CHAPTER 4 SURVEY RESULTS

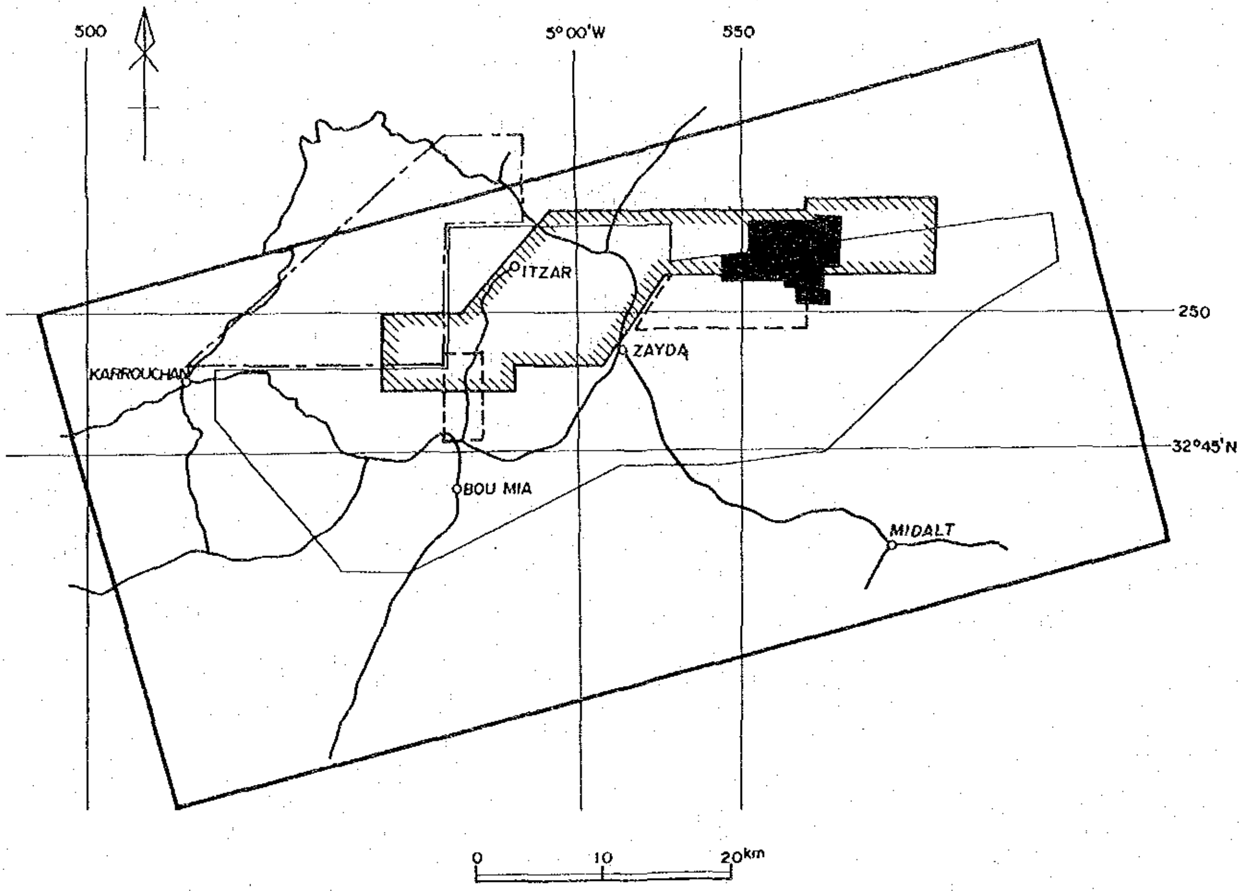
4-1 Geological Survey (Fig. 6)

Geological survey in the first phase included the general geological survey for the entire area and also semi-detail surveys and ore deposit surveys for some parts of the object area. In the second phase survey, more detail geological survey and survey for mineral indications were performed for three selected areas; Karrouchan area, north of Bou Mia, and northeast of Zayda, all of which had been selected as displaying a high potential presence of ore deposits.

In the actual survey, characteristics such as grain size, texture, constituent minerals for the granites, as well as the boundary to different kinds of rocks were checked. For sedimentary rocks, careful observation on its grain size and color of fragmental materials, strike, dip, horizontal variation, cross-bedding, sole mark, etc. were performed to clarify the paleochannel and the depositional direction. Also, for both sedimentary rocks and igneous rocks, the presence of joints, fissures and faults, shape and scale were checked. If a particular rock exhibited signs of mineralization, a detailed sketch survey was conducted to clarify the embedded conditions and the continuity of the mineralization. In addition, each geologist always carried a scintillometer (SPP-NF Type 2) during and measured the radioactivity at each outcrop of the rocks.

For characteristic rocks and mineralized rocks, samples were taken to perform geochronological study, chemical analysis, microscopic observation, x-ray microanalysis, etc.

The results of these geological surveys were synthetically examined together with the results of gravity survey, radon etch survey and diamond drilling performed in parallel from the first to the third phase surveys.



	GEOLOGICAL SURVEYED AREA			RADON ETCH
	GENERAL	SEMI-DETAILED	DETAILED	SURVEYED AREA
PHASE I				
PHASE II				
PHASE III				

Fig. 6 Location Map of Geological Surveyed Area

Consequently, the geological structure, sedimentary mechanism and mechanism of mineralization in the surveyed area were clarified.

The geology of this area is shown in PL-1, PL-2, and PL-3. The High Atlas region, including the surveyed area, is located in the northwest and north of a Pre-Cambrian stable zone developed around the Mauritania Craton, as core, in the northwestern section of the African Continent, and corresponds to a Paleozoic geosyncline zone developed in this marginal zone.

Rocks in this area consist of Pre-Cambrian to Paleozoic crystalline schist and granites intruded during Hercyan orogeny as basements, Permian and Triassic P-T Red Sandstone Formation and β_{P-T} basalt formation, and Jurassic and Cretaceous sedimentary rocks and Cenozoic sedimentary and eruptive rocks.

Crystalline schists are mainly distributed in the eastern part of the surveyed area and crop out on a small scale in the western part of the surveyed area. These rocks consist of chlorite sericite shist, amphibole schist, and quartz sericite schist interbedded with amphibolite. A typical outcrop is located in the eastern Hawli area and is distributed in an area 20 km long and 10 km wide. This rock has a dome structure extending to the north-east direction.

Granitic rocks exposed in the form of a hill at a place east of Zayda village and northwest of Bou Mia village, and they are called Zayda Granite and Bou Mia Granite respectively. These rocks can be classified into granite, porphyritic granite, aplitic granite, granodiorite and migmatite. And aplitic granite indicates slightly higher readings of radioactivity compared to other granitic rocks and has a gently dipped sheet-like or vein-like form.

P-T Red Sandstone Formation gently dips, is distributed near the basements, and consists of, from bottom to top, conglomeratic coarse-grained sandstone fromation, coarse-grained sandstone and fine-grained sandstone

formation, fine-grained sandstone and mudstone formation, and mudstone formation. The conglomeratic sandstone formation has a thickness of several dozen meters at the valley of the basement but occasionally lacks at its saddle portion. P-T Redstone Formation is considered to be the continental sediment since it has redish brown color, sole mark and cross-bedding.

β_{P-T} Basalt Formation has a thickness of about 150 m and is distributed in the northwestern and northeastern parts of this area. Most part of this formation consists of basaltic lava but is partly interbedded with black shale, sandstone and conglomerate and covers P-T Red Sandstone Formation.

Jurassic sedimentary rocks are distributed in the northwestern, northeastern and southern parts of the surveyed area, and the Cretaceous sedimentary rocks are distributed throughout most of the area. However, the Cretaceous formation occasionally lacks the Jurassic formation in lower level and directly covers the P-T Red Sandstone Formation.

The Cenozoic formation consists of Tertiary and Quaternary formations and is distributed in the central part of the surveyed area.

From the results of the geological survey, it has been clarified that the geological structure in this area has the characteristics which reflect the geological history of stabilization developed around the Mauritania Craton as described below.

Most of the basements in the surveyed area, including the area covered with sedimentary rocks, are probably granitic rocks. However, there are high anomalous zones found from the gravity survey in the eastern and northwestern parts of Karrouchan region, and they seem to correspond to crystalline shist. It is presumable that a latent saddle-shaped structure is running almost horizontally at a shallow underground between Zayda Granite and Bou Mia Granite, and the altitude of the basement tends to

decrease in a northern direction at the north side of this saddle-shaped structure, and also in a southern direction at the south side of this structure. Though this saddle-shaped structure looks like a divide on the present basements, it seems that this divide was located further south during the forming period of paleotopography.

Also, from the results of the gravity survey, the presence of a few fault-like structures striking NE-SW to NNE-SSW and continuous ridge-shaped structures was predicted in the basements. Typical ridge-shaped structures are located at the east side of Itzar and at the west side of the central fault. The former performed an important role when forming the Itzar basin structure at the east side. Another basin structure was also predicted at a place south of Bou Mia.

On the top of besement granites, the presence of several grooves similar to valley structure running in the NE-SW, NS and NW-SE directions was predicted. The valley-like structure running in the NE-SW direction continues relatively long, and a fault striking NE-SW is situated on a line extended from the strike of this valley-like structure. From the altitude of the basements, it seems that these valley-like structures dip north at the northern side and dip south at the southern side of both Bou Mia-Zayda Granites. However, from the results of the geological survey and drilling, it appears that the southern side was higher at the time of formation of paleotopography and the resulting structure flowed northward.

From drilling during the second phase, it was ascertained that the altitude of the basement at the northern edge of the surveyed area tended to become lower as it ran from its eastern to western part. Also, in the Karrouchan region in the northwestern part of the surveyed area, the altitude of the basement is currently higher than that of the east side

because of the lift of the northwest block by the Yahia-Oufall Fault, but the thickness of sedimentary rocks above the basement tends to become thicker as they run westward. These facts indicate chat the presence of a large trough or basin structure in the northwest side at the time of sedimentation.

Sedimentary rocks in the surveyed area were generally deposited in the sedimentary basin sandwiched between the Moyen Atlas Mountains in the northwest and the High Atlas Mountains in the south. However, the environment of the sedimentation changed considerably during each geological period, and the thickness and materials of each formation changed considerably in each sector.

Thickness and constituent of the Permian and Triassic formation slightly vary in the north and south sides of Bou Mia-Zayda Granites and in Karrouchan region. At the north side of the Bou Mia-Zayda Granites, this formation is deposited over the gentle northern slope of the basements. Since the basalt formation at the top level is almost horizontal at present, it is considered that this basement structure is almost the same as that of the paleotopography at the sedimentation. Also, the arkose sandstone fromation at the bottom of P-T Red Sandstone Formation, as stated previously, tends to become thicker as it runs northward and westrard. This means that early sedimentation has been progressed from the southeast to the northwest supplying the materials from granitic rocks. In the Karrouchan region northwest of this area, P-T Red Sandstone Formation tends to become gradually thicker and, at the same time, arkose sandstone at the bottom tends to become thicker though its basement consists of crystalline schist. This means that the materials were supplied from the southeastern granites.

In contrast, in the area south of Bou Mia-Zayda Granites, the arkose sandstone is extremely thin or does not exist, even though the basement dips

south, and the mudstone formation directly covered on the basements. This seems to indicate that the materials were supplied from the southern crystalline schists and that the altitude of the basements at that time was higher at the southern part rather than at the central part.

On the other hand, if the valley-like structures of the basement were higher at the south side at the time of sedimentation, as was determined on the basis of the gravity and other surveys and described above, it seems that fragmental material flowed down through these valley-like structures in a NE direction and early sedimentation progressed while depositing the materials in these depressed areas. This can be substantiated by the fact that N to NNE is prominent as the direction of deposition in the arkose sandstone, which was determined in the geological survey from the cross-bedding and sole marks.

The characteristics of sedimentary rocks after the Jurassic Period are described in detail in the previous chapter. From the lithology and distribution of these rocks, the environment of the sedimentation of these rocks is considered to be as follows:

(1) Lias Jurassic:

Shallow sea type sedimentation occurred. Part of the central area remained terrestial.

(2) Dogger Jurassic:

A trough was formed in the High Atlas zone, and abyssal sedimentation occurred.

(3) Cretaceous:

Erosion progressed in the whole area. Shallow lake-water type sedimentation with repeated drying and filling occurred in the early stage, while the shallow sea type sedimentation occurred in the later stage.

(4) Tertiary:

An inland type basin was formed in this area by the Alpine Orogeny in the Miocene Epoch. Thus, an inland type sedimentation environment predominated in the Tertiary.

(5) Quaternary:

Granite in the central area appeared on the ground surface, and sedimentation progressed, filling the inland basin with material.

Ore deposits and mineral indications found in the survey area by the geological survey are illustrated in Table 6, Table 7 and PL-4. They are the sandstone type, stratiformed impregnation type and vein type lead ore deposits, and the vein type, sandstone type, conglomerate type and carapace type uranium indications. Many lead deposits were also found. Some of them are not being exploited currently, but Zayda Mine (sandstone type), Mibladane Mine (stratiformed impregnation type) and Awli Mine (vein type) are currently being exploited. The sandstone type lead ore deposit near Zayada, one of the deposits mentioned above, contains mainly cerucite and galena impregnated in arkosic conglomeratic sandstone at the bottom of the P-T Red Sandstone Formation. This deposit runs along the valley-like structure of the basements, and its scale and grade tend to increase or become higher at a place where the thickness of conglomeratic sandstone formation is large.

According to the results of the radioactivity measurement performed concurrently with the geological survey, the readings were generally 50 to 170 c/s (mean value of approximately 105 c/s) for granitic rocks except aplitic granite, 80 to 200 c/s (mean value of approximately 135 c/s) for aplitic granite, 30 to 110 c/s (mean value of approximately 80 c/s) for P-T Red Sandstone Formation, 30 to 100 c/s (mean value of approximately 50 c/s) for β_{P-T} basalt formation, and 20 to 80 c/s (mean value of approximately 35 c/s) equally for both Jurassic formation and its upper formation.

Results of analysis of U, Th and V for these rocks and formations are indicated in Table 8. The content of uranium was found to be 8 ppm for aplitic granite and 12 ppm for granite. These values of uranium content in granite are higher than the average value generally known (2 to 5 ppm).

Uranium indications were recognized at about 20 places by the geological survey. The maximum radioactivity reading was 13,500 c/s. The results of analysis yielded a value of 0.004% minimum and 0.33% for uranium. These mineral indications can be classified into vein type, sandstone type, conglomerate type and carapace type indications.

(1) Vein type Uranium Indication:

This type of uranium indication is most clearly recognized in the surveyed area and widely distributed on the bank of the Moulouya River, northeast of Zayda and near Sidi Ayyad. Granite porphyry and fine-grained granodiorite dykes intruded into the granitic rocks were suffered the fracturing along the dyke, and the uranium was deposited in these fractured zone. These fracture is accompanied by iron-oxide quartz vein. The widths varies from 5 cm to about 1 m, the lengths continue several meters interruptedly, and the radioactivity values are generally several hundred to thousand c/s, though values as high as 13,500 c/s were observed certain places. Uranium minerals recognized are carnotite, becquerelite and uraninite. The grade of uranium is usually less than 0.03%, though 0.33% detected at certain places.

(2) Sandstone Type Uranium Indication:

There is decolored arkose sandstone in P-T Red Sandstone Formation near the granitic rocks, and the readings of radioactivity at certain places on the arkose sandstone indicate even anomalous values of 200 to 300 c/s. This mineral indication is seen at Assaka Ijdiy and Tarekochid.

(3) Conglomerate Type Uranium Indication:

Boulders of Quaternary conglomerate having high radioactivity (1,500 c/s ±) exist at several places near Paneau-1 to northeast of Zayda.

(4) Carapace Type Uranium Indication:

This indication is seen at Ait Said about 6 km north of Bou Mia. This indication is caused by the uranium concentrated in oxidized zone (carapace-shaped) on the granite surface, and the radioactivity reading was found to be 1,600 c/s, the grade of uranium is 0.072%. Uranium minerals recognized are carnotite and tyuyamunite.

From the results described above, the supply sources of uranium in the surveyed area are considered to be the granitic rocks, particularly the aplitic granite, and the uranium contained in the fractured zone. It has been also ascertained that this uranium tends to concentrate in depressed areas on the surfaces of the granites and in arkose sandstone of the P-T Red Sandstone Formation.

4-2 Gravity Survey

A gravity survey was carried out in the area of about 800 km^2 indicated in Fig. 7 Location Map of Gravity Surveyed Area. Two gravity meters, G-236 and G-366 of La Coste & Romberg Inc., were used in this survey.

Several kinds of correction were applied to observed values of gravity. This resulted in preparing the Bouguer anomaly map of assumed density of ρ=2.5 g/cm^3 as illustrated in PL. 7 Compiled Bouguer Anomaly Map. On the basis of this map, filter analysis and two and three-dimensional modelings were carried out to clarify the underground structure of the surveyed area. The results are shown in PL. 8 Underground Structure Interpreted by Gravity Survey.

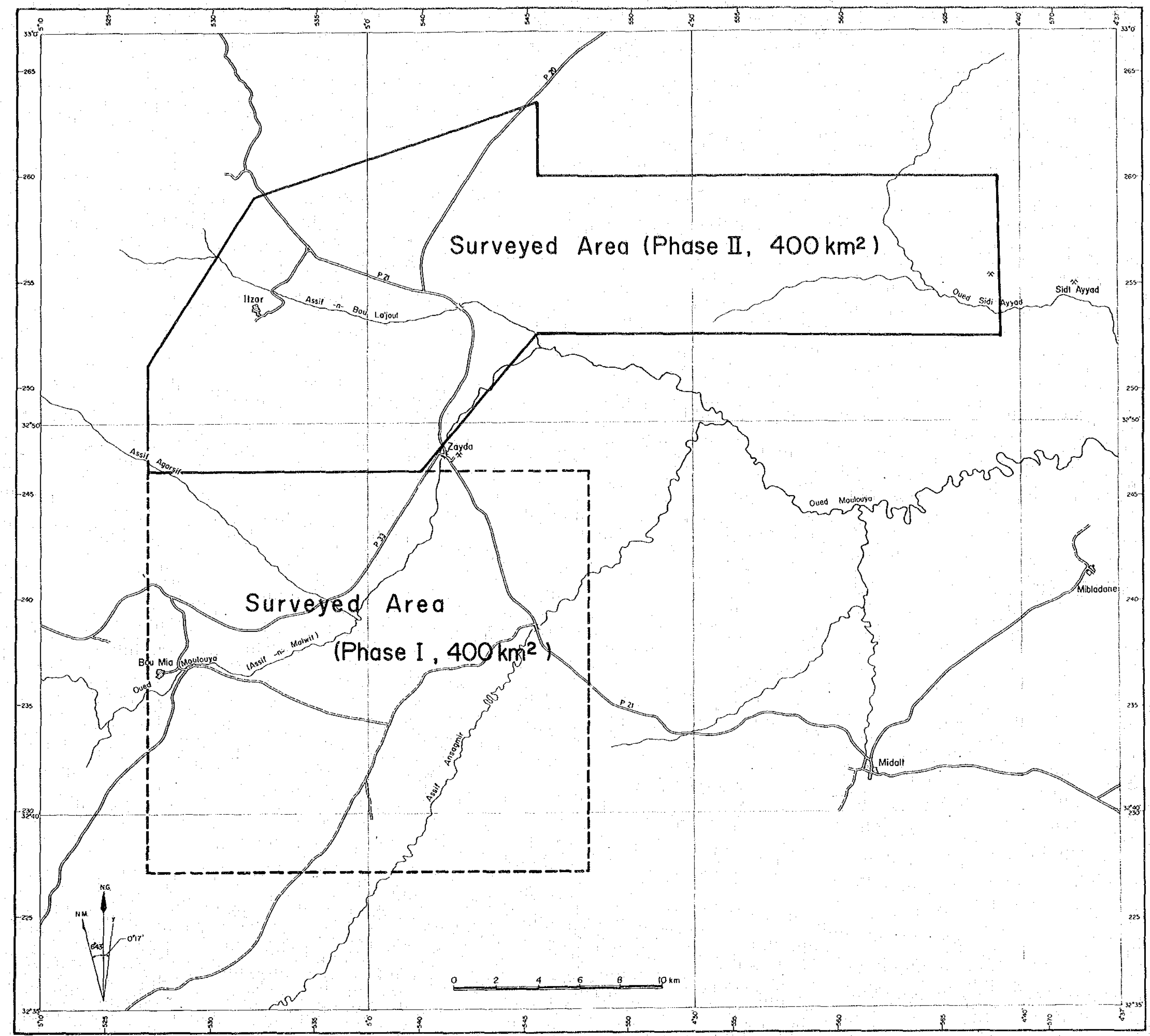


Fig. 7 Location Map of Gravity Surveyed Area

The gravity survey results are summarized as follows:

(1) Bouguer anomaly values in the surveyed area are distributed in a range of -128 to -88 mgal. Low Bouguer anomaly values due to isostasy around the Atlas mountains were measured (See PL. 7).

(2) Relationships between the densities of major formations composing the surveyed area and gravity anomalies are as follows (See Table 9):

Crystalline schists	ρ=2.8 g/cm^3, remarkably high gravity anomaly
Granites	ρ=2.6 g/cm^3, moderate high gravity anomaly
Other sedimentary rocks	ρ=2.4 g/cm^3, low gravity anomaly

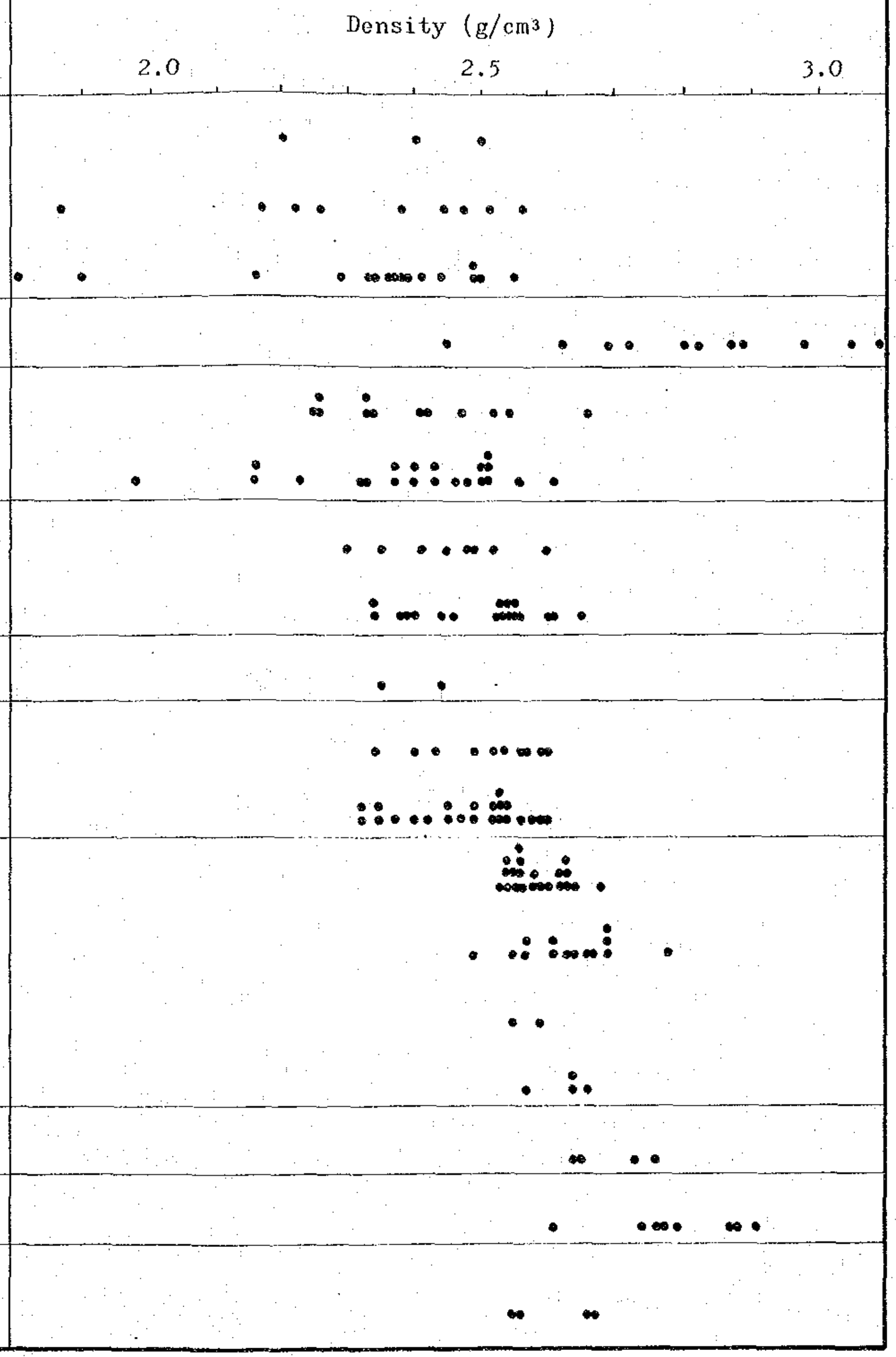
(3) The gravity distribution in the compiled Bouguer anomaly map (PL. 7) is influenced by high density crystalline schists which occur extensively to the north and east of the surveyed area and is subject to the bow or arc shape gravity trend. The gravity values increase north-eastward from the low gravity anomaly developing to the south of Bou Mia, and reach the high gravity anomalies developing to the north of Itzar and on Sidi Ayyad river. It is characterized that the gravity gradient is gradual around Zayda.

Features of the underground structure (PL. 8) described below have been analized from the gravity distribution from which the above discribed gravity trend was eliminated by means of the trend analysis.

(4) A saddle-like structure which starts from the granite outcrops located in Zayda and north of Bou Mia and stretches almost horizontally in the E-W direction in shallow underground was confirmed. This saddle-like structure seems a watershed of the basement granites. However,

Table 9 Distribution of Rock Densities

Geological Age		Geological Unit and Mark		Lithology	Amount	Average of Density	
Cenozoic	Quaternary		Q_3	terrace deposit	3	2.37	2.33
			Q_2	conglomerate, siltstone, mudstone	9	2.32	
			Q_1	conglomerate, siltstone	16	2.33	
			β_{Q2}	basalt lava	11		2.82
	Tertiary		T_2	marl, limestone, siltstone, conglomerate	12	2.40	2.39
			T_1	light brown siltstone, conglomeratic sandstone	21	2.39	
Mesozoic	Upper Cretaceous	Turonian	K_2t	micritic limestone, muddy siltstone, calcareous siltstone, turbidite	8	2.45	2.48
		Cenomanian	K_{2cm}	limestone, calcareous siltstone, poly-colored siltstone, gypsum bed	18	2.50	
	Lower Jurassic	Lias	J_1	limestone, siltstone, marl, sandstone, conglomerate, turbidite, dolomite	2		2.40
	Permo-Triassic	Permo-Trias	β_{P-T}	basalt lava, sandstone, conglomerate	10	2.50	2.48
			P-T	red sandstone, arkose sandstone, siltstone, mudstone	23	2.47	
Proterozoic ~ Paleozoic	Paleozoic ~ Precambrian	Basement Complex	Ap-Gr	aplitic granite	21	2.59	2.60
			Gr	granite	14	2.63	
			Por-Gr	porphyritic granite	2	2.57	
			Cnt-Gr	contaminated granite	4	2.63	
			Gr-Dio	granodiorite	4		2.70
			Sch	crystalline schist	8		2.79
Others				quartz vein, barite vein	4		2.61



it is considered that a watershed at the time of palaeotopography formation would be further southward than the existing one.
The basement structure of the surveyed area is in such a fashion that the north side of the above-mentioned E-W saddle-like structure slopes down northward and the south side of it slopes down south-westward.

(5) Structure of the sedimentary rocks overlaying the basements is generally thin in the east of the surveyed area and thick in the west. The existence of basin-like structures indicating a depression of the basement was pointed out to the east of Itzar and south-east of Bou Mia. The thickness of sedimentary rock is estimated to be 200 to 400 m for the former and 400 to 800 m for the latter.

(6) Fault-like step structures and ridge-like structures of the basements starting from the above-described E-W saddle-like structure and granite outcrops are frequently seen. The direction of these structures is mainly NE-SW to NNE-SSW. Many of fault-like step structures show a good agreement with the location and direction of fault which were confirmed by the geological survey.

(7) On the basement granites, many valley-like structures showing zonal grooves were assumed. Features of main valley-like structures and their apparent directions for each section are as follows:

(i) In the south side of Zayda corresponding to the Phase I area, most of valley-like structures stretch southward or south-westward. These valley-like structures seem to concentrate in the basin-like structure to the south-east of Bou Mia. A typical valley-like structure among them is the one which runs in SSW to the south of Zayda. This structure stretches gradually in a zigzag line over more than 10 km.

(ii) Valley-like structures concentrating in the basin-like structure to the east of Itzar seem to form a lake-like basin for once and then resume their northward course.

(iii) In the north-east of Zayda where the basement is shallow, a few valley-like structures are seen. These structures are roughly parallel with each other and stretch northward. In the areas corresponding to these valley-like structures, radon etch anomalies were measured. Therefore, probable uranium transportation and sedimentation can be expected. This results form the assumption that valley-like structures on the basement controlled the sedimentation of initial sediments.

(8) The stratiformed sandstone type lead ore deposit which mineralized and deposited in the arkose sandstone of the P-T Red Sandstone in the surveyed area tends to be controlled by palaeochannels. Furthermore, it can be considered that the sandstone type uranium ore deposit may mineralize around granites being a source rock, moreover where reduction conditions were satisfactory.

Assuming that the basement structure which has been clarified by this survey maintains the original form of palaeotopography, it can be concluded that the further follow-up of valley-like structures and these comparison and review with various survey results will be significant to the lead and uranium mineral deposit prospecting.

4-3 Radon Etch Survey

The second phase radon etch survey was performed for measuring points spaced at 500 to 1,000 m on centers in an area of about 300 km^2, in the north of Zayda-Bou Mia Granites. In the third phase radon etch survey performed at measuring points on grid lines spaced at 100 to 250 m on

centers in an area of about 39 km^2, north of the Zayda Granite for which high potential of embedding of uranium deposits had been expected as a result of the second phase survey.

From the results of the geological survey, the existence of a large basin structure between the Granite and the Moyen Atlas Mountains was clarified, and also the existence of a formation mainly consisting of P-T Red Sandstone Formation was predicted to be in this basin. As stated previously, a potential presence of arkose sandstone within the P-T Red Sandstone Formation and also a potential presence of sedimentary uranium deposits in this arkose sandstone were predicted.

From the results of the second phase survey, the readings were found to be 4.1 to 798.0 T/sq.mm.30 days. Anomalous values were abstracted from them by the statistic method, and the following areas were determined to be locations where the anomalous values were available:

(1) The Area North of Paneau 1 to Immayn-Ait-Rahhou (north of Zayda Granite):

34 anomalous values were concentrated in this area, and the readings were from 153.8 to 798.0 T/sq.mm.30 days. There were 8 readings which exceeded 500 T/sq.mm.30 days.

(2) The Area North of Assak-n-Tabhirt:

Five anomalous values were concentrated in this area, and the readings were from 219.8 to 357.1 T/sq.mm.30 days.

(3) The Idamrane Micha Area:

Eight anomalous values were found, and the readings were from 215.2 to 274.0 T/sq.mm.30 days.

(4) The Area Near Illaghmane-n-Amar:

Six anomalous values were found, and the readings were from 146.5 to 215.2 T/sq.mm.days.

(5) The Area North of Bou Mia Granite:

Five anomalous values were concentrated in a relatively narrow range, and the readings were from 184.6 to 330.8 T/sq.mm.30 days. However, the readings found in Cretaceous formation were also included for this area.

(6) The Area North of Zayda Village:

Four anomalous values were found at scattered points. The readings were slightly low with 153.8 to 200.0 T/sq.mm.30 days.

The area north of Zayda Granite, selected as the area to be surveyed for the third phase, contained the highest concentration of anomalous values as described above. Granites containing many fractured zones showing significant uranium indications were located in a hinterland south of this area. In parallel with the radon etch survey, diamond drilling for 31 drill holes was performed, primarily in the anomalous zones, in order to confirm the causes of the radon etch anomalous values.

According to the results of the third phase radon etch survey, the minimum value was 8.4 T/sq.mm.30 days and the maximum was 1,215.0 T/sq.mm. 30 days. However, the maximum reading at the same measuring point as previous year was 734.0 T/sq.mm.30 days, which was almost the same as that of previous year. A comparison was made between readings of two years for 120 measuring points, and a positive correlation was found, thus substantiating the reproducibility of this survey method. The mean value of readings was 163.1 T/sq.mm.30 days, which was considerably high compared to the mean value of 92.0 T/sq.mm.30 days of uranium deposit zones in the world. Thus, a potential presence of uranium of ppm level in relatively shallow layers of the surveyed area (probably in or directly below the surface soil) was predicted. Also, some weak correlation between the readings of radioactivity and radon etch was found, from which the presence of radioactive materials near the ground surface had been also

suggested.

As stated above, the anomalous values obtained from the radon etch survey were concentrated in the same zone as the previous year. The range is on the southern slope of the central basin area, and its eastern and western edges approximately coincide with the lines extended northeastward from two NE fractured zones (Ansagmir Fault and G.P. Vein) in the granites. It was that these anomalous values (or zones) were controlled by the geological structure in the surveyed area.

4-4 Diamond Drilling

The contents of drilling work performed in the second and third phase are shown in Table 10, the locations of drill holes is in Fig. 8 and the geology and mineral indications are in Fig. 9.

In the second phase drilling work, drill holes were made in several areas for which the presence of P-T Red Sandstone Formation embedding the lead and uranium deposits had been predicted from the results of the first phase geological and gravity surveys. That is, hole MR-1 (dpeth: 148.30 m) in Tanfi-Micha area, hole MR-2 (depth: 265.95 m) and hole MR-4 (depth: 138.00 m) in Itzar Basin area, and hole MR-3 (depth: 375.70 m) in the area south of Bou Mia. were made respectively. All of these holes were drilled down to the basements, core evaluation and gamma-ray logging were made for each hole after drilling, and then chemical analysis and microscopic observation were performed for altered and mineralized portions.

In consequence, it is found that the elevation of the basements decreases north word and the basements slightly dip west in the area north of the Zayda-Bou Mia Granite. In addition, it is found that P-T Red Sandstone Formation deposited over these basements tends to become thick westward, and arkose sandstone formation at the bottom also tends to become

Table 10 Summary Operational Data for Drill Holes

Year	Drill hole No.	Type of machine	Drilling period	Drilling length (m)	Core Length (m)	Core Recovery (%)	No. of drilling shift: Drilling	No. of drilling shift: Casing etc.	No. of drilling shift: Total	Drilling speed * m/shift	Drilling speed ** m/shift
1979	MR-1	Crelius D-1000	18th MAY 1979 ~ 26th MAY 1979	148.30	126.20	85.1	24	2	26	6.18	5.70
	MR-2	"	30th MAY 1979 ~ 18th JUNE 1979	265.95	248.15	93.3	34	26	60	7.82	4.43
	MR-3	"	22nd JUNE 1979~ 30th JUNE 1979	138.00	114.10	82.7	23	1	24	6.00	5.75
	MR-4	"	8th JULY 1979~ 12th JULY 1979	100.10	63.40	63.3	15	-	15	6.67	6.67
	Total			652.35	551.85	84.6	96	29	125	6.80	5.22
1980	MR-5	L-34	10th OCT 1980 ~ 17th OCT 1980	101.40	81.15	80.0	15.5	2.5	18.0	6.54	5.63
	MR-6	WIRTH-1	29th JUNE 1980~ 5th JULY 1980	75.05	72.65	96.8	12.0	6.0	18.0	6.25	4.17
	MR-7	L-34	29th JUNE 1980~ 5th JULY 1980	69.00	52.40	75.9	15.0	3.0	18.0	4.60	3.83
	MR-8	L-34	6th JULY 1980~ 11th JULY 1980	69.75	61.00	87.5	12.5	2.5	15.0	5.58	4.65
	MR-9	L-34	11th JULY 1980~ 15th JULY 1980	63.00	45.65	72.5	10.5	0.5	11.0	6.00	5.73
	MR-10	L-38	29th JUNE 1980~ 1st JULY 1980	51.00	38.70	75.9	7.0	0	7.0	7.29	7.29
	MR-11	L-34	27th JUNE 1980~ 28th JUNE 1980	47.30	38.75	81.9	4.5	0.5	5.0	10.51	9.46
	MR-12	L-38	2nd JULY 1980~ 5th JULY 1980	47.50	33.65	70.8	8.0	1.0	9.0	5.94	5.28
	MR-13	L-38	6th JULY 1980~ 8th JULY 1980	43.20	31.95	74.0	5.5	0.5	6.0	7.85	7.20
	MR-14	L-38	8th JULY 1980~ 11th JULY 1980	37.00	26.95	72.8	5.0	5.0	10.0	7.40	3.70
	MR-15	WIRTH-1	27th JUNE 1980~ 28th JUNE 1980	45.05	41.60	92.3	4.0	0.5	4.5	11.26	10.01
	MR-16	WIRTH-1	25th JUNE 1980~ 26th JUNE 1980	30.00	23.95	79.8	4.5	0.5	5.0	6.67	6.00
	MR-17	L-34	25th JUNE 1980~ 26th JUNE 1980	29.55	24.80	83.9	3.5	0.5	4.0	8.44	7.39
	MR-18	WIRTH-1	3rd JUNE 1980~ 5th JUNE 1980	22.30	17.65	79.1	4.0	3.0	7.0	5.58	3.19
	MR-19	WIRTH-2	2nd JUNE 1980~ 7th JUNE 1980	26.60	21.25	79.9	8.0	7.5	15.5	3.33	1.72
	MR-20	WIRTH-2	8th JUNE 1980~ 13th JUNE 1980	26.15	18.60	71.1	7.5	7.5	15.0	3.49	1.74
	MR-21	WIRTH-1	11th JUNE 1980~ 12th JUNE 1980	23.85	21.60	90.6	3.5	0.5	4.0	6.81	5.96
	MR-22	WIRTH-1	13th JUNE 1980~ 15th JUNE 1980	25.00	21.75	87.0	6.5	2.5	9.0	3.85	2.78
	MR-23	L-38	17th JUNE 1980~ 20th JUNE 1980	25.00	21.55	86.2	8.5	1.5	10.0	2.94	2.50
	MR-24	L-38	22nd JUNE 1980~ 25th JUNE 1980	30.15	23.45	77.8	7.5	2.5	10.0	4.02	3.02
	MR-25	L-34	20th JUNE 1980~ 22nd JUNE 1980	25.25	22.85	90.5	7.5	0.5	8.0	3.37	3.16
	MR-26	L-38	26th JUNE 1980~ 28th JUNE 1980	25.00	22.40	89.6	6.5	0.5	7.0	3.85	3.57
	MR-27	WIRTH-1	29th MAY 1980 ~ 31st MAY 1980	22.35	19.70	88.1	6.0	0.5	6.5	3.73	3.44
	MR-28	WIRTH-1	1st JUNE 1980~ 3rd JUNE 1980	27.00	24.75	91.7	6.5	0.5	7.0	4.15	3.86
	MR-29	WIRTH-1	6th JUNE 1980~ 8th JUNE 1980	20.00	17.15	85.8	5.0	3.5	8.5	4.00	2.35
	MR-30	WIRTH-1	9th JUNE 1980~ 10th JUNE 1980	18.20	15.15	83.2	4.0	0.5	4.5	4.55	4.04
	MR-31	WIRTH-1,2	14th JUNE 1980~ 19th JUNE 1980	20.00	19.45	97.3	5.5	12.5	18.0	3.64	1.11
	MR-32	WIRTH-1	16th JUNE 1980~ 17th JUNE 1980	20.45	17.30	84.6	4.5	0.5	5.0	4.54	4.09
	MR-33	WIRTH-1	20th JUNE 1980~ 22nd JUNE 1980	25.00	22.55	90.2	6.0	0	6.0	4.17	4.17
	MR-34	WIRTH-1	22nd JUNE 1980~ 24th JUNE 1980	25.10	22.40	89.2	6.5	0.5	7.0	3.86	3.59
	MR-35	L-34	23rd JUNE 1980~ 24th JUNE 1980	10.00	9.80	98.0	4.0	0	4.0	2.50	2.50
	Total			1126.20	932.55	82.8	215.0	67.5	282.5	5.24	3.99

* Drilled per one shift covering net drilling operations. ** Drilled per one shift covering total works conducted.

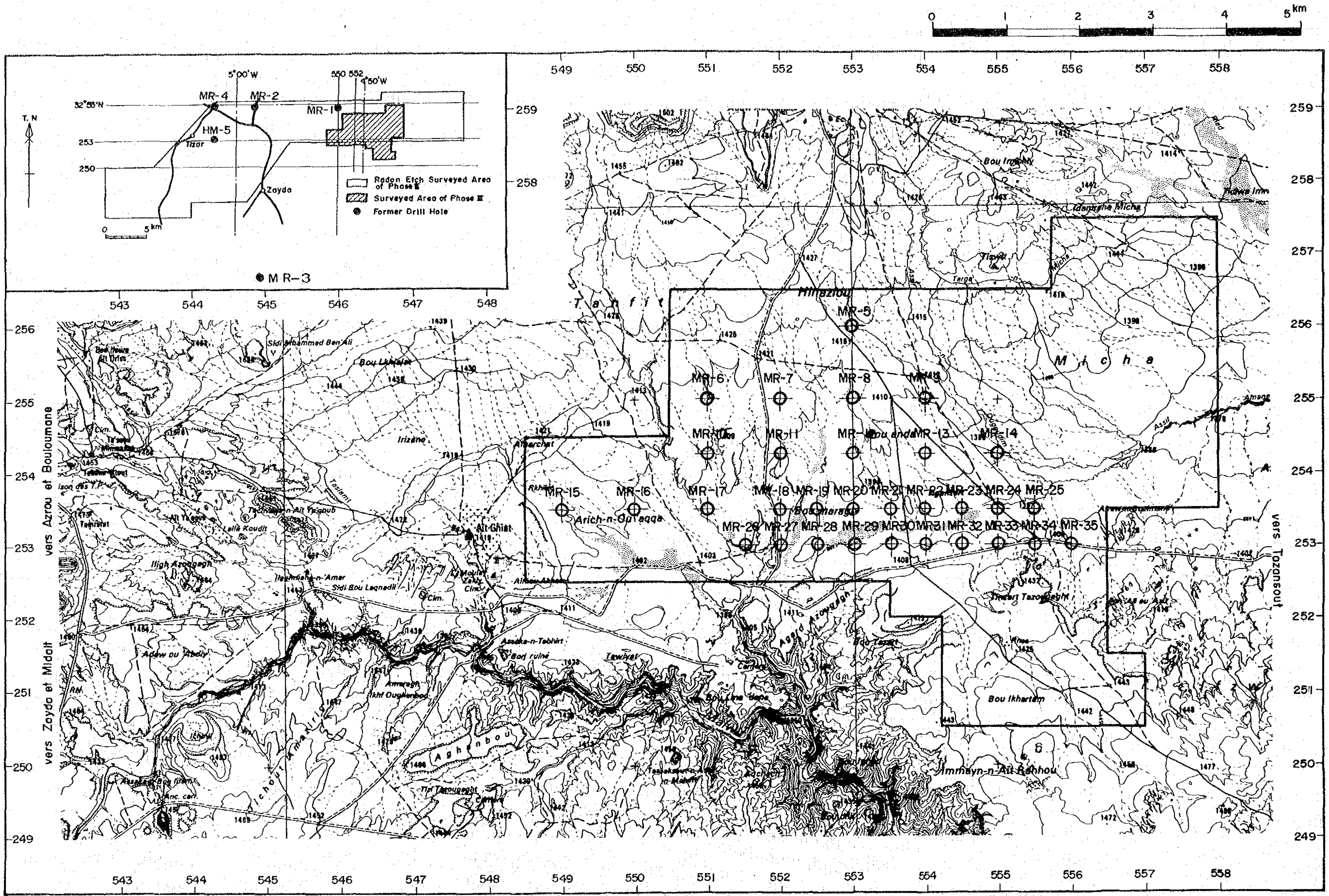
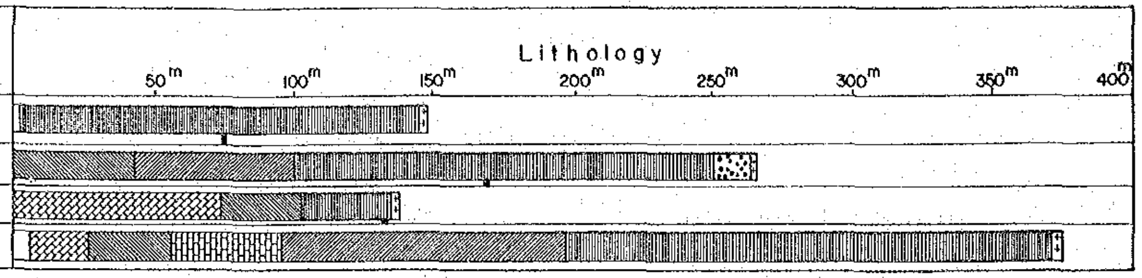


Fig. 8 Location Map of Drill Holes

Year	Number of Drill Hole	Depth (m)	Count of Scintillation (c/s)	Track Etch (T/mm²)		γ-ray Logging: Maximum Reading (c/s)	γ-ray Logging: Depth (m)	γ-ray Logging: Thickness (m)	γ-ray Logging: Count of Core (c/s)	Assay: U (ppm)	Assay: Th (ppm)	Assay: V (ppm)	Remark
1979	MR - 1	148.30	45	180		90	75.50	0.30	—	50	—	—	
	MR - 2	265.95	45	20		50	169.00	1.00	—	140	—	—	
	MR - 3	138.00	45	—		45	133.00	0.80	—	—	—	—	
	MR - 4	100.10 (475.70)	25	25		—	—	—	—	—	—	—	



Year	Number of Drill Hole	Depth (m)	Count of Scintillation (c/s)	Track Etch (T/mm²)		γ-ray Logging: Maximum Reading (c/s)	γ-ray Logging: Depth (m)	γ-ray Logging: Thickness (m)	γ-ray Logging: Count of Core (c/s)	Assay: U (ppm)	Assay: Th (ppm)	Assay: V (ppm)	Remark
1980	MR - 5	101.40	60	356		—	—	—	65				gypsam in the mudstone
	MR - 6	75.05	140	215	○	210	70.00	0.40	70	318	18	28	do
	MR - 7	69.00	75	66		—	—	—	60				do
	MR - 8	69.75	80	77		—	—	—	80				do
	MR - 9	63.00	80	147		—	—	—	50				do
	MR - 10	51.00	60	(245)	○	185	44.0	0.20	60	23	13	53	do
	MR - 11	47.30	130	(273)	◎	400	21.3	0.50	50	516	11	56	do
	MR - 12	47.50	90	(173)		—	—	—	60				baryte in the granite
	MR - 13	43.20	40	(83)	○	210	34.0	0.30	60	135	25	<5	gypsam in the mudstone
	MR - 14	37.00	80	(188)		—	—	—	65				
	MR - 15	45.05	80	220		165	32.0	0.40	60	128	4	18	dissemination of galena and cerusite from 32.40m to 32.80m (Pb 2%)
	MR - 16	30.00	60	73		—	—	—	55				
	MR - 17	29.55	55	92	◎	375	21.5	0.60	60	172	8	39	
	MR - 18	22.30	100	245		155	19.5	1.60	60	28	2	<5	
	MR - 19	26.60	80	269	◎	560	19.3	0.80	60	264	7	11	
	MR - 20	26.15	130	442		130	18.0	—	75	8	14	58	
	MR - 21	23.85	140	683	○	240	16.0	1.60	70	109	13	54	
	MR - 22	25.00	80	615		115	6.0	0.20	80	10	26	66	
	MR - 23	25.00	130	798		—	—	—	80				
	MR - 24	30.15	130	500		—	—	—	60				
	MR - 25	25.25	120	462		145	2.7	0.20	70	15	16	36	
	MR - 26	25.00	75	264		—	—	—	80				
	MR - 27	22.35	135	751		—	—	—	60				dissemination of galena and cerusite from 13.80m to 14.80m (Pb 1.5%)
	MR - 28	27.00	100	797		240	2.0 14.3	0.20 0.20	130	10 6	15 19	67 36	
	MR - 29	20.00	100	430		—	—	—	75				
	MR - 30	18.20	100	678		—	—	—	75				
	MR - 31	20.00	120	485		—	—	—	75				
	MR - 32	20.45	80	183		—	—	—	80				
	MR - 33	25.00	100	288		125	22.0	0.20	70				
	MR - 34	25.10	120	522		—	—	—	50				
	MR - 35	10.00	70	156		230	9.0	0.20	120	27	21	6	

◎ 6 timex of Background Value

○ 3 timex of Background Value

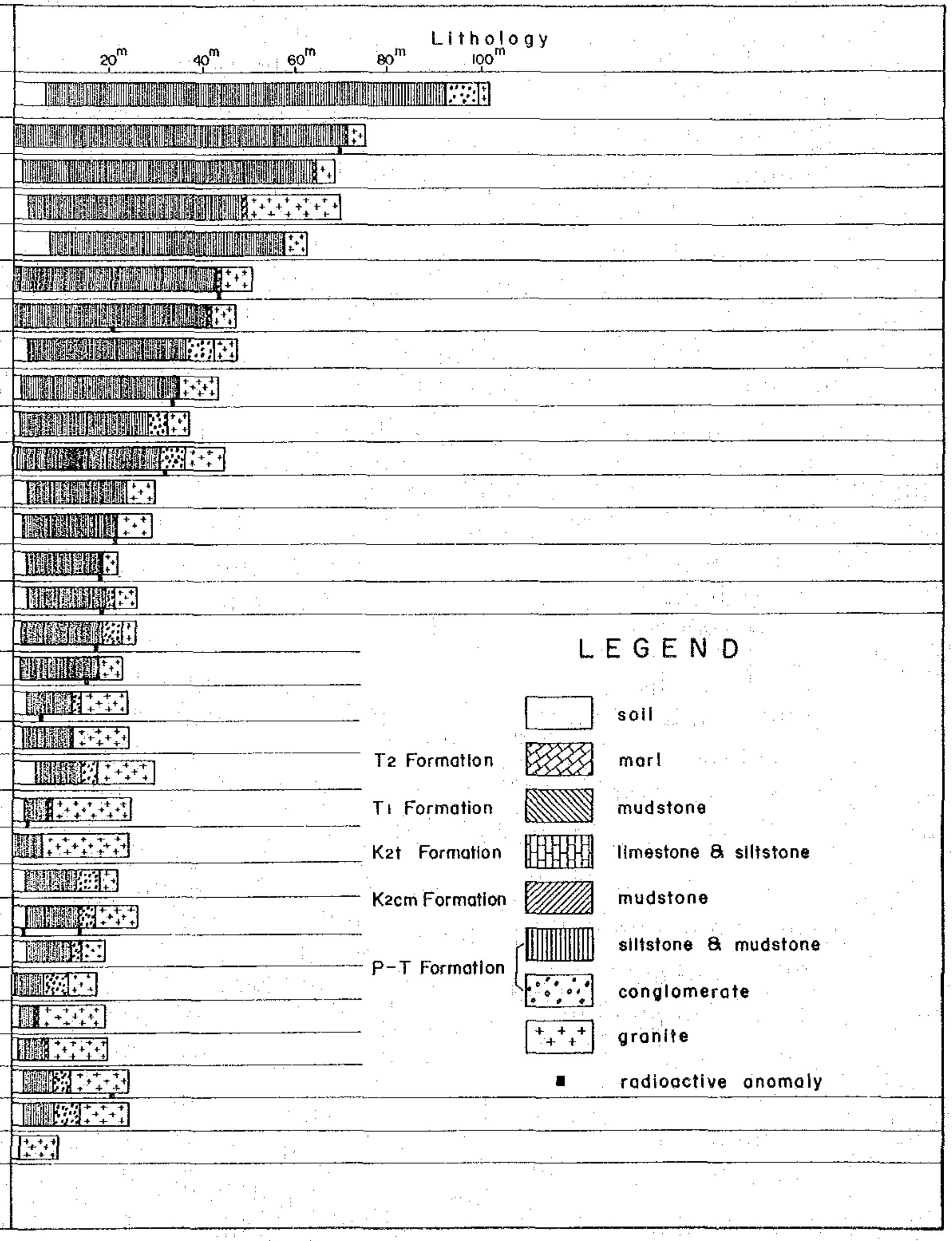


Fig. 9 Summary of Core Logs

thick westward. Also in holes MR-1 and MR-2 in the east, weak uranium anomalies and lead mineralization were recognized in the arkose sandstone of the P-T Red Sandstone Formation. The value of gamma-ray logging (90 c/s) and the value of uranium analysis (0.005%) were found at a depth of between 75.00 m and 75.80 m of hole MR-1; 50 c/s and 0.014% were obtained at depth of between 169.00 m and 170.00 m of hole MR-2. The maximum value of lead mineralization obtained was 0.43% Pb at a depth of between 169.00 m and 170.00 m of the hole MR-2.

In contrast, at hole MR-3 to the south of Zayda-Bou Mia Granite, the P-T Red Sandstone Formation immediately above the basements had no arkose sandstone at its bottom, and the mudstone formation directly covered the basements. Also, it was found that the Tertiary formation deposited directly above the P-T Red Sandstone Formation without having a Mesozoic formation.

The third phase drilling was performed in the area north of Zayda Granite where the potential presence of uranium deposits had been predicted because the anomalous values of the second phase radon etch survey had been concentrated there. Thirty-one drill holes (holes MR-5 to MR-35) were made in total and the total drilled length amounted to 1,120.20 meters.

When each hole was fully drilled, gamma-ray logging, spontaneous potential logging and resistivity logging were performed for each hole, and the geology of sampled cores was examined in detail. In addition, for the portions where anomalies, alteration, or mineralization had been found by gamma-ray logging, chemical analysis and microscopic observation were additionally performed in order to clarify the character of mineralization.

As a result of these diamond drillings, the basement structure predicted from the gravity survey has been confirmed and its details have been clarified. Specifically, it has been confirmed that the basements

consist of granites and that the basements topographically have a NE valley-like structure gently dipping north, and are overlain mainly by P-T Red Sandstone Formation. Particularly, if the NE valley-like structures are extended southward, all extended lines will coincide with the fractured zones with the same strikes in the Zayda Granite. From this, it is assumed that these valley-like structures were formed and developed along the fault or fractured zone.

Also, arkosic sandstone and granule conglomerate at the bottom of the P-T Red Sandstone Formation vary greatly in thickness, being thick at the valley-like structure and thin at its saddle portion. Also, the pebbles of the granule conglomerate primarily have a sub-angular shape. This probably means that early sedimentation filling each part began by accumilation of the materials came from nearby rocks. In addition, interbedded thin layers of arkose sandstone and gypsum layers were frequently recognized in the upper mudstone formation, from which it has been ascertained that the supply sources of debris during seidmentation slightly altered later and that the sedimentation took place under the continental environment and local lake environment.

From the results of gamma-ray logging, radioactive anomalies were detected in several drill holes and some of them indicated uranium mineralization. High anomalous values and analysis values obtained from the radioactivity measurement are shown in the table below.

Anomalous Values by Gamma-ray Logging and Results of Analysis

Drill hole No.	Depth (m)	Lithology	Readings of Radioactive logging (c/s)	Grade of uranium (ppm)
MR-6	70.5 to 70.7	White arkose sandstone	210	318
MR-11	21.4 to 21.6	White arkose sandstone	400	516
MR-11	21.6 to 21.8	White arkose sandstone		412
MR-13	34.8 to 35.0	Granite	215	135
MR-15	32.4 to 32.6	Arkosic granule conglomerate	165	128
MR-17	22.0 to 22.2	Arkosic granule conglomerate	375	172
MR-19	19.4 to 19.6	White arkose sandstone	560	264
MR-21	16.4 to 16.6	Reddish brown fine-grained sandstone	240	109

On the other hand, the presence of uranium was not confirmed in the following drill holes even though high readings of radioactivity were obtained: Hole MR-25 with 145 c/s at a depth of 2.50 m and hole MR-28 with 250 c/s at a depth of about 2.00 m. These depth all correspond to the bottom of surface soil, and the presence of radioactive materials other than uranium at these depths had been predicted.

Also, from the readings of the gamma-ray logging, the following tendency in intensity was recognized, from which the lithology in the area could be distinguished to a certain degree:

Reddish brown fine-grained sandstone $<$ arkose granule conglomerate $<$ granite $<$ white arkose sandstone

Lithology can be also distinguished to a certain degree from the results of the resistivity logging. Particularly from the results of micro resistivity logging, the detection of white arkosic sandstone was possible. Decreased values of resistivity were recognized in the fructured zones of granite.

From the various kinds of loggings described above, it has become clear that these logging methods combined together will be extremely effective for uranium prospection and the determination of formations in future exploration drilling in this area.

CHAPTER 5 CONCLUSION AND VIEW TO FUTURE PROGRAM

5-1 Conclusions

5-1-1 Method of Survey

The surveyed area, about 80 km long (east-west) and about 40 km wide (north-south) with an area of 3,200 km^2, is located in the highland of Haute Moulouya district in the central part of Morocco.

In the first phase survey, the geological outline of the area was confirmed through a geological survey (general survey). And, in three selected areas to the eastern part of Zayda, the northern part of Bou Mia-Zayda and the northern part of Zayda, totalling to an area of 1,100 km^2, a geological survey (semi-detailed survey and survey for ore deposits) was conducted to clarify the geological conditions of the mineralization. And also, a gravity survey was conducted in the area, on about 400 km^2 to the south of Zayda to determine the underground structure in this area.

In the second phase survey, a geological survey (semi-detailed survey) in the area northeast of Karrouchan, a geological survey (semi-detail survey and detailed survey) in the northern part of Bou Mia and northeastern part of Zayda, gravity and radon etch surveys on an area of 400 km^2 to the north of Bou Mia-Zayda Granites and the drilling of 4 holes in the area north of the Granites and in the area south of Zayda were performed respectively, and then geological structure, minerals indications and the underground structures were confirmed for each area in order to select the particular areas having high potential existence of ore deposits.

In the third phase survey, drilling of 31 drill holes and very dense radon etch survey were performed in the area of 39 km^2 in the north of Zayda Granite, and the mineralization in this area was geologically

examined.

This survey method combining geological survey, gravity survey, radon etch survey and drilling for sequentially selecting the promising areas has been proved to be the best method suited to this survey.

5-1-2 Geology and Geological Structure

Geologically, this surveyed area has the basements consisting of Pre-Cambrian to Paleozoic crystalline schists and granitic rocks intruded during Hercynian Orogeny, and also has Permian, Triassic, Jurassic, Cretaceous and Cenozoic sedimentary and eruptive rocks deposited over the basements.

These basements gently dip north at the north side and dip south at the south side of the saddle structure connected between the Zayda-Bou Mia Granites. There are fault structures striking NE-SW to NNE-SSW, ridge-shaped structures, trough structure of northwestern Karrouchan area, and basin structures in these basements. Also, the presence of valley-like structure running mainly in the direction of NNE-SSW on the basements was clarified by the gravity survey and diamond drilling.

Permian and Triassic formations were probably formed by receiving materials supplied from southeast to northwest sides, and the sedimentation was probably controled greatly by the topography of the basements in early stage of the sedimentation. That is, it is considered that there was generally a continental sedimentary environment during which conglemeratic sandstone or conglomerate was deposited on the valley-like structure of the basements and then reddish brown mudstone was deposited as upper part of the formation over the sandstone or conglomerate.

Jurassic formation consists of deep-sea type and partially shallow-sea type sediments, and the central granite region remained as land. Since

the Cretaceous formation consists of lake-water type sediments was distributed throughout the whole region, it is considered that the whole region was below the sea level in this period. Alpine Orogeny occurred during the Miocene of Tertiary and then the Moyen Atlas and High Atlas were uplifted, so that the Tertiary formation was formed by the fragments of nearby rocks deposited in the inland basin. Block movement occurred during Quaternary, the whole region was raised and became land, and then erosion probably progressed until the basements.

5-1-3 Ore Deposits and Mineral Indications

Many lead ore deposits and uranium indications were found in the surveyed area. With respect to the lead deposits, many sandstone type (Zayda), stratiformed type (mibladane) and vein type (Awli) deposits and many mineral indications were recognized. Particularly, the sandstone type lead deposits near Zayda are embedded in arkosic sandstone and granule conglomerate at the bottom of P-T Red Sandstone Formation, and all deposits are distributed on or along the valley-like structures of the basements as clarified by the gravity survey.

With respect to the uranium indications, the vein type indication was detected along dykes or fractured zones in the granites, sandstone type indication was detected in arkose sandstone of P-T Red Sandstone Formation, conglomerate type indication was detected in Quaternary conglomerate, and carapace type indication was detected on the surfaces of granitic rocks. Also, aplitic granite indicated high radioactive intensity. Particularly in the area where there is vein type uranium indication together with granite, it is considered that such granite functioned as source rocks of the sandstone type uranium deposits in the sedimentary rocks.

On the other hand, according to the results of the radon etch survey which was used as an effective means for detecting the uranium deposits in deep underground layers, several anomalous zones were detected in the area north of Zayda Granite, in the area north of Bou Mia Granite, in the area north of Zayda, and in the northeastern part of the surveyed area. The results obtained in the area north of Zayda Granite indicated the significant and many signs of uranium mineralization within the arkosic sandstone formation of P-T Red Sandstone Formation. Though these deposits are considered to be the sandstone type uranium deposits, their grades and scales are insufficient for actual exploitation at present.

Anomalous values of the radon etch survey are considered to have resulted from uranium deposits in the deep underground layers and probably also from radon or radium located immediately below the surface soil in this area, according to the results of logging in drill holes and of geological observation of cores. Therefore, in the future survey, it will be required to clarify the geological conditions of ground surface and the underground geology and to interpret them.

5-2 View to Future Program

Through the collaborated basic survey for the resource development which was continued for three years, the collaboration system has been established between Morocco and Japan, and the prospection techniques have been exchanged between two countries.

Geological structure in the surveyed area has been clarified and also the mineralization has been analyzed by this survey. The results of these studies are shown in the geological maps and in this report.

There are several lead ore deposits already under exploitation in the

area. However, there are still many other zones of lead and uranium indications in the nearby areas. Particularly, it has been clarified from the results of this survey that the sandstone type lead ore deposits tend to be controlled by the valley-like structures of the basements, so that it is desirable to plan and perform future survey and prospection by taking account of this tendency.

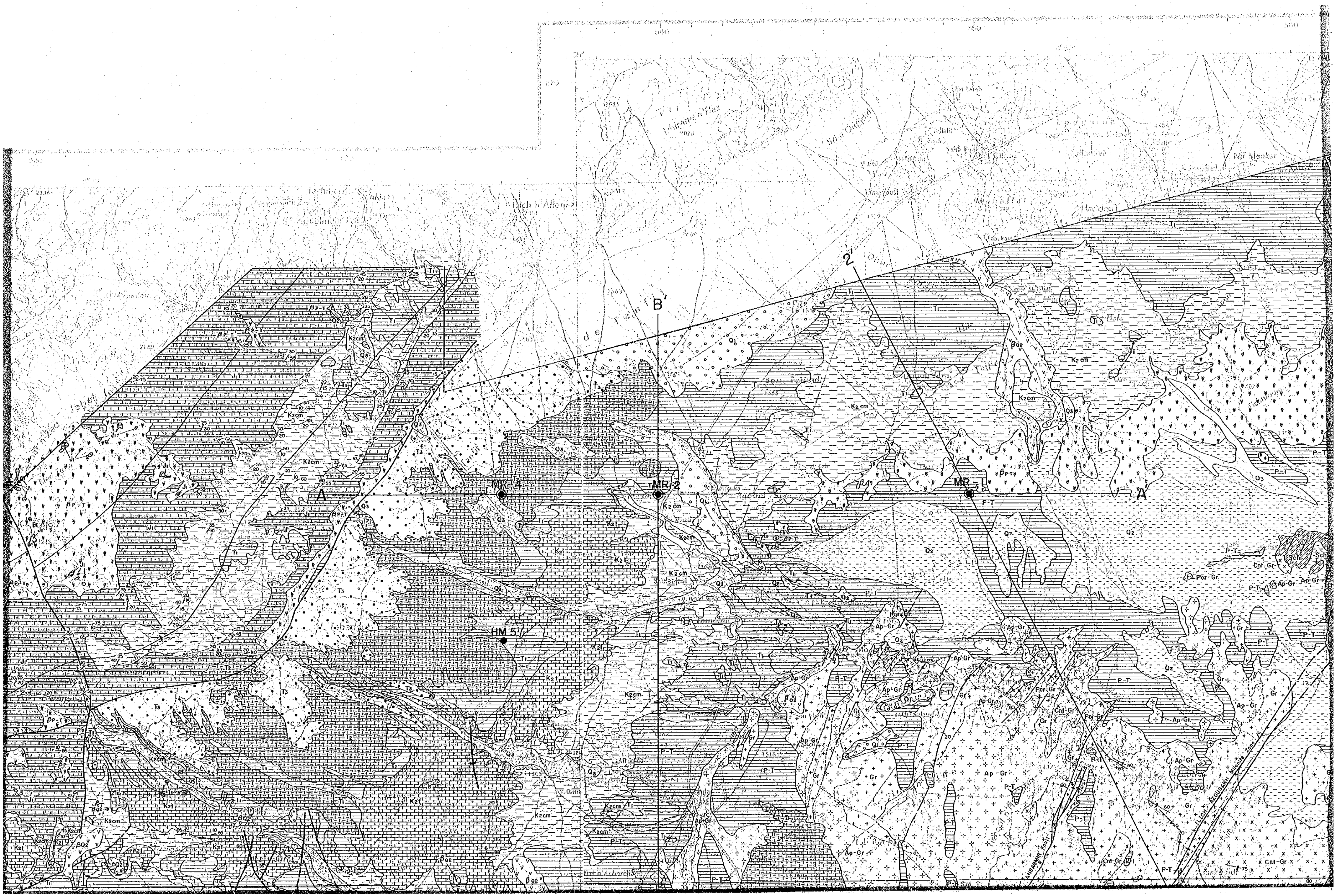
With respect to the uranium deposits, the mineral indications of the uranium were not significant for the economic exploitation in view of the scale and grade of the deposits. However, uranium mineralization detected in the arkose sandstone of the P-T Red Sandstone Formation will suggest a potential existence of uranium deposits in the same formation in this area or nearby areas. Particularly, a high potential of sufficiently economical exploitation will exist at the places where the thickness of the arkose sandstone increases.

Various kinds of survey methods adopted during the basic survey for three years have been proved to be extremely effective for selecting the promising areas within a short period of time. Thus, the use of the same methods is very desirable in the future explorations for the same kinds of ore deposits. Particularly, the use of radon etch survey together with exploratory drilling for performing various kinds of loggings is considered to be very effective for detecting the localized deposits in the uranium prospection.

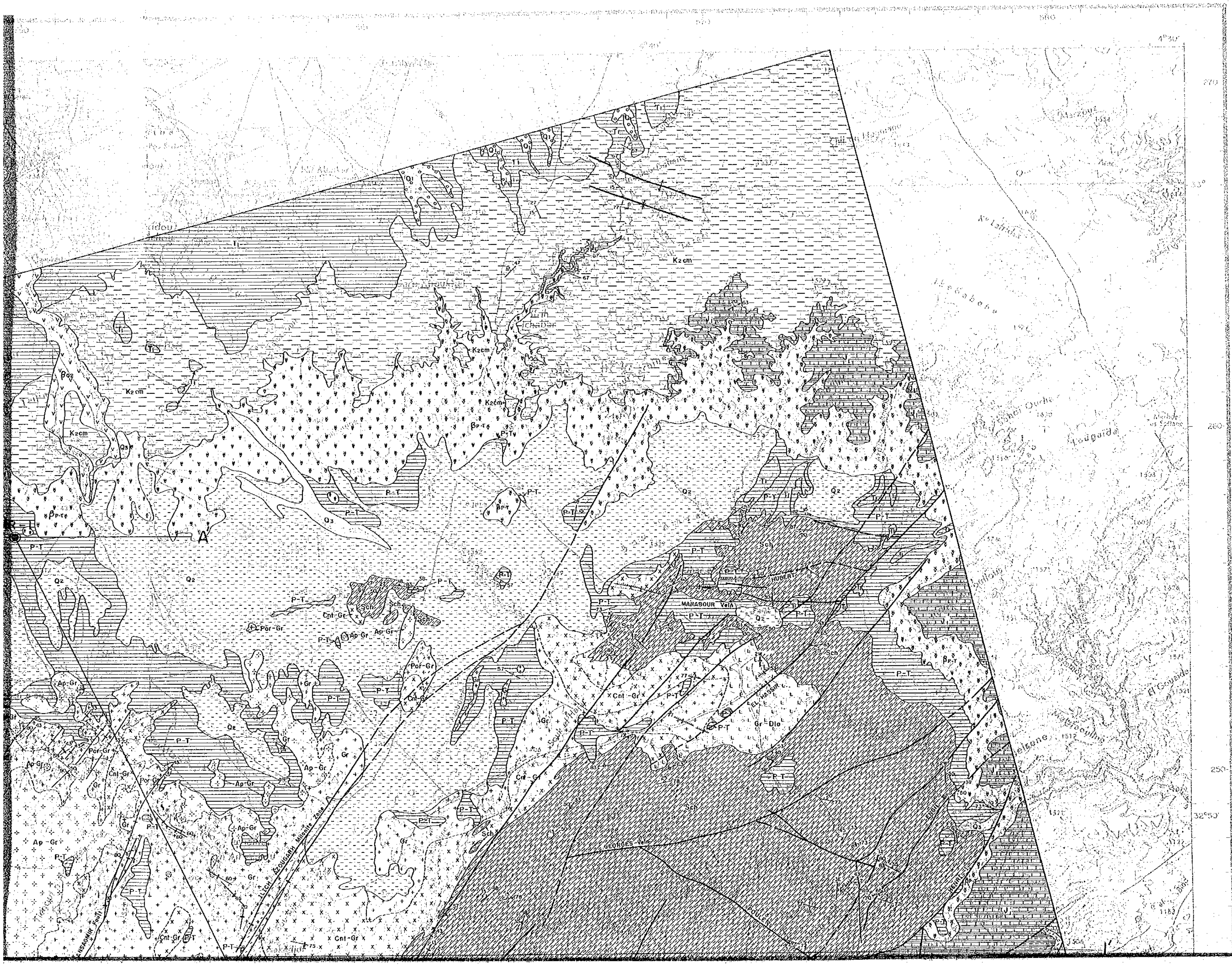
Also, since the anomalous values obtained from the radon etch survey may occasionally reflect the information emitted from the underground uranium deposits, it is desirable to make exploratory drilling in the future for the zones where the anomalous values were detected in the surveyed area. Areas having a potential existence of these uranium deposits will be the area north of Bou Mia, the area north of Zayda, and the anomalous zone in

the northeastern part of the surveyed area.


Plateau d'Ajdir
Ajdir
Timahsinine
Jebel Ifhoud
Koudia Mirssal
Mou Baroud
HM-3



B'
2'
A
MR-4
MR-3
MR-1
A
HM 5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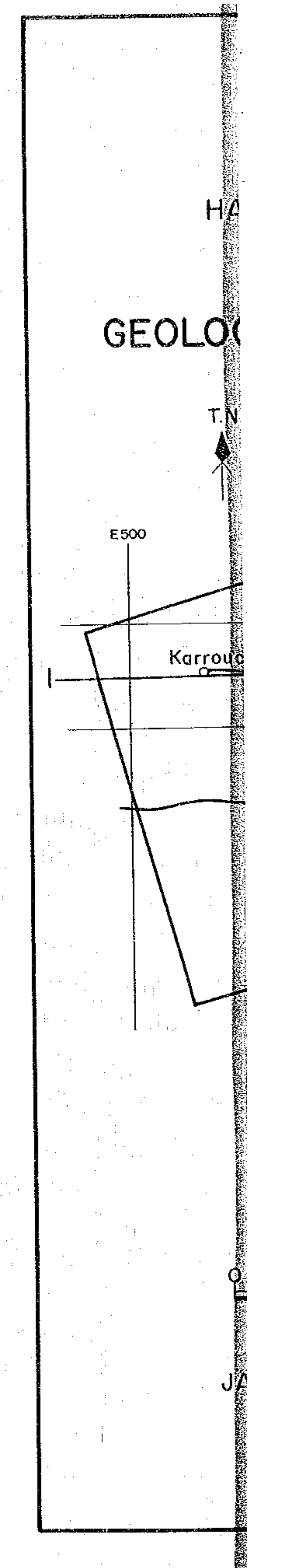
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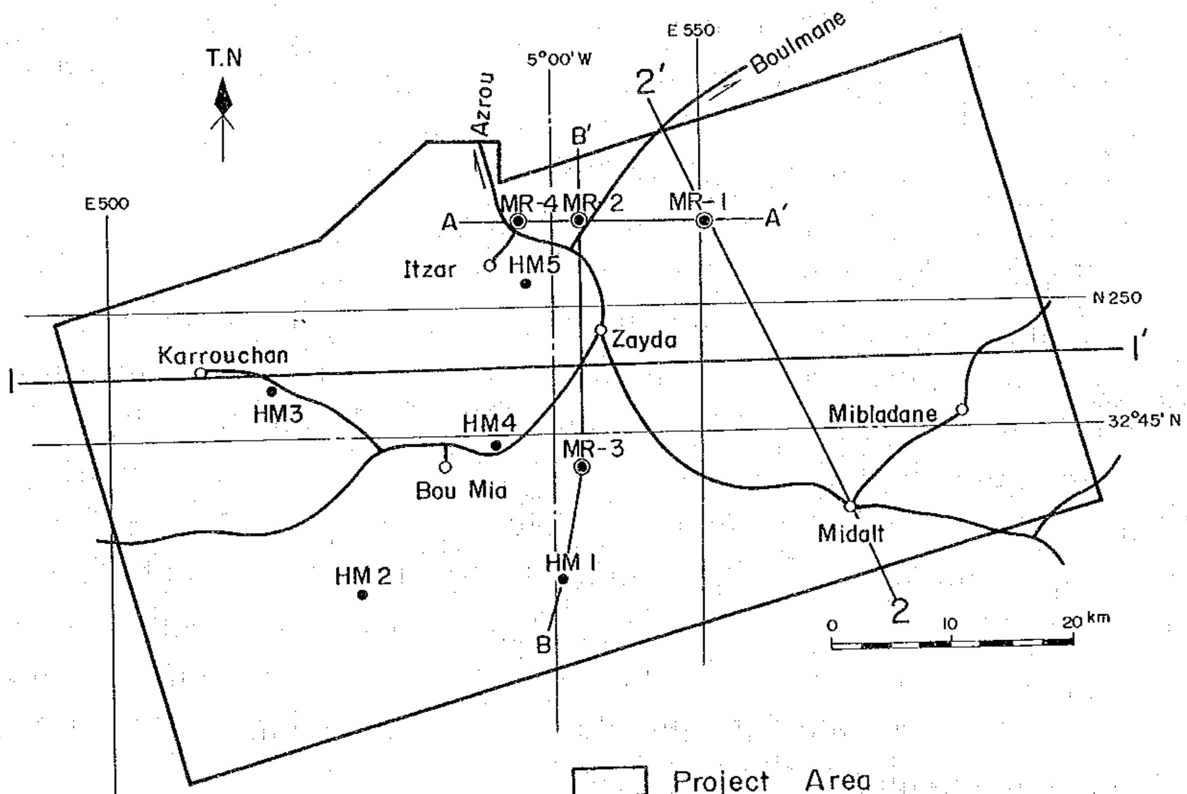
PL. I

GEOLOGICAL SURVEY
OF
HAUTE MOULOUYA AREA, MOROCCO

GEOLOGICAL MAP OF THE SURVEYED AREA



Project Area
HM2 Drill Hole, effected by B.R.P.M
MR-2 Drill Hole (1979)
A–A' Profile Line

Scale 1 : 100,000

0 2 4 6 8 10 km

METAL MINING AGENCY OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY

FEBRUARY 1981

Prepared by MESCO, Inc.