REPORT
ON
THE MINERAL EXPLORATION
IN
THE HAOUZ CENTRAL AREA
KINGDOM OF MOROCCO

(CONSOLIDATED REPORT)

MARCH [illegible]

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Government of the Kingdom of Morocco, the Government of Japan decided to conduct a Mineral Exploration Project in the Haouz Central Area and entrusted the survey to Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ).

The survey and investigation of the Haouz Central Area were carried out over three years from 1987 to 1989 and completed on schedule under close cooperation with the Government of the Kingdom of Morocco and its authorities.

This report summarizes the results of the exploration and investigation executed during three years.

We wish to express our deep appreciation to the officials concerned of the Government of Morocco for their close cooperation extended to the team.

February, 1990

Kensuke Yanagiya
President
Japan International Cooperation Agency

Gen-ichi Fukuhara
President
Metal Mining Agency of Japan

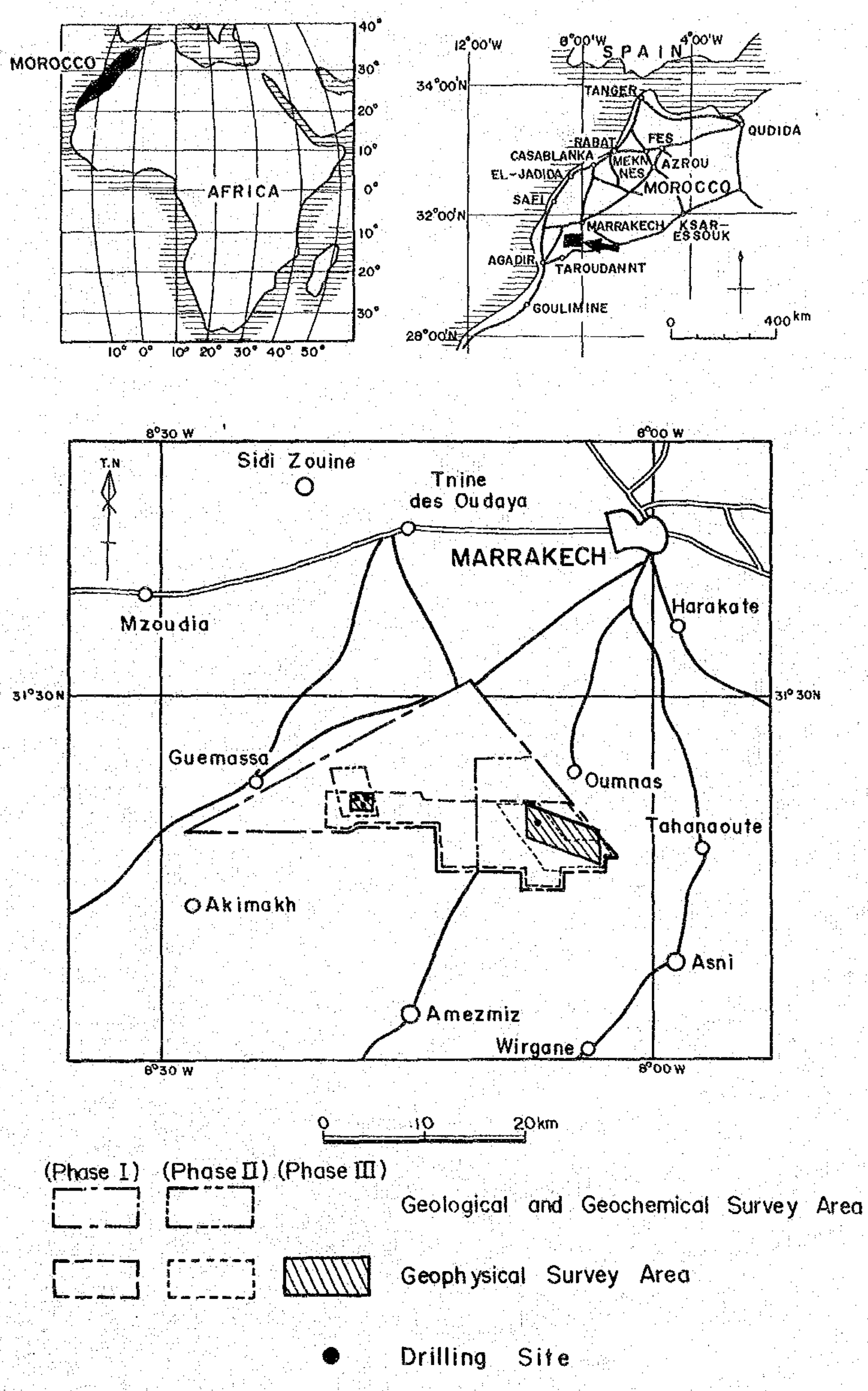

Fig. 1 Location Map of the Survey Area

ABSTRACT

This report summarizes the results of the mineral exploration project executed in the Haouz Central Area, in the Kingdom of Morocco, during three years from 1987 to 1989.

The purpose of this project is to clarify the geological environment and mineralization and to confirm the occurrence of ore deposit.

The Haouz Central Area is an area of 350km^2 located about 330km south-southwest of Rabat.

A series of exploration surveys, geological and geochemical survey, geophysical survey by CSAMT, gravity and IP methods, and drilling exploration were carried out step by step as shown follows:

Geological and geochemical survey (Phase I) = 350km^2, 215 samples
Geological and geochemical survey (Phase II) = 46km^2, 282 samples
CSAMT prospecting (Phase I) = 150 km^2, 302 stations
Gravity prospecting (Phase II) = 40 km^2, 745 points
IP prospecting (Phase II, III) = 30 lines, total 52.8km
Drilling exploration (Phase III) =400 m x 4 holes, total 1,600m

Through the series of surveys, the geological structure and occurring condition of ore deposit have been clarified, and the Eastern Area (Hajar-Amzourh Area) and the Western Area (Frizem Area) have been extracted as the promising areas for the exploration of ore deposit, and then, the Hajar horizon and the Frizem horizon have been extracted as the important zones provided with high potentiality for the occurrence of ore deposit.

(1) Geological and Geochemical Survey

The Carboniferous to Permian Systems composed mainly of pelitic and marly schist and semishist are widely distributed in the survey area. However, their outcrops are sporadic on the surface covered by thick Quaternay sediments.

Numerous drag folds and schistosity plane faults are developed in the schist and semischist to make complicated imbrecate structure generally dipping gently to the northeast.

In the schist and semischist, there develop two specific formations composed mainly of acidic volcanic and pyroclastic rocks, and so-called green rock originated in pyroclastic rock, that is, the Hajar horizon and the Frizen horizon. Mineral indications by gossan and geochemical anomalies of copper, lead and zinc are concentrated in the two horizons above mentioned.

The Hajar ore deposit has been found in the survey area. The Hajar ore deposit has a characteristics of sedimentary volcano-genetic ore deposit containing a large quantity of pyrrhotite. That is, the main part of the ore deposit is bedded orebodies concentrated in lead and zinc, and at the bottom of which networks and veins comparatively rich in copper are accompanied.

(2) Geophysical Survey

By the CSAMT prospecting, it was clarified that the Quaternary covering sediments formed a low resistivity layer and many low resistivity depression zones in the high resistivity basement were recognized especially in the area where the Hajar horizon was presumed to distribute.

By gravity prospecting, the areas where the basement rocks were exposed on the surface and the covering sediments were shallow, and the uplifted zone of the basement were detected as high gravity zones.

By IP prospecting, strong IP anomalies were confirmed being concealed underground in the Lamrah area, in the Frizem area and in the Hajar southwest area not only on the Hajar orebody.

These IP anomalies were associated with magnetic anomalies of different degree of intensity and inferred to indicate a possibility for the occurrence of orebody.

(3) Drilling Exploration

Mineralized parts of copper, lead and zinc have been encountered by all of the 4 drilling holes carried out in the Lamrah area and in the Frizem area. However, they are all low-grade or small-scale ores of network and dissemination types and they are difficult to develope economically. Nevertheless, they are inferred to represent the features of mineralization of the lower parts and the peripheral zones of the massive orebody.

(4) Outlook for the Future

1) To the southwest of the Hajar ore deposit, a weak to medium IP anomaly has been confirmed. It is desirable to clarify the cause of the IP anomaly whether it depends on the occurrence of a concealed orebody or on another reasons.
2) In the Frizem area, it is difficult to expect a large-scale and high-grade massive orebody comparatively in the shallow underground. However, it is recommended to continue the study and survey concerning a possibility of orebody in the deeper place, judging from the increasing trend of IP anomaly to the deeper.

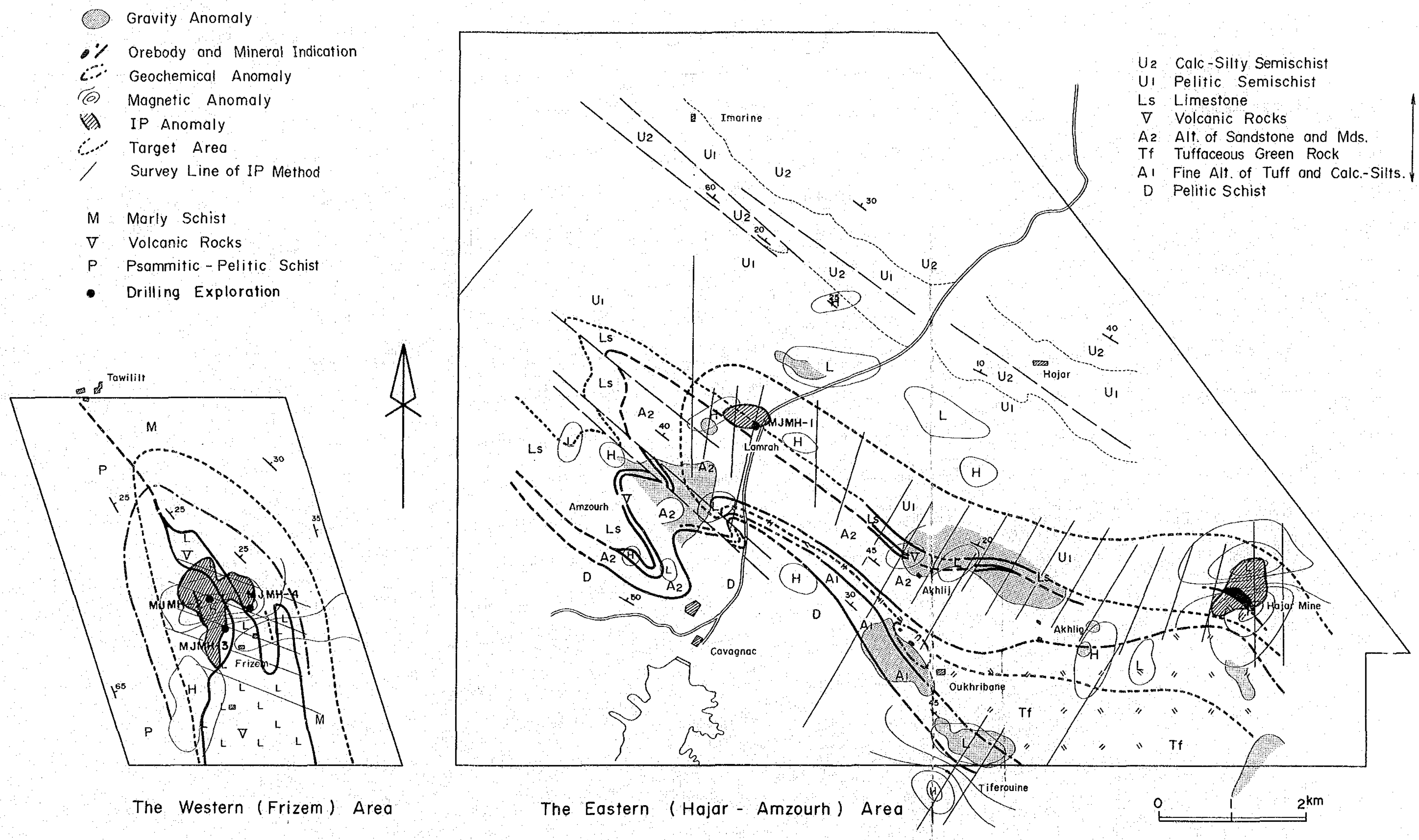

Fig. 2 Synthetic Map of the Exploration Results

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PART I
GEOPHYSICAL SURVEY

CHAPTER 1 OUTLINE OF THE SURVEY

1-1 Survey Area and Survey Purpose

The Haouz Central Area is a trianglar area of 350km^2 located in the west central part of the Kingdom of Morocco, about 330km south-southwest of Rabat (Fig. 1).

The purpose of the survey is to clarify the details of geological features and the occurrence of mineralization. The surveys were carried out under close cooperation with Bureau de Recherches et de Participations Miniéres (BRPM), the official organization of the Government of the Kingdom of Morocco.

1-2 Survey Method and Survey Quantity

The survey methods and survey quantity in each phase are shown on the flow charts in the Fig. 3 and Fig. 4.

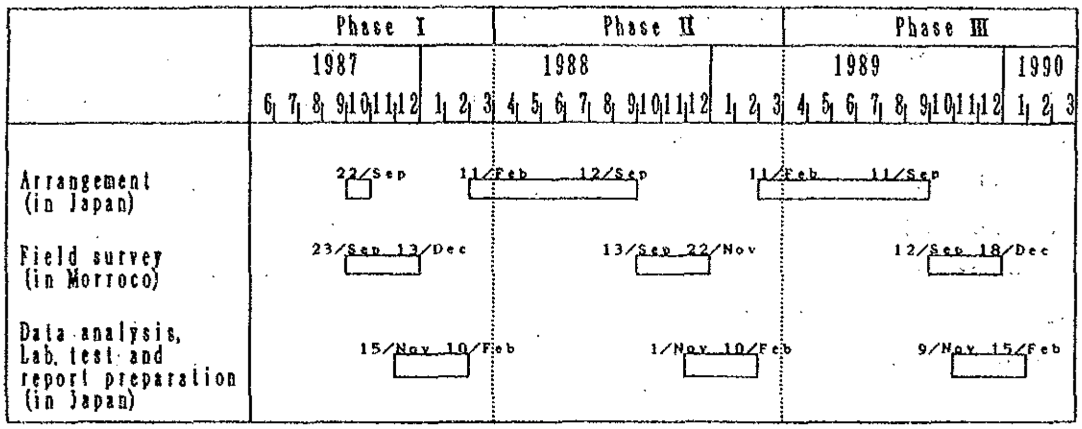
In the First Phase, geological and geochemical survey and geophysical prospecting by means of CSAMT method were carried out. As the result, the Eastern Area (Hajar-Amzourh Area, 34km^2) and the Western Area (Frizem Area, 12km^2) were extracted as the favorable areas for mineral resource.

In the Second Phase, geophysical prospectings by means of IP method and gravity method as well as geological and geochemical survey were carried out in the both areas above mentioned. As the results, the concealed Hajar horizon area (15km^2) and the Frizem mineralized and geophysical anomaly zone (4km^2) were extracted as the potencial areas for the occurrence of ore deposit.

In the Third Phase, IP prospecting and drilling exploration were carried out in the above mentioned extracted two areas.

1-3 Survey Period and Survey Member

(1) Survey Period



(2) Planning and Coodination Member

		Japan Side	Morocco Side
S/W Mission	Leader	Minoru FUJITA (MMAJ)	Assou LHATOUTE (BRPM)
	Staff	Nobuyoshi TAKABE (MFA)	Ahmed LAUALI (BRPM)
	Staff	Hideo TAKANO (MITI)	Hassan SEQQAt (BRPM)
	Staff	Takashi KAMIKI (JICA)	Allal TIJANI (BRPM)
Phase I	Coordination	Yosuke SUZUKI (MMAJ)	Assou LHATOUTE (BRPM)
	Coordination	Fumiko TSUCHIDA (MMAJ)	Ahmed LAUALI (BRPM)
	Coordination	Natsumi KAMIYA (MMAJ)	Hassan SEQQAT (BRPM)
			Allal TIJANI (BRPM)
Phase III	Coordination	Naoki SATO (MMAJ)	Assou LHATOUTE (BRPM)
	Coordination	Koji KOIWA (MMAJ)	Ali BENNANI (BRPM)
			Ahmed LAUALI (BRPM)
			El Bachir BARODI (BRPM)

JICA: Japan International Cooperation Agency
MMAJ: Metal Mining Agency of Japan
MFA: Ministry of Foreign Affairs
MITI: Ministry of International Trade and Industry
BRPM: Bureau de Recherches et de Participations Miniéres

(3) Field Survey Team

		Japan Side	Morocco Side
Phase I	Leader	Juinichi NAKAMURA (MINDECO)	Abdelaziz MELLAL (BRPM) Mahomed BERRADA (BRPM)
	Geol. Geoch.	Eitaro SATO (MINDECO)	Abderrahim QALBI (BRPM)
	Geol. Geoch.	Ryohei OTSUBO (MINDECO)	
	Geophysic	Kazuhiko KINOSHITA (MINDECO)	Said QASRI (BRPM)
	Geophysic	Kazushige WADA (MINDECO)	
	Geophysic	Tadashi OHASHI (MINDECO)	
Phase II	Leader	Jinichi NAKAMURA (MINDECO)	Assou LHATOUTE (BRPM) Ali BENNANI (BRPM) Ahmed LOUALI (BRPM) Hassan SEQQAT (BRPM) Allal TIJANI (BRPM)
	Geol. Geoch.	Ryohei OTSUBO (MINDECO)	Abdelaziz MELLAL (BRPM)
	Geol. Geoch.	Kazuhiro ADACHI (MINDECO)	Abderrahim QALBI (BRPM)
	Geophysic	Akira SAITO (MINDECO)	Mohamed BERRADA (BRPM)
	Geophysic	Kazushige WADA (MINDECO)	Said QASRI (BRPM)
	Geophysic	Tadashi OHASHI (MINDECOO	
	Geophysic	Tatsuo YAMAZAKI (MINDECO)	
	Geophysic	Hirokazu MUTO (MINDECO)	
Phase III	Leader, Drilling	Jinichi NAKAMURA (MINDECO)	Abdrrahim CHBIHI (BRPM)
	Geophysic	Kazuhiko KINOSHITA (MINDECO)	Mahomed BERRADA (BRPM)
	Geophysic	Tadashi OHASHI (MINDECO)	Said QASRI (BRPM)
	Geophysic	Hirokazu MUTO (MINDECO)	

MINDECO: Mitsui Mineral Development Engineering Co., Ltd.
BRPM: Bureau de Recherches et de Participations Miniéres

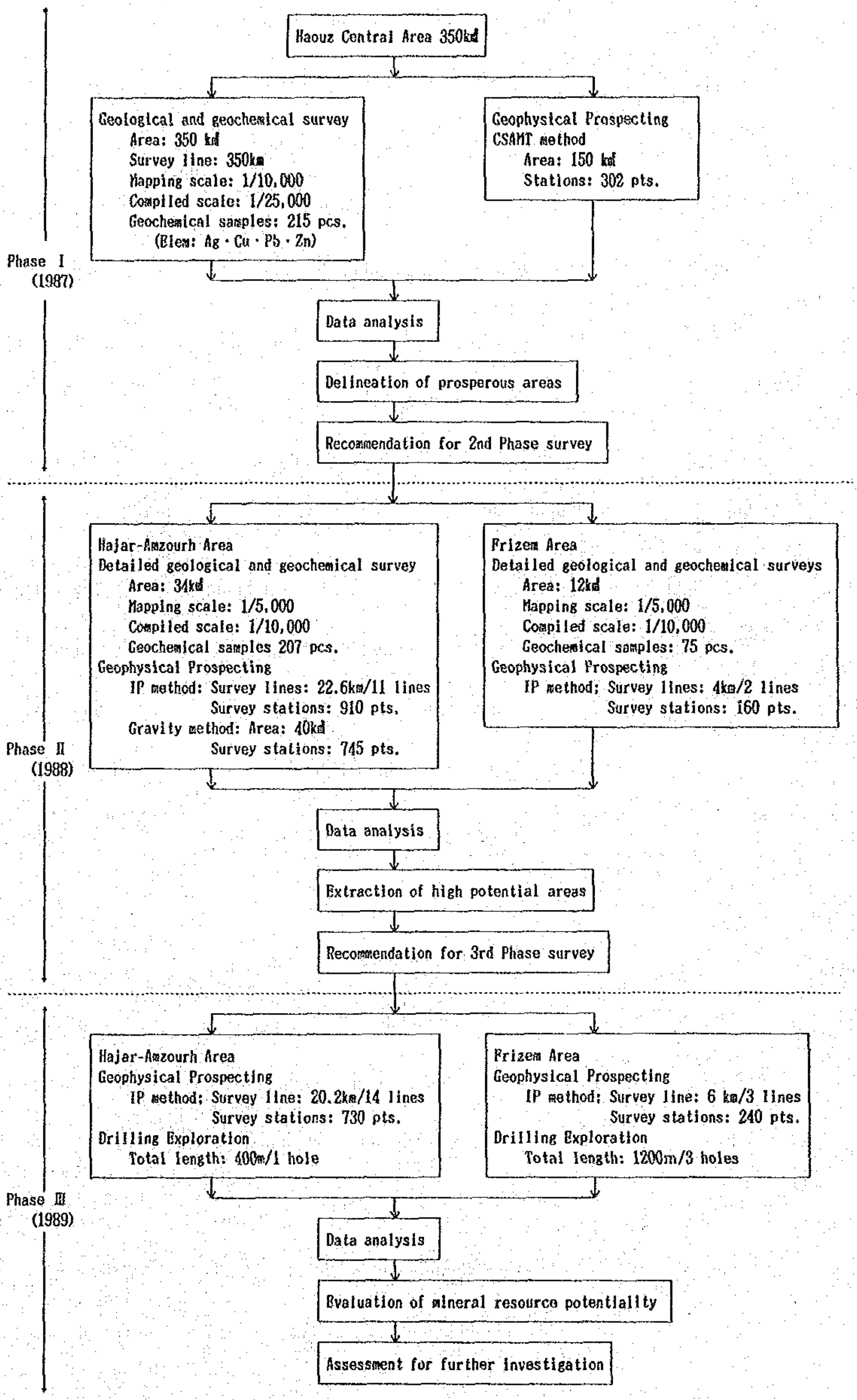


Fig.3 Flow Chart of Survey Progress

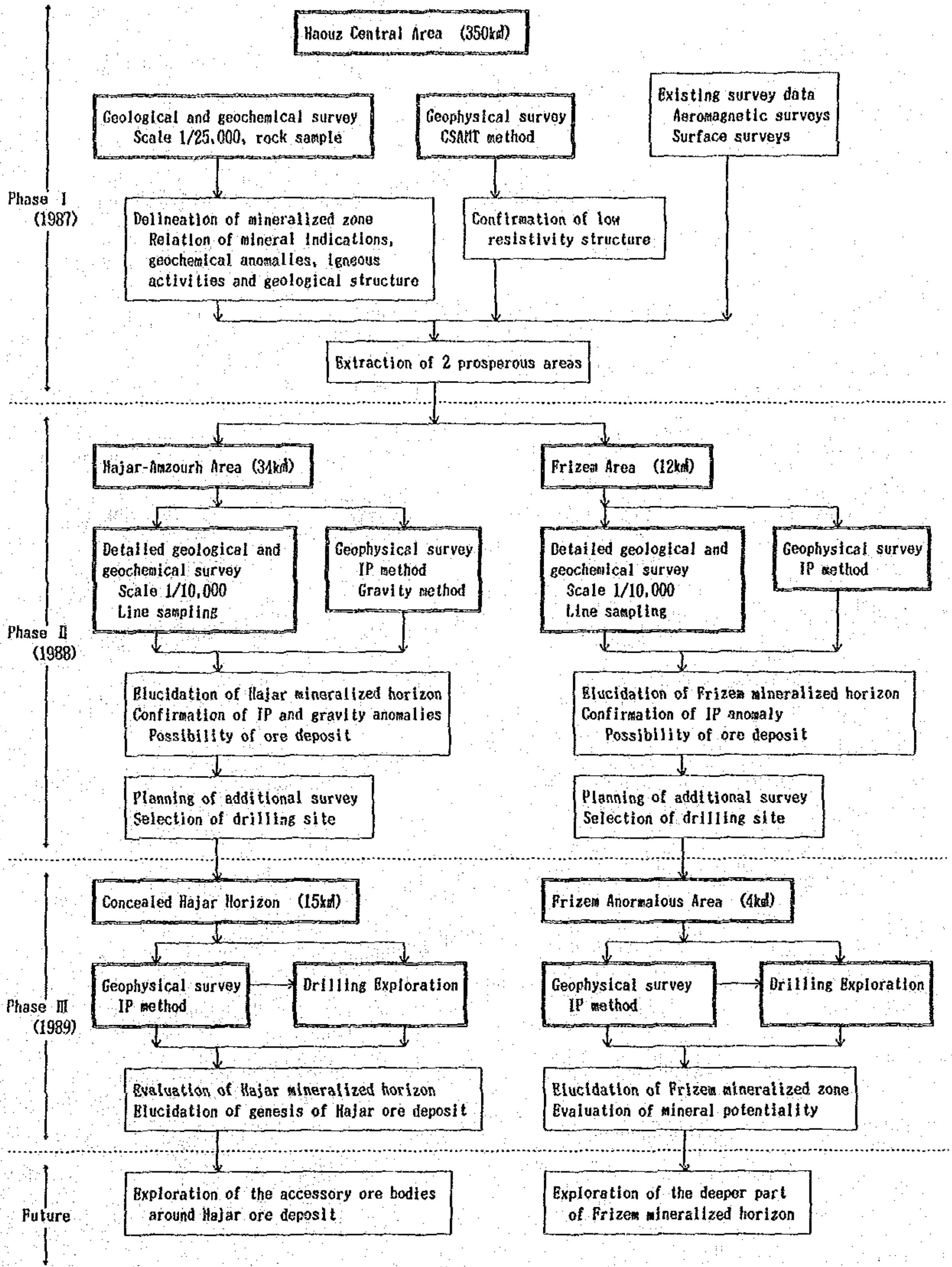


Fig.4 Flow Chart Showing the Extraction of Promising Areas

CHAPTER 2 OUTLINE OF THE SURVEY AREA

2-1 Location and Accessibility

The Haouz Central area is located at the north latitude between 31°20' and 31°30' and at the west longitude between 8°8' and 8°23' in the central western part of the Kingdom of Morocco. The Haouz Central area lies about 30km to 40km southwest of Marrakech city, and in term of the administrative division, it belongs to Marrakech province of the State of Marrakech.

Railway and paved roads are available from Rabat to Marrakech and the distance is about 330km and it takes about 4 to 5 hours. The access to the survey area from the township of Marrakech is convenient for the roads are available to Barrage Cavagnac at the southeast corner of the survey area (about 35km from Marrakech) as well as to Ait Daoud at the northernmost part of the area (about 25km from Marrakech).

2-2 Geography

The survey area is located geographically on a hilly land at the elevation of 500m to 800m above sea level along the northern side of the Haut Atlas Range. In the area, the Paleozoic basement and the Cenozoic sediments are distributed. The land in the area is comparatively undulating and small valleys, where water-flow can be recognized only in the rainy seasons, are well developed irregularly.

The climate in this area is continental, having big difference of temperature. It registers more than 40°C in summer time and less than 0°C in winter season. Annual rainfall is about 300mm but rain is used to be concentrated in the periods of October to November and April to May. Except the rainy seasons, it is dry and is like a desert, with the vegetation seen only along the streams.

The inhabitants are the Berber. They have gathered in small villages along the main rivers. They obtain water supply from the wells. They live on the pasturing of sheep and on the farming of olive cultivation and on the corn crops in rainy seasons.

The Marrakech city has as long history as almost 1,000 years, as a center of the commodity exchange with the people living in the Sahara desert area to the southwest. Nowadays, the city is prosperous as a place for sightseeing in addition to the function of commercial center for agriculture products and industrial art objects. The population is 330 thousand, being ranked as third in Morocco.

2-3 Mining Industry of Morocco

Main industries in the Kingdom of Morocco are the mining mainly of phosphates and the agriculture in which about 50% of the labor force are engaged. The total ore reserve of the phosphate in this country is said to be 63 billion tons, the largest reserves in the world. The phosphates production is almost 20 million tons per annum and the export amount of the phosphates and phosphate fertilizer is more than 40% of the total amount of export from Morocco.

As to the balance of trade, the import has been excessive owing to the rise of oil payment and to the descent of phosphates price, since the oil crisis in 1973. Export covering ratio (export/import in amount) has remained as low as 50% and the balanace of international payments is habitually in deficit which has been compensated by the transfer account and the capital account.

The financial position of Morocco has been placed in the red figure owing to the increase of food import due to draught as well as to the wartime expenditure for the Sahara melee which has been protracted since 1975. The accumulation of international debt reached some 20 billion dollars in the end of 1989, which figure is more than 150% of the GNP (Gross National Product).

Concerning the foreign relation, the Kingdom is in most intimate relation to the European countries, especially to France who used to have suzerainty over Morocco.

The trade relation between Morocco and Japan shows the excess of export from Morocco. Total amount of Moroccan import and export is 200 to 300 million dollars annually, among which the amount to and from Japan occupied 2% or 3%. About 70% of the commodities exported to Japan are composed of fishery products as octopus and squirrel while the export of phosphates occupies a little less than 30%. Most of the imported commodities from Japan are machinery.

In the Kingdom of Morocco, they produce and export such mineral containg lead, copper, zinc, silver, maganese, iron and barite, etc. in addition to the phosphates. It is known that there are some ore deposits in Morocco containing the ore minerals of cobalt, nickel, chrome, uranium and fluorite. The promotion of mining industry is one of the most important policys together with the development of agriculture.

CHAPTER 3 PREVIOUS EXPLORATION

As for the full-scale exploration in the survey area, an airborne geophysical survey was carried out by Geoterrex Ltd., Canada under the contract with the Ministry of Energy and Mining in 1968. Through this survey, many magnetic anomalies were found.

In 1984, the airborne data were re-analyzed and re-interpreted by the cooperation of BRGM, the French governmental organization. In 1985, drilling exploration was conducted by BRPM for the remarkable magnetic anomalies, and the Hajar silver-copper-lead-zinc massive sulfide ore deposit was encountered lying underground at the depth of 200m to 400m.

The drilling of total 27 holes was carried out, and a shaft and adits were opened toward the orebody. The ore reserve was estimated to be about 16 million tons with grade of Ag 74 g/t, Cu 0.86%, Pb 0.86%, and Zn 9.45%.

February in 1988, CMG (Companie Miniére des Guemassa) was establised for the exploitation of the Hajar mine financed by BRPM and ONA (Omnium Nord Africain). The CMG is now under construction and test operation of the Hajar mine.

For the other areas, in 1985 and 1986, surface geophysical survey and drilling were carried out in the areas such as Frizem, Amzourh, Tiferouine, Mjed, etc. where the principal magnetic anomalies had been found. However, significant ore deposit has not been confirmed.

In the surrounding area, aeromagnetic, electromagnetic and radiometric surveys were carried out by Hunting Geology and Geophysics Ltd., England by the investiment of the Arab Mining Co..

The details of the previous exploration are shown in Tab. 1.

Tab.1 List of the Past Exploration in the Haouz Central Area

Area・Sector	Data	Survey Method	Concerned Party	Result
Overall Area	1968	Aero-magnetic ・electromagnetic sv.	Geoterrex-MEM	Bipole magnetic anomalies were found
	1984	Reinterpretation of aero survey	BRGM-BRPM	
	1985	Geological survey (1/50,000)	BRGM-BRPM	
Surrounding Area	1985	Aero-magnetic ・VLF ・radiometric sv.	Hunting-AML.BRPM	
Hajar	1985	Terrestrial magnetic・grav.・elec. sv.	BRPM	
	1985	Drilling (27 holes)	BRPM	High-grade sulfid orebody was confirmed
	~1987	Shaft (235 m) ・Adit	BRPM	
Frizen	1987	Drilling (1 hole)	BRPM	
	1986	Geol. sv., magnetic ・SP VIF・grav. sv.	BRPM	
		Drilling (2 holes)	BRPM	Low-grade ore
Amzourh	1985	Geol. sv., magnetic ・SP survey	BRPM	
		Drilling (2 holes)	BRPM	Pyrrhotite diss.
Tiferouine	1986	Magnetic・gravimetric survey	BRPM	
		Drilling (3 holes)	BRPM	Pyrrhotite diss.
Mjed	1986	Magnetic・gravimetric survey	BRPM	
		Drilling (3 holes)	BRPM	Pyrrhotite diss.
El Haloudi	1986	Magnetic・gravimetric survey	BRPM	
Akhlij	1987	Drilling (1 hole)	BRPM	Low-grade ore

CHAPTER 4 GENERAL GEOLOGY

4-1 Regional Geology in Morocco (Fig. 5)

Most part of the African continent has been kept stable since the beginning of the Paleozoic Era, when it was cratonized. But the northern marginal area of the West African Craton including Moroccan territory was left as a mobile zone, where geosynclinal activities and orogenic movements were active after the Päleozoic Era.

The territory of the Kingdom of Morocco is divided into southern and northern parts by the Atlas Range which is composed of mountaneous land at an elevation of 3,000m to 4,000m above sea level extending about 2,000km in east to northeast direction. the rocks of the Atlas Range are composed of Mesozoic geosynclinal sediments accumulated on the Paleozoic basement, and the range was formed by the uplift during the period of Alpine orogenic movement in Tertiary. The Moroccan territory is divided into three parts in term of geosynclinal structure, Atlas zone in the central part, Anti-Atlas zone in the south and Rif zone in the north. The Atlas zone is again sub-divided into three zones, the Haut Atlas zone extending in west to northwest direction, the Moyen Atlas zone branched from the Haut Atlas zone in north-western direction and the Meseta zone expanding in the east and in the west of the Moyen Atlas zone. The central part of the Haut Atlas zone is composed of the Jurassic sediments accumulated with the marine transgression of the Tethys Sea, while the Meseta zone is composed of the Paleozoic sediments. The surveyed area is located at about the junction of the Meseta zone with the Hault Atlas zone. The folding structure of this Atlas zone is characterized by the repetition of acute-angled anticlines and shallow synclines.

The Anti Atlas zone is composed of the sediments accumulated in the Paleozoic geosyncline, which developed along the marginal area of the Pre-Cambrian craton. This geosyncline was uplifted during the period of Hercynian orogenic movement at the end of Paleozoic Era or at the begining of Mesozoic Era. In the central part of this uplifted zone, lower Paleozoic metamorphic rocks are distributed with the core of the Pre-Cambrian System.

The Rif zone is composed of the sediments accumulated in the Mesozoic to Tertiary geosyncline with the Paleozoic basement. Many nappe structures from north to south were formed during the period of the Alpine orogenic movement.

4-2 Outline of Geology of the Survey Area

The Haouz Central Area is located at the junction zone in which the Meseta zone trending NE-SW direction joins with the Haut Atlas zone and the Carboniferous to Permian Systems are distributed as a basement, although the greater part of the basement rocks is covered extensively by the Quaternary and Neogene sediments.

The Carboniferous to Permian Systems are mainly composed of pelitic and marly schist and semischist. The general trend of the formation is N-S direction in the northern part and WNW-ESE direction in the southeastern part.

The Carboniferous to Permian Systems are distributed intermittently to the northeast in the Central mountain area passing through the Jubilet mountain area, and to the southeast it exterminates between the Cambrian-Ordvician Systems to the west and the Jurrassic System to the east in the Haut Atlas area .

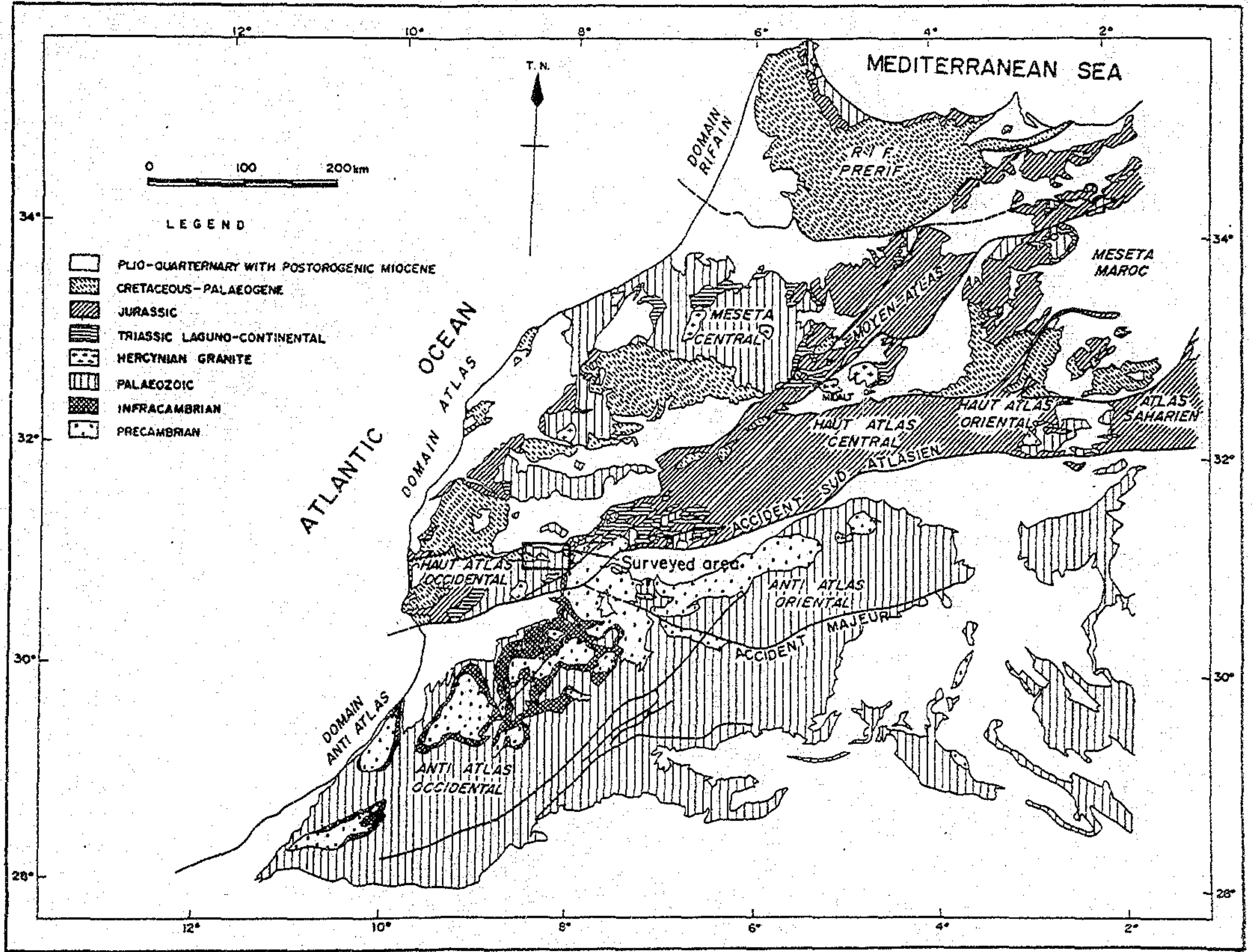


Fig. 5 Geotectonic Map of Northern Morocco

CHAPTER 5 CONCLUSION AND RECOMMENDATION

5-1 Conclusion

(1) The ore deposit in this area is the sedimentary type, copper - lead - zinc sulfide ore deposit occurred in the Carboniferous and Permian Systems. The orebodies are formed in the specific horizons-the Hajar and the Frizem horizons that are characterized by acidic volcanic rocks. The mineralization is considered to be closely connected to the submarine volcanic activity.

(2) A series of exploration, such as geological and gochemical survey, geophysical prospectings of CSAMT method, IP method and gravity method were carried out step by step, and as the results, the Hajar southwest area, the Lamrah area and the Frizem west area were extracted as the anomalous areas which are endowed with high potentiality of the occurrence of ore deposit.

(3) Drilling explorations were conducted in the Lamarah area and the Frizem west area. As the results, the mineralized zones of copper-lead-zinc were confirmed in each hole of toal 4 holes.

The mineralized zones are widely distributed. However, all of them are small-scale or low-grade dissemination ore, network ore and vein-type ore.

All of these ores are thought to be difficult to exploit economically, nevertheless they are inferred to show the mineralization of the lower part and the peripheral part of the large-scale massive ore deposit of sedimentary type.

5-2 Recommendation for the future

(1) To the southwest of the Hajar ore deposit, a weak to medium IP anomaly has been confirmed. It is desirable to clarify the cause of the IP anomaly, whether it depends on the occurrence of a concealed orebody or on another reasons.

(2) In the Frizem area, it is difficult to expect a large-scale and high-grade massive orebody comparatively in the shallow underground. However, it is recommended to continue the study and survey concerning a possibility of orebody in the deeper place, judging from the trend of IP anomaly increasing to the deeper.

PART II
DRILLING EXPLORATION

CHAPTER 1 GEOLOGICAL AND GEOCHEMICAL SURVEY

1-1 Outline of Geology

The basement rocks in the Haous Central Area are composed mainly of pelitic and marly schist and semischist which are correlated to the Carboniferous - Permian Systems and expose sporadic on the surface (Fig. 6, Fig. 7).

(1) The Eastern Area (Hajar - Amzourh Area)

The basement rocks in the Eastern Area are pelitic schist, alternation zone (the Hajar horizon), pelitic semischist, and calcareous - silty semischist from the ascending order (Fig. 8).

The alternation zone is composed of a fine alternation of tuff and calcareous siltstone, acidic pyroclastic rock, an alternation of siltstone and mudstone, pelitic schist, acidic volcanic rock, and an alternation of linestone and mudstone. The alternation zone is important for the mineralized zone in this area (Fig. 9).

So called green rock is the host rock of the Hajar orebody and occupies the foot wall of the orebody. The green rock is usually dark-green and fine-grained showing fine banding structure and slaty features, and thought to be originated in tuffaceous and acidic pyroclastic rock because it contains white phenocryst of 1mm to 2mm in diameter.

The green rock is exposed in the Oukhribane Block accompanied by quartz vein gossans. The K-Ar isotopic age of this rock is 297 ± 15Ma (million years), that is corresponded to the upper Carboniferous age.

The acidic volcanic rock is distributed in the Amzourh Block forming synclinal structure. This rock is thought to represent the latest stage of the volcanic activity accompanied by mineralization. The K-Ar isotopic age of this rock is 294 - 303 ± 15Ma that is correspond to the upper Carboniferous age.

The instrusive rocks in this area are rhyolite, quartz andesite and andesite in dyke and pipe shapes.

(2) The Western Area (Frizem Area)

The basement rocks in the Western Area are classified to pelitic and psammitic schist, acidic volcanic rocks, marly schist, an alternation of siltstone and mudstone, marly and pelitic schist, and pelitic schist from the ascending order (Fig. 10).

The acidic volcanic and pyroclastic rocks are forming a mineralized horizon in this area.

The Frizem east mineralized zone occurs in the marly schist adjacent to the upper part of acidic volcanic rocks, and the Frizem west mineralized zone occurs in the fine alternation of phyllite and siltstone adjacent to the ascending part of the acidic volcanic rocks.

The acidic volcanic rocks are distributed around Frizem village in the apparent width of 0.8km. The sizes of the rocks decreases toward the north and increases toward the south where it is covered with the Quarternary sediments.

The acidic volcanic rocks show very irregular form, which is thought to be caused by the gentle inclination of the rocks and the influence of distortion and dislocation by the dynamic metamorphism.

This rocks is pale-grey or dark-brown in colour. It is composed of two phases, one is the lava phase where the rock is comparatively massive and shows porphyritic texture of quartz and plagioclase, the other is the pyroclastic phase where foliation structure is developed and fragments of pumice are contained.

The K-Ar isotopic age of this rock is 328 $\pm$ 16 Ma that is corresponded to the middle Carboniferous.

As the intrusive rocks in this area, diabase is observed intruding along the schistosity plane faults.

1-2 Geological Structure

The geological structure in this area is influenced and controled intensely by the schistosity. The planes of schistosity and bedding are not always concordant each other in the macrocosmic meaning, though they are more or less concordant in the microcosmic meaning. The schistosity is usually stable regionally, but the bedding structure is distorted and disordered by schistosity and varied intensely.

In the schist and semischist, many schistosity plane faults are developed at the interval of several tens meters and the formations are divided into numerous independent blocks. In each block, very complicated drag folds are developed. In addition, numerous joints parallel to the schistosity are developed at the interval of several millimeters to centimeters, and stepped dislocation are induced by joints.

The area is characterized by imbricate structure formed by numerous schistosity plane faults and drag folds.
In the Eastern Area, schistosity is WNW-ESE trend dipping steeply to NNE. However, bedding plane is more or less same direction to the schistosity dipping gently to NNE repeating drag folds and wavy folds.

In the Western Area, schistosity is NNW-SSE trend dipping steeply to ENE. However, bedding structure dips gently to ENE repeating drag folds and imbricate structure.

In the northern area, schistosity and bedding plane is N-S trend dipping to east.

1-3 Mineralization

The mineral indications in the Haous Central Area are centalized in the Hajar horizon in the Eastern Area, and in the vicinity of the Frizem horizon in the Western Area (Tab. 2).

(1) The Eastern Area

1) Hajar Ore Deposit

The Hajar ore deposit is a Cu-Pb-Zn sulfide ore deposit that is emplaced in the so-called green rock at the depth of 150m to 400m below the surface covered by the Quarternary sediments about 120m in thickness.

The size of the orebody is about 300m in lateral extension, about 400m along dipping direction and maximum 100m in real thickness.

Main ore minerals are chalcopyrite, galena, sphalerite, and pyrrhotite. The characteristic alterations related to mineralization are silicification, argillization and chloritization.

The ore reserve was estimated by the poligonal brock method using the drill data of 21 holes, 8550m in total, with spacing of about 70m.

Ore reserve: 16 million tons
Av. grade : Ag 74 g/t, Cu 0,86%
Pb 2.78%, Zn 9.45%, S 30.3%

2) Tiferouine Magnetic Anomaly

The Tiferouine magnetic anomaly was found about 5km southwest of the Hajar ore deposit.

Drilling of three holes tolalling 1313m was conducted in the remarkable dipole magnetic anomaly and resulted in the confirmation of small-scale veinlets and dissemination of chalcopyrite, pyrite, magnetite and pyrrhotite.

3) Oukhribane Mineralization Zone

The Oukhribane mineral indications are quartz network gossans with several tens meters extensions located about 0.4km west and about 1.0km northwest of Oukhribane village.

The quartz veinlets are usually less than 10cm in width and the maximum grade is 0.31% in Cu and 0.1% in Zn (Fig. 13, Fig. 14).

4) Akhlij Mineralization Zone

In the Akhlji area, one drilling was conducted for the weak magnetic anomaly about 200m west of Akhlij village and small-scale dissemination zone of Pb and Zn was encountered. The assay result was 7 g/t in Aq, 0.01% in Cu, 0.2% in Pb, and 0.6% in Zn in 3m length.

5) Amzourth Magnetic Anomaly Zone

The acidic volcanic rock is distributed in the Amzourh area. This acidic volcanic rock bears pyrrhotite-quartz veinlets and turns to gossans discontineously on the surface.

In the alternation of slate and siltstone which is the lower formation of the volcanic rock, several small-scale gossans are found occurring in the fault zone. The maximum grade of the gossan shows 0.5% in Cu, 1.0% in Pb, and 1.4% in Zn in the width of 1m.

6) Lamrah IP Anomaly Zone

By the IP prospecting in the Second and the Third Phase surveys, a concealed IP anomaly up to 4% in PFE value was detected. This IP anomaly zone was selected for the target of drilling in the Third Phase survey.

(2) The Western Area

1) Frizem East Mineralization Zone

The Frizem East mineralization zone is represented by gossan zone occurring in the marly and pelitic schist, the upper formation of the acidic volcanic rocks. The size of the each individual gossans is 10m x 60m at the largest. The gossans are discontinuously distributed in a distance of some 500m in the direction of NNW-SSE along the schistosity plane of the host rock. The mineralization zone turns gradually to barren carbonate - quartz veins to the north extention, while in the south the features of the mineralization zone is not clear because it is covered with Quarternary sediments.

The gossans are remarkably brecciated. The main constituent minerals are siderite, hematite, goethite and quartz associated with green copper minerals in some places.

In 1986, for the exploration of the deeper place of the gossans, 9 holes of drilling, total length of 2,500m, were carried out by BRPM. And low-grade dissemination ores of copper, lead and zinc were caught by the drilling. The length of the dissemination zone is 4m to 22m in maximum.

The assay results are 10 - 20 g/t in Ag, lower than 1% in Cu and Pb, and 1 - 3% in Zn.

2) Frizen West Mineralization Zone

The Frizem West mineralizatin zone is represented by gassaneous carbonate - quartz veins occurring in the silty - pelitic schist, the lower formation of the acidic volcanic rocks. The main constituent minerals are siderite, calcite and quartz associated with hematite, goethite and pyrite.

The gossaneous veins are developed parallel to the schistosity, trending NNW-SSE direction dipping 30° - 60° to the east. The most remarkable indication is located about 1.4km west of Frizem village. The width of the gossaneous vein is about 2m in average and 4m in maximum. The extension is up to 1.5km.

The average assay of the gossans is 1 g/t in Ag, 0.13% in Cu, 0.58% in Pb, and 0.31% in Zn.

1-4 Geochemical Survey

The geochemical survey was carried out to clarify the distribution of geochemical anomalies and to confirm of the concentration degree of metal elements in each rock type and formation.

The rock samples were collected and analyzed in 4 elements, Aq, Cu, Pb, and Zn.

In the First Phase, a random sampling method resulted in nearly uniform spacing on the basement rock was adopted. In the Second Phase, a line sampling method crossing at right angles with the stratigraphical structure was adopted.

(1) Correlation between Each Element

A clear positive correlation is found between Pb and Zn (cc = 0.70 - 0.82). A week positive correlation is seen between Cu and Zn. While Ag has not correlation with other elements.

(2) Distribution of Geochemical Anomaly

Geochemical anomalous samples were extracted on the basis of the threshold values that were led referring to the value of $(M + 2\sigma)$ (Tab. 3).

As the result, the following fact was clarified:

1) The geochemical anomalies are centerized in the Hajar horizon and in the Frizem area.
2) Zn and Ag are concentrated in the vicinity of fault shearing zone.

(3) Metal Elements by Each Formation

1) The geometric mean value which means the background value in this area is 6ppm in Aq, 27ppm in Cu, 36ppm in Pb, and 120ppm in Zn.

2) The mean value of 3 samples taken from the acidic volcanic rocks is 110ppm in Cu, 217ppm in Pb, and 374ppm in Zn. Each of these values shows 3 times as high as the background values.

3) 18 samples from the Hajar horizon show 180ppm in average value of Zn.

4) The mean value of 4 samples of intrusive rock shows low values such as 0.2ppm in Aq, 7ppm in Cu, 11ppm in Pb, and 39ppm in Zn.

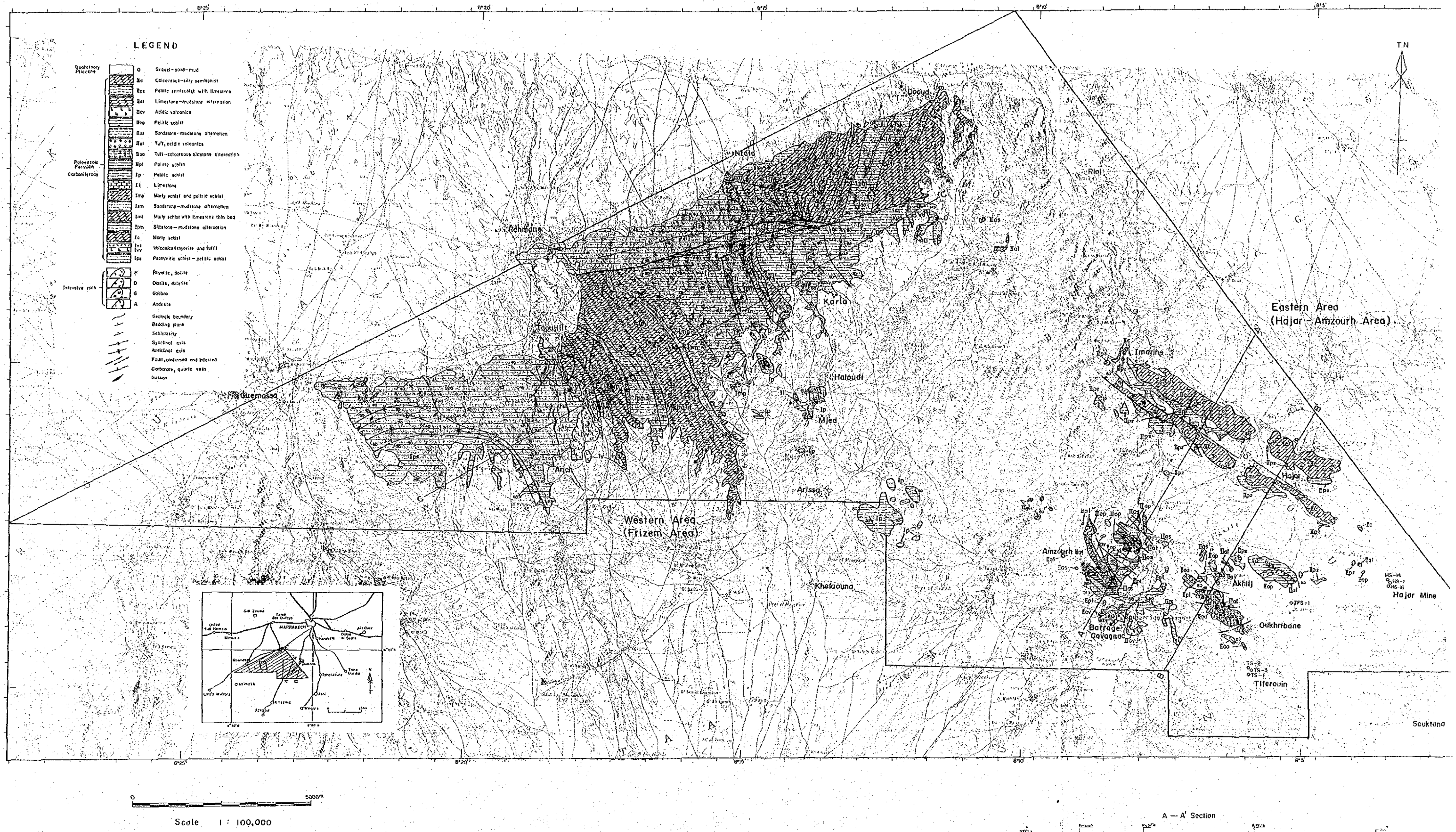
5) The mean value of Zn in the upper formation of the Hajar ore deposit is 74 - 80ppm, which is very low value in the next place to the value of intrusive rocks.

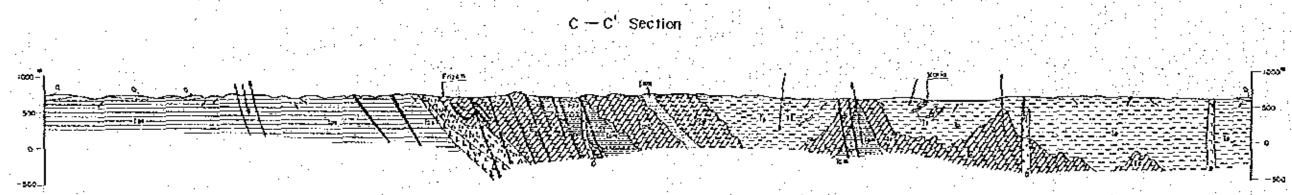
The above mentioned facts lead the following discussions, which can be an evidence of the syngenetic genesis for the ore deposit in this area.

1) The mineralization in this area is in intimate relation to the activitiy of the acidic volcanism.

2) The heavy metal elements such as copper, lead and zinc are concentrated in the specific formation.

3) The mineralization do not influence to the upper formation of the mineralized zone.





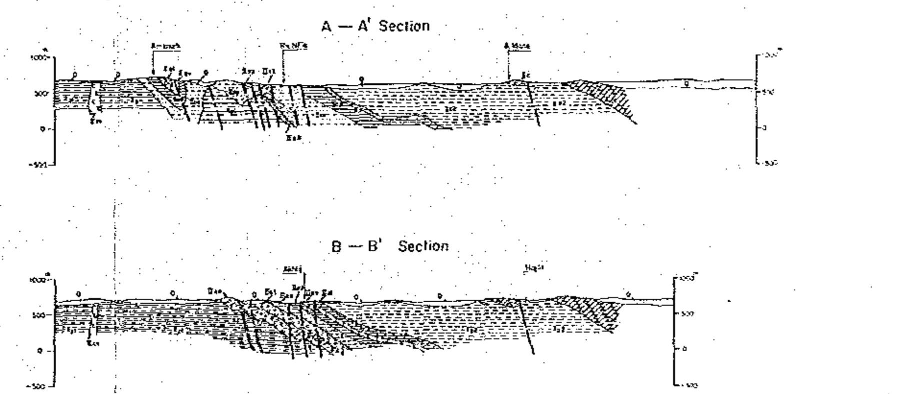


Fig. 6 Geological Map of the Haouz Central Area

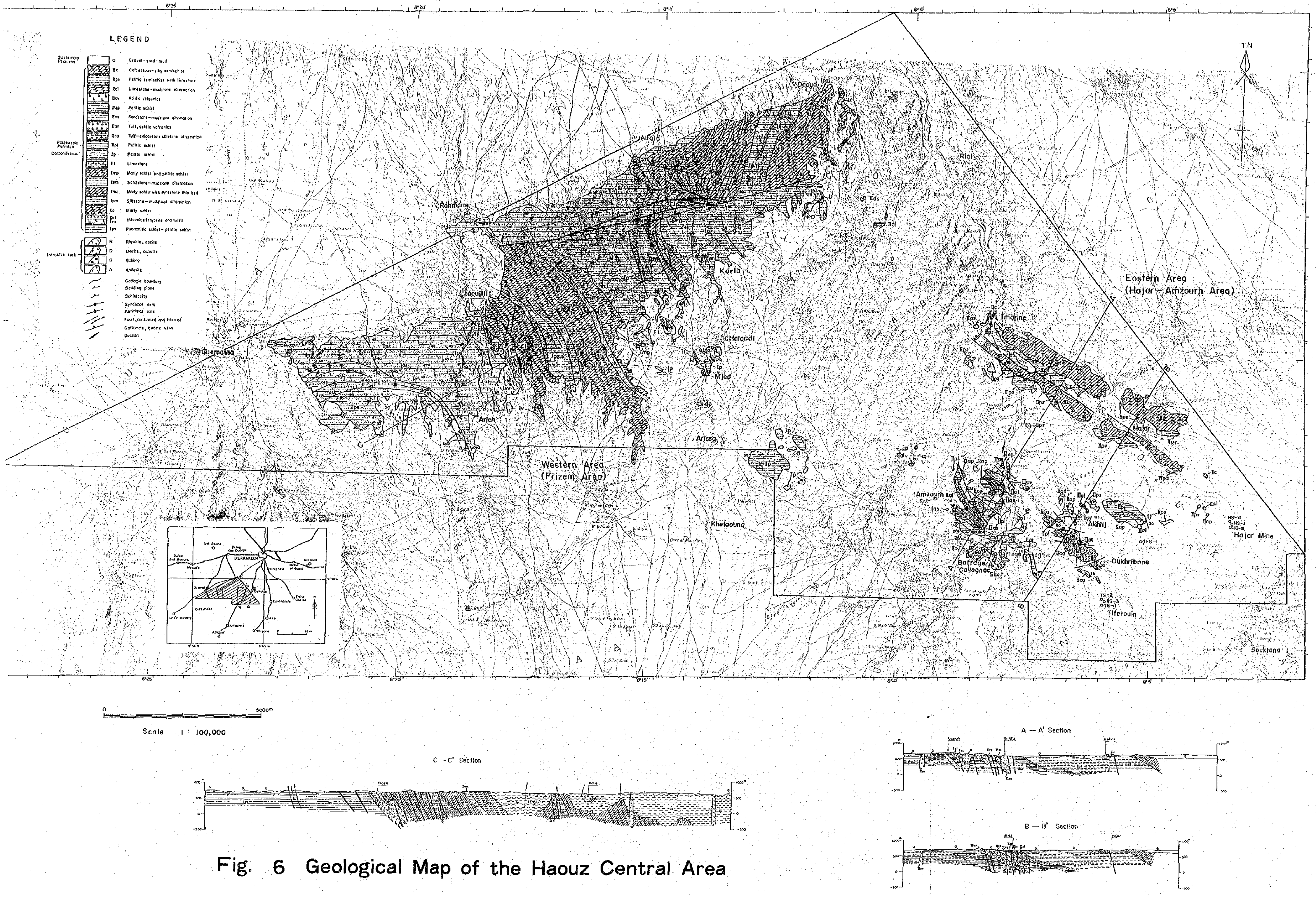


Fig. 6 Geological Map of the Haouz Central Area

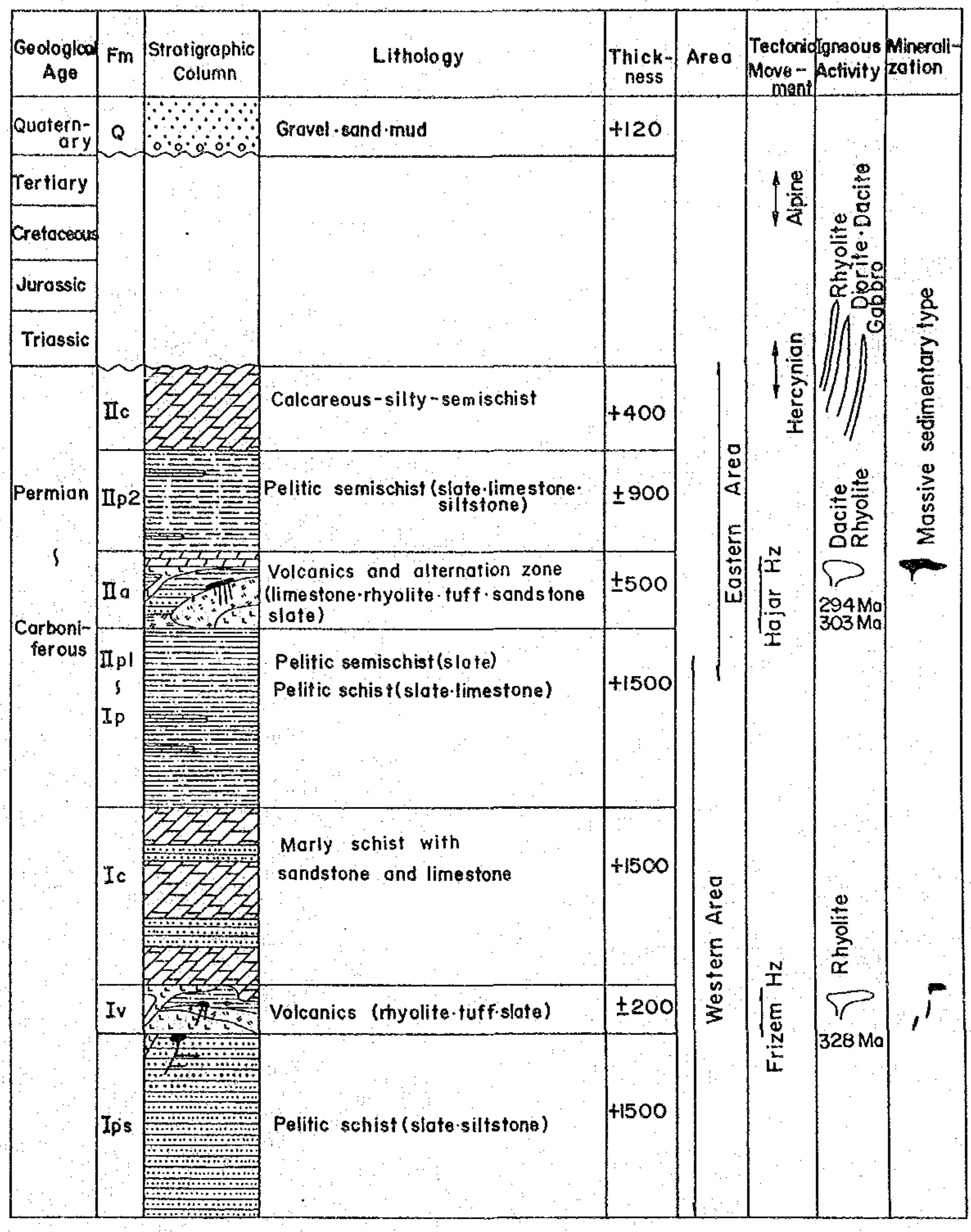


Fig 7 Schematic Geological Column of the Haouz Central Area