KINGDOM OF MOROCCO

REPORT ON GEOLOGICAL SURVEY

OF

THE HAUT ATLAS OCCIDENTAL AREA

(CONSOLIDATED REPORT)

FEBRUARY 1984

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 Occidental 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 works, in turn sought the Metal Mining Agency of Japan for its cooperation to accomplish the task within a period of three years.

The survey works were performed for three years from August 1983 to August 1985 and completed on schedule, in close collaboration with the Government of the Kingdom of Morocco and its various authorities.

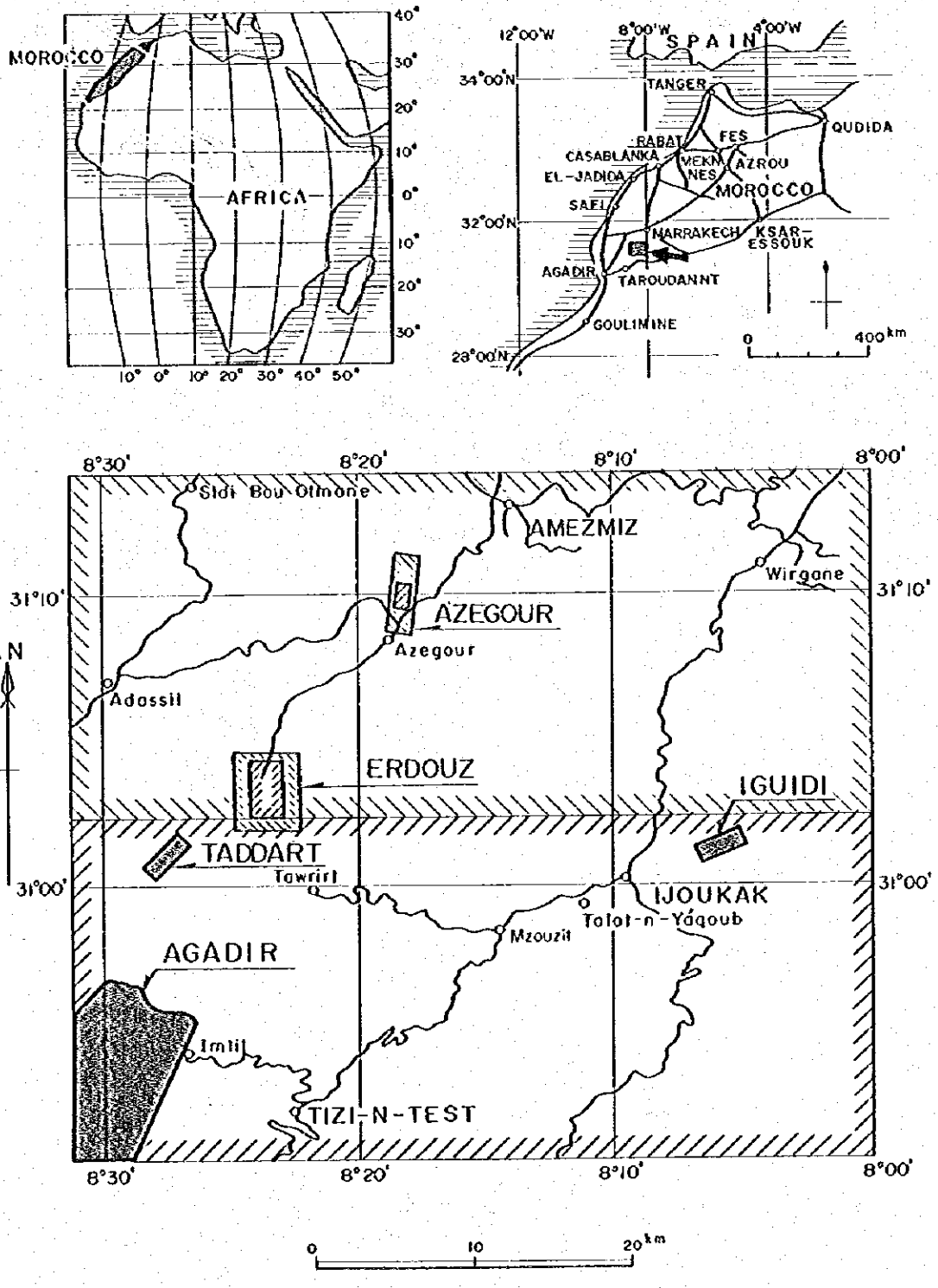
This report submitted hereby summarized the results of the survey performed in the last three years.

We wish to take this opportunity to express our heartfelt gratitude to the Government of the Kingdom of Morocco and the other authorities concerned, as well as to these Japanese authorities of Ministry of International Trade and Industry, Ministry of Foreign Affairs, Embassy of Japan in the Kingdom of Morocco, and the others 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



Phase I Surveyed Area

Phase II Surveyed Area

Phase III Surveyed Area

Fig. 1 Location Map of Surveyed Area

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SUMMARY

This report is summerized the results of the survey performed for three years from August 1983 to August 1985 in the Haut Atlas Occidental area in the Kingdom of Morocco, as the cooperative investigations for the development of mineral resources.

The purpose of this survey is to comprehend the conditions of emplacement of mineral deposits by precious elucidation of geology in the subject area.

The Haut Atlas Occidental area is located at the 100 km south of Marrakech city in the central of Morocco, is topographically in the Haut Atlas mountain range.

The subject surveyed area is approximately 2200 km^2 in which rectangular form of 50 km from east to west and 4.4 km from north to south, and mainly consists of the mountain land at the altitude of 1500m to 3600m above sea level.

The contents of the performed survey works are geological reconnaissance survey and geochemical survey for the whole subject area, detailed geological survey; geochemical survey; CSAMT survey for the Erdouz Sector, detailed geological survey; geochemical survey; SIP survey for the Azegour Sector, detailed geological survey; geochemical survey; magnetic survey; IP survey for the Agadir Sector and semi-detailed geological survey, geochemical survey for the Iguidi and the Taddart Sectors.

The mineral ore deposits and indications have been recognized at the over seventy localities. They are composed of Cu, Pb, Zn, Mo and Barite vein-type ore deposits, Cu, Mo, W, Fe skarn type ore deposits and Cu stock work ore deposits. The country rock of all of these ore deposists are exclusively rocks of before Mesozoic formations and intrusive rocks. The mineralizations have been controled geologically by the intrusive rocks of Hercynian period, by the faults and by the secondary shear fissures.

The subject area, having several ore deposites have been produced in the past such as the Azegour Mine, can be said the large mineral ore deposit area.

As the results of the geochemical surveys, the anomalous zones correspond to these mineralizations have been recognized.

The ore deposits in the Erdouz Sector are Cu-Pb-Zn vein-type ore deposits. From the results of the surveys, the mineralizations are controled by the existance of limestone and fissures. Only south and north ore deposits of in small scale have been recognized.

The ore deposit in the Azegour Sector are Cu-W-Mo skarn ore deposit in the skarn zone replaced limestone of Paleozoic Group.

Especially, the Molybdenum ore deposits at the north of Azegour Mine are controled, geologically, by the boundaries of limestone and other rocks and by the ENE-WSW fissures.

The mineralizations have been recognized at the deeper zone underground, in the southern side of above stated fissure, but they were small in a scale and feeble in a grade.

The ore deposits in the Agadir sector are composed Cu-Mo-W-Fe skarn type ore deposit (Agadir ore deposit) and other small Cu-Mo vein type ore deposits, but the important ore deposit of them is the Agadir ore deposit.

From the results of the surveys, it has been clarified that the mineralization of this ore deposit is controled geologically by the boundaries of limestone and other rocks and by the intrusive rocks. And, it has been

considered that the emplacement of ore deposits is expectable in the deeper part in the underground at the river side area in the neighborings of the Agadir village.

The ore deposits in the Iguidi Sector are Cu-stockwork ore deposits in the dolomites of Paleozoic group. The mineralizations have been controled geologically by the dolomite layers and by the NS faults and fissures.

The slightly large scaled ore deposits at the deeper part in the underground of the western part and of the geochemical anomalous zone has been expected.

The ore deposits in the Taddart Sector are Cu vein type ore deposits in the conglomeratic green schist of Paleozoic Group. Especially, the aggregated veins have been recognized in the western part in this sector. The mineralizations have been controled geologically by the secondary fissures caused by the fault movement, and concentrated in the above stated part.

The enrichment and enlargement of mineralization at the deeper part underground of this aggregated veins zone are expectable.

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PARTICULAR I

INTRODUCTION

CHAPTER 1 OUTLINE 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 between 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 Haut 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.

1-2 Purpose of the Survey

The present investigation is programmed to be carried out with the cooperation of the Bureau de Recherches et de Participations Minieres (B.R.P.M.) of the Kingdom of Morocco, in the Haut Atlas Occidental area of 2,200 km^2, in the period of three years starting in 1983. 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.

1-3 Outline of the Survey Work

The subject area is in rectangular form of 50 km in east and west and of 44 km in north and south, approximately 2,200 km^2.

The subject areas, the methods, contents and periods of the surveys are shown in Table 1 and Fig. 2.

1-3-1 The First Phase Survey

The contents of the survey carried out in the first phase are as follows; The geological reconnaissance survey and the geochemical survey by stream sediments sampling in the Northern Area, in the northern half of the subject area, were carried out. The purpose of the survey was to extract favorable areas for the emplacement of ore deposits, by the synthesized consideration on the relation between the geological structure and the mineralization as well as the geochemical characteristics in the subject area.

The semi-detailed geological survey and the geochemical surveys by soil sampling in the Erdouz Sector (area is approximately 20 km^2) were carried out. The purpose of the survey was to elucidate the relation between the geological structure and the mineralization through clarifying the distribution of the granodiorite and the limestone in which lead-zinc vein type and contact replacement type ore deposits are emplaced.

Also, the detailed geological survey and geochemical survey by rock samples in the Azegour Sector (area is approximately 7.5 km^2) were carried out. The purpose of the survey was to give consideration on the regularity of the formation of ore shoots, by clarifying the distribution of the granite and the limestone in which contact replacement type ore deposits of copper, molybdenum and tungsten, as well as by elucidating the relation between the geological structure and the mineralization.

1) The Northern Area: The survey routes were established with the approximate interval of 5 km in whole area. Especially in such areas as having informations that the indication of mineralization would exist, the survey routes were densely established. Geological survey was carried out by mapping along these survey routes. In the unmapped area, the geological map was prepared by referring to the analysis results of the air photographs of the area.

In parallel with the geological survey, stream sediments were collected at the upstream sides and downstream sides of the confluences of rivers, for the geochemical exploration (elements for analysis: Cu, Pb, Zn, Mo and W).

All the survey datas were described in good order in the route maps of the scale of 1 to 25,000, and based on these route maps, the geological map of the scale of 1 to 50,000 was drawn up. The significant outcrops of the mineralization were precisely mapped with detailed observation.

2) Erdouz Sector: In this sector, the survey routes were established along the existing roads, the main rivers and the ridges so that the interval of the survey routes might have been 300 to 500 meters, and the geological survey was carried out by mapping along these survey routes.

For the field survey, topographical map of the scale of 1 to 5,000 was prepared by the land survey with transit compasses and esron tapes, and using this map as the route maps, geological data and observation results of the mineral indications were described. In and around the area where the Erdouz north ore deposit and the Erdouz south ore deposit are distributed, which was clarified through the geological survey, survey lines of the interval of 50 to 200 meters were established and precise mapping was completed for the conditions of the emplacement of mineral deposits.

Geochemical survey (analysis elements are Cu, Pb and Zn) was carried out by collecting samples of soil at the points of every 25 meters along the above survey lines. Outside of the mineralized area, soil samples were collected at the points approximately every 500 meters along the survey routes.

Upon the basis of these route maps, the geological map of the scale of 1 to 10,000 was drawn up.

3) Azegour Sector: In this sector, the survey routes of the intervals of 300 to 500 meters in right angle to the strike of the limestone bed were established in addition to the survey routes along the several skarnized zones. Geological survey was carried out along these survey routes.

For the field survey, the topographical maps of the scale of 1 to 1,000 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.

In parallel with the geological survey, the geochemical survey (analysis elements are Cu, Pb, Zn, Fe, W and Mo) was carried out by collecting rock chip samples mainly at the points every 25 meters along the strikes of the skarnized zone, where indications of mineralization are included.

Upon the basis of these route maps of the scale of 1 to 1,000, the geological map of the scale of 1 to 2,000 was drawn up.

As for the representative rocks and minerals, samples were collected and were supplied to the examination by microscopic observation, the chemical analysis etc., for the interpretation of geology and mineralization.

1-3-2 The Second Phase Survey

The contents of the surveys carried out in the second phase are as follows; The geological reconnaissance survey and geochemical survey by stream sediments sampling in the Southern Area (1,000 km^2), in the southern

Table 1 Summary of the Survey

Survey Method		Phase I (1983)		Phase II (1984)		Phase III (1985)	
		Area	Amount of Work	Area	Amount of Work	Area	Amount of Work
General Geological Survey		Northern Part	1072.5 km^2	Southern Part	1100 km^2		
Semi-detailed Geological Survey		Erdouz Azegour	20.0 km^2 7.5 km^2			Agadir Iguidi Taddart	60 km^2 3 km^2 3 km^2
Geochemical Survey	Stream Sediment	Northern Part	460 pcs	Southern Part	698 pcs		
	Soil	Erdouz Sector	229 pcs	Erdouz	412 pcs		
	Rock	Azegour Sector	244 pcs			Agadir Iguidi Taddart	304 pcs 227 pcs 148 pcs
Geophysical Survey	CSAMT			Erdouz	5 km^2		
	SIP			Azegour	4.6 km (4 line)		
	Magnetic Survey					Agadir	8 km^2 (520 p.)
	I P					Agadir	15.0km (319 p.)
(Diamond Drilling) (by BRPM)				(Azegour)	(909.80 m)	-	
Period of Survey		17/Jul/1983 ∿ 14/Oct/1983		5/Aug/1984 ∿ 2/Dec/1984		14/Jun/1985 ∿ 26/Aug/1985	

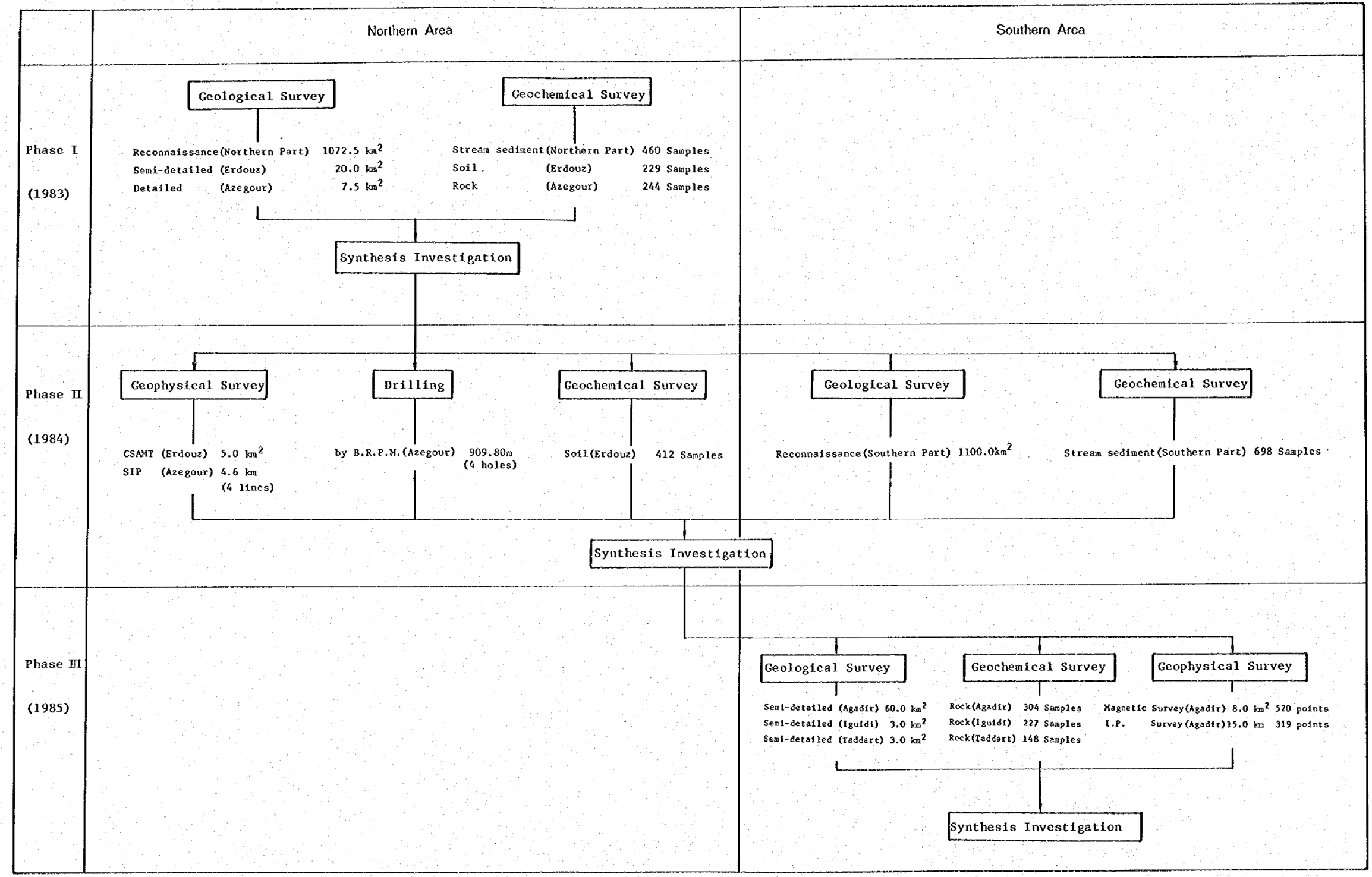

Fig. 2 Flow Chart of Field Work

half of the subject area, were carried out. The purpose of the survey was to extract favorable areas for the emplacement of ore deposit as well as the first phase survey's purpose.

In the Erdouz Sector, the geochemical survey by soil sampling in the rectangular area of 3.6 km in north and south and of 1.2 km in east and west where including the Erdouz north ore deposit and the Erdouz south ore deposit, was carried out. And the CSAMT survey in the area of 5 km^2 in the north slope of Mt. Erdouz was carried out. The purpose of these surveys was to confirm the continuity of both ore deposit.

In the Azegour Sector, SIP survey and diamond drillings (by B.R. P.M.) were carried out to elucidate the downward continuity of skarn-type Mo-Cu-W ore deposit.

1) Southern Area: The survey routes were established with approximate interval of 10 km covering whole of the area. Especially in such areas where information on the indication of mineralization had been available, survey routes were set more densely. Geological survey was carried out by mapping along these survey routes. For the unmapped area, the geological map was prepared by refering to the analysis results of airphotographs of the area.

In parallel with the geological survey, stream sediments were collected at the upstream sides of confluences of rivers for the geochemical exploration (elements of analysis: Cu, Pb, Zn, Mo and W).

All survey datas were described in good order in the route maps of the scale of 1 to 25,000, and based on these route maps, the geological map of the scale of 1 to 50,000 was made up. The significant outcrops of the mineralization were precisely mapped with detailed observation.

2) Erdouz Sector: Regarding to the geochemical survey, nineteen traverse lines running from east to west were established in the area, including two ore deposits, at the interval of about 200 m. Samples of soil were collected at 50 m horizontal interval on each of the traverse line as geochemical samples (analysis element: Cu, Pb and Zn). Travers lines and sampling sites were measured with transit compass and esron tapes.

CSAMT survey was carried out at 27 stations established in the area of about 5 km^2 at the northern slope of Mt. Erdouz. Eleven frequencies ranging from 2^2 Hz (4 Hz) to 2^{12} Hz (4,098 Hz) were applied for measurement. Electric wire directed toward almost east to west, of which both ends were grounded, was installed as the transmission source at about 5.6 km north of the Erdouz Sector.

All data of above survey results was discribed on the map of the scale of 1 to 2,000.

3) Azegour Sector: SIP survey was carried out along four traverse lines running from east to west of which lengths were about 1 km respectively. Total length of traverse lines is 4.6 km, and the total number of observation stations are 144. Traverse line were set at the interval of about 200 m. Electrode spacing is 100 m, electrode separation constant (n) are 1-5, and transmission and receiver bases were set at the center of each traverse line.

Although transmission currents varied according to resistance of electlode, they were within the range of 2A and 5A. Measurements were made utilizing add number harmonics from 1 to 11 of each signal by transmitting rectangular wave signal having basic frequencies of 0.125 Hz, 1 Hz and 8 Hz.

All data of the survey results was discribed on the map of the scale 1 to 2,000. The synthetic analysis was made up refering to the results of the diamond drillgs and of the first phase's geological survey.

Samples of representative rocks were taken for microscopic observation, chemical analysis, SIP test and resistivety test throughout above surveys.

1-3-3 The Third Phase Survey

The contents of the surveys carried out in the third phase are as follows: The detailed geological survey and goechemical survey by rock sampling in the Agadir Sector (60 km^2), expected the existence of favorable ore deposits, were carried out. The purpose of the surveys was to clarify the geological setting of the Cu-W skarn-type mineralization. Fathermore, the magnetic survey and IP survey were executed in this area, the purpose of these survey was to examined the continuity downward of the mineralization by the detection of anomalies and elucidation of the property.

In both area of the Iguidi Sector (3 km^2) and the Taddart Sector (3 km^2), detailed geological surveys and the geochemical surveys by rock sampling were carried out to clarify the condition of emplacement of Cu mineralization.

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.

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 messured 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 messured continuously to get correct data of daily magnetism.

The IP survey in the Agadir Sector was carried out along 19 traverse lines having a correspondance 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.

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) 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 of 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 defraction analysis, IP test and magnetic susceptibility test throughout above surveys.

1-4 Members of the Survey Team

Participated members of survey programming, negotiation and field works in this survey is shown Table 2.

Table 2 Members List of the Survey Team

	Phase I (1983)	Phase II (1984)	Phase III (1985)
Japan			
Coordinator & Administrator	Suzuki Haruo	Baba Yozo	Suzuki Haruo
	Sawaya Shozo	Kita Yoshiyuki	Arakawa Kohei
	Baba Yozo	Hida Kazuhiko	Kita Yoshiyuki
	Hida Kazuhiko		Kikushima Ichiro
	Taketomi Yoshikazu		
	Esawa Tadaaki		
Chief of Mission	Wakabayashi Kensuke	Wakabayashi Kensuke	Wakabayashi Kensuke
Members Geology	Nagumo Yoshihiro	Shibata Kiyohisa	Shibata Kiyohisa
	Shibata Kiyohisa	Nakamura Akitoshi	Nakamura Akitoshi
	Otsubo Ryohei		
Geophysics		Ohya Takashi	Kobayashi Manabu
		Ohashi Tadashi	Ohashi Tadashi
Morroco: Coordinator & Administrator (B.R.P.M.)	Mohamed Chahid	Ahmed Louali	Assou Lhatoute
	Ahmed Louali	Bachir Barodi	Ahmed Louali
	Bachir Barodi	Allal Tijani	Allal Tijani
			Said Barrakad
Members:	Abderrahim Chbihi	Abderrahim Chbihi	Abdelaziz Mellal
	M'hamed Annich	Abderakader Bakkali	Abderakader Bakkali
	Abderrahim Qalbi	Mohamed Berrada	Mohamed Berrada
	Matsutoya Shigeru	Matsutoya Shigeru	Matsutoya Shigeru

CHAPTER 2 OUTLINE OF THE SURVEYED AREA

2-1 Location and Traffics

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 of 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. It is in the Amezmiz county in the state of Marrakech, by the administrative division (Refer to Fig. 1).

As there is a railroad and a paved road from Rabat, the capital of the Kingdom of Morocco, to Marrakech city, the principal city of state of Marrakech, the access is quite easy. There are a paved road from Marrakech to Amezmiz and a partly unpaved Haut Atlas across road along the Nfis river. The distance from Rabat to Amezmiz is about 410 km, and it takes about 5 hours by vehicle.

From main town as Amezmiz to the villages in the surveyed area, there is no other way than on foot or on horsebacks except for some roads along the main rivers which are accessible by vehicles.

2-2 Topography

The surveyed area is mainly composed of the mountainous land at the altitudes of more than 1,000 meters above sea level. In the central part of the subject area, there is a watershed of the Haut Atlas range in the direction of east and west at the altitudes of over 3,000 meters above sea level. Therefore, in the north of which the rivers are flowing northward while, in the south, the rivers are streaming southward. These rivers have dissected the mountainous land deeply and deep gorges. Therefore, the land features in this area are quite steep. The highest summit in this area is the main summit of Idoga Massif of which elevation is 3,616 meters above sea level. As the main rivers, there are Nfis river in the eastern part, Amezmiz river in the central part and Assif Al Mal river the western part in this area.

2-3 Climate and Vegetation

Since Sahara Desert is spread to the south of the subject area, the climate in this area is hot and arid with the temperature of more than 40°C in summer time from July to September. On the contrary, there is snowfall in winter between November and March. The difference of temperature is extreme in this area. Therefore, the vegetation is recognized only in the lowland and along the rivers, and uncovered rocks are exposed in the most of the highland.

2-4 Inhabitants and Industries

The inhabitants in this area are mainly of Berber Tribe, and they are living along main rivers forming small villages. They usually speak Berber language, therefore, it is almost impossible to communicate with them in Arabic which is the official language of the Kingdom of Morocco.

Such steep topographical and severe climatic conditions have checked development of industries and they are living on the stock farming of sheep and goats. They are gentle and diligent generally, and potencial working power is abundant. However, as they are almost no industries in this area, many of them are working away from home to other big cities in the country or in various European countries.

2-5 Outline of Geology

2-5-1 Outline of Geology of Morocco

Most of the African continent has been composed of stable cratons after the Pan African orogenic movement in the period of the late Pre-Cambrian to the early Paleozoic Era (600±200 m.y.). However, the zone along the northwestern side of the West African craton, including Moroccan area, has been an exception, and has been left as a mobile belt. Geosynclinal activities and orogenic movement occured in this zone after Paleozoic Era.

The geosynclinal activities and the orogenic movements in Morocco area are recognized to have been developed step by step as a whole, northward from the southern part of the country, which is close to the Pre-Cambrian craton, to the side of the Mediterranean Sea in the north. By the difference of the characteristics of the lithology and the geological structure accompanied by the above activities and movements, the Moroccan terrain has been divided into three zone geologically; the Anti Atlas zone in the south, the Atlas zone in the central part and the Rif zone in the northern part (Refer to Fig.3).

The Anti Atlas zone occupied the area south of the Accident Sud Atlasien, which is confining the southern limit of the Atlas mountain range. This zone has been cratonized since the Hercynian Orogeny in the period of the late Paleozoic to early Mesozoic Era, and is composed mainly of the Paleozoic sediments accumulated in the shield area which was developed along the northern margin of the stable Pre-Cambrian shield. This Anti Atlas zone is characterized by the comparatively gentle rises of the Pre-Cambrian Group. At present, it is recognized that sedimentary rocks including volcanic product, which are belonging mainly to the lower part of the Paleozoic Group such as Infra-Cambrian and Cambrian Systems, are widely developed around the core of the Pre-Cambrian Group exposed in the central part of the Pre-Cambrian rise.

The Atlas zone is located in the north of the Anti Atlas zone and occupied the Haut Atlas range, the Moyen Atlas range and the Meseta developed in both sides of the Moyen Atlas. The Atlas zone composes the Mesozoic geosynclinal zone developed on the thick Paleozoic sedimentary rocks accumulated in and toward the subsided zone in the north of the above-stated Anti Atlas zone. At the period of the Tertiary Alpine orogenic movement this zone was uplifted to form a part of the continent. As for geology and geological structure, there are remarkable differences between the mountain range and the Meseta. In the area of the mountain range, continuous sedimentation is recognized throughout the Mesozoic Era, as this area is supposed to have been correspondent to the central zone of the sedimentary basin in the Mesozoic geosyncline. In Meseta area, on the contrary, the sedimentation was intermittent and not dominant, leaving wide range of exposures of the basement rocks. These basement rock were heavily mobilized at the period of the Hercynian orogenic movement, which is quite different from the case of the Anti Atlas zone. They have been folded, metamorphosed and intruded by granitic rocks. Also, at the period of the Alpine orogenic movement, the central part of the geosyncline was uplifted to form quite a high mountain range reaching the altitude of more than 3,000 meters above sea level, while merely slight deformation is recognized to have been in the Meseta area in the outer margin of the geosyncline.

The Rif zone is situated in the northernmost part of the Moroccan terrain, and composes Tertiary miogeosynclinal zone formed on the basis of the Paleozoic and Mesozoic sediments. There are many Nappe structures southward from the northern part, and it is thought that this zone is forming a part of the Alpine orogenic zone found running in the southern Europe. By

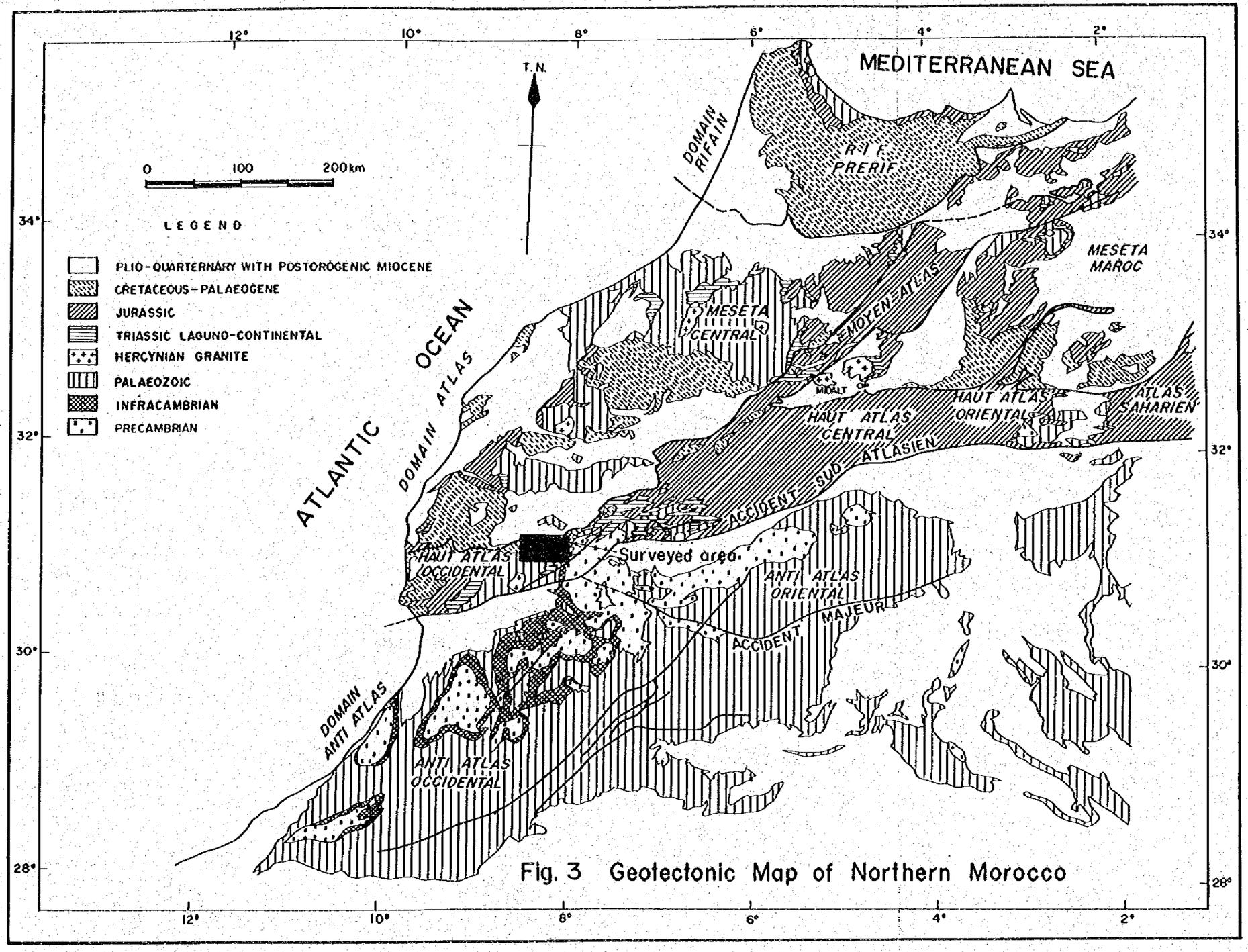

Fig. 3 Geotectonic Map of Northern Morocco

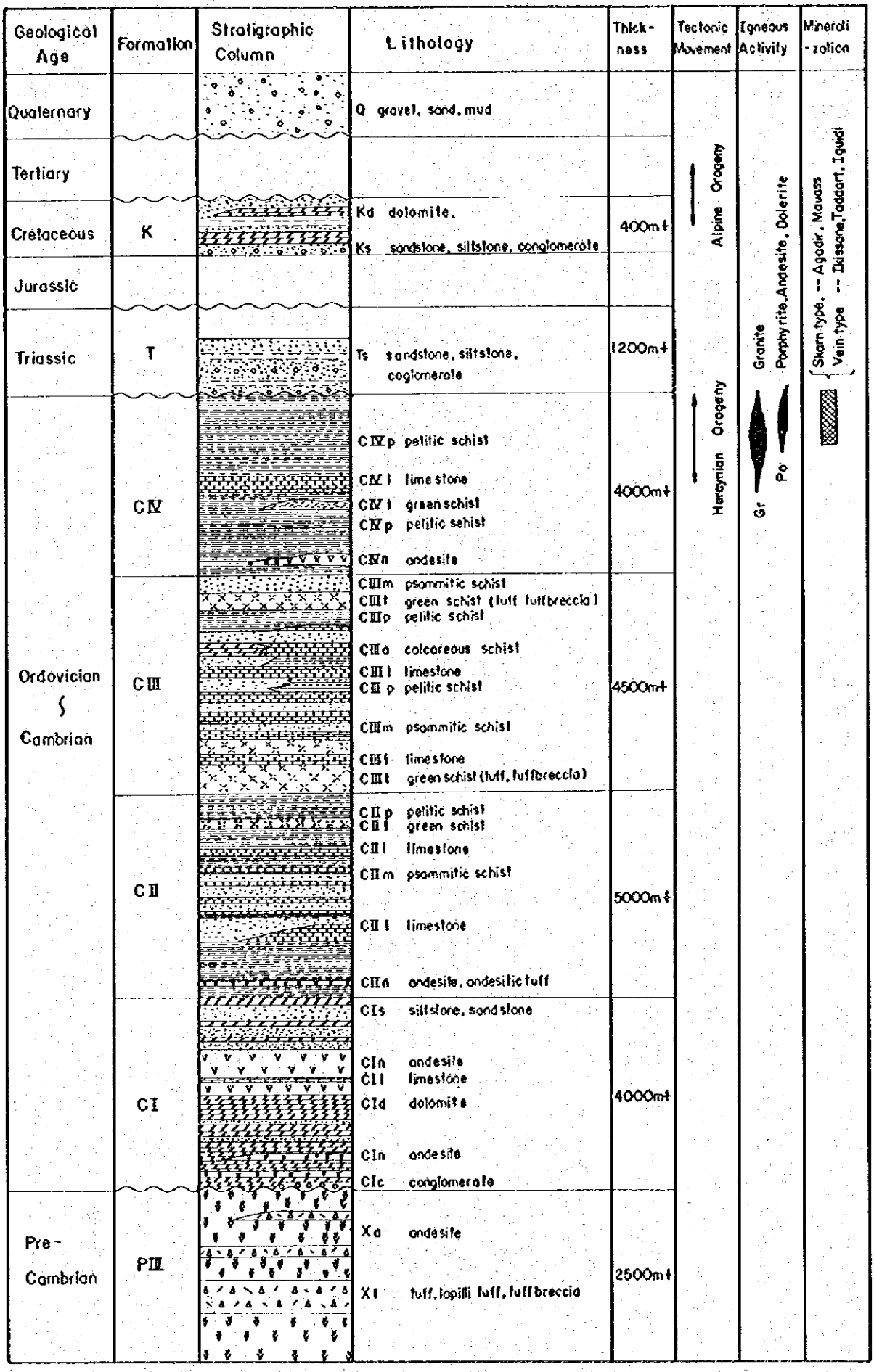

Fig.4 Schematic Geological Column of Surveyed Area

the repetition of the overthrust movement from the north to the south in the period of the Alpine orogenic movement, this Rif zone would have formed arcuate folding mountain range along the Mediterranean Sea, where a great deal of faults are recognized to have been developed.

2-5-2 Geology of the Surveyed Area (Refer to PL.1, PL.2, Fig.4).

The surveyed area is underlain, geologically, by the Pre-Cambrian Group, the Paleozoic Group, the Mesozoic Group, Cenozoic Group and the Intrusive Rocks intruded during Hercynian period. 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 groups is a monoclinic structure having gently inclination westward.

The Paleozoic Group is thought to belong to the Cambrian to Ordovician Systems, and is 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 Paleozoic 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 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 Group. 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.

2-5-3 Geological Structure

The characteristic of the geological structure in the surveyed area are summarised as follows;

1) The Pre-Cambrian Group is the basement rocks of this area. It has been mainly formed during active volcanic activities in continental or shallow water environment. The monoclinic structure inclined westward as the whole of the group has been assumable by its sedimentary structure.

2) The Paleozoic Group is regarded as of the Ordovician and Cambrian age. This group was devided into four formations by the predominant differences of the rock facies owing to the sedimentary circumstance, by the folded structures and by the metamorphosed features.

3) All of these formations are cut by the faults of system of NE-SW, EW, NNE-SSW. It is considered that some of these faults were made up during the hercynian tectonic movement, after the sedimentation of the Paleozoic Group, and which is accompanied with the regional metamorphic and the folding movement.

4) The plutonic rocks as represented by the Tichka Granites affected the thermal metamorphism to the surrounding Paleozoic formations. Some of them formed stocks, and the rest formed the dykes in the Paleozoic formations. Furthermore, some of limestone converted to skarn minerals.

5) The Mesozoic Groups are rest uncomformably upon the Paleozoic Groups in this area. Since the uncomformity plane is flat, it shows that the Paleozoic Group and the plutonic rocks in this area were subjected to erosion of the surface and made up the peneplane after the uplift movement of this area.

6) Post Paleozoic formations are distributed at the places of topographic high and inserted by the faults. But they have low-angled bedding plane nearly horizontal and less deformations. These facts indicate that block movements with faults were made in this area after the Cretaceous.