic granite 244m~ :Mo-Cu mineralized zone
MJT-7	0~300m < 8%	5~42m :Secondary enrichment zone 42m~ :Weak mineralization
MJT-8	0~300m < 8%	9~84m :Secondary enrichment zone 84~170m :Mo-Cu mineralization 170m~ :Weak mineralization

Chapter 7 Conclusions and Recomendations for Future Exploration

7-1 Conclusions

The results of the Cooporative Exploration Survey conducted from 1984 through to 1986 in the Gümüşhane Area, Republic of Turkey, are summarized as follows:

Güzelyayla Area

(1) Copper and molybdenum anomalous zones were found through the geochemical survey (stream sediment and soil) conducted by the UNDP, MTA and Cooperative Exploration Survey. The anomalous area of Cu and Mo was defined as having an area of 1.8 km X 1.8 km.

(2) As a result of the drilling surveys in the second and third phases, the promising mineralized zones were intersected by drill holes, and geological ore reserves were calculated as approximately 49 million tonnes using the assay data of MJT-3, 6 and 8 (ore grade of 0.356% copper equivalent), and as roughly 104 million tonnes including the predominantly molybdenum mineralized zones of MJT-7 and the lower part of MJT-8 (ore grade of 0.300% copper equivalent)

(3) Alteration is zoned from the center of the altered porphyritic granite (Pgl) towards the margin as potassic zone → phyllic zone → propylitic zone. In andesite intruded by the Pgl stock, propylitic zones are commonly

distributed, while the phyllic zone is present close to Pg1. The potassic zone is characterized by the presence of a small amount of potassic feldspar, biotite and many anhydrites, the phyllic zone mostly by $2M_1$ type sericite, and the propylitic zone by chlorite and many magnetites.

7-2 Recommendations for Future Exploration

The following ideas are recommendated to the Government of Turkey for a continued survey in the project area.

As a result of geological, geochemical, geophysical and drilling surveys carried out from 1984 to 1986, it is recommended that the following works be conducted at the most promising areas mentioned above.

① A drilling survey in the phyllic zone in areas apart from the geophysical anomaly areas

② A secondary enriched zone survey in the areas of expected higher copper grade in the upstream area of Hasan and Mat Deres

It is recommended for further explorations that the above-mentioned drilling survey be carried out to confirm an ore deposit in the expected mineralized area. Drilling sites should be changed according to the results of precceeding drill holes.

Part 4 KARADAĞ AREA

Part 4 Karadağ Area

Chapter 1 Geology and Mineralization

1-1 General Geology

The geology of the Karadağ Area is divided roughly into Late Paleozoic Gümüşhane Granite, Lower Cretaceous to Lias Kırıkli Formation, and Upper Cretaceous Zigana Formation. The Zigana Formation is further divided into, five stratigraphic units: Kermutdere, A1, D1, A2, and D2 Members in ascending order. Only the A1 Member (lowest Member of Zigana Formation) is distributed in the survey area. Quartz porphyry, granodiorite and diorite have intruded into the Zigana Formation, and mineralization accompanied by skarnization is embedded at the boundary of the limestone and the andesite of the Zigana Formation. The geological map, geological profile, and schematic geological column are shown respectively in Figs. 42～44.

1-2 Stratigraphy

Gümüşhane Granite : This granite, which is the basement in the area, is widely distributed, stretching in a southwestern direction south of Gümüşhane City. It covers an elliptical area 37 km E-W and 15 km N-S, and the surveyed area is located at the western end of this granite batholith. The granite was dated as 406 Ma by the radiometric Rb-Sr method, indicating intrusion in Early Devonian time.

This rock is generally massive and grayish or yellow white to pink, and its component minerals vary from fine to coarse grained, but the general tendency of the grain size is to be finer toward the periphery and coarser toward the inner part of the granite. Coarse-grained granite is brittle and consists of quartz 2-3 mm in diameter, and abundant biotite. The aplitic part of the granite is compact, massive, and abundant in quartz, plagioclase and feldspar.

Kırıklı Formation : This formation unconformably overlies the Paleozoic Gümüşhane granite and consists of basaltic lava. Basal conglomerate lies locally at the lowest horizon of the formation, and the basalt lava contains thin intercalated beds of sandstone and mudstone.

Basal conglmerate : This rock is locally distributed and is discontinuous. It is pale pink in colour and contains mostly granite pebbles, several to tens of centimeters in diameter and rounded to sub-rounded in shape. The matrix is of pale green to grayish white quartz and feldspar grains.

Basalt lava : Basalt lava is generally dark green to reddish brown in colour and has undergone chloritization and epidotization. The lava contains thin intercalated beds of sandstone and mudstone. It uncomformably overlies Gümüşhane granite, and is a thin layer on the west side of the granite, while on the east side of the granite, it is a thick layer and widely distributed.

Kuşakkaya Limestone Formation : The formation is distributed in a small square at the north part of the surveyed area. It seems to unconformably overlie the Kırıklı Formation. This rock is massive without bedding, and grayish to white in colour. It is reported that fossils correlating with Dogger and Malm stages of the Upper Jurassic have been discovered at Ucbacali located approximately 3 km northeast of Altıntaşlar village.

Zigana Formation : This formation was divided into the Kermutdere, A1, D1, A2, and D2 Members in ascending order by the geological survey of the initial phase. Only the A1 Member is widely distributed in the Karadağ Area. The A1 Member consists of basaltic lava, and a limestone-sandstone bed. Basalt lava is deposited in the lower horizon and its rock facies gradually changes upward to andesite. Basaltic lava exists in the area from the surveyed area to Avliyana. The basalt lava is dark green and contains amygdaloidal texture. Phenocrysts of plagioclase and a small amount of pyroxene are observed through the microscope. These phenocrysts are all altered to chlorite, and only the outline of these crystals remain as unaltered rims. The ground mass of the rock has hyalopilitic texture containing lath shaped plagioclase filled with intersertal glass, but most of them have undergone chloritization and calcitization.

The andesite lava is massive, pale green to dark green in colour, and is partly brecciated. Under microscopic observation, the rock consists characteristically of pyroxene and epidotized plagioclase on the west side of IP survey Line B, whereas hornblende with epidotized and chloritized plagioclase is on the east side of IP Line D.

In the surveyed area, limestone and sandstone beds are intercalated in volcanic rock, and basaltic lava lies at a lower horizon. Andesite lava is in the upper horizon, in contact with the intercalations. The limestone-siltstone, striking N-S with 20° ~ 30° dip, consists of crystalline and massive limestone, black siltstone, and argillaceous mudstone. Limestone exposed at the old Karadağ mine has been crystallized and has undergone skarnitization accompanied with epidote The southern extention of the limestone is dislocated 250 m to the east by a NE-SW fault in the central part of the surveyed area.

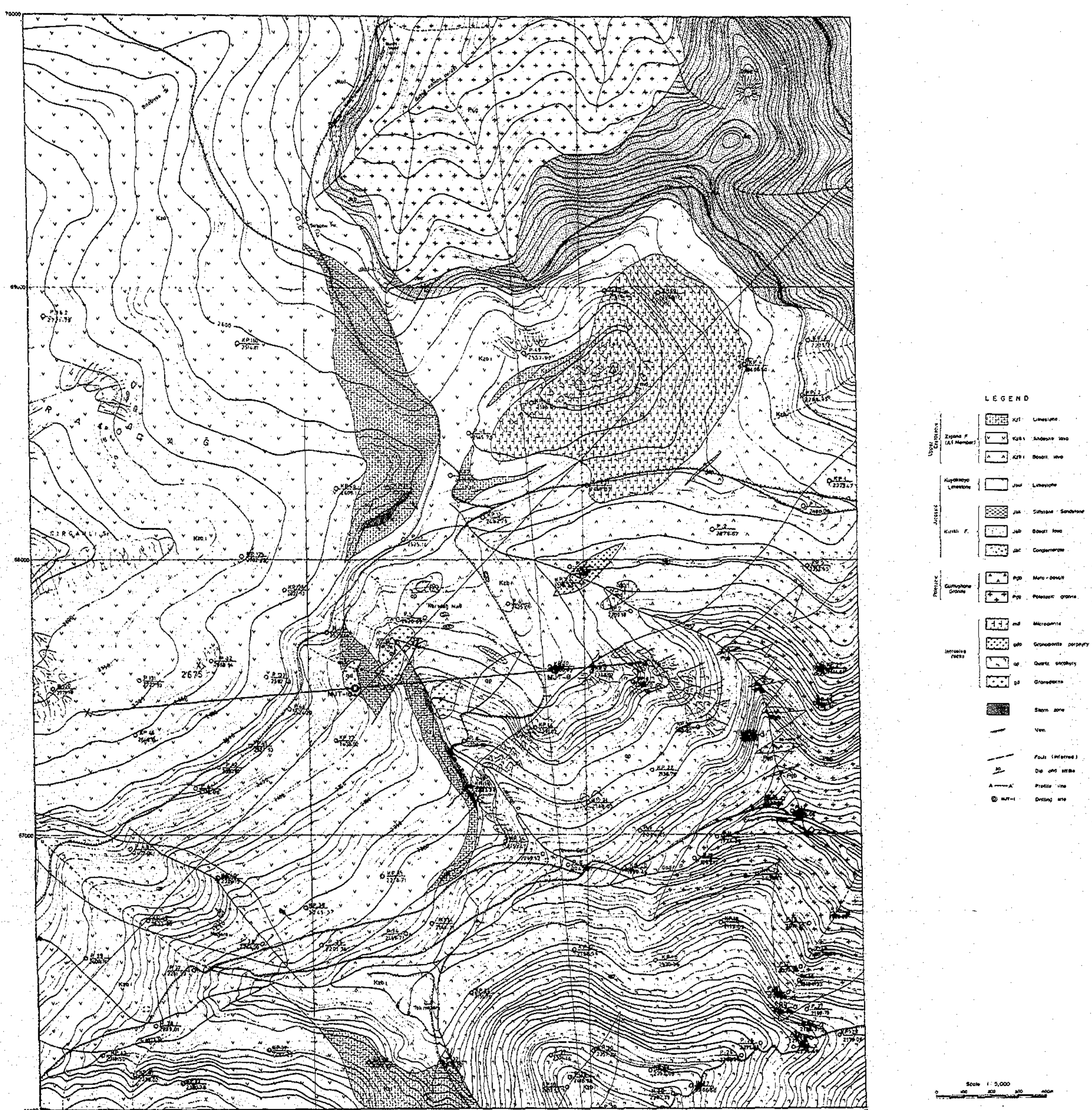

Fig. 42 Geological Map of the Karadağ Area

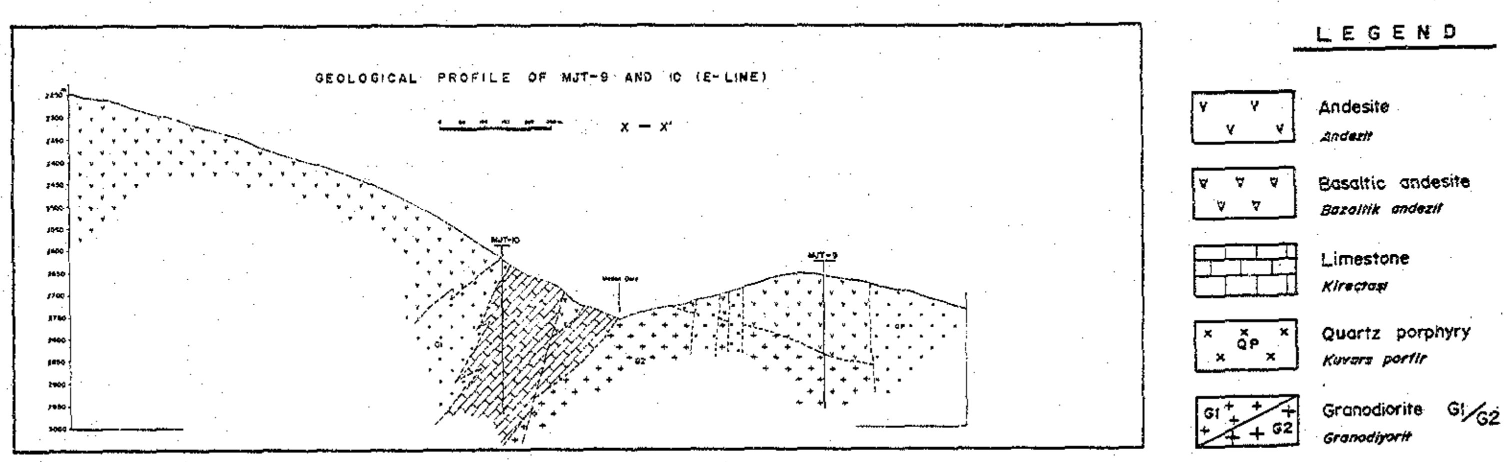

Fig. 43 Geological Profile Maps of the Karadağ Area

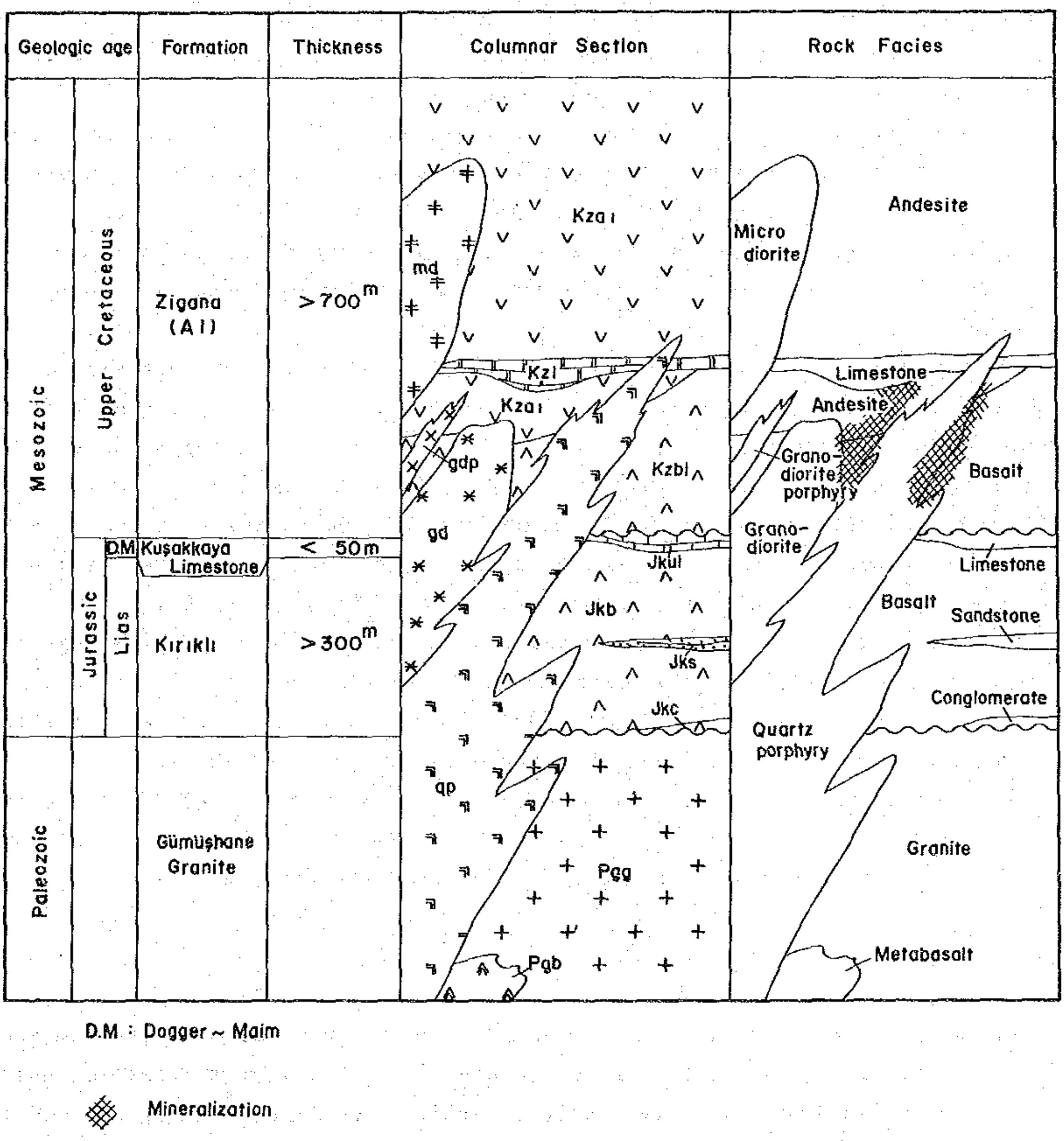

Fig.44 Schematic Geological Column of the Karadağ Area

Intrusive Rocks

Intrusive rocks of the Karadağ Area are classified into altered granodiorite, altered quartz porphyry, diorite and granodiorite. These rocks are independently distributed. Thus their intrusion order is not evident. However, it is inferred that the altered granodiorite and quartz porphyry are the older intrusions, and diorite and granodioritic porphyry are younger intrusions.

Altered granodiorite : The rock is exposed up stream of Maden Dere in the central part of the Karadağ Area as a small ellipsoidal stock. The rock divides a limestone bed extending N-S into two parts Under microscopic observation, it is a hornblende granodiorite consisting of hornblende, plagioclase, and biotite, but these constituent minerals have undergone chloritization and epidotization.

Altered quartz porphyry : The rock is distributed along the west side of the Gümüşhane granite, extending in a NNE-SSW direction. The brecciated part of the intrusion is accompanied by tourmaline, muscovite, and quartz veins. As sulphide ores have been limonitized owing to oxidation on the ground surface, it is difficult to identify the primary sulphide ore. Constituent minerals in the groundmass, except for quartz phenocrysts, have been severely altered to quartz, sericite, epidote and hematite, as observed through the microscope.

Diorite : The intrusive rock outcrops as a stock in the north-east section of the Karadağ Area, forming a hill 800m × 500m in scale. Its microscopic texture is equigranular, and constituent minerals of the rock are albitized plagioclase, and chloritized and epidotized common pyroxene in part.

Granodiorite porphyry : The rock is exposed as a dyke striking NE-SW in the area on the north-east side of Maden Dere. The rock consists of slightly chloritized plagioclase and hornblende in equigranular texture.

1-3 Geological Structure

The Karadağ Survey Area is situated on the north-west side of the Gümüşhane granite which is the basement rock in the area. The Zigana Formation uncomformably overlies the Gümüşhane granite, lacking the Kırıklı Formation and the Kuşakkaya Limestone Formation between both rocks. The rock facies of the Zigana Formation in the area are basalt in the lower horizon and andesite in the upper horizon. A limestone bed with greatly varying thickness is intercalated at the boundary between these two facies and extends south and north.

The limestone bed is divided into two parts by an intrusion of granodiorite in the center part of the surveyed area. A fault striking NE-SW is inferred to exist at the intrusion. All intrusive rocks have intruded along the geologically weak zone (inferred fault zone). By tracing the distribution of exposed intrusives and by following their emplacement direction, it is presumed that two parallel weak zones exist.

1-4 Mineralization and Alteration

As mention above, data and information on the old Karadağ Mine are scarce, although an underground mine was operated in ancient times. However, scattered ore blocks around the mine site indicate that the Karadağ ore deposit may contain copper, lead, and zinc ores with a few amounts of magnetite and pyrite The Karadağ mine probably produced mainly copper.

The Karadağ area is situated in the highlands and its climatic condition is inland type. It is dry, has extreme temperature differences, and in the winter season there is over 3m of heavy snow. These climatic conditions cause severe oxidation of sulphide ores, and primary sulphide ores are barely visible on the surface. X-ray diffraction analysis detected cerucite ($PbCO_3$) which was not identified through naked eye observation.

The samples indicate that copper oxide ore is observed in skarn around the old Karadağ mine site and along Maden Dere. Samples from such places usually contain high grades of copper. The maximum grade among ores collected from around the old Karadag Mine is 19.8% Cu and 13.50% Zn. Ore from Maden Dere is 14.80% Cu, but has a low zinc grade. Lead content of ore was not chemically analyzed, but some lead can be expected in the ore since lead ore was detected by X ray diffraction analysis.

Based on results of the chemical and X-ray diffraction analyses, the ore deposits can be classified into two types : copper, lead, and zinc bearing ore deposits around the old Karadag Mine, and copper ore deposits along Maden Dere. This is to say that there are two different types of ore deposits in the surveyed area.

Quartz porphyry is characteristically accompanied by tourmaline, muscovite, quartz and limonite. Its groundmass has undergone remarkable sericitization. The sericite is $2M_1$ type and well crystallized, as detected by the X-ray diffraction analysis and by microscopic observation. It is not of hydrothermal mineralization type.

Quartz porphyry and granodiorite may be the ore-bringer intrusions. It is supposed that many fissures are distributed centering around the inferred fault, and that mineralization is emplaced along these fissures.

The mineralization is oxidized on the surface, and limonite ore outcrops on the hill, while pyrite remains only in streams.

Chapter 2 Geophysical Survey (SIP and IP Metheds)

2-1 Outline of the Survey

Purpose of the Survey : The survey area is of an area where a mineralized zone of copper, zinc and lead, associated with intrusions in granodiorite and quartz porphyry, had been delineated during geological and geochemical surveys of the initial phase.

In expectation of disseminated types of ores, IP and SIP methods in the second phase were applied to detect an anomalous area and to study the continuity of mineralization at depth by unravelling properties of the anomaly.

Area of the Survey : The location of the target area and the arrangement of survey lines are shown in Figs.3 and 45, respectively.

Length of Survey Line :

SIP : Line H , I 4.0km in two lines 160 points

I P : Line A ～ G 14.0km in seven lines 560 points

2-2 Survey Method

The IP survey was conducted prior to the execution of the SIP survey. The survey methods are the same as the survey specifications, equipments and data processing applied at the Güzelyayla area discussed in paragraph 4-2 of chapter 4 except that a line spacing of 300 m was used.

2-3 Results of the geophysical survey

Rock Sample Measurement : The measurements were carried out on 25 samples taken from the ground surface in the second phase, and on 10 samples from drill cores in the third phase. The results are shown in Table 19 for each rock type, and in Table 20 for the physical properties and the chemical assay. The phase spectrum from these samples can be categorized into seven types like those of the Güzelyayla Area.

The following facts are evident :

① Phases range from 1.7 mrad to 86.9 mrad. They are larger in the mudstone and smaller in the limestone and the andesite lava. The mean value in the former is about eight times the mean value in the latter.

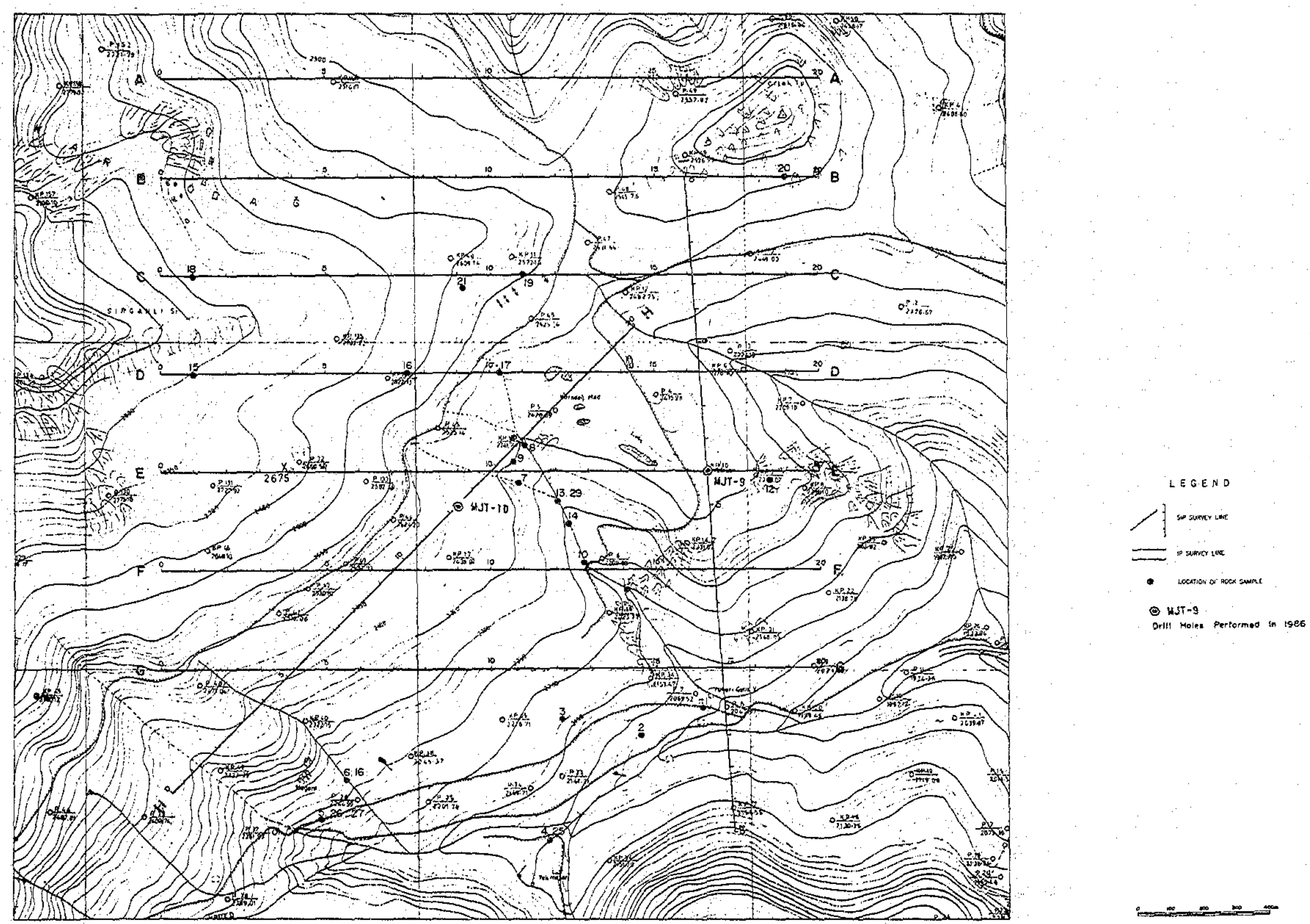

Fig. 45　Location Map of SIP and IP Survey Lines in the Karadağ Area

Table 19 SIP Response in the Classification of Rock (Karadağ Area)

Rock	No. of samples	Phase(-mrad)	PFE (%)	Resistivity (ohm-m)	Phase spectrum type						
					A	B	C	D	X	Y	Others
Andesite	4	3.9 ~ 7.3 (5.23)	0.59 ~ 1.41 (0.88)	4,129 ~ 11,244 (6,605)	2		1				1
Qz. porphyry	7	4.9 ~ 19.5 (9.26)	0.50 ~ 2.61 (1.25)	404 ~ 3,308 (2,035)	1	4			1		1
Diorite	1	11.4	1.61	2,254	1						
Limestone	8	1.7 ~ 12.9 (4.99)	0.20 ~ 2.07 (0.76)	1,625 ~ 7,202 (4,611)	6		1				1
Mudstone	5	5.6 ~ 86.9 (41.36)	0.82 ~ 13.8 (6.55)	454 ~ 11,068 (4,164)		1	1		2		1
Total No.	25				10	5	3		3		4

(   ) : Average value

Table 20 Results of Core Sample Measurements (Karadağ Area)

No.	Location (m)	Rock	Phase (-mrad)	PFE (%)	Resistivity (ohm-m)	Phase spectrum	Cu ppm	Zn ppm	W ppm	Mo ppm	Minera-lization	Alteration
	MJT-9											
1	36.6	Andesite	83.2	18.1	454	X	40	184	5	8	Py	ch-ep
2	172.5	Andesite	7.8	1.4	18,700	A	-	-	-	-	Mag-py	ch-ep
3	273.5	Granodiorite	40.5	5.5	5,260	B,(A)	41	43	-	1	Mag-hema	sericite
	MJT-10											
4	39.2	Granodiorite	99.0	16.6	224	D	155	32	-	-	Py	ch-ep
5	51.0	Skarn	8.2	0.7	499	E	2,000	33	-	1	Malachite	skarn
6	96.0	Limestone	0.5	0.1	8,530	A	580	13	-	-	Massive	
7	235.0	Limestone	7.7	0.9	4,560	E	-	-	-	-	Sac	
8	319.0	Limestone	11.5	1.4	8,790	B	36	54	1	-	Sac	
9	335.0	Limestone	41.1	8.2	1,140	D	47	8	1	-	Sac	
10	344.5	Limestone	43.5	6.2	21,000	B,(C)	-	-	-	-	Muddy	

Abbreviation

ch : chlorite   hema: hematite
ep : epidote   mag : magnetite
Py : pyrite   Sac : saccharoidal

② Values of PFE range from 0.20% to 13.8%, and they are larger in the mudstone, smaller in the limestone and the andesite lava. The mean value of the former is about eight times that of the latter.

③ Resistivity values range from 404 ohm-m to 11,244 ohm-m, smaller in the quartz porphyry (2,035 ohm-m), and larger in the andesite lava (6,605 ohm-m) and the limestone (4,611 ohm-m).

④ Of the phase spectra, ten samples belong to A-type, while X-type, connected with mineralization, is present in a quartz porphyry sample and in two mudstone samples.

⑤ The results of drill cores, two specimens of andesite and granodiorite with high PFE and phase values show that these have low resistivity values of less than 500 ohm-m. Andesite shows X-type phase spectrum and granodiorite shows D-type.

⑥ The skarn from MJT-10 has 2,000 ppm Cu, a higher value than others.

⑦ The core samples from the deeper part of MJT-10 show an increase in phase value. Therefore it is assumed that the bottom of the drill hole approached the mineralized zone.

Results of field measurements : The survey is comprised of the measurements of SIP over two lines totalling 4.0km and IP over seven lines totalling 14km with a line interval of 300 m to delineate the extension of the mineralized zone.

The field data was drawn on the plans and sections of apparent resistivity and PFE respectively, and interpreted with SIP response and model simulation.

Results of the interpretation is shown in Fig. 48 and indicate the following:

① The anomaly distributed at the stream at the east end of Line D in the east survey area originates from an anomalous source (strongly mineralized zone) embedded at shallow depths. It is presumed to be an anomaly caused by sulphide ore (pyrite).

② The anomaly of the south-west survey area results from a deep anomalous source, and is inferred to be related with quartz porphyry. Another anomaly in the south area is embedded in quartz porphyry down from Maden Stream, and is from a shallow anomalous source.

③ The PFE anomaly of greater than 8% in value was detected at depth on the western side of Maden Dere (Line E) corresponding to the limestone strata of the geological profile. The result presumes that the anomaly is a

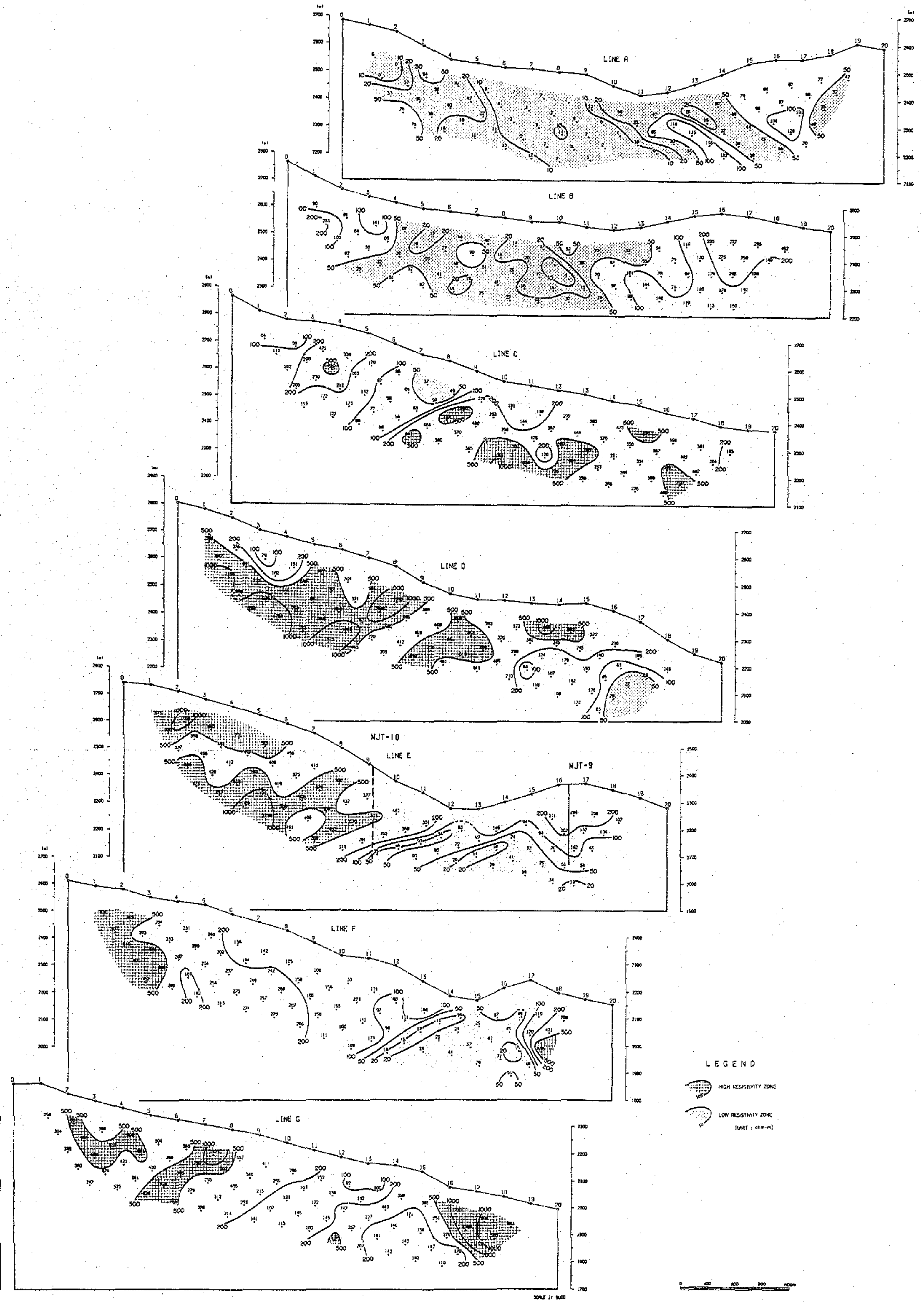

Fig.46 Panel Diagram of Apparent Resistivity [0.125 Hz] (Line A~G)

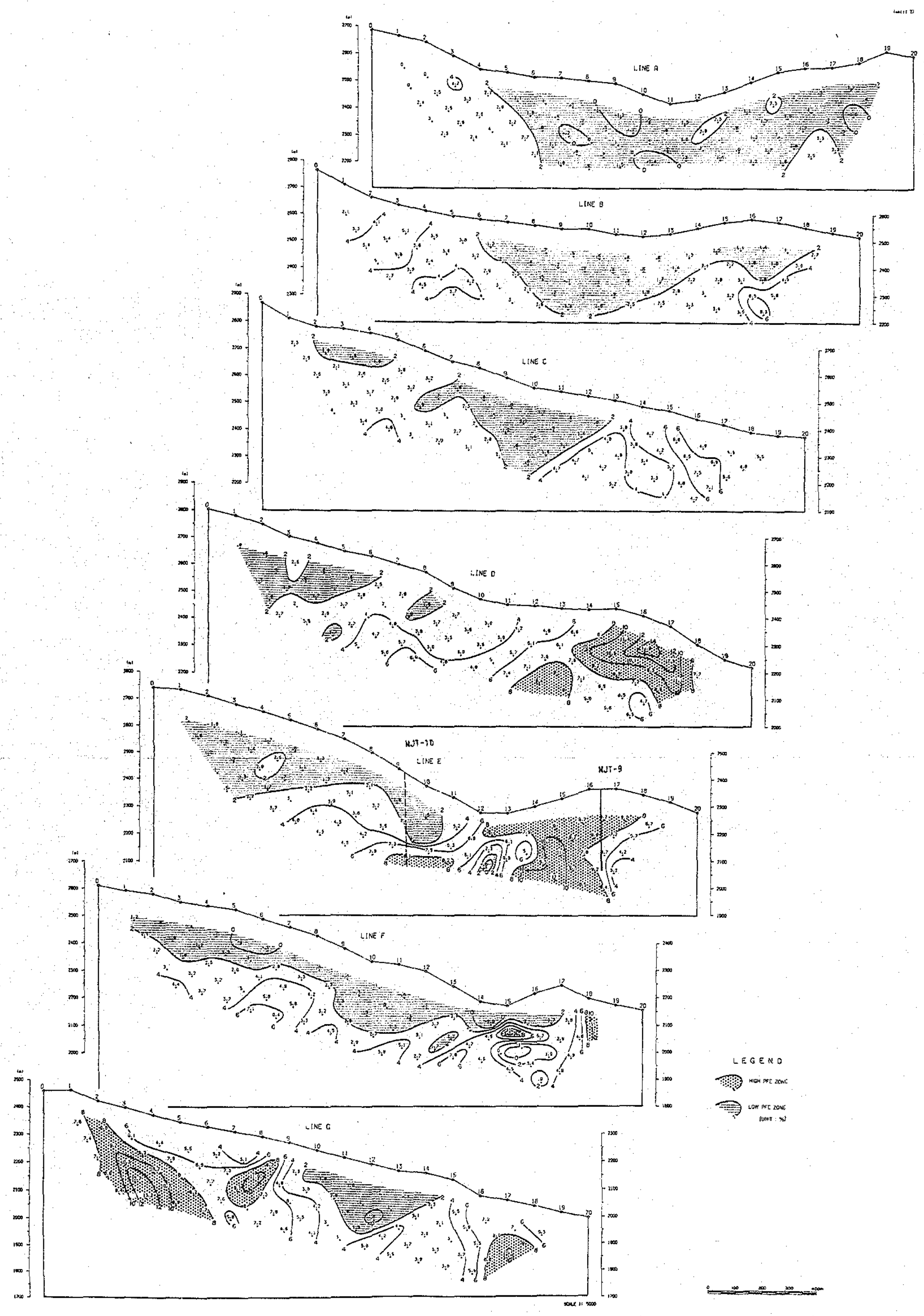

Fig.47 Panel Diagram of PFE [0.125-1.0 Hz] (Line A~G)

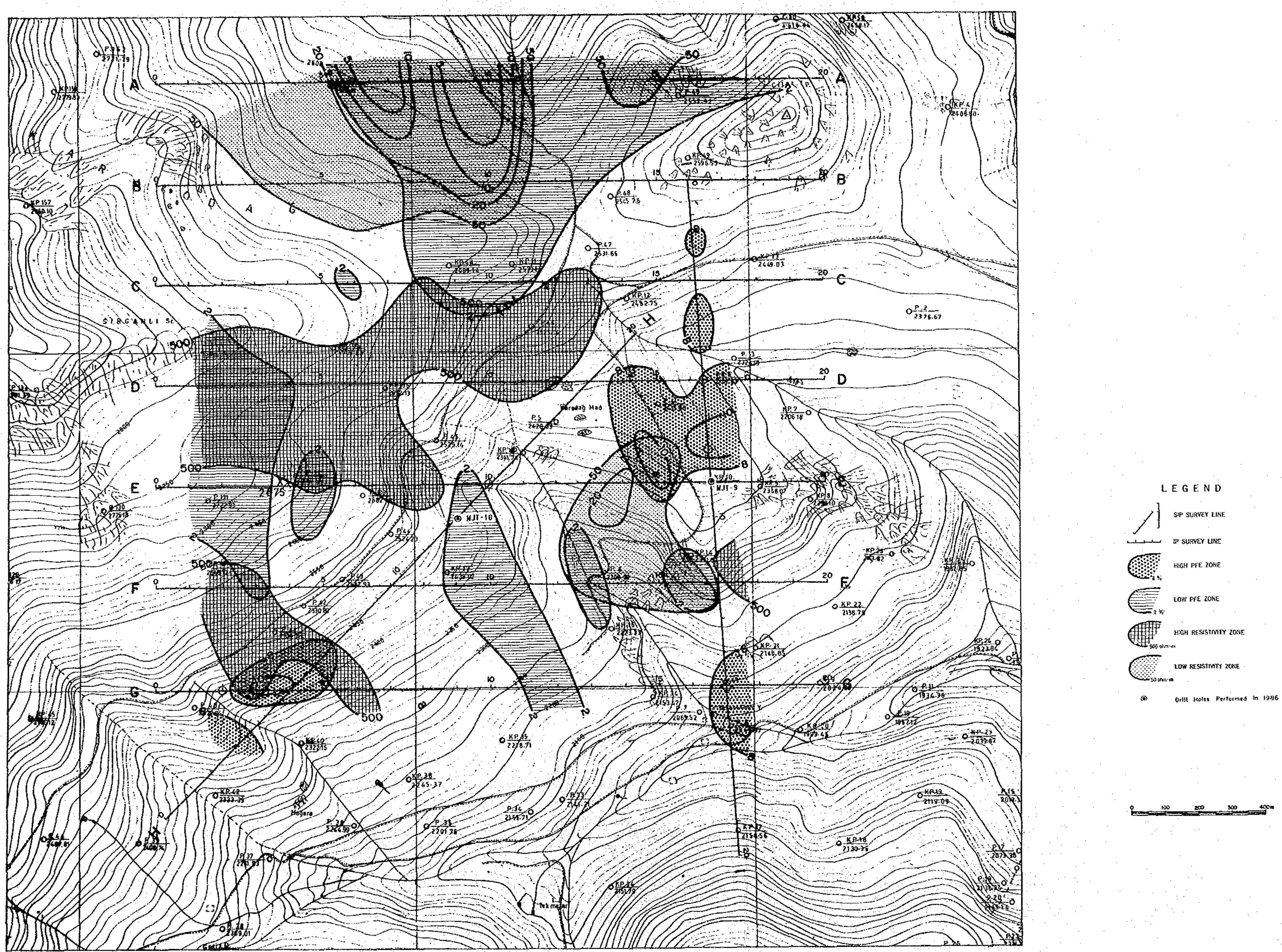

Fig. 48 Geophysical Interpretation Map of the Karadağ Area

skarn type ore deposit.

④ The limestone in the north survey area is regarded as the old Karadağ mining area owing to the scattering of many ore boulders on the surface. However, the PFE responses in the area are less than 8% in value. The result indicates that the Karadağ ore deposit may be embedded only at shallow depths, that it might have undergone oxidation, or that it may be a small scale skarn type ore deposit.

Chapter 3 Drilling Survey

3-1 Outline of the Diamond Drilling

As a result of geological, geochemical and geophysical surveys carried out in the initial and second phases of the project, dissemination and contact type mineralizations were expected as a promising target for future exploration in the Karadağ area. In the third phase, a drilling survey consisting of two holes (total hole length 600m) was planned and subsequenlly carried out in order to explore underground emplacement of the dissemination type ore deposit, and to investigate and unravel the relationship between the emplacement conditions of the ore deposit and the results of the geological, geochemical and geophysical surveys.

The purpose of these holes are as follows:

MJT- 9 : Exploration of the IP and SIP anomaly area

MJT-10 : Exploration of the IP and SIP anomaly area

Location of drill holes

	Y	X	Z [m sea level]
MJT- 9	12 880	67 601	2,382
MJT-10	12 164	67 536	2,386

3-2 Duration and Amount of Work

Drilling No.	Drill length planned	Drill length performed	Dip	Surface soil	Core length	Core recovery	Period
MJT- 9	300m	301.00m	-90°	3.00m	297.60m	98.9%	Aug. 4-Aug. 15
MJI-10	300m	351.00m	-90°	0.70m	328.95m	93.7%	July 7-July 29
Total	600m	652.00m		3.70m	626.55m	96.1%	July 7-Aug. 15

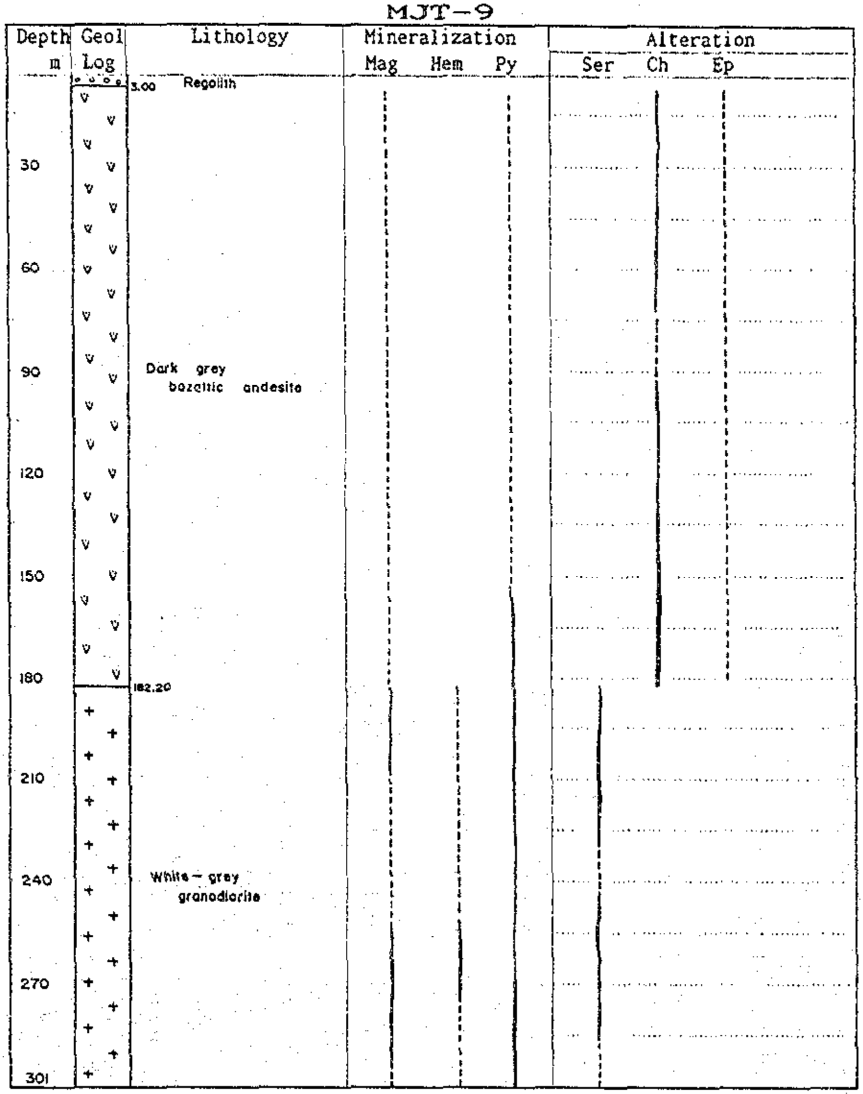

Fig. 49 Geological Log of MJT-9 10号

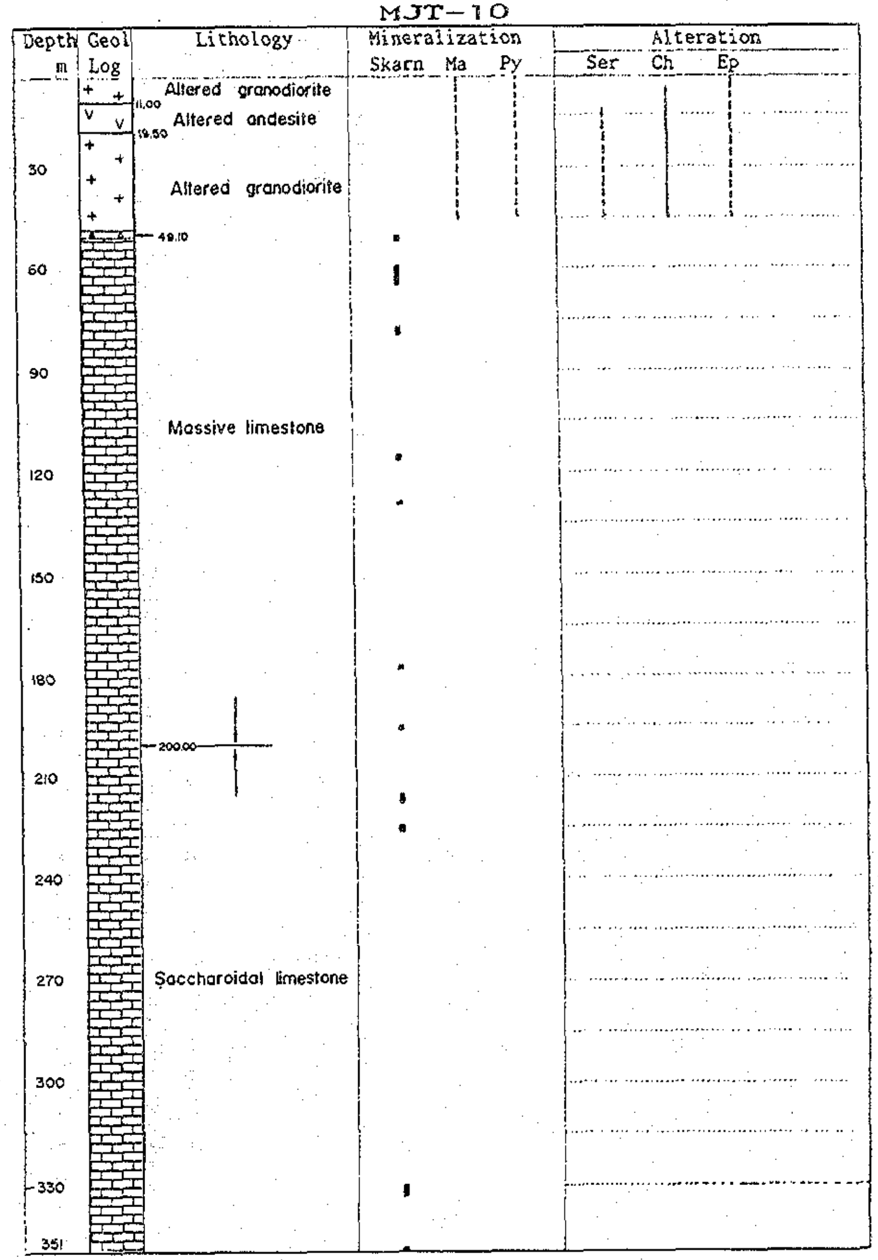

Fig. 49 Geological Log of MJT-10

Table 21 List of Chemical Assay Results of Ore Samples in the Karadağ Area

Sample No	Description	Location	Cu%	Zn%
HH-104	Skarn with oxcp	Eski Maden	13.80	0.85
HH-140	Pourous slag with oxcp	Eski Maden	0.67	2.57
HH-141	Slag with oxcp	Eski Maden	0.47	2.06
HH-142	Pourous slag with oxcp	Eski Maden	0.84	1.95
HH-143	Slag with oxcp (native cp)	Eski Maden	14.80	0.13
HH-144	Oxidized skarn	Eski Maden	0.28	0.56
HH-145	Sil garnet skarn with galena & cp	Eski Maden	0.03	1.17
HH-146	Oxcp	Eski Maden	19.80	13.50
HH-148	Oxcp	Eski Maden	13.50	1.34
HH-149	Sil skarn with oxcp	Eski Maden	0.25	0.31
HH-150	Limonitized skarn with magnetite	Eski Maden	1.26	12.50
HH-151	Qz-garnet skarn with sp and cp	Eski Maden	0.09	1.64
HH-152	Garnet skarn with oxcp	Eski Maden	0.33	3.15
HH-153	Garnet with cp	Eski Maden	0.07	1.17
HH-154	Oxcp & blakish coloured meneral	Eski Maden	1.44	0.22
KK-142	Tour qz breccia with gal and py	Main stream	0.20	0.02
MM-119	Slag(pourous, blakish)	Eski Maden	1.12	1.59
MM-120	Siliceous skarn with oxcp	Eski Maden	3.73	0.64
MM-126	Py-strong ore with oxcp	Maden dere	1.00	0.02
YY-110	Skarn with oxcp	Eski Maden	1.80	3.10
YY-131	Lim garnet & sil skarn with oxcp	Maden dere	0.55	0.01
YY-132	Limonite py ore	Maden dere	0.40	0.02
YY-133	Limonite	Maden dere	0.89	0.10
YY-134	Limonite with qz	Maden dere	0.16	0.16
YY-135	Skarn(garnet) with oxcp	Maden dere	2.61	0.04
YY-136	Skarnized ls with oxcp	Maden dere	0.17	0.01
YY-139	Garnet with oxcp	Maden dere	1.26	0.26
YY-140	ditto	Maden dere	14.80	0.19
YY-141	ditto	Maden dere	2.62	0.19
YY-142	ditto	Maden dere	0.20	0.02
YY-143	ditto	Maden dere	10.40	0.08

Ditection Limit : Cu 10 ppm, Zn 10 ppm
Analytical method : Atomic Absorption and Common Assay

Table 22 List of Chemical Assay Results of Drill Cores in the Karadağ Area

(Unit:ppm)

	Sample	Cu	Zn	Sample	Cu	Zn
MJT-10	0007	680	154	0016	20	12
	0017	30	21	0023	78	22
	0030	17	12	0032	132	29
	0034	151	112	0039	37	60
	0040	155	32	0045	510	17
	0063	1.07%	72	0064	4920	73
	0081	4660	181	0096	580	13
	0099	84	122	0106	34	16
	0117	1.35%	0.92%	0131	1.30%	6320
	0216	245	680			

(Unit:ppm)

	Sample	Cu	Zn	W	Sample	Cu	Zn	W
MJT-10	0219	52	100	1	0289	485	104	1
	0292	20	14	1	0302	20	8	1
	0318	36	54	1	0335	47	8	1
	0340	39	5	1	0346	23	30	1
	0348	9	15	1				
MJT-9	9037	16	13	1	9183	41	11	7
	9185	26	36	11	9196	12	15	3
	9202	10	33	1	9223	22	6	2
	9230	20	7	1	9300	17	17	2

(Unit:ppm)

	Sample	Cu	Zn	Mo	Sample	Cu	Zn	Mo
MJT-9	9187	9	8	1	9191	73	21	1
	9193	8	35	1	9198	21	14	1
	9207	14	6	1	9212	26	31	1
	9216	24	19	1	9234	14	11	1
	9239	14	28	1	9243	9	9	1
	9246	32	26	1	9250	21	14	1
	9254	138	32	6	9257	20	16	1
	9261	25	16	1	9265	57	18	1
	9274	41	43	1	9280	34	39	1
	9288	28	48	1	9295	14	33	2

(Unit:ppm)

	Sample	Au*	Ag	Cu	Mo	Sn	Zn	W
MJT-10	0052	<5	2.6	2000	1	1	33	1
	0351	<10	0.6	40	8	1	184	5
MJT-9	9184	<10	0.1	17	1	1	24	16
	9214	<10	0.3	12	1	1	105	3

(*:ppb)

3-3 Alteration and Mineralization of Drill Hole

MJT-9 【Alteration】 Under general observation, the shallow sections of basaltic andesite near the surface have undergone chloritization, and chlorite increases towards the deep section. Epidote is also recognizable with the appearance of chlorite. Below 182.2m, alteration changes to a white argillaceous zone. Thus the alteration is classified into two zones as follows:

3.00～182.20m: Propylitic zone consisting mainly of chlorite with accessory epidote and calcite.

182.20～301.00m: White argillaceous zone consisting of sericite with quartz and calcite.

【Mineralization】 Mineralization accompanying pyrite and magnetite is observed throughout, from surface to hole bottom, but generally is weak mineralization. Below 182.5m, magnetite and hematite are embedded along fissures and disseminated in the rock.

MJT-10 【Alteration】 Rocks of the drill hole consist of andesite, granodiorite and limestone. The andesite and granodiorite have mostly undergone sericitization, chloritization and weak epidotization. The limestone has undergone sericitization and montmorillonitization.

【Mineralization】 Mineralization with pyrite and magnetite is emplaced in the andesite and granodiorite. Malachite is observed in the skarn and the siliceous part of the limestone.

3-4 Assay Result of Core and ore samples

Drilling survey of the third phase was conducted in two holes, totalling 652.00m in length. Results of chemical analyses of 64 core samples collected from MJT-9, MJT-10, and ore samples (including float chip) are shown in Tables 21 and 22.

Chapter 4 Consideration

4-1 Altered Granodiorite

The granodiorite is classified into two types by differences in the form of intrusion and mode of alteration. One was intersected by drill hole MJT-9 and distributed in large scale under the surface. Another was intersected by drill hole MJT-10 and distributed in small scale on the surface. The two types of granodiorite are summarized in the following table;

		Alteration	Mineralization	Accessory Mineral
MJT- 9	Vs	Pl → Ser,Kao Maf → Chl	Pyrite Magnetite Hematite	Tourmaline Zircon
MJT-10	M	Pl → Ser Maf → Chlorite → Epidote	Pyrite	

Vs:Very strongly altered M:Moderately-altered
Pl:Plagioclase Ser:Sericite Kao:Kaoline Maf:Mafic mineral Chl:Chlorite

4-2 Andesite and Limestone (Zigana Formation)

The A1 Member of the Zigana Formation consists of basaltic andesite, limestone and andesite in ascending order, and is widely distributed in the Karadağ Area. Basaltic andesite has undergone propylitic alteration in MJT-9. The andesite has undergone sericite-epidote-chlorite alteration at the contact with granodiorite in MJT-10. These rocks are accompanied with magnetite and pyrite. The lithology of the drilled core is the same in comparison to that of the surface.

Limestone consists of massive and argillaceous facies along Maden Dere, the lower part of which has undergone skarnitization and is accompanied by copper mineralization. The lithology of MJT-10 is massive in the range of 49.10m to 200m, and gradually becomes saccharoidal below 200m. There are skarn, siliceous, and argillaceous facies in the limestone.

4-3 Altered and Skarn Minerals

Altered minerals in the granodiorite (MJT-9), and altered and skarn minerals in the limestone (MJT-10) are summarized in the following table based on X-ray diffractive analyses.

Location	Country rock	M	Mix	Chl	Ser	Ka	Qz	Kf	Do	An	Ep	Ves	Py
MJT-9 183.0m	Granodiorite				○	□	◎						△
MJT-10 49.5m	Limestone			□	△	◎	□?			○	□?		
MJT-10 60.5m	Limestone	○	△				□?	□	○		?	□	
MJT-10 115.8m	Limestone	?	○				□?		○		□?	□	

M:montmorillonite, Mix:mixed-layer mineral, Chl:chlorite, Ser:sericite, Ka:kaolinite, Qz:quartz, Kf:potash feldspar, Do:dolomite, An:andydrite Ep:epidote, Ves:vesuvianite, Py:pyrite, ◎:abundant, ○:common, □:few, △:rare

4-4 Geological structure

Rocks and formations have been displaced by fault movements along tectonic lines of NE-SW direction. Granodiorite intrudes along the tectonic line and extends widely in a north-south direction below the surface according to a geophysical anomaly and to the determined lithology of MJT-9. Although limestone was inferred to be dipping 30° ~40° west and to be 100~150m in width according to the geological survey, limestone in MJT-10 was dipping more than 50° west and was 200m in width.

4-5 Mineralization

The old Karadağ ore deposit located up the Maden Dere is embedded in the skarn zone of the limestone, and is accompanied by copper, lead and zinc ores. However, the geophysical survey could not directly clarify the emplacement of old Karadağ ore deposits, because they may be embedded in the shallow part, oxidized completely, or small in scale. In the third phase, although two drill holes were conducted in the anomalous area expected to be dissemination-type mineralization and skarn type mineralization, we, unfortunately, could not find either mineralization zones

4-6 Alteration Zoning

Zoning of alteration in this surveyed area is characterized by X-ray diffraction analysis and core sketch as follows;

	Depth(m)	Lithology	Alteration
MJT- 9	3.0~182.2	Basaltic andesite	Chlorite-Epidote
	182.2~301.0	Granodiorite	Sericite-Kaolinite
MJT-10	0.7~ 49.1	Andesite, and Granodiorite	Sericite-chlorite Epidote
	49.1~351.0	Limestone	Montmorillonite Mixed-layer mineral (Chlorite-Sericite)

4-7 Relationship between Geophysical Anomaly and Mineralization

The IP method of the geophysical survey was conducted on seven survey lines 2 km in length with each line 300 m apart in an east-west direction. As a result, three high PFE anomalous zones were found at the east, south-west and south-east parts of the Karadağ area. The SIP survey was subsequetly conducted to survey these anomalous areas in detail on two survey lines H (NE～SW) and I (N～S). The survey results reveal the following:

① The three anomalies in the center, south-west and south-east parts of the Karadağ area are expected to be disseminated type ore deposits.

② The anomaly in the center part of the survey area is expected to be a skarn type mineralized zone embedded in the limestone stratum.

In the third phase, two drill holes were conducted in the anomalous areas expected to be dissemination and skarn type mineralizations. The relation between geophysical anomaly and mineralization is summarized as follows:

MJT- 9 ; The hole was drilled to 301m through altered basaltic andesite of the Zigana Formation and granodiorite. Basaltic andesite (3～182.2m) has undergone propylitc alteration with pyrite, granodiorite has undergone sericitized alteration with magnetite-hematite-pyrite. It is considered that the geophysical anomalies indicated pyritization in andesite and granodiorite.

MJT-10 ; The hole was drilled to 351m through altered granodiorite and limestone. Granodiorite (0.7～46m) has undergone sericitized and chloritized alteration with pyrite. The limestone (46～351m) gradually changed from a massive to a saccharoidal facies. A partial skarn zone with malachite and pyrite occurred. It also is considered that the anomaly indicated weak mineralization of the skarn zone.

Chapter 5 Conclusions and Recomendations for Future Exploration

5-1 Conclusions

The results of the Cooperative Exploration Survey conducted from 1984 through to 1986 in the Gümüşhane Area, Republic of Turkey, are summarized as follows:

Karadağ Area

(1) A skarn stratum was formed at the boundary between the massive limestone stratum and the underlying granodiorite. Granodiorite and quartz porphyry stocks have intruded along the NE～SW striking fault in and adjacent to the area of the skarn stratum. Disseminated mineral showings containing copper or copper-zinc of the Karadağ Area are embedded in the skarn and the stocks.

(2) In the second phase, geological surveys and geophysical surveys (IP and SIP methods) were performed on the area of the promising ore deposit extending into limestone, andesite and intrusive stocks. As a result, three promising anomalous zones were selected. These anomalous zones were detected as PFE anomalies first by conventional IP survey. A detailed SIP survey was performed on these PFE anomalies.

(3) As a result of the drilling survey, it is considered that the geophysical anomaly of MJT-9 indicated pyritization in the andesite and granodiorite and that the IP anomaly pattern of MJT-10 indicates weak mineralization of the skarn zone in the limestone.

5-2 Recommendations for Future Exploration

The following ideas are recommendated to the Government of Turkey for a continued survey in the project area.

Further exploration is requested in the Karadağ Area. It is considered that the geophysical anomalies indicated pyritization in andesite and granodiorite, so an area apart from the geophysical anomalies should be explored by a drilling survey. Drilling sites should be changed according to the results of precceeding drill holes.

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