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KINGDOM OF MOROCCO

REPORT ON GEOLOGICAL SURVEY OF THE HAUTE MOULOUYA AREA

CONSOLIDATED REPORT

FEBRUARY 1981

METAL MINING AGENCY OF JAPAN

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

The Government of Japan, in response to a request by the Government of the Kingdom of Morocco, decided to investigate the potentiality of mineral resources in the Haute Moulouya area of the Kingdom of Morocco and entrusted the geological and other survey works to Japan International Cooperation Agency. The Agency, considering the nature of the works to belong to special field of the investigation of geology and mineral resources, sought the cooperation of the Metal Mining Agency of Japan to accomplish the task.

These survey works carried out during three years from October 1978 to February 1981. During this period, the team, with the cooperate of the Government of the Kingdom of Morocco and its various agencies, was able to complete survey works on schedule.

This report summarizes the results of these surveys for three years, and forms the final survey report.

We wish to express our appreciation to all of the organizations and members who bore the responsibility for the project; the Government of the Kingdom of Morocco, Bureau de Recherches et de Participations Minieres, and other authorities and Embassy of Japan in Morocco.

February 1981

Keisuke Arita
President
Japan International Cooperation Agency

Masayuki Nishiie
President
Metal Mining Agency of Japan

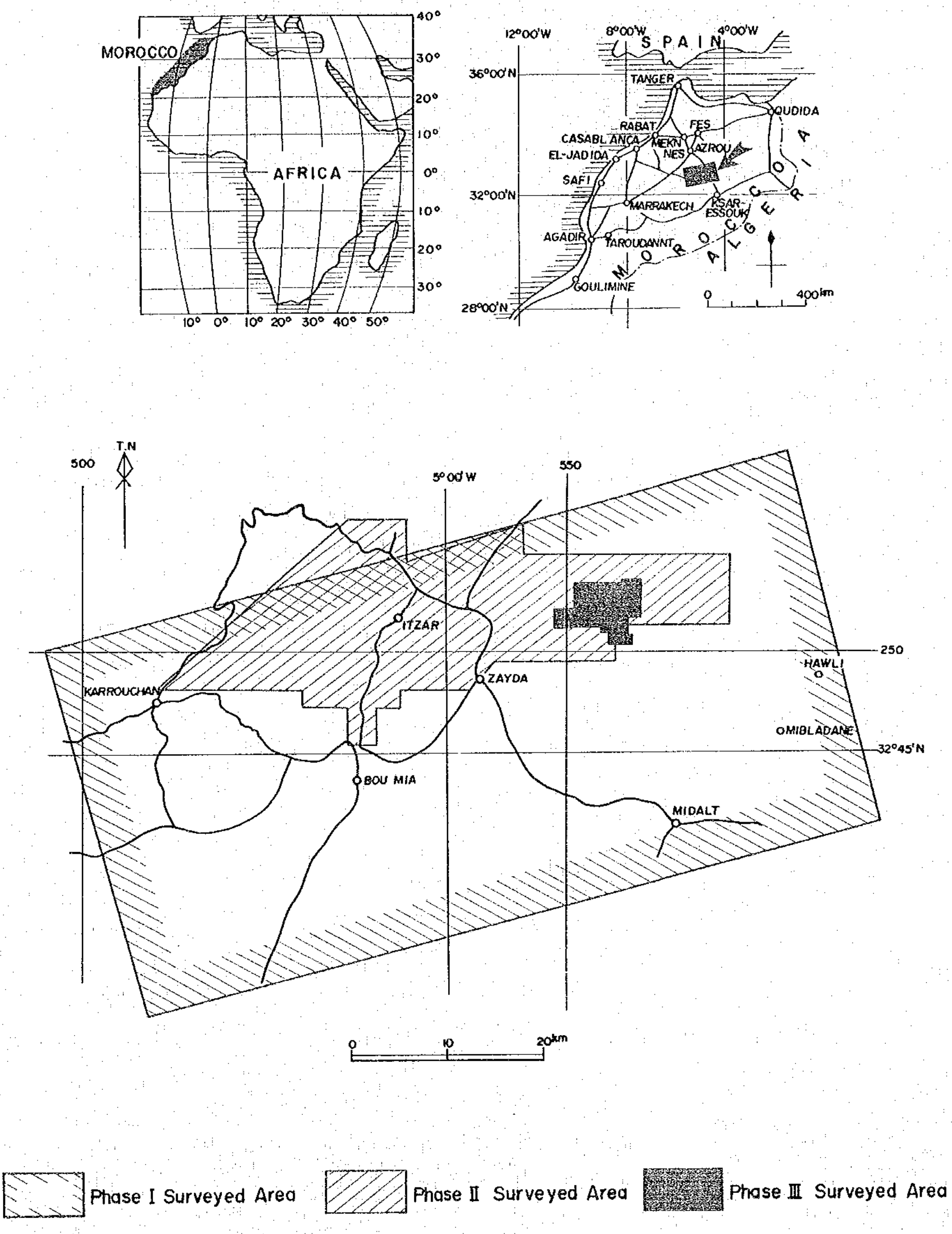

Fig. 1 Location Map of the Surveyed Area

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SUMMARY

(1) In the course of a basic survey for the development of mineral resources in the Haute Moulouya district of Morocco, a geological survey, gravity survey, radon etch survey and drilling work were conducted within the 3,200 km^2 target region for a three year period. Later, specific areas with a high potential presence of mineral resources were selected and the presence of lead and uranium minerals were assessed.

The surveyed area is located in the central region of Morocco, north of Midalt city. This area, 80 km long (east-west) and 40 km wide (north-south) is situated on a plateau with an altitude of 1200 to 1800 m above sea level.

(2) Geologically, the basements in the surveyed area consist of Pre-Cambrian to Paleozoic crystalline schists and granitic rocks intruded during the Hercynian orogeny. The besements are overlain by sedimentary and volcanic rocks deposited during the Permian, Triassic, Jurassic and Cretaceous Periods, and the Cenozoic Era.

From the results of the present survey, it has been clarified that the basements in the surveyed area consisting primarily of granites gently dip north at the northern side and dip south at the southern side because of the presence of a saddle-shaped structure connecting the Zayda Granite and the Bou Mia Granite. Also, in the besements, the presence of a fault structure and a ridge-shaped structure striking NE-SW to NNE-SSW, the presence of basin structures to the east of Itzar and to the south of Bou Mia, and also the presence of a large trough in the west of Karrouchan region have been predicted. In addition, above the basements, the presence of several parallel

valley-like structures continuing relatively far in the NNE-SSW direction and also the presence of short secondary valley-like structures extending in the NE-SW and NS directions have been confirmed.

Generally speaking, the sedimentary rocks overlain the basements were deposited in the sedimentary basin between the mountain land of the Moyen Atlas range in the northwestern region and the High Atlas mountains in the southern region. However, considerable variation in thickness and geological configuration of these formations has been recognized among the northern and southern parts of Bou-Mia Granite and Karrouchan Region.

The Permian and Triassic sediments are greatly controled by the structure and paleotopography of the basements. That is, at the north side of the Zayda-Bou Mia Granites, the paleotopography at the time of sedimentation was almost the same as the present topography. Sediments dip south at the south side of the granites at present. But, at the time of sedimentation, the basements were situated at a place slightly higher than that at the northern side and, in addition, there was a large trough-like sedimentary basin in Karrouchan Region. Thus, according to the changes observed in the thickness and lithology of formations, it seems that the fragments of basements caused by weathering and erosion was developed as they were receiving a supply of materials from the southeast side to the northwest side.

Also, since valley-like structures principally running NNE-SSW were present on the basements, the early sedimentation was probably developed by burying these valleys. At the bottom of P-T Red Sandstone Formation, sandy or conglomeratic materials are heavily de-

posited over the valley-like structure and the Basin structure described above. It is considered that Permian and Triassic sedimentation generally occurred under the continental environment.

In the Jurassic Period, a shallow-sea type sedimentary environment existed but Zayda Granite and its northern part remained terrestial. In the Dogger Jurassic Period, a trough running in the NNE-SSW direction developed in the High Atlas region, and a deep-sea type sedimentary environment developed.

In the Cretaceous Period, the whole area sank below sea level and a lake-type sedimentary environment began. By the Tertiary Period, Alpine orogeny had begun, causing uplifting of the Moyen and High Atlas, and this area became an inland basin in which sedimentation with materials supplied from nearby rocks was developed.

(3) In the surveyed area, the presence of lead deposits and mineralization of uranium has been known for many years. The present survey has been conducted to accurately determine the character and scale of these deposits. During the first phase survey, the geological structure of the surveyed area and the structure of its basements were clarified through geological survey and gravity survey, and the promising areas for exploitation were selected. During the second phase survey, a geological survey, gravity survey, radon etch survey and diamond drilling were performed in more detail, and an area north of Zayda was selected from the areas selected in the previous year as having a high potential presence of mineral deposits. During the third phase survey, the radon etch survey was performed more densely and diamond drillings were conducted at the intersections of grid lines to analyze and evaluate the mineral resources.

As a result of these survey over a three year period, sandstone type lead deposits, stratiformed impregnation type lead deposits and vein-like lead deposits were determined to be the lead deposits in the surveyed area. Particularly, it has been clarified that the sandstone type deposits near the Zayda mine are distributed along the valley-like structure of basements that was predicted from the results of the gravity survey.

Many indications of uranium deposits have been located and clarified; some of them are vein-like mineral indications accompanied by dykes or fractured zones in granite, sandstone type mineral indications in the arkose sandstone of the P-T Red Sandstone Formation, conglomerate type mineral indications in Quaternary conglomerate and carapace type mineral indications on the granite surface. It has been found that aplitic granite among these granites has high uranium content and, together with vein-like uranium mineral indications stated above, had an important role as an original rock of sedimentary uranium deposit. As uranium ore deposits in the areas with uranium indications, both primary minerals such as Pitchblend and Uraninite and secondary minerals such as Carnotite, Becquekerite and Tyuyamunite have been recognized, but the concentration generally has been found to be weak.

From the results of the radon etch survey conducted during second year, high anomalous zones were detected in the area north of Zayda Granite where the P-T Red Sandstone Formation was thickly distributed, in the area north of Bou Mia Granite, and in the area north of Zayda, and the presence of sandstone type uranium deposits in P-T Red Sandstone Formations was expected in each area. Particularly, a high potential presence of useful mineral deposits was predicted for the

area north of Zayda Granite as a result of the geological and gravity surveys.

In the third phase survey, a radon etch survey was performed more densely in this area (an area of about 39 km^2), and diamond drilling of 31 drill holes was conducted with spacings from 500 to 1500 m, mainly within the anomalous zone. After drilling, each drill hole was subjected to gamma-ray logging, spontaneous potential logging and resistivity logging. Core samples were taken from drill holes in which anomalous value or mineral indication had been detected, and then microscopic observation and chemical analysis and x-ray microanalysis were conducted in order to clarify the uranium mineralization and to examine its relation to the anomalous zone detected by the radon etch survey. The results of this exploration indicated the presence of significant uranium mineralization in the arkose sandstone formations of P-T Red Sandstone Formation. Though these formations can be classified into the category of sandstone type sedimentary deposits, the grade of these deposits was low and their scale was small.

Since the reproducibility of this radon etch survey adopted in the uranium prospection for deep layer was found to be excellent, the effectiveness of the survey method adopted has been fully substantiated. However, some effects which seemed to be results of radon or radium located immediately below the ground surface were also observed. It has become clear that the gamma-ray logging in the drill holes can be used as an effective means of uranium prospecting and that resistivity logging can be used as an effective exploration technique for classifying formations and for detecting fractured zones. Importantly, the problems related to the radon etch survey were clarified, mainly

because the survey results were compared for analysis with the underground geological information obtained through diamond drilling performed simultaneously. It is extremely meaningful that the mechanism of the mineralization and radioactive anomalies in the surveyed area has been clarified by this comparison.

(4) From the results of 3 years of basic exploration, it was clarified that there is a potential presence of sandstone type sedimentary uranium deposits in the vicinity of this surveyed area. Since the mineralization of uranium and lead was frequently recognized in the white arkose sandstone formations, priority should be given to exploration for thicker formations of white arkose sandstone in future prospecting.

Also in the course of future exploration for similar kinds of ore deposits, it would be very beneficial to adopt the method of "preliminary survey + detailed survey + ore deposit prospection", in addition to the various other exploration methods which were adopted in the present exploration, to clarify the geological structure and mineralization, and to perform the exploration concentrically in the most promising areas.

In addition, since the anomalous values of the radon etch survey conducted in the surveyed area may occasionally reflect information derived from underground uranium deposits, it is still necessary to give due attention to the area north of Bou Mia and the area north of Zayda where anomalous values were detected, and also to the anomalous zones in the northeastern part of the surveyed area (areas which still exhibit a potential presence of ore deposits) when performing exploration in the future.

CHAPTER 1 INTRODUCTION

1-1 Circumstance of Survey

Morocco has a long history in the development of natural resources. The first cooperation between Morocco and Japan in exploration for the development of natural resources was the cooperative basic exploration in the Anti Atlas region from April, 1975 to April, 1977.

The Government of Morocco later requested Japanese co-operation for the explorations of several new areas. In response to this request, Japan dispatched a preliminary survey team to negotiate from April to May, 1978, and the governments concluded an agreement for joint the exploration in Haute Moulouya district of Morocco.

The purpose of this survey was to perform, with the cooperation for the Bureau de Recherches et de Participations Minieres (BRPM), a geological survey, gravity survey, radon etch survey and diamond drilling (including geophysical well logging) for a three year period, from September 1978 to February 1981, as well as to examine previous information, to select the most promising areas of prospection for each year by clarifying the geology and geological structure in the object area, and to establish a fundamental policy for the prospection and development in future.

1-2 Outline of Survey Works

The survey area has an area of 3,200 km^2, approximately 80 km long (east-west) and 40 km wide (north-south), as shown in Fig. 1. The survey area, survey method, quantity of survey, survey members and survey period for each survey year are shown in Tables 1 and 2.

Table 1 Summary of the Surveys (1978~1980)

Survey Method	Phase I (1978)		Phase II (1979)		Phase III (1980)	
	Area	Amount of Work	Area	Amount of Work	Area	Amount of Work
General Geological Survey	Haute Moulouya	3200 km^2				
Semi-Detailed Geological Survey	Zayda Eastern Part	400 km^2	Karrouchan Northeastern Part	221 km^2		
	Zayda-Bou Mia Part	500 km^2	Bou Mia Northern Part	21 km^2		
	Zayda Northern Part	200 km^2	Zayda Northeastern Part	48 km^2		
Detailed Geological Survey			Bou Mia Northern Part	2.5 km^2		
			Zayda Northeastern Part	2.8 km^2		
Geological Sketch of Ore Deposits	Mibladane, Hawli	2 mine				
Gravity Survey	Zayda Southern Part	400 km^2	Zayda Northern Part	400 km^2		
Radon Etch Survey			Zayda Northern Part	300 km^2 (673 cups)	North of Zayda Granite	39 km^2 (1,277 cups)
Diamond Drilling (Geophysical logging)			Tanfi Micha (MR-1) Itzar Basin (MR-2) Southern Central (MR-3) Itzar Basin (MR-4)	148.30m 265.95m 138.00m (375.10m)	North of Zayda Granite (MR-5 ∿ MR-35)	1126.20m (31 Holes)
(Period of Survey)	11 Sep. 1978 ∿ 18 Dec. 1978		8 May 1979 ∿ 18 Jul. 1979 26 Sep. 1979 ∿ 2 Nov. 1979		19 May 1980 ∿ 22 Jul. 1980 1 Oct. 1980 ∿ 25 Oct. 1980	

Table 2 Members List of the Surveyed Team (1978~1980)

	Phase I (1978)	Phase II (1979)	Phase III (1980)
Japan			
Coordinator & Administrator	Toshiaki Yamamoto	Mitsuru Suemori	Takeo Kuroko
	Yutaka Hatano	Kazunori Kano	
	Kazuhiro Chimura		Nobuhisa Nakajima
	Toyo Miyauchi		
	Kazunori Kano		
	Hisamitsu Moriwaki		
Chief of Mission	Junnosuke Oikawa	Junnosuke Oikawa	Kensuke Wakabayashi
Deputy-chief		Kensuke Wakabayashi	
Members: Geology	Fukio Kayukawa	Fukio Kayukawa	Shinichi Doi
	Kazuharu Umezu	Terumi Ishikawa	Katsumi Hayashi
		Hirotaka Nishimoto	Hirotaka Nishimoto
		Kazuyasu Sugawara	
Geophysics	Kazuhiko Kinoshita	Kazuhiko Kinoshita	
	Shigeji Asaoka	Shigeji Asaoka	
		Tomio Tanaka	
Drilling		Hiroyuki Ohga	Hiroyuki Ohga
Morocco	Rabah Bouchta	Rabah Bouchta	Rabah Bouchta
	Säid Barrakad	Säid Barrakad	Bachir Barodi
	M'hamed Annich	M'hamed Annich	Säid Barrakad
	Shigeru Matsutoya	Shigeru Matsutoya	M'hamed Annich
			Kiyoshi Takashima
			Shigeru Matsutoya

1-2-1 First Phase Survey

The first phase survey involved selecting a specific target area characterised by high potential presence of mineral resources, from the approximately 3,200 km^2 project site. Both a geological survey and a gravity survey were performed in the first phase. However, geological analysis was made using aerial photographs prior to field survey.

During the geological field survey, a rough geological survey was conducted with a route spacing of about 10 km for the whole object area, and a geological semi-detailed survey was also conducted with route spacing of 2 km for the eastern area of Zayda (400 km^2 in area) and one with route spacing of 4 km for the Bou Mia-Zayda area (500 km^2 in area) and the northern area of Zayda (200 km^2 in area). In addition, geological sketches for ore deposite were conducted for Mibladan Mine and Hawli Mine.

All survey results were plotted on a geological map 1/50,000 in scale, produced from a route map with the same scale. Important points were made up sketch maps with a larger scale after performing more detailed geological observation. In addition, for principal rocks and ore minerals, geochronological study, microscopic observation, chemical analysis of rocks and metal components were conducted to collect the necessary informations for study of the geological structure and mineralization in the surveyed area.

A gravity survey was conducted for the 400 km^2 (21 km long, east-west, and 19 km wide, north-south) target area at the southern side of Zayda village. In the actual field survey, gravity observation and levelling for a total of 654 measuring points spaced at an interval of about 500 m were conducted in the surveyed area. Data obtained during field measurement were corrected topographically and for other factors with computer, then a gravity contour map was prepared. Quantitative analysis was made using

filter analysis and simulation based on the gravity contour map, and underground structure in the surveyed area was predicted.

1-2-2 Second Phase Survey

A geological survey, gravity survey, radon etch survey and drilling were performed in the second phase survey for the target areas which more detailed survey had been determined to be necessary from the results of the first phase survey. Then the most promising areas (those with potential presence of ore deposits) were selected.

A semi-detailed geological survey was made for the northeastern part of Karrouchan, and a semi-detailed and detailed geological survey were performed for the northern area of Bou Mia and the northeastern area of Zayda.

In the gravity survey, the same method as in the first phase survey was adopted for the approximately 400 km^2 area located in the north of Zayda-Bou Mia Granite. Then the underground structure of the area was predicted.

In the radon etch survey, an area of about 300 km^2 in the gravity survey area mentioned above was explored. Track etch cups manufactured by Terradex Corporation (U.S.A.) were purchased and buried at measuring points spaced at 500 to 1,500 m on centers, and all cups were kept underground for 25 to 28 days. These cups were embedded at a depth of about 40 cm below the ground surface, and 673 cups out of 749 were effectively recovered, the remaining cups were broken or stolen by local residents. Recovered cups were then returned to Terradex Corporation for etching treatment and for counting of the number of tracks. Terradex's results and primary analysis report were then statistically processed and reexamined, considering the results of the geological survey to detect the anomalous zones.

In the diamond drilling, four drill holes, amounting to a total drilled length of 652.35 m, were made in the P-T Red Sandstone Formation of which the potential presence of lead and uranium deposits had been predicted; that is, hole MR-1 in the Tanfi-Micha area, holes MR-2 and MR-4 in Itzar Basin area, and hole MR-3 in the area east of Bou Mia. Hole MR-4 was further drilled by BRPM to a final depth of 375.70 m, all four holes were drilled to the basements. Sampled cores were subjected to core evaluation by the geologist, then microscopic observation, x-ray microanalysis and chemical analysis were performed for the portion ot cores of which mineralization and alteration had been recognized. Also, gamma-ray logging was conducted in each drill hole.

1-2-3 Third Phase Survey

In the third phase survey, a radon etch survey and diamond drillings were conducted in the north area of Zayda Granite for which more detailed survey had been determined necessary from the results of survey up to the second phase.

In the radon etch survey, the measuring points on the grid lines spaced at 100 to 250 m on centers in the area of about 39 km^2 described above were explored. Adopted survey and analysis methods were the same as those of the second phase. The mineralization was geologically examined by comparing the results to those of the previous year and to the results of diamond drillings performed in this phase. 1277 cups out of 1300 were effectively recovered.

In the drilling work, diamond drillings were performed at the points on the grid lines spaced at 500 to 1,500 m on centers mainly in the radon etch anomalous zones within the surveyed area. The number of drilled holes was 31 from holes MR-5 to MR-35 and the total drilled length of these

holes amounted to 1,126.20 m. Gamma-ray logging, spontaneous potential logging and resistivity logging (normal and micro) were performed in each drill hole, drilled cores were subjected to evaluation by geologist, and then microscopic observation, x-ray microanalysis and chemical analysis were performed for the core portion of which mineralization or alteration had been recognized.

1-3 Previous Surveys and Studies

There are many lead deposits in the surveyed area, and three mines at Mibladane, Hawli and Zayda are currently under exploitation. There are many survey reports and papers related to these mines which have been already published. The potential presence of uranium deposits in this area was first noted and recognized in the 1950's, and geological survey and pilot drilling by BRPM in the vicinity of Tarekochid in the northwestern part of the surveyed area began in 1975; the results of this survey were compiled in a report prepared by BRPM.

A geological map (scale: 1/500,000) for the entire territory of Morocco was completed in 1954, and many studies and surveys on the geological structure of the land have already been made and reported. These results were compiled by A. Michard (1976) and published as Elemente de Geologies, Marocaine.

The geological structure and geological history of the Haute Moulouya district were studies by J. Lorentz (1976), A.F. Mattis (1977),TECHNOEXPORT-USSR (1976), G. Dagallier (1977), J. Caia (1969), and D. Tisserant (1977) and reported with respect to the sedimentary mechanism and formation of ore deposits in the area concerned.

With respect to the surveys and studies on lead deposits in the area, a report on both the Mibladane and Hawli Mines was prepared by R. Bouchta

(1975) while the Zayda Mine was reported on by E. Amade (1965) and J.M. Schmitt (1976). With respect to the Zayda Lead Mine, the discussion on the genesis of lead deposits in the arkose sandstone at the bottom of P-T Red Sandstone Formation deposited in the paleochannel system arround the granite is still continuing since this formation is very unusual in nature.

The first systematic survey on uranium deposits was conducted by SOMAREM (Societe Marocain de Recherches et d'Etude Mineral) organized jointly by U.S.A. and France in 1953. Airborne survey was performed in this district, and geological survey for Assaka Ijdiy, Sidi Ayyad and other areas were also performed. However, these surveys were postponed from 1956, the year of Morocco's independence, to 1969. The survey, with collaboration by the United Nations and AIEA, began in 1970. The uranium indications for the all of Morocco were compiled and reported by J.H. Shepherd (1971), geological review of the potential uranium deposits in Morocco was reported by A. Durandou (1974), and uranium prospection activities became more active.

Several reports have been prepared for the Haute Moulouya district; Tarekochid area was reported on by R. Guerin (1977), Bou Mia area by M. Annich (1977), Sidi Ayyad area by R. Alaoui (1976), and Assaka Ijdiy area by H. EL Harsi (1976).

Some of the references and informative materials available concerning the geophysical survey are the Anomaly Map (scale: 1/500,000) for the entire territory of Morocco, the Report on Gravity and Magnetic Exploration in Haute Moulouya District, prepared by L. Solaini (1965), and the Report on the Survey of Deep Underground Structure in Haute Moulouya District, prepared by G. Tchernych (1977).

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CHAPTER 2. OUTLINE OF THE SURVEYED AREA

2-1 Topography

The surveyed area is located near the central region of Morocco; at 32°30' to 33°03' N. Lat. and 4°30' to 5°07' W. Long., Morocco. This area is within the administrative districts of Midalt County, Ksar es Souk Prefecture, Meknes Province.

The area is a peneplane with altitudes between 1,200 and 1,800 m, in a triangle area sandwiched by the High Atlas Mountains running virtually east-west through the central region of Morocco and the Moyen Atlas Mountains branched in the north-east direction from the High Atlas Mountains.

The High Atlas Mountains is the backbone range of the country, containing several peaks higher than 4,000 m above sea level and extending for a distance of 900 km from the coast of the Atlantic Ocean to Algeria. The Moyen Atlas Mountains runs trending in the north-east direction from Beni Mellal about 100 km west of the surveyed area, through the northwest region of the surveyed area, with a plateau at an altitude of about 2,000 m near the surveyed area.

The surveyed area topographically consists of a basin area having a terrace-shaped and a mountainous zone higher than 2,000 m in altitude surrounding it. The terrace-shaped topography has a terrace-like, or table-like feature composed of Tertiary or Quaternary formations, avoided errosion. The upper portion of the terrace has an altitude of 1,550 to 1,800 m, while the eroded plain portion has an altitude of 1,200 to 1,600 m. Bou Mia Granite and Zayda Granite area is forming a dome slightly higher than the surrounding plain.

The principal rivers are the Moulouya River flowing to the east through the center of the surveyed area, which forms steep valleys at

several places, and the Serreu River flowing through the western part of the surveyed area to the Atlantic Ocean, which forms cliffs at several places.

2-2 Climate and Vegetation

Morocco's weather greatly varies on each sides of the High Atlas Mountains. The northern side of the High Atlas Mountains has so-called Mediterranean weather, and is generally warm except the season of hot air blowing from the southern Sahara Desert, called "Sirrocco", in July and August. A considerable amount of rainfall in the lowland and snowfall in the highlands occurs due to winter depressions. The southern side of the High Atlas Mountains has less rainfall and dry weather and well developed steppe and desert.

The surveyed area is in a peneplane of the High Atlas Mountains, with relatively dry weather. Rainfall, humidity and temperature for the last 30 years, and 1977, in the surveyed area are shown in Table 3.

Vegetation in the surveyed area differs between the flat land in the basin and the mountainous area. In the flat land, needle-leaved stub-shaped grass about 50 cm high, peculiar to the dry land, thrives; trees are seen only in the wet zone along the rivers. In the mountainous area, pines and cedars grow densely but grass is very scarce.

Table 3 Climate in Midalt Area

(by Midalt meteorological station)

Month	Rain fall (m/m) 1949-1977 (year)	Temperature (°C) 1949-1978			1977			Humidity (%) 1977
		max.	min.	av.	max.	min.	av.	av.
1	12.5	19.5	-10.0	6.4	17.8	-4.7	5.8	64
2	18.9	26.1	- 6.9	7.7	20.1	-2.0	8.9	56
3	24.5	25.5	- 3.1	9.5	23.0	-0.5	11.7	43
4	44.3	27.6	- 3.8	11.3	24.9	-0.3	14.0	46
5	32.9	32.2	- 0.1	15.4	27.7	+1.4	14.4	49
6	25.2	34.6	+ 3.2	19.2	34.6	+3.2	18.3	34
7	6.8	36.7	+10.7	24.4	36.0	+10.4	22.1	42
8	7.0	37.2	+ 7.5	24.0	36.0	+7.5	22.4	33
9	19.3	33.7	+ 2.0	20.7	33.3	+9.0	19.4	50
10	14.2	29.3	- 1.2	14.7	25.4	+3.5	13.5	57
11	23.4	23.8	- 2.1	9.6	24.1	-2.5	10.5	38
12	13.6	21.1	-13.5*	5.9	19.2	-1.8	8.6	62
av.	20.2	-	-	14.1	-	-	14.1	48

Note: -13.5: minimum temperature in 1957*

max : maximum min : minimum av : average

2-3 Inhabitants and Industries

Principal cities and towns in the surveyed area are Midalt City (population: 56,500), Bou Mia town (population: 36,500) and Itzar town (population: 30,000), and most of the residents are Berber tribes. Arabians are the next most numerous, but very few foreigners live there.

The majority of the residents are devoted Moslems. Berber dialects are used in daily life, Arabic is the official language, and French is also used. A 6-year grade school is provided in each village to raise the general level of education, and 3-year junior high schools and 4-year senior high schools are located in Midalt City.

The main industries in the area are agriculture, stock farming and mining. Mechanization has been promoted in agriculture by introducing tractors and other equipment in recent years for cultivating wheat. The cultivation of fruits such as apples, pears and melons is increasing. Sheep are mainly raised on pasturage throughout the country, and textile production, through domestic cottage industries, also occurs.

In the mining industry, primarily lead mines are being developed and exploited in Zayda, Mibladane, Hawli and Sidi Ayyad, forming the major mining zone in Morocco.

2-4 Transportation

The surveyed area is situated approximately 230 km southeast of Rabat, the capital of Morocco. Access to the area is on paved road passing through Meknes. It takes about 5 hours by automobile to travel the approximately 300 km through Meknes to the area. There are regular buses making several round-trips daily between Rabat and Meknes and between Meknes and Midalt.

Principal villages in the surveyed area are connected by paved roads in addition to farming roads adequate for use by jeeps, which were formed by the tractors currently in wide use. Thus, transportation is convenient, but the mountain roads frequently cannot be used in winter because of snowfall. Local residents also use horses, donkeys and camels in addition to buses for transportation.

CHAPTER 3. OUTLINE OF GEOLOGY OF THE SURVEYED AREA

3-1 General Geology of Morocco (Fig. 2)

Most parts of African Continent began to turn to the stable Craton after the Pan-African Orogeny occurring from the end of Pre-Cambrian Period to the beginning of Paleozoic Era. However, the northwestern outer zone of the Craton including Morocco had remained exceptionally, as a mobile zone where the orogeny and geosyncline activities frequently occurred even after the Paleozoic Era. Orogeny and geosyncline activities in Morocco, from overall viewpoint, progressed step by step from the southern part of Morocco near the Pre-Cambrian Craton (Mauritania Craton) to the Mediterranean Sea in the north. Thus, the geological structure in Morocco can be generally calssified into three major units; Anti Atlas zone, Moyen Atlas zone and Rif zone on the coast of Northern Mediterranean Sea.

Anti Atlas zone is the Paleozoic geosyncline zone developed along the edge of Pre-Cambrian Craton and extends in the WSW-ENE direction for a distance of about 600 km from the coast of Atlantic Ocean southwest of the surveyed area to the area near the border to Algeria. This zone turned into rigid mass at the time of Hercynian orogeny from the end of Paleozoic Era to the beginning of the Mesozoic Era while the other zones in Morocco were subjected to the Alpine orogeny. The Hercynian orogeny is characterized by the relatively gentle upheaval of Pre-Cambrian basements and, at present, metamorphic, plutonic and sedimentary rocks of lower Paleozoic, Infra-Cambrian and Cambrian systems are widely distributed around the Pre-Cambrian system as a core which is cropped out at the center of the upheaval.

Atlas zone is the area containing both High Atlas and Moyen Atlas and table-shaped low land Meseta spreading the both sides of Moyen Atlas,

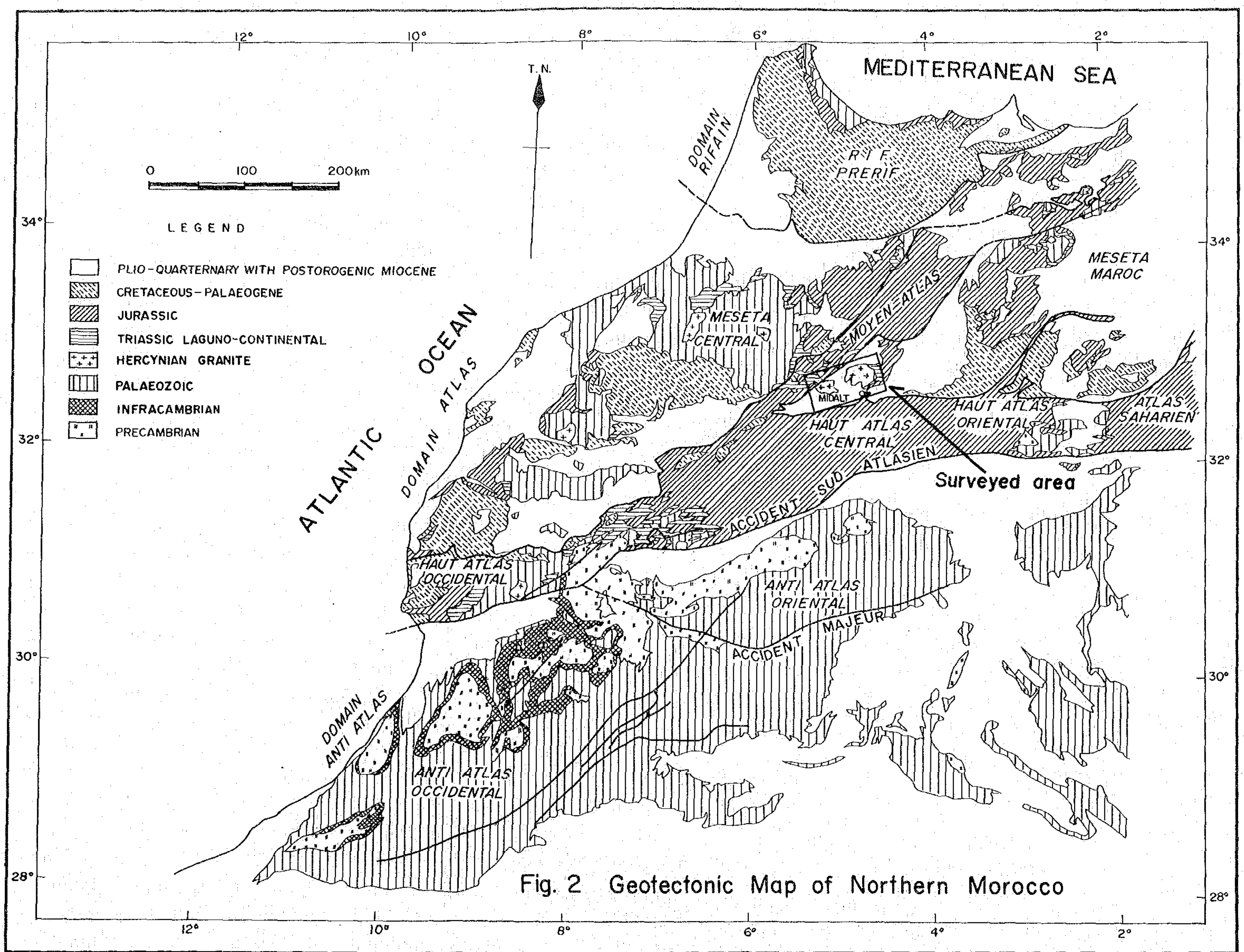
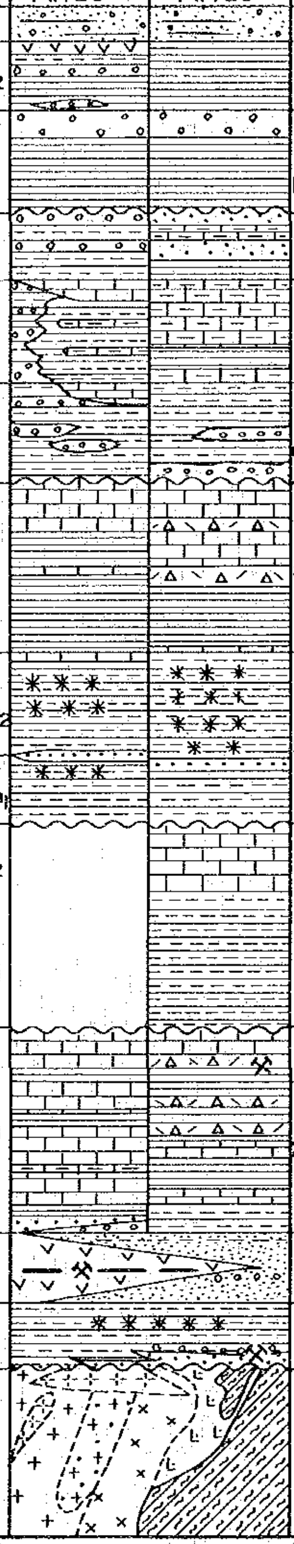


Fig. 2 Geotectonic Map of Northern Morocco



Era	Period		Formation	Thickness M.A.	Thickness H.A.	Description: Moyen Atlas	Description: Haut Atlas
Cenozoic	Quaternary		Q3			Terrace deposit	
Cenozoic	Quaternary	β_{Q2}	Q2 (M.A.), Q2 (H.A.)	15m ±	30m ±	Basalt (lava), calcareous conglomerate, sandstone, siltstone, calcareous siltstone.	Basalt (lava), conglomerate, siltstone, mudstone.
Cenozoic	Quaternary		Q1	25~100m	25~100m	Conglomerate, siltstone.	
Cenozoic	Tertiary		T3	45m ±	35m +	Calcareous conglomerate, calcareous siltstone, sandstone, marl, reddish brown siltstone-mudstone, sandstone.	Calcareous conglomerate, reddish brown siltstone-mudstone.
Cenozoic	Tertiary		T2	60m ±	70m	Limestone, yellowish grey siltstone-mudstone, marl, calcareous conglomerate.	Marl, limestone, siltstone.
Cenozoic	Tertiary		T1	40~60m ±	15m	Micritic limestone, light brown siltstone conglomeratic sandstone.	Light brown siltstone, conglomerate.
Mesozoic	Upper Cretaceous	Turonian	K2t	80m ±	140m ±	Limestone included molluscas and brachiopods, calcareous siltstone included molluscas.	Micritic limestone, muddy siltstone, calcareous siltstone, turbidite.
Mesozoic	Upper Cretaceous	Cenomanian	K2cm (K2cm2)	50m	90m ±	Limestone included molluscas, calcareous siltstone, poly-colored siltstone intercalated with gypsum beds, sandstone, conglomerate.	Siltstone intercalated with gypsum beds.
Mesozoic	Upper Cretaceous	Cenomanian	K2cm (K2cm1)		20~40m		Alternation of red mudstone, shale, sandstone and limestone.
Mesozoic	Middle Jurassic	Dogger	J2d2		50m		Alternation of limestone and thin shale included shell fossils.
Mesozoic	Middle Jurassic	Dogger	J2d1		170m ±		Grey mudstone.
Mesozoic	Lower Jurassic	Lias	J1	0~250m	230m ±	Limestone included coral fragments, calcareous siltstone, marl, sandstone, conglomerate.	Thick limestone, intercalated with Mibladane Pb-Ba ore deposit. Calcareous to sandy siltstone intercalated with turbidite, limestone, dolomite.
Mesozoic	Permo-Triassic		β_{P-T}	0~200m		Basalt (lava), sandstone, conglomerate. Manganese ore bed, coaly shale.	
Mesozoic	Permo-Triassic		P-T	30~300m		Red sandstone, arkose sandstone, granule conglomerate, siltstone, mudstone, partly turbidite, gypsum beds. U. mineralization, Zayda Pb-Ba ore deposit.	
Proterozoic - Paleozoic	Precambrian -Paleozoic		Basement complex			Granite, contaminated granite, porphyritic granite, aplitic granite, granodiorite. Dykes (aplite, granite porphyry). Metamorphic rocks (chlorite-sericite schist, quartz-sericite schist, amphibole schist, amphibolite).	

Fig. 3 Schematic Geological Column of the Surveyed Area

and is separated from the Anti Atlas zone by the South Atals Fault. This zone is the Mesozoic geosyncline area developed over the Pre-Cambrian and Paleozoic basements and became a land as a result of Tertiary Alpine Orogeny. However, geology and geological structure considerably vary in mountainous region and Meseta. Namely, the mountainous region was probably located at the center of the sedimentary basin in the Mesozoic geosyncline, and the occurrence of almost continuous sedimentation throughout the Mesozoic Era in this region is presumable. On the other hand, in the Meseta, the sedimentation was probably taken place intermittently and less significantly because the basements were cropped out in very wide area. Also, while the folded mountains higher than 3,000 m in altitude were formed at the central part of geosyncline during orogeny, the Meseta at the edge of geosyncline was subjected only to weak deformation.

Rif zone is the Tertiary mio-geosyncline zone formed over basements of Paleozoic and Mesozoic, and seems to be part of the Alpine orogeny zone running through South Europe in the view of its geological structural features. This zone was repeatedly subjected to strong push-up stress from north to south during Alpine orogeny, resulting in the formation of arc-shaped folded mountains along the coast of Mediterranean Sea and the significant development of thrust faults.

3-2 General Geology of the Surveyed Area (PL.1, PL.2, PL.3, Fig. 3)

The object area of this survey is located in the central eastern part of Atlas zone within the delta zone where the High Atlas and Moyen Atlas are branched, and will correspond to the western end of Meseta Oranaise. The surveyed area can be classified into three zones; structurally stabilized low land basin in the central part, Moyen Atlas zone in northwestern mountainous region, and High Atlas zone in the southern part.

Rocks distributed in this area are the basements consisting of crystalline schists and granitic rocks which are overlain by Permian and Triassic Red Sandstone Formations as well as Mesozoic, Tertiary and Quaternary sedimentary and eruptive rocks.

Crystalline schists are mainly distributed in eastern part of the surveyed area and crop out in small scale in the western part. These rocks consist of chlorite-sericite schist, amphilolite schist, and quartz-sericite schist interbedded with amphibolite. The crystalline schists in the eastern Hawli are distributed in an area of about 20 km by 10 km, indicating a dome-like folded structure extended in the northeast direction. These schists are considered to be formed during the Pre-Cambrian to Paleozoic Age.

Granitic rocks are closely related to the intrusion during Hercynian orogeny and distributed in the area east of Zayda village and the north-west of Bou Mia village, so that they are called Zayda Granite and Bou Mia Granite respectively. These rocks can be classified into granite, porphyritic granite, aplitic granite, granodiorite and migmatite.
Aplitic granite indicates slightly higher values of radioactivity than other granites, and occurs in gently dipped sheet-like or dyke-like formation.

Permian and Triassic P-T Red Sandstone Formation gently dips, is distributed near the basements and consists of, from bottom to top, conglomeratic coarse-grained sandstone formation, coarse and fine-grained sandstone formation, fine-grained sandstone and mudstone formation, and mudstone formation. Conglomeratic coarse-grained sandstone formation has the thickness of about several dozen meters at the valley of basements and in the northwestern part of the surveyed area but is absent on the saddle part of basements and southern and eastern parts of the surveyed area.

There was an eruption of β_{P-T} basalt formation about 150 m thick at the final stage of Permian and Triassic, and this basalt cropped out in the northwestern and northeastern parts of the surveyed area. Most of basalt consists of basalt lava but, in certain parts, black shale formation, sandstone formation and conglomerate formation are also contained.

Jurassic sedimentary rocks consist of Lias limestone formation distributed in northwestern and eastern parts of the surveyed area, and Dogger mudstone formation and alternating limestone and shale formation distributed in small scale in the southern part.

Jurassic sedimentary rocks are distributed alsmot in every part of the surveyed area and directly overlain P-T Red Sandstone Formation in the central part. These rocks are mudstone in the lower formation and also limestone in the upper formation.

Cenozoic formations consist of Tertiary and Quaternary Systems and are generally distributed in the central part of basin. Tertiary System has been classified into 3 formations of T_1, T_2 and T_3, and the Quaternary System into 4 formations of Q_1, Q_2, β_{Q2} and Q_3.

Features, structures and geochronology of each of these geological units will be described hereinafter.

3-2-1 Crystalline Schists

These rocks generally have dark green color and schistosity, and the texture of original rock hardly remains because of the metamorphism. Particle size of minerals of the rocks is fine-grained with about 1 mm, but some of amphibolite has coarse-grained crystals, each about 5 mm large. Weathering has been generally developed along the schistose plane of this rock, and the rock tends to be easily broken flat. Weathered surfaces have silver-gray color because of mica, and weathered soil is red-brownish

in color.

From the composition of minerals, it is considered that the original rocks of these crystalline schists were muddy rock, sandy rock and basic igneous rock. Also, according to the age determination of the Rb-Sr method conducted by D. Tisserant (1977), age of metamorphism of these rocks is from upper Devonian to middle Permian, which is the same as the period when the granite was emplaced. Palaeontologically, no fossil has been found in these rocks. Thus, though the geological age of original rock is unknown, these rocks are considered to be formed during Paleozoic to Pre-Cambrian.

3-2-2 Granitic Rocks

Both Zayda Granite and Bou Mia Granite form almost round independent hilly zones approximately 100 to 200 m high above nearby area. However, from the results of analysis of drilling and gravity survey conducted in an intermediate area between both granites, it was confirmed that both granites, were the same continuous formation. The features of these granites will be described as follows.

(1) Granite

This rock has white to pink color and is an equally coarse-grained massive bodies containing phenocryst of orthoclase with 4 to 5 mm size. This granite forms the main portion of the granites and seems to gradually turn into other massive granitic rocks.

(2) Porphyritic granite

This rock is distributed in the belt form, 1 to 2 km wide and several km long. The characteristics of this rock are the orthoclase about 2 to 3 cm large arranged with certain directivity. Principal minerals of this rock are quartz, orthoclase, plagioclase and biotite, as same as the granite stated above.

(3) Migmatite

This rock is distributed mainly in the area near the contact zone with crystalline schist. This rock has a slightly dark green color in comparison to granite and equigranular crystals with 2 to 3 mm particle size. It also contains many xenolith, each 1 to 2 m in size, arranged without directivity. It mainly contains minerals such as quartz, orthoclase, plagioclase and biotite in addition to a few amphibolite. Plagioclase richly contains calcium compared to the granite.

(4) Granodiorite

This rock intruded in crystalline schist over an area of 6 km by 3 km crops out in the Sidi Ayyad area in the northeastern part of the surveyed area. This has a dark green color and is dense massive rock containing fine-grained crystals, each about 1 to 2 mm large. It contains minerals such as quartz, plagioclase, biotite and amphibolite, but only few quartz is contained and cannot be recognized by naked eyes. This rock also contains a number of small pieces of clystalline schist and has some relationship with the migmatite stated above.

(5) Aplitic granite

This rock sometimes has stock-shape but generally has gently dipped sheet shape and is distributed in the granite zones described before. Texture is holocrystalline and fine-grained, but pegmatitic large bodies containing crystals of feldspar, quartz and muscovite, each several cm in size, are frequently included. The portion contacting to granite has gradation without clear boundary. It has white to pink color and mainly contains minerals such as quartz, orthoclase, plagioclase, muscovite and biotite. This indicates that this rock has mineral assemblage formed at the final stage of differentiation of granite. Also, this rock tends to indicate gamma-ray intensity about 30 to 50 c/s higher than that of

other granite, so that the distribution of this rock is important when determining the original rocks of sedimentary uranium deposits.

(6) Dykes

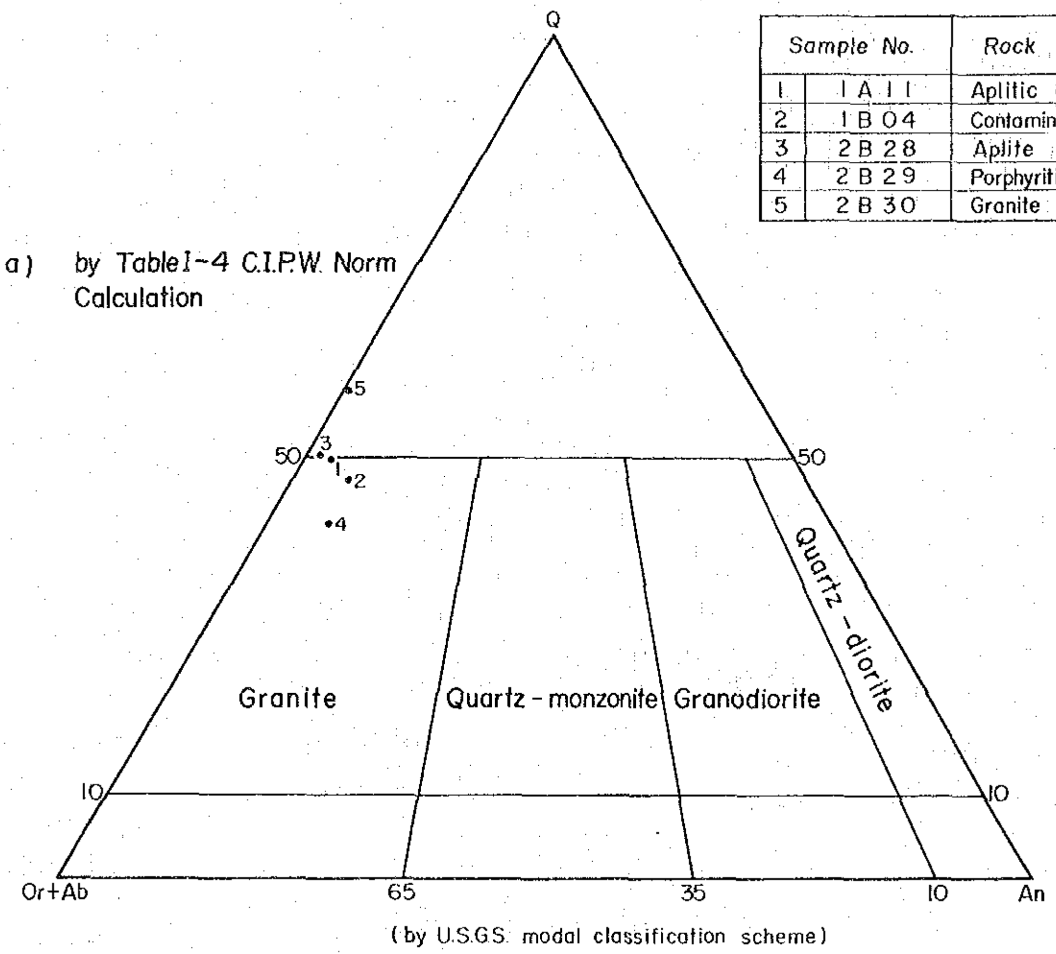
Dykes intruded into crystalline schist and granitic rocks are usually aplite, granite porphyry and fine-grained granodiorite. Aplite dyke is generally 50 cm to 4 m wide and has almost vertical dip. Quartz vein or pegmatite vein is frequently accompanied by the dykes. These dykes are radially distributed in the granites. Gamma-ray intensity in the dykes is not so high and is about the same as that of granite (100 c/s). The dykes of granite porphyry have milky white to brown color and phenocrystes of orthoclase and quartz, and their matrix is holocrystalline consists of medium to fine-grained quartz, orthoclase, and plagioclase. Their gamma-ray intensity, though it is detected less frequently than aplite dykes, is 30 to 50 c/s higher than that of granite, so that they are very closely related to the vein-like uranium indications in this area. Fine-grained granodiorite is seen in the granodiorite zone of the Siddy Ayyad area, and is black fine-grained dense rock. Minerals mainly consist of plagioclase, biotite, amphibole and quartz. Also, fault-type fissures accompanied with quartz vein are well developed along the dykes of this rock and radioactive anomaly is present in such fissures.

Analysis values and calculated norm values of granitic rocks containing the above dykes are shown in Table 4. Also, the triangle diagram showing these calculated values and calculated mode values is shown in Fig 4, from which it is considered that granite, aplitic granite, porphyritic granite and migmatite can be classified into alkaline granitic rocks.

According to the results of age determination by D. Tisserant (1977), granodiorite has an age of $336 \pm 6 \times 10^6$ years, and granite has an age of

Table 4 C.I.P.W. Norm Calculation

Sample No. / Rock Name / Normative Minerals	1. (1A11)		2. (1B04)		3. (2B28)		4. (2B29)		5. (2B30)	
	Aplitic granite		Contaminated granite		Aplite		Porphyritic granite		Granite porphyry	
	wt.(%)	mol.(%)	wt.(%)	mol.(%)	wt.(%)	mol.(%)	wt.(%)	mol.(%)	wt.(%)	mol.(%)
Q	47.54	85.60	44.11	82.28	47.38	85.27	37.77	76.77	53.67	86.67
C	3.31	3.51	4.11	4.52	3.83	4.06	4.31	5.16	5.54	5.27
Or	27.18	5.28	26.83	5.40	26.53	5.15	22.76	4.99	30.96	5.40
Ab	18.26	3.77	16.53	3.53	19.38	4.00	23.64	5.51	7.62	1.41
An	2.20	0.85	5.30	2.14	1.43	0.55	5.69	2.50	0.12	0.04
Salic total	98.49	99.02	96.89	97.88	98.55	99.03	94.16	94.93	97.90	98.79
En-Hy	0.25	0.27	0.43	0.48	0.25	0.27	1.62	1.97	0.18	0.17
Fs-Hy	0.24	0.19	0.57	0.49	-	-	1.80	1.67	-	-
Mt	0.82	0.38	1.19	0.57	0.51	0.24	1.36	0.71	0.44	0.19
Hm	-	-	-	-	0.53	0.36	-	-	0.80	0.48
Il	0.17	0.12	0.66	0.49	0.12	0.08	0.75	0.61	0.50	0.32
Ap	0.02	0.01	0.26	0.09	0.05	0.02	0.31	0.11	0.19	0.06
Femic total	1.51	0.98	3.11	2.12	1.45	0.97	5.84	5.07	2.10	1.21
Q+Or+Ab+An	95.18		92.77		94.72		89.86		92.37	
Q	49.95		47.55		50.02		42.03		58.10	
Or+Ab	47.74		46.74		48.47		51.64		41.77	
An	2.31		5.71		1.51		6.33		0.13	



Sample No.		Rock name
1	1 A 1 1	Aplitic granite
2	1 B 0 4	Contaminated granite
3	2 B 2 8	Aplite
4	2 B 2 9	Porphyritic granite
5	2 B 3 0	Granite porphyry

Fig. 4 Classification of Granitic Rocks

Table 5 K-Ar Age Determination of Granitic Rocks

Sample No.	Rock Name	Location	Mineral	$Ar^{40}R/K^{40}$	Age (m.y.)	Argon Analysis			Potassium Analysis		
						$Ar^{40}R$, ppm	$Ar^{40}R$/Total Ar^{40}	Ave. Ar^{40}, ppm	K, %	Ave. K, %	K^{40}, ppm
1A11	Aplitic granite	Zayda	Biotite	0.01904	300 ± 11	0.1625 0.1620	0.853 0.891	0.1623	7.135 6.837	6.986	8.522
1B04	Contaminated granite	Tighbouba -n-Ouzour	Biotite	0.01954	307 ± 11	0.1402 0.1447	0.929 0.887	0.1425	5.794 6.159	5.976	7.291
2B29	Porphyritic granite	Bou Mia	Biotite	0.01943	306 ± 11	0.1552 0.1595	0.942 0.821	0.1574	6.618 6.656	6.637	8.097

Constants Used

$\lambda\beta = 4.72 \times 10^{-10}$ /year

$\lambda e = 0.585 \times 10^{-10}$ /year

$K^{40}/K = 1.22 \times 10^{-4}$ g./g.

$$Age = \frac{1}{\lambda e + \lambda\beta} \, \ell n \left[\frac{\lambda\beta + \lambda e}{\lambda e} \times \frac{Ar^{40}R}{K^{40}} + 1 \right]$$

Note: $Ar^{40}R$ refers to radiogenic Ar^{40}.

m.y. refers to millions of years.

$316 \pm 17 \times 10^6$ years. Results of measurement by K/Ar method in this time show the ages in the ragne of 300 to $307 \pm 11 \times 10^6$ years as indicated in Table 5.

3-2-3 Permian and Triassic Systems

(1) P-T Red Sandstone Formation

This formation consists of red-brown sandy sediments, and can be roughly divided into coarse-grained sandstone layer, medium-grained sandy layer and fine-grained muddy layer from bottom to top.

The lithology of the coarse-grained sandstone layer reflects the geology of hinterland as supply the pebbles. Thus, the layer mainly consists of fragments of quartz, feldspar and granite in the area where granitic rocks are distributed, and also the fragments of quartz, feldspar, mica and crystalline schist in the area where the crystalline schist is distributed. The grain size is generally 2 to 3 mm, but sometimes coarse-grained pebbles with grain size of several cm or boulders with diameter of about 1 m are accompanied directly above the basements. Generally, the degree of consolidation is good and formation is dense, hard and white to yellowish white in color. Also, cross-bedding, ripple marks and sole marks are frequently observed in this layer.

Medium-grained sandy layer has alternating reddish brown medium-grained sandstone and fine-grained sandstone interbedded with thin layers of mudstone, marl and conglomerate. Most of particles in the sandstone are quartz, and its grain size is 1 to 2 mm. It has a good degree of consolidation and also the cross-bedding.

Fine-grained muddy layer mainly has reddish brown siltstone partly interbedded with mudstone, marl and gypsum formation. The degree of solidification is good but rock easily cracks, creating bead-like fragments.

This layer covers the basements in unconformity. Its thickness varies depending upon the location and reaches to 150 m maximum in the Karrouchan Basin and also to about 50 m in the plain at the center of which both Zayda and Bou Mia Granites are located.

Partial decolorization due to permeance of groundwater after the sedimentation of formation is frequently observed in this layer, and also grayish white spots well developed along joints and bedding planes are frequently seen

(2) β_{P-T} Basalt Formation

Though this formation mainly consists of basalt lava, in some area basalt lava is thined and is replaced by red sandstone. Occasionally, coal formation exists under the lava, and the lava contains thin layers of black shale, gypsum formation and ferromanganese silicate ore bed. Basalt lava shows dark green hard rock facies, and has partially developed vesicle and oxidized zones. Olivine can be observed by naked eyes and the whole formation shows chloritization. At the portion where the vesicles are developed, the vesicles are filled up with chlorite and milky white quartz.

Red sandstone is the medium-grained sandstone consisting of particles of basalt. Black shale has dark black color, good degree of consolidation and thin layer about 5 to 10 cm thick. Gypsum layer about 2 to 3 cm thick is developed in the oxidized zone of the basalt lava.

This formation directly covers conformablly P-T Red Sandstone Formation. Its thickness varies depending upon the location and is about 1 m in the area north of Zayda in eastern part of the surveyed area. However, it becomes more than 100 m in Hawli area further east of the surveyed area. Also, it becomes thick again near the Karrouchan Basin in western part of the surveyed area and reaches to 150 m at its western end.

3-2-4 Jurassic System

(1) J_1 Limestone Formation

This formation mainly consists of limestone interbedded with calcareous siltstone and sandstone. In some areas, red conglomerate and brown mudstone are accompanied in lower level. Limestone shows yellowish white, hard rock facies and contains shell fossil. Calcareous siltstone has yellowish white, and sandstone shows a high degree of consolidation and is light reddish brown medium-grained. Red conglomerate consists of pebbles of basalt and brown sand, which are rounded and 3 to 4 cm in size.

This formation conformably overlies Permian and Triassic Systems. Its thickness varies locally, reaches to 120 to 180 m in the area north of Midalt, to 270 m in the area east to Hawli, and gradually decreases to the north of Sidi Ayyad. Thickness also amounts to 180 m maximum at Bou Mia and Karrouchan, and to 80 to 140 m in the area south of Bou Mia Granite.

With respect to strike and dip of the formation, it has the strike of ENE-WSW and dips south from Midalt to Mibladane, and the both are almost horizontal from east of Hawli to Sidi Ayyad and from Bou Mia to Karrouchan Basin. However, to the area northwest of Itzar, fold structure having an axis of NE strike is seen while the formation occasionally dips south at the southern part of Bou Mia Granite and dips north at the southern end of the surveyed area.

(2) J_2d_1 Mudstone Formation

This formation mainly consists of gray mudstone. Calcareous shale layers, each 10 to 20 cm wide, interbedded in the upper part of this formation. Mudstone has massive shape without bedding and frequently cracks resulting in fragments of bead-like shape. Gray-colored mudstone

is frequently seen in the southeastern of the surveyed area, and reddish brown mudstone in upper layer is well developed in the south of Bou Mia.

This formation conformably overlies J_1 limestone formation. The distribution of this formation is limited to southeastern part and southern end part of the surveyed area. Its thickness is greater than 60 m in the southeastern part and is about 80 m in the southern end part. This formation strikes NE-SW and dips northwest or southeast with an angle of about 10°. In the south of Midalt, this formation has anticline structure with axis in the NE-SW direction and gently waves.

(3) J_2d_2 Limestone Formation

This formation mainly consists of limestone but it contains many layers of siltstone, mudstone and marl in the upper portion. Limestone has gray to light brown color, and siltstone is calcareous and has light brown color. Both mudstone and marl has gray color. This formation crops out in the area south of Midalt and in the southern end part of the surveyed area. The former abundant contains mollusca and ammonite fossils.

This formation unconformably covers J_2d_1 mudstone formation. Its thickness is about 60 m in the area south of Midalt, suddenly becomes smaller as it runs toward east, and it gradually disappears at a point about 3 km away eastward. This formation tends to have similar strike and dip to those of J_2d_1 mudstone formation and has anticline structure with axis of NE-SW direction in the area south of Midalt.

3-2-5 Cretaceous System

Cretaceous System in this area consists of K_{2cm} mudstone formation of Cenomanian Stage and K_{2t} limestone formation of Turonian Stage. K_{2cm} mudstone formation can be divided into K_{2cm1} red mudstone formation

and K_{2cm2} mudstone formation in the southeastern part of the surveyed area.

(1) K_{2cm} Mudstone Formation

This formation mainly consists of various colored soft siltstone associated with red sandstone, mudstone and limestone as well as gypsum layers accompanied. Siltstone consists of alternating formations which is green, reddish brown, yellow and white in color, and occasionally has thick gypsum layers. Sandstone mainly consists of red to brown-colored, medium to fine-grained sandstone and occasionally of thin layers of yellow or white fine-grained sandstone. Limestone is clayey and yellowish white to light red in color and is interbedded as the thin layer, 1 to 4 m thick, within the siltstone or sandstone.

This formation unconformably covers on Permian, Triassic and Jurassic Systems. This is distributed in the eastern part of Zayda, in the areas north and southwest of Bou Mia Granite, and in the area northwest of Itzar. It is 40 m to 60 m thick and distributed almost horizontally. In the area west of Itzar, there is a syncline structure formed as a result of fault movement, and the formation has trending of NE-SW and dips northwest and southeast with an inclination of about 10 to 30°.

(2) K_{2cm1} Red Mudstone Formation

This formation mainly consists of reddish-brown mudstone interbedded with white to brown fine-grained sandstone, and also contains conglomerate and limestone in its upper port. Mudstone has rock facies almost equal to that of reddish-brown siltstone and mudstone of P-T Red Sandstone Formation. Cross-bedding is frequently seen in the fine-grained sandstone. Fossils are rarely found.

This formation unconformable overlies J_1 limestone formation and J_{2d1} mudstone formation. Distribution of this formation is bounded to the

southeastern part of the surveyed area. Its thickness is about 40 m but tends to become thin eastward, and is about 10 m at a point about 5 km south of Hawli. This formation strikes ENE-WSW and dips north or south with an angle of 3° to 10°, and has anticline structure with axis in the NE-SW direction to the southeast of Midalt.

(3) K_{2cm2} Mudstone Formation

This formation is conformable overlying K_{2cm1} red mudstone formation. Its lithology is similar to that of K_{2cm} mudstone formation. It has the largest thickness greater than 70 m in the south of Mibladane. Its strike and dip are the same as those of K_{2cm1} and the feature of this formation shows the gentle waving and the fold structure.

(4) K_{2t} Limestone Formation

This formation mainly consists of calcareous siltstone and limestone occasionally interbedded with sandstone. Calcareous siltstone generally has white to yellowish white, hard rock facies with well developed bedding plane. Two types of limestone are in existence; yellowish white limestone, and white to yellowish white miclite limestone. Sandstone is yellow fine-grained silty sandstone, and muddy turbidite containing limestone nodules and breaccias is also seen in some places. Mollusca fossils are frequently seen throughout the formation.

This formation conformably overlies K_{2cm} mudstone formation. It is distributed in the area near Bou Mia Granite, and southeastern part of the surveyed area and Assaka Idjiy. Its thickness is about 80 m for the former and 135 m for the later. Generally, it has almost horizontal bedding plane, and has basin structure near Itzar and slight fold structure with the axis of NE-SW in the southeastern part.

3-2-6 Cenozoic Era

According to the report by E. Amade (1958), the geology of Cenozoic Era in the surveyed area consists of lake type formations of Miocene-Pliocene of Tertiary and Quaternary Systems. Generally, the Tertiary formation gently dips closely to horizontal from Moyen Atlas mountains north of the surveyed area to the center of the basin and covers the lower formation unconformably. Quaternary formation is distributed throughout the whole area and very gently dips from the southern part of the High Atlas mountains to the center of the basin.

The higher plane forming the encircling part of the basin in the surveyed area consists of diluvial sediments of Tertiary and Quaternary, and the alluvial sediments are deposited in river side and lowland in the southern part of the basin.

(1) Tertiary System

Tertiary system can be calssified, from bottom to top, into T_1 mudstone formation, T_2 marl formation and T_3 sandstone formation.

T_1 mudstone formation mainly consists of reddish brown, slightly soft mudstone which has rarely the bedding plane. However, in the northern part, miclite type limestone formation about 15 m thick is located at the highest level while interbedding of conglomeratic sandstone formations is frequently seen at the side of Moyen Atlas mountains. This limestone formation is about 60 m thick in the western part, 40 m thick in the northern part and 15 m thick in the central part of the basin, and unconformably overlies the all lower formations.

T_2 marl formation has gray or yellowish white color, and mainly consists of silty hard marl containing many pebbles of limestone. It partly contains thin layers of siltstone and limestone which frequently change to conglomerate formations along the Moyen Atlas mountains in the

north of Itzar. This formation is distributed in the same location as that of T_1 mudstone formation. Its thickness is about 60 m in the northern part and 70 m in the central part of the basin, so that the deposit is almost horizontal. It is conformable overlies T_1 mudstone formation of the lower formation.

T_3 sandstone formation has gray or yellowish gray color and consists of hard siltstone, sandstone and mudstone where the bedding plane frequently developed. Calcareous conglomerate formation is frequently interbedded at the foot of Moyen Atals mountains. This formation is about 45 m thick and is conformable with T_2 marl formation.

(2) Quaternary System

Quaternary System can be classified, from lower to upper, into Q_1 silt formation (diluvium), Q_2 silt formation (alluvium) and Q_3 river deposit. It also contains β_{Q2} basalt formation as eruptive rock.

Q_1 silt formation consists of alternating siltstone layers of light yellow, green and brown colored in the lower part, and alternating siltstone and gravel layer in the upper part. However, gravel and sand frequently interbedded even in lower part at the foot of the mountains and occasionally only the conglomerate is in existence. The thickness of this formation is 150 m maximum and it unconformably covers the all lower formations.

Q_2 silt formation mainly consists of white to brown siltstone with slight bedding plane. In a rare case, interbedded conglomerate formation is cemented by calcareous materials. Its thickness is normally 20 m and this formation unconformable overlies the all lower formations except Q_1 silt formation.

Q_3 river sediments are the newest sediments distributed along all rivers in the basin, and mainly consist of siltstone, sandstone and

conglomerate.

β_{Q2} basalt lava is located at a place about 20 km in the north-northeast of Zayda, and corresponds to the southern end of about 10-km long lava flow having the crater in Moyen Atlas mountains to the north of the surveyed area. It forms a round lava hill about 1 km in diameter in a place about 5 km northeast of Zayda. Also, the similar table-like lava flow corresponding to the highest level of topography is recognized in many places such as an area about 7 km southwest of Zayda and an area 3 km east of Bou Mia. This lava has fine-grained hard rock facies with well developed vesicles. Olivine is also occasionally recognizable in the filed observation. This lava covers Q_2 silt formation and partially contains round pebbles exposed on the ground surface as a result of extrusion of lava.

3-3 Geological Structure

3-3-1 Outline of Geological Structure

Geological structure of this area is characterized by the distribution form of the basements, the sedimentary mechanism of sedimentary rocks formed after Hercynian Orogeny and the fault structures cutting these formations.

Granitic rocks of the basements crop out in an area of 400 km^2 to the east of Zayda and in an area of 300 km^2 to the west of Bou Mia. But, from the results of geophysical explorations performed in the past, they are probably distributed in the form of an ellipse extending in the direction of N75°E, approximately 30 km wide in the north-south direction and 60 km long in the east-west direction including the both areas stated above. In early sedimentation stage of Permian and Triassic Periods, a trough zone running in the north-east direction was formed in

Moyen Atlas northwest of the surveyed area. The formation of this trough zone also resulted in the development of many parallel faults with the same direction running through the surveyed area, which means that the valley-like structure was probably formed along these faults as a result of the progress of erosion of the basements.

P-T Red Sandstone Formation is formed by the fragments of weathered and eroded basements along the rivers and low land of the basements under the continental environment. The sedimentation in this area tends to direct to the trough zone at the northwestern side stated above (Karrouchan sedimentary basin). Particularly, the arkosic sandstone and granule conglomerate at the bottom of the formation are more widely distributed in the north of the central granite, tend to have the thickest formation in the southeastern part of Karrouchan sedimentation basin, and also tend to become thicker in the area of valley-like structure of the basements.

β_{P-T} basalt formation was extruded under the on-land environment or under the environment containing lakes partially. Shallow-sea phase took place during Lias Jurassic, and a trough developed in the southern High Atlas during Dogger Jurassic. However, even during this period, part of basements including the central granite zone still remained as islands. Thus, the distribution and rock facies of these formations have the features reflecting these sedimentary environment.

Sedimentary rocks of the middle part of Cretaceous system indicates almost horizontal sedimentary structure and surround the centeral hilly land of the basements, indicating the occurrence of new transgression in this period and of submergence of whole area below sea level.

In Miocene Epoch of Tertiary, after receiving compressive forces in the north-south direction and regression due to the Alpine orogeny, the deformation such as uplifting, folding and faulting occurred in both Moyen

Altas and High Atals regions. In the central basement zone, fault system mainly running in the direction of N30°E had developed and then mainly progressed the block movement. Tertiary sedimentation during this period occurred under the inland basin environment.

Granites reappeared on the ground surface in Quaternary Period and the erosion took place and new rivers were formed.

3-3-2 Fault Structures

Elliptic Granites located in most part of the surveyed area and its vicinity, about several km from the area, probably have been turned into the rigid mass. Then, the following three groups of faults have been developed around the rigid mass of the basements:

(1) Fault in the NE-SW direction passing through Ait Oufalla east of Itzar, and Sidi Yahia about 4 km east of Karrouchan in the north-western part of the surveyed area.

(2) Fault almost in the direction of N80°E (tentatively called "Haut Atlas Northside Fault") along the southern edge of surveyed area, which is almost equal to northern limit of High Atlas region.

(3) Amhrou fault in the direction of N50°E passing near the southeastern Mibladane.

These fault lines are almost parallel to the Permian and Triassic trough structure in Moyen Atlas region, the Mesozoic trough structure developed in High Atlas region and its branched trough structure north-eastward. All of which are located around the central basements body, that is, these faults seem to be reformed along the weak lines in the basement body during Tertiary Alpine orogeny.

In addition to the above faults confining the vicinity of the surveyed area, many faults have been developed in the direction of N30°E

on the central basements. All faults are distributed almost in parallel to each other at 3 to 4 km apart and extend almost ten and several km. Ilich Agougagh Fault Zone has a fractured zone about 400 m wide, by which the Cretaceous formation was depressed at its southern end portion. Thus, these faults seem to be formed during Alpine orogeny after Cretaceous Period. These faults tend to run in the N-S direction in the western Bou Mia Granite and to run across the Cretaceous formation. However, their relation to the Tertiary formation is unknown.

Various kinds of these faults mostly tend to have vertically dis-location and only few of them indicate obvious horizontal transition. Particularly the faults running in the direction of N30°E and NS show this tendency, indicating the trace of transition to the south at the western side of these faults.

In the basements, granite porphyry dykes, closely related to the uranium mineralization, and quartz-barite veins, closely related to the lead mineralization, are observed at many places. The former runs in the direction of N20°E to N40°E in the area northeast of Zayda and of N10°W in the area southwest of Bou Mia. On the other hand, the later runs in the direction of N50°E as in the case of Henri dyke in the eastern part and in the direction of EW in the southern part of Sidi Ayyad and Zayda Granite.

3-3-3 Basin and Graben Structures

During the Tertiary Alpine Orogeny, the orogeny occurred in the Moyen Atlas region and the northwest side of Yahia-Oufalla Fault was uplifted to higher than that of the southereast side. Thus, a basin structure appeared in the area between from the northern part of Bou Mia Granite to Itzar village. In addition, the existence of a basin structure near the area 6 km south of Bou Mia was forecasted by the gravity survey.

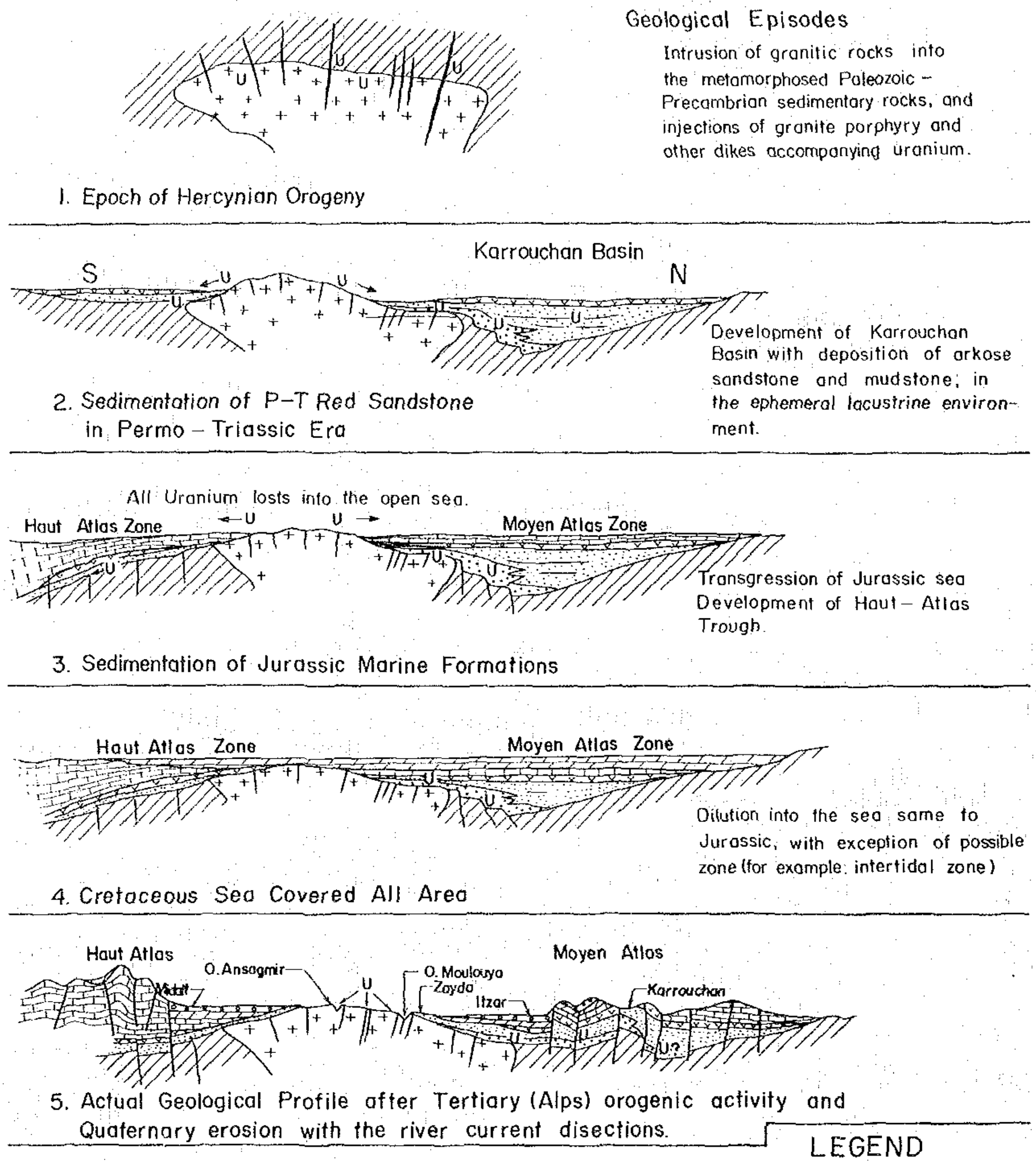
A graben structure is in existence in Ilich Azougagh Fault Zone stated before, and also a small-scale graben structure exists in the western part of the Bou Mia Granite. In these areas, there is a formation having gently dipped synclinal structure sandwiched between two approximately parallel faults about 4 km aparted and this formation gently dips north and continues to the Itzar basin zone.

Also, from the results of analysis of underground structure, the presence of many palcochannels on the basements toward this basin and graben structures was forecasted. The prevailing direction of the paleo-channels is persistently NE but NW also occurs occasionally.

3-4 Geological History (Fig. 5)

No fossil has been found in the crystalline schists, one of basement rocks, so that the age of the formation is unknown. However, from the results of age determination by the Rb-Sr method, the age of metamorphism of these rocks is considered to be from the later Devonian Period to the middle Permian Period. Thus, though the geological age of original rocks of these schists are still unknown, they are considered to be formed during Paleozoic to Pre-Cambrian Period.

The time of intrusion of the granitic rocks is considered to be the latest Carboniferous of Paleozoic Era (Hercynian orogeny). According to the results of isotopicage determination reported by D. Tisserant (1977), it seems that the granodiorite intruded and solidified first and, very short time later, the granite and aplitic granite solidified. Aplitic granite has irregular but sheet-like shape and particularly has a upside-down dish shape in the western half part of Zayda Granite. It means to be caused because alkaline component was concentrated in the sheet form upper part of granite body during the cooling process after the intrusion.



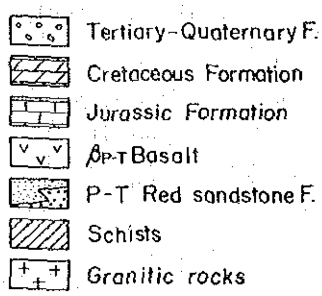


Fig. 5 Illustrative Profiles for Geological History and Movement of Uranium.

At the stage when weathering and erosion progressed to a certain degree after the uplifting of the basements, Karrouchan Basin, a trough-shaped sedimentary inland basin, extended to NE-SW direction was formed in the northwestern part of this surveyed area. The width of this basin is about 40 km. Basement rocks had been reduced their heights as they run into the basin during this period, and thus the southeastern side became higher while the northwestern side lower. On the basement rocks, valley-like structures running along faults in the NE-SW direction and small basin structure were in existence.

During Permian and Triassic Periods, the clastic materials produced by weathering and erosion of basement rocks was deposited under the continental environment. During early stage of this sedimentation, arkose sandstone containing coarse-grained iron oxide was deposited in the low land and valley-like structure on the basements. Then, the clastic materials became gradually finer as the sedimentation progressed, and was then thickly deposited, forming the P-T Red Sandstone Formation. During the last half of Permian Period, basalt errupted and widely covered the sedimentary rocks stated above. Since the basalt, β_{P-T} basalt, partially contains thin layers of gypsum and conglomerate, so, it is considered that the environment at that time was condition having local lakes.

During the Lias Period of Jurassic, the transgression progressed from east-northeastern region and invaded the whole surveyed area, and further progressed more than 200 km in the southeast direction. Since the central part of this surveyed area had a high plateau shape, there is no Jurassic deposit, and the rock facies of Jurassic in nearby area indicates the shallow-sea facies such as limestone abundant in coral fossils, mudstone and shale. During the Dogger Period, deep trough running in the direction of ENE-WSW developed in the High Atlas region passing the

southern edge of the surveyed area, and dark gray mudstone showing the deep-sea facies was thickly deposited in the central part of the region.

During the Turonian stage of Cretaceous Period, a transgression occurred widespreadly again, the whole area including the basements submerged below the sea level, and K_2 limestone formation was deposited. During the Cenomanian stage immediately before the Turonian stage, K_{2cm} mudstone formation consisting of red mudstone, gray sandstone and dark gray mudstone was deposited. This formation is widely distributed in almost whole surveyed area, and the environment of sedimentation was probably of shallow-lake type since relatively many gypsum layers are interbedded.

Though the formation of troughs, transgression and regression occurred during the sedimentation of Permian and Triassic Systems and Cretaceous System. However, relatively stable sedimentation progressed as a whole without any great movement, so that considerable unconformity was rarely observed between those formations.

However, the geological distribution stated above was the most greatly affected by Alpine orogeny occurred during Miocene of Tertiary Period, by which the whole area of Morocco became a land and was subjected to the compressive forces in the north-south direction, resulting in the development of faults mainly running in the N30°E direction in the central basements zone. In the Moyen Atlas region, Yahia-Oufalla Fault and many other faults having the vertical dislocation mainly were developed. Several part of the basements became higher than the central part. In the High Atlas region, due to the strong deformation, mountainous region having over-folded structure higher than 3,000 m was formed.

By the uplifting in the surrounding area in the Tertiary age, the central part of the surveyed area formed an inland basin, and sedimentary

rocks consisting of siltstone, mudstone and conglomeratic sandstone was deposited in this area. Since the Tertiary conglomerate sedimentary formation is thick in the northern part and has fine-grained layers in the southern part, it seems that uplifting in the Moyen Atlas occurred before that in High Atlas. Tertiary formation consists mainly of the materials came from the surrounding areas, and no materials caused by the weathering of granite body is recognized. This means that no erosion of granite occurred up to the Quaternary Period after the sedimentation of Jurassic System and that the basement rocks reappeared on the ground surface in the Quaternary Period.

Quaternary sedimentation progressed along the foot of mountains and rivers and deposited in the inland basin. The eruptive rock, Quaternary β_{Q2} basalt, directly overlies the granitic rocks and lava flows along the present terrain, so, its eruption seems to occurred in nearly recent years.

3-5 Ore Deposits and Mineral Indications

Many large scaled lead ore deposits are located in the surveyed area, forming one of the most important mining areas in Morocco. Particularly, 3 mines in Zayda, Mibladane and Hawli are currently being exploited and have excellent dressing plants. However, no uranium mine is currently being exploited. But many uranium indications were detected and prospection is being performed in some areas.

Previously known ore deposits and deposits and mineral indications confirmed by the present survey are shown in Tables 6, 7, and Plate 4.

3-5-1 Lead Ore Deposits

Lead Ore deposits in this area are distributed in the area near Zayda Mine at the center of surveyed area, in the area near Mibladen Mine in the southeastern part, and in the area near the Hawli Mine in the eastern part. These ore deposits can be classified into three kinds as follows.

(1) Sandstone Type Lead Ore Deposit

This is the deposit developed mainly near Zayda. This deposit is accompanied by Permian and Triassic arkose sandstone formed along the paleochannel of the basements. This deposit has thickness of 2.5 m to 10.0 m, area of 300,000 to 40,000 m^2 and more than 66 ore bodies, and the amount of the ore is about 16 million tons. Main ore minerals are cerussite and galena but baryte and small amount of fluorite are also associated. The mean grade is 3% of Pb.

(2) Stratiformed Impregnation Type Lead Ore Deposits

These are the ore deposits developed near Mibladane. The host rocks of these deposits are limestone, dolomite and mudstone of the lower Jurassic System, and the conglomerate of the middle Cretaceous System. These are the stratiformed deposits having several layers of ore each 5 to 50 cm wide in the formation about 10 to 20 m thick. More than 12 ore bodies were confirmed. Ore minerals are cerussite, galena, and small amount of molybdenite. Baryte is also seen as vein mineral.

(3) Vein Type Lead Ore Deposits

They are mainly distributed in the Hawli area in the eastern part where the basements are located. Veins, width of 0.5 to 40.0 m, extent of several hundred meters to several km, and depth of 100 to 200 m. Ore minerals mainly consist of cerussite and galena accompanied by small amount of molybdenite and chalcopyrite. Vein-forming minerals are baryte, quartz

and calcite. More than several dozens of veins were confirmed and they are distributed in an area of about 20 km by 20 km.

3-5-2 Uranium Indications (Table 8)

Four kinds of uranium indications are recognized in the surveyed area; vein-like type, sandstone type, carapace type and conglomerate type.

(1) Vein-like Type Uranium Indications

This mineral indications are recognized on both banks of Moulouya River in the northeastern part of Zayda where more than 15 veins are found, and also in the Bou Mia Granite where several veins are observed. The scale of the vein is from several cm to 3 m maximum, and the extent of strike is from 30 m to several km. The vein generally strikes NS to N30°E, and is present as a quartz vein containing iron oxide along the fractured zone in the granite or along the dyke. Reading of gamma-ray measurement at the outcrop of mineralization was 13,500 c/s maximum, but generally readings of several hundred to several thousand c/s were prevailing. Uranium ores recognized were Uranitite and Carnotite.

(2) Sandstone Type Uranium Indications

This indications were recognized in P-T Red Sandstone Formation, such as, near Bou Mia Granite, in the drill hole MR-2 in second phase survey, and in the drill holes MR-11 and MR-19 in third phase survey. Indications were all detected in the decolored arkose sandstone of the mudstone formation. Carnotite was recognized as the ore mineral but the grade was low in all cases. In addition, in Tarekochid in the southern part, small-scale stratiform-like uranium indication was detected at the boundary between coarse-grained arkose sandstone and fine-grained arkose sandstone.

Table 6 List of Pb-Cu-Ba Mineralizations in the Surveyed Area (PHASE II)

(1)

No.	Name	Location	Kind of Ore	Host Rock		Type	Amount of Ore Body	Unit Ore Body				Ore Minerals	Samples		Assay				
				Formation	Rock			Area / Length (m)	Thickness (m)	Direction	Dip		No.	*	Pb (%)	Cu (%)	Ag (ppm)	Au (ppm)	Ba (%)
①	Bou Tsakourt	SE of Zayda	Pb,Ba	paleozoic	granite	vein	6	200-500	0.1-2	N80°E -N80°W	80°N	galena, barite	1E07-1E12	P	14.2	0.13	93	<0.1	
②	Sidi Sáid	N of Midalt	Cu	P-T	sandstone	impregnation	1	15x15	0.2	-	-	green Cu minerals	1F05	P	6.2	0.70	42	<0.1	
③	Assaka Ijdiy	do	Pb,Ba	paleozoic	granite	vein	3	500	0.1-4	N85°E -N80°W	90°	galena, barite	1E01,1E14	P	8.8	0.08	35	<0.1	
④	Ich áft	do	Cu,Pb,Ba	do	do	do	1	5	0.1	N60°W	90°	green Cu minerals galena, barite	1F14	P	0.44	3.15	24	<0.1	
⑤	Aït Said	N of Bou Mia	Pb,Ba	P-T	arkose sandstone	stratiform	1		1-1.8	horizontal		galena, barite	2A07-2A12	C	1.30				2.12
⑥	Tabelkirt	SW of Bou Mia	do	paleozoic	granite	vein	1	500	0.3-0.7	N60°E	90°	galena, cerussite, barite	2B06,2B07	C					
⑦	Tamarout	W of Bou Mia	do	do	do	do	2	50	0.3	N84°W	90°	do	2B20,2B21	C	0.13				3.20
⑦	do	do	do	P-T	arkose sandstone	stratiform		30x50	0.6	horizontal		do	2B25,2B26	C	1.26				2.22
⑧	Zayda	near Zayda	do	do	arkose sandstone	do	66	Max. $3x10^5$	2.5-10	do		galena, barite	1A12, 1D01,1D19	P	3.76	0.02			4.14
⑨	Anc	N of Midalt	Cu,Pb,Ba	J_1	dolomite	mississippi valley	many	10x10	0.1-0.2	-	-	chalcopyrite, galena, barite	4I04-4I06	P	16.9	0.94	195	<0.1	
⑩	Mibladane	Mibladane	Pb,Ba	J_1 & K_2cm_1?	do	do	do	200-300	0.1-0.3	-	-	galena, barite	4J14-4J17	P	11.2	0.05	38	<0.1	
⑪	Sidi Ayyad	Marabout	do	precambrian -paleozoic		vein	5	500-1000	1.5	N80°W -EW	80°S -90°	do	1K31,1K32	P	22.5	0.04	62		

Note : Samples * C: channeled sample, P: piece sample

List of Pb — Ba Mineralizations in Bou Mia North Sector (PHASE II)

(2)

No.	Name	Location		Kind of ore	Host Rock		Type	Ore Body		Ore Minerals	Assay Results				Note
		X	Y		Formation	Rock		Distributing Scale (m)	Thickness (m)		Sample No.	Average Sampling width (m)	Pb%	Ba%	
⑫	Boutazart	527.6	241.5	Pb, Ba	P - T	sandstone	stratiform	700(+)x500(+)	1.9 ~4.5	galena	BMN-10~BMN20	3.18	1.52	6.74	
⑬	Pb-Mineralization near "Carapace"	528.0	243.5	Pb, Ba	P - T	do	do	150(+) x ?	1.00~1.80	galena	-	1.20	1.30	2.12	depend on first phase survey

List of Pb — Ba Mineralizations in Zayda NE Sector (PHASE II)

(3)

No.	Name	Location		Kind of ore	Host Rock		Type	Ore Body		Ore Minerals	Assay Results			
		X	Y		Formation	Rock		Distributing Scale (m)	Thickness (m)		Sample No.	Average sampling width (m)	Pb%	Ba%
⑭	Aït Rahhou	554	251	Pb, Ba	P - T	sandstone	stratiform	1,000 x 400	0.2 ~ 1.0	galena, cerussite	K1 - K7	0.55	6.47	4.85
⑮	Ikhf Oughanbou	546	251.5	Pb, Ba	do	sandstone	stratiform	400 x 400	0.2 ~ 0.6	do	K15 - K19	0.38	1.23	6.46

Table 7 List of Radioactive Mineralizations (PHASE I)

(1)

A. Vein-like Type

No	Area	Vein No.	Structure		Radioactive Mineralization			Remarks
			Length (m)	Width (m)	max. Length(m)	max. Width(m)	max. Radio-activity(c/s)	
△1	Sidi Ayyad	F-1	600+	0.05-3	30	3	8,000	strike NE-SW
		F-2	200+	0.05-0.1	10(?)	0.1	2,000	strike N30° W-S30° E
			(being many veins except F-1, F-2)					
△2	Ifzwane	1	100+	1	5+	0.1	600	strike N17° W-S17° E
△3	Immayn-n-Aït Rahhou	1	30+	0.05	2 - 3	0.05	1,500	strike NE-SW (veins 1, 2)
		2	30+	0.05	2 - 3	0.05	2,500	
		3	1,000+	10	40-50	1	500	strike NE-SW
△4	Paneau-1	1	500+	3	2+	1	7,000	strike NE-SW (veins 1-5)
		2	100(?)	?	20(?)	1(?)	3,000	
		3	?	?	20(?)	1(?)	3,000	
		4	300+	1-3.5	1	0.05	300	
		5	100	1	10(?)	1	2,500	
△5	Granite Porphyry	1	1,000+	10	5±	0.05	2,800	strike NE-SW
△6	Assaka-n-Tabhirt	1	200+	0.1	10	0.1	13,500	strike N40° E S40° W (veins 1, 2)
		2	200+	0.1	5	0.15	3,000	
		3	500+	2	3+	1(?)	300	strike NE-SW (veins 3, 4)
		4	100+	1	3+	1(?)	400	
△7	Dique	1	40+	4	10+	0.4	3,500	strike N25° E-S25° W

B. Sandstone and Carapace Type

No	Area	Anomaly No.	Structure		Radioactive Mineralization			Remarks
			Length (m)	Width (m)	max. Length(m)	max. Width(m)	max. Radio-activity (c/s)	
△8	Assaka Ijdiy	1	1,000	250	300+	40+	2,000	graben structure

C. Quaternary Sedimentary Type

No	Area	Anomaly No.	Structure		Radioactive Mineralization			Remarks
			Length (m)	Width (m)	max. Length(m)	max. Width(m)	max. Radio-activity (c/s)	
△9	Paneau-1	1					1,500	conglomerate floats
		2			5±	0.1	2,000	anomaly within black and white sediments on granite surface
△10	Assaka-n-Tabhirt	1			3±	0.2-0.3	400	anomaly in the river sand with black materials

(2)

List of Uranium Mineralization in Bou Mia North Sector (PHASE II)

No.	Name	Location		Structure		Uranium Mineralization			Assay Results			Note
		X	Y	Length (m)	Width (m)	Max. Length (m)	Max.Width (m)	Max.Radioactivity (c/s)	U%	Th%	V%	
△11	"Carapace"	528	243.5	?	2m+	?	2m+	1,600	0.072	0.002	0.030	depend on firt phase survey

(3)

List of Uranium Mineralizations in Zayda NE Sector (PHASE II)

No.	Name	Location		Uranium Mineralization					Assay Results				
		X	Y	Length (m)	Width (m)	Max. Length (m)	Max. Width (m)	Max. Radioactivity (c/s)	Sample No	Average Sampling Width	U%	Th%	Pb%
△12	Dique Vein	542.5	249	40	4	20	1.5	4,200	ZNE01-03, ZNE06	1.1	0.014	<0.010	-
△13	Assaka-n-Tabhirt west Vein	547.5	251.5	600+	3	10	0.05	1,000	K13, K14	0.05	0.046 ~ 0.059	<0.010	-
△14	Assaka-n-Tabhirt Vein	548.5	251.5	1,000	3	10	0.15	13,500	-	-	-	-	-
△15	GP Vein	550	251.5	3,500+	30	5	0.05	2,800	-	-	-	-	-
△16	Paneau-1 West Vein	551.5	251.5	2,500+	5	40	1.0	3,000	K12,K22,K23 ZNE9 - 15	0.36 0.46	0.005 ~ 0.026 0.010	<0.010 -	2.22 -
△17	Paneau-1 Vein	551.5	251.0	3,500+	20	40	5	3,500	ZNE16 - 28 ZNE31 - 38 ZNE39 - 42	0.86 1.03 0.63	0.012 0.059 0.021	- - -	- - -
△18	Paneau-1 East Vein	552.0	251.5	3,000+	20	5	0.1	1,500	K9,K10,K24	0.10	0.074	<0.010	(0.017)
△19	Aït Rahhou North Vein	554	250.5	2,500+	20	10	0.40	600	K21	40	0.020	<0.010	-
△20	Aït Rahhou South Vein	553	248.5	2,500+	20	10	0.10	1,200	K11	0.10	0.010	<0.010	-

Table 8 Chemical Analysis of Rock Samples for U. Th. V.

No.	Sample No.	Rock Name	Location	Composition U (%)	Th (%)	V (%)	Remarks
1	1A02	Porphyritic granite	Ilaghmane -n- 'Amar	0.045	<0.002		900 c/s
2	1A07	Fe-quartz vein	Assaka -n- Tabhirt	0.004	<0.002		350 c/s
3	1A11	Aplitic granite	Zayda	<0.002 *(0.0008)	0.003		
4	1A14	Limonitized sheared granite porphyry	Dique vein	0.071	<0.002		3,500 c/s
5	1B04	Contaminated granite	Tighbouba -n- Ouzour	<0.002	0.003		120 c/s
6	1B05	Aplitic granite	do	<0.002 *(0.0008)	0.004		175 c/s
7	1B09	Granite porphyry	South of Paneau-1	<0.002	0.003		2,000 c/s
8	1C02	Contaminated granite	AÏt Toughach	<0.002	<0.002		
9	1C12	Aplitic granite	Bou Issamsad	<0.002	0.002		200 c/s
10	1D05	Arkose sandstone	Ilaghmane -n- 'Amar	<0.002	<0.002	0.003	60 c/s
11	1D10	Granite porphyry	G-P vein	<0.002	<0.002		200 c/s
12	1D13	do	Assaka -n- Tabhirt	0.139	<0.002		1,000 c/s
13	1D14	Arkose sandstone	Paneau-1	0.005	0.003	0.015	3,000 c/s
14	1D15	do	do	0.061	<0.002	0.003	7,000 c/s
15	1D16	Granite porphyry	G-P vein	0.008	<0.002		1,500 c/s
16	1D18	Red siltstone	North of Dique	<0.002	<0.002	0.003	130 c/s
17	1D20	Porphyritic granite	Assaka -n- Tabhirt	<0.002	<0.002		
18	1F11	Calcareous siltstone	Assaka Ijdiy	<0.002	<0.002	0.003	500 c/s
19	1F12	Muddy siltstone	do	0.005	<0.002	0.007	400 c/s
20	1F13	do	do	0.004	<0.002	0.016	2,000 c/s
21	1G12	Fe-quartz vein	Immayn -n- AÏt Rahhou	<0.002	<0.002		1,500 c/s
22	1G15	do	do	<0.002	<0.002		500 c/s
23	1G19	do	Ifzwane	0.024	<0.002		600 c/s
24	1J18	Granite	Bou Archicha	<0.002 *(0.0012)	<0.002		50 c/s
25	1K08	Fe-quartz vein	Sidi Ayyad	0.188	<0.002		2,000 c/s
26	1K09	Granodiorite	do	<0.002	<0.002		
27	1K22	Microgranodiorite	F-1 vein (Sidi Ayyad)	0.085	<0.002		2,500 c/s
28	2A04	Aplitic granite	Bou Mia	<0.002	<0.002		150 c/s
29	2A13	Aplitic granite (carapace)	AÏt Saïd	0.072	<0.002	0.030	1,600 c/s
30	2B24	Aplitic granite	Tamarout	<0.002	<0.002		
31	2B28	Aplite	do	<0.002	0.003		160 c/s
32	2B29	Porphyritic granite	Bou Mia	<0.002	<0.002		200 c/s
33	2B30	Granite porphyry	do	<0.002	0.002		180 c/s
34	2B31	do	do	<0.002	0.002		180 c/s
35	3R05	Arkose sandstone	Jbel Talaghine	<0.002	<0.002		150 c/s
36	3R06	do	do	<0.002	<0.002		
37	3R08	do	do	<0.002	<0.002		
38	3R09	do	do	<0.002	<0.002		
39	3R11	do	do	<0.002	<0.002		
40	3R12	do	do	<0.002	<0.002		100 c/s
41	3R13	do	do	<0.002	<0.002		100 c/s
42	3R14	do	do	<0.002	<0.002		
43	3R15	do	do	<0.002	<0.002		100 c/s

The above samples are rock pieces.

Remarks: *Radioactivity (c/s) is on the sampling point.*

* : Results of checked chemical analysis

(3) Carapace Type Uranium Indication

This indication was detected at a point about 7 km north of Bou Mia. This uranium was considerably deposited together with quartz and iron-oxide in the concavity on the exposed granite surface in Permian and Triassic Ages. The scale of the outcrop is small with length of 3 m and thickness of about 30 cm, and it has a lens-like shape. The reading of gamma-ray measurement was about 1,600 c/s.

(4) Conglomerate Type Uranium Indication

This outcrop was recognized in the Cenozoic conglomerate formation on the southern bank of the Moulouya River northeast of Zayda. Conglomerate indicating high value of radioactivity contains large boulders about 1 to 2 m large, but this type of indication was found only at one place.