tion (such as small ore veins in the southeastern part). However, as pointed out in the geochemical survey by the stream sediment carried out in the North Area, Cu values would possibly pick up such anomalies as to related to the dykes of granite. As the fairly large interval of the sampling points was taken in this geochemical survey, the presence of the continuity between the Erdouz North ore deposit and the Erdouz South ore deposit was not confirmed, although only one indicative value of Cu was recognized between the two ore deposits (at the north of the latter). It is thought to be necessary to consider over the execution of the survey by establishing grid with smaller interval of the sampling points, in future program.

2-2-3 Mineralization

In this area, the Erdouz North ore deposit (Cu, Pb, Zn) is located on the northern slope of the range at the approximate altitude of 2,650 meters above sea level, while the Erdouz South ore deposit (Cu, Pb, Zn) is located on the southern slope of the range, at the approximate altitude of 2,800 meters above sea level. There are remains of open pits and old tunnels showing the way of mining in the past. Most of the old tunnels have been destroyed already and there is no other way for the information on the features of the ore deposits than to map the outcrops of the ore deposit and to estimate from the old records. There are several indications of lead-zinc mineralization in the northeast of the Erdouz North ore deposit and in the southwestern part of this area, where the explorations by the trenching and by the tunnelling of the length of 10 m or so are recognized to have been carried out.

The characteristics of the principal ore deposits and the indications of mineralization are described in the following.

1) Erdouz North ore deposit (Refer to PL-13-1): This ore deposit was worked between 1927 and 1972. Total length of the tunnels is 2,840 meters (4 levels: 2,692mL, 2,672mL, 2,652mL, 2,635mL), and the production was recorded to have been 30 tons of lead, 23,8 tons of zinc and 25,47 kg of silver. The wall rocks of the ore deposit are mainly limestone and calcareous schist. On the geological structure, the area where this ore deposit is distributed is along the axis of a large scaled anticline in this area, where complicated tight fold structures are recognized. In the northwestern side and in the southern side, which are correspondent to the upper horizons of the limestones bearing the ore deposit, pelitic schist and psammitic schist are distributed with the thickness of 50 to 100 meters. The mineralization is inferior in these areas where the pelitic and psammitic schists ard distributed.

The ore deposit is lead-zinc bearing quartz veins along the fissures accompanying the clay-fracture zone. There are 5 ore veins recognized in an approximate area of 100 m x 100 m. The strikes of the veins are N45°E or N10°E and the dip is mostly as steep as 70° ∿ 80° to the southeast. The horizontal extension of each ore vein recognized is about 150 meters. By the old records, the ore deposit is as wide as 10 cm ∿ 50 cm and the continuity is estimated to be 10 to 20 meters usually, although the figure of maximum 50 meters is recorded. Around junctions of the fissures, ore shoots are formed, where ore grades are comparatively high.

The ore minerals are mainly galena and sphalerite with less amount of chalcopyrite and pyrite. Under microscope, the sphalerite is massive and often has dots of chalcopyrite partly, while galena and chalcopyrite are recognized along the periphery of the sphalerite and in some cracks. Very small amount of tetrahedrite and gersdorffite are recognized. Electron Probe Micro Analysis revealed that tetrahedrite contains lots of silver. (Table 8, Table 10). Tetrahedrite is contained in sphalerite and galena, while gersdorffite is found surrounding pyrite grains (Table 7-2, GK-90).

The ore grades of the ore deposit is not obvious, because the underground mapping was impossible due to the collapse of the old tunnels. The ore grades at the outcrops on the surface are Cu: 0.08 ∿ 0.46 %, Pb: 0.41 ∿ 35.66 %, Zn: 4.80 ∿ 40.03 % and Ag: 9 ∿ 660 g/t (Table 11-1, MR-14, MR-15, MR-16, MR-17, GK-90, GK-91, GK-92, GK-93). Taking average of these ore grades, they are Cu: 0.2 %, Pb: 8.5 %, Zn: 13.5 % and Ag: 170 g/t. Therefore, it is possible to expect such ore grades as high as Cu: 0.2 %, Pb + Zn: 15 ∿ 20 % and Ag: 100 g/t.

The mineralization is thought to be controled by the lithology of the wall rock and by the geological structure, viewing the points that the wall rocks are limestone and calcareous schist, that the ore deposits are confined to the characteristic part on the geological structure where complicated folding structures are developed along the axis of the fold and that the location of the ore deposit is close to the Erdouz fault. Especially, it is a tendency that ore shoots are formed around junctions of the fissures. It is thought that the igneous rocks related to the mineralization would be the porphyrite dykes distributed along the Erdouz fault.

2) Erdouz South ore deposit (Refer to PL-13-2): The area around this ore deposit is underlain by limestone, psammitic schist, and calcareous schist. The strike of the beds is almost north and south, and the dip is as steep as 60° ∿ 80° to the west.

The fissures developed in the limestone and in parts of the calcareous schist are of the following three systems;

N 45°E system with the dip of 60° ∿ 80° to the east
N 20°E system with the dip of 70° ∿ 80° to the east
N 60°E system with the dip of 40° ∿ 50° to the north
N 35°E system with the dip of 40°± to the east

The ore deposits are recognized in an area of 150 m x 200 m. There are the ore deposits of vein type emplaced along the above fissures and the ore deposits of stratiform type seated along the bedding planes of the limestone. Both of them are lead-zinc ore deposits associated with quartz. The former is as wide as 5 cm to several ten centimeters forming steep ore veins along fracture zones in addition to the disseminated orebody in some places. The latter ore deposits have the width of 10 cm to 30 cm and are in the form of several almost horizontal layers of the ore deposits. The mineralization is recognized in an area within 10 m or 15 m of the steeply dipping ore veins. It is thought that the ore deposits would have been emplaced after the openings were formed along the bedding planes at the period of the folding movement.

The ore minerals are mainly galena and sphalerite associated with less amount of chalcopyrite and pyrite. Under microscope, tetrahedrite is recognized in addition to the above-stated (Table 7-2, GK-72, GN-52).

The ore grades of the outcrops on the surface are Cu: 0.03 ∿ 1.20%, Pb: 0.16 ∿ 4.30%, Zn: 0.40 ∿ 10.00% and Ag: 16 ∿ 220 g/t (Table 11-1, MR-9, MR-10, MR-11, GK-73). Average grades are Cu: 0.39%, Pb: 1.31%, Zn: 3.14% and Ag: 94 g/t. However, as the underground mapping was almost impossible for this ore deposit, it is doubtful whether these figures are representing the average grades of the orebodies appropriately. As far as observed at the outcrops on the surface, it is comparatively easy to distinguish the ores from the wall rocks. Therefore it is thought to be easy to obtain higher grade of ores by hand picking.

As there is no record, the production from the ore deposit is not certain. By the estimation from the wastes piled on the surface, the mining would have been carried out by the adit only, and the production is thought to have been between several 10 tons and about 100 tons.

The factors controling ore shoots are thought to be the species of the wall rocks, the fissure systems and the folding structures. That is, it is a tendency that the ore deposits are distributed exclusively in the limestone. In many cases, the ore deposits are found in such parts of the limestone as the intraformational foldings are well developed. It is thought that the ore deposits would have been emplaced along the cracks in the limestone and in the spaces along the bedding plans in the folding structures. The igneous rocks recognized around the ore deposit are microgranite, but it is not certain whether this microgranite is related to the formation of the ore deposit.

The area of the mineralization clarified in the present survey is in anoval shape of about 300 meters in east and west and about 400 meters in north and south. However, by the results of the geochemical survey, the possibility has been indicated that the mineralized area would be extending several 100 meters further to the north.

3) Other indications of mineralization: At several places in the southeastern part of this area, outcrops of lead-zinc veinlets are recognized. Of them, the outcrops at the altitude of 2,700 meters above sea level (MR-7) is seated in a porphyrite dyke with the approximate width of 10 meters. The ores of 4 ∿ 5 seams of thin veinlets of the width of several centimeters are recognized in a width of about 1 meter. The ore grades are Pb: 8.40% and Zn: 0.25% (Table 11-1, MR-7). The other indications are dissemination along fissilities in limestones (MR-8, GK-74) and their continuities are as far as several meters.

2-2-4 Discussion

The existence of the ore deposits has been known in this area, and small scaled exploration and mining were carried out. However, as the topographical features are steep in this area, it was quite rare that consideration was given to the ore deposits in relation to the geology and the geological structure in the surrounding areas. In the present investigation, the general and semi-detailed geological survey with simple land survey and the geochemical survey by soil sampling were carried out. As the results of these surveys, it has been clarified that the mineralization in this area is related intimately to the geological structure and it has become possible to extract the favorable areas for the emplacement of ore deposits. These facts are thought to be suggesting that the survey methods as were employed in the present investigation would be effective. Especially, it is important that the complicated geological structures have been elucidated clearly by plotting the locations of the outcrops of the mineralization on the maps.

The geology and the geological structures clarified in the present surveys are described in the following. That is, it has been clarified that limestone, psammitic schist, pelitic schist, and calcareous schist are distributed in the eastern part of this area, that green schist is distributed predominantly in the western part of this area, that an anticlinorium has been found in the central part with almost horizontal axis running in the form of the letter 'S' from the northeast to the southwest, that the area has been blocked by the faults of the E-W system and of the NE-SW system and that the component rocks and the geological structures are characteristically different among these blocks. It is thought that the period of the formation of these faults would be indicated to have been after the completion of the folding structure by the difference of the scale of the structures.

As to the mineralization in this area, there are lead-zinc ore deposits of the vein type. In certain areas, these vein type ore deposits are revealing fairly intense mineralization, being concentrated in the form of several seams of ore veins as are the cases of the Erdouz North ore deposit and the Erdouz South ore deposit. But there are indications of weakly mineralized ore veins as shown by those scatteringly distributed in the southeastern part of this area. The intensely mineralized zones are located in the area where limestone or alternation of limestone and pelitic schist are distributed. Especially, in the area where limestone is distributed, the ore deposits have a tendency to form enriched part of mineralization while in the area where other rocks are distributed mineralization is apt to be inferior. The Erdouz North ore deposit and the Erdouz South ore deposit are distributed along the Erdouz fault, which has the trend in the direction of NE-SW. Furthermore, the former ore deposit is located along the anticline axis where intense folding structures are recognized, while the latter ore deposit is found in the intraformational folding zone characterized with tight folds. These facts are thought to be revealing that the mineralization in this area would have been controled heavily by the geological structures such as faults and folding structures.

By the results of the present geochemical survey, the strong anomalies of each of the three elements of Cu, Pb and Zn are in good correspondence with the above-stated two areas where the ore deposits are distributed. These anomalous zones are indicative of the extension of the ore veins. The weak anomalies are distributed in the surrounding areas of the strong anomalous zones. These weak anomalous zones are indicating the possibilities that the mineralization would be continuous in the northeastern extension of the Erdouz North ore deposit and in the northern area of the South ore deposit. These facts are thought to be suggesting that the geochemical survey method by collecting soil samples as was employed in the present investigation would be quite effective for the exploration of ore deposits distributed in this area. It is noted that, among the above three elements, Pb and Zn have high correlative relation and that either of these two elements would play sufficient role for the purpose of the survey. As for the element of Cu, a tendency has been recognized that the Cu values could be indicative of the presence of granitic dykes. Therefore, it is necessary to give full consideration on this point in future exploration.

Based on the above-mentioned considerations on the results of the surveys, the favorable areas to be recommended to warrant further investigations are around the Erdouz North ore deposit and around the Erdouz South ore deposit. It is notable that fair amount of lead is contained in the mineralization around the outcrops of the Erdouz North ore deposit, and it is expected that there would be continuity of the ore deposit to the depth. Also, in the northeastern area of this ore deposit, there is an extension of the weak anomalous zone by the geochemical survey, and it is thought to be necessary to clarify the distribution of faults as well as to pursue the distribution of the limestone beds. Lead is also highly contained in the mineralization around the outcrops of the Erdouz South ore deposit, and the continuity of the ore deposit can be expected to the depth. By the results of the geochemical survey, the anomalous zone is extending toward north from the ore deposit. It is thought to be desirable to carry out further exploration to the depth of the ore deposit as well as in the northern area.

The presence of the continuity between the Erdouz North ore deposit and the Erdouz South ore deposit has not been clarified in the present surveys. The area between the two ore deposits is underlain by the thick layers of psammitic schist and pelitic schist and is forming high mountain range. However, it is estimated that the folding structures in this area have gently plunging axes, and it is thought to be possible that the limestones are distributed below the level where these two ore deposits are located, and that mineralization could reach these limestones. Therefore, it is necessary to take the area between these two ore deposits as the area where further exploration would be warranted.

2-3 Azegour Sector (Refer to Fig.13)

The Azegour Sector is located in the north of the central part of the North Area. It is a strip of an area of about 1.5 km in east and west and about 5 km in north and south. In the south of this area, there is a village called Azegour. A branched stream from the Amezmiz river passing around this village is spitting the subject area and flowing toward the north, forming deep valley, in the central part of this area. After flowing across the surveyed area and joining with another stream flowing from Entifa in the northern end of the surveyed area, this river is streaming down toward the Amezmiz village.

Although it is possible to drive vehicles from Amezmiz to Azegour and from Azegour to Tizgui village, there is no other way than of foot or on horseback for the access to any other places in the surveyed area.

In the southern part (about 1,500 meters above sea level) of this area, there is Azegour mine, which was worked actively in the past. This mine produced copper, tungsten and molybdenum. There are remains of the old tunnels left there.

2-3-1 Geology and Geological Structure

(1) Geology (Refer to PL.5-1, PL.5-2, PL.5-3, PL.5-4, PL.6-1, PL.6-2)

This area is underlain, geologically, by the metamorphic rocks belonging to the Cambrian system of the Paleozoic group and granite and porphyrite intruding them in addition to the sedimentary rocks of the Mesozoic Cretaceous system. The metamorphic rocks of the Paleozoic Cambrian system are composed of pelitic schist, spotted schist, gneissose schist, limestone and calcareous schist.

The pelitic schist is black and phyllitic rock, easily foliated. Megascopically, biotite and muscovite are recognized. The spotted schist is black or dark brown in color, and many black spots about 1 mm in diameter are recognized, with naked eyes. Under microscope this rock is composed of biotite, muscovite, chlorite, plagioclase, quartz and tourmaline, bearing

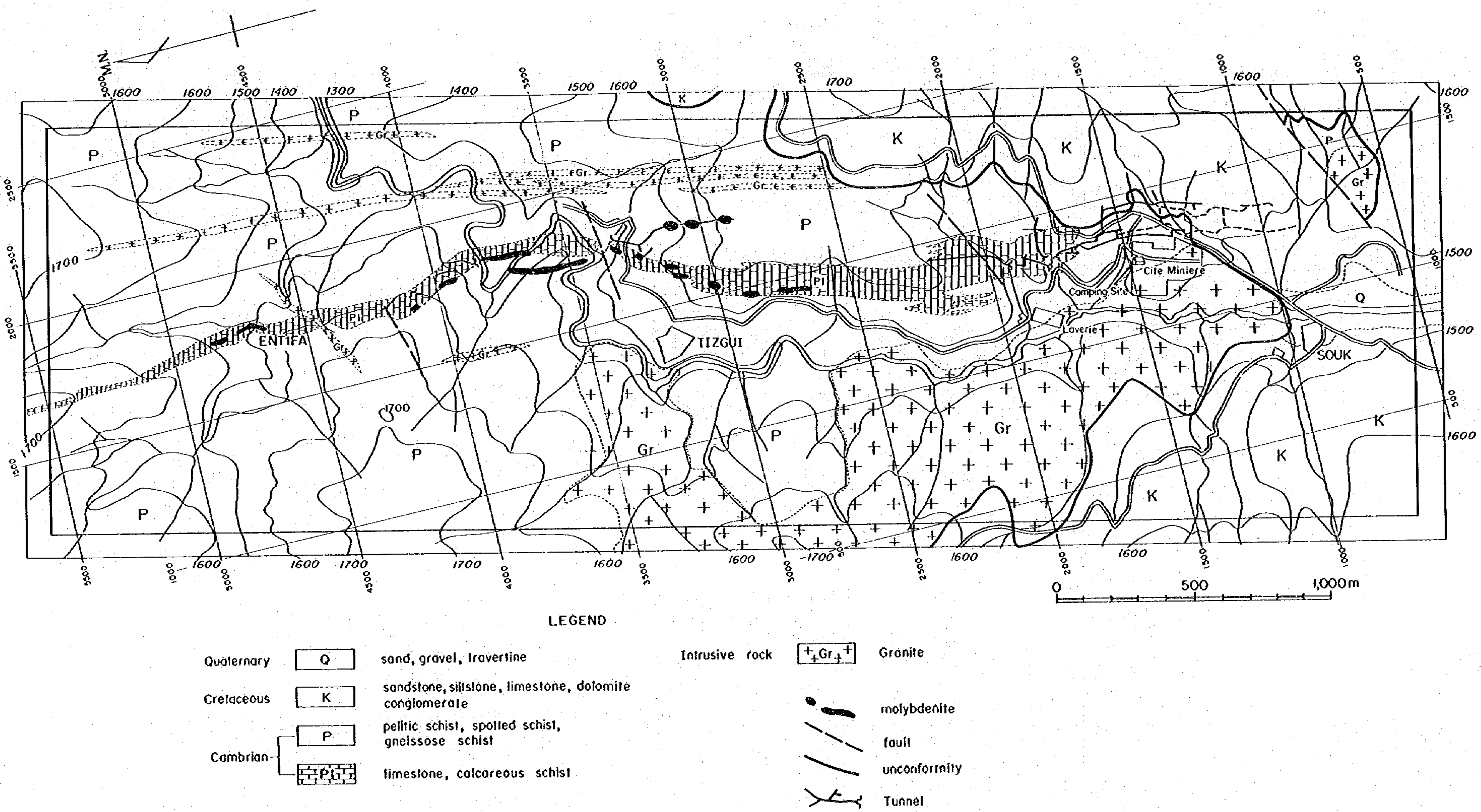


Fig. 13 Index Map of Azegour Sector

stripes of white and dark grey. It is thought that this schist would have been originated from pelitic rocks (Table 7-1: GN63A). The boundary between the pelitic schist and the spotted schist is not obvious due to gradual transition. These two schists are widely distributed except in the area where granite is distributed, as the large part of the Cambrian system in this area is constituted by them. The gneissose schist contains whole of the white or dark grey quartzose rocks, which are generally thought to have been silicified severely. They are found inserted in limestone and pelitic schist in contact with limestone, with the thickness of several meters to several ten meters. The gneissose schist is hard rock and often forms topographical rises, saved from erosion. Some of them have lamina structure of sedimentation, which is thought to have been formed by the silicification of limestone and calcareous schist and some of them have fine grained tuffaceous texture, which is originated from tuff. These textures are indicative of the original rocks (Table 7-1: GK-77, GR-56, GN-69A). Some other of them have appearance of gneisses, and in such case, it is almost impossible to estimate their original rocks.

The limestone is white or dark colored massive rock, which often forms steep cliffs. As this limestone has been recrystallized, fossils have not been recognized. The limestons are well continuous, having swells and pinches of the width of 100 to 200 meters. They are traced from the southern end to the northern end of the surveyed area. By the detailed observation, the limestones have insertions of layers of gneissose schist and pelitic schist. Along the boundary planes with these rocks of different lithology, garnet skarns are often recognized. The calcareous schist is a peculiar rock, composed of an alternation of limestone and pelitic schist with the thickness of the order of several centimeters. Usually, it has thickness of several meters or over 10 meters. The calcareous schist is distributed in and around the limestones.

As the lithofacies of the above-stated metamorphic rocks are similar to those found in the Erdouz Area, it is thought that they would belong to the Cambrian system of the Paleozoic group.

The granites are light carmine or white in color, and are hard rock, which are widely distributed in the form of stocks in the western area of the westside of the southern part of the surveyed area. They are also recognized in the form of dykes intruding in the direction of north and south, with the width of several meters to several 10 meters. The granites in the form of stocks are medium to fine grained holocrystalline granite. Under microscope, quartz, orthoclase, plagioclase and biotite are recognized. Plagioclase has been albitized and sericitized and perthite texture is recognized in orthoclase (Table 7-1, GR-19). The granites in the form of dykes are in characteristic appearances of light carmine color, and are fine grained holocrystalline rock. They are found to have been branched from the above-stated granites, and to have intruded the rocks in the surrounding areas. Some of them have porphyritic texture (Table 7-1, GR-59) and some others are of the character of porphyritic rock (Table 7-1; GR-60).

The dykes of porphyrite are grey brown or grey green.

Phenocrysts of pyroxene and feldspars are recognized. Generally, the dykes are striking in the direction of ENE-WSW, which is almost in right angle to the general strikes of the schist distributed in this area.

The sedimentary rocks of the Cretaceous system of the Mesozoic group are quite thick and are composed of alternation of sandstone, siltstone and dolomite. They are distributed in the highland in the southern part of the subject area. These sedimentary rock are found to have been accumulated unconformably on the massif of the Paleozoic group, after the peneplanation of the Paleozoic massif. They are gently dipping (under 10°) toward the south.

The sandstone is composed of fine quartz grains of the diameter of less than 1 mm, and is red or light carmine in color. The sandstone occupies the lowest part of the Cretaceous system. The siltstone is light carmine mixed with white or green color. This siltstone has insertions of thin layers of gypsum, which are as thin as less than several meters. The thickness of the dolomite beds is several meters to over 10 meters. Several beds have been recognized in the alternation with the above-stated siltstone. Generally, the dolomite forms steep cliffs, saved from erosion.

(2) Geological Structure

The geological structure in this area is characterized by the monoclinic structure which is represented by the metamorphic rocks of the Cambrian system of the Paleozoic group, dipping to the east. The geological structure is also characterized by the development of the fissures in the direction of ENE-WSW, by the intrusion of granitic bodies, by the existence of the peneplain of the Paleozoic massif and by the sedimentation of the Cretaceous system on the peneplain with gentle dipping.

However, by the detailed observation of the limestone contained in the metamorphic rocks which have apparent monoclinic structure, several small folding structures are recognized with the axes trending north and south and dipping gently to the north, and it has been evidenced that the structure is not necessarily monotonous. Also, in the north of this area, the limestone forms a large scaled anticline evidently. The axis of this anticline is trending almost north and south and is dipping gently to the north. It is noted that the repetition of synclines and anticlines is recognized in the west of this anticline. Accordingly, it is possible that the metamorphic rocks in this area would occupy a part of the east wing of the above anticlinorium.

From the results of the present surveys and from the old records of the underground of the Azegour mine, it is thought that the granitic body in this area is dipping with an angle of 30° to 50° to the east. Also, the dykes of the granite are predominantly trending in the direction of north and south, with the steep dipping. These facts are thought to reveal that the periods of the intrusion of the granites would have been after the completion of the folding movement of the Cambrian system of the Paleozoic group.

There are several faults dipping steeply to the north, with the strikes in the direction of ENE-WSW, and it is evident that the blocks in the north side of these faults had been dislocated to the west. The intrusion of porphyrite dykes are recognized along part of these faults in the same direction. It is a tendency that the superior mineralization and skarnization are distributed along these faults as well as in the area where these faults are concentrated.

The Cretaceous formations accumulated on the peneplain of the basement are gently dipping toward the south monotonously. This fact is thought to be revealing that only the tilting of the formation occurred after the sedimentation of the Cretaceous system.

2-3-2 Results of the Geochemical Survey

In the Azegour Sector, geochemical survey was carried out, in parallel with the geological survey, by collecting rock chip samples for the analysis of minor metal elements contained in them, for the purpose to clarify the presence of the possible mineralization and to detect such zones as the high grade ores are concentrated in the skarnized zones extending in the north of the Azegour mine. Localities of the sampling points are shown in the PL.12-1, PL.12-2, PL.12-3 and PL.12-4, and the results of analysis (six elements of Cu, Pb, Zn, Mo, W and Fe) are listed in the Table 12-3. The samples collected at total 206 points by the present survey team were analysed, while the analysis results of the 38 samples collected in the surrounding areas of the localities where the above samples were collected were supplied by B.R.P.M., who independently carried out the chemical analysis. Consideration was given on the results of the analysis of the samples at the total 244 points including both of the above-stated.

Values of the chemical analysis were treated statistically, and the consideration was given on the characters of the population, the anomalies and the correlative relation among the elements. The anomalous values detected are shown in the PL.9-1, PL.9-2, and PL.9-3 and the examination for the presence of the relation to the mineralization was completed.

(1) Statistic treatment

For the statistic treatment, logarithm of the analysis values, which show almost normal distribution, was employed for the consideration, as the distribution of the analysis values of each element had an extreme partiality for low grade side.

Statistical values of every element analysed and thresholds for anomalous values are shown in the Table 4-1. The histograms of the logarithmic values of the elements of Cu, Pb, Zn, W, Mo and Fe are displayed in the Fig. 9-1 to Fig. 9-6. Cumulative frequency distributions of the elements of Cu, Pb and Zn are shown in the Fig. 9-7, and those of the elements of W, Mo and Fe are shown in the Fig. 9-8.

For the establishment of the anomalous values, statistic values of G, G+σ and G+2σ were employed as the standards of the classification. The indicated zone, the weakly anomalous zone and the remarkably anomalous zone are determined as follows, and the results are shown in the PL-9.

Table 4-1 Statistic Values and Threshold Values of Rock Samples in Azegour Sector

Variable \ element	Cu	Pb	Zn	W	Mo	Fe
Number	244	244	244	206	244	244
Minimum value	7.000 ppm	5.000 ppm	5.000 ppm	1.000 ppm	1.000 ppm	0.20000%
Maximum value	13500.000 ppm	5800.000 ppm	14000.000 ppm	990.000 ppm	6400.000 ppm	38.00000%
Arithmetic mean	214.212 ppm	98.963 ppm	422.122 ppm	19.800 ppm	66.208 ppm	3.25710%
Logarithmic mean (Lm)	1.701	1.556	2.100	0.466 ppm	0.948	2.355
Logarithmic standard deviation (SD)	0.540	0.494	0.612	0.635	0.613	0.353
$G = \log^{-1} Lm$	51 ppm	36 ppm	126 ppm	3.0 ppm	9 ppm	2.27%
$G+\sigma = \log^{-1}(Lm+SD)$	175 ppm	112	515 ppm	12.7 ppm	37 ppm	5.11%
$G+2\sigma = \log^{-1}(Lm+2SD)$	604 ppm	347 ppm	2109 ppm	54.4 ppm	150 ppm	11.51%
Skewness (SK)	(10.874)→1.621	(11.407)→0.809	(7.274)→0.401	(.)→ .	(12.541)→1.365	(4.498)→0.203
Kurtosis (KU)	(138.451)→3.082	(140.709)→1.469	(68.000)→0.758	(.) .	(173.280)→3.258	(28.477)→1.058
Classification of anomalies						
Strong anomaly $\geq G+2\sigma$	Cu≥604	Pb≥347	Zn≥2109	W≥54	M≥150	Fe≥11.51%
Weak anomaly > $\geq G+\sigma$	604>Cu≥175	347>Pb≥112	2109>Zn≥515	54>W≥13	150>Mo≥37	11.51%>Fe≥5.11%
Indication > $\geq G$	175>Cu≥51	112>Pb≥36	515>Zn≥126	13>W≥3	37>Mo≥9	5.11%>Fe≥2.27%

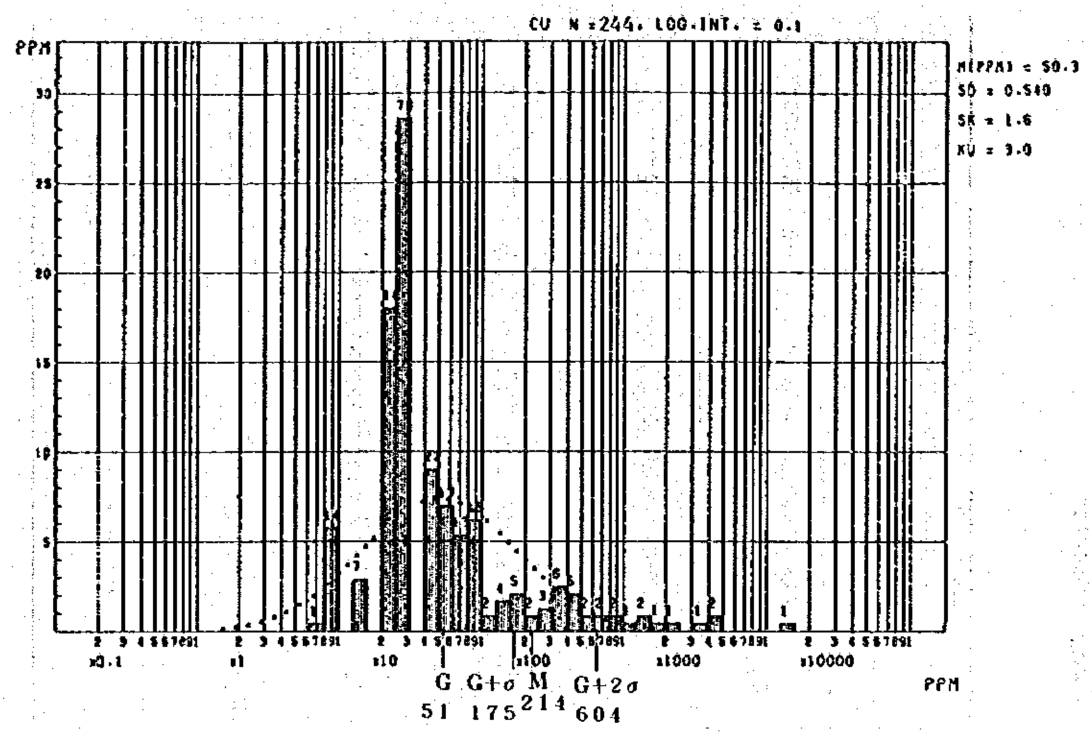


Fig. 9-1 Histogram for Cu of Rock Samples in Azegour Sector

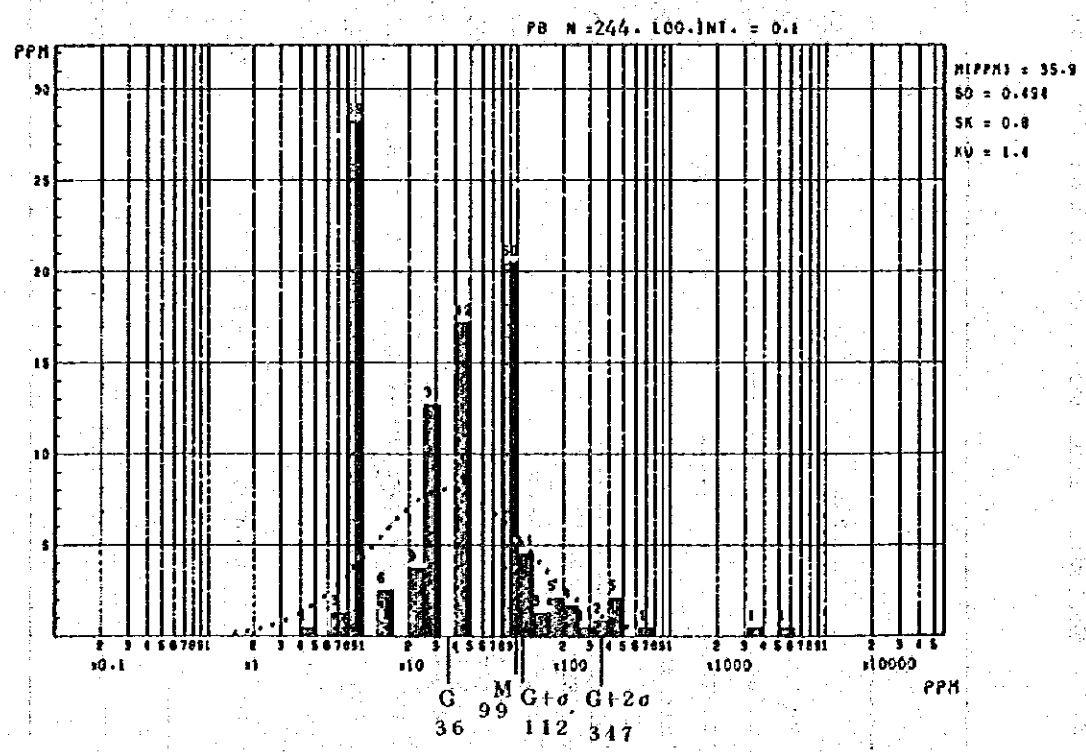


Fig. 9-2 Histogram for Pb of Rock Samples in Azegour Sector

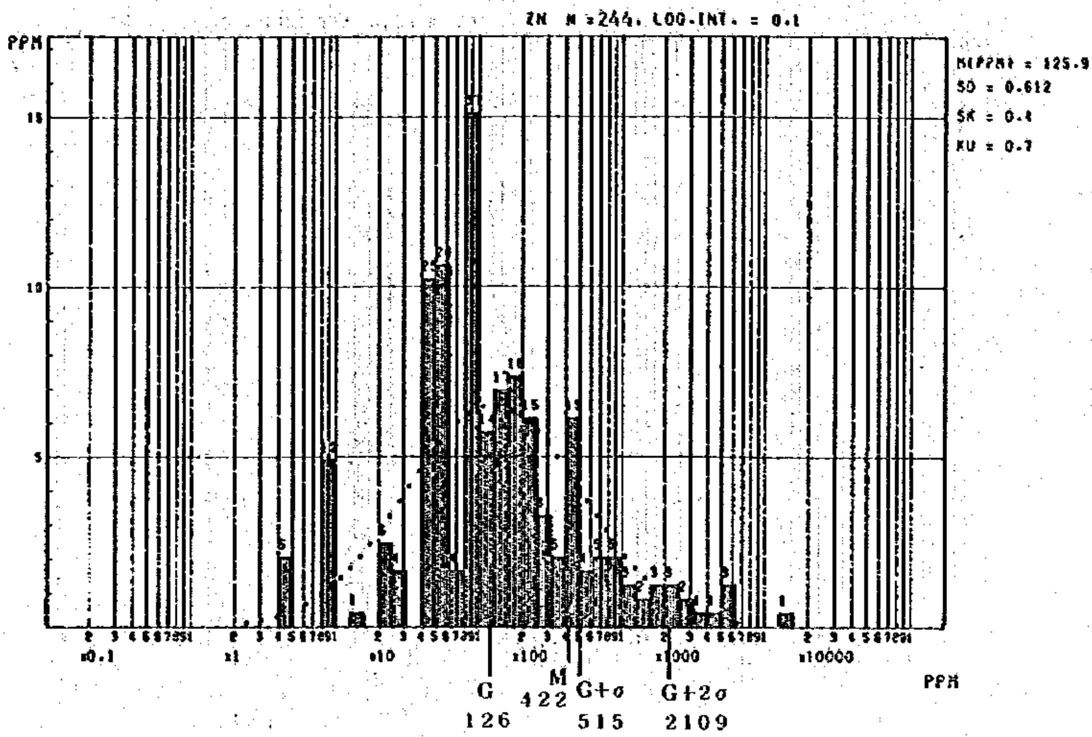


Fig. 9-3 Histogram for Zn of Rock Samples in Azegour Sector

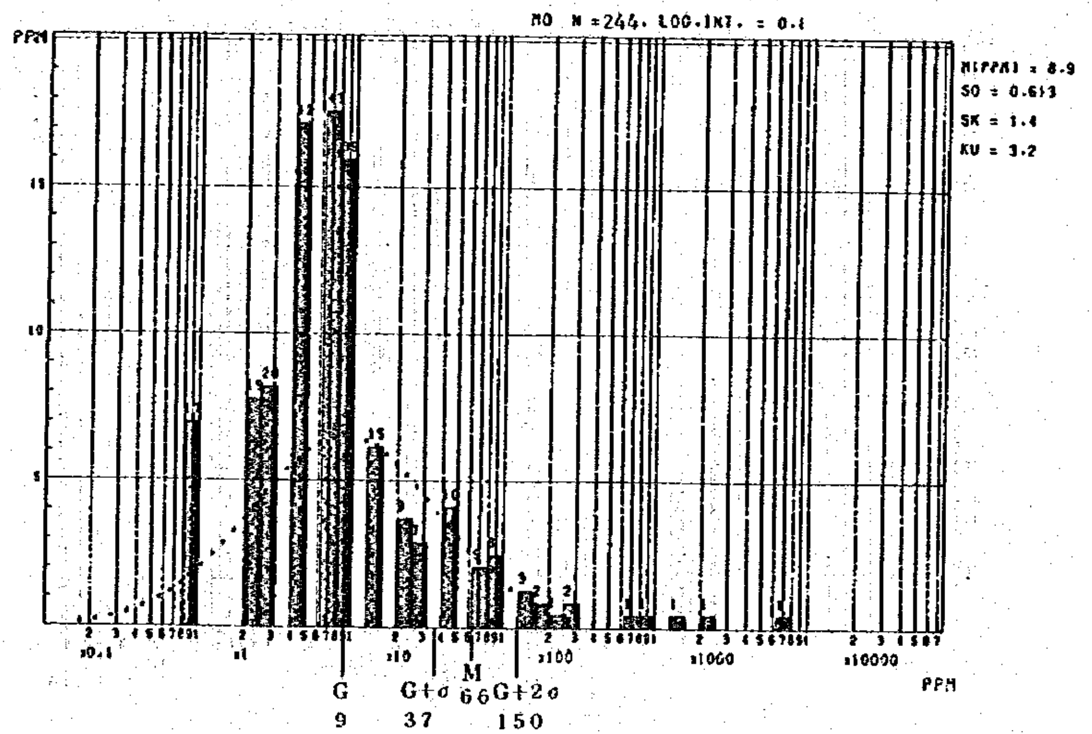


Fig. 9-4 Histogram for Mo of Rock Samples in Azegour Sector

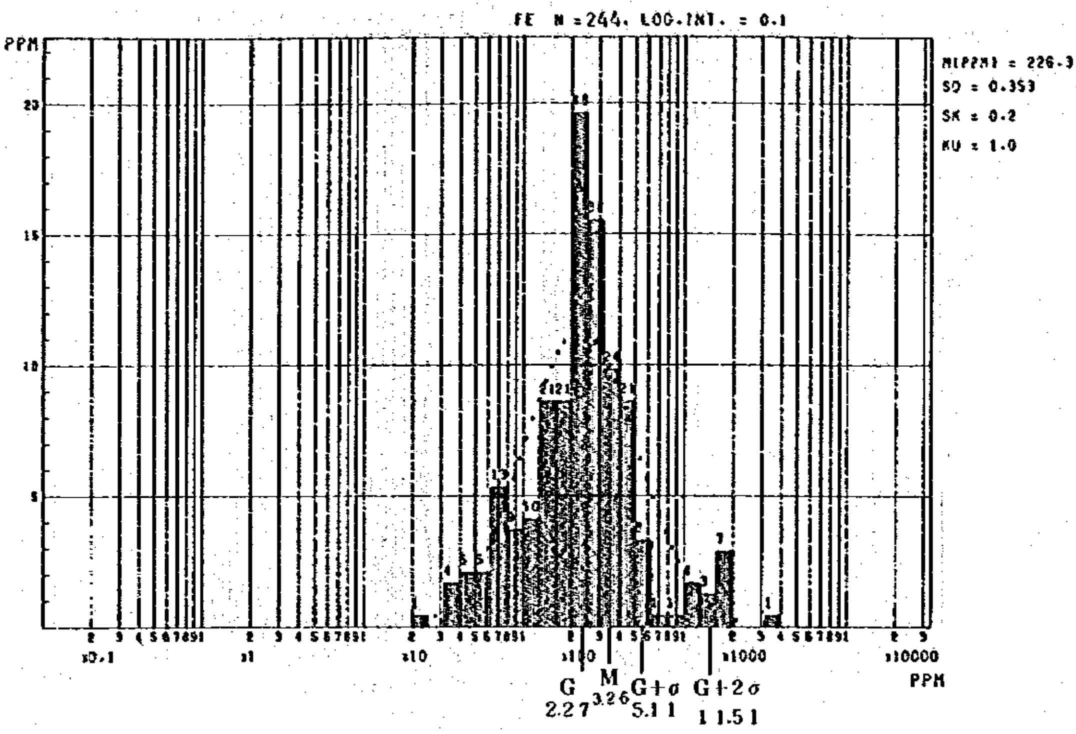


Fig. 9-5 Histogram for Fe of Rock Samples in Azegour Sector

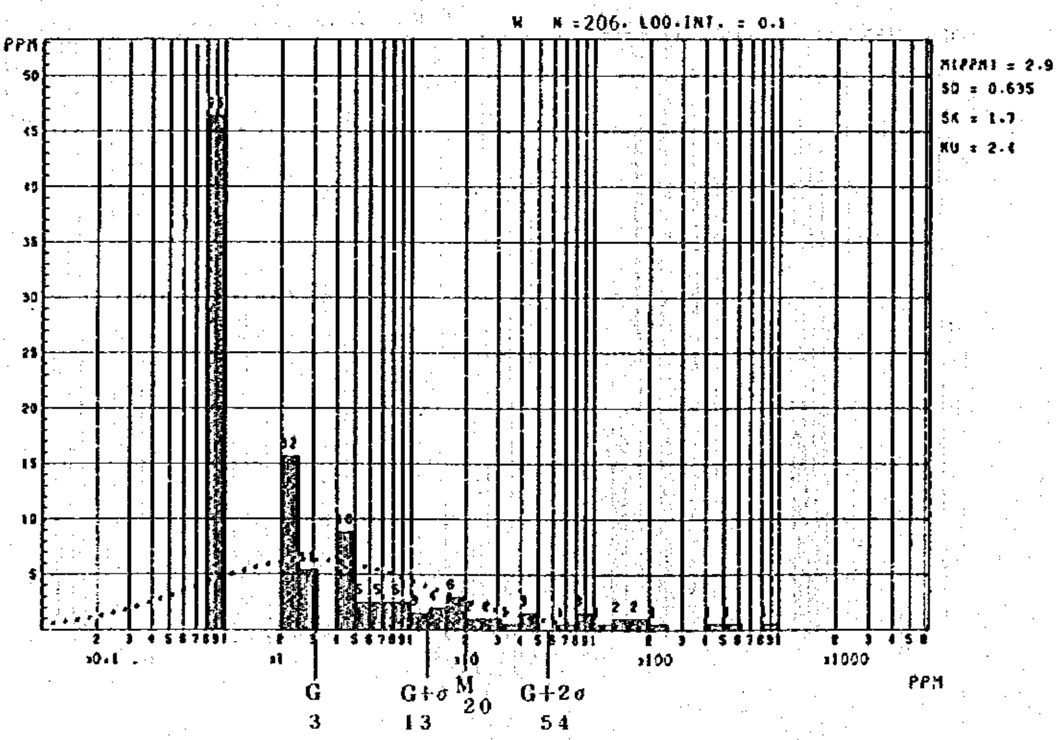


Fig. 9-6 Histogram for W of Rock Samples in Azegour Sector

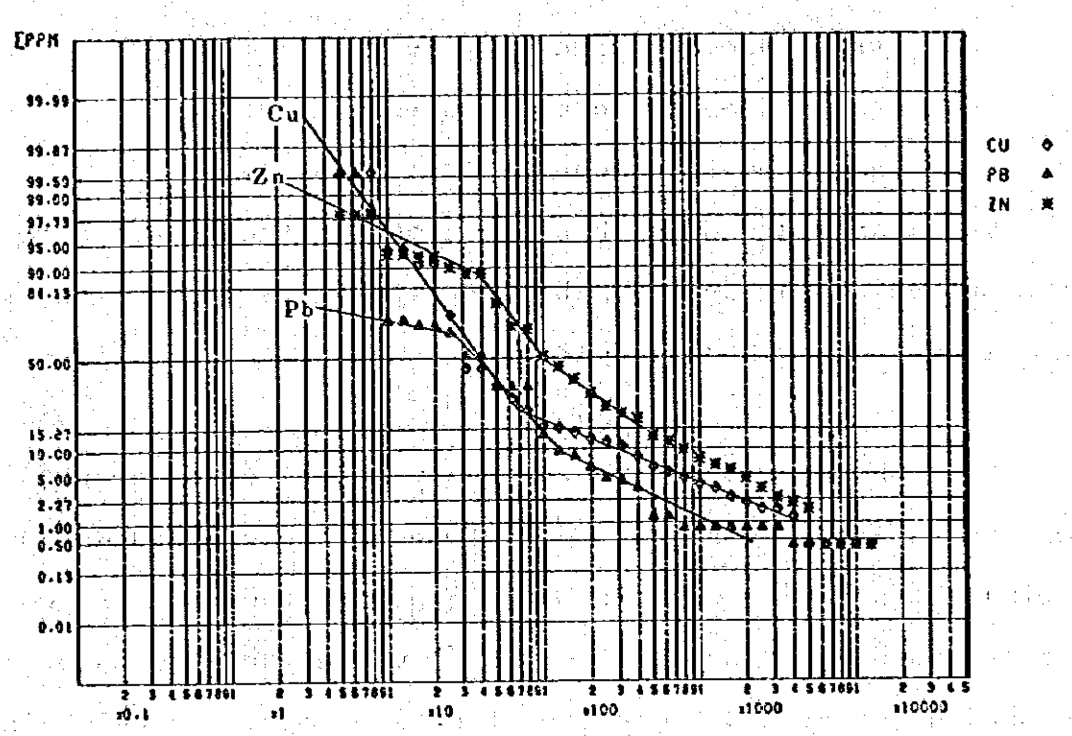


Fig. 9-7 Cumulative Frequency Distribution for Cu, Pb and Zn of Rock Samples in Azegour Sector

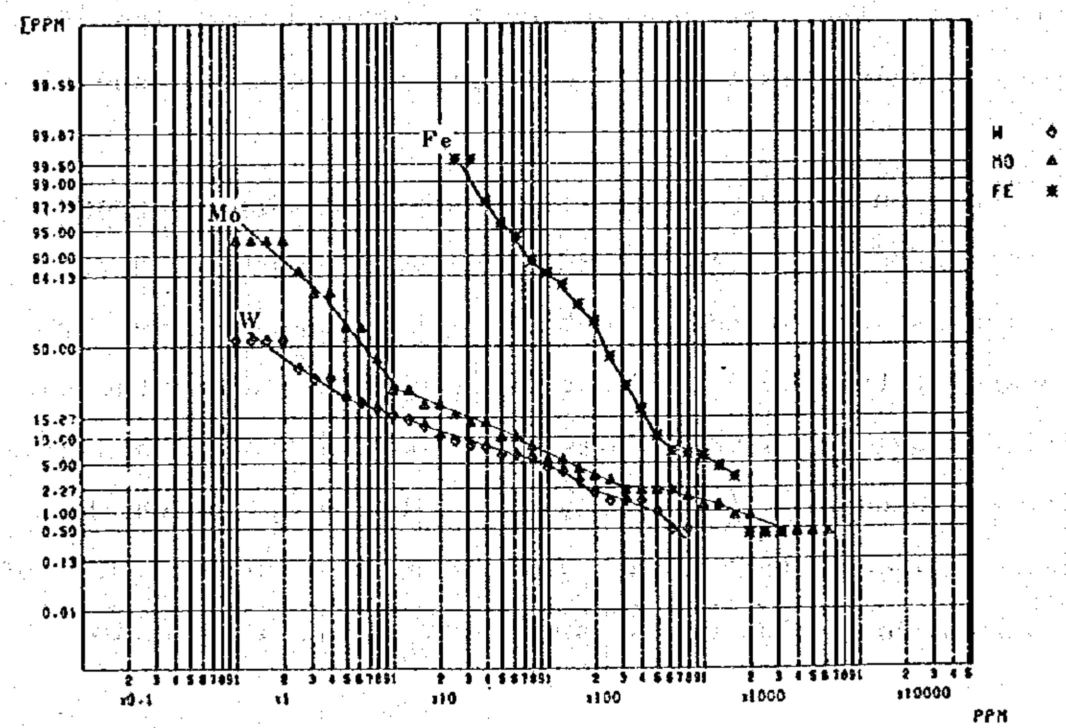


Fig. 9-8 Cumulative Frequency Distribution for W, Mo and Fe of Rock Samples in Azegour Sector

Strong anomaly zone		$\geq G + 2\sigma$
Weak anomaly zone	$G + 2\sigma >$	$\sim \geq G + \sigma$
Indicated zone	$G + \sigma >$	$\sim \geq G$

The characters of each population and the relation to the anomalous values as well as the correlative relation among the elements are described as follows.

1) Cu: On the cumulative frequency distribution graph, there is a slight bending point between Cu 50 ppm and Cu 70 ppm. Viewing the position of this bending point, the point is correspondent roughly to the level of the G value, and the values under the bending point and those over the same point are belonging to different population. The values under the bending point are thought to be revealing the background values in this area. Accordingly, the establishment of the above thresholds of the anomalous values is thought to fulfil the required conditions.

2) Pb: On the cumulative frequency distribution graph, there is a bending point between Pb 100 ppm and 120 ppm. This position is correspondent to the level of the G value. The values over this bending point and the values under the same point are belonging to the different populations. The values under the bending point is thought to be revealing the background values in this area. Therefore, the establishment of the above thresholds of the anomalous required condition.

3) Zn: On the cumulative frequency distribution graph, there are slight bending points at around 100 ppm and at around

500 ppm. As to these positions, the former is correspondent roughly to the level of the G value, while the latter is correspondent to the level of the G+σ value. It is thought to be possible that the values divided by these points are belonging to the different populations. Here, the values under the G value was taken to be the background values and the above thresholds were established.

4) Mo: On the cumulative frequency distribution graph, there is a bending point at around Mo 10 ppm. This position is thought to be correspondent to the level of the G value. The values over the bending point and the values under the same point are belonging to the different populations. The values under the bending point is thought to be revealing the background values in this area. Therefore, the establishment of the above thresholds of the anomalous required condition.

5) Fe: On the cumulative frequency distribution graph, there are the bending points at around Fe 2.00 % and at around 5.00 %. As to these positions, the former is correspondent roughly to the level of the G value, while the latter is correspondent to the level of the G+σ value. It is thought to be possible that the values divided by these points are belonging to the different populations. Here, the values under the G value was taken to be the background values and the above thresholds were established.

6) W: On the cumulative frequency distribution graph, there

is a slight bending point at around W 13 ppm. This position is thought to be correspondent to the level of the G value. The values under the bending point and the values over the same point are belonging to the different populations. The former values are thought to be revealing the background values in this area. Accordingly, the establishment of the above thresholds of the anomalous values is thought to fulfil the required condition.

7) Mutual relation among the analysed elements: Consideration was given on the mutual relation of the analysed elements of Cu, Pb, Zn Mo, Fe and W, and the results as shown in the Table 4-2 have been obtained. By this table, the element of Cu has slight correlative relations with Zn and Fe, although it has almost no correlation with other elements. Pb has almost no correlation to any other elements. Zn has slight correlative relation with Cu and Fe, but it has almost no corelation with other elements. Mo has almost no correlation with other elements. Fe has slight correlative relation with Cu and Zn, although almost no correlation has been recognized between Fe and any other elements. W has slight correlative relation with Cu and fair correlation with Fe. Almost no correlation is recognized with Mo.

As a whole it can be said that there is no correlative relation among these elements. This fact is thought to suggest that the different species of mineralization would be located in different areas.

Table 4-2 Correlation Coefficients of Rock Samples in Azegour Sector

	CU	PB	ZN	W	MO	FE	
CU	1.00000 0.0000 244	0.00958 0.8814 244	0.24986 0.0001 244	0.23297 0.0008 206	-0.01247 0.8460 244	0.30364 0.0001 244	CORRELATION COEFFICIENTS
PB	0.00958 0.8814 244	1.00000 0.0000 244	0.00333 0.9587 244	-0.01178 0.8669 206	0.06089 0.3425 244	-0.01237 0.8473 244	
ZN	0.24986 0.0001 244	0.00333 0.9587 244	1.00000 0.0000 244	0.08603 0.2200 206	-0.01785 0.7810 244	0.18418 0.0038 244	PROB > IRI UNDER HO:RHO=0
W	0.23297 0.0008 206	-0.01178 0.8669 206	0.08603 0.2200 206	1.00000 0.0000 206	-0.00331 0.9624 206	0.62782 0.0001 206	
MO	-0.01247 0.8460 244	0.06089 0.3425 244	-0.01785 0.7810 244	-0.00331 0.9624 206	1.00000 0.0000 244	0.00350 0.9566 244	NUMBER OF OBSERVATIONS
FE	0.30364 0.0001 244	-0.01237 0.8473 244	0.18418 0.0038 244	0.62782 0.0001 206	0.00350 0.9566 244	1.00000 0.0000 244	

(3) Consideration on the anomalous zones

The results of the consideration on the extracted anomaly zones of each of the elements are as follows.

Cu: The strong anomalous values were recognized at 14 localities. All of them but 1 locality are distributed in the skarnized zones. The locations of these anomalous values are as follows; 3 points concentrated at the outcrop of the Azegour ore deposit, which is at around 1,600 m (North distance), 2 points at around 2,800 m, 2 points at around 3,000 m (southeast of the Tizgui village), 2 points at around 3,500 m, 3 points at around 4,000 m, 1 point at around 4,200 m (between Tizgui and Entifa). The weak anomalies are distributed around these strong anomalies, as well as at around 2,200 m in the limestone area in the eastern part and in the vicinity of Entifa. Concerning these anomalous zones, the presence of the remarkable relation to the Cu mineralization is not obvious, except the case of the anomalies around the Azegour ore deposit. However, viewing as a whole, the distribution of these anomalous values seems to be along the fissures of the trend in the direction of ENE-WSW and occasionally along the northern side of the granite dykes. The indications of Mo mineralization are recognized in part of these areas.

Pb: The strong anomalous values detected were at 9 localities. Of these anomalous values, 6 points are found in the skarnized zone, 2 points are in the limestone zone, 1 point is in the spotted schist which means that the anomalous values are detected in other zones than the area where the limestones are distributed. Generally, the anomalous values are independently located as seen in the cases of the anomalous value at around 4,200 m, that at around 4,000 m, that at around 3,800 m and that at around 3,200 m. Rather concentrated anomalous values are there as recognized in the cases of 3 points at around 3,400 m (1 point is in the limestone) and 2 points at around 1,900 m (in the limestone and in the spotted schist). The weak anomalies are not concentrated and they are distributed in any of the areas represented by skarnized zone, limestone zone and pelitic schist zone. There is a slight relation between the distribution of the weak anomalous values to that of the strong anomalous values, and it is difficult to take them zonally. The lead mineralization is weak in this area and the relation of these anomalous values to the indications of lead mineralization is not certain. If anything, it could be said that there would be some relation between the anomalous values and the lead mineralization as to the two of the anomalous values; the one is that found at around 3,400 m, which is situated in the north side of the fault trending in the direction of ENE-WSW, and the other is that found at around 1,900 m, which is located in the east side of the known mineralization is poor.

Zn: The strong anomalous values detected are at 12 localities. All of these strong anomalous values are distributed in the skarnized zones as follows; 3 points at around 3,000 m, 4 points between around 2,600 m and around 2,800 m, and 1 point each independently at around 4,000 m, at around 3,300 m and at around 2,400 m. The weak anomalous values are scatteringly distributed in the area from around 2,200 m to around 3,000 m, and are recognized in the area close to the strong anomalies. They are not detected around the Azegour ore deposit. Taking both the strong anomalous values and the weak anomalous values into consideration, there is an area where intense zinc mineralization is found from around 2,00 m to around 3,000 m, and the mineralization is weakened toward the north and towsard the south.

Mo: The strong anomalous values detected are at 12 localities. All of these strong anomalous values are distributed in the skarnized zones as follows; Those which are distributed in rather concentrated form are in two areas, that is, 3 points from around 4,700 m ∿ 4,800 m (around Entifa) and 3 points at around 3,600 m (north of Tizgui). The others are at around 4,400 m, at around 4,200 m, at around 3,400 m, at around 3,300 m, at around 2,600 m, at around 2,300 m and so on. The weak anomalous values are distributed in the surrounding areas of the strong anomalous values as well as in several other localities. On the surface of the Azegour ore deposit only weak anomalous values are comparatively concentrated. The anomalies including the weak anomalous values are correspondent to the area where molybdenum disseminations are recognized in the skarnized zone megascopically. That is, such areas are found around Entifa, between Tizgui and Entifa, around Tizgui, in the area southeast of Tizgui and around the old tunnel located in the limestone in the eastern part of the subject area. Accordingly, it is thought that these anomalous values are reflecting the indications of molybdenum mineralization, remarkably. Also, viewing from the fact that there are no strong anomalous values around the Azegour ore deposit, it is thought to be necessary to give full attention to the weak anomalous values in future exploration.

Fe: The strong anomalous values were recognized at 12 localities. All of them but 1 locality are distributed in the skarnized zones. The locations of 7 points of these anomalous values are concentrated on the surface around the Azegour ore deposit. The other anomalous values are scatteringly distributed at the localities at around 4,000 m, at around 3,500 m, at around 3,200 m, and at around 3,000 m. The weak anomalous values are distributed close to the strong anomalous values in the area at around 4,000 m. However, in the other localities, they are not necessarily distributed close to the strong anomalous values. As there are small amounts of pyrite, specularite and chalcopyrite recognized to be contained in the Azegour ore deposit, it is thought that the Fe anomalies around this area would be reflecting the presence of these ore minerals. Some of the Fe anomalies found in the other areas are distributed along the faults and along the dykes of granite, which are trending in the directions of ENE-WSW. Therefore, it is thought to be possible that these anomalous values are suggesting the indications of iron mineralization in this direction.

W: The strong anomalous values were recognized at 13 localities. All of them are distributed in the skarnized zones. The locations of these anomalous values are described as follows; 3 points on the surface of the Azegour ore deposit, 3 points at around 2,400 m (north of Azegour), 2 points at around 2,900 m (southeast of Tizgui), 2 point each at around 3,800 m (between Tizgui and Entifa), and 1 point each at a locality at around 2,200 m (in the skarnized zone in the eastern part), at around 3,400 m (north of Tizgui) and at around 4,600 m (Entifa).

It is a tendency that the weak anomalous values are associated with the strong anomalous values. The W anomalies are weakly related to the locations where the indications of molybdenum mineralization are distributed, and they have a tendency to be distributed in the northern side of the faults and the dykes, which are trending in the direction of ENE-WSW.

2-3-3 Mineralization (Refer to Fig. 10, Fig. 11)

The mineralization in this subject area is represented by the copper-molybdenum-tungsten ore deposit which is associated with skarns around the Azegour mine, by the disseminated molybdenum ore deposits in the skarns in the northern area of the Azegour mine and by the hematite ore deposits of the vein type distributed at several places in the subject area.

(1) The Azegour ore deposit is a replacement deposit of copper-molybdenum-tungsten, contained in the skarnized zone mainly of garnet. Although the mine is not operated at present, the production from 1930 to 1956 was recorded to be about 900,000 tons of the crude ores with the grades of Cu: 1.4 ∿ 2.8%, MoS_2: 0.2 ∿ 0.7%, WO_3: 0.35% ±. The area developed for the mining of this deposit is 1,300 meters in north and south and 150 meters in east and west. The lowest level developed is at the altitude of 1,338 meters above sea level, and the difference from the outcrop on the surface to this lowest level is about 200 meters. The skarnization is most intensely recognized in the deeper part, and all the limestones have been skarnized in the portion below the 1,448 meter level. It seems that over ten orebodies had been emplaced in the skarnized zone. The massive orebodies are 20 ∿ 50 meters in major axes and 5 ∿ 20 meters in minor axes. The ore minerals are molybdenite, scheelite and chalcopyrite, associated with less amount of galena, sphalerite, pyrite and hematite. The skarn minerals are mainly garnet (Grossularite-Andradite) and vesuvianite,

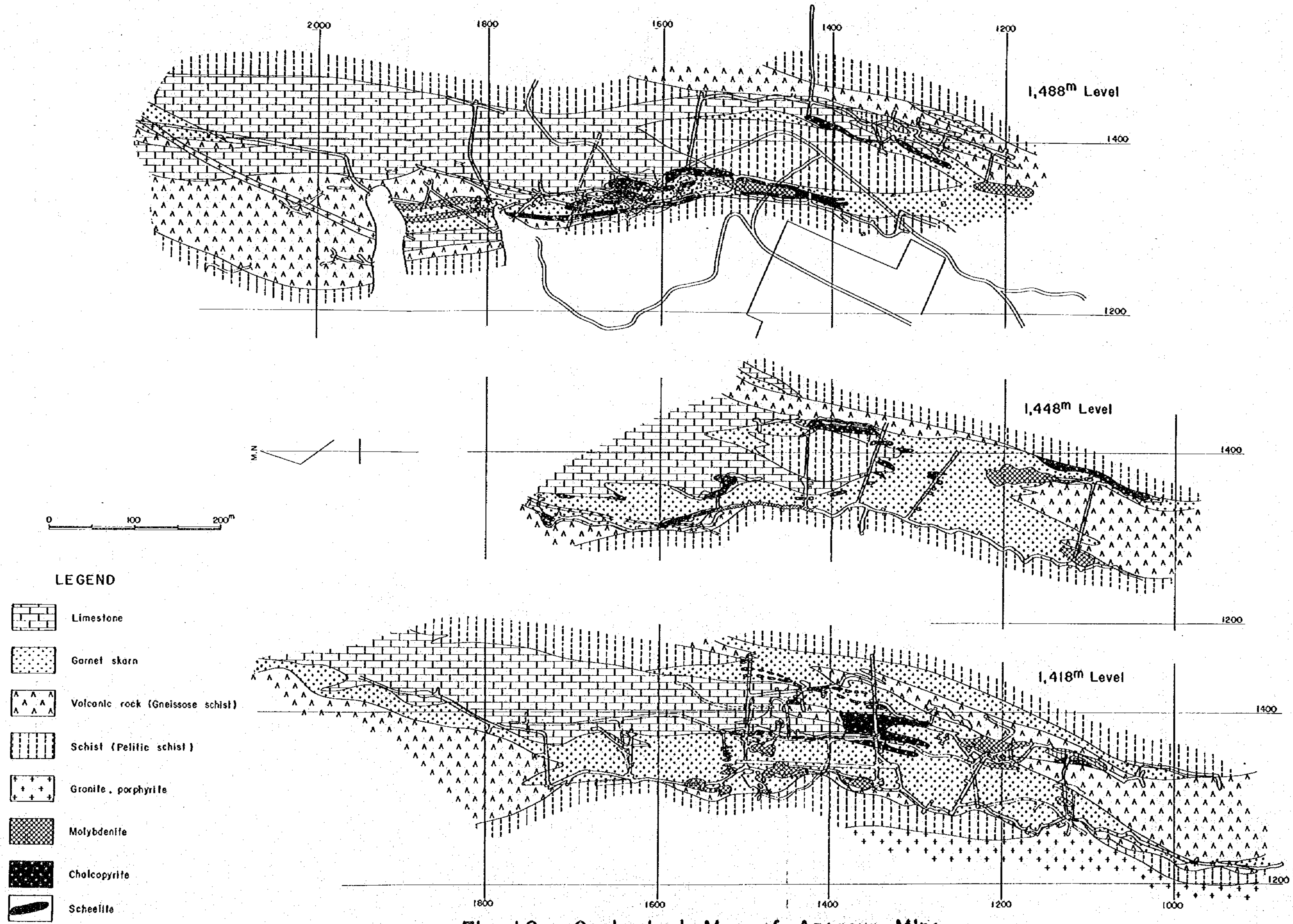


Fig. 10 Geological Map of Azegour Mine
[after Permingeat, F., et Bourg, P.(1957)]

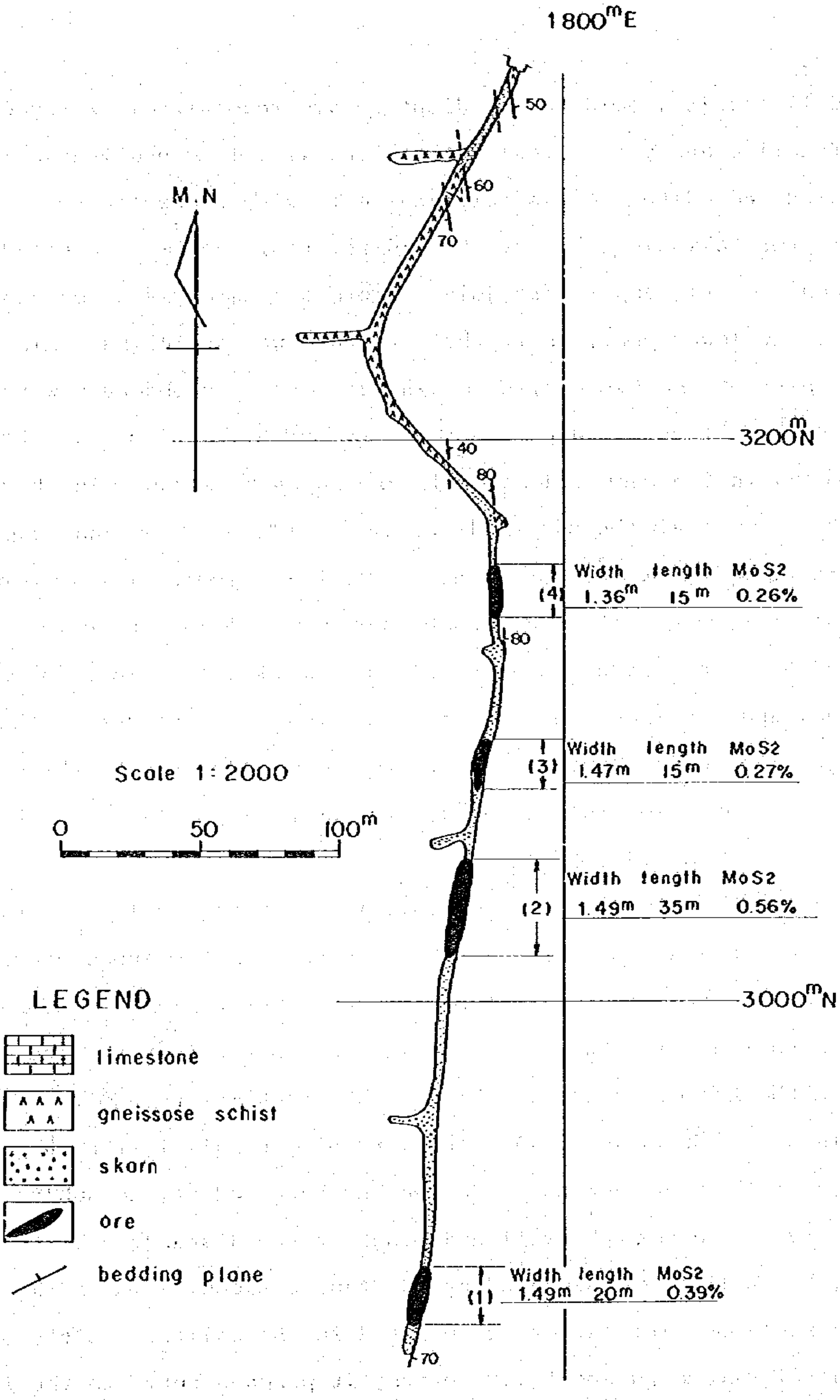


Fig. 11 Sketch of Tizgui Tunnel (1380m Level)

wollastonite, epidote and diopside are recognized. X-ray diffractive analysis revealed that scheelite is closely associated with andradite whereas molybdenite is with grossularite. (Refer to Table 13). By the old records, the two skarnized zones in the upper part join to form a single skarnized zone in the lower part, as if the structure was anticline. Also, in a part of the surface, a folding structure is observed with an axis of gentle dip (about 10° to north). The granite body found in the west side of this ore deposit is subsiding toward the east with the dip angle of 30° ∿ 40°, and the lower part is occupied by this granite. In the area south of this ore deposit, a granite body has been recognized in the further east of the area where the extension of the skarnized zone is expected, and the limestone beds are in the form to be cut by this granite body. However, there are thick coverings of the Cretaceous formation in this area, and the details are not certain.

(2) The molybdenum ore deposit in the northern area is recognized in a narrow skarn zone extending from the above-stated ore deposit. There are two limestone beds replaced to form skarn minerals; the one is of the same horizon of the ore deposit in the Azegour mine, as thick as about 80 meters and the other is as thick as about 10 meters, running parallel with the above. The former is continuous to the northern end of the subject surveyed area with swell and pinch in the distance of more than 5 km, although dislocated by the faults trending in ENE-WSW direction. The latter is inserted in the pelitic schist, and after extending about 500 meters, it pinches out. In the lime-

stone bed, layers of gneissose schist and pelitic schist are inserted, and along the boundaries with the other rocks and with the inserted layers, skarnized zones are formed in the narrow bands. Generally, these skarnized zones are as wide as 30 cm to 1.0 meter. 4 or 5 zones are found in the southern part and 1 ∿ 2 zones are recognized in the northern part. The skarnization is recognized to be more intense in the areas where tight folds are found in the limestones and where fissures or porphyrite dykes of the trend in the direction of ENE-WSW are recognized. In such areas, the width of the skarnized zones is up to 10 meters or 30 meters. The skarn minerals are mainly garnet (Grossularite-Andradite), but diopside and wollastonite are also recognized. Especially, wollastonite is abundant in the area north of Tizgui. It is a tendency that the skarnization is less intense toward; the north, and no skarn minerals are recognized in the area north of Entifa. Around Entifa, skarn minerals are recognized only in the valleys and are not recognized on the high lands. This fact is suggesting that the northern limit and the upper limit of the skarnization are existing around Entifa. The extensive skarnization can be expected in the depth of this area.

The molybdenum mineralization is recognized disseminated in the skarnized zones. Generally, the indications of molybdenum mineralization are found along the bedding planes of the original rocks with the width of several centimeters to over ten centimeters. Their extensions are traced in the distance of several meters to several ten meters. In many cases, the mineralization is solely of molybdenum, but in some cases, it is associated with chalcopyrite and pyrite. Under microscope, the molybdenite is recognized disseminated in the prismatic and scalelike form. Pyrite and chalcopyrite are recognized with the gangue minerals and around the molybdenite (Table 7-2, GN-73, GN-76).

The places where the indications of molybdenum mineralization are recognized on the surface are; in the southeast of the Tizgui village (around 2,700m, 2,800m), in the east of the Tizgui village (3,000m ∿ 3,100m), in the northeast of the Tizgui village (3,600m ∿ 3,800m), between Tizgui and Entifa (around 4,000m) and around Entifa (4,600m ∿ 4,800m). Especially, in the area from the east of the Tizgui village to Entifa, the mineralization is comparatively intense. The highest grade of the ores samples at the outcrop in the east of the Tizgui village is MoS_2 0.29% (MK-68) with the width of about 60cm, while the grades of the ore collected at the outcrop in the northeast of the Tizgui village are MoS_2: 0.23% (MN-74) with the width of 10 cm and MoS_2: 0.42% (MR-12) with the width of 60 cm. However, in average the ore grade is less than MoS_2: 0.10% at the outcrops. Meanwhile, the assay results, by B.R.P.M., of the samples collected in the skarnized zone along the tunnels located at the east of the Tizgui village are showing the presence of four orebodies. The sizes and the ore grades are as follows.

(1) Around 2,900m: width 1.49m extension 20 m MoS_2: 0.39%
(2) Around 3,050m: width 1.49m extension 35 m MoS_2: 0.56%
(3) Around 3,100m: width 1.47m extension 15 m MoS_2: 0.27%
(4) Around 3,150m: width 1.36m extension 15 m MoS_2: 0.26%

These data are thought to reveal that the mineralization is more intense in the depth and that the ore grades are higher in the deeper part.

It is thought to be fissures trending in the direction of ENE-WSW that are controling the mineralization of molybdenum. Along these fissures, dykes of granite or those of porphyrite were often recognized to have been intruded along these faults, and also sometimes these fissures are recognized to have dislocated the strata of limestone horizontally. In such places skarnizations are recognized to be more intense to form large scaled skarnized zones, and the molybdenum ore minerals are recognized disseminated with naked eyes. Therefore, it is estimated that both the skarnization and the mineralization would have been intensified along these fissures. The ore deposit in the Azegour mine is located in such an area as the fissures are concentrated and it is thought that the location of this ore deposit is related to the intensity of the mineralization in this area.

(3) Vein type hematite ore deposits

The vein type hematite ore deposits are recognized at several places in this area. They are ore veins with the width of 10 cm to 1 meter, containing mainly specularite as the ore minerals. They are seated in the skarnized zones and in the schist, but these ore deposits are of no significance.

2-3-4 Discussion

Because the Azegour mine, which used to be operated actively in the past, is located in this area, fair amounts of the detailed surveys have been done in the vicinity of the mine area. However, investigations have not been carried out sufficiently in the northern area of this mine. In the present program of the investigation, the general and the detailed geological surveys with simple land survey were carried out. Geochemical survey was also carried out in parallel with the geological survey, by collecting rock samples mainly around the skarnized zones. By the results of these surveys, it has been clarified that the mineralization in this area is related intimately with the geological structure, and it has become possible to extract the favorable areas for the possible emplacement of ore deposits. These facts are thought to be suggesting that the detailed methods of the surveys as employed in the present investigation program were quite effective methods for the exploration of ore deposits in this area.

The characteristics of the geological structure which have been clarified by the present surveys are that the Cambrian system (?) of the Paleozoic group is distributed almost in the linear form in the direction of north and south, showing monoclinic structure with the dip to the east, that the intrusion of granite into the Paleozoic formations is recognized, part of which is extending in fairly long distance in the form of dykes in the direction of north and south, and that there are such fissures as running across the above-stated dykes in the direction of ENE-WSW, which have dislocated the strata in small scales and which have accelerated the intrusion of the porphyrites.

Of the mineralization found in this area, the replacement ore deposits are most significant. Large scaled ore deposits of copper, molybdenum and tungsten are recognized in the Azegour mine. In the northern area of this mine, the skarnized zone is extending in a distance of about 4 km, in which some disseminated orebodies of molybdenum are recognized. The relations between the mineralization and the geological structure in this northern area are summarized in the following.

The limestone, the mother rock for the ore deposits, is found to be continuous with swell and pinch in the direction of north and south, with the approximate width of 80 meters, although slightly dislocated by the faults in places. It extends until it joins the limestones which is found to be composing anticlinorium in the north area. Accordingly, it is thought to be possible that the Paleozoic formations which are revealing monoclinic structure apparently are on the east wing of this anticlinorium. It is thought that this situation would be evidenced by the facts that there are folding structures often recognized in the limestone with the axes gently dipping to the north and that a tendency is recognized to show the presence of syncline at the depth of the Azegour mine.

It is thought that the skarnization is more intense toward the south from the area around Entifa, where the northern limit of the skarnization is existing, and that the extension of the skarnization is greater in the deeper part. Therefore, in the area south of Entifa, in the subject area, the deeper part is thought to be favorable for the existence of ore deposits, which would warrant further exploration. Meanwhile, the mineralization of molybdenum is also thought to be more intense in the deeper part, viewing from the results of the survey on the surface and of the mapping in the underground at the east of Tizgui.

It is thought that these skarnization and the mineralization would have been intensified especially along the faults of the trend in the direction of ENE-WSW, which would have controlled the mineralization.

By the results of the geochemical survey, it is remarkable that the Mo anomalies are reflecting the indications of molybdenum mineralization in the skarnized zone. There is a tendency that the Cu anomalies are concentrated in the northern side of the above-stated faults. Anomalous values of Pb and Zn are recognized to be related to the molybdenum mineralization. The anomalous values of Pb are scatteringly distributed, while the anomalous values of Zn are concentrated in the central part of this area. Anomalous values of Fe are concentrated around the Azegour mine area, and they are not obviously related to the indications of molybdenum mineralization. The distribution of W anomalies has similar pattern to that of Mo and Cu anomalies.

From the above results, it is thought as to the mineralization in this area that molybdenum ore deposits would possibly be emplaced in the area north of the Azegour mine, and especially it can be said that the deeper the favorable portions for the mineralization are, the greater the expectation for the results of the exploration would be. Accordingly, the area from the southeast of Tizgui to Entifa, especially the deeper portion of this area, would warrant further positive exploration, because the indications of molybdenum mineralization as well as the geochemical anomalies of Mo have been recognized in this subject area by the geological survey and the geochemical survey.

CHAPTER 3 CONCLUSION AND RECOMMENDATION FOR THE SECOND PHASE SURVEY PROGRAM

3-1 Conclusion

As the first phase investigation, reconnaissance, semi-detailed and detailed geological surveys as well as geochemical survey (stream sediments, soil, rock) were carried out, for the purpose of extracting highly favorable areas for the emplacement of ore deposits in each of the surveyed area.

The conclusion obtained from the results of the first phase investigation is as follows.

3-1-1 North Area

The North Area is underlain, geologically, by the formations of the period of Pre-Cambrian, Paleozoic, Mesozoic and Cenozoic Eras. The former twos are recognized to compose the basement in this area. Especially, the Paleozoic formations are widely distributed in whole of this area.

The Paleozoic formations have been metamorphosed by the regional metamophism and the metamorphic rocks such as psammitic schist, pelitic schist, green schist and limestone have been formed. The pelitic schist is distributed predominantly in the eastern part of the surveyed area, and the limestone is distributed predominantly in the central part, while both the pelitic rocks and the green schist are distributed in the western part. Concerning the geological structure of the Paleozoic formations, there are remarkable characteristics represented by such factors as the foldings with the axes of the trend in NE-SW direction, formed in the period of the Hercynian orogenic movement, the intrusion of igneous rocks such as Azegour granite, and the blocking by the fault movements of the trends in E-W or NE-SW.

The formations of the Mesozoic and later periods are distributed in the northern part and around the topographical rises, and viewing from the distribution, it is estimated that there would have been a fault movement by which the thrust up of the southern side occurred.

The mineralization in this area is confined in the area where the Paleozoic formations are distributed. Vein type ore deposits of copper-lead-zinc and barite and skarn type ore deposits of copper-molybdenum tungsten and iron are recognized. The indications of these mineralization are revealing zonal arrangement of mineral assemblages under the control of the fissure systems such as faults and in relation to the intrusion of the granite. The scale of the mineralization represented by the largest barite ore deposite is with the width of 20 meters, with the extension of 80 meters and with the vertical continuity of 110 meters. This ore deposit is being operated at present. However, the other indications of vein type ore deposits are as wide as from several centimeters to 120 cm, with the horizontal extension of several meters to several ten meters. The ore grades are; Cu: 0.01 ∿ 2.05%, Pb: 0.08 ∿ 13.0%, Zn: 0.12 ∿ 4.8% and Ag: 11 ∿ 540 g/t. Generally, the higher the ore grades are, the smaller the scales of the ore deposits are.

By the results of the geochemical survey by the stream sediments, anomalous values of the elements of Cu, Pb and Zn have very distinct correlation, and their distributions are well coincident one another in such areas as in the down-stream area of the Erdouz ore deposit, around the Areg area where the indications of mineralizations are concentrated, and in the eastern area where small scaled indications are scatteringly distributed. The anomalous values of W are concentrated around the Azegour granite and around the area in the east of Erdouz where granites are distributed. It is noted that part of the anomalous values of Cu and those of Mo are concentrated along the main stream of Nfis river, and that no direct relation of these anomalous values to the mineralization has been recognized.

By the above results, as the mineralization in this area is generaly weak and no other favorable areas are detected by the geochemical survey, it is considered that the possibility of the emplacement of ore deposit are not so high in this area.

3-1-2 Erdouz Sector

This area is underlain, geologically, by the schists of the Cambrian system including lithofacies of alternation in which limestones are predominant. The geological structure is characterized by the anticlinal folding structure found in the central part of the area with the axis in NE-SW direction, and by the blocking by the faults of E-W system and NE-SW system.

As to the mineralization in this area, there are vein type lead-zinc ore deposits. Mineralization is recognized rather concentrated around the Erdouz North ore deposit and around the Erdouz South ore deposit. Weak mineralization is recognized along the extension of these ore deposits and in the southeastern area. The Erdouz North ore deposit is located in the limestone beds along the axis of the folding. By the old records, the area of the mineralization is approximately 100 m x 100 m, and five ore veins are found in the fracture zone trending in the direction of NE-SW. The sizes of the several ore deposits are about 10 meters in horizontal extension and about 10 cm in width. Viewing from the assay results of the outcrops, the ore grades of the order of Pb: 8% ±, Zn: 8 ∿ 10% and Ag: 100 g/t are expected. The Erdouz South ore deposit is located in the limestone area trending in N-S direction, where tight folds are recognized, and the mineralization is recognized along the fissures in the direction of north and south, and filling the spaces along the bedding planes in the limestone. The area of the mineralization is thought to be 150 m x 200 m and the sizes of the ore deposits along the fissures are taken to be 10 ∿ 50 cm in width and 10 ∿ 20 m in horizontal extension, while the sizes of the layered ore deposits are taken to be 30 cm in width and about 10 meters in horizontal extension. The ore grades are thought to be Pb: 2% ±, Zn: 7 ∿ 10% and Ag: 90 g/t. Both of the above two ore deposits are located along the Erdouz fault of NE-SW system.

The factors to control the localization of the mineralization are thought to be the species of the mother rocks, the fissure systems and the folding structures.

The distinct correlation has been recognized between the distribution of the mineralization and the results of the geochemical survey, with all of the three elements of Cu, Pb and Zn. The intense anomalies are concentrated around the Erdouz North ore deposit and around the Erdouz South ore deposit, and are tending to indicate the directions of the extension of the ore veins. By the distribution of the weak anomalies, the extension areas of the mineralization are suggested and certain slight indications of mineralization have been detected.

By the above results, emplacement of ore deposits would be expected in the area including the Erdouz North ore deposit and the Erdouz South ore deposit, especially at the depth of this area.

3-1-3 Azegour Sector

This area is underlain, geologically, by the schist of the Cambrian system extending in the direction of north and south, with the insertions of limestons of the thickness of 80 ∿ 150 meters, and by the Azegour granite body occupying the western part of this area. The geological structure in this area is characterized by the monoclinic structure of N-S trend, dipping 40° ∿ 70° to the east and by the faults trending in ENE-SWS direction.

The mineralization in this area is represented by the skarn type ore deposits of copper, molybdenum and tungsten in the Azegour mine and by the disseminated ore deposits of molybdenum in the skarnized zone which is distributed along the limestone bed of the approximate width of 80 meters, extending northward from the Azegour mine. The Azegour mine has produced approximately 900,000 tons of crude ores of the grades of Cu: 1.4 ∿ 2.8%, MoS_2: 0.2 ∿ 0.7% and WO_3: 0.35%. The area for the mineralization to be emplaced is 1,300 meters in north-south and about 150 meters in east-west, and the difference between the surface outcrop and the developed lowest level is about 200 meters. The skarnization is more intense in the deeper part, where the limestones are wholly skarnized, while the skarnization is recognized in two zones of the approximate width of 15 meters in the upper part. There are over 10 orebodies in the skarnized zones. The sizes of these orebodies are 20 ∿ 50 meters in major axes and 5 ∿ 20 meters in minor axes.

The skarnization in the northern area is recognized up to around Entifa which is located about 4 km north of the Azegour mine. The skarnized zones are recognized as wide as 30 cm to 100 cm, along the hanging and the foot walls of the limestone as well as along its boundary planes with other rocks. The intense skarnization is recognized along the fissures trending in ENE-WSW direction and in such areas as tight folds are recognized. In such area, the width of the skarnized zones is up to 10 meters to 30 meters. As a whole, the skarnization becomes less intense gradually toward the north, and the northern limit of the skarnization is thought to be around Entifa.

The molybdenum mineralization is recognized in many places from the Azegour mine to around Entifa. Especially, the mineralization is intense in the area from the southeast of the Tizgui village to the midway of Entifa and Tizgui. The indication of molybdenum mineralization on the surface at the east of the Tizgui village is recognized to be as wide as 60 cm with the grade of MoS_2: 0.13%, while, on the level at the depth of 200 meters in the underground, the mineralization extends 15 ∿ 35 meters with the approximate width of 1.5 meters, having the ore grades of MoS_2: 0.26 ∿ 0.56%. It is thought that the molybdenum mineralization is more intense in the deeper part, as is the case of the skarnization.

The factors controlling the mineralization in this area are thought to be the form of the limestones and the fissure systems in the direction of ENE-WSW.

By the results of the geochemical survey, the distribution of the Mo anomalies is reflecting the areas where the indications of molybdenum mineralization are recognized in the skarnized zones. Also, a tendency is recognized that the Cu anomalies are concentrated in the northern side of the above fissure.

By the above-stated results, it is thought in this area that the area between Azegour and Entifa, especially the depth of this area, would be an area where superior molybdenum mineralization could be expected.

3-2 Recommendation for the Second Phase Survey Program

Based on the conclusion obtained from the initial program of the investigation as well as from the results of the present phase surveys and the consideration on the results, the following surveys are recommended as the second phase investigation program.

(1) South Area

Geological survey, geochemical survey ---- area 1,100 km^2

(2) Erdouz Sector

It is thought that the area of 3 km x 1 km, including the Erdouz North ore deposit and the Erdouz South ore deposit, would be the favorable area for the emplacement of ore deposits, and that this area would warrant further exploration.

The following surveys are recommended.

1. Detailed geological survey, geochemical survey: to confirm sizes and grades of the ore deposits and to estimate the continuity of the ore deposits.

2. Geophysical exploration: to estimate the continuity of the ore deposits to the depth.

(3) Azegour Sector

It is thought that the favorable area for the emplacement of ore deposit warranting further exploration would be the area of 4 km x 1.5 km from the Azegour mine to Entifa, including the limestone zone and the area where the limestones are expected to exist in the depth.

The following surveys are recommended.

1. Geophysical exploration: to comprehend the figures and the forms of the skarnized zones at the depth.

2. Drilling: to grasp the states of skarnized zones and mineralization at the depth. It is desirable to carry out this drilling after the results of the geophysical exploration are obtained (execution B.R.P.M.).

APPENDICES

Table 5 List of Rock and Ore Samples

(1)

No.	Sample No.	Geo-logi-cal unit		Location	Rock Name	Thin Sec-tion	Pol-ished Sec-tion	X-ray Analy-sis	Whole rock analy-sis	Mineral Analysis					
										Cu ppm	Pb ppm	Zn ppm	Ag ppm	MoS2 (%)	W (%)
1	GR 11	Ig	Northern area	Erdouz, N	Porphyrite	o			o						
2	" 17	"		" "	Diorite or dioritic gabbro	o			o						
3	" 19	"		Toulkine, N	Granite	o			o						
4	" 76	Xa		Iguer-n-kouris, SE	Andesite	o									
5	MR 21	Pp		Areg S	Galena, chalcopyrite		o	o		Δ	Δ	Δ	Δ		
6	" 26	"		Anebdour NE	Galena,chalcopyrite,pyrite		o	o		Δ	Δ	Δ	Δ		
7	GK 8	Pl		Targa mine	Galena, limonite		o	o							
8	" 21	Ig		Anammer E	Quartz diorite	o			o						
9	" 105	"		Ourigh SE	" "	o			o						
10	" 111	Pp		Tassa Wirgane	Tuffaceous sandstone	o									
11	" 114	Xa		" "	Porphyrite	o									
12	" 120	Pp		Tizi Mill W	Chalcopyrite, limonite		o	o							
13	" 127	Pl		Targa mine	Galena					o	o	o	o		
14	GN117	Ig		Targa	Dolerite	o			o						
15	" 131	Pp		SMIM Barite Mine	Galena, sphalerite		o(2)	o		o	o	o	o		
16	" 133	"		Imigdal NW	Biotite schist	o									
17	" 156	"		Assif Al Mal mine	Pyrite, limonite		o	o							
18	" 157	"		"	Sphalerite, galena		o	o							
19	" 162	Pt		Imi-n-Erkha	Andesite	O									
20	" 167	Pp		Aghrass mine	Sphalerite, galena		o(2)	o		o	o	o	o		

(2)

No.	Sample No.	Geo-logi-cal Unit	Location	Rock Name	Thin Sec-tion	Pol-ished Sec-tion	X-ray Analy-sis	Whole rock Analy-sis	Mineral Analysis Cu ppm	Pb ppm	Zn ppm	Ag ppm	MoS_2 (%)	W (%)
21	MW 1	Pl	Northern area Tilfltine tunnel	Galena, chalcopyrite		o(2)	o		o	o	o	o		
22	" 2	"	"	" "					o	o	o	o		
23	MW 3	"	"	" "					o	o	o	o		
24	" 4	Pl	"	" "					o	o	o	o		
25	" 5	Pm	Areg tunnel	Chalcopyrite, pyrite		o	o		o	o	o	o		
26	" 6	"	"	" "					o	o	o	o		
27	" 7	"	"	" "					o	o	o	o		
28	" 8	"	"	" "					o	o	o	o		
29	" 9	"	"	" "					o	o	o	o		
30	GR 14	Pt	Erdouz sector	Green schist	o									
31	" 45	Ig	"	Diorite	o			o						
32	" 50	Pt	"	Andesitic tuff	o									
33	MR 4	Pp	"	Sphalerite, pyrite					o	o	o	o		
34	MR 5	Pl	"	Sphalerite, galena					o	o	o	o		
35	" 6	Pp	"	Galena					o	o	o	o		
36	" 8	Pl	"	Sphalerite, galena					o	o	o	o		
37	" 9	Pl	"	Chalcopyrite, pyrite					o	o	o	o		
38	" 10	Pl	"	Galena					o	o	o	o		
39	" 11	Pl	"	Sphalerite					o	o	o	o		
40	" 14	Pa	"	"					o	o	o	o		
41	" 15	Pa	"	"					o	o	o	o		

(3)

No.	Sample No.	Geo-logi-cal Unit	Location	Rock Name	Thin Sec-tion	Pol-ished Sec-tion	X-ray Analy-sis	Whole Rock Analy-sis	Mineral Analysis					
									Cu ppm	Pb ppm	Zn ppm	Ag ppm	MoS_2 (%)	W (%)
42	MR 16	Pa	Erdouz sector	Galena, sphalerite					o	o	o	o		
43	" 17	Pa	"	Sphalerite					o	o	o	o		
44	GK 72	Pl	"	Sphalerite, galena		o	o							
45	" 73	Pl	"	Sphalerite					o	o	o	o		
46	" 74	Pl	"	"					o	o	o	o		
47	" 90	Pl	"	Sphalerite, galena		o (2)	o		o	o	o	o		
48	" 91	Pa	"	" "					o	o	o	o		
49	" 92	"	"	" "					o	o	o	o		
50	" 93	"	"	Galena, sphalerite					o	o	o	o		
51	XK 1	Pl	"	Clay			o							
52	GN 52	"	"	Sphalerite, galena		o	o							
53	" 55	"	"	Iron gossan					o	o	o	o		
54	" 61	Ig	"	Porphyrite-augite, diorite	o			o						
55	" 69	Pl	"	Galena					o	o	o	o		
56	GR 56	Pg	Azegour sector	Schistose rock	o			o						
57	" 59	Ig	"	Porphyrite	o			o						
58	" 60	"	"	Quartz porphyry	o									
59	MR 12	Pl	"	Skarn					o				o	o
60	GK 77	Pg	"	Andesite	o									
61	MK 42	Pl	"	Skarn					o				o	o
62	" 44	"	"	"					o				o	o

(4)

No.	Sample No	Geological Unit	Location	Rock Name	Thin Section	Polished Section	X-ray Analysis	Whole Rock Analysis	Mineral Analysis					
									Cu ppm	Pb ppm	Zn ppm	Ag ppm	MoS2 (%)	W (%)
63	MK 45	Pl	Azegour sector	Skarn					o				o	o
64	" 46	"	"	"					o				o	o
65	" 47	"	"	"					o				o	o
66	" 48	"	"	"					o				o	o
67	" 49	"	"	"					o				o	o
68	" 51	"	"	"					o				o	o
69	" 52	"	"	"					o				o	o
70	" 53	"	"	"					o				o	o
71	" 54	"	"	"					o				o	o
72	" 55	"	"	"					o				o	o
73	" 56	"	"	"					o				o	o
74	" 57	"	"	"					o				o	o
75	" 58	"	"	"					o				o	o
76	" 59	"	"	"					o				o	o
77	" 61	"	"	"					o				o	o
78	" 62	"	"	"					o				o	o
79	" 63	"	"	"					o				o	o
80	" 64	"	"	"					o				o	o
81	" 65	"	"	"					o				o	o
82	" 67	"	"	"					o				o	o
83	" 68	"	"	"					o				o	o

No.	Sample No	Geo-logi-cal Unit	Location	Rock Name	Thin Sec-tion	Pol-ished Sec-tion	X-ray Analy-sis	Whole Rock Analy-sis	Mineral Analysis					
									Cu ppm	Pb ppm	Zn ppm	Ag ppm	MoS2 (%)	W (%)
84	MK 69	Pl	Azegour sector	Skarn					o				o	o
85	GN63A	Ps	"	Spotted schist	o									
86	" 69A	Pg	"	Schistose rock	o									
87	" 73	Pl	"	Molybdenite, pyrite		o	o		o				o	o
88	" 76	"	"	" "		o	o		o				o	o
89	" 94	Pg	"	Schistose dacite	o									
90	" 104	Ig	"	Pegmatite			o							
91	"116A	"	"	Lamprophyre	o									
92	MNA62	Ps	"	Skarn					o				o	o
93	MN 74	Pl	"	"					o				o	o
94	" 106	Pg	"	"					o				o	o
95	" 107	"	"	"					o				o	o
96	GH 1	Ps	"	"			o							
97	" 2	"	"	"			o							
98	" 3	"	"	"			o							
99	" 4	"	"	Molybdenite, pyrite		o	o							

Index of geological units:
Pp; Palaeozoic peritic schist
Pg; " gneissose schist
Pt; " green schist
Pm; " psammitic schist
Ig; Igneous rocks
Ps; Palaeozoic peritic schist
Pl; " limestone
Pa; " calcaleous schist
Xa; Pre-cambrian andesite

Index of mineral analysis: Δ; Analysed by B.R.P.M.

Table 6　Whole Rock Analysis and C. I. P. W. Norm Calculation

(1)

Whole Rock Analysis

SAMPLE NO.	GK-21			GN-61			GN-117			GR-11			GR-17		
	WT.%	WT.%	MOL.%	WT.%	WT.%	MOL.%	WT.%	WT.%	MOL.%	WT.%	WT.%	MOL.%	WT.%	WT.%	MOL.%
SIO2	55.36	56.52	61.06	58.75	59.69	66.53	49.35	51.45	57.50	61.02	61.96	68.65	55.96	57.34	61.95
TIO2	1.19	1.22	0.99	1.34	1.36	1.14	1.83	1.91	1.60	1.19	1.21	1.01	1.13	1.16	0.94
AL2O3	17.34	17.70	11.27	16.46	16.72	10.98	16.10	16.79	11.05	16.35	16.60	10.84	17.09	17.51	11.15
FE2O3	1.91	1.95	0.79	3.76	3.82	1.60	4.00	4.17	1.75	2.65	2.69	1.12	1.91	1.96	0.80
FEO	5.10	5.21	4.70	2.73	2.77	2.59	8.62	8.99	8.40	3.38	3.43	3.18	4.89	5.01	4.53
MNO	0.12	0.12	0.11	0.15	0.15	0.14	0.27	0.28	0.27	0.10	0.10	0.10	0.13	0.13	0.12
MGO	4.78	4.88	7.86	2.63	2.67	4.44	3.24	3.38	5.63	2.68	2.72	4.49	4.54	4.65	7.49
CAO	6.83	6.97	8.07	3.19	3.24	3.87	4.61	4.81	5.75	2.01	2.04	2.42	6.58	6.74	7.80
NA2O	4.04	4.12	4.32	5.47	5.56	6.00	6.53	6.81	7.37	4.98	5.06	5.43	4.08	4.18	4.38
K2O	1.01	1.03	0.71	3.35	3.40	2.42	0.02	0.02	0.01	3.31	3.36	2.38	1.03	1.06	0.73
P2O5	0.20	0.20	0.09	0.47	0.48	0.23	1.33	1.39	0.66	0.67	0.68	0.32	0.19	0.19	0.09
BAO	0.06	0.06	0.03	0.13	0.13	0.06	0.01	0.01	0.00	0.14	0.14	0.06	0.06	0.06	0.03
H2O+	0.0			0.0			0.0			0.0			0.0		
H2O-	2.45			2.37			4.65			2.36			2.41		
TOTAL	100.39	100.00	100.00	100.80	100.00	100.00	100.36	100.00	100.00	100.84	100.00	100.00	100.00	100.00	100.00

C.I.P.W. Norm Calculation

SAMPLE NO.	GK-21		GN-61		GN-117		GR-11		GR-17	
	WEIGHT(%)	MOL.(%)	WEIGHT(%)	MOL.(%)	WEIGHT(%)	MOL.(%)	WEIGHT(%)	MOL.(%)	WEIGHT(%)	MOL.(%)
Q	5.52	18.90	5.22	23.41	0.0	0.0	12.04	41.33	6.79	22.78
C	0.0	0.0	0.0	0.0	0.14	0.35	2.47	5.00	0.0	0.0
OR	6.10	2.25	20.13	9.75	0.12	0.06	19.88	7.36	6.24	2.26
AB	34.91	13.69	47.06	24.19	57.61	28.37	42.82	16.84	35.39	13.59
AN	26.76	19.78	10.64	10.31	14.80	13.74	5.94	4.40	25.91	18.76
SAL.TOTAL	73.29	54.63	83.05	67.67	72.67	42.51	83.16	74.93	74.33	57.40
WO - DI	2.77	4.90	1.07	2.49	0.0	0.0	0.0	0.0	2.67	4.63
EN - DI	1.72	3.53	0.93	2.49	0.0	0.0	0.0	0.0	1.66	3.33
FS - DI	0.88	1.37	0.0	0.0	0.0	0.0	0.0	0.0	0.85	1.30
EN - HY	10.43	21.38	5.73	15.40	0.84	2.17	6.78	13.93	9.93	19.93
FS - HY	5.30	8.26	0.0	0.0	1.04	2.04	2.27	3.55	5.07	7.75
FO - OL	0.0	0.0	0.0	0.0	5.31	19.47	0.0	0.0	0.0	0.0
FA - OL	0.0	0.0	0.0	0.0	7.25	18.37	0.0	0.0	0.0	0.0
MT	2.83	2.51	3.49	6.40	6.05	6.74	3.91	3.48	2.84	2.47
HM	0.0	0.0	0.03	0.06	0.0	0.0	0.0	0.0	0.0	0.0
IL	2.31	3.13	2.59	4.60	3.62	6.17	2.30	3.12	2.20	2.92
AP	0.47	0.30	1.11	0.91	3.21	2.52	1.58	0.99	0.45	0.28
FEM.TOTAL	26.71	45.37	16.95	32.33	27.33	57.49	16.84	25.07	25.67	42.60

Whole Rock Analysis (2)

GR-19			GR-45			GR-56			GR-59			GK-105		
WT.%	WT.%	MOL.%	WT.%	WT.%	MOL.%	WT.%	WT.%	MOL.%	WT.%	WT.%	MOL.%	WT.%	WT.%	MOL.%
75.68	75.54	82.07	46.30	48.58	51.62	65.57	66.33	71.67	61.09	63.10	69.08	65.75	67.30	73.69
0.17	0.17	0.14	1.53	1.61	1.28	0.56	0.57	0.46	0.82	0.85	0.70	0.61	0.62	0.51
13.47	13.45	8.61	17.42	18.28	11.44	16.37	16.56	10.54	15.61	16.12	10.40	15.30	15.66	10.10
0.88	0.88	0.36	2.17	2.28	0.91	0.41	0.41	0.17	1.88	1.94	0.80	1.71	1.75	0.72
0.29	0.29	0.26	6.68	7.01	6.23	2.16	2.19	1.97	3.59	3.71	3.39	2.59	2.65	2.43
0.02	0.02	0.02	0.15	0.16	0.14	0.04	0.04	0.04	0.10	0.10	0.10	0.10	0.10	0.09
0.14	0.14	0.23	9.09	9.54	15.10	2.19	2.22	3.57	3.07	3.17	5.17	2.64	2.70	4.41
0.66	0.66	0.77	7.78	8.16	9.29	3.28	3.32	3.84	2.28	2.35	2.76	1.28	1.31	1.54
3.99	3.98	4.19	2.84	2.98	3.07	5.74	5.81	6.08	4.46	4.61	4.89	2.84	2.91	3.09
4.81	4.80	3.33	1.13	1.19	0.80	2.11	2.13	1.47	3.44	3.55	2.48	4.63	4.74	3.31
0.03	0.03	0.01	0.20	0.21	0.09	0.18	0.18	0.08	0.34	0.35	0.16	0.12	0.12	0.06
0.04	0.04	0.02	0.02	0.02	0.01	0.24	0.24	0.10	0.14	0.14	0.06	0.12	0.12	0.05
0.0			0.0			0.0			0.0			0.0		
0.42			4.69			1.37			3.54			2.94		
100.60	100.00	100.00	100.00	100.00	100.00	100.22	100.00	100.00	100.36	100.00	100.00	100.63	100.00	100.00

C.I.P.W. Norm Calculation

GR-19		GR-45		GR-56		GR-59		GK-105	
WEIGHT(%)	MOL.(%)	WEIGHT(%)	MOL.(%)	WEIGHT(%)	MOL.(%)	WEIGHT(%)	MOL.(%)	WEIGHT(%)	MOL.(%)
32.45	79.04	0.0	0.0	13.67	46.63	12.00	40.58	24.52	61.08
0.54	0.78	0.0	0.0	0.0	0.0	1.16	2.32	3.58	5.26
28.38	7.46	7.01	2.33	12.63	4.65	21.01	7.67	28.03	7.54
33.71	9.41	25.21	8.92	49.21	19.23	39.01	15.11	24.62	7.03
3.15	1.65	33.00	21.99	12.84	9.46	9.66	7.05	5.92	3.19
98.22	98.35	65.22	33.24	88.35	79.96	82.85	72.72	86.67	84.09
0.0	0.0	2.58	4.11	1.21	2.13	0.0	0.0	0.0	0.0
0.0	0.0	1.74	3.22	0.75	1.54	0.0	0.0	0.0	0.0
0.0	0.0	0.63	0.89	0.38	0.60	0.0	0.0	0.0	0.0
0.35	0.51	3.64	6.72	4.77	9.74	7.90	15.99	6.74	10.04
0.0	0.0	1.32	1.86	2.43	3.77	4.00	6.16	2.58	2.93
0.0	0.0	12.87	33.93	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	5.16	9.38	0.0	0.0	0.0	0.0	0.0	0.0
0.51	0.32	3.30	2.64	0.60	0.53	2.82	2.47	2.54	1.64
0.53	0.49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.32	0.31	3.05	3.73	1.08	1.46	1.61	2.15	1.19	1.17
0.07	0.03	0.49	0.27	0.42	0.26	0.81	0.50	0.28	0.13
1.78	1.65	34.78	66.76	11.65	20.04	17.15	27.28	13.33	15.91

Table 7-1 Microscopic Observation of Thin Sections

(1)

Sample No.	Geological Age	Rock Name	Microscopic Observation
GR 11	Ig	Porphyrite	Plagioclase phenocrysts have totally been replaced by dusty albite with tiny crystals of chlorite, sericite and epidote. Mafic phenocrysts, probably hornblende (0.9x0.7mm in average), have also been completely replaced by green chlorite, epidote and sphene. Groundmass which was originally composed of medium-grained plagioclase and hornblende (?) was replaced by albite, chlorite, epidote, sericite and sphene. Magnetite was partly replaced by hematite. Dark brownish porphyrite, completely altered at hydrothermal condition.
GR 17	Ig	Diorite or dioritic gabbro	Brown hornblende has been retrogressively altered with the following process: hornblende → pale green actinolite → chlorite + epidote + sphene. Augite is still remained within the crystals of hornblende. Plagioclase has strongly replaced by dusty albite (+ epidote, chlorite, sericite and calcite) along crystal margins and cleavages. Apatite and magnetite are also present. Some sheared parts filled with well-oriented actinolite and chlorite are observed. Strongly altered dark green diorite or dioritic gabbro (saussuritisation)
GR 19	Ig	Granite	The rock is chiefly composed of quartz, oilgoclase-andesine plagioclase, k-feldspar and small amount of biotite and magnetite. Plagioclase has partly been replaced by dusty albite (+ sericite). The replacement of magnetite by hematite is common. Some orthoclase shows perthite texture.

Sample No.	Geological Age	Rock Name	Microscopic Observation
			Fresh biotite granite.
GR 76	Xa	Andesite	Phenocrysts are idiomorphic plagioclase (12.0x4.0mm ~ 3.0x0.7mm) which have become to weakly dusty albite with tiny crystals of chlorite, sericite and calcite. Minerals forming groundmass are lath-shaped plagioclase (albite), magnetite and quartz. The replacement of magnetite? by hematite as well as by limonite is distinct. Round or irregular shaped druses filled with quartz, k-feldspar? albite, sericite, calcite and chlorite are observed. Albite-calcite-quartz vein and albite-quartz vein are observed. Dark reddish andesite, altered at hydrothermal condition.
GK 21	Ig	Quartz-diorite	Original rock was chiefly composed of quartz, brown or greenish brown hornblende and plagioclase. Hornblende was retrogressively replaced by the assemblage of actinolite-chlorite, epidote, brown biotite and sphene and was finally transformed into the assemblage of chlorite-epidote-sphene. Plagioclases have perfectly been altered into dusty albite (+ epidote, sericite and chlorite). (Saussurite alteration) Small amount of secondary quartz is also formed. Strongly hydrothermally altered quartz-diorite.
GK 105	Ig	Quartz-diorite	Plagioclase crystals (2.1x1.6mm in average) have completely altered into dusty albite (+ biotite, sericite and few calcite).

Sample No.	Geological Age	Rock Name	Microscopic Observation
			Mafic mineral, probably hornblende, was perfectly decomposed into biotite-sericite assemblage. k-feldspar is rarely observed. k-feldspar may have been formed during the time of hydrothermal alteration by which biotite and sericite were formed. Small amount of magnetite is found. Blue tourmaline is well developed. The hydrothermal alteration appeared in this specimen must have been accompanied with strong addition of K_2O (k-metasomatism) and boron (greisenization). Dark greenish grey quartz-diorite, completely altered at hydrothermal condition.
GK 111	Pp	Tuffaceous sandstone	Clastic grains (2.0x1.5mm in average) are of rock fragments and quartz. Rock fragments are composed of siliceous rock, shale and andesite. Fragmental quartz showing sub-angular to sub-rounded form have strong wavy-extinction. Matrix is composed of quartz, albite, clay minerals (probably chlorite/smectite), illite (sericite) with small amount of calcite. Magnetite has partly been replaced by hematite. It is difficult to distinguish illite from secondary sericite. Hydrothermally altered dark grey tuffaceous sandstone.
GK 114	Xa	Porphyrite	Phenocrysts: Only plagioclase is observed. Lath-shaped andesine with albite twinning of 2.2x0.4mm in average is replaced by albite with tiny crystals of chlorite, sericite and chlorite. Mafic minerals, probably pyroxene, also suffered the alteration into the assemblage of chlorite, calcite and opaque

Sample No.	Geological Age	Rock Name	Microscopic Observation
			showing their pseudomorphs. Groundmass is chiefly composed of albite, plagioclase with minor amounts of chlorite, calcite, sericite, quartz and opaque minerals. Plagioclase is completely replaced by dusty albite with sericite and chlorite. Irregular shaped druses filled with pale green chlorite, calcite, quartz and albite are observed. These druses are surrounded by aphanitic (fine-grained) zone chiefly composed of lath- or needle-shaped albite, chlorite and opaque minerals. The presence of aphanitic zone indicates that the rock must be not of intrusive but of extrusive nature. Dark reddish porphyrite, altered at hydrothermal condition having druse filled with alteration minerals.
GN 117	Ig	Dolerite	Originally, this rock was composed of plagioclase (1.8x0.4mm in average) and mafic mineral (0.8x0.6mm in average) showing typical ophitic texture. Plagioclase has been completely altered into dusty albite (+ chlorite, calcite). Mafic mineral, probably clinopyroxene or hornblende, has also been completely replaced by green chlorite, calcite and sphene. Apatite and magnetite are present. Secondary quartz is found filling the interstitials of ophitic texture. Dark grey dolerite, completely altered at hydrothermal condition.
GN 133	Pp	Biotite schist	Porphyroclasts of plagioclase (with tiny crystals of sericite, biotite and chlorite) is surrounded by the assemblage of plagioclase (albite?), biotite, sericite and quartz with small amounts of epidote, magnetite, apatite, bluish green tourmaline and sphene.

Sample No.	Geological Age	Rock Name	Microscopic Observation
			Pale brown to greenish brown biotites show coaser tabular to columnar forms. Sericites are smaller flakes and show pale green to colourless. Sphene has trend to accompany with biotite and epidote with sericite. Quartz vein is observed. Dark grey biotite schist, derived from dacitic or andesitic tuffaceous sediment.
GN 162	Pt	Andesite	Phenocrysts (or clastics): Only plagioclase is present. Plagioclases of 0.4x0.3mm in average have been altered into albite. Mafic minerals, probably pyroxene or hornblende, have also been perfectly replaced by pale green chlorite, calcite, epidote and sphene, although no pseudomorphous texture can be observed. Groundmass (or matrix) is composed mainly of albite, quartz and chlorite, with subordinate amounts of sericite, chlorite and sphene. Most of these minerals are hydrothermal products. Sericite is mostly replaced by chlotite and both minerals show network form. Magnetite occurs widely in accessory amounts. Weak schistosity is observed. Dark green andesite (~andesitic tuff) altered at hydrothermal condition.
GR 14	Pt	Green schist	This rock is chiefly composed of green or greenish brown mica, green chlorite, calcite, quartz and albite with small amounts of bluish green tourmaline and apatite, calcite aggregates form lenticular shapes. Schistosity is well developed. Fine-grained biotite-chlorite green schist.

Sample No.	Geological Age	Rock Name	Microscopic Observation
GR 45	Ig	Diorite	This rock is similar to GR 17. Original rock was chiefly composed of brown hornblende, plagioclase with small amount of apatite and magnetite. Brown hornblende was replaced first by actinolite and sphene and then by chlorite-calcite-epidote-sphene assemblage. Plagioclase were almost completely replaced by dusty albite (+ chlorite). Pyrite was formed by hydrothermal alteration. Calcite veins are observed. Dark green diorite, suffered very strong hydrothermal alteration.
GR 50	Pt	Andesitic tuff	This rock is very similar to GN 162. Clastic materials are of dusty plagioclase crystals (0.7x0.4mm in average) which have been altered into albite plus chlorite and sericite. Matrix is mainly composed of albite, quartz, green chlorite, epidote, calcite, sericite, sphene, magnetite and limonite. Calcite veins are observed. Dark green endesitic tuff, altered at hydrothermally condition.
GN 61	Ig	Porphyrite-augite diorite	Augite (0.5x0.4mm in average) is mostly replaced by chlorite-calcite-epidote-sphene. Plagioclase (1.2x0.4mm in average) has completely been altered into dusty albite with small amounts of epidote and chlorite crystals. Secondary quartz formed by hydrothermal alteration is filling the interstitial part of plagioclase crystals, and some shows micrographic intergrowth with albite.

Sample No.	Geological Age	Rock Name	Microscopic Observation
			Some columnar mafic mineral is perfectly reserved. Strongly altered reddish porphyrite - augite diorite.
GR 56	Pg	Schistose rock	This rock is similar to GN 69A but with few quartz as a Porphyroclast. Original rock was probably dacite. Porphyroclasts are of plagioclase and corroded quartz. Plagioclases (1.6x1.2mm in average) have been replaced by dusty albite-oligoclase (+ sericite, calcite, chlorite). Mafic phenocrysts (0.8x0.5mm in average), probably hornblende or pyroxene, were transformed into tremolite amphibole and chlorite. The groundmass is chiefly composed of albite-oligoclase, quartz, biotite, sphene and apatite. Magnetite as well as pyrite are observed. Vein chiefly composed of quartz and sodic plagioclase is found.
GR 59	Ig	Porphyrite	This rock is resemble to GR 11. Ophitic and porphyritic textures are clearly observed. The replacement of plagioclase by dusty albite with sericite and chlorite is common. Mafic minerals, probably pyroxene or hornblende, were also transformed into chlorite (+ calcite and sphene). Apatite and magnetite are original minerals. The replacement of magnetite by hematite is clear. Secondary quartz formed by hydrothermal alteration fills the interstitials in ophitic texture, and shows micrographic texture at some contact with albite.

Sample No.	Geological Age	Rock Name	Microscopic Observation
			Reddish porphyrite, altered at hydrothermal condition.
GR 60	Ig	Quartz porphyry	Phenocrysts were plagioclase (2.1x1.8mm in average), quartz and mafic minerals. Plagioclase was totally replaced by dusty albite (+ sericite). Mafic minerals (0.3x0.2mm in average), pyroxene or hornblende, were also transformed into chlorite-leucoxene assemblage showing their pseudomorphs. Rounded or corroded form quartz phenocrysts (1.4x1.3mm in average) are well preserved. Groundmass is chiefly composed of fine-grained quartz albite and sericite. Hematite is common. Light reddish quartz porphyry, altered at hydrothermal condition.
GK 77	Pg	Andesite	Phenocrysts: Plagioclase is observed. Plagioclases (2.0x2.4mm - 0.4x0.6mm) are presumably andesine and/or oligosclase and have been replaced by dusty albite with tiny crystals of calcite, chlorite and sericite. Groundmass consists of plagioclase (albitic), pale brownish green actinolite, quartz, pale brown biotite, calcite and sphene. Actinolite and biotite are both chloritized along their crystal margin and cleavage. Dark reddish andesite, altered at hydrothermal condition.
GN 63A	Ps	Spotted schist	The rock is mainly composed of brown biotite, muscobite, pale green chlorite, albite and quartz with small amounts of sphene, magnetite, hematite and brown tourmaline. Brown biotite has partly been retrogressively replaced by green chlorite. Dark grey spotted biotite-muscovite schist derived from pelitic sediment.

Sample No.	Geological Age	Rock Name	Microscopic Observation
GN 69A	Pg	Schistose rock	The constituents are clinopyroxene (diopside or hedenbergite), pale green hornblende (actinolite or tremolite), dusty albite (with tiny crystals of chlorite) and quartz. Some coarse-grained quartz show round corroded form indicating their origin of phenocrystic quartz. Leucoxene is dispersed widely. Magnetite is partly transformed into hematite. Apatite is seen as accessory. Schistosity shown by parallel arrangement of constituting minerals, particularly hornblende, and white and green bands are observed. Clinopyroxene-hornblende-bearing schistose rock, derived from dacite or dacitic tuffaceous rock.
GN 94	Pg	Schistose dacite	This rock is very similar to GN 162, but with quartz as porphyroclast or phenocryst. Phenocrysts or porphyroclasts are quartz and plagioclase with small amounts of tiny sericite crystals. Rounded or corroded quartz crystals came from dacitic volcanic materials are observed. Groundmass is chiefly composed of brown-pale green biotite, albite quartz and sphene with small amount of greenish blue tourmaline. Weak parallel arrangement of minerals, especially of biotite, indicate the deformation process to form this specimen. Schistose dacite or dacitic tuff altered at hydrothermal condition.
GN116A	Ig	Lamprophyre	Phenocrysts are idiomorphic chlorapatite (1.4x0.8mm in average) and dark brown biotite (1.3x0.4mm in average). Some chlorapatite contains many inclusions near centre of the crystal (sieve tex-

Sample No.	Geological Age	Rock Name	Microscopic Observation
			ture). Groundmass is composed of fine-grained biotite, apatite, plagioclase (Oligoclase-andesine) and magnetite. Magnetite is partly altered into hematite and limonite. Calcite vein or veinlet is observed. Chlorapatite-biotite dark brown lamprophyre (kersantite?).

Table 7-2 Microscopic Observation of Polished Sections

(1)

Sample No.	Location	Macroscopic Observation	Microscopic Observation
MR-21	Tizgul 2km south from Areg	Malachite stained quartz vein	Ore minerals are composed of abundant galena and a little amount of chalcopyrite, covelline and sphalerite. Galena is scattered in a quartz vein. Chalcopyrite occupies in and around the galena crystal. Sphalerite is associated with chalcopyrite. Covelline is an alteration product of chalcopyrite.
MR-26	1.2km north-east of Anebdour	Azurite-malachite quartz vein	Mineral assemblage is a little amount of galena, chalcopyrite, sphalerite, pyrite, azurite and limonite. Galena, chalcopyrite, sphalerite and pyrite are disseminated in the vein, whereas azurite and limonite fill small cracks in other minerals. Sphalerite contains small dots of chalcopyrite.
GK-120	0.5km west of Tizi mil	Copper bearing quartz vein	Ore minerals are composed of mainly chalcopyrite and limonite and a few amount of chalcocite, azurite and pyrite. Chalcopyrite is in a massive form and changes into chalcocite, azurite and limonite in and around its crystal. This is a fairly oxidized sample.
GK-90	Erdouz Sector	Sphalerite-galena ore	Ore minerals are composed of lots of sphalerite, a few amount of galena, chalcopyrite and few or scarce amount of pyrite, tetrahedrite and gersdoffite. Sphalerite is in a massive form and a part of it contains chalcopyrite dot. Galena and chalcopyrite fill the small cracks and crystal periphery of sphalerite. Tetrahedrite is within sphalerite and galena. Gersdoffite is surrounding pyrite crystal.

Sample No.	Location	Macroscopic Observation	Microscopic Observation
GK-72	Erdouz Sector	Sphalerite-galena ore	Mineral assemblage is nearly the same as GK-90.
MW 1	Tilfline Tunnel	Sphalerite-galena quartz vein	Ore minerals consist of large amount of galena and sphalerite, small amount of chalcopyrite, azurite and limonite and scarce tetrahedrite. Galena is scattered in the vein and is replaced by azurite and limonite along its periphery. Sphalerite is pure crystal containing little chalcopyrite dot. Chalcopyrite is in association with sphalerite or dis-semination in gangue mineral. Both minerals are replaced by azurite and limonite along their crystal boundaries. Tetrahedrite exists as small particles (10 μm ∿ 100 μm in size) in galena and/or sphalerite.
GN-52	Erdouz South	Sphalerite-galena ore	Ore minerals consist of abundant sphalerite and galena, a small amount of chalcopyrite and pyrite and few tetrahedrite. Sphalerite, containing no chalcopyrite dot, disseminates in the ore vein. Both galena and chalcopyrite exist in close association with sphalerite. Tetrahedrite is contained mainly in galena and a few in sphalerite.
GN-157	Assif Al Mal Mine No.4 vein	Sphalerite-galena ore	Ore minerals consist of lots of sphalerite and a few amount of galena, chalcopyrite and pyrite. Sphalerite is fairly pure crystal containing little chal-copyrite dot and is massive in form.

(3)

Sample No.	Location	Macroscopic Observation	Microscopic Observation
			Galena and chalcopyrite often coexist and occupy the periphery of sphalerite and pyrite. Pyrite used to exist as an eu-anhedral crystal.
GN-156	Assif Al Mal Mine No.3 vein?	Copper ore	Ore minerals consist of a few amount of pyrite and limonite and very few amount of chalcopyrite and sphalerite. Pyrite disseminates in the ore and its crystal margin is changed into limonite. The ore suffered strong oxidation.
GN-131	SMIM Barite Mine	Sphalerite-galena ore	Ore minerals consist of abundant galena and sphalerite, a few amount of chalcopyrite and tetrahedrite. Galena is in a massive form. Sphalerite, containing almost no chalcopyrite dot, is either in association with galena or in dissemination in gangue minerals. Tetrahedrite, rich in silver revealed by EPMA, exists (a) in association with sphalerite and galena (b) as a single crystal in gangue minerals. Chalcopyrite is surrounding the above-mentioned minerals.
GN-167	Aghrass Mine	Galena-sphalerite ore	Ore minerals consist of abundant sphalerite and galena, a few amount of arsenopyrite and very few amount of chalcopyrite, tetrahedrite and pyrite. Sphalerite is in a massive form. Galena exists either in contact with sphalerite or fills the interstices of arsenopyrite which shows dissemination or aggregation in the ore.

Sample No.	Location	Macroscopic Observation	Microscopic Observation
GH-4	Agegour Sector	Molybdenite bearing skarn	Ore minerals consist of a large amount of molybdenite, a small amount of pyrite and markasite and very few amount of chalcopyrite. Molybdenite is flaky crystal and disseminates among the skarn. Pyrite, marcasite and chalcopyrite also disseminate in the skarn.
GK-8	Targa Mine	Galena ore	Ore minerals consist of abundant galena and limonite, very few amount of pyrite, chalcopyrite and tetrahedrite. Galena is disseminated in the ore and alters to limonite in its periphery. Chalcopyrite and tetrahedrite are enclosed as small particles (20 μm in diameter) in galena crystal.
MW-5	Areg Tunnel	Copper bearing quartz vein	Ore minerals consist of chalcopyrite and pyrite with subordinate amount of azurite and limonite. Chalcopyrite and pyrite are disseminated in the vein and are replaced by azurite and limonite with their crystal boundaries.
GN-73 GN-76	Azegour Sector	Molybdenite bearing skarn	Both specimen contains the same mineral assemblages. Ore minerals consist of abundant molybdenite and a little amount of pyrite and chalcopyrite.

Table 8 Observation of X-ray Microanalysis

Sample No.	Locality	Observation
GK-90	Erdouz	Freibergite is enclosed in either galena or sphalerite as minute particles (0.03 mm ∿ 0.01 mm in diameter). Gersdorffite (NiAsS) is found to be fringing pyrite crystal.
GN-167	Aghrass mine	Arsenspyrite is replaced by galena. Anisotropic Pb-As-S mineral under ordinary optical microscope is found to be a mixture of arsenopyrite and galena under electron probe micro analyser.

Table 9 Photomicrographs

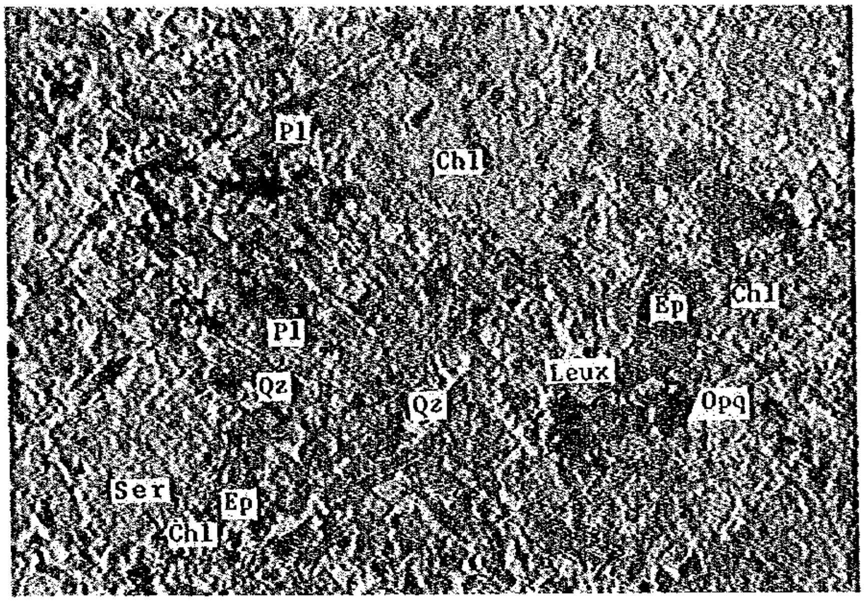
Photo No.	Sample No.	Rock Name	Photo No.	Sample No.	Rock Name
1, 2	GR-11	Porphyrite	57, 58	GN-94	Schistose dacite
3, 4	GR-17	Diorite or dioritic gabbro	59, 60	GN-116A	Lamprophyre
5, 6	GR-19	Granite	61	MR-21	Galena, chalcopyrite
7, 8	GR-76	Andesite	62	MR-26	Galena, chalcopyrite, Pyrite
9, 10	GK-21	Quartz diorite	63	GK-8	Galena, limonite
11, 12	GK-105	Quartz diorite	64	GK-120	Chalcopyrite, limonite
13, 14	GK-105	Quartz diorite	65	GN-131	Galena, sphalerite
15, 16	GK-111	Tuffaceous sandstone	66	GN-131	Galena, sphalerite
17, 18	GK-114	Porphyrite	67	GN-131	Galena, sphalerite
19, 20	GN-117	Dolerite	68	MW-1	Galena, chalcopyrite
21, 22	GN-133	Biotite schist	69	GN-156	Pyrite, limonite
23, 24	GN-162	Andesite	70	GN-157	Sphalerite, galena
25, 26	GN-162	Andesite	71	GN-167	Sphalerite, galena
27, 28	GR-14	Green schist	72	GN-167	Sphalerite, galena
29, 30	GR-14	Green schist	73	GN-167	Sphalerite, galena
31, 32	GR-45	Diorite	74	GN-167	Spahlerite, galena
33, 34	GR-50	Andesitic tuff	75	MW-1	Galena, chalcopyrite
35, 36	GN-61	Porphyrite~augite diorite	76	MW-5	Chalcopyrite, pyrite
37, 38	GR-56	Schistose rock	77	GK-72	Galena, sphalerite
39, 40	GR-56	Schistose rock	78	GK-90	Sphalerite, galena
41, 42	GR-59	Porphyrite	79	GK-90	Spahlerite, galena
43, 44	GR-59	Porphyrite	80	GK-90	Sphalerite, galena
45, 46	GR-60	Quartz porphyry	81	GK-90	Sphalerite, galena
47, 48	GR-60	Quartz porphyry	82	GN-52	Shalerite, galena
49, 50	GK-77	Andesite	83	GN-73	Molybdenite, pyrite
51, 52	GN-63A	Spotted schist	84	GN-76	Molybdenite, pyrite
53, 54	GN-69A	Schistose rock	85	GH-4	Molybdenite, pyrite
55, 56	GN-69A	Schistose rock	86	GH-4	Molybdenite, pyrite

Abbreviation

Qz	Quartz	Cal	Calcite
Pl	Plagioclase	Carb	Carbonate
Or	Orthoclase	Px	Pyroxene
Bi	Biotite	Ep	Epidote
Hb	Hornblende	Chl	Chlorite
Cpx	Clinopyroxene	Amp	Amphibole
Opx	Orthopyroxene	Act	Actinolite
Ti	Sphene	Ser	Sericite
Ap	Apatite	Mv	Muscovite
Clay	Clay minerals	Al	Albite
Rf	Rock fragments	Kf	K-feldspar
Leux	Leucoxene	Tl	Tourmaline
Opq	Opaque minerals		

Sp	Sphalerite	Mo	Molybdenite
Cp	Chalcopyrite	Gf	Gersdorffite
Gn	Galena	Py	Pyrite
Td	Tetrahedrite	Asp	Arsenopyrite
Cc	Chalcocite	Lim	Limonite
Cv	Covellite	G	Ganque

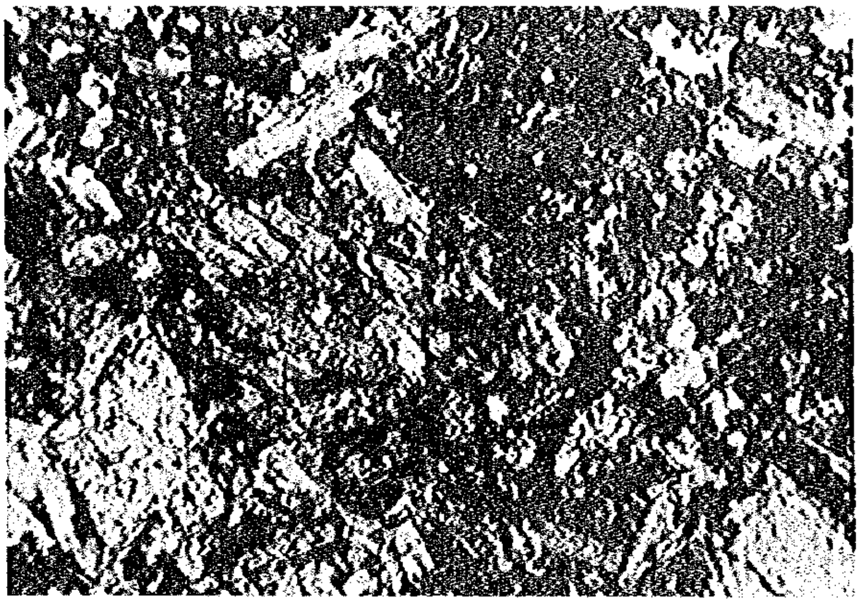
(1) GR-11



open nicol

0 0.5mm

(2) GR-11



crossed nicols

0 0.5mm