Chapter 2 Compilation of Existing Documents

Existing documents relevant to the Project were mainly collected in the archive of National Office of Mines with the courtesy of this Office. National Office of Mines provided the Project Team with a number of valuable maps, reports, data sets and other relevant documents which include 7 geological reports, 5 geochemical exploration reports, 3 geophysical exploration reports, 16 reports on mineral occurrences and 2 annual reports.

2.1 Documents on Geology and Geochemical Exploration

Nation-wide geological mapping, including the Krib-Mejez el Bab area, is vigorously being carried out by National Office of Mines at the present time. The results have been successively published in the geological maps at scales of 1 to 50,000, 1 to 100,000, 1 to 200,000 and 1 to 500,000, and also in the geological structure map at a scale of 1 to 1,000,000. The regional geology of the Krib-Mejez el Bab and adjacent areas has been investigated by Pertuisot (1979), Stranik et al. (1994), Dali (1995), Ben Haji Ali (1997), Mahjoub et al. (1997) and Fakraoui et al. (1998), and is published in the geological maps at a scale of 1 to 50,000. During the current year's investigation, 6 geological maps at a scale of 1 to 50,000 and 1 geological map at a scale of 1 to 500,000, which cover the Project Area, are purchased as shown in Table 14. The geological maps at a scale of 1 to 200,000 are currently out of print.

Geochemical stream sediment sampling, with a density of 3 samples/km^2, is being regionally carried out by National Office of Mines with purpose to locate promosing mineral occurrences for exploitation. Its results are documented in geochemical prospecting maps at a scale of 1 to 50,000.

The geochemical prospecting reports (Table 15) by Guedria et al. (1989, 1990 and 1991), Loukil (1991) and Layeb (1997) are available for the Bou Khil, El Akhouat-Argoub Adama, Bazina Kebira and Oued Jebes prospects which are included in the current year's exploration program.

Table 14 Geological Maps and Reports

Pertuisot, V. (1979); Carte géologique de la Tunisie, Echelle : 1/50.000, Feuille n° 33 Teboursouk, Notice explicative : Republique Tunisienne, Ministere de L'industrie des Mines et de L'energie, Direction des Mines et de la Géologie, Sous-Direction de la Géologie.
Stranik, Z., Biely, A. et Salaj, J. (1994); Notice explicative de la carte géologique de la Tunisie à 1/50.000, Oued Zarga, Feuille n° 26 : Republique Tunisienne, Ministere de L'industrie, Office National des Mines, Direction de la Géologie.
Dali, F. (1995); Notice explicative de la carte géologique de la Tunisie à 1/50.000, Gafour, Feuille n° 40 : Republique Tunisienne, Ministere de L'industrie, Office National des Mines, Direction de la Géologie.
Ben Haj Ali, M. (1997); Notice explicative de la carte géologique de la Tunisie à 1/50.000, Jendouba, Feuille n ° 32 : Republique Tunisienne, Ministere de L'industrie, Office National des Mines, Direction de la Géologie.
Mahjoub, K., Hatira, N. et Taamallah, N. (1997); Notice explicative de la carte géologique de la Tunisie à 1/50.000, Les Salines, Feuille n° 45 : Republique Tunisienne, Ministere de L'industrie, Office National des Mines, Direction de la Géologie.
Fakraouni, M., Ghanmi, et Hatira, N. (1998); Notice explicative de la carte géologique de la Tunisie à 1/50.000, Nebeur, Feuille n° 39 : Republique Tunisienne, Ministere de L'industrie, Office National des Mines, Service Géologique de Tunisie.
Republique Tunisienne, Ministere de L'economie National, Office National des Mines, Departement de la Géologie, Service Géologique National (1985); Carte Géologique de la Tunisie, Echelle : 1/500.000

Table 15 Geochemical Exploration Reports

Guedaria, A., Aissa, L.B., Tagorti, M.A., Loukil, C. et Taloura, B.B. (1989); Interpretation des resultats de prospection strategique de la zone des domes, Feuille Teboursouk : Office National des Mines, Departement Laboratoire, Valorisation et Services de Géochimie.
Ditto (1990); Prospection Géochimique Strategique de la Feuille de Gaafour au 1/50000 : Office National des Mines, Departement Laboratoire,Valorisation et Services de Soutien Service Géochimie.
Ditto (1991); Prospection Géochimique Strategique de la Feuille de M'jez el Bab : Office National des Mines, Departement Laboratoire,Valorisation et Services de Soutien Service Géochimie.
Loukil, C (1991); Jebel Ech-Chehid prospection géochimique tactique : Office National des Mines, Services de Géochimie.
Layeb, M. (1997) Synthèse géologique et géochimique des series de couverture de la structure diapirique de J. Ech-Chehid secteurs retenus favorables pour la recherche des metaux de base : Office National des Mines, Direction de la Recherche Miniere Division Inventaire, Projet Recherche D'anomalies.

2.2 Documents on Geophysical Exploration

National Office of Mines of Tunisia is enthusiastically conducting a nation-wide gravity survey with a density of 1 measuring point/km^2. Its results are published in regional Bouguer anomaly maps at a scale of 1 to 50,000. The regional gravity map of the Gafour quadrangle at a scale of 1 to 50,000 by Jean-Claude (1999) includes the Bou Khil and El Akhouat-Argoub Adama prospects which are the targets for the current year's geophysical exploration.

Electric prospecting has been carried out for the mineral occurrences in Argoub Adama and Bazina. Its results are documented in the reports by national Office of Mines as shown in Table 16

Table 16 Geophysical Exploration Reports

Jean-Claude, G. (1999) Expertise des levés gravmétrique CG-01 et CG-02. (Zone des Domes Tunisie) : Office National des Mines de Tunisie.
Office National des Mines de Tunisie (1996) Levé polarisation provoquee Campagnre 96, Prospect Agroub Adama, Repport Intermédiaire.
Office National des Mines de Tunisie (1996) Levé polarisation provoquee, Prospect Bazina, Repport Intermédiaire.

2.3 Documents on Mineral Occurrences

A total of 18 major mineral occurrences, including abandoned and small-scale mines, have been identified in the Project Area (Figure 18 and Table 17), and are documented in the reports of the 1 to 50,000 quadrangles to which they belong (Table 18).

There are known two diapirs related to lead and zinc mineralization in the Project Area, called the J. Ech-Cheid and J. El Mourra (Figure 18). The relationship between these diapirs and the mineralization is documented by Hammami (1996). National Office of Mines of Tunisia has carried out detailed investigations for mineral occurrences such as the Oued Jebes, Koudiat Soda, Koudiat Safra, Argoub Adama, El Akhouat, Jebel Ouiba and Bou Khil, and has published in the investigation reports listed in Table 19. Of these mineral occurrences, the Koudiat Soda, Koudiat Sofra, Argoub Adama and El Akouat are regarded as promising and are documented by Hammami (1993).

In addition to the documents cited in the tables of this chapter, two annual reports (1989, 1990) summarize the results of investigations by National Office of Mines of Tunisia in the Project Area (Table 20).

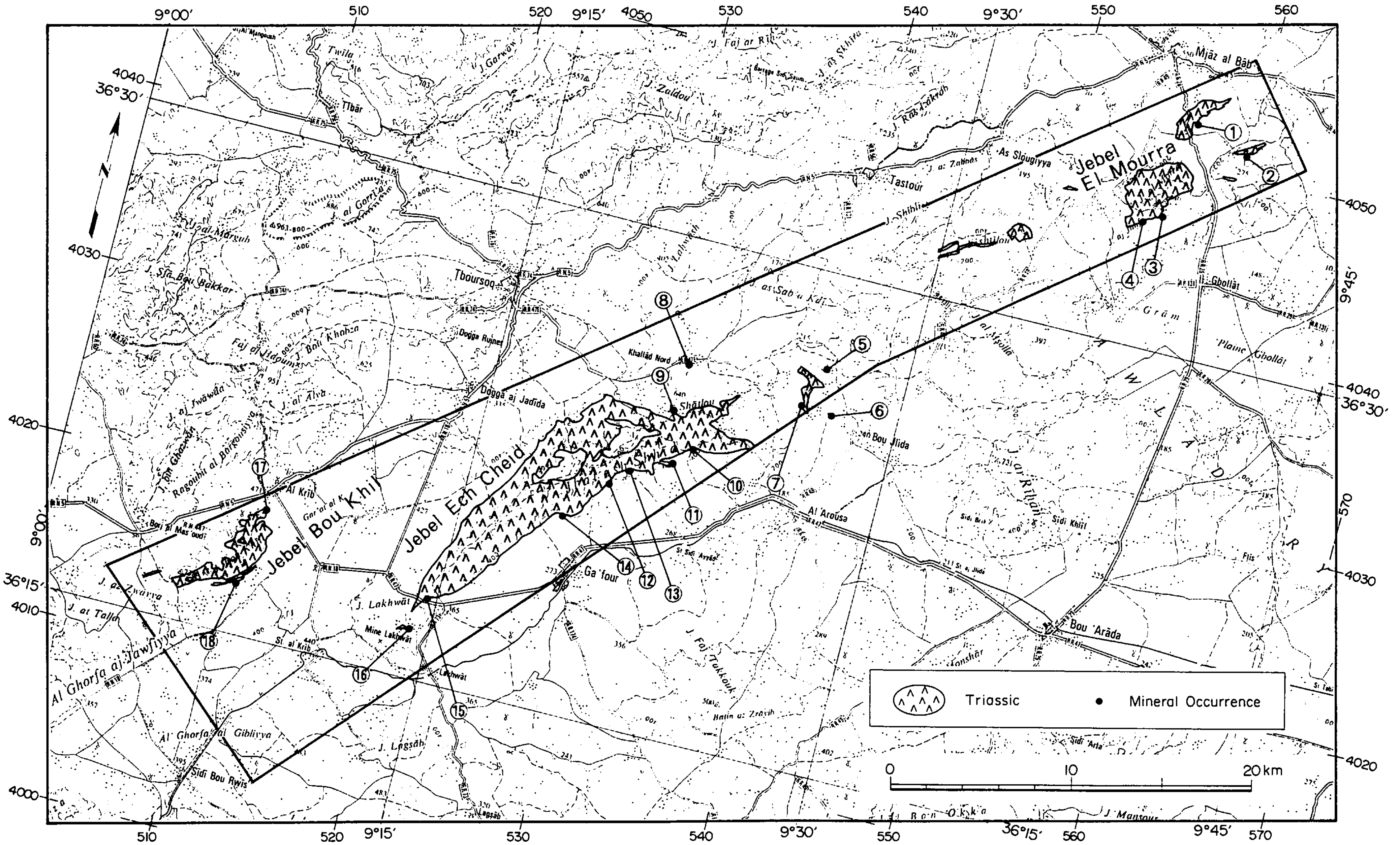


Figure 18 Distribution Map of Mineral Occurrences

Table 17 List of Mineral Occurrences in the Krib-Mejez el Bab Area

No	Name	Commodity	Mode of Occurrences	Host Rocks (Age)
1	Jebel Bou Mouss	Pb, (Ba)	veins	limestone, marl (late Cretaceous)
2	Dar Chebka	Pb, Zn	lenses	marl, limestone (Eocene)
3	Kef Lasfar	Pb, (Zn)	veins	limestone (late Crtaceous)
4	Oued Jebes	Zn, Pb	veins	limestone (late Crtaceous)
5	Assioud	Pb, Ba	fracture filling	limestone, sandstone (early Cretaceous)
6	Siliana	Fe, Pb, Ba	veins	limestone, marl (early Cretaceous)
7	Mahjoubia	Pb, Zn	veins, dissemination	breccia, marl (Triassic-Cretaceous)
8	Ain Younes	Pb	veins	sandstone (early Cretaceous)
9	Jebel Chetlou	Pb	veins, stratiform	sandstone, limestone (Eocene)
10	Koudiat Tlilett	Pb	dissemination	Breccia (late Cretaceous -Eocene)
11	Koudiat Soda	Pb	veins, stratiform	sandstone, marl (late Cretaceous -Eocene)
12	H'Zamel Assoued	Pb	stratiform	sandstone, marl (early Cretaceous)
13	Koudiat Safra	Pb	stratiform	sandstone, marl (late Cretaceous -Eocene)
14	Koudiat Bazina Kebira	Pb, (Zn)	fracture filling	limestone (Eocene)
15	Argoub Adama	Pb, Zn	dissemination	marl, limestone (Triassic- late Cretaceous)
16	El Akhouat	Zn, Pb	veins	limestone, marl (late Cretaceous)
17	Jebel Ouiba	Pb	veins	marl, limestone (late Cretaceous)
18	Bou Khil	Pb, Zn	massive	dolomitized breccia (Triassic- late Cretaceous)

Table 18 Investigation Reports on Mineral Occurrences (regional survey)

Coopération ONM-BRGM (1982-1985) Projet zone de domes, Inventaire gitologique, Feuille au 1/50,000 Gafour : Office National de Mines, Bureau de Recherches Géologiaue et Minieres.
Coopération ONM-BRGM (1982-1985) Projet zone de domes, Inventaire gitologique, Feuille au 1/50,000 Mejez el Bab : Office National de Mines, Bureau de Recherches Géologiaue et Minieres.
Coopération ONM-BRGM (1982-1985) Projet zone de domes, Inventaire gitologique, Feuille au 1/50,000 Teboursouk : Office National de Mines, Bureau de Recherches Géologiaue et Minieres.
Hammami, M. (1996) Données géologiques, gitologiques et géochimique de l'alignement J. Ech Cheid-J. El Mourra (Taboursouk-Mejez el Bab) Volume 3 : D-Données gitologiques : Office National de Mines, Division Inventaires, Projet : Recherches D'anomalies

Table 19 Investigation Reports on Mineral Occurrences (detailed survey)

Chikhaoui, M., Hatira, N., Khalfaoui, A. et Hamouda, A. (1993) Etude géologique et géochimique du prospect de L'oued Jebs, secteur Mejez El Bab, résultats et proposition de sondages : ONM-MG Centre Zitoua, Le Kef
Sellami, A. (1995) Etude géologique préliminaire du secteur de Argoub Adama (Feuille au 1/50,000 de Gaafour) (Phase Tactique) : Office National de Mines, Direction de la Recherche Miniere, Division Prospection. Projet : Fej Lahdoum-Thibar.
Hammami, M. et Mansouri, A. (1989) Mine Lakhouat études géologique, prospection geochimique et géophysique, et reconnatssance par sondages O.N.M. –1986-1988 : Office National de Mines, Division Miniere du Nord Subdivision de Beja (ONM. GMX SB. 89_02).
Hammami, M. (1993) Travaux de recherche effectues sur la flanc est du Jebel El Akhouat : Office National de Mines, Direction de la Recherche Miniere, Division Inventaires.
Sellami, A. et Chikhaoui, M. (1996) Etude géologique du secteur de Jebel Ouiba (Region du Krib) (Feuille au 1/50,000 de Gaafour) : Office National de Mines, Direction de la Recherche Miniere, Division Prospection. Projet : Fejlahdoum-Thibar.
Snoussi, S. (1987) Jebel Boukhil, Etude géologique et miniere : Office National des Mines.
Mansouri, A. (1988) A propos de l'ancien gite zincifere de Bou Khil, Principaux resaltats d'une synthèse de travaux antérieurs, Proposition de travaux complémentaires.
Mansouri, A. et Sellami, A.(1989) Division Miniere du Nord Subdivision de Beja, Gisement de Bou Khil, Secteur de la 'Colonne Dante', synthèse géologique et évaluation des réserves : Office National des Mines.
Ditto (1990) Division Miniere du Nord Subdivision de Beja, Bou Khil Travaux D'exploration, Situation de la reconnaissance potentiel minier et perspectives Zn. Sr. Pb : Office National des Mines.
Sellami, A.(1990) Fiche Signaletique sur les travaux de recherches minieres réalises a Bou Khil Jusqu'au mois d'avril, 1990: Office National des Mines, Subdivision de Beja.
Sellami, A. et Mansouri, A. (1993) Les travaux de recherche réalises a Bou Khil (Principaux résultats de la campagne de sondage 1992-1993) : Office National des Mines, Départment de Gites Mineraux Srevice Prospection Miniere et Exploration.
Hammami, M. (1993) Mise au point sur les travaux tactiques réalises sur le flanc est du Jebel Ech Cheid : Office National de Mines, Direction de la Recherche Miniere, Division Inventaires.

Table 20 Annual Reports

Mansouri, A. (1989) Division Miniere du Nord Subdivision de Beja, Rapport Annuel 1988 : Office National de Mines, ONM. GBX.SB.89.01.
Mansouri, A. (1990) Division Miniere du Nord Subdivision de Beja, Rapport Annuel 1989 : Office National de Mines, ONM. GBX.SB.90.01.

Chapter 3 Bou Khil Prospect

3.1 Airphoto Analysis

The airphoto interpretation is made for the monochromatic air photographs at a scale of 1 to 25,000, obtained in the Republic of Tunisia, covering an area of 25 km^2 that includes the Bou Khil prospect. The purposes of the interpretation are to verify faults, beddings and other lineaments and to discriminate lithology in relation with the mineralization in the prospect.

The specifications of the used air photographs are shown in Table 21 and the result of interpretation is illustrated in Figure 19.

Table 21 Specifications of Air Photographs

Location	Photo No.	Number of photos	Remarks
Bou Khil	1368-1371, 1348-1347	6 sheets	Project:74TU359/250 UAG412

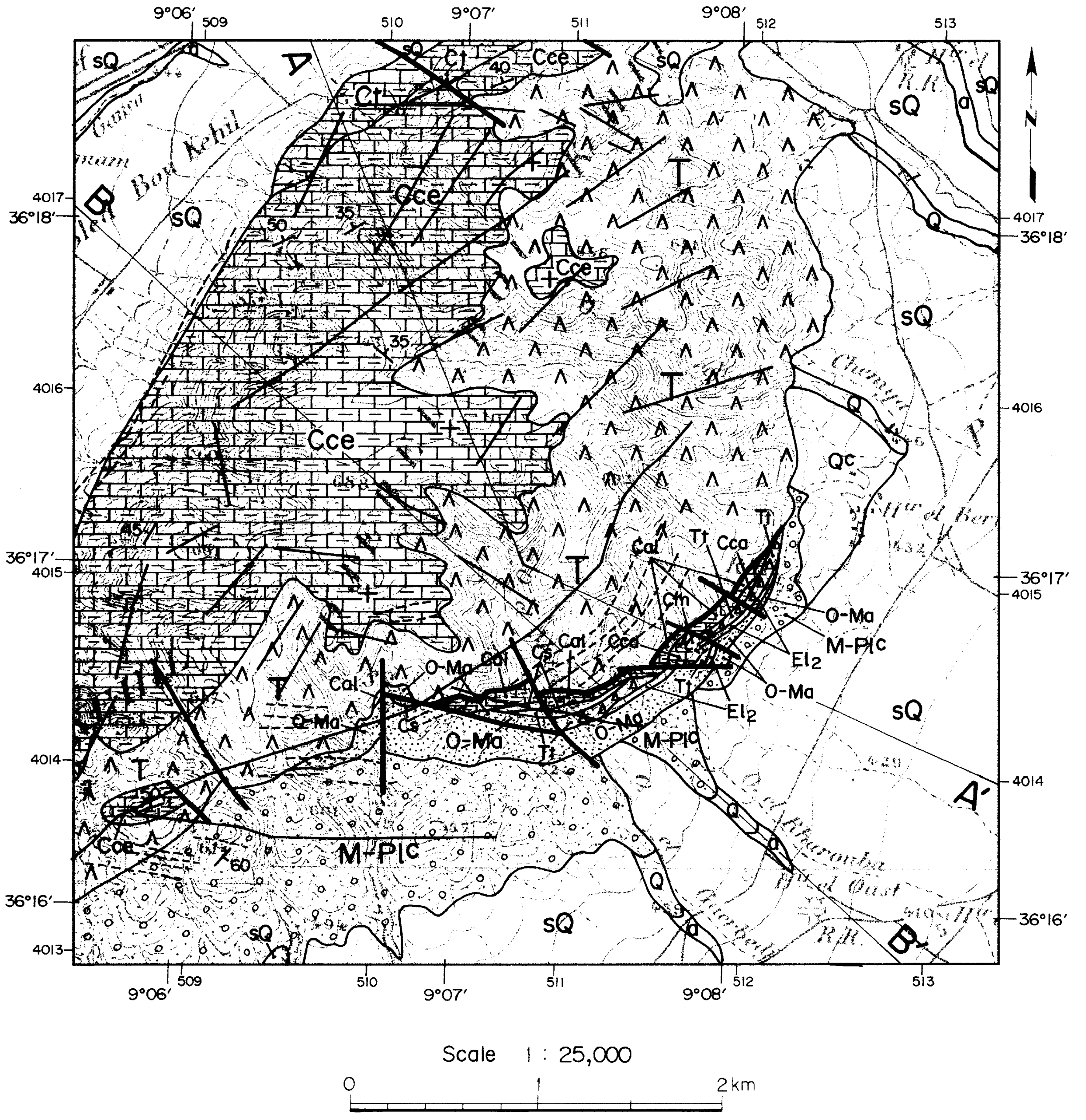
A number of lineaments, which are interpreted as possible faults, are observed in association with the Triassic, Cretaceous and Tertiary systems. Most of them trend either in the NE-SW, E-W or NW-SE direction, of which the NE-SW trending lineaments are most predominated. Lineaments, possibly indicating beddings, are observed all of the Triassic, Cretaceous and Tertiary terrain. They trend in the NE-SW to E-W directions in the Triassic and Tertiary terrain and in the NE-SW to ENE-WSW directions in the Cretaceous terrain.

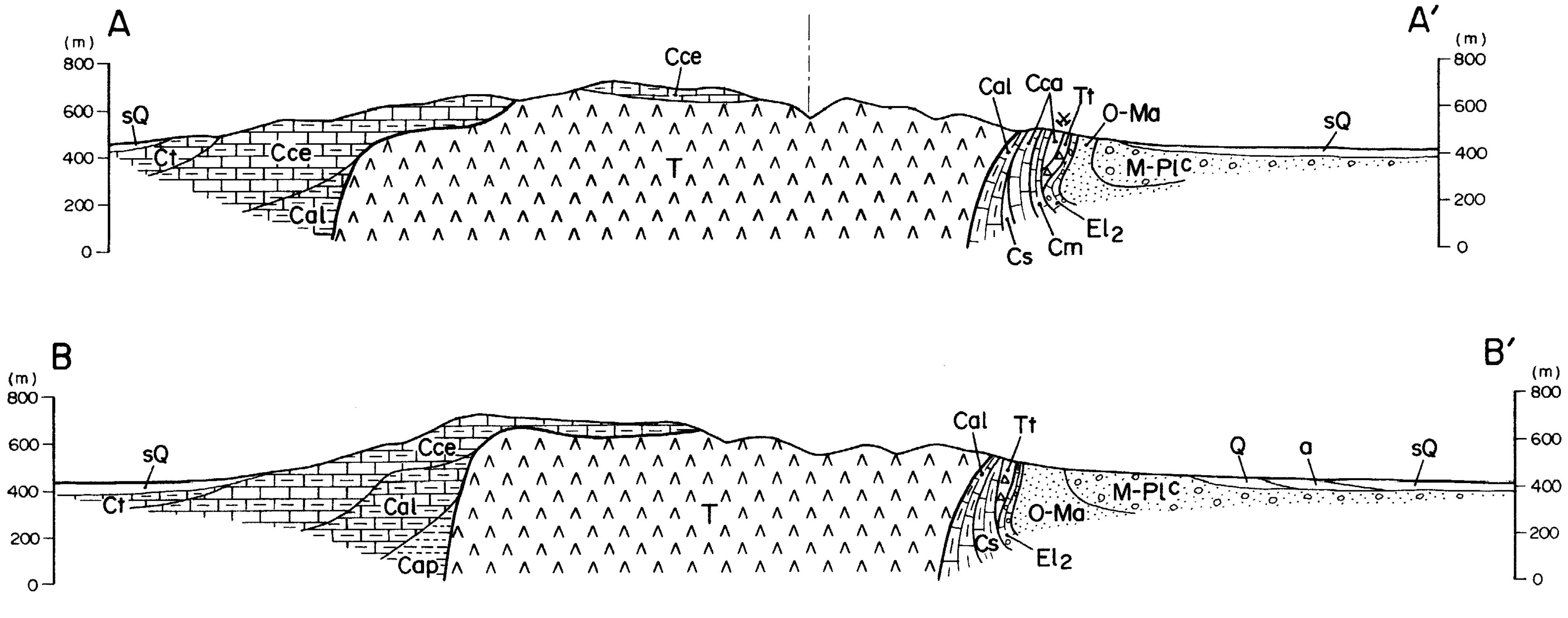
3.2 Geological Prospecting

3.2.1 Methodology

The purpose of the geological prospecting was to investigate geology, geological structures and mineral occurrences in the prospect in order to verify dome structures with respect to Pb-Zn mineralization.

The geological prospecting was principally carried out along the measuring lines set for the geophysical prospecting, aiming at producing a geological fact map at a scale of 1 to 5,000. A topographic map at a scale of 1 to 5,000 was prepared, by enlarging a published topographic map at a scale of 1 to 50,000, for the supplemental prospecting along creeks between the geophysical measuring lines. Rock and ore samples were collected from selected outcrops useful for identifying stratigraphy and





LEGEND

Quaternary	Holocene	a	gravel, sand, clay
	Pleistocene	sQ	soil
	Pleistocene	Qc	calcareous conglomerate
	Pleistocene	Q	siltstone, conglomerate
Tertiary	Miocene ~ Pliocene	M-Plc	sandstone, conglomerate, marl, sand, clay
	Oligocene ~ Miocene	O-Ma	sandstone
	Eocene	El2	limestone, conglomerate
Cretaceous	Maastrichtian	Cm	marl, limestone
	Campanian	Cca	limestone
	Santonian	Cs	marl, limestone
	Turonian	Ct	limestone, marl
	Cenomanian	Cce	limestone, marl
	Albian	Cal	limestone, marl
	Aptian	Cap	marl, sandstone
Triassic		Tt	Transition zone dolomite, calcite, marl, celestite
		T	gypsum, clay, sandstone, dolomite, limestone

Fault

Lineament

Figure 19 Geological map and cross section of Bou Khil Prospect geological structures.

The prospecting result was compiled into a geological map at a scale of 1 to 25,000, together with geological cross sections of the same scale. Collected samples were submitted for microscopic observation of thin and polished sections, X-ray diffraction analysis and/or chemical analysis.

3.2.2 Geology

The Bou Khil prospect encompasses an area of 5x5 km, including the Bou Khil diapir body. The stratigraphy comprises, in its ascending order, the Triassic, Cretaceous, Tertiary and Quaternary systems. The geological plan and cross sections of the prospect are shown in Figure 19, and the schematic stratigraphic section, in Figure 20.

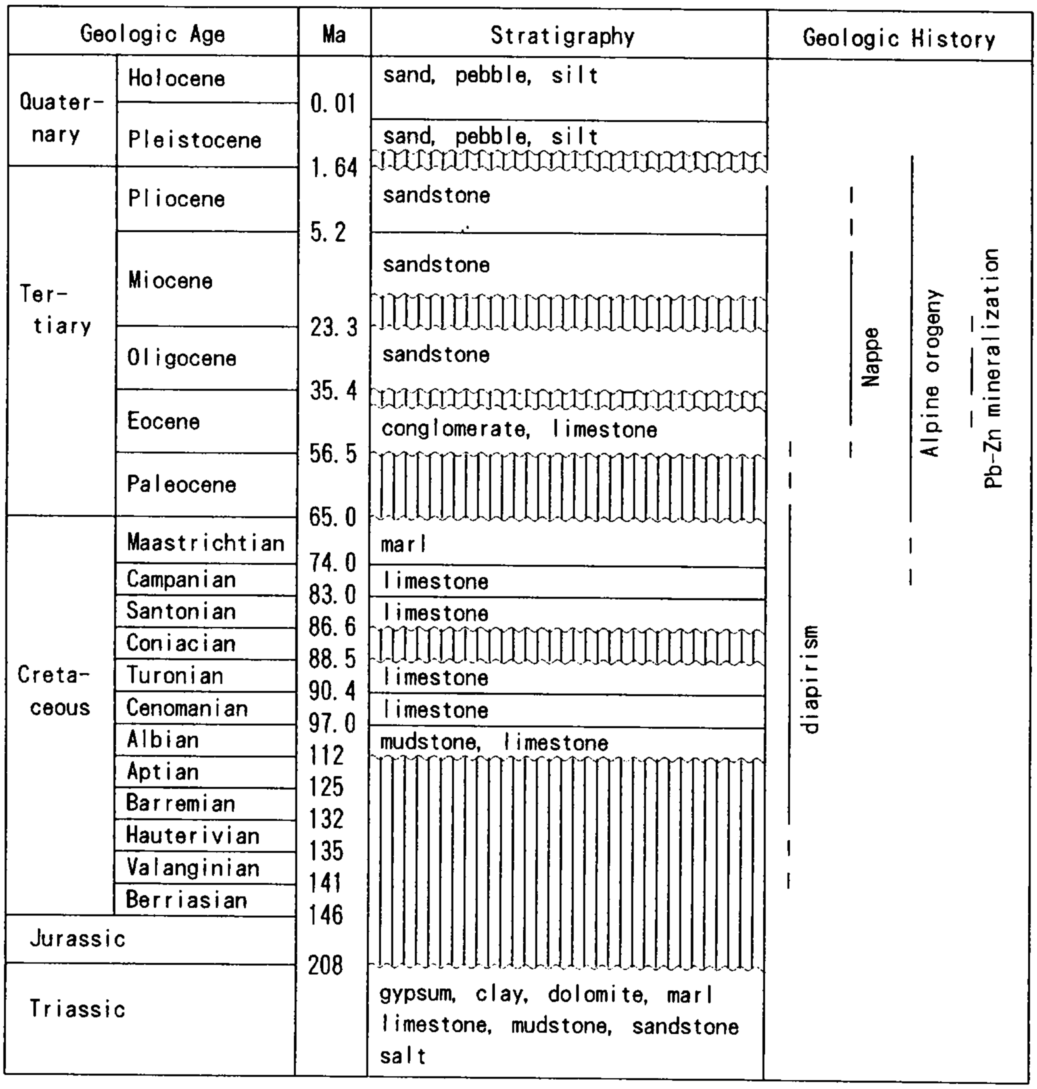


Figure 20 Schematic stratigraphic section

The Triassic system is composed of gypsum, clay, dolomite, marl, limestone, argillite and meta-sandstone. Their sedimentary structures are extremely disturbed by folding, over-folding and faulting of various scales and attitudes due to diapirism. Accordingly, continuity of each stratum is very poor. Lithology of the Triassic system is inhomogeneous as a whole, comprising mixed blocks or fine alternations of various rock types, although a single type of rocks occasionally forms a mappable unit in places. Relatively soft marl, argillite and gypsum tend to be easily eroded away, which results in highlighting massive or stratified outcrops of harder dolomite, limestone and meta-sandstone. The Bou Khil diapir body abuts on the Cretaceous and Tertiary systems along its southeastern side, while its northwestern side is covered by the Cretaceous system. A stratum of possible Triassic is interbedded between the Cretaceous and Tertiary systems to the southeast of the diapir body. It is interpreted that the diapir body near the surface constitutes the 'umbrella' part of its mushroom shape (Perthuisot, et. al., 1999).

The Cretaceous system comprises, in stratigraphically ascending order, argillite and limestone of Albian, argillaceous limestone of Cenomanian, Limestone of Turonian, limestone of Santonian, limestone of Campanian and marl of Maastrichtian. The system can be divided into two groups from its distribution relative to the diapir body; one, extensively distributing in the northwestern side and comprising formations of Albian, Cenomanian and Turonian, and the other, distributing in the southeastern side and forming lenses of Albian, Cenomanian, Santonian, Campanian and Maastrichtian formations. Of the formations of the latter group, the Albian contacts with the Triassic system and consists of dark gray to dark green-gray argillite, fragmented by weathering, and limestone containing Belemnite fossils. The Cenomanian formation comprises alternation of massive limestone and stratified marl. The Turonian limestone is characteristically black on fresh outcrops and is called 'Bahloul' in Tunisian. The Santonian limestone is grayish white and massive. The Campanian limestone, hosting Bou Khil ore deposits, is grayish white and massive or weakly stratified. The Maastrichtian marl is grayish white and weakly stratified.

The Tertiary system comprises, in stratigraphically ascending order, Eocene conglomerate and limestone, and Oligocene, Miocene and Pliocene sandstones. These Tertiary rocks distribute to the southeast and west of the diapir body. The Eocene conglomerate forms the base of the Tertiary system and contains fragments of Triassic and Cretaceous rocks. The Eocene limestone contains abundant Nummulites fossils. The terrestrial sandstones of Oligocene through Pliocene are porous, weakly consolidated and fine to medium grained, consisting mostly of rounded quartz grains. The Quaternary system comprises alluvial deposits, such as calcareous conglomerate, gravel, sand and mud, and alluvial soils. The Bou Khil hill is composed of alluvial soils and utilized for cultivation.

3.2.3 Geological Structure

The Bou Khil diapir body takes an mushroom form on cross section and is covered by the Cretaceous system for its northwestern half. The southeastern half forms an 'umbrella' of the mushroom resting over the Cretaceous and Tertiary systems. The Triassic system shows no systematic sedimentary structure, being extremely disturbed due to diapirism. Strata of the Cretaceous system, covering the northwestern half of the diapir body, have a general strike of the NE-SW direction and dips of 30 to 50° to northwest which flatten towards the top of the diapir body. Stratigraphically continuous successions of the Cretaceous system from Barremian through Maastrichtian has been deposited between the Bou Khil diapir and the Fedj el Adoum diapir to the northwest, forming a synclinal structure in between. The Cretaceous system covering the northwestern half of the Bou Khil diapir corresponds to the southeastern limb of this syncline. The synclinal structure has been developed by progressive diapirism with deposition of the Cretaceous system, which has resulted in deposition of Cretaceous strata thicker in its axial zone and thinner towards the diapir bodies. In contrast, Cretaceous and Tertiary strata in the southeastern side, striking in the NE-SW to ENE-WSW directions, show near vertical dips or are even overturned under the 'umbrella' of the Triassic mushroom due to diapirism. In the southeastern side of the diapir, a number of strike-slip faults, running in the NW-SE to WNW-ESE directions, are well developed and laterally dislocate the Triassic, Cretaceous and Tertiary systems. Cretaceous strata are extremely variable in their thickness in general and tend to be discontinuous laterally. Blocks bounded by strike-slip faults differ in their stratigraphy from one to another.

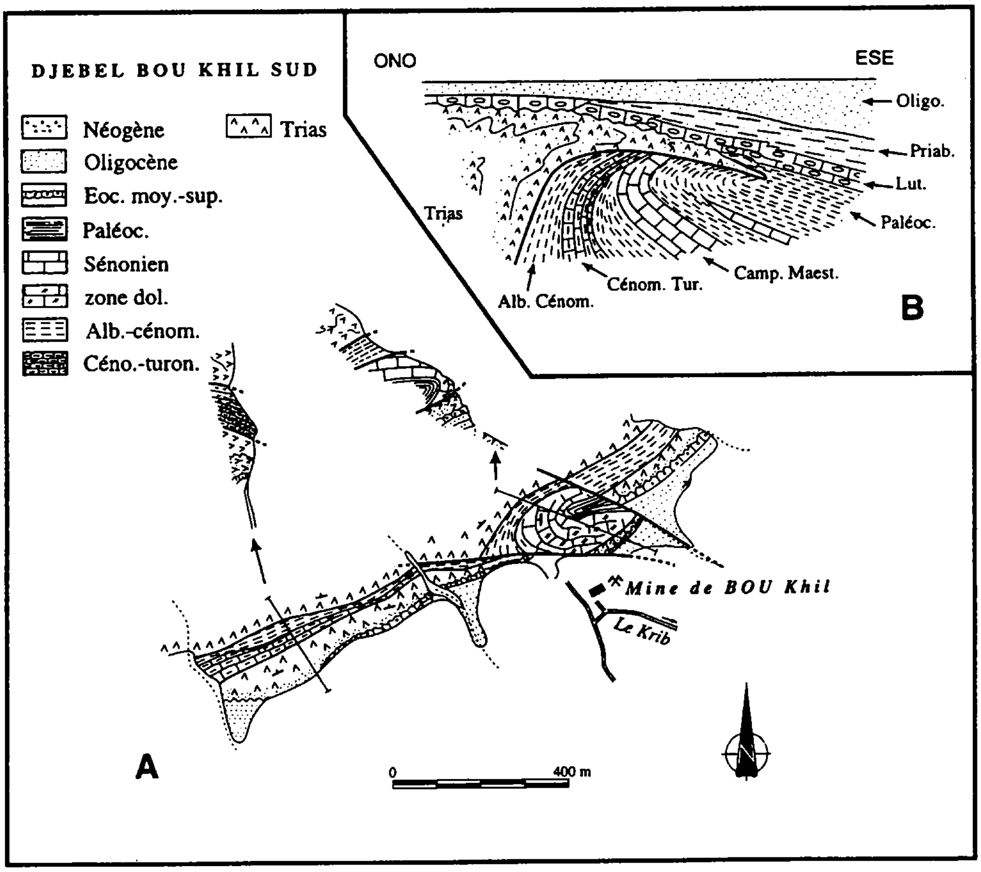
The Bou Khil diapir has been vigorously investigated by National Office of Mines, the Republic of Tunisia (Snoussi, Mansouri, Sellami and others), and is described in various reports published by the Office. Figure 21 shows a model of the Bou Khil diapir proposed by Perthuisot et al.(1999). According to this model, the history of formation of the diapir structure can be summarized as follows;

- The diapirism initiated in late Cretaceous and continued to early Tertiary.
- The diapir emerged out to the surface or the shallow sea bottom through the overlying Cretaceous system and took a mushroom shape, with its part laterally flowing over the surface or the sea floor and covering the Cretaceous system. This event intensely deformed the Cretaceous system adjacent to the Triassic diapir and reversed its stratigraphic sequence under the umbrella part of diapir

mushroom.

- The top of the diapir was then covered by the Eocene and the Oligocene series in early Tertiary.
- The diapirism was revitalized in Oligocene, at the climax of the Alpine diastrophism, and further deformed the preexisting Cretaceous and Tertiary systems with the umbrella part of diapir being turned inward.
- Erosion during the Quaternary period exposed the diapir body of the present day, comprising the main stem and the stratified umbrella of mushroom.

The stratified umbrella, extending southeastward, is called 'transition zone' for the convenience of description, and characteristically consists of dolomite, argillite and limestone.



The Bou Khil diapir [from Perthuisot et al., 1987, modified]. A: geological map of the south flank; B: reconstruction of the diapir structure during Oligocene times.

Figure 21 Geology and structure of the Bou Khil Diapir (Perthuisot et. al., 1999)

It is observed in the vicinity of the geophysical measuring line B1 in the southwestern part of the Bou Khil prospect that the Triassic diapir body contacts with the Oligocene series where the Oligocene and Miocene sandstones. At this locality, argillite xonoliths of the Albian stage are included in the Triassic, which implies the Cretaceous system underlying the Tertiary system near the contact with the diapir. A limestone lens of Cretaceous, bounded by faults, is also observed near the contact with the Triassic diapir. The Triassic system is irregular in its boundary with other systems. In part, a stratum of the system, containing abundant gypsum, overlies the Oligocene and Miocene series with a moderate inclination. Strata of the Cretaceous and Tertiary systems strike in the ENE-WSW direction in general. The geological structure of the Bou Khil prospect is very complex with development of numerous faults, trending generally in the WNW-ESE and NNE-SSW directions, which include strike-slip faults.

In the vicinity of the geophysical measuring line B2, the stratigraphic sequence comprises the Triassic system, the Albian argillite, the Cenomanian limestone and marl, the Triassic shale and dolomite of the transition zone, the Oligocene sandstone, and the Miocene sandstone in its ascending order. The Eocene series is lacking in along the lines B1 and B2 and their vicinity. In this part of the prospect, faults trending in the WNW-ESE direction are well developed.

In the vicinity of the line B3 to the southwest of the old Bou Khil mine, the stratigraphic sequence comprises the Triassic system, the Albian argillite, the Santonian limestone, the Triassic celestite, shale and dolomite of the transition zone, the Eocene conglomerate and limestone, the Oligocene sandstone and the Miocene sandstone in its ascending order (Figure 22). Strata of the Cretaceous and Tertiary systems strike in the ENE-WSW direction in general. The celestite deposit is formed in the transition zone at the contact with the Cretaceous system. It is believed that the contact between the Eocene and the Triassic is non-tectonic, with the former being deposited directly over the latter, although brecciation is partly observed.

In the vicinity of the line B4 passing by the old Bou Khil open pit, the stratigraphic sequence comprises the Triassic system, the Albian argillite and limestone, the Campanian limestone, the Maastrichtian marl, the Triassic shale and dolomite of the transition zone, the Eocene conglomerate and limestone, the Oligocene sandstone and the Miocene sandstone in its ascending order. The Campanian limestone and the Maastrichtian marl are over-folded, with the former directly contacting with the transition zone. The Bou Khil Pb-Zn ore deposit is formed in the Campanian limestone contacting with the transition zone. Strata of the Cretaceous and Tertiary systems strike in the ENE-WSW to NE-SW directions and are overturned.

In the vicinity of the line B5 to the northeast of the mine, the stratigraphic sequence comprises the Triassic system, the Albian argillite, (the Campanian limestone), the Triassic shale and dolomite of the transition zone, the Eocene conglomerate and limestone, the Oligocene sandstone and the Miocene sandstone in its ascending order. The Campanian limestone forms lenses bounded by strike-slip faults on both hanging and foot walls (Figure 23).

In the vicinity of the line B6 to the east of the mine, the Triassic system laterally extends forming an 'umbrella' directly over the Oligocene sandstone. No Cretaceous system is exposed.

As above described, the stratigraphic sequence differs from one place to another. This variety in stratigraphic sequence may be attributed to the diapirism that has made the Cretaceous strata laterally variable in their thickness and/or broken them, limestone in particular, into a number of blocks in the course of its progress.

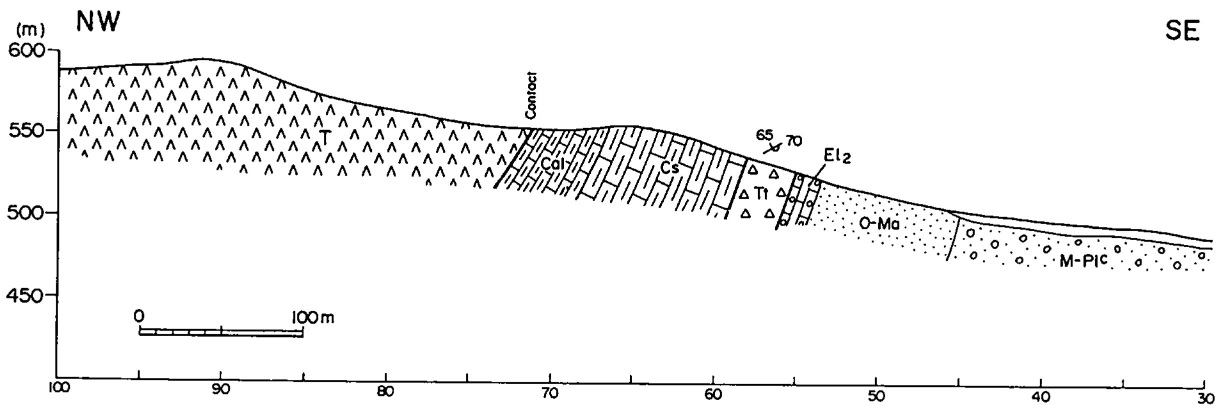


Figure 22 Geological section of the geophysical measuring line B3

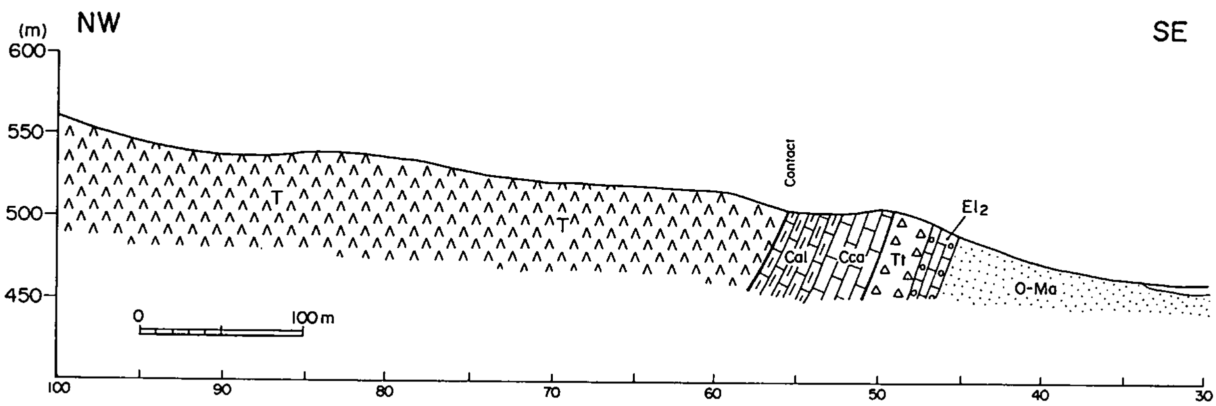


Figure 23 Geological section of the geophysical measuring line B5

3.2.4 Mineralization

The Bou Khil deposit is located at the coordination of 36° 33' 52" N and 9° 36' 54" E, at an elevation of 500 m above sea level on a hill about 20 km west southwest of the town of Gafour. The National Office of Mines started exploration of this prospect in 1985, in order to prove substituting resources for the El Akhouat Mine, about 10 km to the east, which was about to exhaust its resources at the time. Various investigations were carried out, looking for minable resources in and around old workings and mineral indications then known in the prospect. The initial drilling campaign commenced in 1989 and identified potentially economical mineralization. The follow-up drilling with the total length of 1,500 m identified minable ore reserves of 1,200 k tons with the combined Pb+Zn at 10 %, in addition to the previously mined amount of ores of 400 k tons with the combined Pb+Zn at 10 %.

The Bou Khil Pb-Zn ore deposit is situated in the Campanian limestone of late Cretaceous at the contact with the bottom of 'umbrella' (transition zone) of the Triassic diapir(the Model in the ONM report, Perthuisot, 1999). The ore deposit is categorized into the Mississippi Valley type, occurring to the proximity of the Triassic diapir in the Dome zone of northern Tunisia. The mineralization is mostly limited in the Cretaceous limestone contacting with the Triassic transition zone, although the Triassic is also mineralized in part. The ore deposit comprises stratiform or lenticular bodies parallel to beddings and veinlets or networks filling fractures in the limestone. Ore minerals are galena, sphalerite and pyrite associated with gangue minerals such as calcite, dolomite and celestite. The host limestone is subjected to dolomitization which is stronger in the hanging wall, the Triassic transition zone. The ore deposit has been confirmed by drilling to an extent of approximately 100 m in strike length and more than 100 m in dip length with thickness ranging from several to 20 m. This ore deposit is limited within a block bounded by faults. A celestite ore deposit occurs in the Triassic system to the southwest of the Pb-Zn deposit. Minor celestite mineralization is also observed in the Triassic transition zone in the same block where the Bou Khil deposit is located. Ore samples were collected from a waste dump beside an abandoned mine working and were submitted for chemical analysis. The analytical result is shown in Table 22.

Table 22 Analytical Result of Ore Samples

Sample No.	Cu (ppm)	Pb (%)	Zn (%)	Fe (%)	Mn (ppm)	Cd (ppm)	Mg (%)	Ca (%)	Sr (ppm)	Ba (ppm)	Ag (ppm)
BKH09C	2.4	1.78	26.00	1.97	790	394.3	0.07	18.99	450.8	56.3	<0.3
BKH18C	36.1	3.50	12.60	1.05	1016	1218.4	2.30	21.99	418.4	115.4	38.9
BKH19C	1.5	0.77	7.60	9.17	1084	105.3	2.25	21.59	264.7	35.6	<0.3
BKH20C	11.2	0.87	8.30	1.51	314	4.1	1.88	30.79	586.1	140.3	<0.3
BKH13C	93.6	0.01	0.06	3.67	1668	<2.0	1.56	3.30	4.8%	121.9	<0.3

A mineralization model is generalized as follows.

As sediments were accumulated in the Cretaceous basin, diapirism was initiated due to difference in density between the underlying Triassic system including evaporites and the consolidated sediments at the bottom of the Cretaceous system. With increasing consolidation of sediments at depth, squeezed intra-strata water, which dissolved metallic elements and hydrocarbons, started migrating laterally and upwards. Highly saline water squeezed out of the Triassic rock salt, gypsum and other evaporites migrated through permeable channels formed by fracturing of rocks particularly in the vicinity of the contact between the ascending Triassic diapirs and the intruded Cretaceous system. The saline water, mixing with metalliferous solution squeezed out of the Cretaceous sediments, further migrated upwards through faults and fractures and, if physico-chemical conditions were appropriate, precipitated minerals on the tops or limbs of diapirs where structural spaces, such as fractured zones or permeable strata, were available. The mixed solutions were able to migrate further away from diapirs, if permeable channels were available, and to precipitate minerals at any locations, if physico-chemical conditions allowed. Metallic elements, such as lead, zinc, barium and so forth, are believed to have been dissolved out mostly of the Cretaceous sediments, although the Triassic evaporites may have supplied some amounts of them.

Meanwhile, strontium migrated in solutions through channels in the Triassic system and was concentrated under Triassic cap rocks (Figure 24).