Chapter 4 Comprehensive Interpretation

4-1 Central Zalturbulak prospect

4-1-1 Geology

The relative location of Central Zalturbulak Prospect within the entire Zalturbulak Area is indicated in Figure. II-4-1-1. The geology of the Area is illustrated in Figure. II-4-1-2, together with a representative cross section.

The geology of the Area principally comprises volcanic and sedimentary rocks of Ordovician age, intruded by Devonian to Carboniferous granitoids and other intrusions. Characteristics of each geologic unit are described below.

(1) Ordovician Series

The Ordovician Series is the oldest in the Area and distributes in a north-south trending belt in the eastern part. The series comprises pyroxene andesites and sedimentary rocks which are not differentiated in the geological maps because it is virtually impossible to distinguish them into mappable units due to poor exposure and similarity of the sandstone and the andesite in their appearances on weathered outcrops.

The andesitic volcanics are composed of greenish dark gray lavas and pyroclastics. The pyroclastics are mostly fine grained tuff, lacking coarse grained fragments.

The sedimentary rocks, of clastic nature, mainly consist of siltstone and fine-grained sandstone showing grey-black to greenish dark grey colours. They are generally massive and compact, and are often hornfelsic due to thermal effect by later intrusions. It is, therefore, extremely difficult to distinguish them from andesite unless laminae are developed in places.

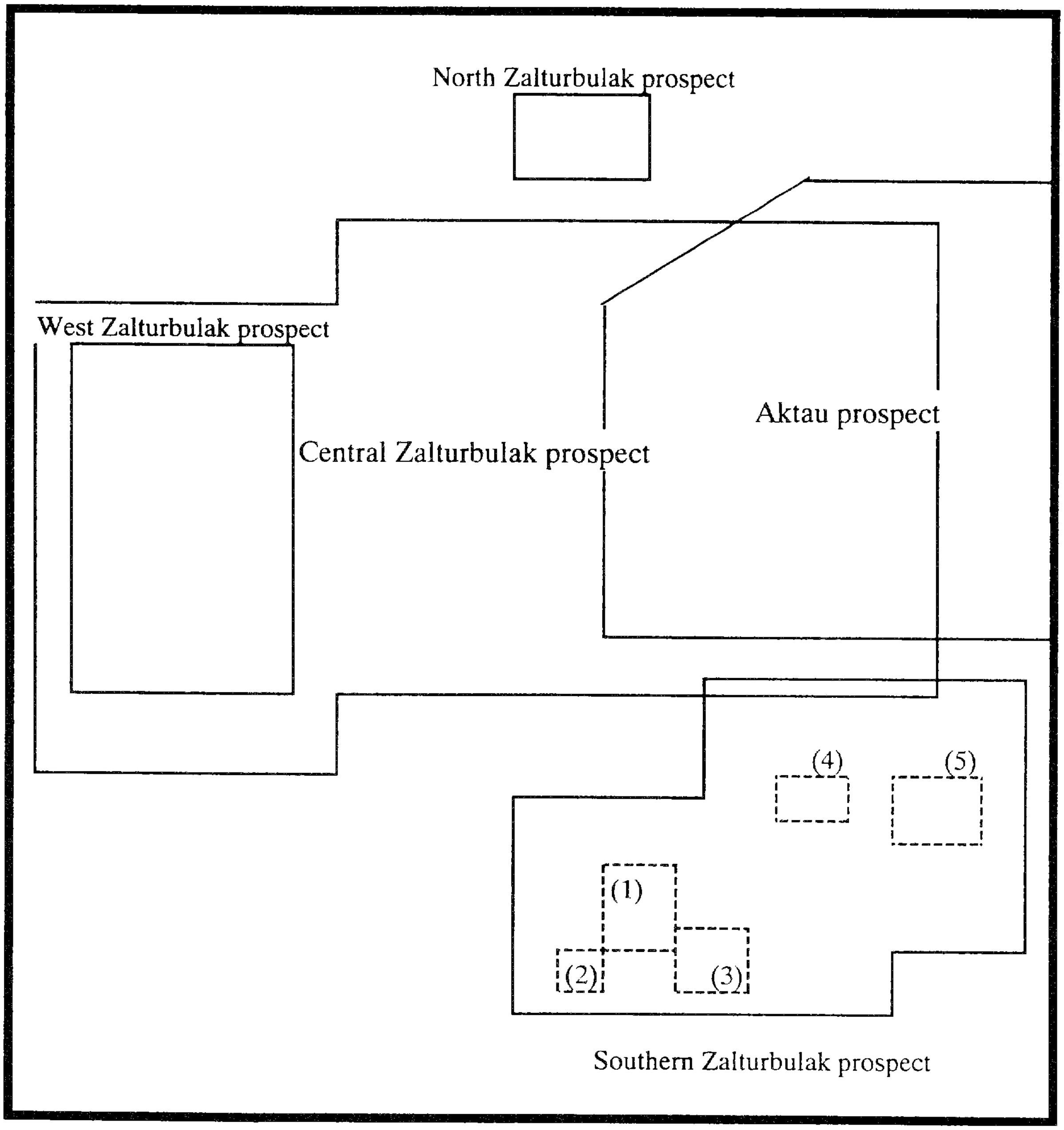
(2) Granitoids

The Devonian to Carboniferous granitoids occupy a cosiderable portion of Zalturbulak Area, forming a batholithic body. The granitoids can be devided into those belonging to Karamendin Complex of Devonian to Carboniferous age and those constituting a part of middle to late Devonian Terektin Complex.

1) Karamendin Complex

The granitoids of the Karamandin Complex in this area include medium-grained biotite-hornblende granodiorite(hereinafter called 'granodiorite' unless otherwise quoted for its particular mineralogy) and hornblende biotite granite(hereinafter called 'granite').

The granodiorite, the most common intrusive facies of Karamendin Complex, occupy 70 % of Zalturbulak Area. It is mostly medium grained and leucocratic, and is generally uniform in its composition. The age of intrusion is determined of middle to late Carboniferous, corresponding to Variscan(Hercynian), based on the result of K-Ar age



(1) Central Zalturbulak zone
(2) Southwestern Zalturbulak zone
(3) Eastern Zalturbulak zone
(4) Northern Zalturbulak zone
(5) Northeastern Zalturbulak zone

Figure II -4-1-1 Index Map of the Zalturbulak Area

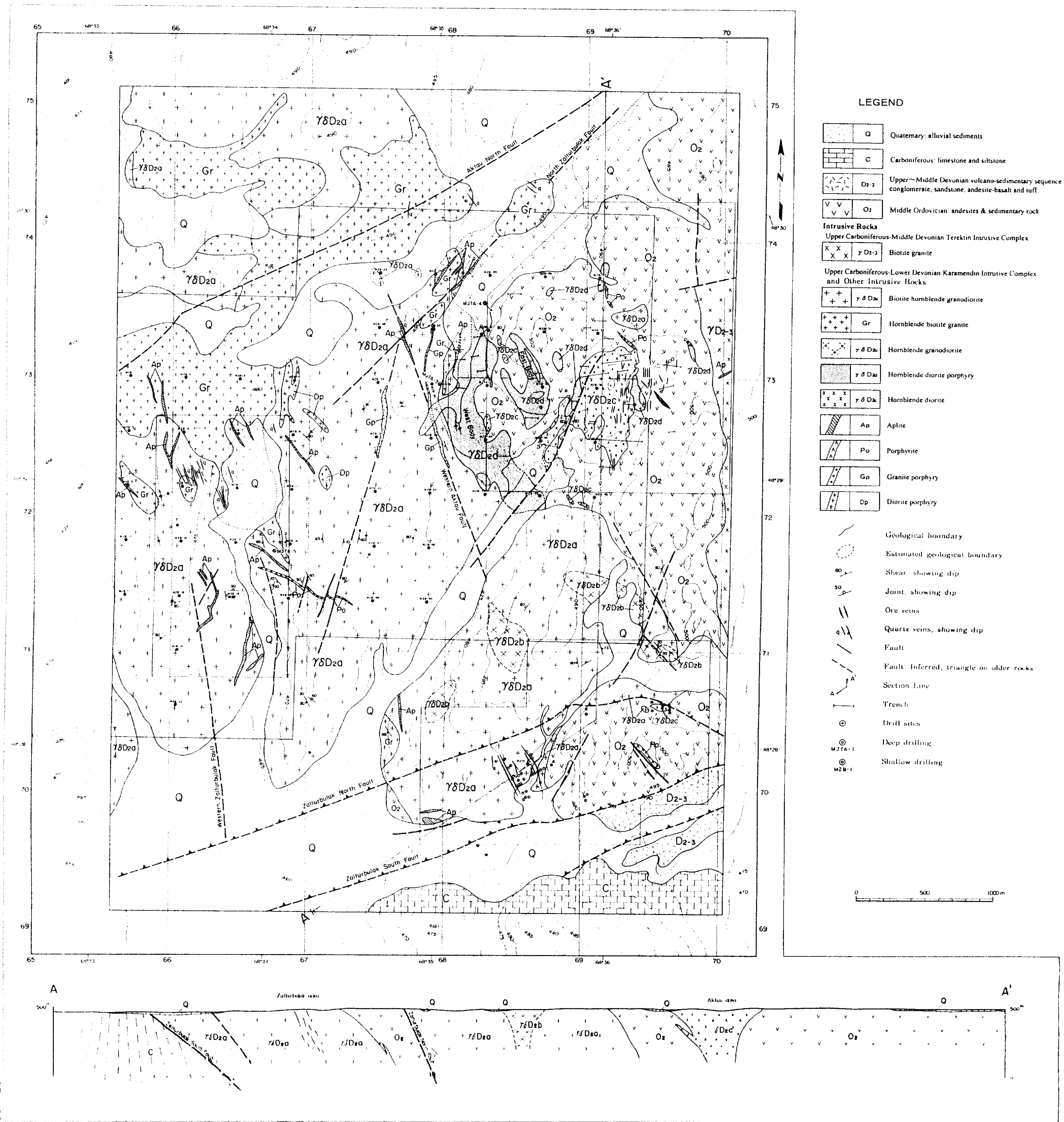


Figure II -4-1-2 Geological Map of the Zalturbulak Area determination indicating 328±16 Ma and 297±15 Ma for two samples collected in Western Zalturbulak. The result of whole rock chemical analysis of two granodiorite samples indicates that contents of SiO_2, Na_2O and K_2O range from 64.5 to 65.6 %, from 3.2 to 3.5 % and from 3.2 to 3.53 % respectively(Appendix 8). This range of chemical composition is plotted in the granodiorite domain of calc-alkaline rock series in the Si_2O-Na_2O+K_2O diagram as defined by Science Academy of the former USSR(Serykh, 1996, Appendix 8). A large mass of the granite is located in the northern part of the area. It is mostly medium grained leucocratic with pinkish tint, accompanying fine grained facies in places. The granite also occurs as a stock branching south-southeastward off the northern main body in Western Zalturbulak and as a small intrusion within the granodiorite body in Aktau. A sample of the granite collected in West Zalturbulak indicates K-Ar ages(whole rock) of 295±15 Ma, which is also correlated to Variscan. The whole rock analysis of a sample indicates the contents of SiO_2, Na_2O and K_2O at 70.6 %, 2.7 % and 3.5 % respectively(Appendix 8), falling in the granite domain of calc-alkaline rock series in the Si_2O-Na_2O+K_2O diagram. Judging from its K-Ar age, mineralogy and chemical composition, it appears reasonable to assume that the granite has been differentiated from the granodiorite forming an extensive batholith in the general area.

2) Terektin Complex

Distribution of Terektin Complex is limited in the eastern margin of the Area. The rocks are essentially medium grained, leucocratic, with pinkish tint, biotite granite. They are mostly massive, though schistosity is locally developed.

(3) Other Intrusions

Other inrusions than described above include hornblende diorite porphyry, pyroxene-hornblende diorite, aplite, porphyrite and granite porphyry. Of these, hornblende diorite porphyry(hereinafter 'diorite porphyry') and pyroxene-hornblende diorite(hereinafter diorite) are important in terms of mineralization of the Area. It may be reasonably assumed that these two intrusions are genetically related to each other because of the similarity in their compositions and the proximity in their locations of emplacement.

Two oval-shaped intrusive bodies of the diorite porphyry distribute near the contact between the Ordovician volcano-sedimentary rocks and Karamendin Complex, trending in the NNW-SSE direction with long axes ranging from 600 to 1300m and widths of some 300m. A number of small stocks are also located within the volcano-sedimentary rock distributing area. Intrusions of the diorite porphyry invariably form hornfelsic contact aureoles around them. The rocks are fine grained, compact and contain about 20 volume % of plagioclase phenocrysts with sizes less than 1mm within fine grained, holocrystalline matrices. They contain an insignificant amount of mafic minerals, commonly comprising hornblende, occasionally accompanied by pyroxene and/or biotite. A sample of the diorite porphyry indicates a K-Ar age of 373±11 Ma, late Devonian age, which is correlated to the last stage of Caledonian orogeny. The whole rock analysis of a sample presents the contents of SiO_2, Na_2O and K_2O at 63.4 %, 2.2 % and 3.6 % respectively(Appendix 8). The composition is plotted at the boundary between the granodiorite and quartz diorite domains of calc-alkaline rock series in the Si_2O-Na_2O+K_2O diagram.

A sizable intrusion of the diorite is located in association with the Aktau mineralization and elongates in the N-S direction with its long and short axes of 800m and 400m respectively. A few small bodies also distribute around diorite porphyry intrusions. The diorite intersected by the drill hole, MJTA-4, is of the same kind, although subjected to a different degree of alteration. The diorite is invariably black, fine grained, compact and holocrystalline.

As aforementioned, the diorite porphyry and the diorite are closely related to each other in their genesis. Therefore, they are grouped in the same intrusive unit for the purpose of discussing the related mineralization and alteration in this report.

Aplite is fine grained, compact rocks and mainly distributes in the northern part of the Area, forming dikes several meter wide. The aplite dikes occur within or closely associated with hornblende-biotite granite, which suggests that these two types of intrusions are closely related to each other in genesis.

Two granite porphyry dikes, some 400m long, are located along NNW-SSE and N-S running faults in the western part of Aktau. The rocks are pinkish light gray in color and contain a minor amount of feldspar phenocrysts with grain sizes up to 2 mm in matrices comprising fine grained feldspars and quartz.

Occurrences of porphyrite are limited to the eastern part of the Area and insignificant in terms of mineralization and alteration.

4-1-2 Fault Structure

Three fault systems are observed in Zalturbulak Area, namely, NNW-SSE, ENE-WSW and NE-SW systems.

NNE-SSW Fault System: Faults running in this direction vary in their scale considerably and are most prevailing in the entire Area. The Western Aktau fault, along which sizable granite porphyry and aplite dikes intrude, is one of the major faults of this system and bounds the western limit of the eastern IP anomaly. A number of diorite porphyry and granite stocks, aplite dikes and quartz veins are also elongating or striking in this direction, which suggests that their emplacement has been controlled by this fault system.

Inclinations of faults, dikes and veins with this direction are mostly vertical or near vertical. Most slickensides observed in drill cores of the holes, MJTA-1 and -2, indicate vertical dislocation, which may suggest that faults of this system are of normal nature.

ENE-WSW Fault System: Typical examples are the Zalturbulak North and the Zalturbulak South faults located in Southern Zalturbulak. These faults have shallow dips to north and are continuous for considerable distances. The Zalturbulak South fault bounds the southern limit of the Devonian Series which overthrusts the Carboniferous Series to the south.

NE-SW Fault System: A type of this system is the North Zalturbulak fault. Aplite dikes intrude along or parallel to this fault. Intrusions of hornblende-biotite granite in the proximity of this fault appear to be also controlled by structures of this trend. The result of the 2nd Year's rock-geochemical prospecting indicates gold and copper geochemical anomalies elongating in the NE-SW direction to the south of the Zalturbulak fault. These geochemical anomalies are implied to reflect underlying gold and copper mineralization controlled by fractures parallel to this system, because isogals around the anomalies trend in the same direction. The drill hole, MJTA-4, which is located just to the west of one of the major NE-SW trending faults and drilled to east with inclination of 70° has failed to intersect any notable fractured zone correlative to the major fault. Two sets of numerous fractures and quartz/pyrite veinlets are observed in this hole; one indicates angles to the core axis ranging from 0 to 10° and the other, from 20° to 50°. The former set suggests that the fractures incline 60° to 80° to east, and the latter suggests that they incline either 60° to 90° to west or 20° to 50° to east. Since most faults and fractures of this system observed on surface indicate steeper inclinations than 50°, usually to west, it is inferred that they inclines steeply to east or, in many cases, to west.

The above fault systems can be interpreted for their genesis as follows.

Zalturbulak Area has been situated in a regional stress field with the maximum compression axis in the NNE-SSW direction for a long period from late Devonian(indicated by the age of diorite porphyry intrusion) to Carboniferous(ref. Part I, 3-1). Within the stress field, extension fractures striking in the NNE-SSW direction have formed and provided passages for intrusions and hydrothermal solutions. Some of the extension fractures have turned into normal faults, gravitationally dislocating their hanging wall ground downwards. This stress field has also developed a number of reversed faults, as well demonstrated by the Zalturbulak South and North Faults. With respect to the NE-SW fault system, faults of this direction are expected to show left-lateral displacement within this stress field. On the contrary, however, displacement by the North Zalturbulak Fault appears to be dextral judging from relative dislocation of geologic units on the both sides of the Fault. This implies that the Fault may have been formed earlier than late

Devonian and rejuvenated in later ages, because faults of this direction, formed earlier than early Devonian, are commonly developed in the northwestern part of Terektinsky Uprift Geologic Province(ref. Part I, 3-3-4).

4-1-3 Characteristics of Mineralization

In Central Zalturbulak, two occurrences of mineralization have been located during the 3-Year period of the current investigation, namely, the disseminated Cu mineralization related to the Devonian diorite porphyry in Aktau prospect and the disseminated Cu-Mo mineralization related to the late Carboniferous granite in West Zalturbulak prospect. In this section, the characteristics of these occurrences of mineralization are described, referring to the result of this year's drilling operation as well as those of the previous two years' investigations. Drilling profiles are shown in Figure II-4-1-3 . The investigation results are compiled in Table II-4-1-1 and are illustrated as a composite map in Figure II-4-1-4.

4-1-4 Mineralization Related to Diorite Porphyry

1) Mode of Occurrence

This mineralization occurs in an Ordovician volcano-sedimentary rock distributing area in the western part of Aktau and comprises Au and Cu concentrations to geochemical levels. On the surface, the mineralization is recognized in a vast plain as a constellation of scattered outcrops of silcified rocks in the center and of surrounding propylitized rocks. The geological prospecting, geochemical rock sampling and shallow pilot and deep exploratory drilling to date have confirmed that the NE-SW trending zone of mineralization is associated with the northern half of an oval diorite porphyry body elongating roughly in the N-S direction(Figure. II-4-1-4). The mineralization, in association with quartz-sericite alteration, comprises chalcopyrite occurring as dissemination accompanied by a large amount of pyrite or in quartz-pyrite networks. Pyrite is by far dominated in amount to quartz in quartz-pyrite networks. Intense mineralization often occurs along walls of dikes or within fault zones. Two outstanding Cu values are recorded at1308 and 934 ppm for two drill core samples of 3m sections of the Hole, MJTA-4. The highest Au value is recorded at 470 ppm for the same core sample that indicates the copper value of 1308 ppm.

2) Alteration

The alteration of Aktau is distinguished into three zones, namely, propylitic, quartz-sericite and quartz-tourmaline zones, based on the results of geological prospecting, drill

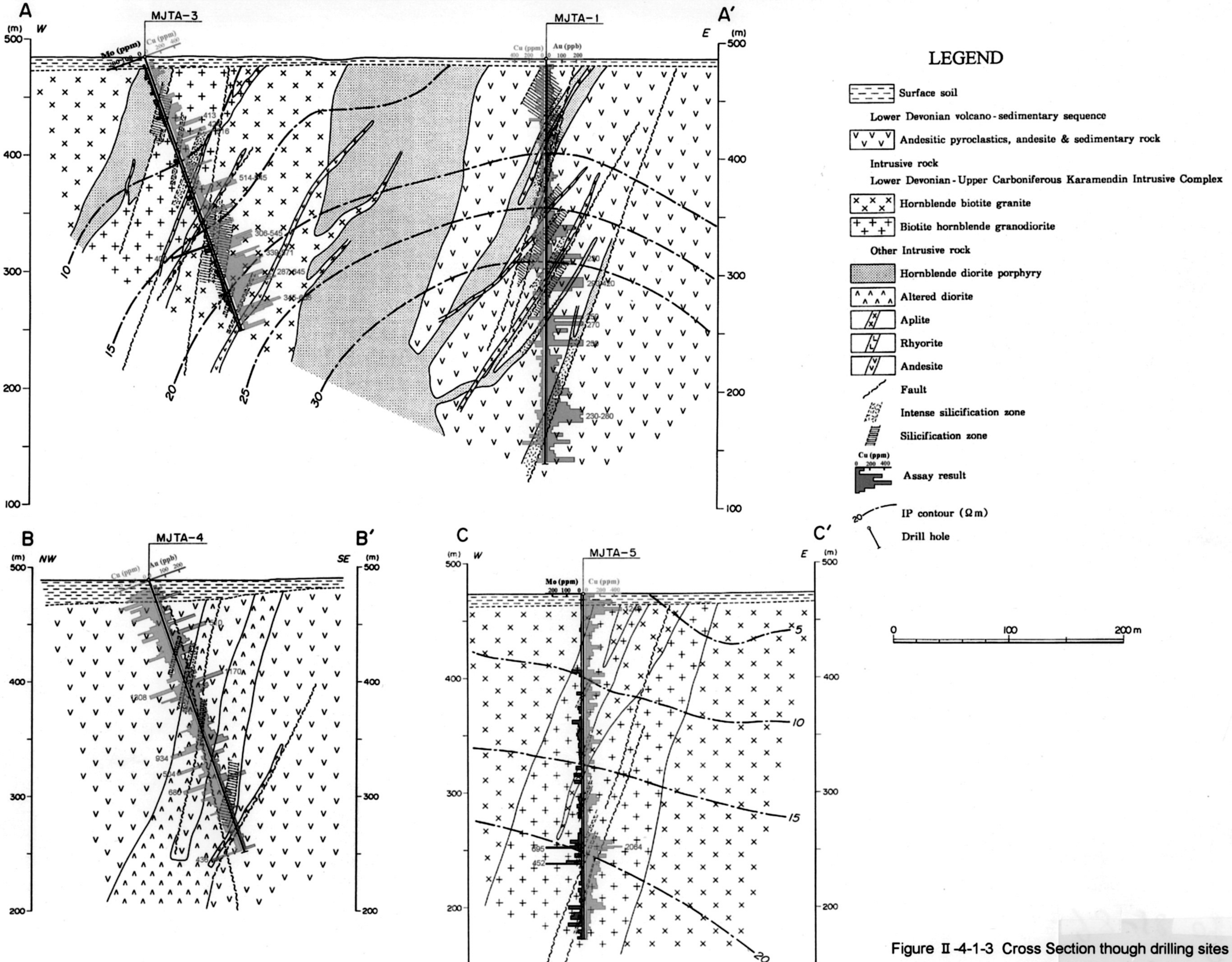


Figure II-4-1-3 Cross Section though drilling sites

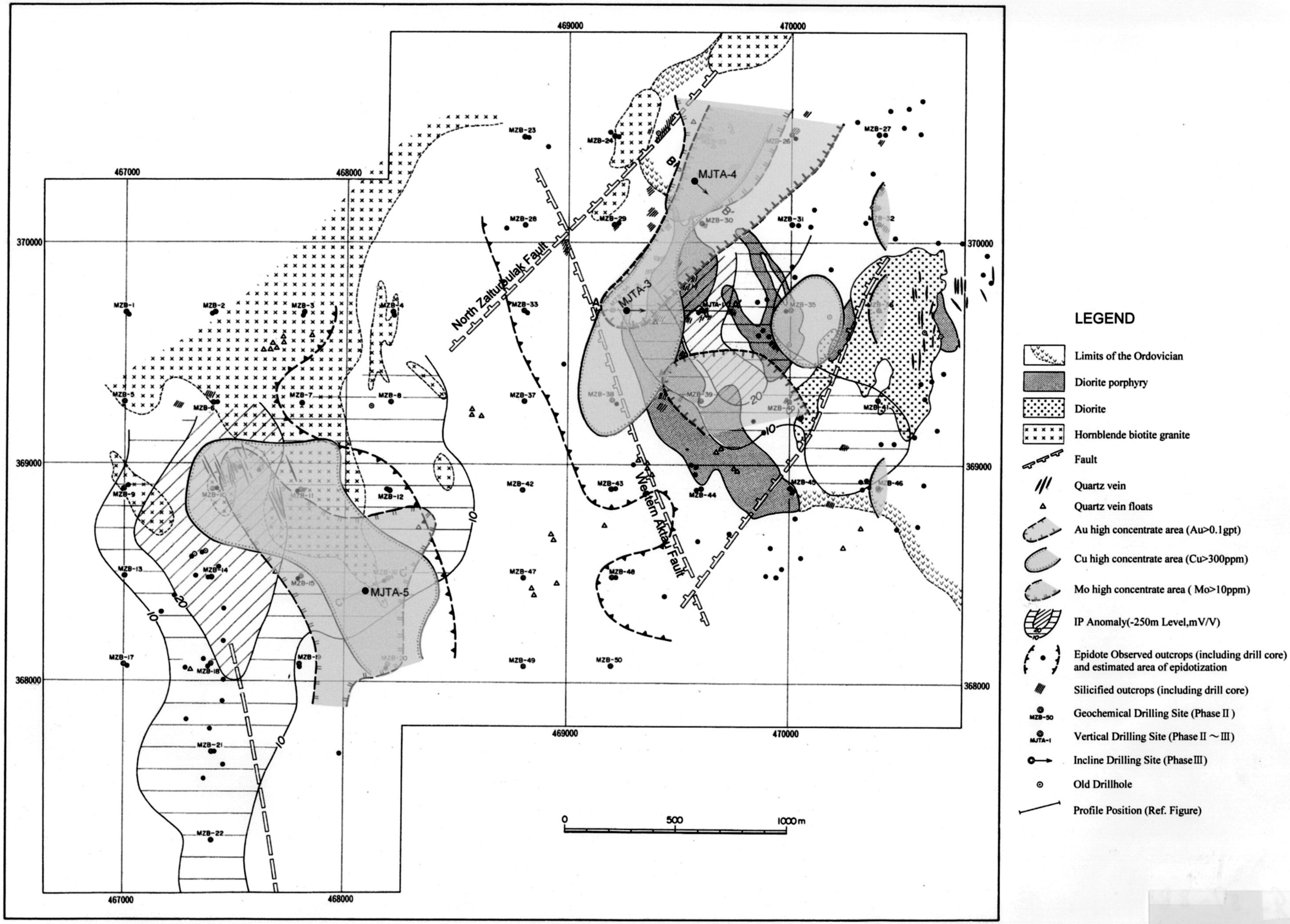


Figure II-4-1-4 Interpretation Map of Geology, Geochemistry, Mineral Occurrence and Geophysical Survey of Central Zalturbulak Prospect

Table II-4-1-1 Mineralization stage in the Central Zalturbulak area

	Mineralization			Alteration		T°C
	Type	Ore minerals (identified)	occurrence	zone	type	100 200 300 400
Aktau west	Barren	pyrite		propylite	chlorite epidote calcite	
Aktau west	Cu-Au-(Ag)	pyrite calcopyrite pyrrhotite magnetite electrum Pentlandite	pyrite-quartz-chlorite network veins	quartz-sericite	quartz sericite chlorite epidote calcite	
Aktau west	Cu-Au	pyrite calcopyrite pyrrhotite magnetite	pyrite-quartz network veins	quartz-tourmaline	quartz sericite tourmaline	
Aktau west	Au	electrum	quartz & calcite veins,	propylite	epidote calcite	
Western Zalturbulak	Barren	pyrite	veinlets	propylite	chlorite epidote calcite	
Western Zalturbulak	Mo	molybdenite calcopyrite pyrite	dissemination	sericite	sericite chlorite epidote	
Western Zalturbulak	Mo-Cu-Au	molybdenite calcopyrite pyrite	pyrite-quartz-chrorite network veins	quartz-sericite	quartz sericite chlorite epidote	
Western Zalturbulak	Mo-Cu-Au-Ag-Pb(-Zn)	pyrite calcopyrite molybdenite galena	quartz vein,pyrite-quartz network	quartz-sericite	quartz sericite chlorite epidote	
Western Zalturbulak	Au-(Cu)	?	quartz-chlorite vein	quartz-chlorite	quartz chlorite epidote	

core observation and various laboratory tests(Table II-4-1-1 and Figure. II-3-1-1).

(a) Propylitic Zone

The propyrite zone is characterized by an alteration mineral assemblage comprising chlorite, epidote and calcite. The alteration zone laterally distributes surrounding the quartz-sericite zone which will be described below. Chlorite often occurs as thin films along fractures, occasionally accompanying epidote. Under microscope, it is observed that chlorite partly replaces mafic minerals. Epidote occurs in association with chlorite or replaces mafic minerals, often forming distinct speckles. Calcite is a common alteration mineral in this zone, forming veinlets or replacing plagioclase. Calcite veinlets often crosscut epidote-chlorite veinlets. In addition to these alteration minerals, minor amounts of gypsum, montmorillonite and sericite are identified by X-ray diffraction analysis of the samples collected in the propylitic zone.

(b) Quartz-Sericite Zone

The quartz-sericite zone is characterized by an alteration mineral assemblage of quartz and sericite, although chlorite veinlets are often observed in this zone. This zone is distinguished from the propylitic zone by visual identification of silicification. It is observed in drill cores that quartz veinlet networks, as evidence of silicification, develop overprintig the propylitic alteration. Therefore, the propylitic alteration precedes the quartz-sericite alteration. The quartz-sericite zone extends from the vicinity of the shallow drill hole. MZB-39, located just to the south of the center of the main diorite porphyry body, northwards to the vicinity of the hole, MZB-25, trending parallel to the porphyry body. The alteration observed in drill holes is characterized by development of several millimeter thick pyrite+quartz±chlorite veinlets and their networks surrounded by abundant pyrite dissemination. Silcified rocks on outcrops contain abundant iron oxides, developing superficial white blooms of powdery sericite. Epidote is also observed, though much less in frequency than chlorite.

X-ray diffraction analysis for rock samples of this alteration zone has identified such alteration minerals as quartz, sericite, sericite-montmorillonite mixed layers, epidote, chlorite, chlorite-montmorillonite mixed layer minerals, gypsum and kaolinite. Sericite-montmorillonite mixed layers and chlorite-montmorillonite mixed layer minerals are identifed in a number of drill core samples of the quartz-sericite and the quartz-tourmaline zones in the hole, MJTA-1. However, they occur in limited depths to 100 m or less from the surface, and are excluded from the indicator minerals for the alteration zoning.

(c) Quartz-Tourmaline Zone

The quartz-tourmaline zone is characterized by intense silicification and presence of tourmaline as a unique alteration mineral. MJTA-1 is the only drill hole that has intersected this alteration zone. This alteration is mostly observed in association with major crushed zones in the drill hole. The lateral extension of the alteration zone has not been defined, because no surface evidence of this alteration has been located except for a tourmaline-bearing andesite float found about 100 m west of the shallow hole, MZB-25. The silicification associated with this alteration is considerably intense and often obliterates the original textures of rocks completely. Abundant pyrite is disseminated in association with the silicification. Tourmaline forms globules with diameter of about 1 mm, indicating a radial texture like spherulite. The maximum content of tourmaline is estimated at about 10 % in volume. A minor amount of sericite is also associated with this alteration, filling hairline fractures or replacing a part of plagioclase. Chlorite and epidote are observed only where the silicification is weak, which implies relic of the propylitization. Calcite is also found occasionally, replacing a part of plagioclase.

(d) Advanced ArgillicAlteration

No mappable unit of advanced argillic alteration has been defined either on the surface or in any drill holes. X-ray diffraction analysis has identified a minor amount of kaolinite in a surface sample of silicified rocks and a trace of questionable pyrophyllite in a drill core sample of MJTA-1.

(e) Calcite-Epidote Alteration

Numerous calcite veinlets, carrying epidote, typically occur in MJTA-1 and crosscut the above three alteration types from(a) through (c). Since calcite and epidote are common alteration minerals associated with these types of alteration, it is practically impossible to outline this type of alteration as a zone.

3) Mineralization

The mineralization related to the diorite porphyry is distinguished into three types in accordance with combinations of metallic elements and with associated alteration types, namely, ① Cu-Au, ② Au-(Cu) and ③ Au subtypes in ascending order of the stages of mineralization. Their characteristics are described below.

(a) Cu-Au Type

The mineralization of Cu-Au type is typically observed in the hole, MJTA-4 and is characterized by Cu and Au concentrations in pyrite and pyrite-quartz veinlets and in their networks. The mineralization is mainly accompanied by the quartz-sericite alteration. Microscopic observation of polished sections has identified such ore minerals as pyrite, chalcopyrite, pyrrhotite and magnetite accompanying minor electrum, molybdenite, cubanite and gersdorffite. Chalcopyrite occurs as dissemination in association with pyrite veinlets or as inclusions within pyrite grains. A particular type of magnetite, containing silica, is identified under microscope and may indicates a certain temperature range of the mineralization.

The mineralization and the associated alteration are suggested by their distributions to have taken place along a major fault extending northeastward from the northern part of the major diorite porphyry intrusion. Noteworthy copper values which are obtained for two 3-m sections of MJTA-4 are 1308 and 934 ppm but are by far too low for any economic consideration. Several core samples of 3-m sections indicate Au values in the order of hundreds ppb but are very sporadic in their occurrences. A couple of analytical results of 2490 and 4150 ppm Cu for drill core samples are also recorded in the previous investigation during the former USSR period but only for the very short drilling sections of 0.2 m. The explorations to date have, therefore, been unsuccessful to locate Cu and/or Au mineralization of this type with any economic significance.

No fluid inclusion suitable for determination of homogenization temperature has been identified in surface and drill core samples submitted for fluid inclusion analysis during the current investigations. For the Aktogai Ore Deposits, the mineral association of pyrrhotite, magnetite and cubanite, which characterizes the Cu-Au mineralization in Aktau as well, indicates homogenization temperatures ranging between 320 and 490°C(Zvezdov et. al, 1993) and is considered to have formed in an early stage of its mineralization process. The magnetite that contains silica, has been reported to occur in the Tengumori Ore Body of Kamaishi Deposits in Japan(Shiga, 1988 & 1989) and is interpreted to indicate its formation temperature at around 300°C. These indirect evidences suggest that the mineralization of this type in Aktau has been also formed within a similar temperature range of 300 to 400°C.

(b) Au-(Cu) Type

The mineralization of this type comprises sporadic Au concentrations in association with the quartz-tourmaline alteration observed in the Hole, MJTA-1. The ore minerals such as chalcopyrie, pyrrhotite, magnetite and electrum are observed under microscope, accompanied by abundant pyrite. A core sample for 0.2 m section of MJTA-1 indicates Au and Cu contents of 500 ppb and 600 ppm respectively in association with abundant pyrite. Au and Cu values for ordinary drill core assay runs of 1 to 3 m do not exceed 250 ppb and 200 ppm respectively.

(c)Au Type

The mineralization of this type, characteristically without any notable concentration of Cu, is accompanied by the calcite-epidote alteration overprinting the quartz-sericite or the quartz-tourmaline alteration. A typical occurrence is the 10 m section from 190 to 200 m of MJTA-1. The uppermost 2 m of the section is a fault zone containing angular fragments of diorite porphyry. Calcite-epidote networks are well developed in the 8 m section below the fault zone. The average Au content for the 10 m section is estimated at 0.4 g/t, which is regarded significant for a geochemical concentration. Fluid inclusion analysis of a quartz vein sample at 201.9 m of MJTA-1 indicates homogenization temperatures ranging between 105 and 218^{c} C with a mode at 165° C. The rock geochemical prospecting has outlined a gold anomaly, without any anomalous copper values, to the south of the diorite porphyry body. The gold anomaly may reflect a mineralization of this type.

(d) Other Mineralization

Weak concentrations in Mo or Cu, without any notable increases in values of other elements, are occasionally associated with relatively intense silicification in the hole, MJTA-4.

3) Recapitulation of the Mineralization related to Diorite Porphyry

The characteristics of mineralization related to the diorite porphyry are summarized in the upper half of Table II-4-1-1.

The mineralization of Au-Cu type distributes from the nothern end of the diorite porphyry body northeastward to the vicinity of the prospecting hole, MZB-25, in association with quartz-pyrite networks in the quartz- sericite alteration zone. Along this zone of mineralization, a major fault trending in the NE-SW direction can be assumed on the basis of the surface geochemical features and the Bouguer gravity anomaly. This assumed fault may have played an important role for controlling emplacement of the Au-Cu type mineralization. The mineralization-alteration process is interpreted as follows;
Regional propylitic alteration has taken place accompanied by intrusion of the diorite porphyry. A K-alteration zone may have been also formed at this stage but is not identified with firm evidences in the current investigation.

Following the propyritic alteration, the mineralization of Au-Cu type has been introduced in association with pyrite-quartz networks. Noteworthy Au and Cu values are recorded from the mineralization of this type. Therefore, this is considered to be the main mineralization stage. This stage is characterized by the alteration mineral assemblage of quartz- sericite –chlorite, which is comparable to that of a phyllic alteration zone often associated with the porphyry style mineralization. However, the quartz-sericite alteration zone in Aktau is not so extensive as those associated with ordinary porphyry copper/molybdenum ore deposits which have been commercially exploited. The highest Au and Cu grades obtained to date are 0.4 g/t and 0.1 % respectively for a 3m section in MJTA-4. The contents of Au and Cu are generally higher in MJTA-4 than in MJTA-1, while pyrite is more predominating in MJTA-1 than in MJTA-4. This may imply that MJTA-4 is located relatively closer to the main mineralization zone and that MJTA-1 represents a surrounding pyritic zone. Judging from the ore mineral assemblage, the mineralization may have been introduced by hydrothermal solutions with temperatures of about 300° C or higher.

Following the main mineralization-alteration stage, weak Au and Cu mineralization has been introduced in association with the quartz-tourmaline alteration.

At the waning stage of the mineralization process, weak Au mineralization has taken place accompanied by carbonitisation. The Au anomaly, which has been outlined to the south of the diorite porphyry body by the rock geochemical prospecting, may be related to this mineralization. Temperatures of hydrothermal solutions for this mineralization range from105 to 218° C, according to the result of fluid inclusion analysis.

4) Follow-up Exploration

A composite map is prepared by compiling all the data to date and shown in Figure. II-4-1-4. A Cu-Au concentration was outlined by the 2nd Year rock geochemical prospecting, elongating in the NE-SW direction from the central part(near MJTA-1) of the diorite porphyry body northward. The hole, MJTA-4, drilled in the center of the Cu-Au geochemical concentration during this year's field campaign, includes mineralization and alteration which are similar in their features to those associated with porphyry style ore deposits in general. However, the mineralization is no higher in concentration of Cu and Au than a level of geochemical significance. Although only two drill holes have been put down in the geochemical concentration to date, there will be a little possibility to locate the mineralization of this type with any economic significance in size and grade, taking account of its extension confined within Ordovician series which terminates some 400m north of MJTA-4, bounded by North Zalturbulak fault. No improvement in the degree of concentration with depth is expected either, judging from the assay results of drill cores of the two holes.

(2) Mineralization Related to Granite

A branch of hornblende-biotite granite(hereinafter called 'granite') stems out of its main body in the northwestern part of Zalturbulak and extends south southeastward. A geochemical concentration of copper and molybdenum was outlined in association with the branch of granite by the 2nd year's rock geochemical prospecting. Mineralization of copper, molybdenum and gold is intersected by the hole, MJTA-5, drilled in the center of the geochemical concentration. Similar mineralization is also observed inassociation with the granie in the hole, MJTA-3, drilled in West Aktau. It is, therefore, reasonably assumed that the mineralization of this type has been formed in association with stocks of the granite branching from the main granite body.

1) Mode of Occurrence

The mineralized zone is characterized by development of abundant quartz-pyrite networks and/or pyrite-chalcopyrite dissemination, though only floats of quartz veins are observed on the surface. Overprinting these quartz-pyrite networks and pyrite-chalcopyrite, a number of quartz veinlets are occasionally observed in MJTA-5 and are concentrated with Au, Ag, Pb and Zn as well as Cu and Mo. The amount of quartz in the quartz-pyrite networks is comparatively small to that of pyrite. Alteration associated with mineralization is limited within or in close proximity of fractures. Where development of fractures is poor, unaltered rocks often remain between fractures.

2) Ore Minerals

Primary ore minerals are pyrite, chalcopyrite, molybdenite, magnetite, pyrrhotite, galena and electrum in descending order of the amount. Chalcopyrite occurs as dissemination or inclusions within pyrite. Molybdenite is mostly associated with extremely fine quartz veinlets which can be identified only under microscope.

3) Alteration

Chloritization and epidotization are ubiquitously developed both in MJTA-3 and-5, and are locally overprinted by quartz-sericite or clay alteration. Three alteration zones are distinguished, focusing on quartz-sericite and clay alteration.

(a)Propylitic Alteration Zone

This alteration zone is characterized by alteration mineral assemblage comprising chlorite, epidote and/or calcite. Chlorite and epidote form fine veinlets or replace mafic minerals. Epidote often occurs as speckles scattered in rocks, which features outcrops of propylitic alteration for field identification. Pyrite is disseminated along fine fractures in association with chlorite. Calcite, partially replacing silicates, is observed under microscope and rarely forms distinct veinlets.

(b) Argillic Alteration Zone

This alteration zone is characterized by alteration mineral assemblage comprising sericite, chlorite and epidote, and is occasionally associated with weak Mo mineralization. Sericite is mainly observed along fractures, often replacing other alteration minerals. Pyrite is very little in amount in association with this alteration zone. No evident silicification can be visually identified. Sericite/smectite mixed layer minerals and smectite are identified by X-ray diffraction analysis in addition to the above alteration minerals. This type of alteration is observed in MJTA-5 but not in MJTA-3.

(d) Quartz-Sericite Alteration Zone

This alteration zone is characterized by intense silicification and abundant sulfides exceeding 1 % in volume. Silcification is mostly accompanied by development of quartz networks. Chlorite is often formed, occasionally together with epidote, along walls of quartz veinlets composing networks. Sericite mostly replaces a part of plagioclase but occasionally occurs along fractures. Mafic minerals in this alteration zone are ubiquitously replaced by epidote, chlorite and/or calcite.

2) Mineralization

The mineralization is characterized by Mo concentration as described in Chapter 2, and is classified into 4 types according to elements associated with Mo and visual characteristics of mineralization and alteration.

(a) Mo Type: This type of mineralization typically occurs as weak concentration of Mo in the drill hole section between 98.0 and 175.0 m of MJTA-5, in association with the argillic alteration. Molybdenite is rarely identified with the aid of a hand lens. Ore minerals identified under microscope are molybdenite, chalcopyrite, magnetite and pyrite in slightly siliceous parts. No concentration of other metallic elements than molybdenum is recognized in any notable degrees in association with this type of mineralization. It is probable that the mineralization has preceded the main alteration-mineralization stage, however no decisive evidence is obtained to date.

(b) Mo-Cu-Au Type: This type of mineralization occurs in association with the quartz-sericite alteration. Association of distinct quartz networks and dissemination of abundant sulfides are the distinguishing characteristics of the mineralization. Typical Mo, Cu and Au concentrations are observed in the drill hole sections from 174 to 183 m and from 209 to 260 m of MJTA-5 and that from 171 to 233 m of MJTA-3. The mineralization is stronger in the intruded granodiorite than in the intruding granite in MJTA-3 as shown in Figure. II-4-1-3. Several 10m-sections between 120 and 240 m of MJTA-3 indicate Cu contents of 500 ppm or higher. Chalcopyrite, pyrite, molybdenite, magnetite and bismuthinite are the ore minerals identified under microscope.

(c) Mo-Cu-Au-Ag-Pb-Zn Type: This type of mineralization also occurs in the quartz-sericite alteration zone. Several assay runs of MJTA-5 indicate notable concenrations of Au, Ag, Cu, Pb, Zn and Mo within a mineralization zone of the Mo-Cu-Au type. A typical occurrence is the 2m-section(an assay run) from 219 to 221 m which shows an assay result of 280 ppb Au, 14 ppm Ag, 2064 ppm Cu, 1060 ppm Pb, 403 ppm Zn and 85 ppm Mo. In this section, quartz networks are crosscut by several fine quartz veins, in which dissemination of chalcopyrite and molybdenite is visually identified. A number of quartz veins are located in association with biotite granite some 500 m northwest of MJTA-5 and often accompany appreciable concentrations of Au, Ag, Pb and Mo. This surface mineralization can be compared with that of the 2m-section from 219 to 221 m of MJTA-5. Fluid inclusions in five surface samples of the quartz veins show homogenization temperatures ranging from 220 to 340° C(ref. to Appendix 10(5) of JICA/MMAJ, 1998).

(d) Au-Cu Type: A typical occurrence of Au and Cu concentrations is the 7m-section from 122 to 129 m of MJTA-3. The averages of Au and Cu are estimated at 370 ppb and 555 ppm respectively for the section. This type of mineralization is associated with pyrite-chlorite-quartz veins. Fluid inclusions in a sample, which is collected from a fine chlorite-quartz vein with weak Au-Cu mineralization at 233.1 m of MJTA-3, indicate a bimodal distribution of homogenization temperatures ranging from 180 to 300° C with two peaks at 190 and 270° C.

4) Recapitulation of the Mineralization related to Granite

The mineralization related to the granite has been brought about by intrusion of the granite differentiated from the granodiorite in late Carboniferous. As observed in MJTA-3, the mineralization is more distinct in surrounding intruded rocks than within the intruding granite. A series of the different types of mineralization has taken place in advancing order of Mo dissemination, Mo-Cu-Au quartz networks and Au-Ag-Cu-Pb-Zn quartz veins in West Zalturbulak, while the main mineralization stage of Mo-Cu- Au quartz networks has been followed by the Cu-Au type associated with chlorite-quartz veins in West Aktau. Comparing MJTA-3 and-5, Cu and Au values are generally higher in the former, and Mo values are higher in the latter. This difference in concentrations of these elements may be attributed to difference in geological backgrounds of the loci of the mineralization. To be more specific, the mineralization in West Zalturbulak has been formed within a batholithic granodiorite-granite complex, while that in West Aktau, in the periphery of the complex where the Au-Cu mineralization of late Devonian has preceded.

Fracture development is very poor in granitoids distributing in the general area. Intensity and extent of the porphyry style mineralization are primarily dependent on density of fractures and extent of their development. There will be, therefore, a little possibility for the mineralization of this category with any economic significance in size and grade in West Zalturbulak and West Aktau.

5) Follow-up Exploration

The Cu-Mo concentrations outlined by the rock geochemical prospecting are proved to be caused by the underlying Mo-Cu-Au mineralization in association with the granite bodies. Overprinting the main Mo-Cu-Au mineralization, the multi-element mineralization(Au, Ag, Cu, Pb, Zn and Mo) is located in the western part and is interpreted to have been formed in a later stage of the series of mineralization processes.

It may be reasonable to assume that favourable loci for the Mo-Cu-Au mineralization are peripheral zones of the granite bodies off-shooting from the main body in the northwest. No geochemical concentration of Mo, Cu and Au are located in association with such favourable zones, other than those drill tested by MJTA-3 and-5. In addition, fracture development, which is essential for a porphyry style deposit of economic significance, is generally poor in granitoids of the general area. Therefore, no target for further exploration virtually remains in West Zalturbulak and West Aktau from the geological and geochemical points of view.

One of the two outstanding IP anomalies, located to the west of the Cu-Mo geochemical concentration, remains untested. However, the records of the investigations during the former USSR era provide no supporting information for possible economic mineral concentration associated with the IP anomaly. Therefore, the priority of the IP anomaly is low for a follow-up exploration target.