NO.

REPORT ON THE MINERAL EXPLORATION
IN
THE MARRAKECH-TEKNA AREA,
THE KINGDOM OF MOROCCO
PHASE III

MARCH 2005

JAPAN INTERNATIONAL COOPERATION AGENCY
JAPAN OIL, GAS AND METALS NATIONAL CORPORATION

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Preface

The Japanese Government decided to conduct a mineral exploration program consisting of geological, and geophysical surveys in the Marrakech-Tekna area situated in the central-west of Morocco, in response to the request from the government of the Kingdom of Morocco. The purpose of the program is to estimate its potential for mineral deposits. The Japanese Government entrusted the implication of the plan to the Japan International Cooperation Agency (JICA, presently independent administrative corporation International Cooperation Organization), and JICA entrusted the enforcement of the program to the Japan Oil,Gas and Metals National Corporation (JOGMEC) due to the specialty of the program.

JOGMEC started the survey program for the send year in the fiscal year of 2003, and dispatched a survey team to Morocco from August 30 to October 26, 2004.

The field survey program in the area has completed as scheduled in cooperation with the Bureau of Mineral Research of Morocco (Bureau de Recherches et de Participations Minieres).

This report describes the result of this year’s survey, and contributes a part of the final report. Finally, we would like to express a deep appreciation for the cooperation of the concerned governmental organizations of Morocco, Ministry of Foreign Affair, and Economy and Industry of Japan, Embassy of Japan in Morocco, and many other cooperators.

November 2004

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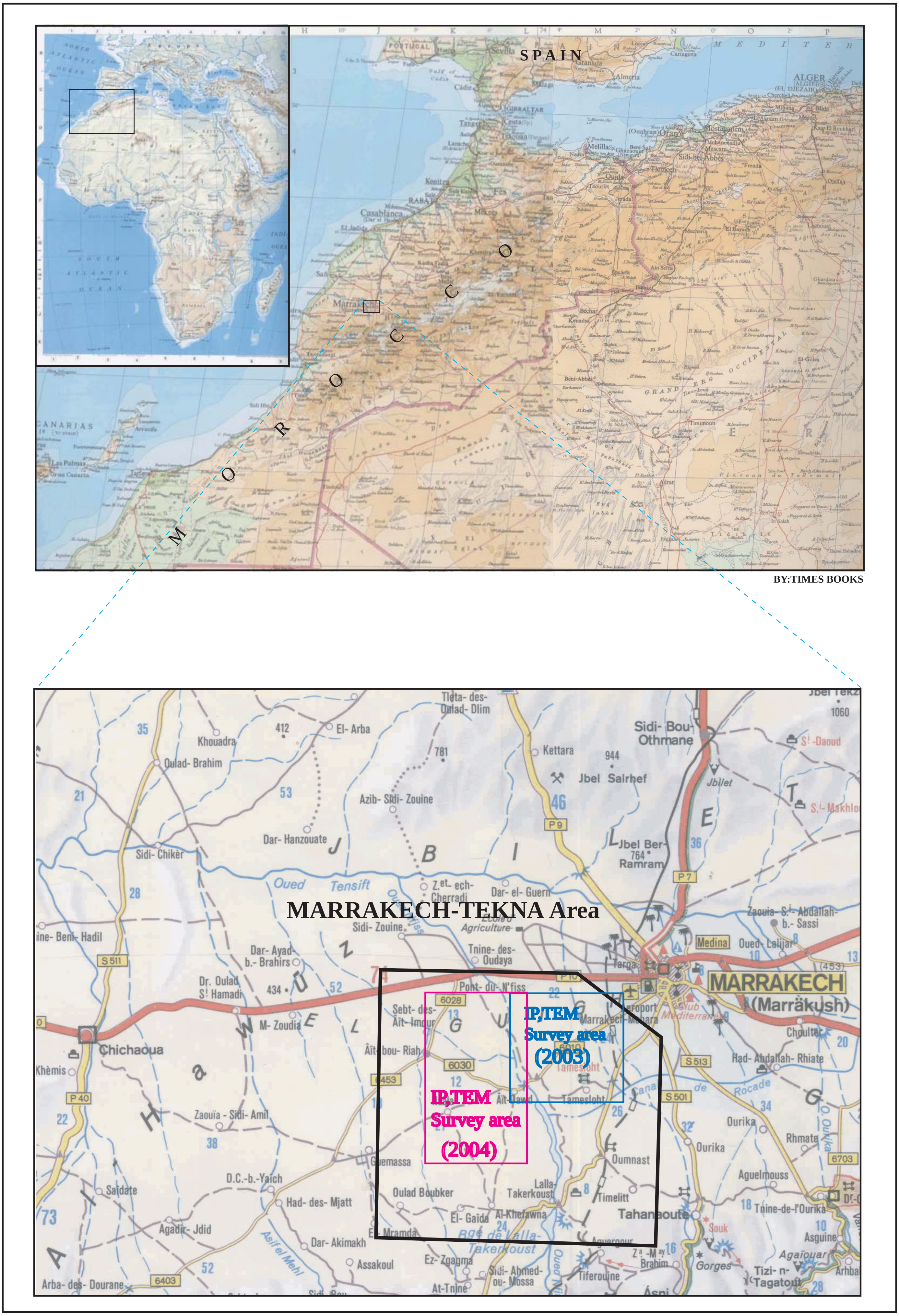

Fig.1 Location map of the project area in Morocco

Abstract

The survey has been conducted to extract potential zones of the volcanogenic massive sulfide ore deposits, mainly consisting of copper, lead, and zinc, by means of survey and interpretation of the geological setting and the status of the known ore deposits in the Marrakech-Tekna area, the Kingdom of Morocco. Another object of the survey is to transfer the concerned technology to the Moroccan organization which jointly worked with.

This year’s survey program, as the third year’s one, has been performed for the districts where some magnetic and conductive anomalies were detected in the first year’s survey.

The electric survey IP method has been performed in the six districts to the west of Marrakech, where the airborne magnetic and electromagnetic anomalies were detected in the first year’s program. Much time has spent to complete the survey in the Azzouz district due to the rugged topography, however, good data has obtained in this area. The survey has revealed that some chargeability and resistivity anomalies indicating possible mineralization potential. The anomaly zone overlies the magnetic anomaly zone detected by the previously performed survey.

In the northern three districts, Hbibi, Harch, and Maouch, no IP anomaly has been detected. Judging from the status of the surface, it its thought that the airborne magnetic anomalies in the Hbibi and Harch districts would be caused by some artificial material. It is not clear the cause of the magnetic anomaly in the Maouch district, VMS may perhaps be under the sediment.

The low resistivity young sediments overlies the southern two district, Khefawna and Talzelt, and these area have no significant IP anomaly. The magnetic anomaly in the Khefawna district is similar shape to that of the magnetic anomaly zone in the Khefadra mineral occurrence to the northwest of the district. Therefore it is thought that some potential for the massive sulfide ores exists in the khefawana district.

The TEM method electromagnetic prospecting has been concentrated in the Azzouz district based on the IP survey result, together with the Khefawna district. In the Azzouz district, it is presumed that low resistivity–high conductivity zone concordant to the IP anomaly exists. Several faults are also presumed there.

In the Khefawna district, a simple two layers structure of the low resistivity young sediments and high resistivity Paleozoic formation exists.

According to the above results,this year’s survey recommends to confirm that the geophysical anomaly zones reflect some sulfide ores consisting of pyrrhotite concentration, by a drilling program in the following districts.

1) Azzouz district: Drilling length 500 to 600 meters, Two to three points.
2) Khefawna district: Drilling length 400 to 550 meters, One point

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Part III Conclusion and Recommendation

Part I General

Chapter 1 Introduction

1-1 Survey History and Object

(1) First year's survey

The first year's survey was performed to extract potential target zones for the volcanogenic massive sulfide ore bodies, being mainly composed of copper, lead, and zinc, by means of survey and interpretation of the geology and ore mineral occurrences. Another purpose of the program is to transfer the exploration technology to the Moroccan organization that jointly worked with. The survey program is based on the Scope of Work and Minutes of Meeting signed on July 17, 2002.

The following points have been clarified in the geological and drilling surveys.

1. The known ore deposits, Khwadra, Dree Sfar, Kettara, Hajar, and Frizen are the copper, lead, zinc, and iron massive sulfide deposits hosted in the alteration of muddy and sandstone layers, and muddy and quartzite layers of the Sarhlef Formation of the Visean stage in the Jebilet and Guemassa Districts.
2. These deposits show stratiform, massive, lenticular, and banded forms, mainly consisting of the assemblage of pyrrhotite, pyrite, sphalerite, galena, and pyrite.
3. The acidic and basic volcanic rocks are distributed nearby the ore deposits, and they are associated with the mineralization.
4. The mineralization of the deposits is classified to the early-stage I, relatively weak magnetism and represented by the hexagonal pyrrhotite, and the early-stage II, strong magnetism and represented by monoclinic pyrrhotite, and the later-stage, weak magnetism and represented by pyrite.
5. The mineralization are classified into following types; a) early=stage I dominant type showing medium magnetism due to the duplicate mineralization of the early-stage and later-stage (Dree Sfar Deposit), b) Early-stage I + later-stage duplicate type showing medium to low magnetism (Frizen and Kettara Deposits), c) early-stage II + Later-stage duplicate type showing high to low magnetism (Khwadra and Hajar Deposits).
6. There is some potential for weak magnetism massive sulfide ores in the medium to weak anomaly zones.

In the airborne geophysical survey, Which planed based on the above mentioned result, following anomaly zones are listed up in addition to the conventional high magnetism anomalies represented by pyrrhotite.

1) Low resistivity anomaly + high to medium magnetism anomaly: for the potential of the high magnetism massive sulfide ores.

2) High magnetism anomaly: for the potential of the high magnetism massive sulfide ores.
3) Low resistivity anomaly: for the potential of the medium to low magnetism massive sulfide ores.

(2) Second year’s survey

The second year’s survey was performed for the anomaly zones extracted by the first year’s survey program, showing magnetic or conductivity anomalies.

The electric prospecting IP method was applied in eight zones nearby Marrakech city. It needed much time to measure due to broad young sediments showing low resistivity and frequent noise caused by well pumps nearby, but this problem was solved by increasing output power rather than usual level to obtain efficient data. As a result, it was revealed that some IP anomaly zones existed in the MJTK-IP-1 district, while any effective data was not obtained in the deep part in the MJTK-IP-6 and -7 districts due to the thick young sediments. In the other districts, no positive data to indicate ores was obtained.

The electromagnetic prospecting TEM method was concentrated in the MJTK-IP-1 district, based on the electric IP prospecting result. Cenozoic sediments are about 150 m thick in the MJTK-IP-1 district, 200 m thick in the MJTK-IP-6 district, and more than 250 m in the MJTK-IP-7 district. In the MJTK-IP-6 and MJTK-IP-7 districts, some banded structure corresponding with stratification has been observed. In the MJTK-IP-1 district, the young sediments gently dip to the northeast. The resistivity structure interpreted for the Paleozoic does not exactly reflect the actual resistivity of the rocks due to the IP effect, showing imaginary high resistivity zones. These are correlated with the IP anomaly zones obtained by the electric prospecting IP method.

Furthermore, BRPM conducted surface magnetic and gravity surveys for the obtained anomaly zone in the MJTK-IP-1 district consecutively. The result of the survey revealed that a clear high gravity zone exist in the center part of the district, and a positive magnetic anomaly on the south side of the zone and also a negative magnetic anomaly on the north side of the zone. It is thought that a high density, magnetic body exists in the underground of this area.

From the above mentioned result, two possible cases can be considered.

1) A volcanic body possibly exists around the zone centering the IP survey line No.8 in the central district. The IP anomaly (high chargeability zone) surrounds the half circle of the igneous body in the northern side, and this is correlated to the mineralized zone and disseminated zone of the associated igneous body. The positive and negative

magnetic anomaly and high gravity zones are correlated with the igneous body.
2) A large scale sulfide ore deposit possibly exists in the central district as a steep dipping massive to stratiform body in the underground surrounded by the IP anomaly zones (low resistivity, high chargeability zone) . The positive and negative magnetic and high gravity anomaly zone is corresponded with a pyrrhotite-rich ore body.

A drilling program consisting of two holes to verify the survey result was planed in the zone. As a result, it was revealed that the underground status was close to the case 1), and the magnetic anomaly was correlated with a gabbro body. Many veinlets containing sphalerite grains are seen in the muddy schist and sandy schist in the east side drilling hole. It is thought that the low resistivity zone is probably corresponded with graphite contained in the muddy schist.

It is impossible to distinguish magnetic igneous bodies and pyrrhotite minerals from the magnetic and gravity data. On the other hand, it is possible that the weak IP anomalies (low resistivity, high chargeability) obtained in this year's electric prospecting IP method possibly reflects graphite rich beds.

Accordingly, it is thought that the pick-up of drill targets should be done from the consideration from the combination of the airborne magnetic anomalies and ground magnetic and electric IP anomalies. Selection of drill sites, direction, dip and depth of drill holes should be done based on such consideration.

(3) Third year's survey

This year's program, as the third year's one, has been planed to check the zones eliminated from the second yea's program, by the electric IP method, and to select potential zones from IP anomaly zones for following-up by the electromagnetic TEM method. After the electromagnetic TEM survey. These survey results have been considered with the first year's survey results, and final drill targets have been selected. The transference of the survey technique to the Moroccan organization has been successfully achieved.

1-2 Coverage and Outline of Survey

The survey area is situated in the central area of Morocco as shown in Figure -1, about 330 kilometers south from the capital city Rabat, north of **Auto Atlas mountains, southwest of Marrakech, 31 deg. 23 min. to 31 deg. 36 min. north in longitude and 8 deg. 9 min. to 8 deg. 20 min. west in latitude. Table I-1-1 shows the six survey districts selected for the electric IP method, two of them have been surveyed by the electromagnetic TEM method.

Table I-1-1 Survey contents and amount of works

・ Electric survey (IP method)

District	District Code	Method	Length (line)	Number of Point
Azzouz	MJTK-IP04-1	Dipole-Dipole	39.9km（*）	1635
Hbibi	MJTK-IP04-2	Dipole-Dipole	1.5km(=1.5km×1 line)	55
Harch	MJTK-IP04-3	Dipole-Dipole	2.0km(=2.0km×1 line)	80
Maouch	MJTK-IP04-4	Dipole-Dipole	1.6km(=1.6km×1 line)	60
Khefawna-N	MJTK-IP04-5	Dipole-Dipole	6.0km(=2.0km×3 lines)	240
Talzelt-N	MJTK-IP04-6	Dipole-Dipole	6.0km(=2.0km×3 lines)	240
Total			57.0km	2310

*(=3.0km×3 lines+2.8km×1 line+2.7km×1 line+2.5km×1 line+2.3km×1 line+2.2km×2 lines+2.0km×6 line ＋1.5km×2 lines+1.2km×1 line)

・ Electromagnetic survey（TEM method）

Area name	Tx-Rx configuration	Number of stations	Length of survey lines
Azzouz	In loop	146	
	Fixed loop		300m*3lines*2loop
Khefawna	In loop	19	
Total		165	1,800m

Figure I-1-1 shows the survey lines of the electric prospecting IP method, plotted on the airborne magnetic prospecting map

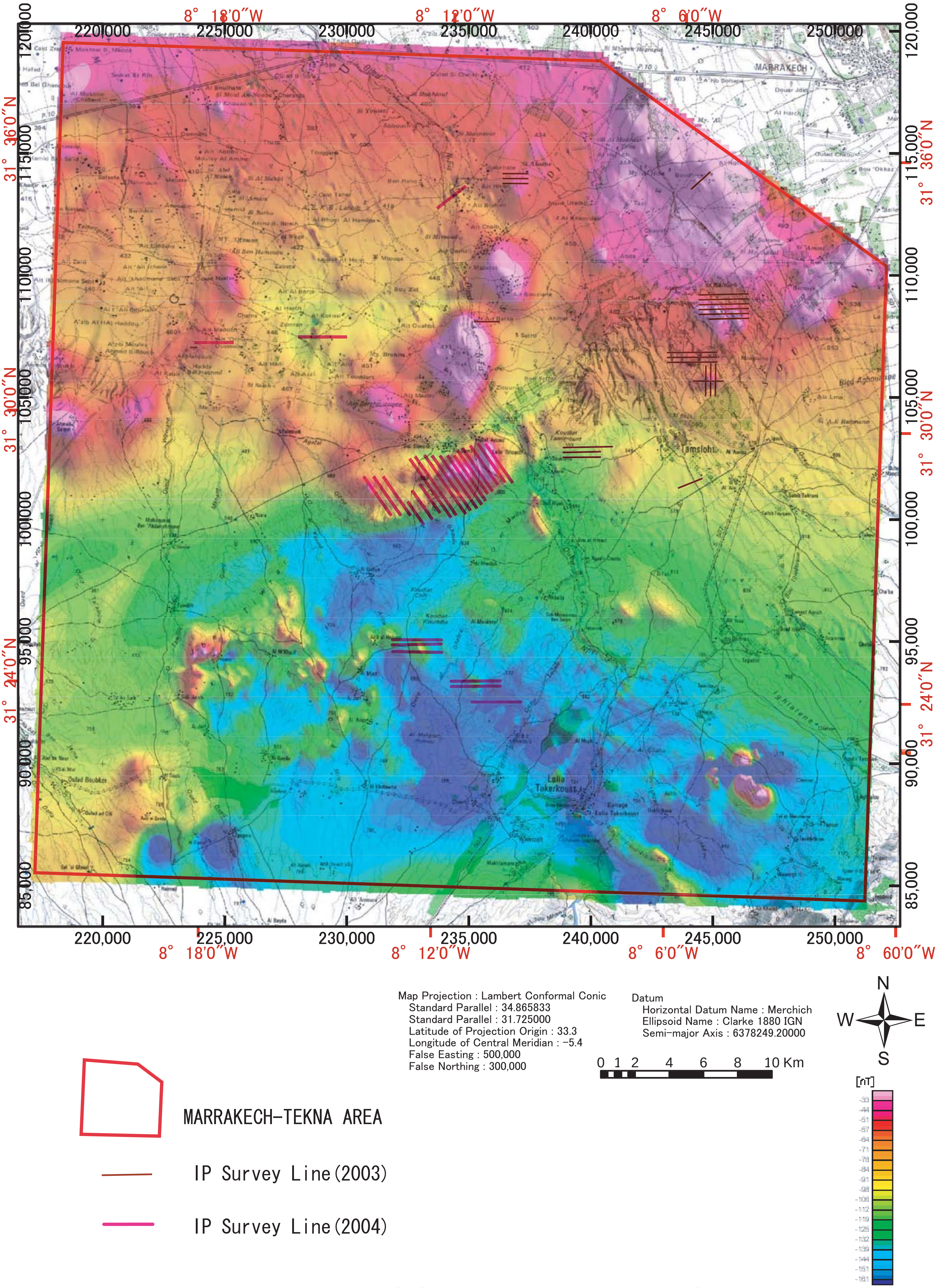


Fig.I-1-1 Residual magnetic intensity and IP survey line

1-3 Survey Team

The members of the survey team are as follows.

Japan side

Jyunichi ISHIKAWA	Geotechnos Co. Geoscience Department
Kuraei IWAKI	Geotechnos Co. Geoscience Department
Tadashi NAKAYU	Geotechnos Co. Geoscience Department
Mitsuyoshi SAITO	Geotechnos Co. Geoscience Department
Toshimasa KOBAYASHIi	Geotechnos Co. Geoscience Department

Morocco side

El Bachir BARODI	Directeur de l'Exploration, Bureau de Recherches et de Participations Minieres: BRPM
Hassan MAZNOUDI	BRPM
Abdallah MOUTTAQI	BRPM
N'hamed ANNICH	BRPM
Mohamed NAJAHI	BRPM
Ahmed KORCHI	BRPM
Lahcen HMAIDOUCH	BRPM
Mustapha CHAIB	BRPM
Said QASRI	BRPM
Mohamed EL YAGOUBI	BRPM
Mohamed IDRISSI AZAMI	BRPM
Zakaria JIRARI	BRPM
Driss DRISSI	BRPM
Abdallah MEKKAOUI ALAOUI	BRPM

Inspector

Gen KOJIMA	Japan International Cooperation Agency Natural Resources and Energy Conservation Team Group II

1-4 Survey Period

The geophysical survey in the field has been performed from August 31 to October 22, during a period of 53 days.

The inspector has stayed in the field from September 6 to September 15.

Chapter 2 Geography

2-1 Location and Access

The survey area is situated about 330 kilometers south of the capital city, Rabat, north of the

Anti-Atlas Mountains, and southwest of Marrakech.

The access road from Rabat to the survey area is almost paved, and Rabat and Casablanca, about 100 kilometers apart, is connected by the paved trunk freeway. Between Casablanca and Marrakech, about 200 kilometers, there exist a paved trunk road, taking about three hours by car. The railway service is also available between Casablanca and Marrakech.

International airports are located in Marrakech and also in Rabat and Casablanca, connecting to European principal cities, Paris, London, etc.

2-2 Topography and Drainage

The altitude of the survey area ranges between 400 to 600 meters, showing gentle hilly topography. The survey area is situated in the Haouz Plain, in between the Jebilet Mountains to the north, and the Guemassa Mountains to the south. The Jebilet Mountains and Guemassa Mountains are underlain by weakly metamorphosed Paleozoic sedimentary and volcanic rocks, and the Haouz Plain is underlain by Paleozoic basement rocks, being overlain by Tertiary to Quaternary sedimentary rocks. Outcrop of the area is very scarce.

The principal drainage in the area is the Oued Niss River, running to the north-northeast in the west, and joining to the Oued Tensift River outside of the area.

2-3 Climate and Vegetation

The climate of the area is of arid-inland, temperature widely varies day and night, and season to season, over 40 degrees in Celsius in summer and near zero degree in winter. The vegetation in the area is generally poor, however, some plants adequate for arid area like olives, grapes, wheat, etc. are cultivated. Sheep pasturage is also common. The rainy season ranges April and May, and October and November, and the annual precipitation is about 300 millimeters. Occasional heavy rainfalls in the rainy season give some rigorous damage. Table I-2-1 shows temperature and precipitation in Marrakech.

Table I-2-1 Temperature and precipitation in Marrakech

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp.max.(°C)	17	20	23	26	29	33	38	38	33	28	23	18
Temp.min.(°C)	3	6	10	11	14	17	20	20	18	14	10	6
Prec.(mm)	29	31	31	33	20	8	2	3	10	17	27	34

Highest and lowest temperature: Average temperature for every month

Precipitation: Average precipitation for every month

By the Tourist Bureau, the Government of Morocco

2-4 Infrastructure

Marrakech City, situated to the east of the survey area, is an international tourist city having population of 350,000 and over 100 year's history, and designated as a "World Heritage". The electricity, water supply, road system, Medical facility, communication facility, and other infrastructure of the city are satisfactory arranged. The road to the survey area is nicely paved. Mobile telephone is well usable in almost whole survey area.

Chapter 3 Existing Geological Data

Followings are basic geological information of the study area, referring the last year's report .

3-1 General Geology of Surrounding Area

1) Distribution

The central part of the Jebilet Mountains to the north of the survey area is underlain by the Paleozoic sedimentary rocks showing N-S to NNE-SSW strike, and east dip. The Paleozoic is mainly composed of Devonian to Permian muddy rocks, intercalating limestone, tuff, and sandy layers. Acidic or basic igneous sills are also intercalated in some places.

The Visean upper Carbonate in the central part of the Jebilet Mountains and the Guemassa District is composed of muddy rocks, acidic volcanic rocks, basic volcanic rocks, rhythmic alternation of those and phyllite of the Sarhlef Formation, overlying carbonate rocks of the Tequsim Formation, and uppermost muddy rocks. Figure I-3-1 shows the geological map of the survey area, and Figure I-3-2 shows the integrated geological columner sections, and Figure I-3-3 shows the geological cross section.

The sedimentary rocks consist of shale, slate, and shist, containing abundant sericite and chlorite due to intense regional metamorphism, and mineralization and alteration.

2) Sedimentary Environment

In some places, the hanging-wall alkali alteration is more intense than that of the footwall. It suggests that the hydrothermal activity has been continued after the ore formation, or duplicated with the ore formation activity.

Regarding the principal elements, Al_2O_3 and TiO_2, V, K_2O and P_2O_5 are positively correlated, and SiO_2, CaO and Fe_2O_3 are negatively correlated, showing the same tendency of the seawater. The dispersion of SiO_2 in the Hajar, Draa Sfar, and Kettara Deposits is due to the change of clastic origin material supply caused by the acidic volcanic activity. The high tendency of CaO in the Khwadra Deposit, compared with the other deposits, is due to the abundance of biogenesis origin material supply. In the rare-earth element pattern, LREE is rich showing Eu anomaly, but this is due to the effect from the island arc clastic material supply. It is possible that the tendency of the total rare-earth element, TREE, increase in the hanging-wall of the ore deposit is due to the transfer of the elements from the footwall to hanging-wall by the hydrothermal solution.

The sulfur isotope in the muddy rocks is scattered between –35 and +25 per mill, showing tendency of lighter to the hanging-wall side. It is thought that the sedimentary environment has been shifted from reduction to oxidation (Kajiwara 1989, Kajiwara and Kaiho 1992, Komuro 1999).

3) Characteristics of Volcanic Rock

The chemical component and radioactive age of the volcanic rocks distributed around the ore deposits in the survey area have been investigated in the first year’s survey.

The result of the chemical analysis revealed that the rare earth element pattern is rich in the light rare earth elements, the Eu anomaly shows some flat pattern, and the principal components SiO_2 and (K_2O, Rb, Ba, Cs) show the negative correlation, showing same tendency in the acidic volcanic rocks in the Hajar, Khwadra, and Draa Sfar Deposits. These acidic volcanic rocks, therefore, have similar geochemical property, being different from the acidic volcanic rocks, tonalitic mylonite, in the neighboring ore deposit, Safsafa Deposit. Comparing the LIL elements and HFS elements of the basic volcanic rocks, dolerite, in this area and the basaltic rocks in other areas, it is made clear that the basic volcanic rocks in this are show the characteristic of the island arc, rich in LIL elements, being different from N-MORB, poor in LIL and HFS.

Based on the result of the K-Ar radioactive age dating to obtain the mineralization age and igneous activity age, it has been made clear that there exist following main activities, plutonic igneous activity, acidic volcanic activity, and mineralization – alteration activity (the Guemassa Mountains, Jebilet Mountains). The plutonic activity and acidic volcanic activity is 290 to 360 Ma in age, and the mineralization - alteration is 260 to 320 Ma in age. The age of the Jebilet Mountains is corresponded with the last period of the igneous activity, and that of the Guemassa Mountains is corresponded with after the igneous activity.

3-2 Outline of Ore Deposits

In the surrounding area, following known ore deposits are distributed, the Kettara Deposit in the central Jebilet Mountains, the Draa Sfar Deposit and Khwadra Deposit in the southern rim of the Jebilet Mountains near the boundary with the Tertiary formation, the Hajar Deposit in the eastern edge of the Guemassa Mountains, and the Frizen Deposit in the western area.

The ore deposits in the Jebilet and Guemassa districts are the massive sulfide type, mainly composed of copper, lead, zinc, and iron minerals. The deposits are hosted in the alternation of muddy rock and sandstone, alternation of muddy rock and chart, and acidic volcanic rocks of the Sarhlef Formation of Carboniferous Visean.

Figure I-3-7 shows the location of the ore deposits and mineral occurrences.

These ore deposits show the layered, massive, and lenticular form, and are mainly composed of the mineral composition of pyrrhotite, pyrite, sphalerite, galena, and chalcopyrite. The acidic and basic volcanic rocks around the deposits are genetically related with mineralization.

According to Watanabe (2001), the formation in the Hajar Deposit area is classified into three members, the lower, middle, and upper. The lower member consists of an alternation of silt and mudstone, intercalated by dacitic to rhyolitic lava and pyroclastic rocks. The middle member consists of sulfide ore. The upper member consists of 150 to 200 meters thick silt and mudstone, intercalated by thin layers of limestone. In where the sulfide ore body disappears, the upper member overlies the lower member directly. It indicates that the igneous activity intermittently continued after principal mineralization period, because pyroclastic rock is partly seen in the upper member. The main ore deposit of the Hajar Deposit is 50 to 90 meters thick, and traceable to both sides at least 200 to 300 meters.

The near surface of the deposit has undergone oxidation about 20 meters thick. The pyrite replaces pyrrhotite in the oxidized zone. Non-oxidized ore bodies are composed of 75 to 95 percent of pyrrhotite, being accompanied by sphalerite, galena, chalcopyrite, pyrite, and arsenopyrite.

Pyrrhotite veinlet networks exist underneath the massive ore bodies. The veinlet cuts the stratigraphic planes at steep angle. The host rocks of the networks are rhyolite, pyroclastic rocks, and mudstone, and having undergone silicification and chloritization. The alteration by biotite and alkali feldspar is seen in the rhyolite, and chloritization is overlapped on this. Some group of veinlet parallel to the bedding plane appears near the bottom of ore bodies, and grades to the massive part. The rhythmical alternation of sedimentary rocks and sulfide ore layers are seen in parts, and it indicates that those sulfide minerals are of submarine genesis. The principal hydrothermal alteration minerals are chlorite and sericite, and some biotite in the lower part of the ore body. The significant characteristic of the ore deposits is that iron sulfide minerals originally deposited as pyrite has been replaced by pyrrhotite due to the Hercynian metamorphism. It is very difficult to estimate the temperature and property of the original hydrothermal solution at the ore formation stage due to the metamorphism.

The thick clastic material derived from the land terrain has covered the sulfide ore bodies during and after the ore formation stage in the Marrakech area.

(2) Characteristic of Sulfide

The object of this year's survey is to reveal the characteristic of subsurface massive sulfide ore deposits in the target area, and to extract potential targets for the next year's program, judging from the state of the ore deposits in the Jebilet and Guemassa districts. The characteristic of the massive sulfide ore deposits in the area is as follows.

1) Classification of the mineralization and the occurrence of Pyrrhotite

The Khwadra, Draa Sfar, Kettara, and Frizen Deposits are classified into the massive sulfide ore deposit, judging from their deposit form, mineral assemblage, and associating igneous rocks. As a result of the investigation of the occurrence, ore mineral, and host rocks, it has been made clear that a duplicated mineralization process of the early stage and later stage formed these deposits. The sulfide minerals of both stages exist in paragenesis with quartz.

The early and later stage mineralization is represented by pyrrhotite and pyrite respectively, in view of the Fe-S series mineral. In the Khwadra and Hajar Deposits, the early stage mineralization is divided into two, the early I represented by pyrrhotite and early II represented by monoclinic pyrrhotite. The hexagonal pyrrhotite in the early I stage has been extensively replaced by the monoclinic pyrrhotite in the early II stage, and the monoclinic pyrrhotite in the early II stage has been altered to marcasite.

The homogenized temperature of the fluid inclusion in quartz, in paragenesis with the hexagonal pyrrhotite in the early I stage is 270 to 280 ℃. The monoclinic pyrrhotite in the early II stage shows 230 to 250 ℃ as well as quartz and sphalerite, and has been crystallized directly as such mineral. The homogeneous temperature of the quartz, in paragenesis with pyrite and sphalerite, of the later stage is 200 to 250 ℃.

2) Characteristic of sulfur isotope

The sulfur isotope ratio of the sulfide minerals in the Khwadra, Draa Sfar, Kettara, Hajar, and Frizen Deposits show distinct difference for each ore deposit on the early stage mineralization. The sulfur isotope ratio is lowest for the Khwadra Deposit, and gets higher for the Draa Sfar, Kettara, Hajar, and Frizen Deposits in order. Such big variation of the sulfur isotope within same ore deposit or ore district is contrastive with the uniformity in the Japanese Kuroko ore deposits. The cause of such difference can be explained by the different conditions of physical chemistry of ore formation, contamination of biogenic sulfur, various volume of sulfur supply from seawater to hydrothermal system, etc. This suggests that different ore formation environment for each ore deposit. It is said that the Khwadra Deposit contains relatively much biogenic sulfur contamination, and the Hajar and Frizen Deposits obtain relatively great contribution from the magma origin.

3) Mineralization and magnetism

The intensity of the magnetism around the ore deposits is related with the various types of pyrrhotite for each ore deposit. The Khwadra and Hajar Deposits specifically containing the monoclinic pyrrhotite cause high magnetism, the Draa Sfar Deposit containing the hexagonal (early I stage) and monoclinic pyrrhotite (Early II stage) causes neighboring high and weak magnetic anomalies, and the Kettara and Frizen Deposits containing the hexagonal pyrrhotite and duplicative pyrite cause only weak magnetism. It is possible to expect some potential for weak magnetic massive lead-zinc sulfide ore deposits, composed of hexagonal pyrrhotite and pyrite, such as the Kettara and Frizen Deposits in the weak to moderate magnetic anomalies. Also it is possible that relatively weak magnetic massive lead-zinc sulfide ore deposits composed of the hexagonal and monoclinic pyrrhotite exist in some highly magnetic and weak magnetic neighboring anomaly zones.

4) Summary

The characteristic of the massive ore deposits around the survey area is summarized as follows.

(1).The massive sulfide ore deposits around the survey area were formed by duplicated mineralization activity. The mineralization can be divided into three stages, the early I stage, early II stage, and later stage.

(2) The early I stage mineralization is represented by the hexagonal pyrrhotite, showing slightly weak magnetism. The early II stage mineralization is represented by the monoclinic pyrrhotite, showing intense magnetism. The later stage mineralization is represented by pyrite, showing weak magnetism.

(3) The homogenized temperature of the quartz, in paragenesis with sulfide minerals, is 270 to 280 ℃ for the early I stage, and 230 to 250 ℃ for the early II stage, and 200 to 250 ℃ for the later stage. It is thought that this indicates temperature gradient of the ore formation.

(4) The great change of the sulfur isotope ratio in the same district can be explained by the different conditions of physical chemistry of the ore formation, contamination of biogenic sulfur, different volume of the sulfur supply from sea-water origin to hydrothermal system, etc. The Khwadra Deposit in the northwest area contains relatively much biogenic sulfur contamination, and the Hajar Deposit in the southeast area and Frizen Deposit in the southwest area have relatively great contribution from magma-origin sulfur.

(5) The type of the ore deposits is classified as follows.

a. Early I stage dominant type, moderate magnetic anomaly (Draa Sfar Deposit)

b. Early I + later duplicate type, moderate magnetic anomaly (Frizen Deposit, Kettara Deposit)

c. Early II + later duplicate type, high magnetic anomaly + low magnetic anomaly (Khwadra Deposit, Hahar Deposit)

3-3 Mining of Surrounding Area

The mining product is the greatest foreign currency income source for Morocco at present, and occupies about 30 percent of the total export value, about six percent of GDP. The most important mineral product of Morocco is phosphorite mainly consisting of apatite, and Morocco is the third largest exporting country in the world, following U.S and China.

Other than phosphorite, Morocco also exports silicon, lead, copper, zinc, silver, and manganese. Ore deposits of gold, cobalt, nickel, iron, uranium, and fluorite are also known in this country.

The massive sulfide ore deposits exist in the surrounding area of the survey area. The Draa Sfar Mine to the north of the survey area and the Hajar Mine to the east are in operation at present. The Kettara Mine to the north of the survey area was in operation in the past.

The Kettara Mine situating to the north of the survey area was discovered in 1937, and been operated until 1982 for pyrrhotite ore. The pyrrhotite was utilized as reducing agent for phosphate ore produced in Morocco. It is said that the mine still remains about 10 million tons of reserve at present.

The Draa Sfar Mine situating to the northeast of the survey area started their iron ore production in 1953. The ore is in the oxide zone near surface. BRPM performed a magnetic survey and drilling program in 1962, and succeeded to discover a thin lenticular body of copper-bearing pyrrhotite ore. BRPM mined out about 4 million tons of ore from a zone down to 150 meters during a period from 1968 to 1982. During a period from 1986 to 1996, BRPM performed drilling programs, then sold the mine to a private company, Compagnie Miniere des Guemassa (CMG) in 1997. The Draa Sfar Deposit is hosted in a rhyolite body and overlying rhyolitic tuff in vertical. The ore body extends more than 800 meters to both sides, and is overlain by silty rock.

The Hajar Mine is situated 35 kilometers south of the Marrakech. BRPM discovered the ore by their drilling program for a magnetic anomaly zone in 1984, and continued their exploration activity until 1988. ONA and BRPM founded a new company, Compagnie Miniere des Guemassa (CMG), and CMG bought the mine. CMG started operation in 1992, and is producing about 100,000 tons of zinc, 40,000 tons of lead, and 30,000 tons of copper in every year.

Table I-3-1 Main ore deposits and gossans around the area

Ore deposits or gossans	Summary
Kettara	- 1956: Cuprous pyrite 1956-1965:Survey for phosphates 1964-1981:Produced 8Mt ore including 5.3Mt of Pyrrhotite 1982:Closed.
Draa Sfar	1953:Gossan exploited 1962:magnetic survey and drilled (12holes). Cuprous pyrite discovered. Operated at present.
Hajar	Discovered in the 1984 by BRPM. Mining commenced during 1992. 3,000t/d, averaging 10.5% zinc, 3% lead, 0.3% copper and 60g/t silver in 2001.
Frizem	1984:Magnetic survey
Khwadra	2000:Drilling survey.

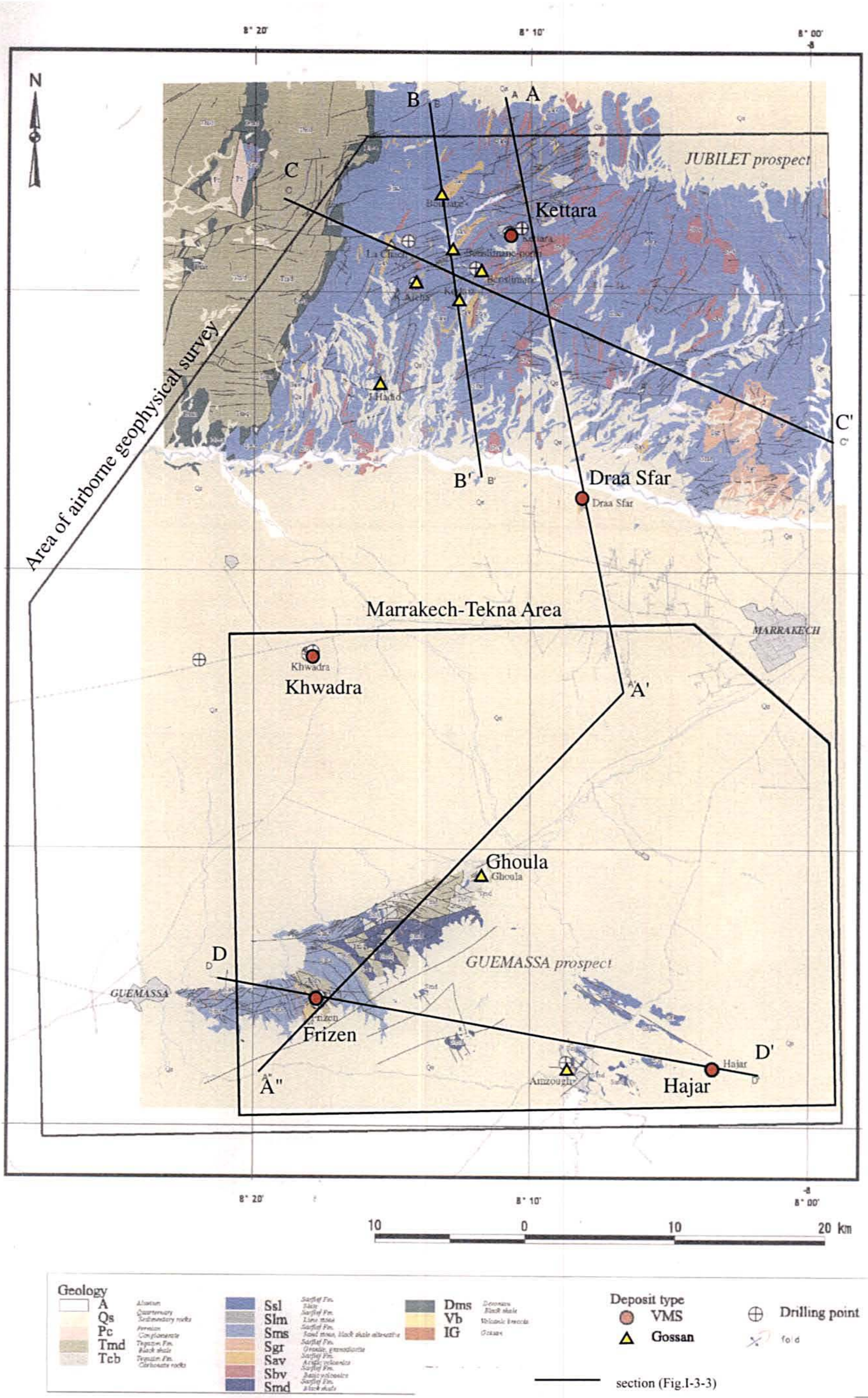


Fig. I -3-1 Existing geological map of the project area in Morocco

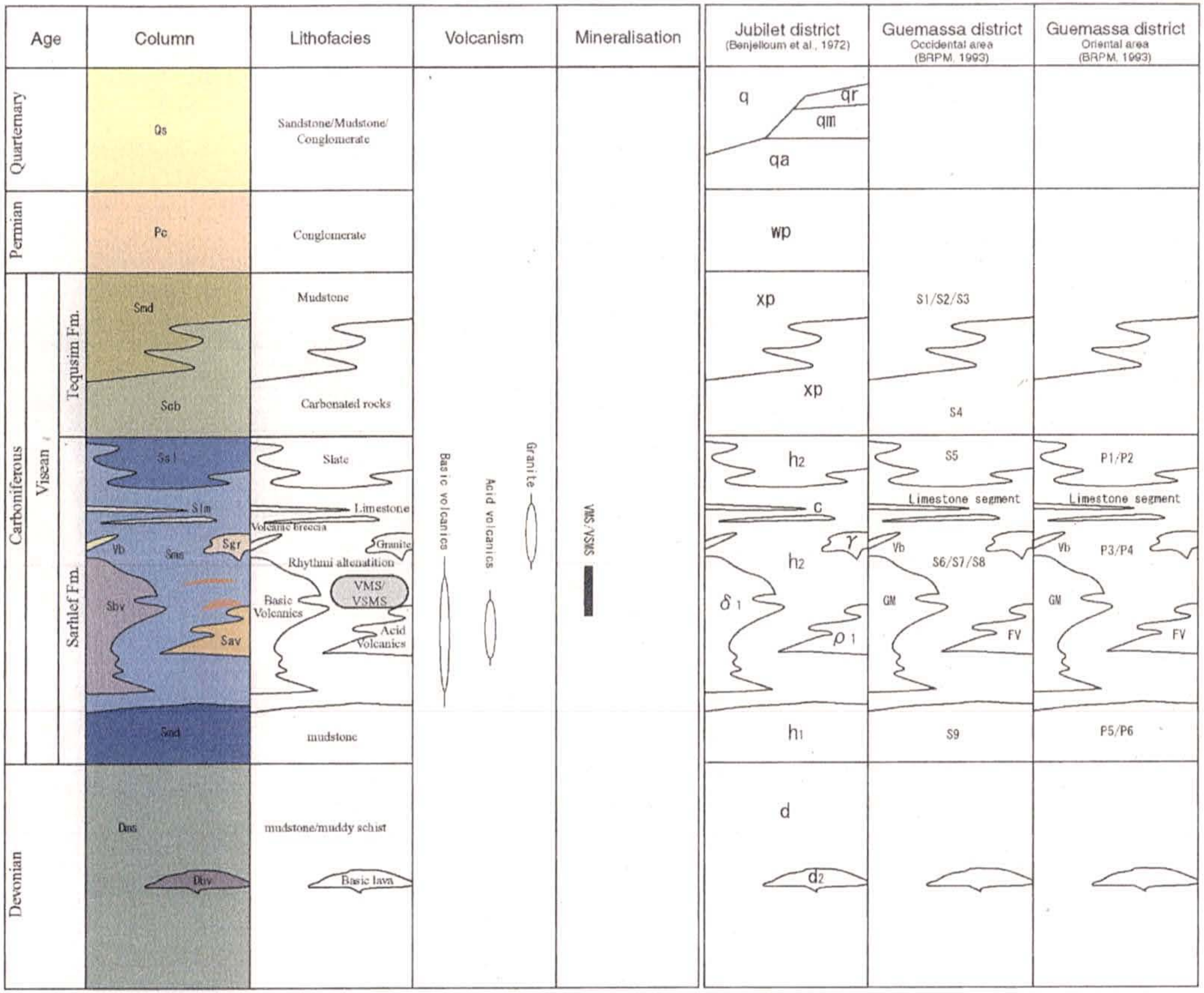


Fig. I -3-2 Geological stratigraphic columnar section of the project area in Morocco

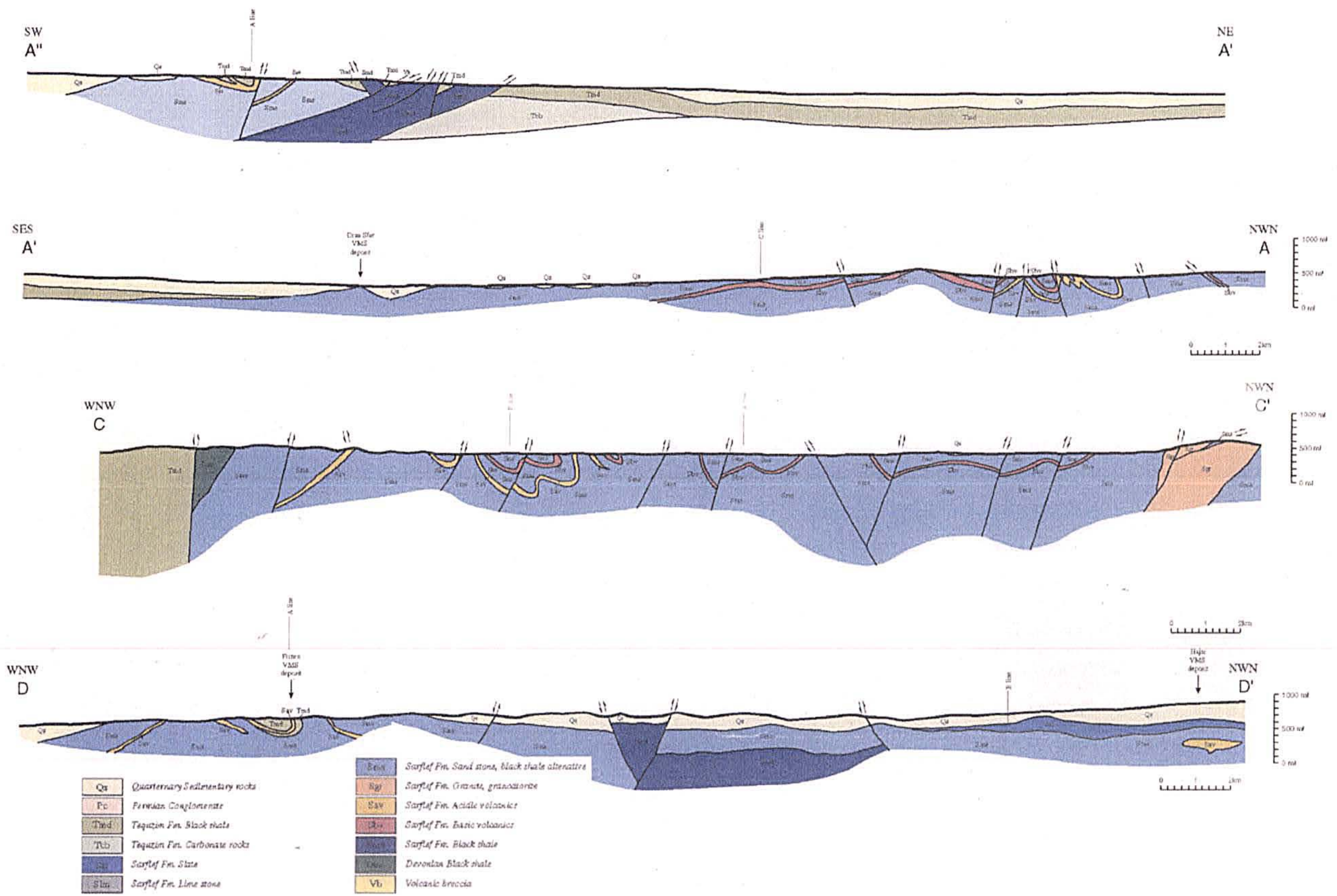


Fig. I -3-3 Geological section of the project area in Morrocco

Chapter 4 Integrated Investigation of the Survey Result

4-1 Characteristics of Geological Structure and Mineralization

The outcrops of the Paleozoic are very rare in this year's survey areas, mostly being covered by the young sediments.

However, the massive sulfide ores are emplaced in the Paleozoic sediments in the surrounding areas. The ore deposits are of stratiform, massive lenticular, and banded forms. The ores are mainly composed of pyrrhotite, pyrite, sphalerite, galena, and chalcopyrite. The acidic and basic volcanic rocks are distributed around the ore bodies.

The rhyolite and rhyolitic pyroclastic rocks are distributed in the foot-wall side of the ore bodies, but these rocks contain visible quartz grains, being hard due to the alteration, and showing black to dark grayish. These appearance is different from the foot-wall dacite of Japanese kuroko ore. Also the hanging-wall muddy rocks in the area are rich in calcareous material, being rather resemble to the Mexican Mesozoic hanging-wall mudstone than Japanese hanging-wall mudstone in the Akita kuroko areas.

Regarding the principal dipping direction of the ore deposits in the surrounding areas, noticing this sort of stratification relations, dipping directions of the northern Kettara Deposit; to the south-southwest, north-northeast Draa Sfar Deposit; to the west, northwest Khwadra Deposit; to the east-southeast, southeast Hajar Deposit; to the north, and southwest Frizen Deposit; to the northeast. It is supposed that some kind of syncline structure in general scope exist there. This year's survey area is correlated with the place where the ore horizon surrounding the syncline structure exists underneath the young sediments, Cenozoic sediments (Figure I-4-1).

In the Khefawna, although its geological structure is unclear due to thick covering with the young sediments, the Paleozoic calcareous schist outcrops on the surface, dipping to the east.

In the Azzouz district, the northwest side of the Major Fault, called Guemassa N Fault also, is covered by the thick young sediments. The southeast side of the fault is lifted up, greater in the southwestern part, therefore it is possible to consider that the fault is a hinge fault. The southeast side of the fault is a high plateau area, but the area nearby the fault is eroded, forming rugged topography. The rocks in the southeastern side of the fault are Paleozoic muddy schist and calcareous schist, accompanied with tuffaceous schist. Many small scale east dipping faults are distributed in the Paleozoic, therefore it probably is a thrust fault. The formations generally dip to the east, being relatively concordant to the thrust fault, but cut by fault in many parts. Many of the faults are accompanied with gossan and barren quart veinlets. Dolerite intrusive dykes cut the fault in part. Almost all Paleozoic rocks are rich in calcareous material, being correspond to the hanging-wall of the massive sulfide deposits. There is some epigenetic hydrothermal and underground water activity, judging from the existence of quartz veins and gossan. BRPM revealed some lead and zinc content, maximum 1 % Pb, in the gossan.

4-2 Geophysical prospecting anomaly and mineralization

The electric prospecting IP method has been performed in the six districts, to the west of Marrakech city. It has been revealed that a high charge rate, low resistivity IP anomaly exists in the Azzouz district, however no significant IP anomaly has been detected in the other districts. The IP anomaly I the Azzouz district is concordant with a part of the magnetic anomaly.

The electromagnetic prospecting TEM method has been applied to the Azzouz district together with some works in the Khefawna district after the electric prospecting IP method. In the Azzouz district, a low resistivity, high conductivity zone apparently exists being concordant to the electric prospecting IP method anomaly. Also it is presumed that some faults exist there. In the Khefawna, some simple two layers structure consisting of low resistivity young sediments and high resistivity Paleozoic formations.

The IP anomalies in the Azzouz district shows slightly stronger magnetic anomaly than that of small scale disseminated ores, and is not interpreted by an existence of some igneous bodies. It is thought that the anomaly reflects a concentration of pyrrhotite ores. The electromagnetic prospecting IP method has revealed two spots of high conductivity anomalies other than a low resistivity anomaly zones being concordant to the IP anomaly zone.

No IP anomaly indicating some ores has been detected in the Khefawna district in this survey program.

4-3 Potential for ore deposit

No surface outcrops of rhyolite or dacite hanging wall rocks exists in the Azzouz district, therefore it is difficult to assure suitable geological environment for massive sulfide deposits. It is thought that the barren quartz veins has been caused by epigenetic hydrothermal activity after the principal massive sulfide genesis. The gossan also has been caused by epigenetic underground water activity, but it contains more lead and zinc than normal iron hydroxides concentrated parts. It probably indicates that there is some supply source for these elements somewhere in the underground. It is possible that the underground water containing soluble lead and zinc elements run through some ore bodies.

If the TEM anomaly zones and their magnetic anomalies in the vicinity areas had caused by existence of some igneous bodies such as gabbro or diorite, it is difficult to tell the cause of the its significant chargeability, low resistivity, and the nonexistence of the igneous body in the drill hole GS5. On the other hand, it is difficult to explain the existence of the charge rate and low resistivity by concentration of graphite, thin layers on the surface, because of the magnetic anomaly. Accordingly, the possibility of existence of pyrrhotite concentration is remained by the elimination method.

No data indicating some ores has been obtained in the IP and TEM prospecting in the Khefawna district, however BRPM recognizes some potential for Khwadra deposit type massive sulfide ores in the district, due to the interpretation of the surface magnetic anomaly.

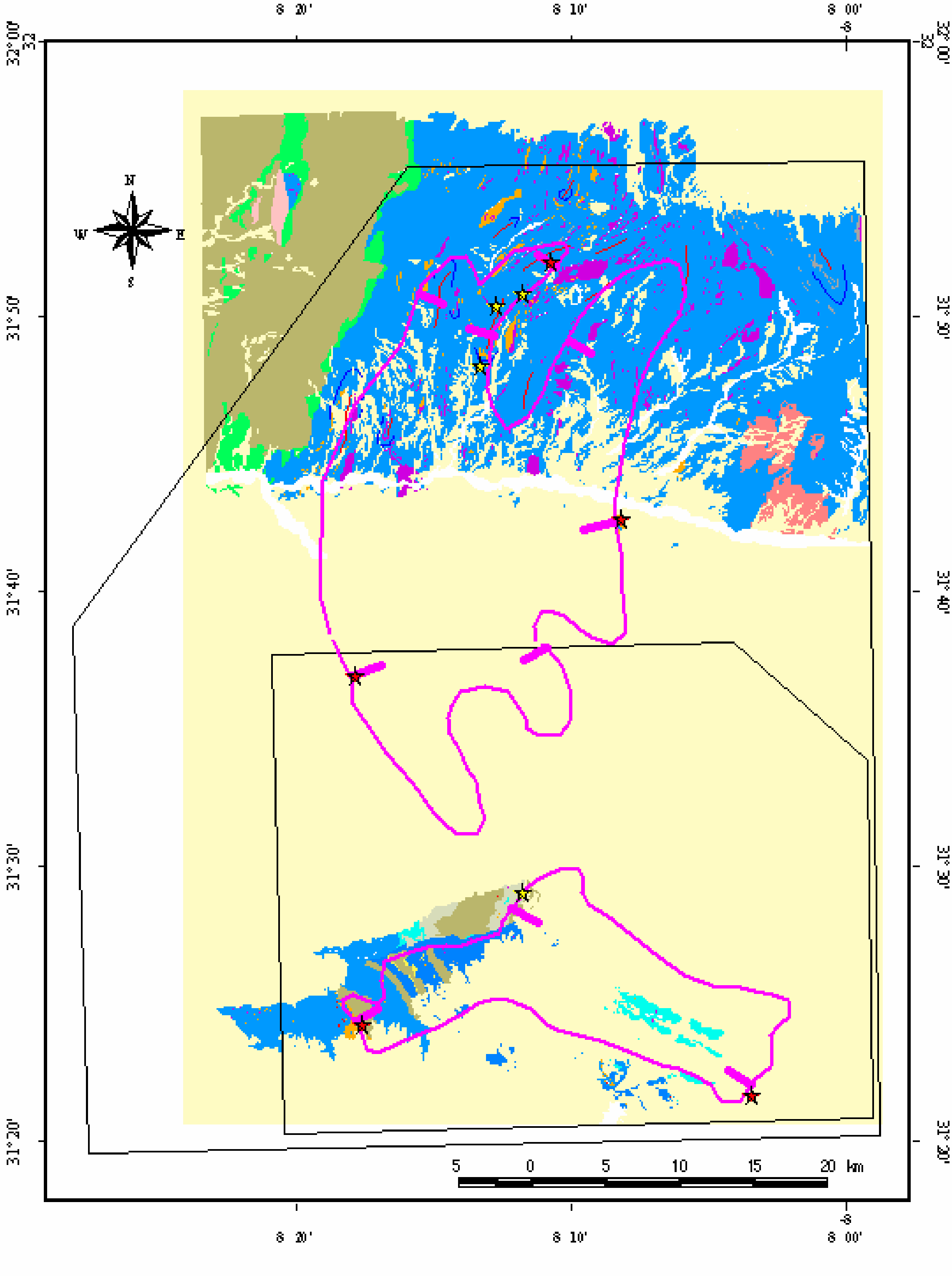


Fig.I-4-1 Regional structure and distribution of ore deposits

Chapter 5 Conclusion and Recommendation

5-1 Conclusion

The geological structure and the status of the mineralized zones in the Azzouz and Khefawna districts have considered as follows, based on the various geophysical prospecting results.

In the Azzouz district, it is possible that pyrrhotite rich massive sulfide ore bodies exist underneath the anomaly zones of the high chargeability parts of the electric prospecting IP method, the high conductivity parts of the electromagnetic prospecting TEM method, and magnetic anomaly zone. If it is of the kuroko type, acidic volcanic rocks such as rhyolite could be the foot wall side of those ores (Figure I-5-1 Concepts).

In the Khefawna-N district, some indications for metallic mineral potential has been obtained, however, no magnetic body was found in the past drill hole HE1 conducted by BRPM. No evidence has been found telling the cause of the magnetic anomaly. The potential of massive sulfide ore is still not negligible, since the area is covered with young sediments with lower resistivity whose thickness exceeds the prospecting ability.

5-2 Recommendation for next stage survey

The intensity and scale of the IP anomalies and the high conductivity of the TEM method in the Azzouz district exceeds those of small scale dissemination of pyrrhotite, therefore, it is judged that there is some potential for massive sulfide ores in the district. Two or three drill holes program is recommended to confirm the potential.

In the drilling operation, the deviation of drill hole often happens due to the schistosity, stratification, and fault, therefore, directing to the northwest is recommended to reduce the deviation, and also to obtain more geological information effectively. If this way is employed, the drilling site will be settled on the southeastern plateau, so that easier accessibility and lesser additional road operation are expected.

From the above mentioned reason, the following drilling program is recommended, consist of three holes as shown in Figures I-5-2 and I-5-3.

Table I-5-1 Scheme of proposed drilling

District	Hole	Drilling length	Dipping	Direction	Target
Azzouz	MJTK-3	500m	-70 deg	325 deg	Mg., H- cond. H.C.R
	MJTK-4	600 m	-55 deg	325 deg	Mg., H-cond. H.C.R
Khefawna	MJTK-5	500 m	-70 deg	270 deg	Mg

Whereas Mg: magnetic anomaly
H-cond: high conductivity
H.C.R: high charge rate

MJTK-3 and MJTK-4 are to confirm the potential zones of highly concentrated pyrrhotite because of high conductivity, and high charge rate, accompanied with magnetic anomaly.

MJTK-5 is to confirm the potential zone for pyrrhotite rich ores interpreted by BRPM.

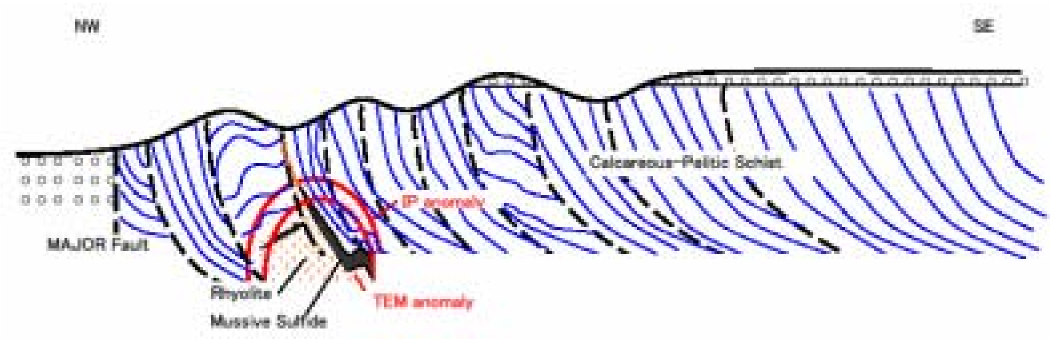


Fig.I-5-1 Concepts (Azzouz)

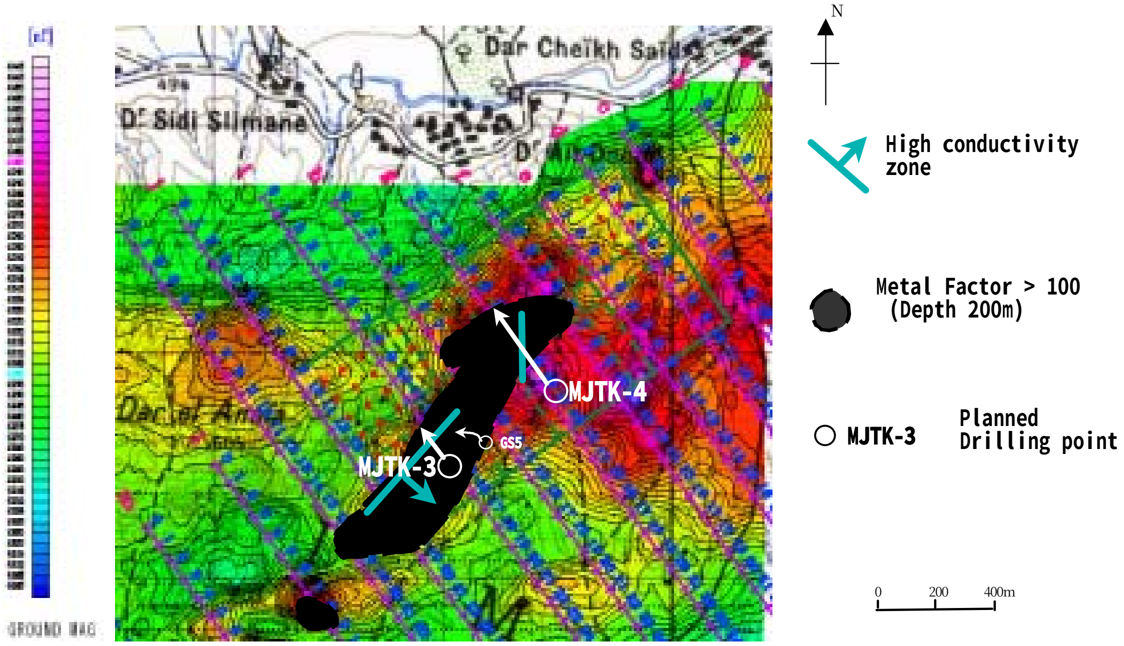


Fig.I-5-2 Concepts of MJTK-3 and MJTK-4 (Azzouz)

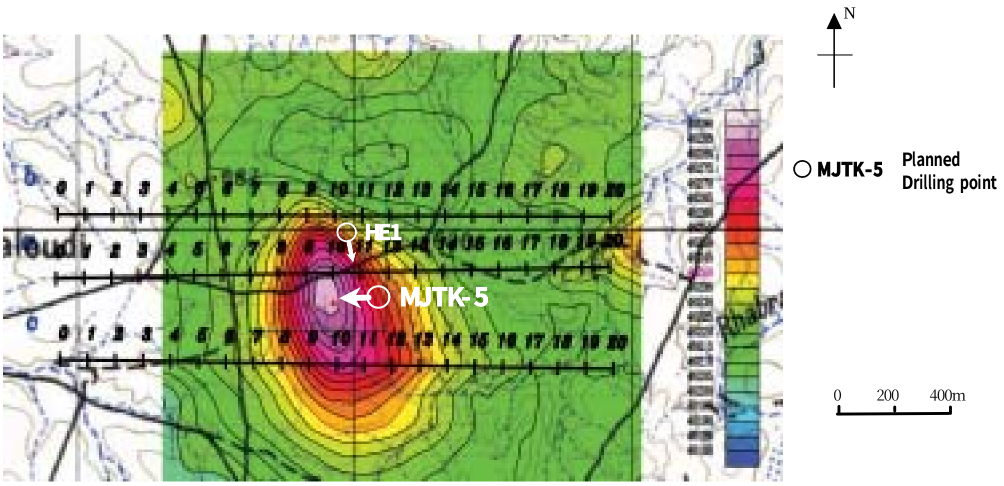


Fig.I-5-3 Concepts of MJTK-5 (Khefauna)

Part II　Details

Chapter I　Outline of Survey

1-1　Basic concept

It is difficult to consider that The airborne magnetic and electromagnetic anomalies detected by the first year's survey has been caused by some mineralized zones containing pyrrhotite mineral, since it is generally very difficult to decide drilling point, direction, and dipping only from the airborne anomalies due to its limitation of accuracy.

The ground geophysical survey, which can obtain more accurate and detailed data for the potential, is normally performed with following airborne surveys, if some anomalies are detected, and the prospecting risk for much funds for further works such as drilling is lowered by integrated data analysis.

Based on the airborne and ground geophysical survey result, the drilling survey will be planed to know the cause of geophysical anomalies and directly to confirm the geology and existence of ore minerals in the underground.

1-2　Survey flow

The electromagnetic prospecting IP method has been applied for the anomaly zones detected by the first year's airborne magnetic and electromagnetic surveys, and some IP anomaly zones, that presumably related to the geological structure, has been extracted. The ground electromagnetic prospecting TEM method has been planned to extract potential zones and their exact position and form. The survey result has been interpreted together with the first year's survey result and known existing data. Finally, the high potential zones for mineralized zones and suitable zones to know the geological structure for ores have been selected for the drilling program survey. The drilling plan has included proposed drilling depth, and direction and plan of holes.

The flow of the survey plan is as follows.

Detection of anomaly zone by airborne magnetic and electromagnetic survey

↓

Investigation

↓

Selection of prospecting districts for IP survey

↓

According to survey result,　Low potential zone: abandon,

High potential zone: continue or increase survey

↓

Investigation of IP anomaly: intensity, form, position etc.

↓

Selection of further prospecting

↓

TEM method electromagnetic prospecting

↓

Understand of three-dimensional shape of resistivity structure

↓

Investigation of potential for expected mineralized zone

↓

Plan of drilling survey: position, depth, direction

↓

Drilling survey: sampling of cores to know geology

↓

Contemporaneous plan for further drilling or stop drilling

↓

Finish drilling

↓

Integrated investigation

↓

Final evaluation of potential. Plan for further step ?

Chapter 2 Geophysical Prospecting

2-1 Electric prospecting IP method

2-1-1 Object of survey

Following the second year's survey, this year's survey performed extraction of potential target districts based on the result of the first year's airborne magnetic and electromagnetic surveys and the ground magnetic prospecting result performed by BRPM in some parts of the area in the past. This year's survey has been planned to make clear its resistivity structure of the extracted district, and also to extract IP anomaly zones by the electric IP method.

2-1-2 Survey area and work done

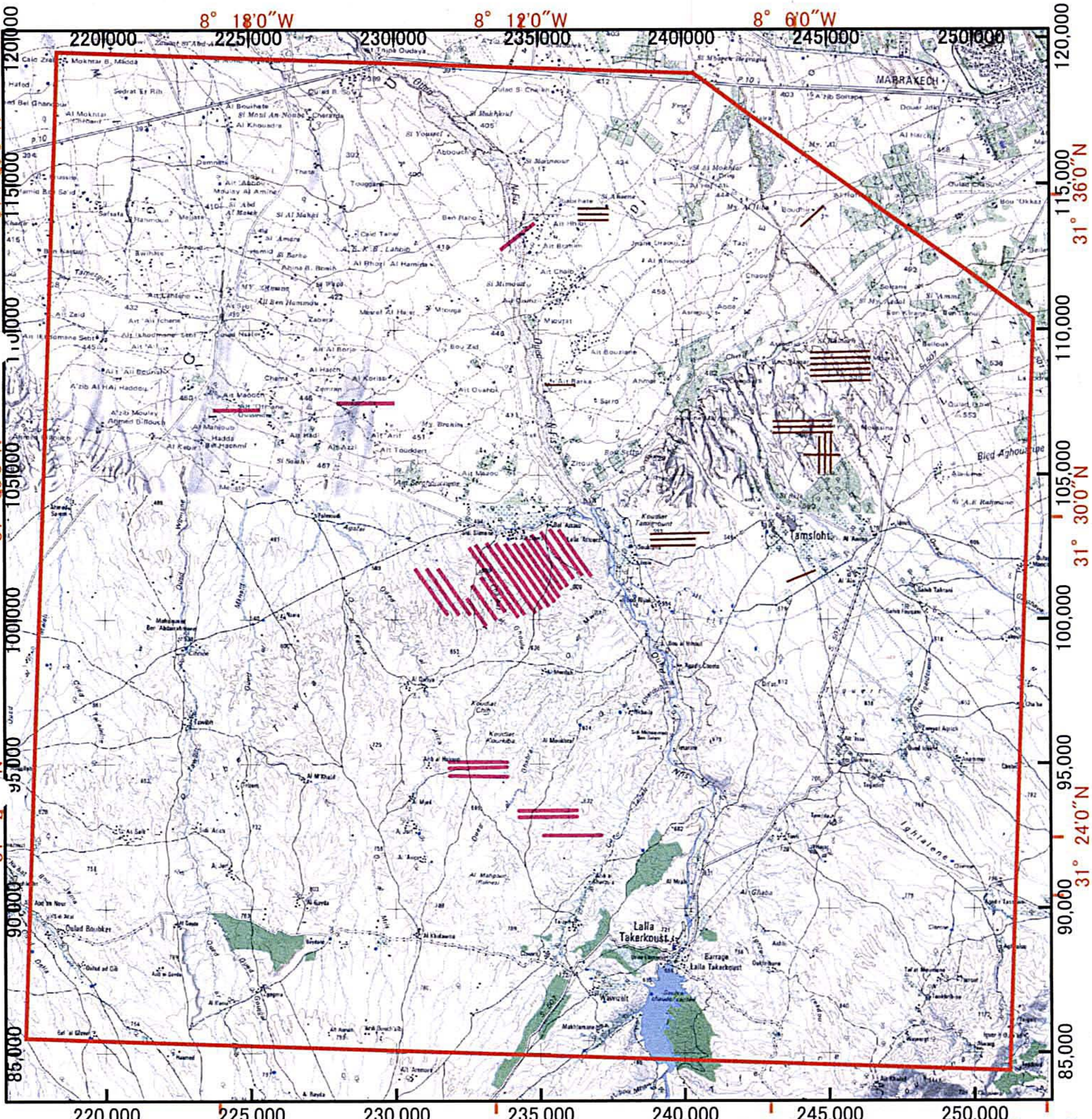
The survey district is situated about 20 kilometers southwest of Marrakech city,. Six target districts have been selected based on the survey result of the airborne magnetic survey and ground magnetic survey. Figure II-2-1-1 shows the survey area, Figure II-2-1-2 shows the survey lines in the Azzouz district, Figure II-2-1-3 shows the survey lines in the Hbibi, Harch, and Maouch districts, and Figure II-2-1-4 shows the survey lines in the Khefawna-N and Talzelt districts. The coordinate of the survey base point for each district in the end of the report.

Table II-2-1-1 shows the work done.

Table Ⅱ-2-1-１ List of survey amount

Area	District sign	Number of lines	Total length	Number of points
Azzouz	MJTK-IP04-1	18 lines [1.2km×1 , 1.5km×2] [2.0km×6 , 2.2km×2] [2.3km×1 , 2.5km×1] [1.7km×１, 2.8km×1] [3.0km×3]	33,900m	1,635
Hbibi	MJTK-IP04-2	1 line	1,500m	55
Harch	MJTK-IP04-3	1 line	2,000m	80
Maouch	MJTK-IP04-4	1 line	1,600m	60
Khefawna-N	MJTK-IP04-5	3 lines [2km×3]	6,000m	240
Talzelt-N	MJTK-IP04-6	3 lines [2km×3]	6,000m	240
Total		27 lines	57,000m	2,310

Hereafter ., Khefawna-N is renamed to Khefawna, and Talzelt-N to Talzelt.



Map Projection : Lambert Conformal Conic
Standard Parallel : 34.865833
Standard Parallel : 31.725000
Latitude of Projection Origin : 33.3
Longitude of Central Meridian : -5.4
False Easting : 500,000
False Northing : 300,000

Datum
Horizontal Datum Name : Merchich
Ellipsoid Name : Clarke 1880 IGN
Semi-major Axis : 6378249.20000

0 1 2 4 6 8 10 Km

N W E S

MARRAKECH-TEKNA AREA

IP Survey Line (2003)

IP Survey Line (2004)

Fig.II-2-1-1 Location map of survey area

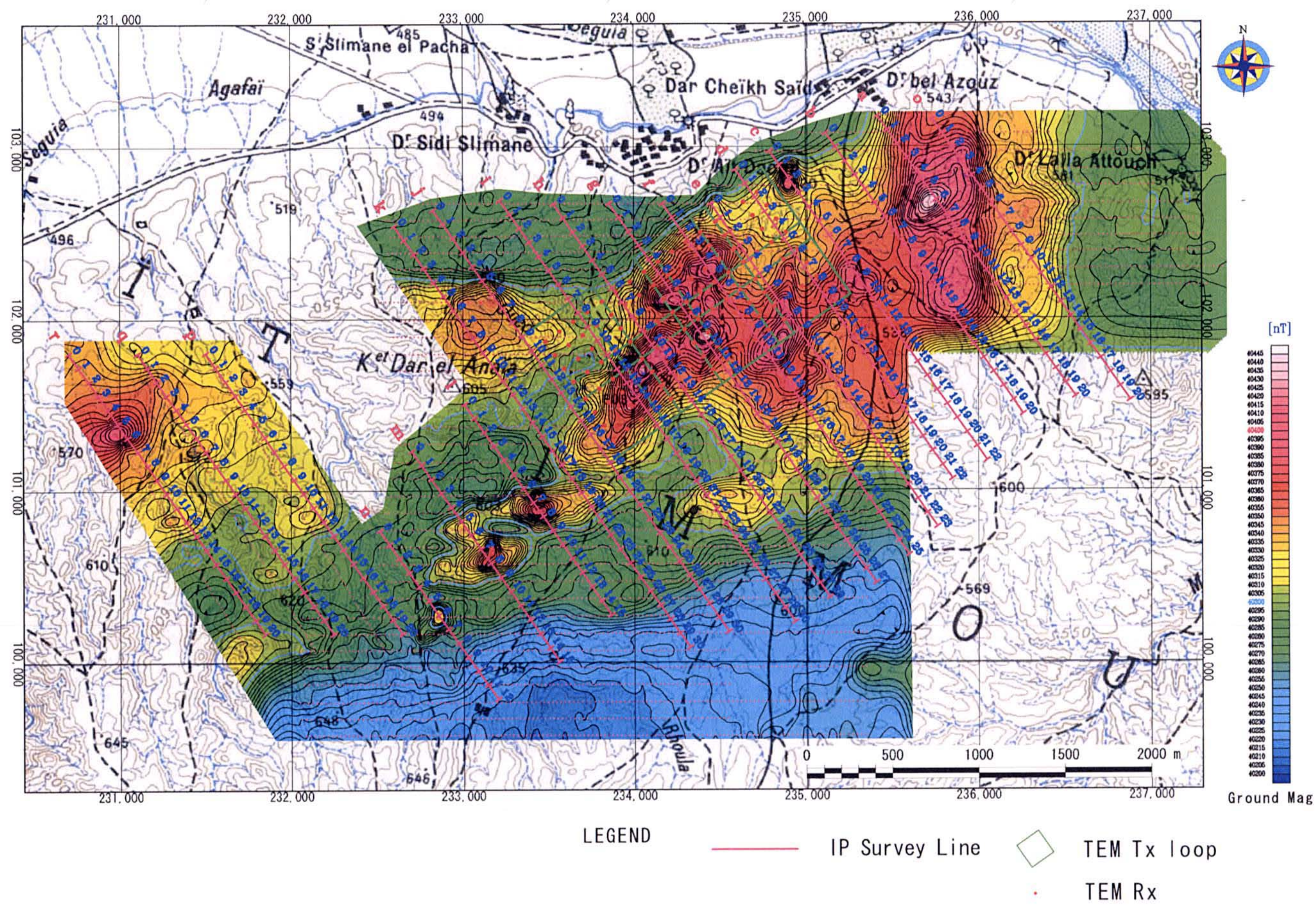


Fig.II-2-1-2 Survey location map at Azzouz area

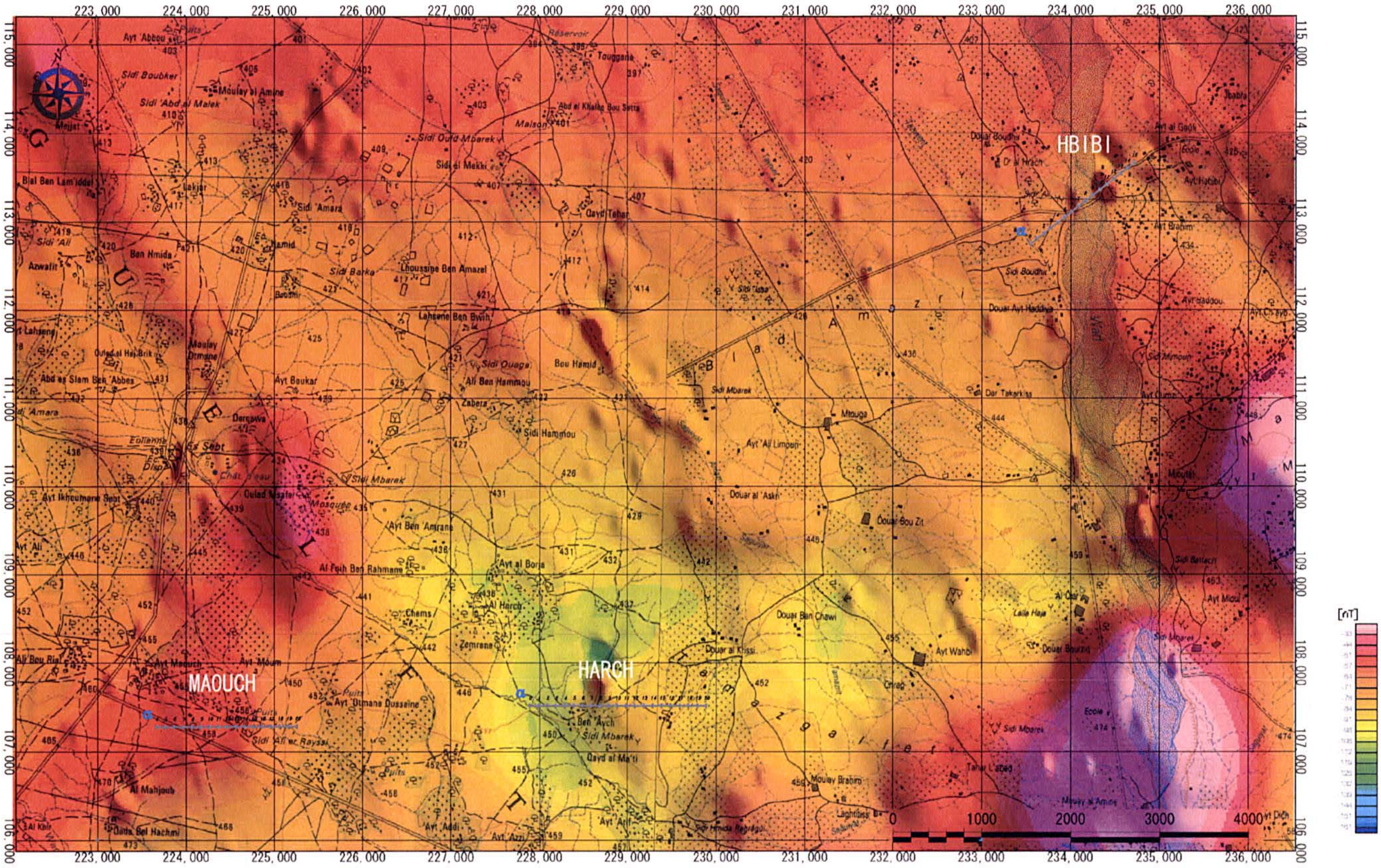


Fig.II-2-1-3 Survey location map at Hbibi-Harch-Maouch area

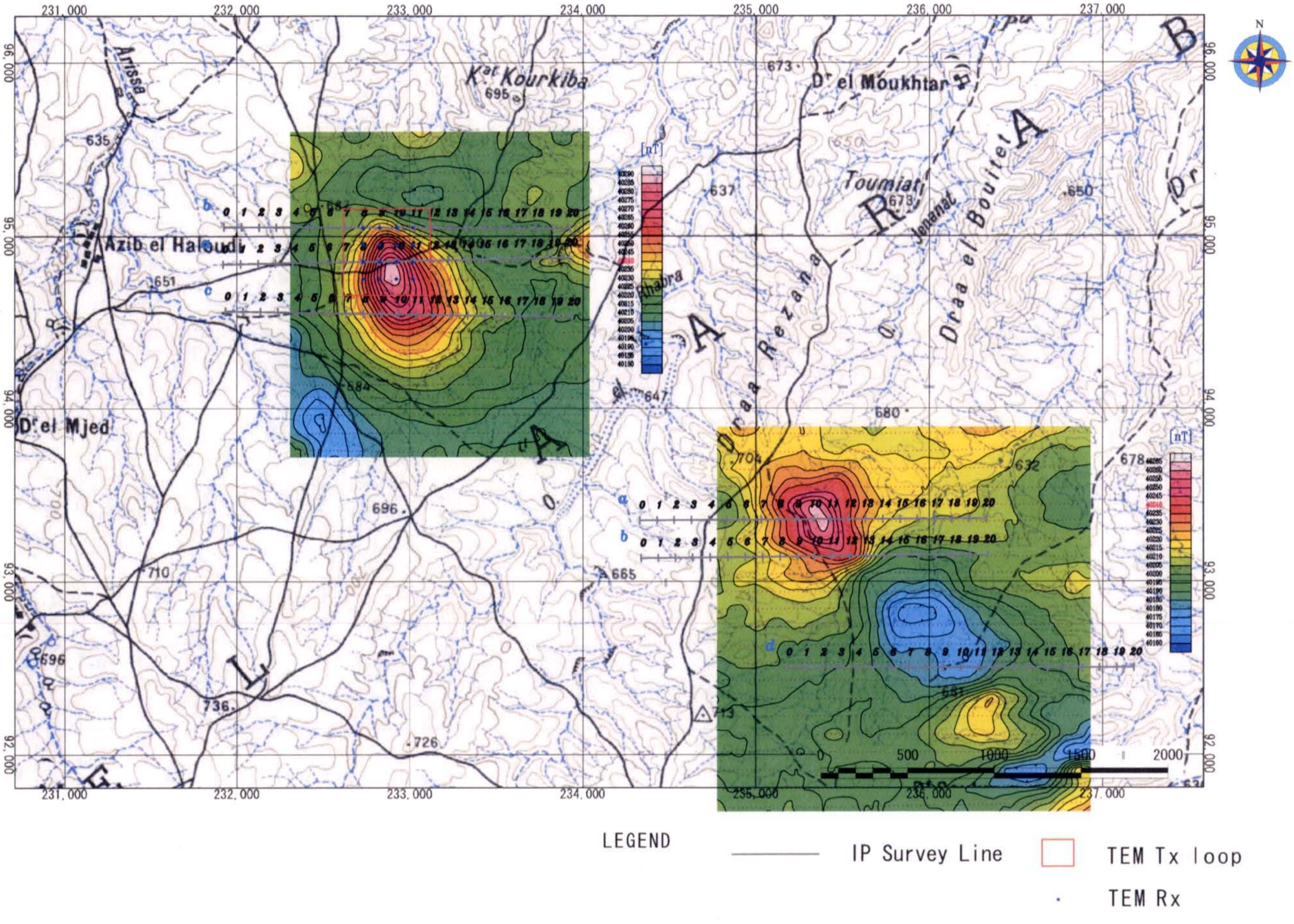


Fig.II-2-1-4 Survey location map at Khefawna-Talzelt area