### 4-2 Akmola prospect

### 4-2-1 Geology

Terrestrial pyroclastic rocks of early Devonian are extensively developed in Akmola and intruded by granitoids and porphyritic intrusions(Figure. II-4-2-1). The pyroclastic rocks comprise mainly fine grained rhyolite tuff and welded tuff accompanying minor andesite lava, sandstone and shale. Of the intrusions, medium grained granite occupies a large area, more than 10 km long in the east-west and about 2.5 km wide in the north-south, and is intruded by fine grained porphyritic granite stocks, quartz porphyry/porphyritic dacite stocks and dikes and andesite dikes. Most stocks have dimensions in the order of 500m by 200m. These intrusions are collectively grouped into the Karamendin Complex and are believed to range from Devonian to Carboniferous for their intrusion ages. Characteristics of each geologic unit are described below.

(1) Lower Devonian System

Distribution of the fine grained rhyolite tuff is most extensive of all the pyroclastic rocks in Akmola. The rhyolite tuff can be distinguished into two varieties, aphanitic and porphyritic. The former variety is creamy colored felsic rocks, often containing very minor plagioclase fragments, and is characterized by development of distinct platy joints. The latter, dark brown to brown in color, varies from rhyolite to dacite in its composition and contains quartz and plagioclase fragments of 1 to 3mm in sizes upto 30 volume % within vitreous matrices.

The welded tuff, being interbedded within the fine grained rhyolite tuff, is vitreous in texture and brown to brownish gray in color. Welded texture, comprising 1 to 3 mm thick vitreous layers, is characteristically well developed.

The andesite lava occurs as lenses interbedded within the rhyolite tuff and is limited in its distribution in the southeastern and southwestern corners of the Akmola exploration area. The andesite is dark gray to dark brown in color and porphyritic, containing abundant plagioclase phenocrysts with sizes of 1 to 4 mm.

The shale and sandstone occur as lenses interbedded within the pyroclastic rocks and is limited in their distribution in the southeastern corner of the exploration area. The shale is dark gray to purplish brown in color, hard and flinty, and often tuffaceous. The sandstone is dark gray to dark brown in color, mainly fine to medium grained, and occasionally argillaceous or tuffaceous.

(2) Karamendin Complex

The medium grained biotite-hornblende granite extensively distributes in the center of the Akmola exploration area with a dimension more than 10 km long in the east-west and about 2.5 km wide in the north-south. It intrudes the terrestrial pyroclastic rocks of the lower Devonian system as above explained. The granite, showing pinkish gray color in fresh specimens, comprises such major rock-forming minerals as K-feldspar, plagioclase, quartz, hornblende and biotite in descending order of the amount. Under microscope, most samples of the granite indicate adamellitic compositions containing nearly equal amounts of K-feldspar and plagioclase. However, the number of the samples submitted for the microscopic examination is still insufficient to specify the composition of the granite as a whole. Therefore, this intrusion is simply called 'granite' or 'medium grained granite' at this stage. Hornblende and biotite are more or less chloritized in many occurrences. Visual identification of biotite is sometimes very difficult due to extremely fine grain sizes.

The fine grained porphyritic granite forms several stocks some 700 m long and 200 m wide, elongating in the NE-SW direction. These stocks distribute in the center of the Akmola exploration area, intruding the medium grained granite. Its dikes, several meters in width, are also located in the eastern part. The porphyritic granite, showing pink color, comprises such rock-forming minerals as K-feldspar, plagioclase, quartz, hornblende and biotite, and contains euhedral plagioclase phenocrysts with sizes of about 4 mm within holocrystalline matrices with crystal sizes of 1 to 2 mm.

The quartz porphyry/porphyritic dacite occurs in the center of the Akmola area as stocks and dikes trending in the NE-SW direction. The long axes of the stocks range from 200 to 500 m in length. These stocks intrude the medium grained granite. Their intrusive relation with the porphyritic granite is unclear, although they occur geographically in its close proximity.

The quartz porphyry/porphyritic dacite contains quartz and plagioclase phenocrysts with sizes of 4 to 8 mm within matrices comprising quartz, feldspar and biotite. Hornblende phenocrysts are rarely identified. The amount of phenocrysts varies considerably even within a single intrusive body. Hereunder, the term 'quartz porphyry' is assigned to the porphyry containing a larger amount(30 to 60 volume %) of phenocrysts within relatively coarse grained matrices, and the term 'porphyritic dacite', to that containing less phenocrysts in relatively fine grained matrices. Most stocks and dikes of the quartz/ dacite porphyry are subjected to intense alteration. A sample, which is collected from a quartz porphyry dike(striking N 20° E, 18 m wide) subjected to minimal alteration, indicates a K-Ar age of 310±6 Ma, which is correlated to early Carboniferous.

The andesite occurs as dikes with widths of 1.5 to 5 m and contains hornblende and pyroxene as major mafic minerals. It is subjected to chloritization and shows dark green color on outcrops. Chloritization is the most prevailing alteration associated with the andesite dikes intersected by the drill holes during the 3rd Year's campaign, although quartz-sericite alteration and pyrite dissemination are also observed in part.

In addition to the above major intrusions, floats of quartz diorite porphyry and diorite porphyry are occasionally found in the course of the surface prospecting. Their modes of occurrence in-situ are unknown but are probably derived from intrusions of minor scales. The quartz diorite porphyry, gray in color, contains euhedral plagioclase phenocrysts with sizes of about 4 mm within holocrystalline matrices comprising quartz, plagioclase, hornblende and biotite of about 1 mm sizes in descending order of the amount. K-feldspar is hardly observed. The diorite porphyry, dark green to gray in color, contains abundant euhedral phenocrysts of plagioclase with sizes of about 4 mm within holocrystalline matrices comprising plagioclase, hornblende and minor quartz of 1 to 2 mm sizes.

**4-2-2 Alteration**

According to the field observation, a combined zone of quartz-sericite and argillic alteration is outlined for an area of some 2300 m long north-south and 1600 m wide east-west, enclosing a number of stocks of the porphyritc granite and the quartz porphyry/porphyritic dacite in the center of the Akmola exploration area. Chlorite-epidote alteration is developed in the fine grained rhyolitic tuff and the medium grained granite surrounding the alteration zone (Figure II-4-2-2). It is interpreted on the basis of the core observation of the 4 holes drilled in the 3rd Year's campaign that the alteration sequence is 1) chlorite-epidote, 2) argillic and 3) quartz-sericite alteration in their advancing order. Alteration zoning of the Akmola area differentiates 4 alteration zones, namely, unaltered, propyritic, argillic and quartz-sericite. The argillic and quartz-sericite alteration zones distribute in an extremely complicated fashion controlled by fracture systems. Minor clay and calcite veins, post-dating the quartz-sericite alteration, are locally developed. Characteristics of each alteration zone are described below.

(1) Unaltered –weak altered Zone

Rhyolitic pyroclastics in the southern and northwestern parts are unaltered. Very minor sericite-smectite mixed layer minerals and calcite are occasionally identified by the

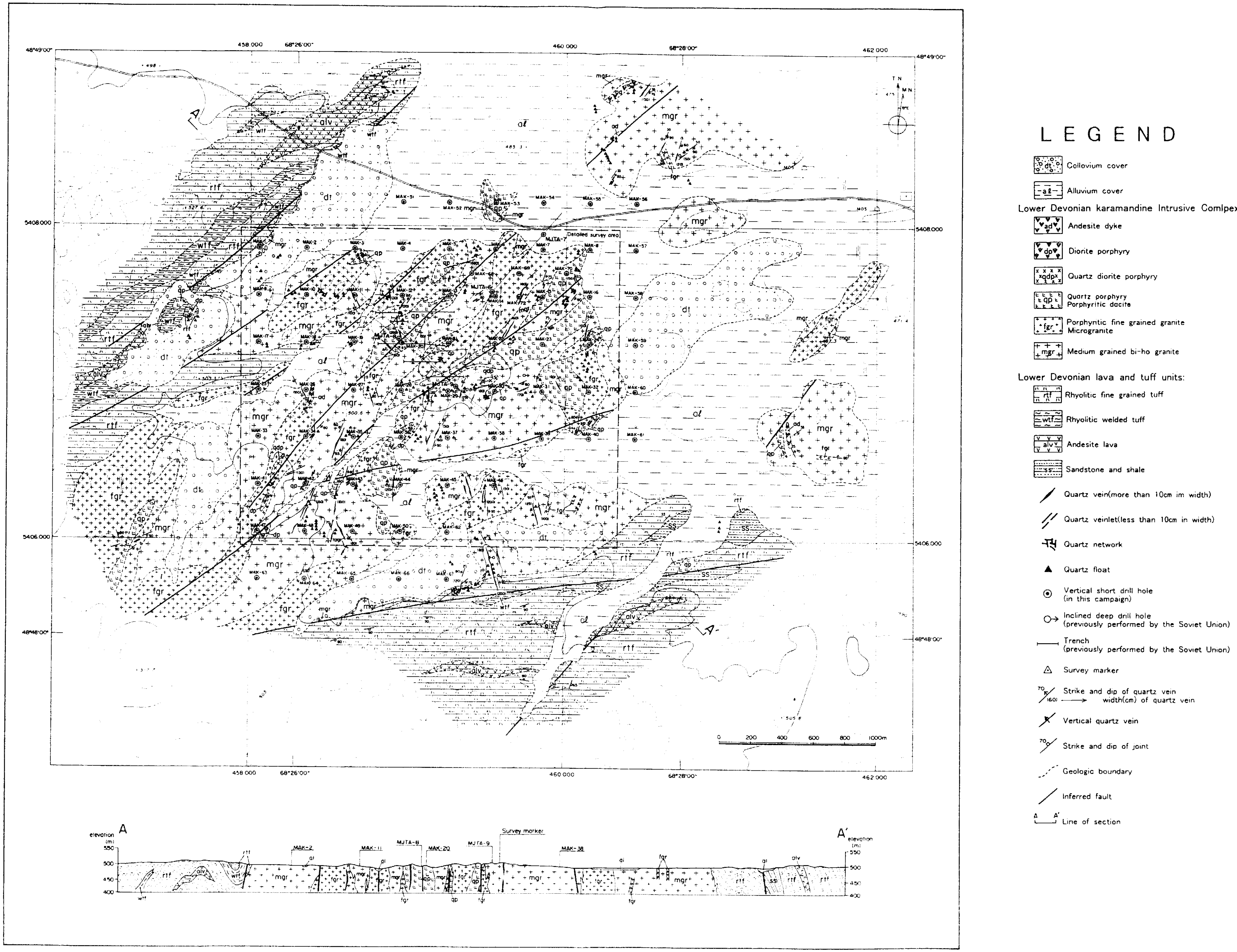


Figure Ⅱ-4-2-1 Geological Map of the Akmola Area

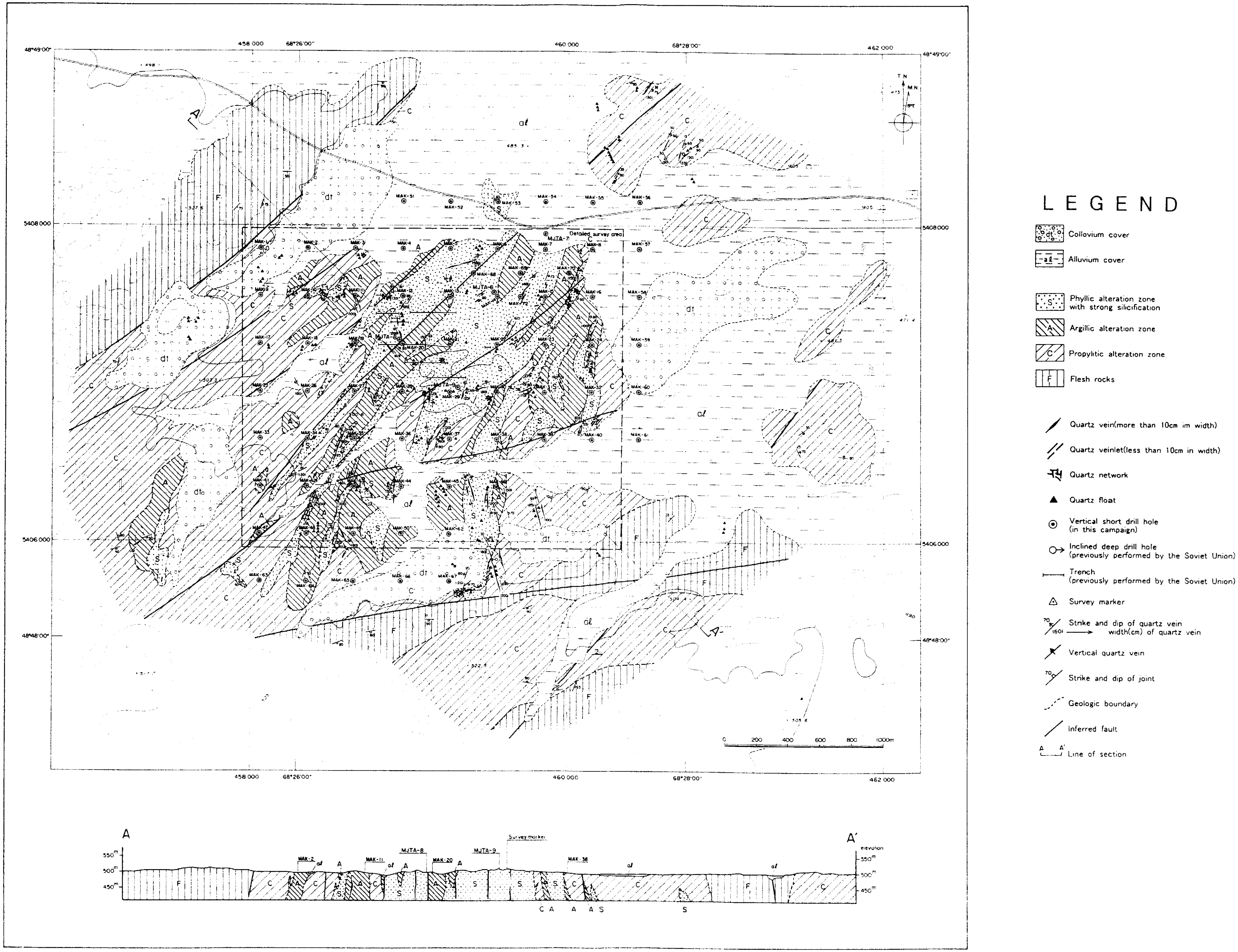


Figure Ⅱ-4-2-2 Alteration Zoning Map of the Akmola Area

X-ray diffraction analysis and the microscopic observation of thin sections. Rocks are judged unaltered, where alteration is visually very weak or more specifically hornblende is devoid of alteration.

(2) Propylitic Alteration Zone

In this alteration zone, biotite, hornblende and occasionally a part of plagioclase are altered to chlorite and/or epidote causing dark green appearance of rocks. According to the result of X-ray diffraction analysis, a large amount of chlorite is commonly contained, accompanied by minor chlorite-smectite mixed layer minerals, sericite-smectite mixed layer minerals, pyrite and calcite. Under microscope, mafic minerals are largely altered to chlorite and partly to epidote, while a part of plagioclase is often altered to sericite.

(3) Argillic Alteration Zone

The argillic alteration zone distributes in an area of some 2300 m long north-south and 1600 m wide east-west in the center, inter-fingering with the quartz-sericite alteration zone controlled mostly by the NE-SW fracture system. Alteration minerals identified by the X-ray diffraction analysis are sericite-smectite mixed layer minerals, smectite, kaolinite, chlorite, chlorite-smectite mixed layer minerals, pyrite and calcite. Where the alteration is weak, e.g. in the drill hole, MJTA-7, only chloritization of mafic minerals and argillization of plagioclase are observed, with the original texture of rocks being well preserved. Where the alteration is intense, the original texture is completely obliterated, with development of minor quartz veinlets and sericite.

(4) Quartz-Sericite Alteration Zone

This alteration zone overprints the above two alteration zones and distributes in the same extent as of the argillic alteration zone, controlled by the NE-SW fracture system. Rocks subjected to this alteration present white, fine grained appearance, with the orignal rock texture being completely obliterated. The alteration is often accompanied by numerous quartz veinlets and networks as well as abundant pyrite dissemination. It is interpreted, based on the field and drill core observation, that the alteration postdates the propylitic and the argillic alterations and that the NE-SW fracture system has played an important role for its emplacement. Quartz, sericite and pyrite are characteristically abundant in altered rocks according to the results of X-ray diffraction analysis and microscopic observation of thin sections. It is distinguished from the argillic alteration by its by far intense silicification and lack of sericite-smectite mixed layer minerals. Where the alteration is weak, minor relicts of chlorite and feldspar are occasionally observed.

### 4-2-3 Mineralization

Two types of mineralization have been recognized in the Akmola exploration area, namely, Mo mineralization associated quartz networks and pyrite dissemination, and Au mineralization in quartz veins with widths ranging from 0.2 to 5.0 m. The former is limited in its occurrences within the quartz-sericite alteration zone, and the latter occurs in all of the three alteration zones. The latter mineralization is fully explained in the 2nd Year Report. This section will describe the characteristics of the Mo mineralization associated with quartz networks and sulphide dissemination, for which significant new data are collected through the drilling campaign of the 3rd Year's Investigation.

1) Mode of Occurrence

The Mo mineralization occurs within the quartz-sericite alteration zone formed mainly in the medium grained granite body and the quartz porphyry stocks. An oxide zone is developed to the depth of 20 to 40m from the surface. Outcrops are prominently stained with hematite forming networks, veinlets, speckles and dissemination, where the mineralization is expected, and are often shuttered or brecciated.

The Mo mineralization, as observed in drill cores, is confined within the quartz-sericite alteration zone and invariably associated with quartz networks. Sulfides, which can be visually recognized, are mostly pyrite, minor chalcopyrite and rarely molybdenite. Pyrite and chalcopyrite occur as dissemination of 0.5 to 1 mm grains, 1 to 5 mm thick veinlets or speckies about 1 cm across. Molybdenite is extremely fine grained in general for visual identification. Where identifiable, it forms thin films along fractures or walls of quartz veinlets. Extremely fine grains of these sulfides are also disseminated in quartz veins and veinlets. The total amount of sulfides reaches 1 to 5 volume %, where concentrated. Sulfide dissemination is best developed in MJTA-9, followed by MJTA-8 and then MJTA-6. The alteration which is observed in MJTA-7, is the argillic one but without any notable concentration of sulfides.

2) Ore Minerals

The ore minerals commonly observed under microscope are pyrite, goethite, chalcopyrite, pyrrhotite, molybdenite, galena and electrum. Also rarely identified are magnetite, covellite, bornite, sphalerite, bismuthinite, arsenopyrite, chalcocite, native silver and aikinite($PbCuBiS_3$). Of these, chalcocite and native silver occur only near surface.

3) Mineralization

Mineralization with an average grade of 0.045 % Mo is intersected for the 38.0 m section between 210 and 248 m of MJTA-9(Figure II-4-2-3). The host rocks, comprising medium grained granite, are subjected to extremely intense silicification with dense development of quartz networks. Such alteration minerals as quartz, sericite and chlorie are identified by the X-ray diffraction analysis. The total amount of sulfides is visually estimated at 3 to 4 volume %. The sulfides consist of mainly pyrite, subordinate molybdenite and very minor chalcopyrite. Molybdenite occurs as fine euhedral crystals with the maximum size of 50 microns and is concentrated upto 2 to 3 volume % as observed under micro- scope. It forms independent constellations from other sulfides but occasionally occurs as inclusions within pyrite.

Mo values above and below the mineralized section are significantly elevated to several tens ppm for appreciable intervals. Increases of Mo values to this order for substatial intervals are also indicated in MJTA-6 and-8 as well, although no such high concentration as in the mineralized section in MJTA-9 is intersected by these drill holes. It may be expected that economically noteworthy mineralization occurs in the vicinity of these holes.

Fluid inclusions of 3 core samples collected from quartz networks in MJTA-8 indicate homogenization temperatures ranging from150 to 220° C, while those of fluid inclusions of surface samples range between 250 and 360° C. Salinity of the fluid inclusions of the same core samples shows a bimodal distribution, with one population ranging from 8 to 10 % and the other, from 20 to 28 %.

**4-2-4 Follow-up Exploration**

The Mo mineralization, intersected for an appreciable interval by MJTA-9, is associated with quartz networks and intense pyritization within the quartz sericite alteration zone and is formed in close proximity to the contact between the intruded medium grained granite and the intruding quartz porphyry. These modes of occurrence imply that the mineralization is of a porphyry style.

Although the degree of Mo concentration is considered sub-economic at this stage, the drill holes to date are too scarce in number and too widely spaced to verify its economic significance. Some additional drill holes with appropriate intervals will be required for an adequate economic assessment of the mineralization.

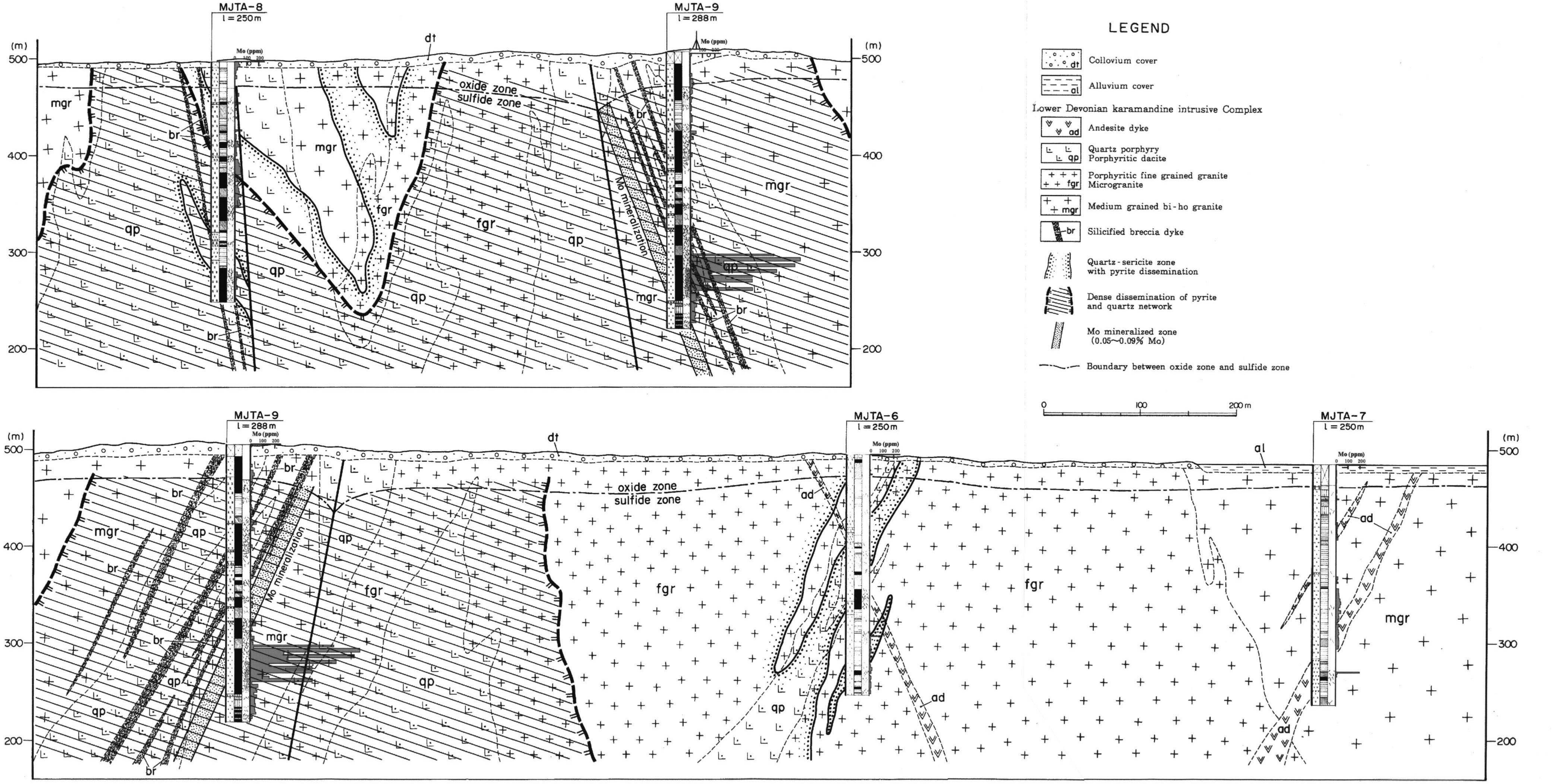


Figure II-4-2-3 Cross Section though drilling sites

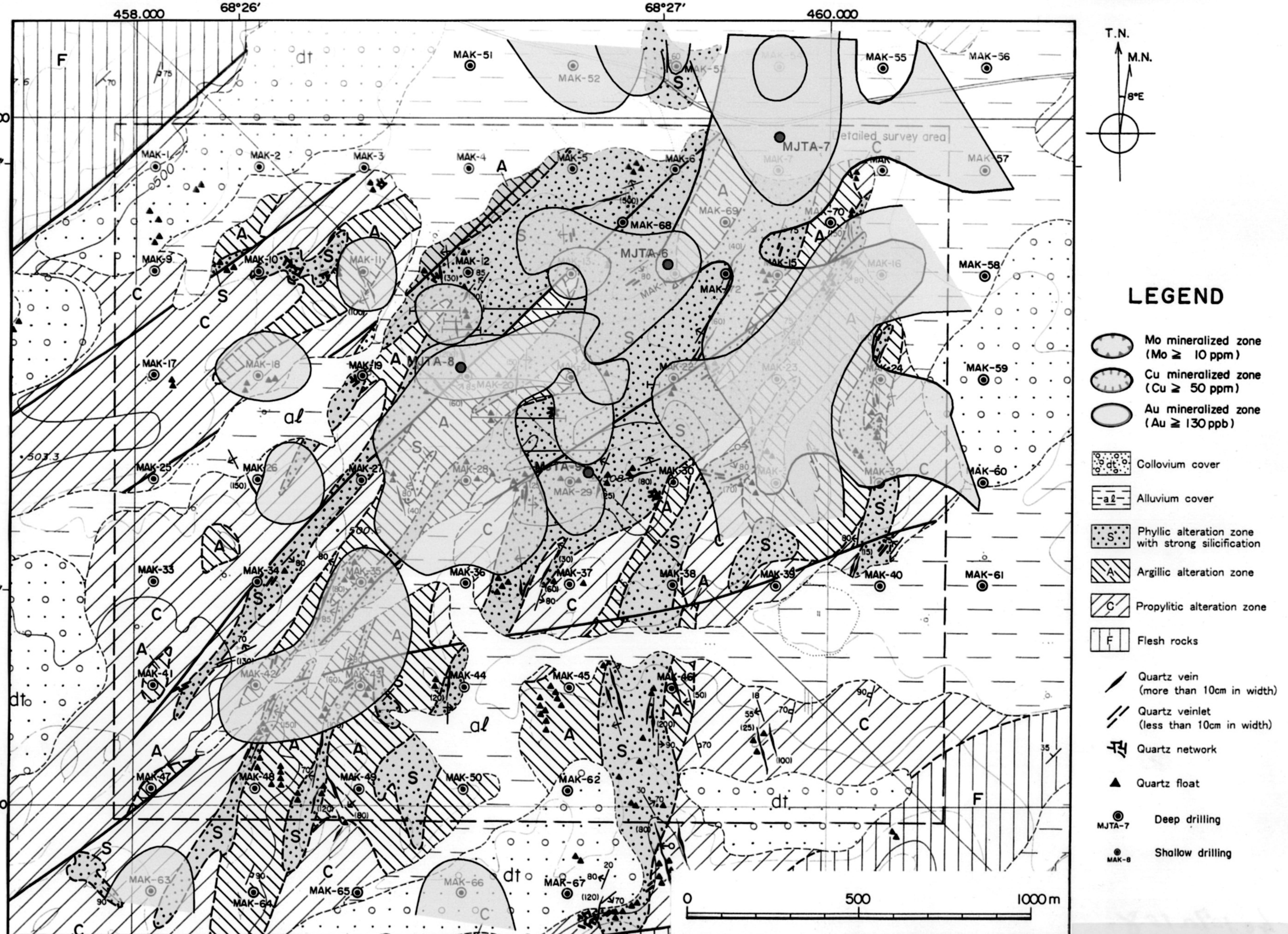


Figure II-4-2-4 Interpretation Map of Geology. Alteration and Geochemistry of Akmola Area

### 4-3 Type of the mineralization and the geotectonic position

In this section, the geotectonic position of the mineralization in the Central Zalturbulak and Almola area will be considered. The occurrence of mineralization in this area is similar to those of porphyry type mineralization. Zvezdov et al (1993) was divided the porphyry type deposits of CIS countries into four types. In this study, data from the Central Zalturbulak and Almola area are compared with Zvezdov et al (1993) data (Table II-4-3-1).

1) Geotectonic position

Au-Cu mineralization in Aktau West corresponds to the Porphyry copper and gold-copper type of Zvezdov et al (1993). All data, such as high Cu/Mo & low Cu/Au ratio of the mineralization zone, existence of magnetite and hematite as main ore minerals and low $K_2O$/ $Na_2O$ ratio & low S/I values of associated igneous rock, strongly shows that the mineralization is similar to the porphyry copper and gold-copper type. Zvezdov et al (1993) correlated this type of mineralization to 'Diorite models' which formed in island arcs.

Cu-Mo mineralization associated with granite in Western Zalturbulak and Aktau West shows low Cu/Mo ratio of the mineralization zone, medium $K_2O$/ $Na_2O$ ratio & low S/I values and resembles 'Gold-bearing porphyry molybdenum-cooper 'type or 'Gold containing porphyry molybdenum-cooper type. However, Cu/Au ratio is exceptionally low. The reasons of this are thought as follows:

The mineralization of Aktau West has been formed superimposing on the previous Au-Mo mineralization and probable remelted the Au and Cu in the existing mineralization. In Western Zalturbulak, main Cu-Mo mineralization has been followed by the Au-Ag-Cu-Pb-Zn. This mineralization might have been affect the Cu/Au ratio. Zvezdov et al (1993) correlated this type of mineralization to 'Granodiorite models' or 'Monzonite models', which formed on marginal area of continent.

Akmola mineralization is characteristic of very low Cu/Mo ratio and correlative to Porphyry molybdenum type. However, from nature of host rock, it is similar to 'Gold-bearing porphyry molybdenum-cooper 'type or 'Gold containing porphyry molybdenum-cooper type. In Akmola area, instead of magnetite, pyrrhotite is observed in many polished section. A few Ilmenite are also recognized. Theses ore minerals may reflect the difference of circumstances between Akmola mineralization and Cu-Mo mineralization associated with granite in Zalturbulak. Although it is certain that the Akmola mineralization have been formed within continent or marginal continent, the age and regional stress field are assumed to have been different from that of Western Zalturbulak and Aktau West.

**TableII-4-3-1 Comparsion of porphyry type deposit**

| | This survey | | | Zvezdov et.al (1003) | | | |
|---|---|---|---|---|---|---|---|
| | Aktau west | Western Zalturbulak | Akmola | Porphyry copper & gold-cooper porphyry | Gold-bearing porphyry molybdenum-copper | Gold-containing porphyry copper-molybdenum | Porphyry molybdenum |
| Main ore-forming minerals | Pyrite,chalcopyrite, magnetite, pyrrhotite (hematite,cubanite) | Pyrite,molybdenite,chalcopyrite (magnetite,hematite) | Pyrite,molybdenite,chalcopyrite,pyrrhotite(magnetite, ilmenite,hematite) | Pyrite,chalcopyrite, magnetite, hematite,bornite(pyrrhotite) | Pyrite,chalcopyrite,molybdenite(bornite,magnetite, galena,sphalerite) | Pyrite,chalcopyrite,molybdenite,bornite(galena,sphalerite) | Pyrite,molybdenite, chalcopyrite(scheelite,cassiterite) |
| **Mineralized element** | | | | | | | |
| Mineralization | Cu-Au | Mo-Cu-Au | Mo | Cu-Au | Cu-Mo-Au | Mo-Cu-Au | Mo |
| Associated mineralization | Pb-Zn | Pb-Zn-Ag | | Pb-Zn | Pb-Zn-Ag | Pb-Zn-Ag | Sn-W |
| **Geochemical peculiarities of ore** | | | | | | | |
| Cu/Mo ratio in primary ore* | 267:1(MJTA-4) | 3.9:1(MJTA-5), 26.4:1(MJTA-3) | 1:10(MJTA-9) | 200:1-250:1 and greater | 30:1-200:1 | 15:1-40:1 | 1:1-20:1 |
| Cu/Au ratio | 57700:1(MJTA-4) | 2400:1(MJTA-5), 6600:1(MJTA-3) | 1:1460(MJTA-9) | 8500:1-75,000:1 | 10,000:1-200,000:1 | 75,000:1 and greater | more than 200,000:1 |
| **Geochemistry of the associate rock** | | | | | | | |
| $K_2O/Na_2O$ ratio | 0.41-0.43 | 0.49-0.53 | 0.50-0.57 | 0.1-0.4 | 0.5-0.8 | 0.9-1.2 | 1.2 |
| Granitoids series** | I | I | I | I | I | I-S | S |
| $S/I=Al_2O_3(Na_2O+K_2O+CaO)$ | 0.82-0.99 | 0.96-1.01 | 0.93-1.01 | 0.6-0.9 | 0.7-1.0 | 0.8-1.1 | 0.9-1.3 |
| Granitoids series*** | magnetite | magnetite-ilmenite | magnetite-ilmenite | - | - | - | - |
| **Deposit model** | | | | "Diorite" | "Granodiorite | "Monzonite" | "Granite" |

*MJTA-4 :130-220m,MJTA-5:204-289m,MJTA-3:171-231m,MJTA-9:213.5-248m
**:Chappell and White,1974
***:Ishihara,1977