KINGDOM OF MOROCCO

REPORT ON GEOLOGICAL SURVEY

OF

THE HAUT ATLAS OCCIDENTAL AREA

(PHASE III)

FEBRUARY 1968

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

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PREFACE

The Government of Japan, in response to the request of the Government of the Kingdom of Morocco, decided to conduct a geological survey for mineral exploration in the Haut Atlas area of the Kingdom of Morocco, and commissioned its implementation to the Japan International Cooperation Agency.

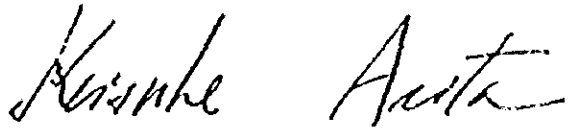
The Agency, taking into consideration of the importance of technical nature of the survey work, in turn sought the Metal Mining Agency of Japan.

This year's survey was for the third phase survey, and as for this current year, a survey team was formed consisting of five (5) members, and sent to the Kingdom of Morocco. The team stayed there for seventy four (74) days from June 5, 1985 to August 26, 1985. During the period of its stay, the team, in close collaboration with the Government of the Kingdom of Morocco, especially with Bureau de Recherches et de Participations Miniers, was able to complete survey works on schedule.

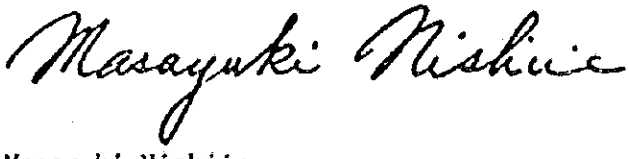
This report submitted hereby summarized the results of the survey performed for the third phase survey, and it will be also formed a portion of the final report that will be prepared with regard to the results obtained in the first and second phases.

We wish to take this opportunity to express our heartfelt gratitude to the Government of the Kingdom of Morocco and the other authorities concerned for their kind cooperation and support extended to the Japanese survey team.

January, 1986



Keisuke Arita
President
Japan International Cooperation Agency



Masayuki Nishiie
President
Metal Mining Agency of Japan

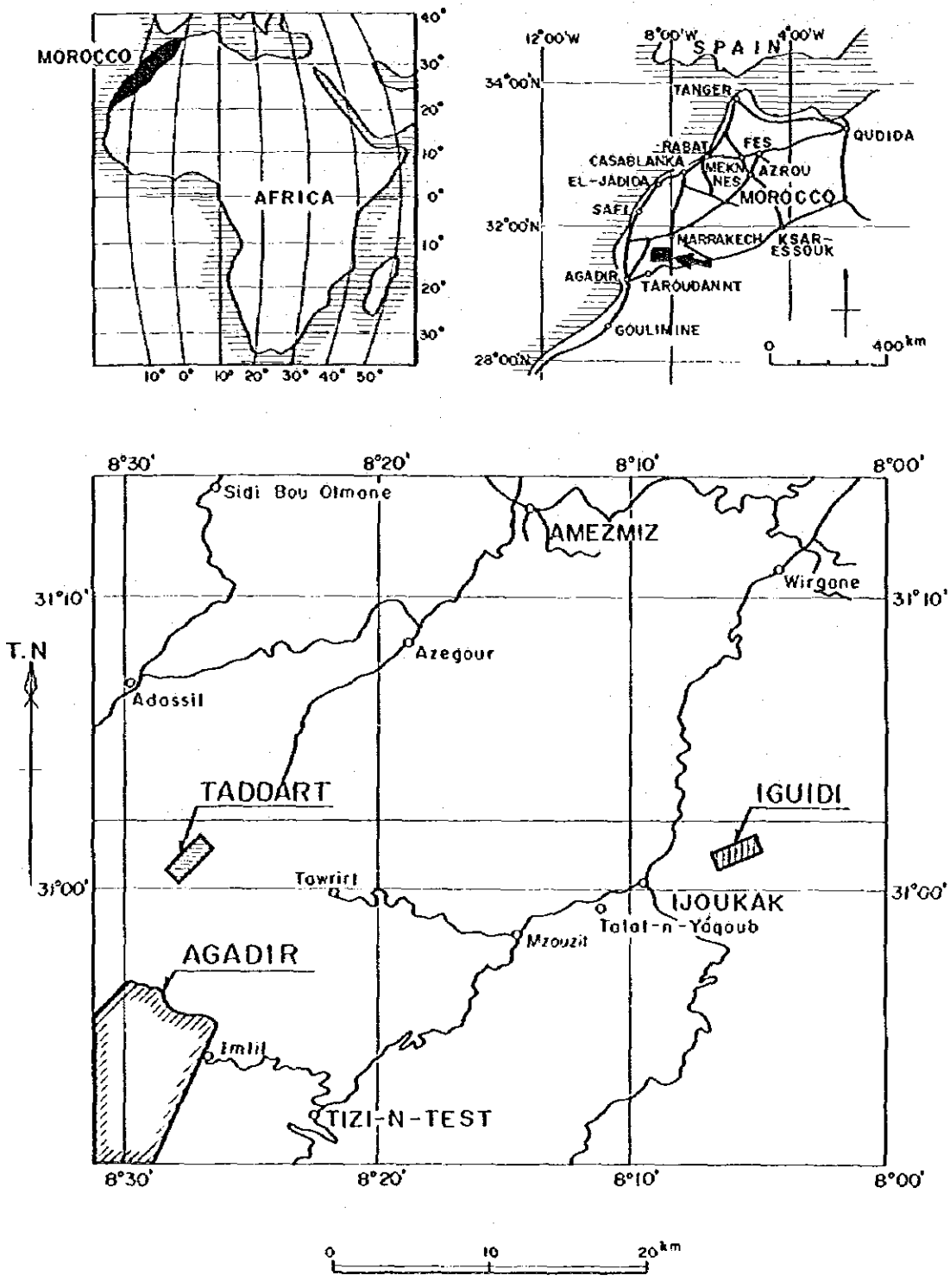


Fig. 1 Location Map of Surveyed Area

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SUMMARY

Purpose of the third phase survey of the cooperative investigations for the development of mineral resources in the Haut Atlas Occidental Area of the Kingdom of Morocco was to clarify the distribution and emplacement of skarn type ore deposit contains copper and tungsten and to elucide the relationship between geological structure and mineralization and the its continuity to the deeper part in underground in the Agadir sector, and to clarify the distribution and emplacement of copper mineralization in the Iguidi and Taddart Sectors.

The contents of survey carried out in each sector are as follows.

o Agadir Sector: Semi-detailed geological survey; surveyed area 60 km^2, surveyed route 114.7 km.
Geochemical survey (rock); number of collecting samples=304, analysis element=3 of Cu, W, and Mo.
Geophysical exploration (magnetic survey); surveyed area 8 km^2, number of observation points=520.
Geophysical exploration (IP Method); surveyed length 15 km, number of observation point=319.

o Iguidi Sector: Semi-detailed geological survey; surveyed area 3 km^2, surveyed route 17.7 km.
Geochemical survey (rock); number of collecting samples=227, analysis element=2 of Cu and Ag.

o Taddart Sector; Semi-detailed geological survey; surveyed area 3 km^2, surveyed route 18.4 km.
Geochemical survey (rock); number of collecting samples=148, analysis elements=2 of Cu and Ag.

o Rock identification by thin section=22 samples, Ore mineral identification by polish section=21 samples, X-ray diffraction=20 samples, Ore chemical analysis (Cu, W, Mo)=80, (Cu, Ag)=95, IP test=23, Measurement of Magnetic susceptibility=23.

Result of Survey

1) Agadir Sector: This sector is underlain mainly of conglomeratic green schist, psammitic schist, pelitic schist, crystalline limestone and calcareous schist of the Paleozoic Group and associated Hercynian granites intruded them. The Palcozoic formations strikes NS or NE-SW, and show the monoclinic structure dipping eastward, and is widespreaded whole of the sector. The granites exposured in the western part in this sector forming stocks and dykes, and affected strong thermal metamorphism to the surrounding formations, especially, made the skarn mineral replaced partially limestone.

The geological structure in this sector is characterized by the monoclinic structure of the Paleozoic formation, the block movement by the faults trending of N80°E, N80°W, NS, N50°W, and the intrusion of the Tichka granites.

As the mineralization, copper-molybdenum vein ore deposits and copper-tungsten-molybdenum skarn ore deposit were recognized in this sector. The vein ore deposits were observed three places, these ore deposits are small scaled and low grade ore deposits of which less than 1.0 meter in width and less than several-10 meters in length. The skarn ore deposit was recognized in the north-south trend limestone which is about 400 meters in width near the Agadir village.

The skarn zones range from several meters to 20 meters in width and from 15 meters to 500 meters in length, and the distribution is reached about 2 kilometers along the limestone. The mineralization, consist of chalcopyrite and pyrrhotite, were recognized partially in the skarn zones,

and range from several meters to 20 meters in width and from 15 meters to 100 meters in length. Especially, predominant mineralization was observed near the riverside. The grades of the outcrop on the surface is Cu: 0.6%, Mo: 0.01%, W: 0.03%.

As the results of the geochemical survey, Cu strong anomalous values is distributed with the correspondence to the mineralized skarn and vein ore deposit in the southwestern part.

As to the W and Mo anomalous values, since most of analysis values are under the detectable limit, the correspondence to mineralization was not clear.

As the results of the magnetic survey, the short waved-medium amplitude anomalies are distributed in the mineralized area, especially in the skarnized area, these strong anomalies are correspond to the mineralized skarn.

As the results of the IP survey, three IP anomalies in the skarnized area and one IP anomalies in the vein distributed area were recognized. The former three anomalies show low resistivity and high FE values and seem to correspond to the mineralized skarn.

Especially, the anomalous zone centering the river near the Agadir village is a large and strong anomalous zone and correspond to the strongest mineralization in this sector.

From the examination these results, it has been assumed that the ore deposit intermittently continue more than 100 meter in the depth.

From the result of this phase surveys. It has been considered that the center of mineralization is situated at the riverside near the Agadir village and the intermittent ore deposit of several 100 meters in lateral and more than 100 meter in depth are made. However, since the grades of the out crop is low. It is necessary to confirm the emplacement and enrichment of ore deposit.

2) Iguidi Sector: This sector is underlain by the Pre-Cambrian andesite and the Paleozoic dolomite and siltstone associated with intruded dolerite.

The Paleozoic formation is besides in fault contact with the Pre-Cambrian Group by the N50°E fault along the northwest margine, unconformably overlies the Pre-Cambrian Group.

The Paleozoic formations in the southeast side of the fault stikes N50°E ∿ N70°E, and dips 30° ∿ 70° northwest, and consist of upper, middle and lower dolomites and siltstone. Upper dolomite is 2 meter to 30 meters, middle dolomite is 20 meters to 70 meters and lower dolomite is more than 500 meters in each thickness and each dolomites is more than 2 kilometers in length.

The geological structure in this sector is characterized by the subsidence of southeast block caused by the above faults, the monoclinic structure dipping northwestward of the Paleozoic formations, the displacement by the NS faults and the fissures of NS and NE-SW system in the dolomite bed.

Mineralization in this sector was recognized as the copper stockwork ore deposits accompanied with quartz veinlets along the fracture of NS and NE-SW in the dolomite. Mineralizations were observed about 2 kilometers along the dolomite, especially, have been enriched near the N10°E faults and NS fissures.

The ore deposit concentrated along the N10°E fault near the old adits in the western part range from 1.0 meter to 15 meters in width and is about 250 meters in length. The average grade is Cu: 1.3%.

As the results of the geochemical survey, Cu anomalous zones are correspond to the mineral indications on the surface such as near the old

adits in the western part, near the N10°E fault and NS fissure in the central part and at the eastern margine in the middle dolomite especially, the weak Cu anomalies were recognized in the upper dolomite in the eastern part in this sector.

From the results of this phase survey, it has been clarified that the ore deposit is copper stockwork ore deposit limited in the Paleozoic dolomite and mineralization is spreaded about 2 kilometers along the dolomite. Furthermore, it has been elucided that the control factors of mineralization are N10°E faults and NS fissures.

3) Taddart Sector: This sector is underlain by green schist, psammitic schist, pelitic schist and limestone which are corrilated to the Paleozoic CII and CIII Formations. These formations strike generally NS to N30°E and dip 30° to 70° eastward.

The geological structure in this sector is characterized by the monoclinic structure of the Paleozoic formations and the block movement caused by the faults of EW, NE-SW, NW-SE and NS trends.

Mineralizations were recognized as the copper vein ore deposit accompanied with quartz veins in the conglomeratic green schist. The quartz vein aggregated area, about 400 meters x 400 meters, accompanied with silicified zone were recognized in the western part in this sector. This area is bordered by the above mentioned fault, and mineralizations are concentrated in this area.

The ore veins range generally from several centimeters to several meters in width and from several 10 meters to several 100 meters in length.

Their strikes show various trends such as EW, NS, NE-SW, NW-SE systems, and mineralization were recognized partially in these veins. Ore minerals are composed mainly of chalcopyrite, malachite and azurite. The grades of ore veins is generally Cu 0.5% to Cu 4.0%, the average grade has been assumed Cu 2.5% and Ag 20 g/t.

As the results of the geochemical survey, both of Cu and Ag elements have shown the same tendency. Strong anomalous zone are distributed as elongated form along the western and southern margines of above mentioned vein aggregated area. It has been recognized that these anomalies shows the well correspondence tendency to the ore veins.

From the results of this phase survey, it has been clarified that the mineralization in this sector made the silver being copper vein ore deposit which is geologically controled by the secondary fractures caused by the fault movement. Though the ore veins on the surface ore comparatively small and low grade, it is necessary to confirm the condition of emplacement of these veins in the deep part.

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INTRODUCTION

CHAPTER 1 CIRCUMSTANCES AND PURPOSE OF THE SURVEY

1-1 Circumstances of the Survey

The Kingdom of Morocco is rich in mineral resources, and there is a long history of the development of mineral resources.

As the cooperative investigations for the development of mineral resources betwen the Morocco and the Japan, there have been two investigations; the one is the Basic Cooperative Investigation for the Development of the Mineral Resources in the Anti Atlas Area carried out for three years between April, 1975 and April, 1977, and the other is the investigation of the same category in the Haute Moulouya area carried out for three years from September, 1978 to February, 1981.

After these investigations, cooperative surveys in several new projects were requested by the government of the Kingdom of Morocco. Upon the request, the delegation for preliminary investigation and negotiation of the agreement was despatched in May, 1983, and the execution of the surveys in the Haut Atlas Occidental area was agreed.

The present investigation was programmed to be carried out in cooperation with the Bureau de Recherches et de Participations Minieres (B.R.P.M.) of the Kingdom of Morocco, in Haut Atlas Occidental area of 2,200 km^2, during the period of three years starting in 1983. In the first phase of the program, geological survey and geochemical survey were carried out in an approximate area of 1,100 km^2 of northern part of the subject area. Especially, more accurate geological survey and geochemical survey were carried out in Erdouz Sector and in Azegour Sector which were regarded promissing.

Geological survey and geochemical survey were carried out as the second phase of the program, in the southern part of the subject area succeeding the works made in the first phase. More accurate geochemical survey and geophysical exploration were carried out in Erdouz Sector and geophysical exploration and drillings (by B.R.P.M.) were carried out in Azegour Sector where emplacements of promissing mineral resources were expected by the survey made during the first phase.

In the third phase of the survey program, detailed geological survey, geochemical survey, magnetic survey and IP survey were carried out in the Agadir Sector. And in both area of the Igudi Sector and the Taddart Sector, detailed geological surveys and geochemical surveys were carried out. Above three sector had been considered favorable areas of emplacement of ore deposit by the survey made during the second phase.

1-2 Purpose of the Survey

The purpose of the investigation is to comprehend the conditions of the emplacement of mineral deposits by precise elucidation of geology in the subject area through executing various methods of surveys.

Purpose of the surveys in Agadir Sector was to clarify the geological conditions of the Cu-W skarn type mineralization, and to examine the continuity downward of the mineralization and its property by the detection of magnetic and IP anomalies.

Purpose of the surveys in Iguidi and Taddart Sectors were to elucide the conditions of emplacement of Cu mineralization.

CHAPTER 2 OUTLINE OF THE SURVEYS

2-1 Outline of the Surveyed Area

The subject surveyed area is located in the central western part of the Kingdom of Morocco. It is topographically in the western part of the Haut Atlas Range, which runs across the central part of Morocco from east to west. The subject area is in rectangular form of 50 km from east to west and 44 km from north to south, between 30°50'26" and 31°14'14" of the north latitude and between 8°00' and 8°31'23" of the west longtitude. The area is approximately 2,200 km^2. The subject area is in the County of Amezmiz in the State of Marrakech according to the administrative division (Refer to Fig. 1).

Since railroad and paved road are available from Rabat, the capital of Kingdom of Morocco, to Amezmiz, the principal township in this district, the access is quite easy. Furthermore, a main road (partially unpaved), which is acrossing Haut Atlas Range, is running in about the center of the southern part of the area from Marrakech to Taloudant along Nfis River, and bus service is made available on it. Distance between Rabat to Ijoukak village, which is at the northwestern edge of the southern area, is about 420 km and it takes about 6 hours by automobiles. Possible means of transportation from Ijoukak to each village in the area are walking or horse riding except on the roads running along some of main rivers.

The surveyed area is mainly composed of mountainous land at the altitude of more than 1,000 meters above the sea level. In the central part of the southern area, there is a watershed of Haut Atlas Range at the altitudes of over 3,000 meters above the sea level. These rivers dissected the mountainous land deeply to form deep gorges. Therefore, the land features in this area are quite steep. The highest summit in the southern area is the main summit of Idga Massif of which elevation is 3,616 m above the sea level.

Since Sahara Desert is spread in the south of the subject area, the climate in this area is hot and arid of which temperature reaches 40°C, in summer from July to September. On the contrary, snowfalls are observed in this area during winter season from November to March to indicate wide ambient temperature variations. Therefore, vegetations are recognized only in lowlands along rivers, and uncovered rocks are exposed in most of the highlands.

Inhabitants in this area are mainly of Berber Tribe, and they are living along main rivers forming small villages. They usually speak Berber, therefore, it is sometimes impossible to communicate with them in Arabic which is the official language of the Kingdom of Morocco. Such steep topographical conditions and severe climatic conditions have checked development of industries and they are living on the stock farming of sheeps and goats. They are gentle and diligent in general, and potential working power is abundant. However, many of them are working away from home in big cities in the country or in various European countries.

2-2 Contents and Methods of the Surveys

Contents of the surveys carried out during the present phase are geological survey, geochemical survey and geophysical survey. Their contents and amounts are shown in Table I.

2-2-1 Geological Survey and Geochemical Survey

The contents of the surveys carried out in this phase are as follows:

- Geological survey (route and grid) and geochemical survey by rock samplings in the Agadir Sector.
- Geological survey (route and mineralized zone) and geochemical survey by the rock samplings in the Iguidi and the Taddart Sectors.

Field works were carried out during the term of 74 days from June 14, 1985 to August 26, 1985 under the cooperation of B.R.P.M. of the Kingdom of Morocco. Three Japanese engineers organized a crew including a native assistant and labourers, hence three crews were composed. Four wheel drive vehicles or horses were utilized for transporting men and gears from the camp to the surveyed area. Main camp station for the survey and for arranging surveyed results was established in Ijoukak village, which is at the northeastern edge of the southern area, utilizing a lodging house of an old mine. Tentative camps were established according to movements of surveyed area for improving efficiency of surveying work.

Survey routes, sampling points for geochemical survey, and precise surveys were determined as follows according to degrees of necessities in respective areas:

1) Agadir Sector: The survey routes were established with approximate interval of 1 km covering whole of the area. Especially, in such areas having high potentialities of mineralization, survey routes were set more densely. And in the area where ore deposits are aggregated, survey was carried out along thirty traverse lines (the length of each lines; 450 m to 500 m) of the interval of 100 m in right angle to the strike of the limestone bed.

In parallel with the geological survey, the geochemical survey (analysis elements are Cu, W and Mo) was carried out by rock samples, mainly at the points of every 50 m on the traverse lines.

For the field survey, the topographic maps of the scale of 1 to 5,000 and of 1 to 2,500 were prepared by the land survey with transit compass and esron tapes, and using these maps as the route maps, geological data and observation results were described on them. Upon the basis of these route maps, geological maps of scale of 1 to 10,000, and of 1 to 5,000 were drawn up.

2) Iguidi Sector: The survey routes were established with approximate interval of 500 m covering whole of the area, and along the dolomite beds. Geological survey was carried out on these routes. Geochemical survey (analysis elements are Cu and Ag) was carried out by rock samples at the points of every 50 m on the lines along the dolomite beds.

For the field survey, the topographic maps of the scale of 1 to 2,500 were prepared by the land survey with transit compass and esron tapes, and using these maps as the route maps, geological data and observed results were described on them. Upon the basis of these route maps, geological maps of scale of 1 to 5,000 were drawn up, and geochemical results were shown on the maps of scale of 1 to 2,500.

3) Taddart Sector: The survey routes were established with approximate interval of 500 m covering whole of the area. Especially, in such area (400 m x 400 m) having numerous veins, sixteen traverse lines running from east to west with interval of 25 m were established. Samples or rock were collected at the veins across the each traverse lines for geochemical survey (analysis elements: Cu and Ag).

For the field survey, the topographic maps of the scale of 1 to 2,500 and of 1 to 500 were prepared by the land survey with transit compass and esron tapes, and using these maps as the route maps, geological and geochemical data were described on them. Upon the basis of these route maps, geological maps of scale of 1 to 5,000 and geochemical anomaly maps of scale of 1 to 600 were drawn up.

Samples of representative rocks of surveyed areas were taken for microscopic observation, chemical analysis, X-ray diffraction analysis throughout above surveys.

Table I Contents of the Survey Works

Geological and Geochemical Survey	Field Works	Subject Area	Amount of Survey		Number of Geochemical Samples	
			Area (Km^2)	Route length (Km)	Survey Team	B.R.P.M.
		Agadir Sector	60.0	114.7	304	
		Iguidi Sector	3.0	17.7	227	
		Taddart Sector	3.0	18.4	148	
	Laboratory Works	Items				
		Rock determination by thin section			22	
		Ore mineral identification by polished section			21	
		X-ray diffraction			20	
		Ore chemical analysis (Cu, W, Mo)			50	30
		" (Cu, Ag)			70	25
		Geochemical samples analysis: Rocks (Cu, W, Mo)			300	4
		Geochemical samples analysis: Rocks (Cu, Ag)			350	25
Geophysical Survey	Field Works	Subject Area	Survey Method	Area(Km^2)	Amount of Survey	
					Survey Length (Km)	Survey Points
		Agadir Sector	Magnetic Survey	8	-	520
		"	IP Survey	-	15.0(191ine)	319
	Laboratory Works	Items			Survey Team	
		Magnetic Susceptibility Measurements of Rock Samples			23	
		IP Measurements of Rock Samples			23	

2-2-2 Geophysical Survey

The contents of the survey carried out in this phase are magnetic survey and IP survey in the Agadir Sector. Field works were performed during the term of 65 days from June 23, 1985 to August 26, 1985 under the cooperation of B.R.P.M. of the Kingdom of Morroco. Base camp station for the survey was established in the Agadir village utilizing a private house.

1) Magnetic Survey

The magnetic survey in the Agadir Sector was carried out at 520 stations established in the area of about 8 km^2. Stations were set at interval of 100 m along the geological survey routes and at interval of 50 m on the same traverse lines of geochemical sampling. Surface magnetisms were measured by Proton Magnetometer at the survey points. During the survey period, same type Proton Magnetometer installed at the base-camp, and the magnetism at base point was measured continuously to get correct data of dialy magnetism.

2) IP Survey

The IP survey in the Agadir Sector was carried out along 19 traverse lines having a correspondence to the geochemical traverse lines, of which length were about 0.8 km respectively. Total length of traverse lines is 15 km, and erectrode spacing is 50 m, total number of observation stations are 319. Erectrode separation constants (n) are 1-5, transmission currents were the range of 0.1A and 0.5A. Measurements were made by the dipole-dipole setting and frequencies of 0.3Hz and 2.5Hz.

Samples of representative rocks of surveyed areas were taken for IP test and magnetic susceptivity test throughout above surveys.

The results of above geophysical explorations were discribed on the maps of scale of 1 to 5,000, and executed analysis correlating to the results of geological surveys.

2-3 Member of the Survey Team

Participated member of survey programming, negotiation and field works in this phase is as follows.

2-3-1 Survey programming and Negotiation

1)	Japan side		
	SUZUKI	Haruo	J I C A
	ARAKAWA	Kohei	M M A J
	KITA	Yoshiyuki	M M A J
	KIKUSHIMA	Ichiro	M M A J
2)	Morocco side		
	Assou	LHATOUTE	B.R.P.M.
	Ahamed	LOUALI	B.R.P.M.
	Allal	TIJANI	B.R.P.M.
	Said	BARRAKAD	B.R.P.M.

2-3-2 Member of Survey Team

1)	Japan side			
	WAKABAYASHI	Kensuke	Leader	MINDECO
	SHIBATA	Kiyohisa	(geology)	MINDECO
	NAKAMURA	Akitoshi	(geology)	MINDECO
	KOBAYASHI	Manabu	(geophysics)	MINDECO
	OHASHI	Tadashi	(geophysics)	MINDECO
2)	Morocco side			
	Abdelaziz	MELLAL	(geology)	B.R.P.M.
	Abderkader	BAKKALI	(geology)	B.R.P.M.
	Mohamed	BARRADA	(geophysics)	B.R.P.M.
	MATSUTOYA	Shigeru	(geology)	B.R.P.M.

JICA : Japan International Cooperation Agency
MMAJ : Metal Mining Agency of Japan
B.R.P.M. : Bureau de Recherches et de participations Minieres
MINDECO : Mitsui Mineral Development Engineering Co., Ltd.

CHAPTER 3 OUTLINE OF GEOLOGY

Based on the results of the past investigation, the first phase survey and the second phase survey, outline of geology of this area is summarized as follows.

3-1 Outline of the Regional Geology

Hout Atlas region including the surveyed area is located in the northwest of the Pre-Cambrian stable zone that developed Mauritanian craton at the northwestern part of african continent as its neuclear, and it corresponds to geosynclinal zone developed in the Paleozoic age in its circumferencial area. These beds finally formed crystalline schist and metamorphic rocks at the end of paleozoic era by the regional metamorphism accompanied with folding and intrusion of plutonic rocks. After the above movements, peneplanation of basement rocks were proceeded in this area, and superpositions of continental-shallow water-marine sediments were made during the Mesozoic and Tertiary age owing to upheavals and subsidences of the basement rocks repeatedly occured. It is considered that the upheaval of Haut Atlas mountain range to such high altitude as seen today was made during the period of Alpine Orogenic Movement in Miocene age, especially in Pliocene age. (Refer to Fig. 2).

3-2 General Geology of the Surveyed Area

This area is underlain by the Pre-Cambrian Group (PIII) as the basements, the Paleozoic Group (CI, CII , CIII, CIV), the Mesozoic Group. (Trias System: T, Cretaceous System: K) and Cenozoic Group (Eocene: E, Allvium: Q) (Refer to Fig. I-1).

The Pre-Cambrian Group, which is the basement of this area, is distributed in the east marginal area, and consist of andesitic lava and pyrocrastics. The structure of the group is a monoclinic structure having gently inclination westward.

The Paleozoic Group are thought to belong to the Cambrian to Ordovician Systems, and are widely distributed occupying the greater part of the surveyed area. In this report, this group was divided into CI, CII , CIII and CIV Formations in ascending order according to differences of constituent rocks and geological structures. The CI Formation is composed of the alternation of dolomite, siltstone and andesites, and is distributed in the southeastern part of the area. This formation is characterized by the monoclinic structure that dips about 30° westward, and by the weak metamorphism. The CII Formation is mainly distributed in the northwestern and southern part of the area that trends northeast, is composed of psammitic schist, pelitic schist and thin limestone, and is characterized by the monoclinic structure, that dips about 30° northeastward in the northwest part and dips about 70° northwestward in the southern part. The CIII Formation is distributed from northern central part to southwestern part of the area, and is composed of limestone, psammitic schist, pelitic schist, calcareous schist and green schist. This formation is characterized by the anticlinorium structure having the northeast trending axis. The CIV Formation is widely distributed from the northeastern part to southern central part of the area, is composed mainly of thick layer of pelitic schist, and is characterized by the folded structure having the northeast trending axis.

The Mesozoic Group is composed of Triassic System, Jurrasic System and Cretaceous System.

The Triassic System consists of red sandstone, conglomerate and basalt lavas, is distributed around the Wirgane village in the northeastern part and along the midstream area of Nfis river. This system unconformably covers on the peneplane of the Paleozoic Group, and is cut by faults.

Jurassic System is composed of the greyish white alternations of sandstone and shale containing gypsum, which is underlying the Cretaceous formations in the western part of the area. In the west of the subject area, the thickness of this system is greater gradually, and the system composes one of the significant geological units, but it does not compose important geological unit by any means in this area.

Cretaceous System is distributed rather extensively stretching east to west direction from the midstream area of the Amezmiz river in the northern part of the surveyed area to the midstream area of the Assif Al Mal river. The Cretaceous System is also distributed in small areas on the topographical rises and in the area cutting by faults. This system is composed of red sandstone and dolomite, and unconformably overlies the peneplane of Palcozoic formation, Triassic and Jurassic formations.

The Cenozoic Group in this area comprises the Tertiary Eocene series and Quaternary alluvium deposit. The Eocene series is composed mainly of limestone, sandstone and congromerate. On the topographical high in the area where the Cretaceous formation is distributed, the Eocene series is found to lie occupying small areas, conformably on the Cretaceous formation. The Eocene series is also found in the mountain foot zone in the north of the Amezmiz village. The alluvium deposits are extensively distributed in the plain in the northern marginal zone of the surveyed area, and also distributed in the small lower land along rivers. They are composed of the gravels of various rocks derived from the hinterland.

All of the intrusive rocks occur in the Paleozoic Group in this area, and are overlain by the Mesozoic Group. The intrusive rocks consist of the stocks of granite, granodiorite and dolerite, and the dykes of microgranite and porphyrite. Granite stocks are represented by the Tichka Granites in further western area of the southwestern part of this area and the Azegour Granites in the northern central part in this area. All of these granites are characterized by the existence of alkali felspar and their intrusion forms are inharmonious to the folded structures of the Paleozoic System. Especially, beside the strong thermal metamorphism observed in the circumference of the granites, the skarn ore deposits replacing limestone are observed.

The dolerite stocks are observed near the Targa village in the eastern part in this area.

The dykes of intrusive rocks are generally within 10 meters in width, and occur in the circumference of the granite stocks. The strike of dykes are shown the various directions such as NE-SW, NNE-SSW, NNW-SSE and E-W, and their inclination angles are generally steep except inclinations of low angle about 10° in the southwestern part in this area.

Geological structure in this area are characterized by the monoclinic structure of Pre-Cambrian Group, the folded structure of Paleozoic Group and the block movement.

Basic pattarn of these geological structure were completed after the intrusion of Hercynian granite. And after that, the peneplane of the basement rock was made up.

The formations after Paleozoic, accumulated unconformably on these basement rock, were affected by the block movement at the Alpine orogenic period. Therefore, these formations have been formed gently monoclinic structure.

3-3 Outline of Ore Deposit in the Surveyed Area

There is no working mineral deposit being mined in large scale in the surveyed area except some barite vein deposits and copper vein deposits being mined in small scale by private companies. On the other hand, it should be noted that Azegour ore deposit (Cu, W, Mo), Erdouz ore deposit (Ag, Pb, Zn) and Assif Al Mal ore deposit (Cu, Pb, Zn) in the northern area were

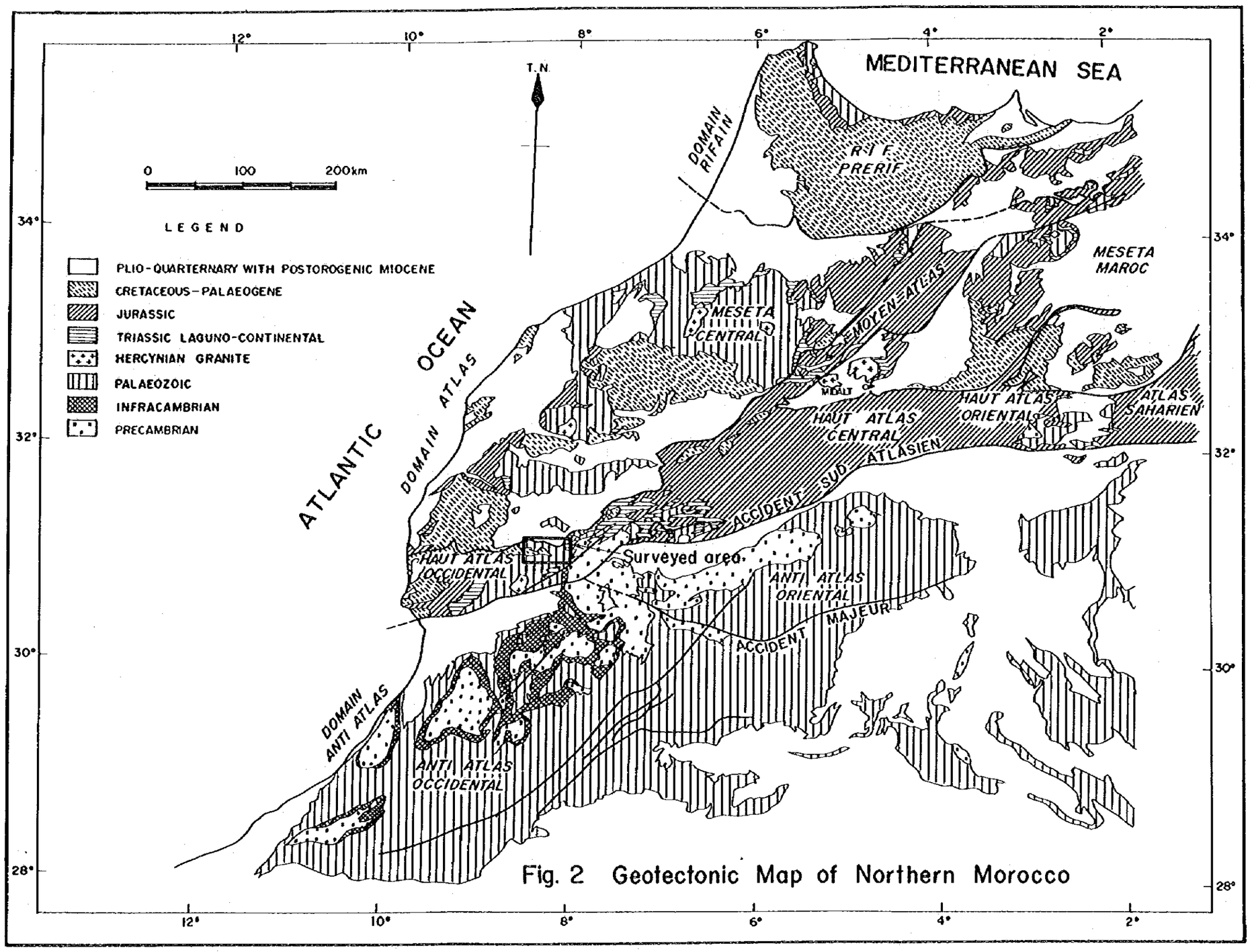


Fig. 2 Geotectonic Map of Northern Morocco

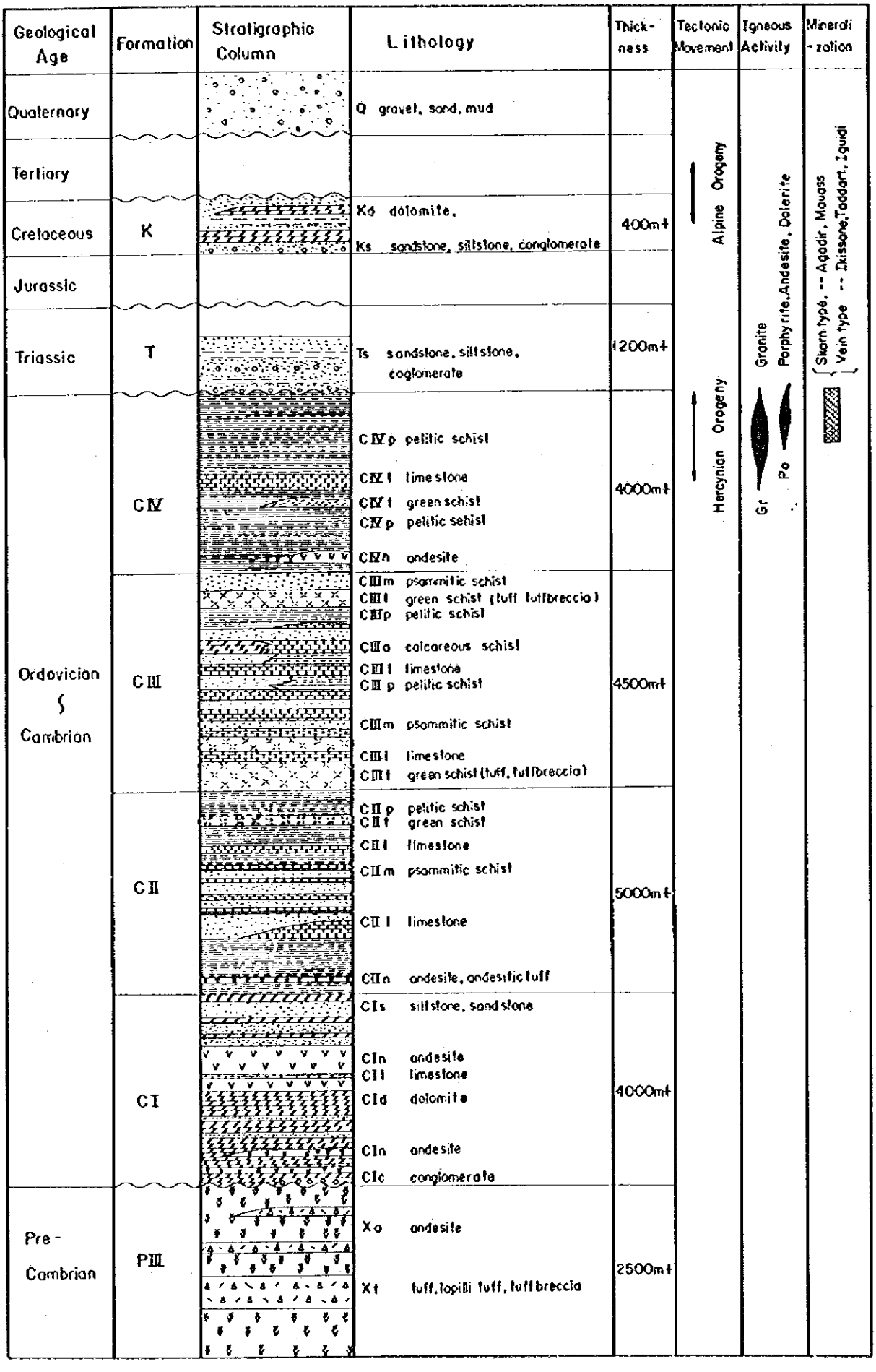


Fig. I-1 Schematic Geological Column of Surveyed Area

actively mined until 1950s, and Gundafa ore deposit (Cu, Pb, Zn) and L'Ounein ore deposit (Cu) in the southern area were actively mined until 1970s.

As to the types of mineralization, although vein-type ore deposits are found most frequently, skarn-type ore deposits and a stockwork ore deposit are observed as well. The vein-type ore deposits contain copper, lead, zinc, silver, molybdenum and barite, the skarn-type ore deposits contain copper, tungsten and iron, and the stockwork ore deposit contains copper. The country rock of all of these ore deposits are exclusively rocks of the Pre-Cambrian Group, the Palerozoic Groups and the intrusive rock of Hercynian Period, and none of mineralization exists in the rocks after Paleozoic age. This facts suggests that the mineralizations in this area have the close relationship with the intrusive rocks in the Hercynian period of the end of Palerozoic Era.

PARTICULARS

I GEOLOGICAL SURVEY, GEOCHEMICAL SURVEY

CHAPTER 1 AGADIR SECTOR

This sector is located in the south western part in the area. There is a trafic way by vehicles from Ijoukak to the opposit river side of Imlil along the Nfis river (about 2 hours) and by foot or horsebacks from Imlil to the Agadir village at the center in this sector (about 1.5 hours) as the way from Ijukak to the Agadir. However, from Ijoukak to the Tizirt village in the southern side, there is no other way than by vehicles (about 4 hours) along the detour road through the Tizi-n-Test.

It has been clarified that this sector is overlain by the Paleozoic Group; crystalline limestone, calcareous schist, green schist, pelitic schist, psammitic schist and granites intruding in them. Furthermore, chalcopyrite-pyrrhotite-wolframite skarn ore deposits replaced limestone and molybdenum-quartz vein ore deposits have been recognized in this sector by the second phase survey.

In this phase, follows above results, semi-detailed geological survey and geochemical survey were carried out to confirm the precise distributions and the emplaced conditions of mineralization.

In addition, magnetic survey and IP survey in the favorable zone of emplacement of mineralization were carried out. The results of these survey will be state other paragraph.

1-1 Geology

This sector is underlain by the CII , CIII, CIV Formation of the Paleozoic Group, the Hercynian intrusive rocks and the Cretacious System of Mesozoic Group (Refer to PL.I-1-1 ∿ PL.I-1-4, Fig. I-2).

1-1-1 Paleozoic CII Formation

The CII Formation is distributed in the northwestern parts in this sector, mainly composed pelitic schist.

The pelitic schist is a black or blackish green phyllitic rock of which consists of chlorite-sericite schist and biotite-quartz schist. The original rock is considerably to be mudstone and siltstone.

The lower part of this formation shows frequently gneissose rock facies affecting thermal alteration and silicification by the granite intrusion (A.I-1, A.I-2; a138, S58).

The formation strikes from north to south generally, and dips about 70° eastward. However, in the part where granite intruded, strikes and dips show various trends caused by the distervance of granite intrusion. This formation is over 1000 meters in thick and is overlain conformably by the CIII Formation.

1-1-2 Paleozoic CIII Formation

The CIII Formation, limestone predominant, is widespreaded whole over the sector, and consist of green schist, psammitic schist, pelitic schist, crystalline limestone and calcareous schist.

The green schist is light green or dark green rock which has shown from fine and hard to coarse and porous features and it is rarely accompanied by conglomerate beds. The rocks consists of epidote-chlorite schist, quartz-chlorite schist, etc. Beside the rocks frequently remains lapilli and tuff-breccia texture and rarely remains subrounded gravel structure about 10 centimeters in diameter. It is considered that original rocks of them should be andesitic and dacitic volcanic rocks (A.I-1, A.I-2; S35, S62, a77).

The distribution of this green schist is recognized in the area from the Agadir village to its west with the trend of north to south, but no out crops of green schist is observed in the southern part of this sector.

The psammitic schist is, pale green hard rocks observed medium to corse grain texture, consist of chlorite-quartz schist and sericite-quartz schist. By the microscopic observation, medium to corse grained quartz and plagioclase are recognized as main constituent minerals, and biotite, sericite, carbonaceous mineral and zircon are recognizable (A.I-1, A.I-2; W7, a143). It forms alternative layers with the crystalline limestone and the pelitic schist, and shows several ten meters to several 100 meters in thickness.

The pelitic schist is a black or blackish green phyllitic rock of which consists of chlorite-sericite schist and biotite quartz schist. It forms alternative layers with the limestone, the psammitic schist and green schist, and is several to several 10 meters in thickness.

The crystalline limestone is a massive rock with variation in color, such as white, black, yellowish gray, greenish gray. Thickness of the layer ranges from several meters to several tens meters. However, the layer is traceable horizontally because of its continuity is relatively good.

As thick limestone in this sector, there are the limestone trending north to south, its thickness is about 400 meters near the Agadir village, and the continuous thick limestone from the northeast to southwestern part.

The calcareous schist consists of alternative rock of thin layers of psammitic schist or pelitic schist and limestone of which thicknesses are several centimeters. The rock was nominated as "Calcareous Schist" because it shows characteristically rough and striped appearance owing to portion is leached at the ground surface.

In this sector, the calcareous schist is distributed in the area between the above two limestones, and frequently changes to limestone in gradual relation, forms alternation with limestone.

In the northern part, the CIII Formation is accumulated psammitic schist, green schist (conglomeratic), limestone, alternation of clacareous schist and limestone in ascending order (west to east) with the thickness of about 5000 meters as a whole.

It strikes generally NS to NE-SW direction except partly NW-SE direction, and dips 50° to 80° eastward.

On the contrary, in the southern part, the CIII Formation composed by limestone and calcareous schist lacking green schist is widespreaded. It strikes NE-SW direction and dips 50° ∿ 70° eastward.

1-1-3 Paleozoic CIV Formation

This formation is distributed in the east of the eastern marginal part, and composed by pelitic schist. It is overlain conformably the CIII Formation and it strikes NE-SW direction and dips 50° ∿ 70° eastward.

1-1-4 Intrusive Rocks

All of the intrusive rocks occur in the Paleozoic Groups in this sector, and the intrusive rocks consist of the stocks of granite and granodiorite and dykes of microgranite and porphyrite.

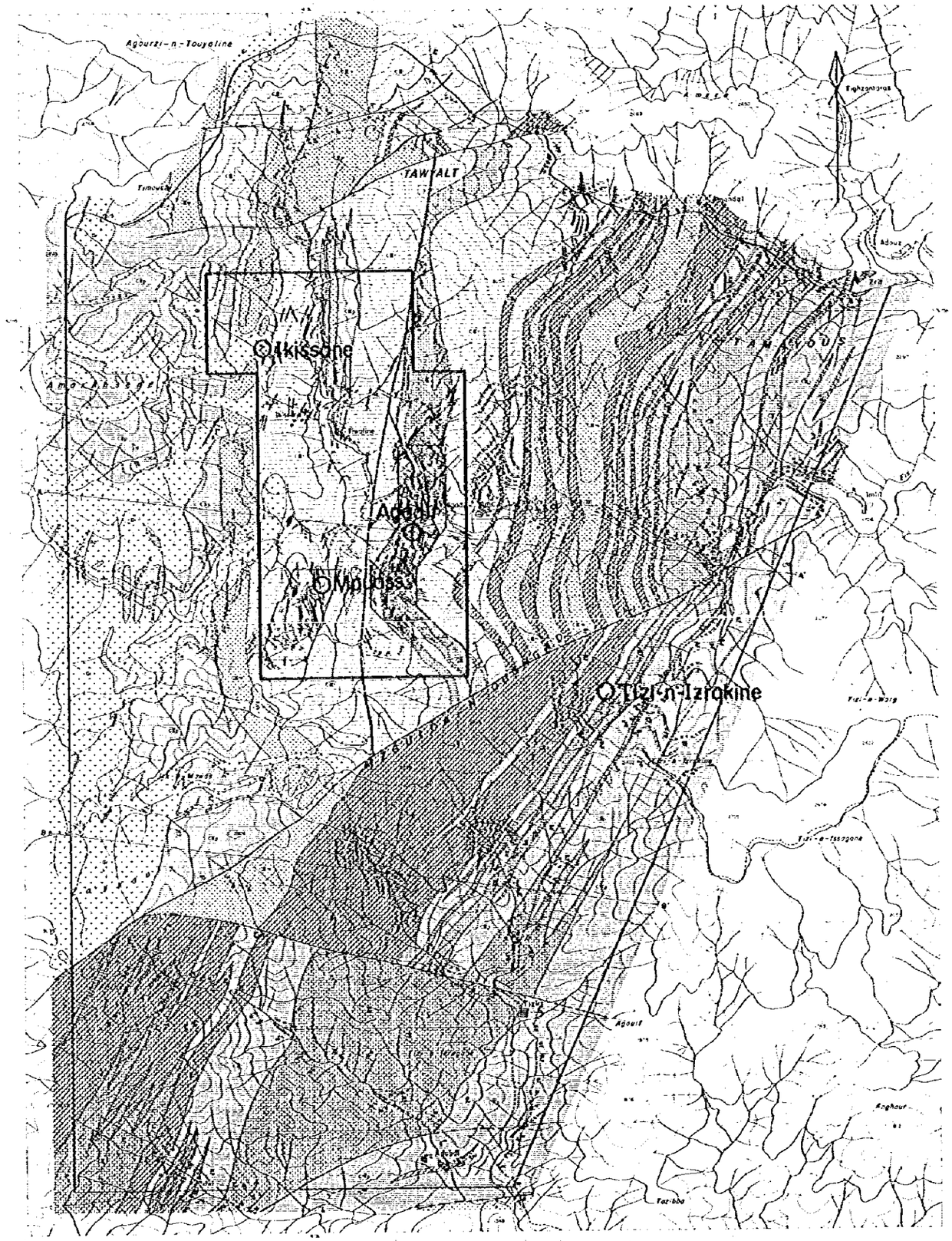
1) Granite stock (Gr)

The huge granite complex stock, reaching 10 and several kilometers in diameter, are exposed in the Tichka Massif at the southwest of this sector, and it called as "Tichka Granite".

The eastern margine of the Tichka Granite is observed around the Agadir village in the southwestern part of the surveyed sector.

These granite are characteristically compose of the phenocryst of quartz and kali-feldsper, and show various lithofacies such as a pink coarse-grained holocrystalline granite, diorite to a whiue fine-grained aplitic granite.

Quartz, plagioclase, orthoclase, biotite and hornblend are commonly recognized as a phenodryst and zircon and apatite are observed as



LEGEND

- Triassic: Ts sandstone, siltstone
- Ordovician–Cambrian
  - CIV Formation: CIVp pelitic schist
  - CIII Formation: CIIIs limestone; CIIIa calcareous schist; CIIIp pelitic schist; CIIIm psammitic schist; CIIIt green schist (tuff, tuff breccia)
  - CII Formation: CIIp pelitic schist
- Intrusive rocks: Gr granite; Po porphyrite; Ap aplite; skarn
- fault
- bedding plane
- axis
- detailed geological survey sector
- ore deposits mineral showings

Fig. I-2 Index Map of Agadir Sector

accessory minerals under microscopic observation (AI-1, AI-2; W1, W2, W21, S63, a58, a136).

This rock forms frequently the dykes and sheets in the marginal part of the stock. The surrounding rocks have been subjected to the silicification and to biotitization and change to the gneissose rock. Skarn minerals such as garnet, amphibole, replaced the limestone are found near the Agadir village.

2) Aplite Dykes (Ap)

These rocks are observed in the granites as dykes less than 10 meters in width. They are generally white compact fine-grained rock but rarely recognized large phenocrysts of feldspar. They are regarded as oplitic dyke derived from above granites. Microscopically, quartz, K-feldspar, plagioclase biotite and little amount of apatite and zircon are observed. The felsic ratio is shown as Quartz=K-feldspar > plagioclase. Phenocrysts in the porphyritic rocks are mainly composed by idiomorphic or hypidiomorphic plagioclases, rarely composed by quartz and K-feldspar, however, in the non-porphyritic rock, quartz and K-feldspar are recognized as additional phenocryst (AI-1, AI-2; S6, a3, a131).

3) Porphyrite dykes

These rocks, less than 10 meters in width, are observed at many places throughout in this sector. These rocks are dark gray to greenish grey in color, and phenocrystes of biotite and hornblende are recognizable by naked eye. Microscopically, phenocrysts of plagioclase, biotite, pyroxine and hornblende are observed. These minerals are affected by alteration as a whole, that is, plagioclase was changed to sericite and pyroxine and hornblende were altered to chlorite. (AI-1, AI-2; W4, S38, a187)

1-1-5 Mesozoic Trias System

This system is distributed on a small area near the Adabdi village in the southern marginal part in this sector. It is composed mainly red corse-grained sandstone, and is in fault contact with Paleozoic Group. It strikes E-W direction and dips 50° southward.

Though it consist only by red sandstone in this sector, it consists of alternations of sandstone and shale, conglomerates and red sandstone in southern side of this sector.

This system is correspond to the southwestern extension of the system along the Nfis river which is recognized by second phase survey.

1-2 Geological Structure

The characteristics of the geological structure in the Agadir sector are shown the monoclinic structure of the Paleozoic formations having the trends of NE ∿ NE-SW direction and the inclinations eastward, the granite intrusion and block movement by the fault of various trends.

The Paleozoic Group is presumed to be Ordovican to Cambrian System.

Since the CII Formation is composed of pelitic schist, it is considered that the formation has been formed in the marine circumference, and since the CII Formation is composed of green schist, psammitic schist, pelitic schist and limestone, it is considered that the formation has been made in the continental or shallow water condition accompanied with volcanic activity. Besides, since the CIV Formation is composed mainly of pelitic schist, it is considered that the formation has been accumulated in the marine circumference. Furthermore, since these formations are accumulated conformably, it is presumed that the uplift and the subsidence occured in this area are comparatively moderate.

After the deposition of Paleozoic formations, the tectonic movement associated with the regional metamorphism, folding and faults took place all over the Haut Atlas region.

As the result of this tectonic movement, the Paleozoic formations were metamorphozed into schist facies rocks, and folded structure having the axis of NE to NE-SW direction were prevailed in this region.

The eastward monoclinic structure in this sector is occupied a local part of the above regional folded structure.

The period of this tectonic movement is regarded Hercynian age, end of the Paleozoic era.

Plutonic rocks, represented by the Tichka Granites, were intruded to the Paleozoic formations, and thermal metamorphism affected to the surrounding rocks of them. These rocks are observed as the stocks in the western part and at the many places in this sector, and skarn minerals replaced limestone are also observed.

The Mesozoic Group which is composed of the Triassic red sandstone is in fault contact with the Paleozoic Group at the southern most in this sector. However, from the result of first and second phase surveys, it is clarified that the Paleozoic Group and the plutonic rocks are formed a peneplane before the sedimentation of the Mesozoic Group, and that the fault movement and block movement occured in the Alpine orogenic movement at the end of the Tertiary period.

Faults observed in this sector show the trends of N80°E, N50°E, NS and N80°W directions. And the displacement by these faults affected the Paleozoic Group, therefore, drag-foldings near the faults are predominant near the faults.

These facts are suggest that the vigorous block-movement took place in this area.

1-3 Results of Geochemical Survey

In the Agadir 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 condition of mineralization and to detect the emplacement status of unknown skarn ore deposit.

Samples of rock chips were taken at each 50 meters horizontal intervals on 30 east-west traverse lines which were set taking interval of every 100 meters along the elongation of skarns and mineralizations.

Total number of samples is 304. Sample locations of these samples are shown in PL.I-1-5, and analysis results of Cu, W and Mo elements are shown in A.I-8.

Values of the chemical analysis were treated statistically and the consideration was given on the characters of the population, the anomalies and correlative relation among the element. Detected anomalies were illustrated in PL. I-1-6.

1-3-1 Statistic Treatment

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

However, no statistic treatment was carried out on W, because the W-values of 267 samples out of 304 were obtained at lower than 5 ppm, and Mo-values of 299 samples out of 304 were obtained at lower than 10 ppm.

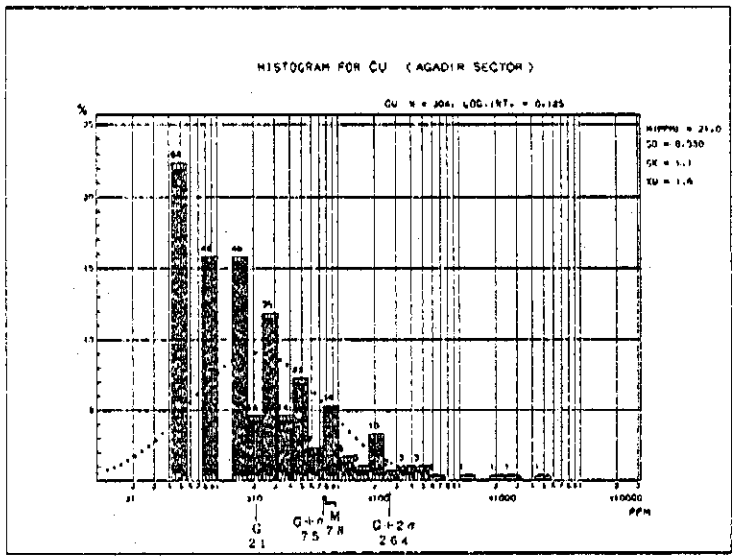
Statistical values of every element and thresholds for anomalous values are shown in Table I-1. The histograms of the logarithmic value

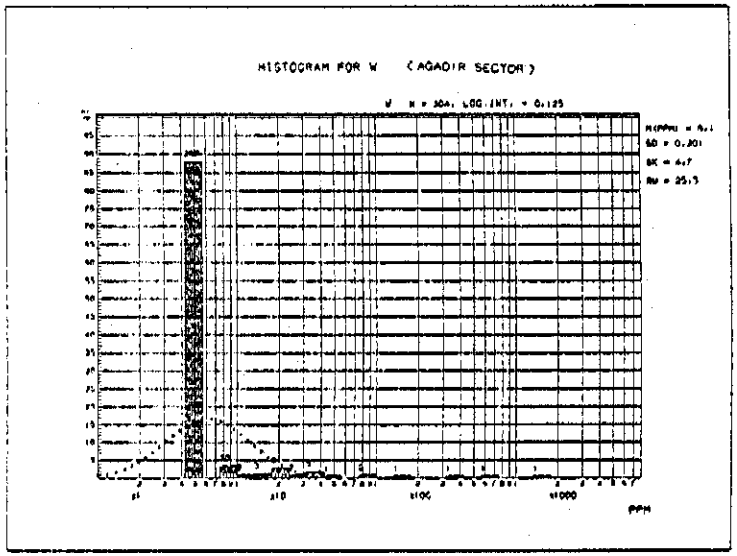
Table I — 1 Statistic Values and Threshold Values of Rock Samples in Agadir Sector

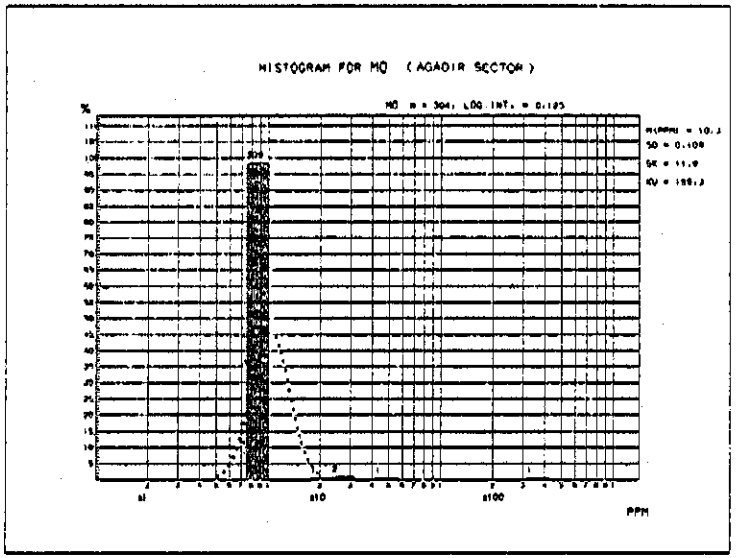
Variable \ Element	Cu	Mo	W
Number	304	304	304
Minimum value	5 ppm	10 ppm	5 ppm
Maximum value	4,400 ppm	410 ppm	1,400 ppm
Arithmetic mean	77.9 ppm	11.6 ppm	15.7 ppm
Logarithmic mean (Lm)	1.322	-----	-----
Logarithmic standard deviation(SD)	0.550	-----	-----
$G = \log^{-1}(Lm)$	21.0	-----	-----
$G+\sigma = \log^{-1}(Lm+SD)$	74.5	-----	-----
$G+2\sigma = \log^{-1}(Lm+2SD)$	264.00	-----	-----
Skewness (SK)	1.135	-----	-----
Kurtosis (KU)	1.675	-----	-----
Clasification of anomalies	(ppm)	(ppm)	(ppm)
Storong anomaly ($\geqq G+2\sigma$)	$Cu \geqq 264.0$	$Mo \geqq 400$	$W \geqq 1{,}000$
Weak anomaly ($G+2\sigma > \backsim \geqq G+\sigma$)	$264.0 > Cu \geqq 74.0$	$400 > Mo \geqq 20$	$1{,}000 > W \geqq 100$
Indication ($G+\sigma > \backsim \geqq G$)	$74.0 > Cu \geqq 21.0$	-----	-----

Table I — 2 Correlation Coefficients of Rock Samples in AgadirSector

	Cu	W	Mo	Note
Cu	1.00000 0.0000 304	0.05904 0.3049 304	0.43624 0.0001 304	.....CORRELATION COEFFICIENT .....PROB>IRI UNDER HO:RHO=0 .....NUMBER OF OBSERVATION
W	0.05904 0.3049 304	1.00000 0.0000 304	0.00876 0.8791 304	
Mo	0.43624 0.0001 304	0.00876 0.8791 304	1.00000 0.0000 304	







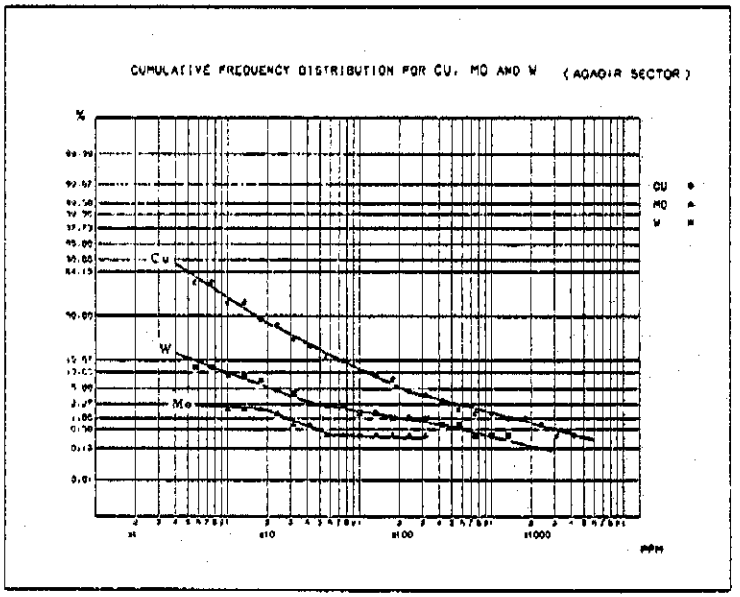


Fig. I — 3 Histogram and Cumulative Frequency Distribution for Cu, Mo and W of Rock Samples in Agadir Sector

of the Cu, W and Mo elements are shown in Fig. I-3 and cumulative frequency distribution of above element are shown in Fig. I-3.

The characters of population of each element and the relation to the anomalous value, and correlative relation among the elements are discribed as follows:

1) Cu: For establishing anomalous values for Cu elements, statistic values of G, G+σ and G+2σ were employed as the standards of the classification. Indicated zone, weak anomalous zone, and strong anomalous zone are determined as follows and the results are shown in the above Plates.

Strong Anomalous Zone	$\geqq G + 2\sigma$
Weak Anomalous Zone	$G + 2\sigma > \sim \geqq G + \sigma$
Indicated Zone	$G + \sigma > \sim \geqq G$

Points of inflections are observed on the cumulative frequency distribution graph near Cu 25 ppm and near Cu 250 ppm. The former position approximately corresponds to G value, and the latter position approximately corresponds to G+2σ value. Especially, since values below 25 ppm and above 25 ppm belong to different populations respectively, it is considered that values below 25 ppm indicate the background values of Cu in this area. It is, therefore, considered that establishments of anomalous values and thresholds as above are allowable required conditions.

2) W: Detectable limits of 87.8% of analysis results of W were below 5 ppm. Therefore, these are unsuitable for statistic treatments, weak anomalous value of more than 100 ppm and strong anomalous value of more than 1,000 ppm were adopted on this consideration.

3) Mo: Detectable limits of 98.3% of analysis results of Mo were below 10 ppm, these are unsuitable for statistic treatments. Therefore, weak anomalous value of more than 20 ppm and strong anomalous value of more than 400 ppm were adopted on this consideration.

4) Mutual relation among the analyzed elements Cu, W and Mo are shown in Table I-2. Based on this table, the slight relationship between Cu and W seems to be detectable, but it is difficult to discuss on the correlation of these two elements because the analysis results of W have rarely effective values. The relationship between Cu and Mo and between W and Mo are scarcely recognized.

1-3-2 Considerations on Anomalous Values

Ore deposits in the Agadir Sector are recognized in several skarn zones in the limestone which is 400 meters in width and located through the neighbering of the Agadir village, and in the conglomeratic green schist at the Mauass area in the southwest of the village. Therefore, the anomalous values of each elements on this geochemical survey have considered on the relation of these mineralizations.

1) Cu (PL. I-1-6)

Strong anomalous values were observed at 13 points, 5 points of them are correspond to the located area of skarn zones, and 8 points of them are correspond to the Mauass area which contains vein-type pre deposits.

These anomalous values roughly accorded to mineralizations which have been recognized by the geological survey, especially, the later indicates suggestively the directions of the ore veins.

The weak anomalous values were recognized besides in the outer zone and in the extension area of the strong anomalous, distributed in the forms corresponding to the elongations of the skarns which mineralizations have not been recognizable by the field survey.

2) W (PL. I-1-6)

One strong anomalous value and 4 weak anomalous values were detected independently in the skarn zone in the limestone. The relation between W-mineralization and skarnization have not clarified because the most of analysed values are under the detectable limit as a whole.

3) Mo (PL. I-1-6)

One strong anomalous values and 4 weak anomalous values were merely recognized, and three anomalous values of them are correspond to the existence of ore veins in the Mauass area.

Only weak anomalous values were obtained in the skarn zone, therefore, it may be shown the tendency of the strong relation to the granites rather than the relationship between skarnization and Mo mineralization.

1-4 Mineralization

Ore deposits and mineral indications clarified by this survey were observed at four places in this sector. These locations of mineralization display in the PL. I-1-7.

As to the types of mineralization, skarn type deposits and vein-type ore deposits were recognized. The Agadir ore deposit at the neghboring of the Agadir village is the skarn type ore deposit contains copper, tungsten and iron. As the vein type ore deposit, the copper-iron ore deposit in the Mouass area, southwest of the Agadir village, the molybdenum-copper ore deposit near the Ikissane village and copper lead ore deposit near the Tizi-n-Izrakine were recognized. Outline of these deposits are as follows.

1) Agadir ore deposit

Geology of the neighborings of the Agadir village are composed of the conglomeratic green schist and crystalline limestone of the CIII Formation. The limestone is about 400 meters in width, and trends from NS to NW-SE direction. The green schist forms thin layer in the outer zones of the limestone and intercalated thin layer in the limestone. These beds dips about 70° eastward.

Stocks and dykes of granite assumed the branches of the Tichka Granite were recognized in this area. The granite stock is distributed slight widely in the east of limestone. The dykes of NS trends with steeply dips and various trends with gentle dips about 10° were observed.

As the faults, the fault of N10°E trend pass through the westside of this area and the fault of N30°W trend across the limestone were observed, and the displacement and drag foldings were recognized.

In the limestones, several skarn zones elongated along its trend were recognized. These skarn zones are from several meter to 40 meters in width and comparatively continued from 50 meters to 500 meters. Especially, they are formed predominant in width and length at the foot and hanging wall of the limestone and at the contact parts with the granite.

The skarnizations were recognizable about 2,000 meters north-south centering the Agadir village. Skarn minerals are composed of garnet, diopside, hedenbergite and tremolite.

Mineralization mainly consists of chalcopyrite and pyrrhotite are observed in the parts of skarn zones. The sizes of mineralizations are several to 20 meters in width and about 100 meters in length, and as the ore minerals, chalcopyrite, pyrrhotite, pyrite limonite, chalcocite and small amount of covelline, molybdenite, tetradimite and native bismuth are recognized (A.I-3, A.I-4; W10, S33, S46, N15-2).

These mineralization have a tendency to concentrate at the parts having the steep dipped granite dykes, especially, the comparative concentrated mineralization part was recognized at the riverside near the Agadir village.

The results of chemical analysis of the outcrops are shown the grades of Cu: 0.01% ∿ 4.35%, Mo: 0.01% ∿ 0.03%, and W: 0.01% ∿ 0.23%, however, average grade at the riverside outcrop, comparatively concentrating mineralization (about 6 meters in width) shows the low grade of Cu: 0.60%, Mo: 0.01% and W: 0.03% (A.I-6).

2) Agadir west (Mauass) ore deposit

This part, located at about 1,500 meters southwest of the Agadir villages, is underlain by the conglomeratic green schist intercalated with the pelitic schist of Paleozoic CIII Formation.

The formation has the strike of north-south in the north and the strike of NW-SE trend in the south in this part, and shows the monoclinic structure dipping eastward. And many granite dykes showing gentle dip are also recognized.

The mineralizations were recognized at the northeastern area, west marginal area and southern area in this part. They are fissure filling vein type ore deposits contain chalcopyrite and pyrrhotite associated with quartz vein. However, skarn minerals such as garnet and dispside are recognized at the some part of them, it is considered that the calcareous rocks near the fissures are replaced. The vein ore deposits in the northeastern area and in the western marginal area strike N30°E and dips 80° eastward, and the vein ore deposits in the south area show the strike of N50°W trend and the deip of 70° eastward. All of these ore deposits are about 1.0 meter in width, and the former two are several 10 meters in length and the later is about 20 meters in length.

Ore minerals are composed of chalcopyrite, pyrite, limonite, chalcocite and small amount of molybdenite and covelline (A.I-3; B9-8). As the results of the analysis, the grades of outcrops of them were obtained Cu: 0.04% ∿ 1.30%, Mo: 0.01% ∿ 0.02% and W: 0.01% ∿ 0.02% (A.I-6).

3) Ikissane ore deposit

This ore deposit is located at the north of the Ikissane village. The host rocks of this ore deposit are the conglomeratic green schist and granite contact with it. This ore deposit is the molybdenum copper quartz vein deposit. The ore veins are composed of parallel five or seven veins which are about 30 centimeters in width and from several to several 10 meters in length.

Ore minerals are composed mainly molybdenite accompanied small amounts of chalcopyrite and pyrite.

The ore samples from these veins in the second phase survey show the grades of Cu: 0.01% ∿ 0.05%, Mo: 0.03% ∿ 0.46%.

Furthermore, the quartz veins contains mainly chalcopyrite were recognized at the north and south of this ore deposit with in scale of 30 cm in width and 10 and more meters in length. As the results of analysis on the outcrops, though one of them shows the grade of Cu: 0.78%, Mo: 0.01% and W: 0.01% (A.I-6, W6), they generally show the low grades.

4) Tizi-n-Izrakine ore deposit

This ore deposit is located near the Tizi-n-Izrakine in the eastern central part in this sector, and is the copper-lead vein ore deposits in the crystalline limestone of the Paleozoic CIII Formation as the host rock.

The ore deposits consist of several veins trending NW-SE and NNE-SSW directions. The veins are of from 5 to 10 centimeters in width and of from 10 to 15 meters in length.

Ore minerals are composed of chalcopyrite and small amounts of tetrahedrite, pyrite, arsenopyrite etc. (A.I-3, S65).

This ore deposit had been explorated in the small scale in the past by B.R.P.M. The analysis results of the samples on the outcrops show the grade

of Cu: 0.06% ∿ 0.25%, Pb: 0.02% and Zn: 0.02% ∿ 0.04% in the second phase survey, therefore, it is difficult to be the subject ore deposit for production on the view point of the scale and the grades.

Since the mineralizations except the Agadir skarn ore deposit in this sector are narrow vein ore deposit, it is unexpectable that these ore deposits are to be grate amount of their ore reserve. Furthermore, as to the Agadir ore depost, though the scale of the skarn zones shows 30 meter in width and 200 meters in length, the scale and the enrichment of them seem to slightly small.

1-5 Discussion

In this area, various mineral indications such as the copper-tungsten-iron skarn ore deposit and molybdenum vein ore deposit have been recognized by the second phase survey. However, it have been not examined saficiently to clarified the condition of emplacement, the scales and the continuities of ore deposits and mineral indications based on the relation between the mineralization and the geological structure.

Therefore, detailed geological survey and geochemical survey were carried out in this phase to clarify the relationships between the geological structure and the mineralizations for the purpose to obtain the guiding principle of further exploration.

The geology, the geological structure and the mineralizations elucidated by this phase survey are summarized as follows.

This area is underlain by Paleozoic Group and Mesozoic Group and associated with Hercynian intrusive rocks.

The Paleozoic Group, regarded as of Ordovician and Cambrian age, is widespreaded in this area and is separated to the blocks by the faults of NE-SW, ENE-WSW, NS, WNW-ESE directions.

This Paleozoic Group is correlated to the CII , CIII Formations which were divided by the defferences of the constituent rocks, the metamorphosed feature and the geological structures in the second phase survey.

The characteristics of these formation are discribed as followings.

CII Formation: This formation is the lowermost formation in this area, and mainly consists of pelitic schist. This formation shows frequently gneissose rock facies by the intrusion of granite stocks, and is distributed trending of north-south in the western parts in this sector. The relation to the upper formation is conformably.

CIII Formation: This formation is widespreaded in this sector, and consist of conglomeratic green schist, crystalline schist, psammitic schist, pelitic schist and calcareous schist. The relationships to the upper and lower formations are conformably. It is characterized that the green schist is predominant in the lower part and limestone is predominant in the upper part of this formations.

CIV Formation: This formation, characterized by the thick pelitic schist, is distributed in the eastern marginal part and its outer.

These Paleozoic formations strikes generally from north to south or from northeast to southwest, but, shows the drug folding near the faults. They shows a monoclinic structure dipping of 50° ∿ 70° eastward as a whole.

The Mesozoic Group, consists of the Triass red sandstone, is distributed as a small area of the southern margine in this sector, and is in fault contact with the Paleozoic Group.

As the intrusive rocks in the Hercynian age, the Tichka Granite was exposed from the western margine to the west of this sector, and dykes derived from this granite were observed at many places. These granites have affected the metamorphism to the surrounding rocks, therefore, the gneissose

rocks affected by granitization and the skarn mineral replaced limestone have been formed.

As the ore deposits and mineral indications, the copper-molybdenum-tungsten-iron skarn ore deposit near the Agadir village, the copper iron vein ore deposit in the Mauass area, which is located at the southwest of the Agadir village, the molybdenum-copper vein ore deposit near the Ikissane village and the copper-lead vein ore deposit near the Tizi-n-Izrakine were clarified. Since the stocks and dykes of granite were recognized in the neighborhood of above ore deposit, it is consider that the mineralization in this sector is formed by the post-igneous action followed the intrusion of granite.

The Agadir ore deposit contains chalcopyrite and pyrrhotite mineralizations was formed in the several skarn zones which is replaced partially limestone beds of about 400 meter in width.

Skarn zones range from several to 30 meters in width and from several 10 meters to about 500 meters in length, especially, have a tendency to be made a larger form at the hanging and foot wall and at the contact part of limestone with the granites. The skarnization were recognizable about 2,000 meters north to south centering the Agadir village.

The mineralizations were recognized in the parts of skarn zones, and range from several meters to about 20 meters in width and from 15 meters to 100 meters, especially along the steep granite dykes.

The ore grades of the outcrop at the reverside, concentrating mineralization comparatively, is Cu: 0.60%, Mo: 0.01% and W: 0.03%.

Other ore deposit were the small scaled ore deposit ranging from 30 centimeters to about 1.0 meters in width and showed low grades.

As the results of geochemical survey by the rock sampling carried out in the area contain the Agadir ore deposit and Mauass ore deposit, Cu anomalous zone were observed the distribution and the elongation reflecting the skarn zone and mineralization. However, W and Mo anomalous values were not recognized the distribution correspond to the skarn and mineralizations because almost of all analysed values are under the detectable limit as a whole.

These facts show that the geochemical survey by Cu element is most effective method to extract the skarn zones and the mineralizations in this sector.

It has been made clear that the relationship between mineralization and geological structure in this sector by this phase survey. And it has been elucided that the mineralization is controled by the geological structure.

Therefore, it seems possible that the evaluation of this ore deposit will be estimate by the confirmation of its continuity, especially, in the underground.

CHAPTER 2 IGUIDI SECTOR

This sector is located at the 5 km northeast of Ijoukak in the eastern part in this area. From the Rikt village at the beside of main road along the Nfis river to this sector, there is only way by foot or horsebacks (about 1 hours).

In this sector, the copper stockwork ore deposits in the Paleozoic dolomite have been recognized by the geological survey and the geochemical survey by stream sediments in the second phase.

In this phase, semi detailed geological survey and geochemical survey by the rocks were carried out to clarify the distribution and the emplaced condition of mineralization.

2-1 Geology

This sector is underlain by the Pre-Cambrian andesites, dolomite and siltstone of the Paleozoic CI Formation and dolerite dyke (PL.I-2-1, Fig. I-4).

The Pre-Cambrian andesites consists of andesitic lave and andesitic pyroclastics, is distributed trending from the northeast to southwest along the northwestern margine in this sector. The andesitic lava is dark green to greenish red massive compact rock which is characterized by the trachite texture contains euhedral plagioclase. The pyroclastics are composed of andesitic tuff, lapili tuff and tuff breccia showing the various color from dark green to reddish purple.

The Pre-Cambrian andesites is overlain unconformably by or in fault contact with the Paleozoic Group.

The dolomite of the Paleozoic CI Formation is greyish white to dark gray massive rocks. The dolomite consist of three layers which strikes N50°E to N70°E, and dips 30° to 70° northwest. The upper dolomite is about 2 kilometers in length and 2 meters to 30 meters in thickness. The middle dolomite is more than 2.4 kilometers in length and 20 meter to 70 meters in width. These are intercalated by the siltstone and shows the swelling and shrinkage. The lowermost dolomite is more than 2.4 kilometers in length and more than 500 meters in thickness and distributed in the southeastern part in this sector. The siltstone is pale green to greyish green tuffaceous brittle rocks which tends to make the wethered soil.

The dolerite is distributed in the northwestern part in this sector as a inserted form by faults. And it is deep green rock affecting the thermal metamorphism. The constituent minerals are chlorite considered from hornblend, epidote and plagioclase. It is assumed that the intrusion of dolerite took place at the end of Paleozoic era.

2-2 Geological Structure

Geological structure in this sector is characterized by the N50°E trend fault separating Pre-Cambrian Group and Paleozoic CI Formation, the monoclinic structure of the CI Formation and the existance of N10°E trend fissures.

Since the Pre-Cambrian is usually overlain unconformably by the Paleozoic CI Formation in the surroundings of this sector, the depth of the basement has been considered comparatively shallow. However, in this sector, the relation of these formation is separated by the N50°E fault, and it has been resulted in the relative subsidence of the southeastern block.

This fault corresponds to the northeastern extension of the Iguidi fault which is the big structural fault along the Nfis river in this area, and it dips steeply northwestward.

The Paleozoic CI Formation, in the southeast side of this fault, shows a monoclinic structure which strikes NE-SW trend and dips 30° ∿ 70° north-

westward. Several faults trending N10°E are recognized in this formation. These faults resulted in the displacement reached from several to several 100 meters, and cutting the above N50°E fault.

Furthermore, many fissures were recognized in the dolomite layers. These faults are composed of three fissure systems of the M10°W ∿ N30°W system dips 70° ∿ 80° eastward, the N15°E ∿ N35°E system dips 80° eastward and N70°E system dips 60° ∿ 70° north. It has been considered that these fissure is secondary fissured caused by the N10°E faults.

2-3 Results of Geochemical Survey

In the Iguidi Sector, geochemical survey was carried out by collecting rock samples for the analysis of minor elements contained in them, for the purpose to clarify the condition of mineralization, especially, to detect the emplacement status of copper stockwork mineralization in the dolomite layer.

Samples of rock chips were taken at trisect point on traverse lines which were set taking interval of about 50 meters along the mineralized dolomites. Total numbers of these samples is 228, sample location of them are shown in PL. I-2-2 and analysis results of Cu and Ag elements are shown in A.I-9.

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 PL. I-2-3.

2-3-1 Statistic Treatment

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

However, no statistic treatment was carried out on Ag, because the W-values of 171 samples out of 227 were obtained at lower than 0.4 ppm.

Statistical values of each element and thresholds for anomalous values are shown in Table I-3. The histograms of the logarithmic value of the Cu, Ag elements are shown in Fig. I-5 and cumulative frequency distribution of each element are shown in Fig. I-5.

The characters of population of each element and the relation to the anomalous value, and correlative relation among the elements are discribed as follows:

1) Cu: For establishing anomalous values on Cu element, statistic values of G, G+σ and G+2σ were employed as the standards of the classification. Indicated zone, weak anomalous zone, and strong anomalous zone are determined as follows and the results are shown in the above plates.

Strong Anomalous Zone	$\geqq G + 2\sigma$
Weak Anomalous Zone	$G + 2\sigma > \sim \geqq G + \sigma$
Indicated Zone	$G + \sigma > \sim \geqq G$

Points of inflections are observed on the cumulative frequency distribution graph near Cu 20,000 ppm, near Cu 400 ppm and near Cu 100 ppm. The former two position approximately corresponds to G+2σ and G value. Especially, since values below 100 ppm and above 100 ppm belong to different populations respectively, it is considered that values below 100 ppm indicate the background values of Cu in this area. It is, therefore, considered that establishments of anomalous values and thresholds as above are allowable required conditions.

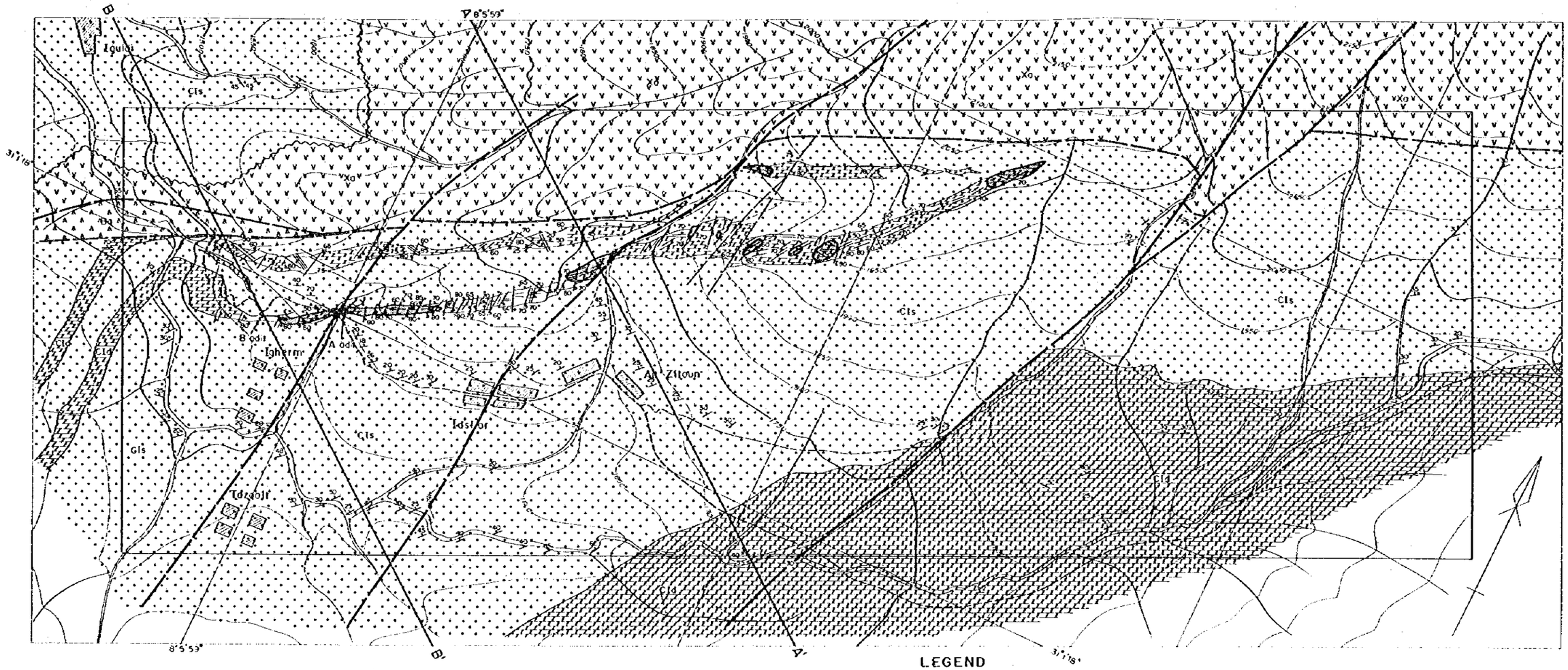


Fig. I-4 Index Map of Iguidi Sector

Table I — 3 Statistic Values and Threshold Values of Rock Samples in Iguidi Sector

Variable \ Element	Cu	Ag
Number	227	227
Minimum value	10 ppm	0.4 ppm
Maximum value	82,000 ppm	4.8 ppm
Arithmetic mean	2,679 ppm	2.6 ppm
Logarithmic mean (Lm)	2.604	-----
Logarithmic standard deviation(SD)	0.855	-----
$G = \log^{-1}(Lm)$	402	-----
$G+\sigma = \log^{-1}(Lm+SD)$	2,877	-----
$G+2\sigma = \log^{-1}(Lm+2SD)$	20,606	-----
Skewness (SK)	0.336	-----
Kurtosis (KU)	0.655	-----
Clasification of anomalies	(ppm)	(ppm)
Storong anomaly ($\geq G+2\sigma$)	$Cu \geq 20,606$	$Ag \geq 20$
Weak anomaly ($G+2\sigma > \sim \geq G+\sigma$)	$20,606 > Cu \geq 2,877$	$2.0 > Ag \geq 1.0$
Indication	$2,877 > Cu \geq 402$	-----

Table I — 4 Correlation Coefficients of Rock Samples in Iguidi Sector

	Cu	Ag	Note
Cu	1.00000 0.0000 227	-0.15060 0.0232 227	.....CORRELATION COEFFICIENT .....PROB>IRI UNDER HO:RHO=0 .....NUMBER OF OBSERVATION
Ag	-0.15060 0.0232 227	1.00000 0.0000 227	

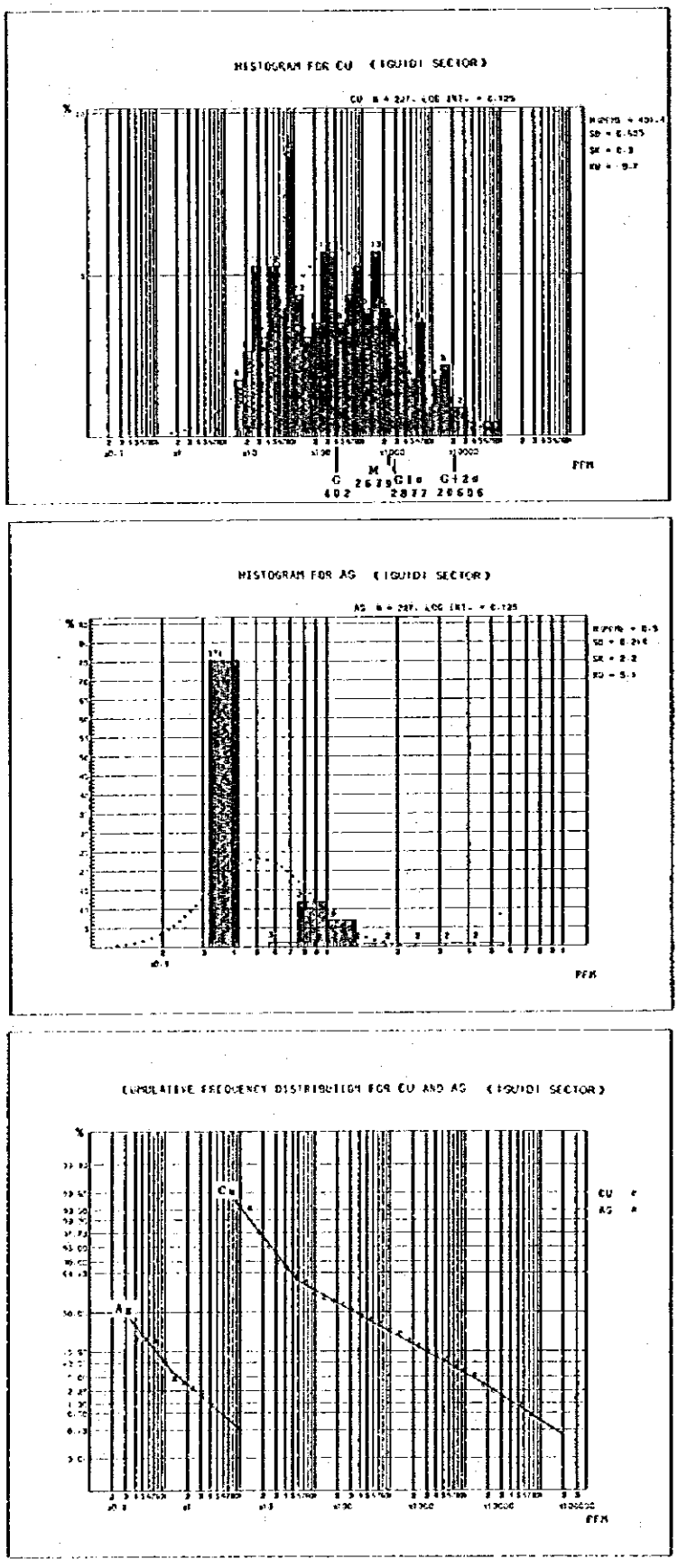


Fig. I — 5 Histogram and Cumulative Frequency Distribution for Cu, Ag of Rock Samples in Iguidi Sector

2) Ag: The detectable limits of 75.3% of the analysis results of Ag were below 2 ppm. Therefore, these are unsuitable for statistic treatments. The strong anomalous value of more than 2 ppm, and the weak anomalous value of more than 1 ppm were adopted on this consideration.

3) Mutual relation among the analyzed elements: Correlation coefficients of elements, Cu and Ag were shown in Table I-4. Based on this table, no relationship were found between Cu and Ag.

2-3-2 Considerations on Anomalous Values

The mineralizations in the Iguidi sector are copper-stockwork ore deposit in the dolomite of the Paleozoic CI Formation, especially, in the mineralized middle dolomite, many fissures associated with quartz veinlets were recognized. Therefore, the examination on the anomalous values was made to correlate above-mentioned mineralization.

1) Cu (PL. I-2-3)

Strong anomalous values were observed at six points, three points of them exist near the lower old adits in the western part, and other three points is located in the eastern part (K10 point), and rest one is located at the Hll in the upper dolomite. Weak anomalous values are distributed around above strong anomalous values, at the about 150 meters east of the upper old adit, near the K15 and at the eastern edge of dolomite. The distributions of these anomalous values are correspond to the faults and fissures of NS trend or NE-SW trend.

From the general viewpoints contains weak anomalous values, it has been considered that the mineralized zone is widespreaded from the eastern part of the upper dolomite to the whole of the middle dolomite, especially, since the mineralization is distributed in the both of upper and middle dolomites, the dominant mineralization in the lower part in the underground are expectable.

2) Ag (PL. I-2-3)

Strong anomalous values were observed at seven points. The three of them were recognized at the western margine of the upper dolomite and the two of them were detected at the eastern margine of the middle dolomite, and other strong anomalous values and weak anomalous values were scattered at the places. No relationship between these anomalies and geological structure was recognized.

The Ag anomalous values agreed with the Cu anomalous values were only observed at the eastern margine of the middle dolomite, almost all of the Ag anomalous values have a tendency to exist at the outer zone of Cu mineralizations.

2-4 Mineralization

Copper stockwork ore deposit associated with quartz veinlet were observed in the dolomite layers, especially in the middle dolomite layers. And the small scaled exploration by trenching and tunneling had been carried out at some places. Since predominant mineralizations were observed along the faults and fissures trending NS or NE-SW directions, it suggest that these mineralizations have been controled by these fissures.

As the survey result of the old adits (A adit and B adit) at the 1,600 m above sea level, the copper mineralization along the strike of the dolomite (about 25 meters in width) were recognized (PL. I-2-4).

The mineralized zone ranges from 1.0 meters to 15 meters in width and reaches about 250 meters in length.

In this mineralized zone, the networks of quartz veinlet ranging from several milimeters to 30 centimeters are predominant, and the surrounding rocks are affected by strong silicification.

The quartz veinlets are mainly composed of NS trend and ENE-WSW trend veinlets, and copper ore minerals disseminated in the quartz veinlets and silicified rocks.

Ore minerals are composed mainly of chalcopyrite, chalcocite, azurite and malachite, and shows green color by the oxidation at the surface.

Under microscopic observation, covelline, chrysocolla, magnetite and hematite are recognizable (A.I-3, A.I-4; a162, a190, s81, s82, s83).

As the analysis results on the sample of this mineralized zone, the grades of Cu: 0.04% ∿ 4.18%, and Ag: <0.3 g/t ∿ 5.2 g/t were obtained.

Based on this survey results, the ore reserve above Cu 0.5% of the upper part of old adit level (about 25 m average height) is roughly estimated about 60,000 ton and its grade is about Cu 1.3% (A.I-7).

Moreover, the low grade copper mineralization were observed in places in the dolomite, and the mineralizations were recognized about 2 kilometers along the dolomite. Generally, the mineralizations are limited in the middle dolomite in the western part, but are recognizable in the upper dolomite as in the middle dolomite in the eastern part. This fact suggest that the mineralization is spreaded in this part.

Since the eastern part is 200 meters and 300 meters higher than the western part, the confirmation of the condition of mineralization is remained as the further problem in this sector.

The dolerite was recognized along the N50°E fault separating the Pre Cambrian group and the Paleozoic Group.

Though it is not clear the relationship between this intrusive rock and the mineralizations, there is a large possibility that this dolerite bring to the mineralization because no other igneous rocks are observed, therefore, it has been assumed that the copper mineral solutions associated with quartz rise along the NS trend faults and deposited in the cracks in the dolomite as the post-igneous actions of the dolerite intrusion.

2-5 Discussion

In this sector, since the existence of copper stockwork ore deposit has been clarified and the mineralized boulders have been recognized in places of about 2 kilometers by the second phase survey, the detailed survey to make clear the condition of the emplacement of ore deposit were carried out in the phase for the purpose to elucidate the relationship between geological structure and mineralization.

As the results of this survey, it has been clarified that the sector is underlain by the Pre-Cambrian andesites, dolomites and siltstone of the Cambrian CI Formation, which are bordered by N50E fault, and the dolerite along this fault.

And, it is elucidated that the dolomites are composed of three layers trending from N50°E to N70°E and dipping from 30° to 70° northwestward; the upper dolomite is 2 meters to 30 meters in thickness the middle dolomite is 20 meters to 70 meters in thickness and lower dolomite is more than 500 meters in thickness, and they are continued more than 2 kilometers along their strikes.

The geological structures are characterized by the subsidence of the southeast side block of above fault, the monoclinic structure dipping northwestward of the Paleozoic CI Formation, and the predominant NS faults and NS and NE-SW fissured in the dolomite.

The Mineralizations were observed in the eastern half of about 500 meters of the upper dolomite and in the middle dolomite of about 2,000 meters, especially, it has been recognized that the mineralizations are concentrated near the NS faults and fissures.

The ore deposits are copper stockwork ore deposits associated with quartz veinlets which is filled in the cracks of NS and NE-SW directions.

The ore deposit near the old adits is 1.0 meter to 15 meters in width and about 250 meters in length. The ore reserve above adit level of about 25 meters in average height, is roughly estimated about 60,000 ton and its grade is assumed about Cu 1.3%.

As the results of the geochemical survey in this phase, the Cu anomalous values are distributed generally correspond to the mineral indications, especially, they show the tendency to concentrate along the NS fissures. However, Ag anomalous values are distributed at the outer zone of copper mineralization and show different distribution from Cu anomalous zone.

From above facts, it is considered that the mineralization in this sector have veen controled following geological structures;

In this sector, the Paleozoic Group in the southeastern side subsided by the block movement associated the faulting, and the Pre-Cambrian was in fault contact with the Paleozoic Group. And during this movement, the Paleozoic Group was tilted and made the monoclinic structure dipping northwestward, the NS trend faults occured concurrently and displaced in a small scale, and NS and NE-SW fissures took place in the dolomite.

After the faulting, the dolerite intruded along the fault, and the mineralization with quartz veins occured as the post igneous action, especially, there is a large possibility that the mineralization progressed along these fissures.

Among the recognized mineralizations, the mineralization near the old adits of about 250 meters is most predominant, and it has been expected that the considerable ore reserve exist, however, they are slightly low grade and oxidized ore are predominant. Therefore, it is difficult to produce economically unless the confirmation the enrichment of mineralization in the lower part in the underground.

On the contrary, in the eastern part, the weak mineralization distributed in the considerable area, since this part is 200 meters high than western part comparatively, it is assumable the this part will be made the enrichment of the mineralization in the lower part in the underground.

Therefore, it is necessary to confirm the condition of the mineralization in the lower part of this part.

CHAPTER 3 TADDART SECTOR

This sector is located at the neighboring area of the Taddart village in the central west in the area. There is a trafic way by vihicles from Ijoukak to the Tawrirt village (about 2 hours), and there is no other way than by horsebacks to the Taddart Sector crossing over the pass (about 4 hours).

In this sector, the copper vein ore deposits in the conglomeratic green schist of Paleozoic CIII Formation have been recognized by the second phase survey.

In this phase, semi-detailed geological survey and geochemical survey by rocks were carried out to clarify the distributions and the emplaced condition of mineralization.

3-1 Geology

This sector is underlain by the Paleozoic CIII Formation and the CII Formations. The CIII Formation is composed by green schist, pelitic schist, psammitic schist and limestone. The CII Formation is composed by the thick pelitic schist and psammitic schist, and is distributed in the western part of this sector (PL.I-3-1, Fig. I-6).

The green schist is pale green to dark green rock, ranges from hard compact rock facies to conglomeratic rock facies, generally consists of conglomeratic facies contains pebbles of 1 centimeter to 20 centimeters in diameter. The pelitic shist is the black and blackish green phyllitic rocks and forms the thick layers. The psammitic schist is pale green hard and compact rock having a medium to corse grained granular texture. Though the psammitic schist forms alternation beds with the pelitic schist in the CIII Formation, it make thick bed in the CII Formation.

The limestone is the crystalline limestone in various colors such as greyish white, pale green, pink etc.. It forms thick bed more than 200 meters in the eastern part, and makes the alternation bed with the green schist and the pelitic schist.

The relationship between the CIII Formation and the CII Formation is conformable, and they strike generally NS to N30°E, and dip 30° to 70° eastward.

As the intrusive rocks in this sector, the dyke of granodiorite was only recognized. Under microscopic observation, quartz and plagioclase are recognized as the phenocryst, and almost all of plagioclase is changed to the sericite (A.I-1, A.I-2; W34).

3-2 Geological Structure

The geological structure in this sector is characterized by the monoclinic structure of the Paleozoic Group and the faults cutting across above formations.

Minor drag foldings due to the faulting were observed near the faults, and their strikes and dips varied precipitously. However, in general, these formations strike near north-south, and made the monoclinic structure dips eastward.

As the major fault, the faults trending EW, NE-SW, NW-SE and NS were observed in this sector. These faults displaced the formations and the consituent rocks in both side of faults were different each other.

The many fissures aggregated area boundering by these fault were recognized in the western part in this area, and copper mineralizations accompanied with quartz along these fissures were observed.

The granodiorite stock about 1 kilometers in diameter were recognized at about 2 kilometer west of this sector, however, in this sector, only one dyke of granodiorite about 10 meter in width were recognized, therefore, the igneous activity in this sector seems to be not vigously.

From above fact, it is considered that the regional metamorphism and the folding occured in this sector at the end of the Paleozoic era, and the intrusion of the plutonic rock followed them. And after above movement, the faulting concerning the block movement took place in this sector.

3-3 Results of Geochemical Survey

In the Taddart sector, geochemical survey was carried out by collecting rock samples for the analysis of minor elements contained in them, for the purpose to clarify the condition of copper mineralization associated with quartz veins.

Samples were taken on the quartz veins across east-west traverse lines which are set taking the interval of every 25 meters from north to south in the area of 400 m x 400 m in the western part, and other samples were taken on the quartz veins of this area in this sector. Total numbers of samples is 148, sample locations are shown in PL.1-3-2 and analysis results of Cu and Ag elements are shown in A.I-10.

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 PL. I-3-3, PL. 1-3-4.

3-3-1 Statistic Treatment

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

Statistical values of every element and thresholds for anomalous values are shown in Table I-5. The histograms of the logarithmic value of the Cu, Pb, Zn and Mo elements, are shown in Fig. I-7 and cumulative frequency distribution of above element are shown in Fig. I-7.

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 remarkable anomalous zone are determined as follows, and the results are shown in the above plates.

Strong anomalous zone	$\geqq G + 2\sigma$
Weak anomalous zone	$G + 2\sigma > \sim \geqq G + \sigma$
Indicated zone	$G + \sigma > \sim \geqq G$

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: Points of inflections are observed on the cumulative frequency distribution graph near Cu 2,100 ppm and near Cu 250 ppm. The former position approximately corresponds to G+2σ value, and the latter position approximately corresponds to the level of G value. Especially, since values below and above 250 ppm belong to different population respectively, it is considered that values below 250 ppm indicate the background values of Cu in this sector. It is, therefore, considered that establishment of anomalous values and thresholds as above are allowable required conditions.

However, all of the values over than Cu 10,000 ppm were shown as the value as the Cu 10,000 ppm, therefore, the strong anomalous values of Cu

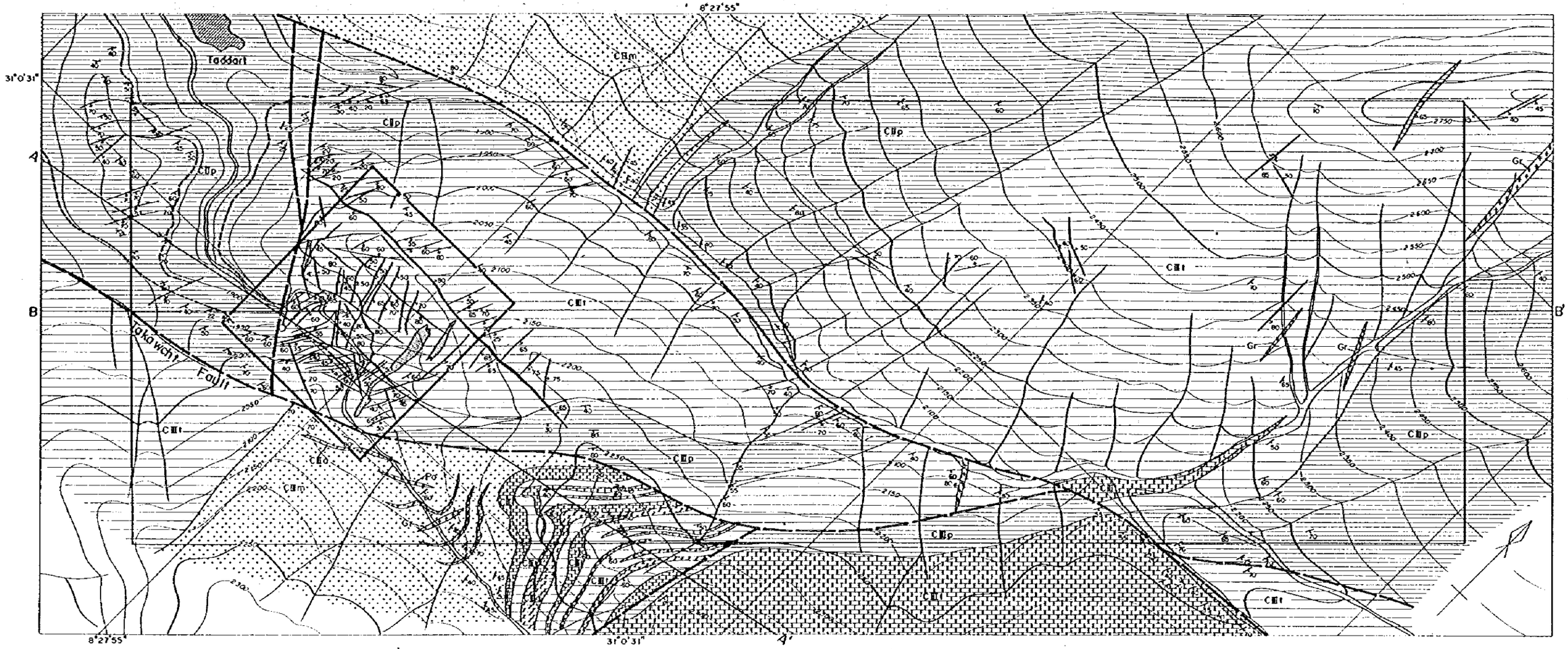


Fig. I-6 Index Map of Taddart Sector

Table I — 5 Statistic Values and Threshold Values of Rock Samples in Taddart Sector

Variable \ Element	Cu	Ag
Number	148	148
Minimum value	7.00 ppm	0.1 ppm
Maximum value	10,000> ppm	62.0 ppm
Arithmetic mean	1,687.8ppm	2.3 ppm
Logarithmic mean (Lm)	2.412	-0.519
Logarithmic standard deviation(SD)	0.913	0.742
$G = \log^{-1}(Lm)$	258 ppm	0.30 ppm
$G+\sigma = \log^{-1}(Lm+SD)$	2,113 ppm	1.67 ppm
$G+2\sigma = \log^{-1}(Lm+2SD)$	17,298 ppm	9.23 ppm
Skewness (SK)	0.361	1.377
Kurtosis (KU)	-1.096	0.631
Clasification of anomalies	(ppm)	(ppm)
Storong anomaly ($\geqq G+2\sigma$)	Cu>10,000	Ag>9.2
Weak anomaly ($G+2\sigma > \backsim \geqq G+\sigma$)	10,000≧Cu>2,133	9.2≧Ag>1.7
Indication ($G+\sigma > \backsim \geqq G$)	2,133≧Cu>258.2	1.7≧Ag>0.3

Table I — 6 Correlation Coefficients of Rock Samples in Taddart Sector

	Cu	Ag	Note
Cu	1.00000 0.0000 148	0.57855 0.0001 148	.....CORRELATION COEFFICIENT .....PROB>IRI UNDER HO:RHO=0 .....NUMBER OF OBSERVATION
Ag	0.57855 0.0001 1148	1.00000 0.0000 148	

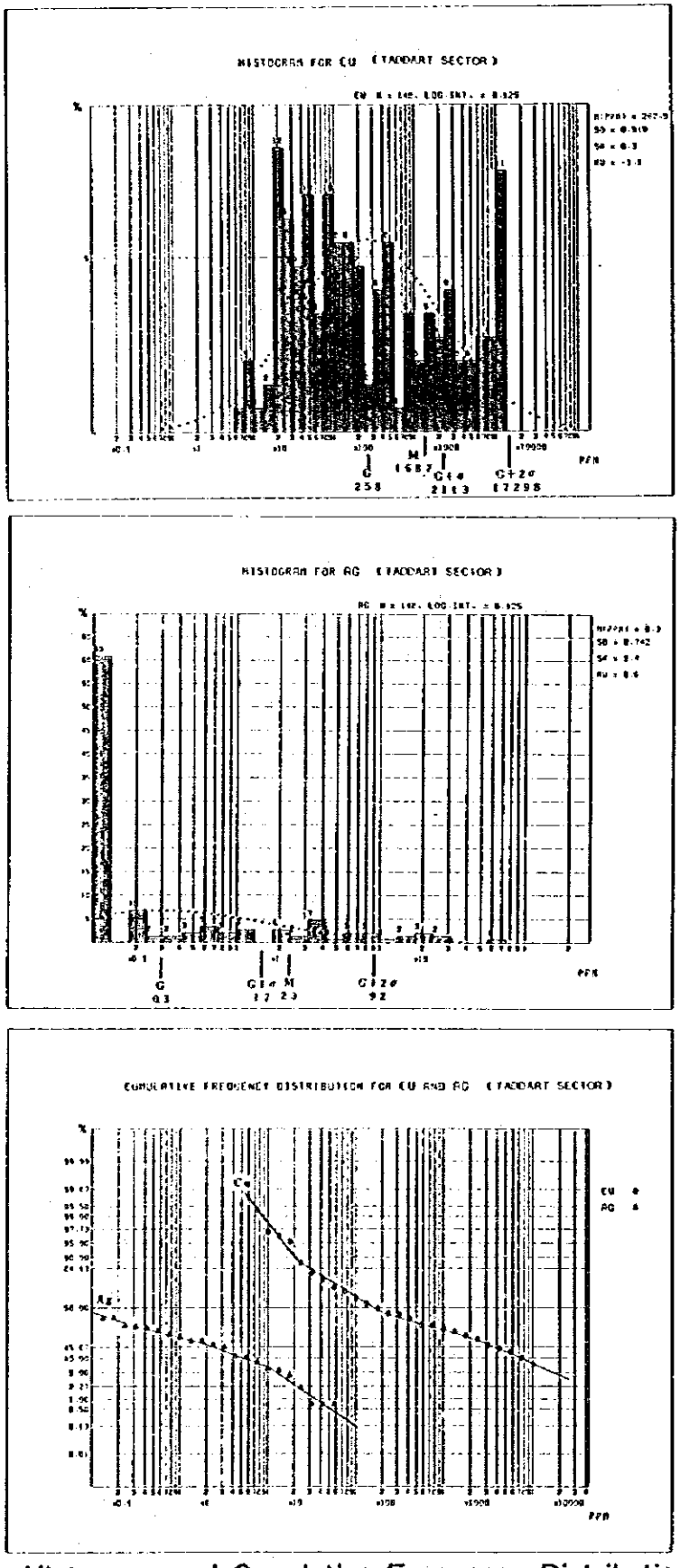


Fig. I — 7 Histogram and Cumulative Frequency Distribution for Cu, Ag of Rock Samples in Taddart Sector

element are utilized the more than 10,000 ppm.

2) Ag: Points of inflections are observed on the cumulative frequency distribution graph near Ag 1.7 ppm and near Ag 10 ppm. These positions corresponds to G+σ value and G+2σ value respectively. Especially, groups of values below 1.7 ppm and values above 1.7 ppm are belonging to different populations respectively, and it is considered that those below 1.7 ppm indicate the background values of Ag in this area. It is, therefore, considered that establishments of anomalous values and thresholds as above are allowable required conditions.

3) Mutual relation among the analysed elements: Correlative coefficients among elements, Cu and Ag were obtained as shown in Table I-6. Based on this table, the slight relationship was found between Cu and Ag to indicate the correlation coefficient as low. These relationships suggested that the ore deposits in this area are mainly consisted of copper and silver.

3-3-2 Considerations on Anomalous Values

The ore deposits in the Taddart sector are copper quartz vein ore deposit in the conglomeratic green schist of the Paleozoic CIII Formations. Especially, these veins were comparatively concentrated in the western part in this sector. Therefore, the examination on the anomalous values was made to correlate above-mentioned mineralizations.

1) Cu (PL. I-3-3)

Strong anomalous values were observed at eleven points. These are mainly distributed in the southern part and northwestern part of vein-aggregated zone in this sector. Weak anomalous zone and indication zone are distributed around the above strong anomalous zone and at the several isolated points.

The tendency of these distribution are made form along the west margine and south margine of the vein aggregated zone. And they have been elongated three directions of NE-SW, WNW-ESE and NNW-SSE.

2) Ag (PL. I-3-4)

Strong anomalous values were observed ten points. Eight of them are accord to the Cu strong anomalous values. Weak anomalous zones and indication zones are distributed around the strong anomalous values and generally accord to the Cu anomalous zone.

As the results of geochemical survey by the rocks in this sector, both of Cu and Ag anomalous values were distributed in the same places as showing by the correlation coefficients and were correspond to the mineralized veins, that is, it has been recognized that the these anomalous zones are elongated to the NE and SE direction as the center at the southwest part in the vein aggregated area.

These facts suggest that the mineralization of copper and silver was made at the southeastern part in the vein aggregated area as the center of mineralization.

3-4 Mineralization

Numerous quartz veins were observed in the conglomeratic green schist of the CIII Formation and in the pelitic schist of the CII Formation, and the copper mineralizations were recognized partially in above mentioned veins. Especially, the quartz vein aggregated zone about 400 meters x 400 meters was recognized in the western part in this sector and malachite and chalcopyrite are recognizable by naked eye.

The scale of veins are several centimeters to several meters in width and several 10 meters to several 100 meters in length. As the trends of veins are recognized as E-W, N-S, NE-SW, NW-SE systems. The characteristics of these veins are as follows.

1) EW system: The width ranges from 1.0 meter to 2.0 meters, some of them is several 100 meters in length and dips more than 70° southward. This veins are composed of siderite and barite associated with quartz at the foot and hanging wall. The grade of Cu is less than 1.0%, and mineralizations are comparatively weak.

2) NS system: The width ranges from 10 centimeter to 50 centimeters, and the length ranges from 30 meters to 100 meters. The veins dip about 40° eastward and show partially the grade of Cu: 3% ∿ 4%, but in general, show the low grade.

3) NE-SW system: The width ranges from 20 centimeter to 2.0 meters and the length ranges from 50 meters to 100 meters. The veins dip about 40° southeastward and are composed of the quartz associated with chalcopyrite and malachite. The mineralizations are comparatively predominant, and the grades of more than Cu 2.0% are recognized.

4) NW-SE system: The width ranges from 20 centimeters to 1.0 meters, and the length are several 10 meters. The veins dip about 40° northeastward, and are composed of quartz partially associated shear zones. Though these veins show partially the high grade (Cu 4.81%), the mineralizations are generally weak.

The contour diagram of strikes and dips of these veins are shown Fig. I-8.

Ore minerals are mainly composed chalcopyrite and malachite, under microscopic observation, besides the phenocryst and dissemination of chalcopyrite and pyrite are recognized, malachite chrysocolla, limonite and covelline along the cracks are observed.

The highest grade of vein shows Cu: 8.20% and Ag: 114 g/t with 40 centimeters in width. However, the grades of mineralized veins show generally Cu: 0.5% to 4.0%.

It is assumed that the average grade of the veins is Cu: 2.5% and Ag: 20 g/t.

In this sector, the non-mineralized and low grade quartz veins were recognized, therefore, all of veins are not available to produce.

3-5 Discussion

Since this sector is located at the inconvenience traffic place, no survey was carried out in the past. However, from the copper mineralization associated with quartz veins have been recognized by the second phase survey, the survey to make clear the condition of emplacement of ore deposit were carried out in this phase for the purpose to elucidate the relationship between mineralization and surrounding geological structure.

As the result of this survey, it has been clarified that the geology in this area is composed of the conglomeratic green schist, pelitic schist, psammitic schist and limestone of the Paleozoic CII , CIII Formations. These formations consist of the alternation of above-mentioned rocks have formed the monoclinic structure trending near north-south and dipping about 50° eastward. And, it has been elucided that this sector effected with the block movement caused by the fault of E-W, NE-SW, NW-SE, NS trend.

Though the quartz veins were recognized all over this sector, the quartz vein aggregated area, about 400 meters x 400 meters, accompanied with silicified zone were also recognized in the western part in this sector.

These quartz veins range generally from 20 centimeters to 2.0 meters, and their strikes show various trends such as EW, NE-SW, NW-SE and NS systems. It is considered that these veins have been made as the secondary fructure by the faulting.

The copper mineralizations were recognized partially in these veins, especially, the high grade ore veins were observed at the southwest part of the vein aggregated area. The highest grade of ore veins is Cu 8.0%, Ag 115

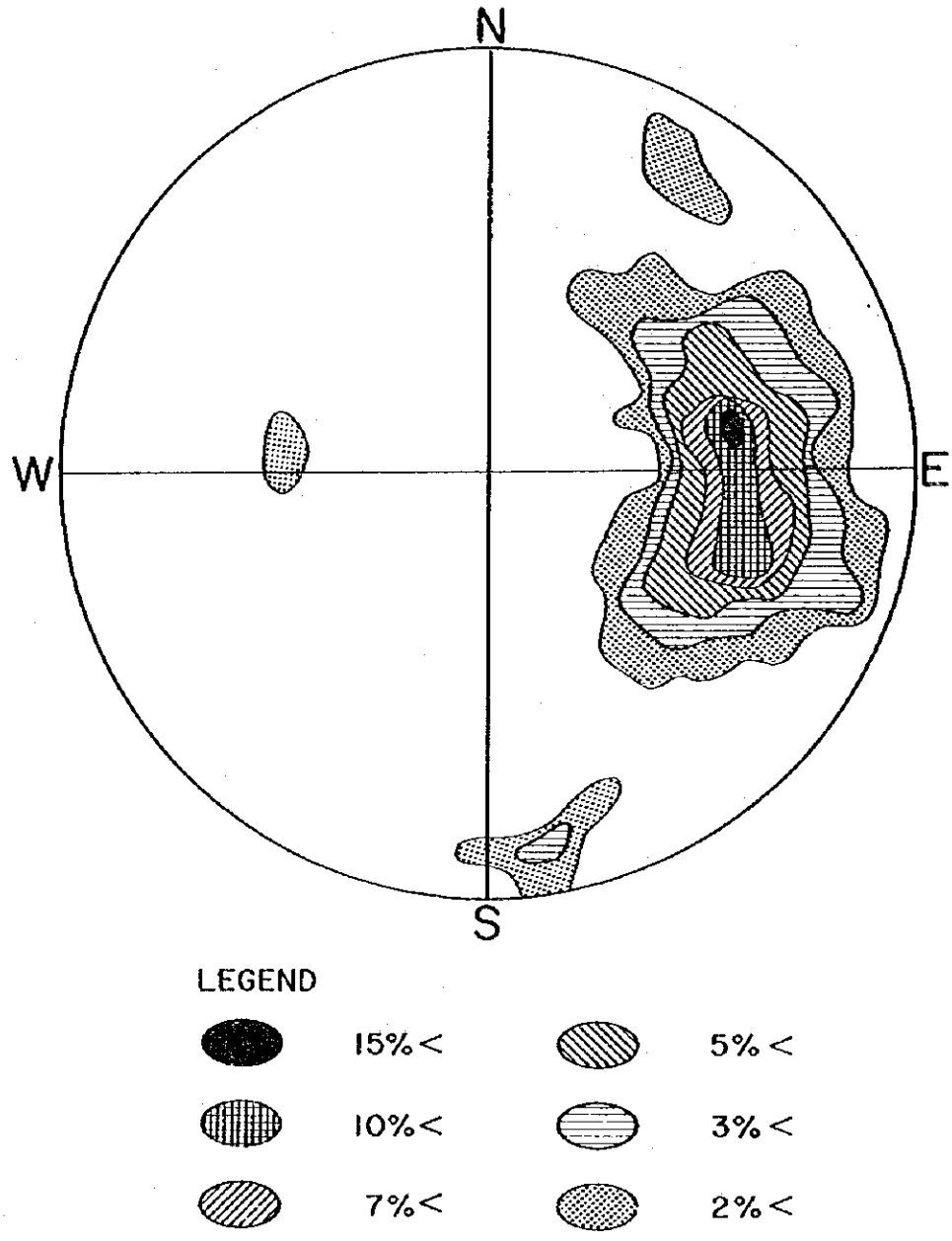


Fig. I-8 Orientation Diagram for Ore Vein, Taddart Sector

g/t, but the grades of veins are generally from Cu: 1.0% to Cu: 4%.

As the results of geochemical survey, both of Cu and Ag element have shown the same tendency. The strong anomalous zone are concentrated at the above-mentioned vein aggregated area, and the anomalous zones are distributed along the western and southern margine of above vein aggregated area, correspond to the major faults.

From the above facts, it is considered that the mineralization in this sector has been controled by the following geological structures.

In this area, the Paleozoic CII , CIII Formations have been suffered tectonic movement associated with the regional metamorphism and the folding. After this movement, the block movement caused by faults occured in this sector, and in the western part of faults intersecting, secondary fructures zone have been made concurrently.

It is considered that the quartz contains copper has been supplied continuously from the deep in underground through the above fracture zone, and the copper quartz veins visible at present have been made.

As to the igneous activity concerning to the mineralizations, though the granodiorite dyke in this sector has a posibility to be the concerning igneous rocks, but it could not make clear by this survey.

Although some copper vein deposit in this sector shows the copper grade of several %, generally, the grades of veins are low as a whole. Therefore, it is far from sufficient on quantity of ore reserve, it is necessary to confirm the condition of mineralization in the deep part in the underground.