Chapter 3 Bou Khil Prospect

3.1 Geology

3.1.1 Geology and Geological Structure

(1) 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 13, and the schematic stratigraphic section, in Figure 14.

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

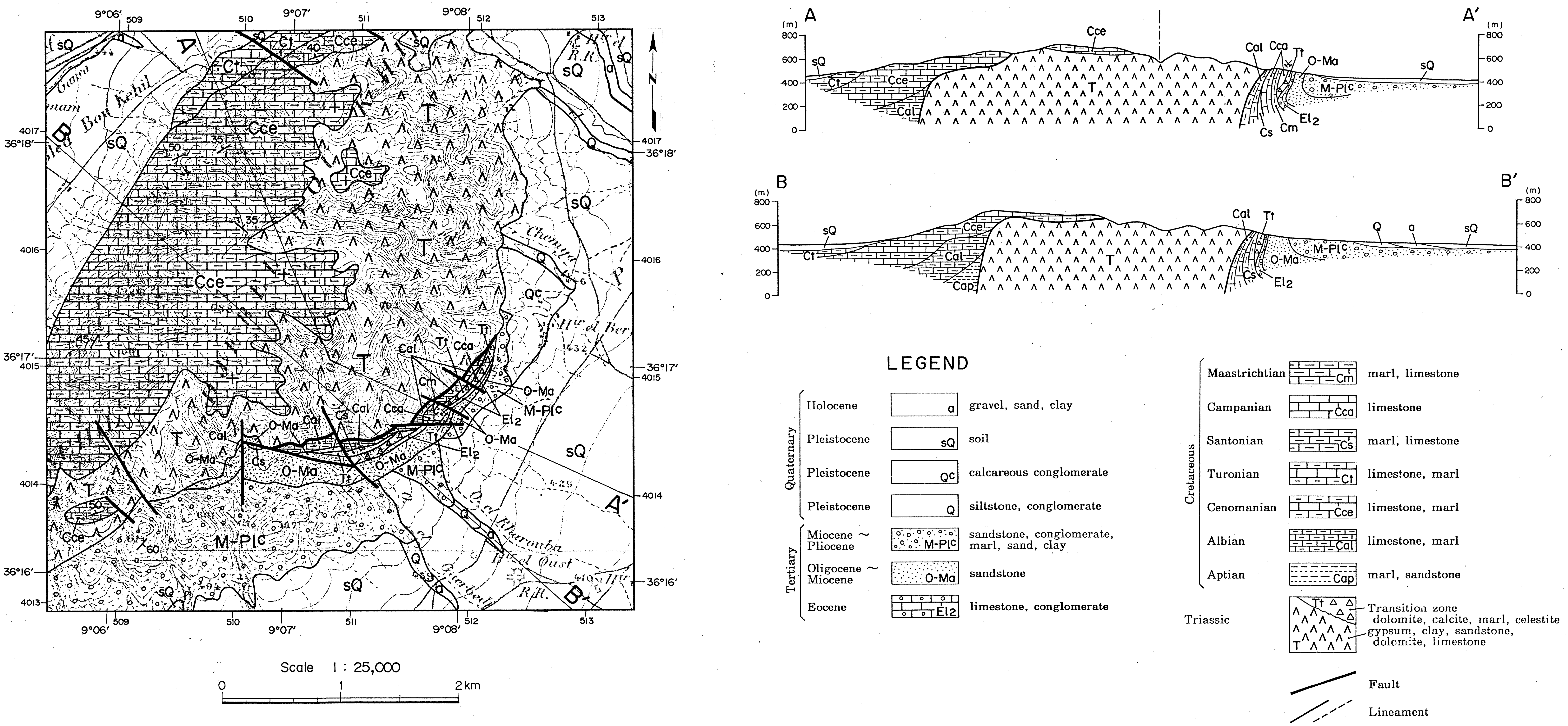


Figure 13 Geological map and cross section of Bou Khil Prospect

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.

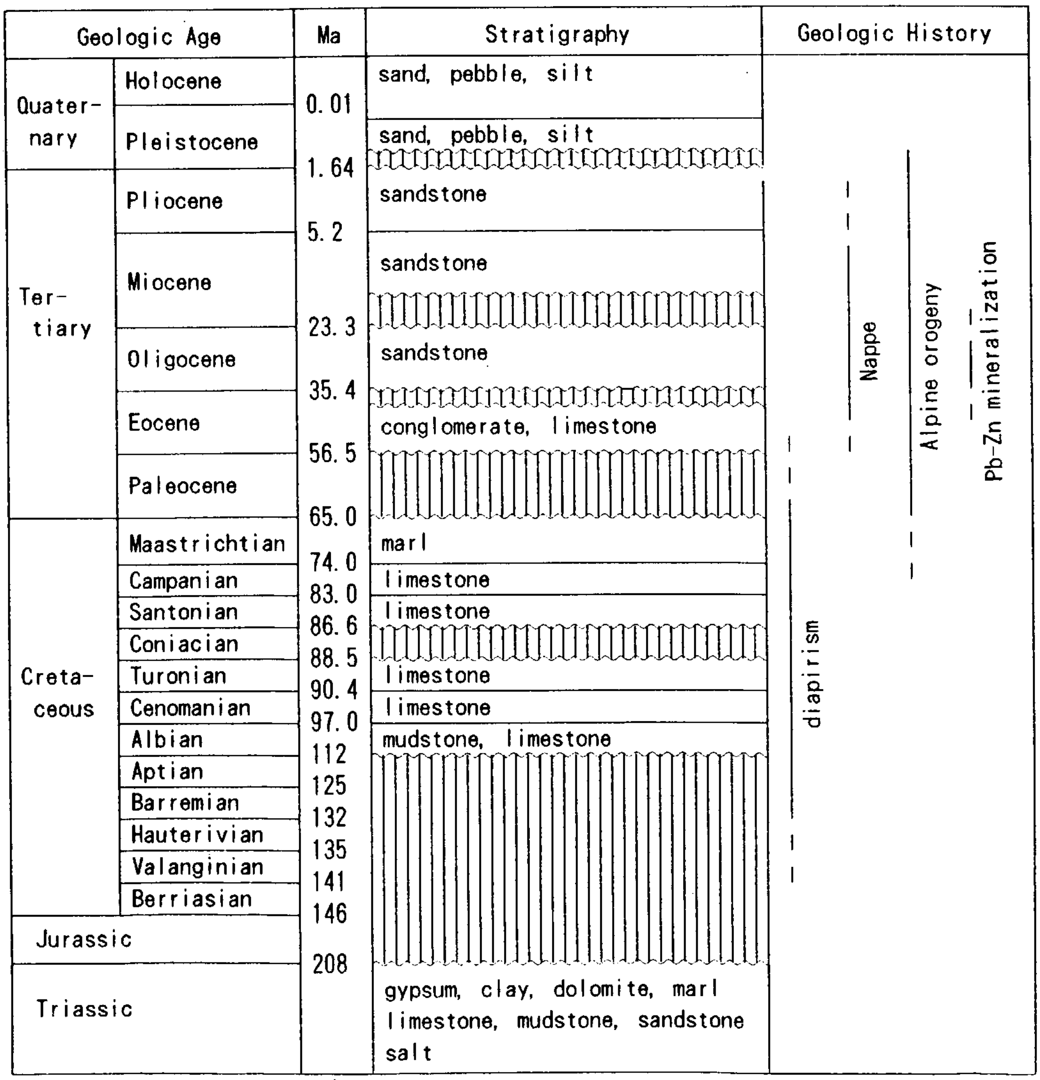


Figure 14 Schematic stratigraphic section

(2) 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.

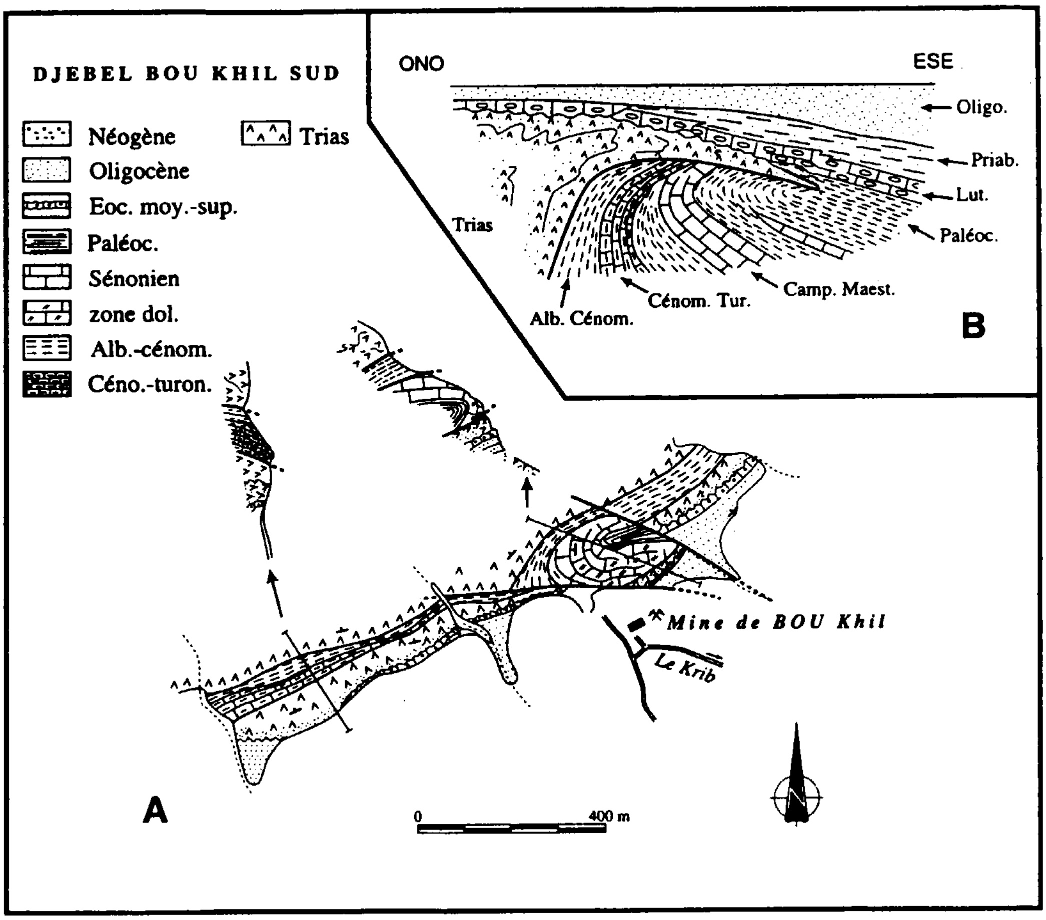
The Bou Khil diapir has been vigorously investigated by National Office of Mines, the Republic of Tunisia (Snoussi, Mansouri, Sellami and others), and is described in various reports published by the Office. Figure 15 shows a model of the Bou Khil diapir proposed by Perthuisot et al.(1999). According 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 15 Geology and structure of the Bou Khil Diapir (Perthuisot et. al., 1999)

3.1.2 Mineral Occurence

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.

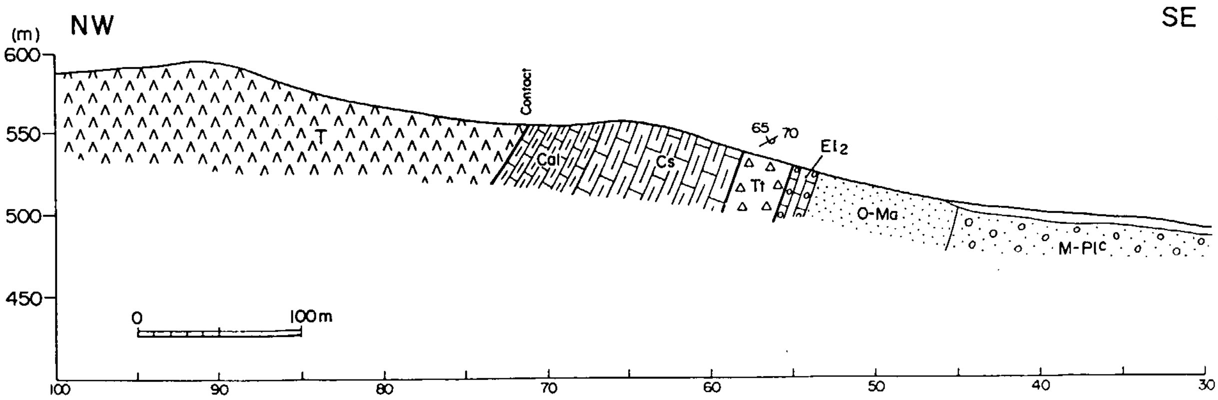


Figure 16 Geological section in Bou Khil

3.2 Geophysical Prospecting

In the Bou K'hil prospect, geophysical surveys using a gravity and IP methods are carried out along 8 measuring lines with a total line length of 11.3 km covering an area of 3 km^2 .

3.2.1 Methodology

(1) Layout of Measuring Lines

The 8 measuring lines, the line numbers from B0 through B7, are laid out by open traverse surveying using an electro-optical distance meter and a transit compass. Measuring stations are set along each line principally at an interval of 50 m.

The baseline B0 with a total length of 3,000 m is set centering the old mine site of Bou K'hil along the boundary between the Triassic and Cretaceous systems where ore bodies are located. Other 7 measuring lines, principally 1,000 m long each, are laid out perpendicularly to the baseline at an interval of 500 m with the initial stations at their southeastern ends.

The coordinates of these measuring lines is determined the northern Tunisia surveying coordination by the Lambert Projection (hereinafter called Lambert Coordinate System), all coordinates are transformed to the UTM (Universal Transverse Mercator Projection) and the Geographical Coordinate Systems. Of all outputs of the current investigation, the geophysical maps are prepared in accordance with the Lambert Coordinate System, on which all existing topographic, geologic, regional Bouguer anomaly maps are based. The elevation of each measuring station is determined by leveling using a digital auto-level, Model SDL30-1, manufactured by Sokia Co., Ltd., in order to achieve the accuracy of 10 cm $\pm$ required for the gravity survey.

(2) Gravity Survey

The gravity measurement is taken principally at an interval of 250 m along all 8 measuring lines. In the neighboring area, the gravity survey project was carried out with a density of one measuring point for an approximately one square kilometer by ONM. The regional gravity map shown Figure 20 was produced by compiling the four prospect areas, Bou K'hil, El Akouat, Bazina Kebira and Siliana on the 1 to 200,000 scale gravity map of ONM.

Relative gravity to that at the known station is measured using a gravimeter, Model D with a detection accuracy of 0.1 μgal, manufactured by La Coste & Romberg Co., Ltd..

A gravity value at each measuring station is estimated using a relative gravity at the measuring point and the gravity value.

A Bouguer gravity value is also estimated for each measured gravity value using latitude correction, elevation correction and topographic correction.

The density in the vicinity of measuring stations, which is used for the Bouguer and topographic corrections, is usually determined by the result of density measurement of rock samples, the gradient of G-H correlation diagram, comparison of the topographic map with Bouguer anomaly maps for several assumed densities. Taking these results into consideration, the correction density of 2.33 g/cm^3 is adopted in the current gravity survey for the purpose of comparison.

In the current survey, the first vertical derivative filter, a kind of low-cut filter, and the trend surface analysis are adopted for extracting the shorter wavelength component. The Bouguer anomaly distribution of ONM (Figure 17), in which the number of measuring stations per unit area is one quarter of the current survey or less, is utilized as the trend surface for estimation of residuals. The result of first vertical derivative filtering extracts a boundary between two subsurface geologic bodies with different density structures, e.g. a fault, a intrusive contact and so on.

A profile analysis along the 7 measuring lines, B0 through B6, is made so that the gravity residuals match with the subsurface density structures along these measuring lines. The best-fit models for given residuals are interactively approximated for its size and density structure, using the software for magnetic and gravity profile analysis, GM-SYS (Version3.6), developed by Northwest Geophysical Associates Co., Ltd. in USA.

(3) IP Survey

The IP survey is carried out for the 7 measuring lines, B0 through B6, according to the following specifications.

- Electrode Configureuration: Dipole-Dipole Array
- Electrode Spacing (a): 100 m
- Electrode Separation Index (n): 1 to 5
- Transmitted Current: Frequency = 0.125 Hz, Square-Wave with 50 % Duty Cycle
- IP Method: Time Domain
- Equipment Generator: Honda, Model ET4500 (Max. Output = 4.5 kVA, 3-Phase Alternate, 200 V)

  Transmitter: Chiba Electronic, Model CH-400 (Max. Output = 1000 V − 10 kVA)

  Transmission Controller: Zonge Engineering (USA), Model XMT-32

  Receiver: Zonge Engineering (USA), Model GDP-32(Accuracy = 1 μ V)

Apparent resistivity and Chargeability are measured. The integration range from 450 msec to 1100 msec for chargeability estimation corresponds to that of the Newmont standard which is normally used in the time domain IP method.

It is necessary to analyze the measured anomaly by 2-dimensional modeling analysis for geometry of a causative body on the relevant cross section. In the current investigation, field data are interpreted by combination of the 2.5 dimensional FEM (Finite Element Method) modeling and inversion using the constrained non-linear regression method.

(4) Laboratory Test

Density, resistivity and chargeability are measured in laboratory for 21 samples collected from outcrops within and around the prospect.

Two ore samples, collected from a waste dump of the old Bou K'hil mine, are added for the chargeability measurement. Water , immersing the samples, indicated conductivity of 708 μS/cm, equivalent to 14.1 Ωm, at a temperature of 23° C at the time of measurement.

3.2.2 Result of Gravity Survey

(1) Regional Gravity Distribution (Figure 17)

The NE-SW and crosscutting NW-SW gravity trends are predominated in the region including the Bou K'hil prospect, reflecting the regional geological structure, according to the regional gravity distribution. The Bou K'hil prospect is located at the southeastern end of an extensive rectangular area of gravity high which is outlined by the 0 mgal contour and extends southeastward from the vicinity of the Lambert coordination of 420,000E and 350,000N. A zone of steep gravity gradient, bounding the southeastern end of the extensive gravity high, runs in the ENE-WSW direction near the western boundary of the prospect. The northeastern part of the prospect is situated on a saddle of a narrow gravity high stretching towards another gravity high in the southeastern part. The southern part lies in the marginal zone of an extensive gravity low which is outlined by the 0 mgal contour and trends in the NW-SE direction.

(2) Gravity Distribution of the Prospect (Figure 18)

The prospect can be principally divided into the northeastern and southern parts on the basis of the gravity distribution. The gravity in the northeastern part is relatively invariable, ranging between –6 and –5 mgal, and tends to become higher northwestwards. The southern part is situated in the transition zone from the northern part with relatively high gravity to the southern gravity low, and indicates swift decrease in gravity southwards from –7 mgal to –12 mgal. The contact between the Triassic and Cretaceous systems appears to correspond to a part of steep gravity gradient in the southern part, while no characteristic gravity feature is observed in association with the contact in the northeastern part. Therefore, it will be very difficult to identify the contact between the two systems based on the gravity distribution. As aforementioned, the Bou K'hil mine is located at the inflexion of a zone of steep gravity gradient. In more detail, it appears also associated with a local gravity high jutting out southwards at its southern end. In association with this local gravity high, a celestite ore deposit is located to the north of the station B0-100. The gravity high is bounded by the E-W line connecting the stations B3-75 and B0-175 for its southern limit.

(3) Residual Gravity Anomaly (Figure 18)

There are located four characteristic residual gravity anomalies in the prospect, two high anomalies exceeding 0.4 mgal in the central and western parts, and two low anomalies below –0.2 mgal in the northern and southwestern parts. The triangular high residual anomaly centering the station B4-75 corresponds to high density limestone of Cretaceous. Its southern margin trends in the ENE-WSW direction and is characterized by steep residual gravity gradient. The Bou K'hil mine and the celestite deposit as above mentioned are located in this marginal zone of residual gravity anomaly. The high residual gravity anomaly in the vicinity of the station B1-125 appears to indicate distribution of Triassic dolomite. These high residual gravity anomalies, together with the minor high in the vicinity of the station B 5-0, are aligned in the E-W direction. The low residual gravity anomaly in the northern part is open to the north and may reflect evaporite components of the Triassic system that are lower in density than other Triassic sedimentary rocks. The low residual gravity anomaly in the southwestern part can be correlated to Tertiary sedimentary rocks that are high in porosity and low in density. The 0 mgal contour appears to correspond to the contact between the Triassic and Cretaceous systems in the southern part. However, no specific feature of residual gravity is associated with the northern contact, as is the case for the gravity distribution.

(4) First Vertical Derivative Gravity Anomaly (Figure 18)

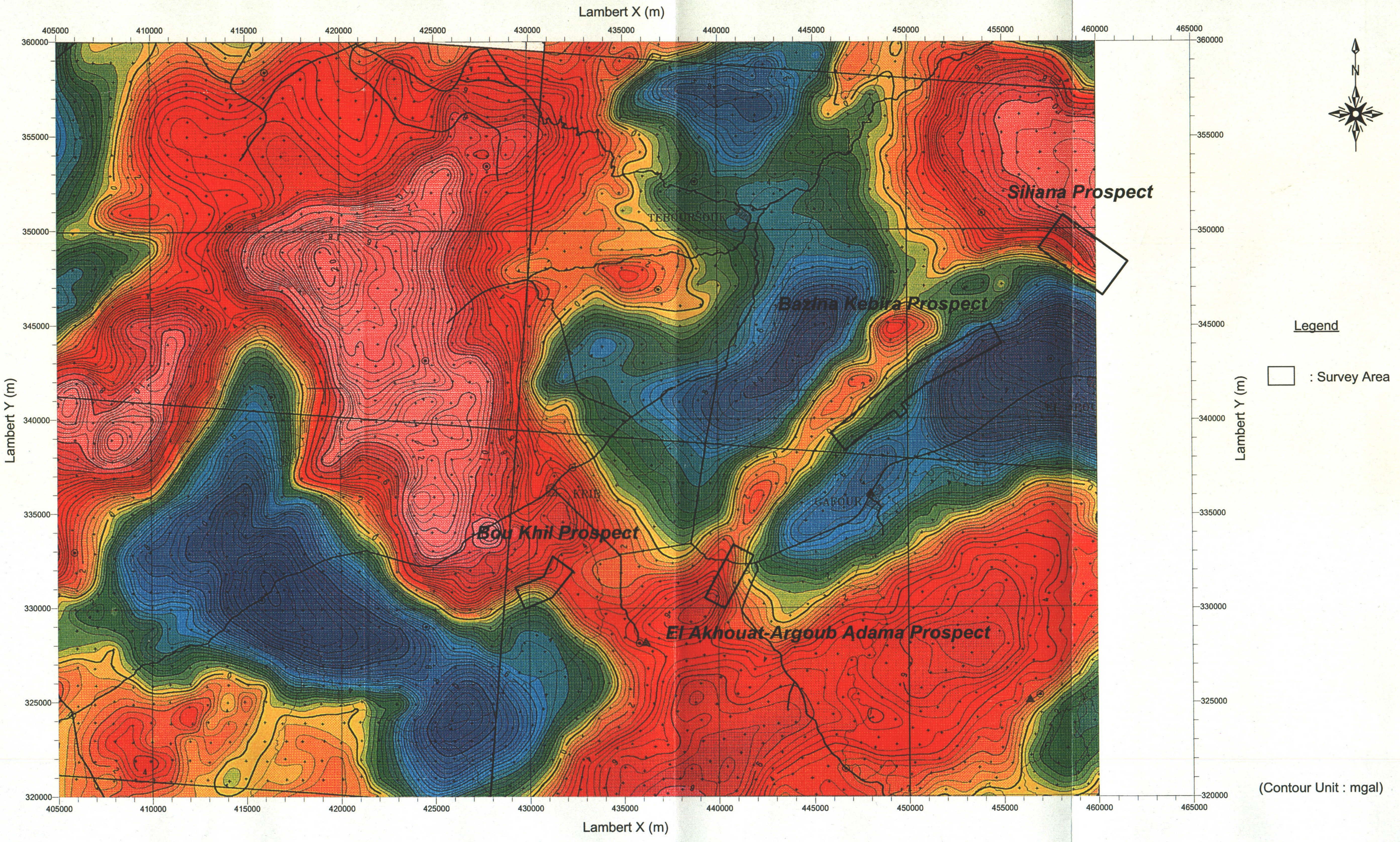
The distribution of first derivative gravity is similar to that of residual gravity except for the northern part of the prospect.

In the northern part, the Triassic-Cretaceous contact appears to follow the 0.003 mgal/km contour north northeastwards from the vicinity of the station 0-175. However, a relatively low zone of first derivative gravity with a width of about 200 m crosscuts the contact, running in the NW-SE direction along the northeast side of the line B5. This first derivative gravity low may suggest a certain structural break.

(5) Cross Section Analysis (Figure 19)

The gravity structures are composed of a low density layer with density difference ranging from – 0.10 to – 0.19 g/cm^3 and the underlying gravity basement with density difference of from 0.01 to 0.06 g/cm^3 that is correlated to Cretaceous limestone. The low density layer distributed in the southeastern part of each section may reflect Tertiary sandstone and conglomerate. A high density anomaly in the northwest of the line B1 located in the southwest part of the prospect can be correlated to the Triassic system.

On the other lines low density layers distribute in the Triassic system zone.



Part of ONM, 1999

Figure 17
Regional gravity map (Density : 2.33g/cm^3)
Scale 1 : 200,000
February, 2002

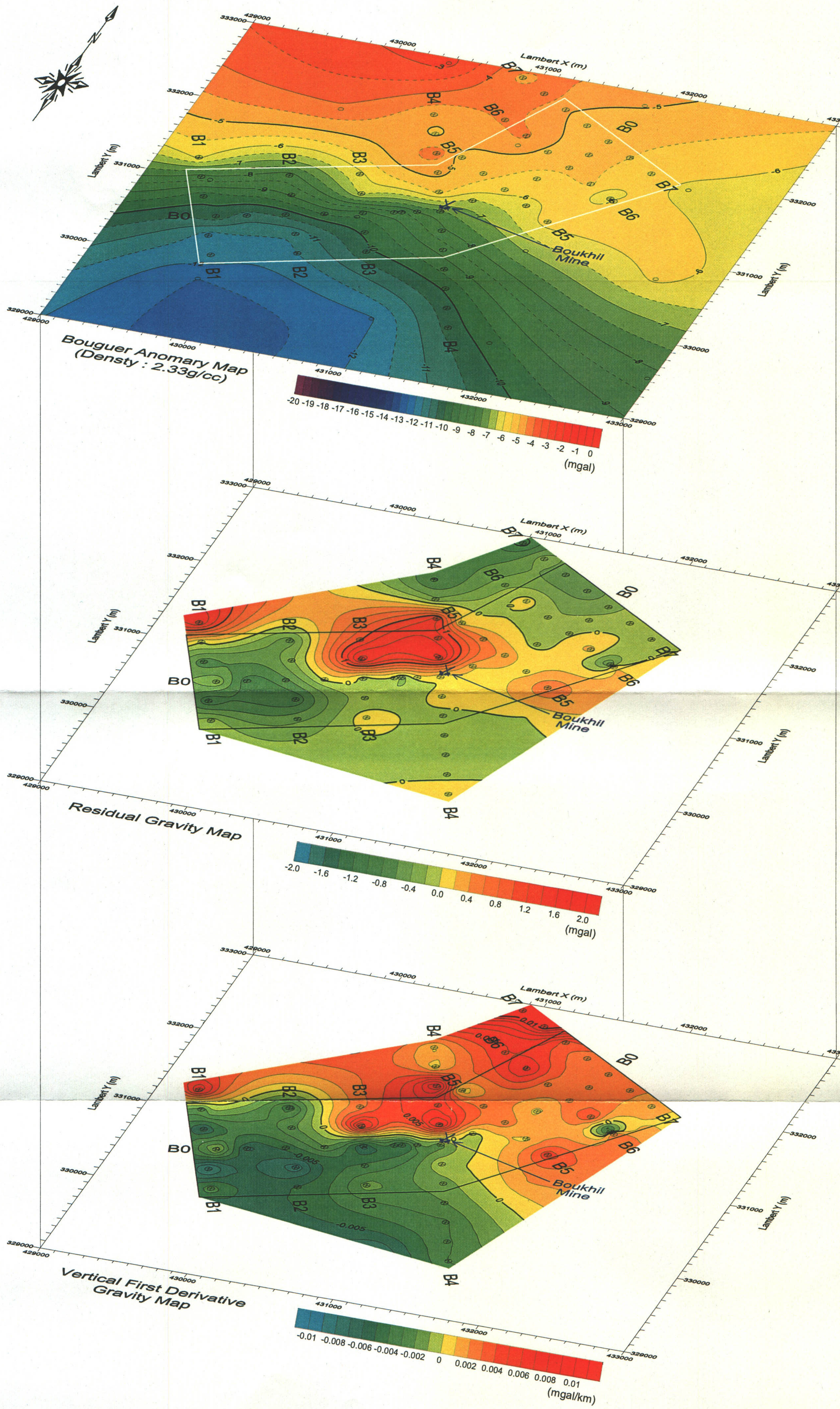
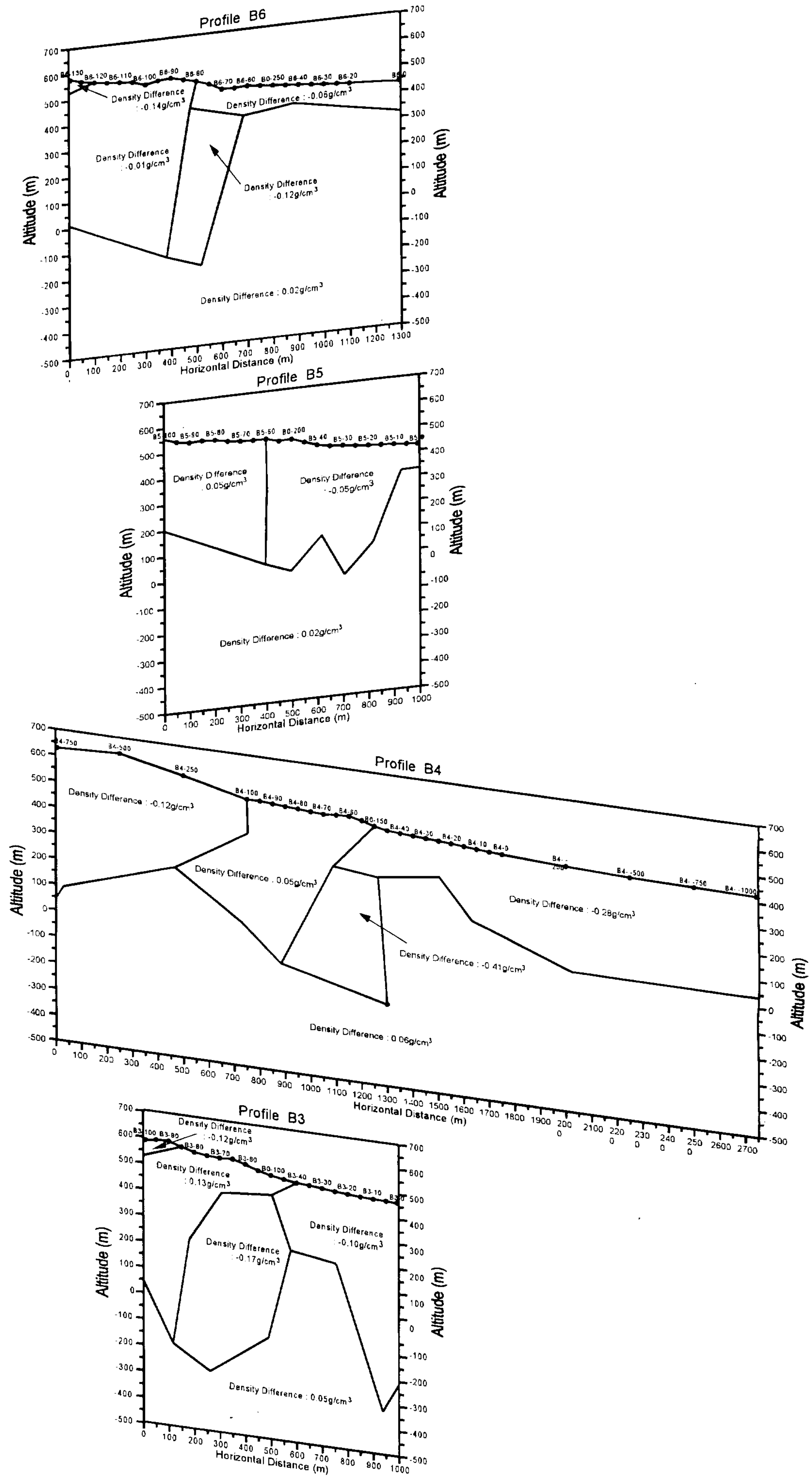


Figure 18 Panel diagram of gravity survey plan map in Bou Khil prospect



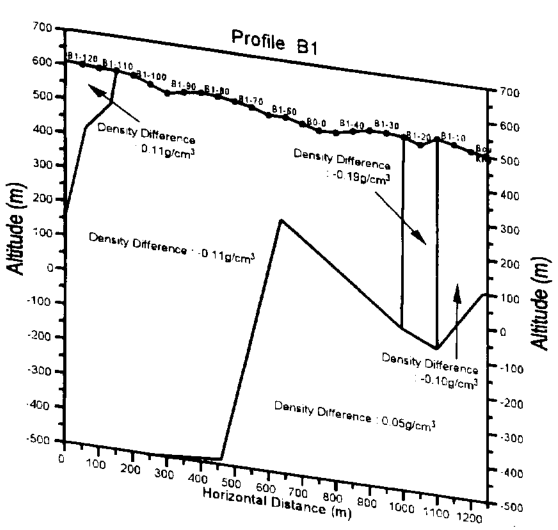


Figure 19 Panel diagram of 2-D gravimetric analysis section in Bou Khil prospect

3.2.3 Result of IP Survey

(1) Modeled resistivity and chargeability (Figure 20 and 21)

The resistivity that is obtained by the modeling based on the measured data in this prospect ranges from 0.1 to 1,127Ωm, averaging at approximately 80Ωm. A zone of low resistivity, equal to 1Ωm or less, is identified along the contact between the Triassic and Cretaceous systems to the northwest of the line B 0 that runs longitudinally in the center of the prospect. This zone of low resistivity approximately corresponds to the zone of low density that is outlined as the result of the gravity survey. Therefore, this zone can be interpreted to comprise rocks with high porosity such as evaporites of Triassic diapirs or poorly consolidated sandstone and argillite of Tertiary. Further, the values of resistivity in this zone are even lower than those estimated on the basis of the result of laboratory test of rock samples. Although underestimation of resistivity is often experienced in the course of inversion, the lowness of resistivity to this degree would require to assume existence of intra-stratum or pore water with salinity nearly equivalent to sea water that indicates resistivity of 1Ωm or less. Since the Bou K'hil ore deposit and the celestite alteration in the center of the prospect is associated with this zone of low resistivity, low resistivity of this kind may be related to mineralization. It is, however, still premature to make a conclusive remark with this respect, because low resistivity is also observed in other areas where no mineralization has been identified.

High resistivity, equal to 100Ωm or higher, is observed in the northwestern hill area of the prospect. Rocks with high resistivity are generally high in density as well, and may be correlated to the Cretaceous limestone that indicates high density. However, the Triassic system that includes abundant evaporites with low density also distributes in this zone of high resistivity. Besides, high residual gravity is observed in association with the Triassic system in places such as the vicinity of the station B 1-100 in the western part. Therefore, high resistivity may be caused by the Cretaceous system in a shallow depth over the Triassic terrain. In addition, slopes in the Triassic terrain are generally very steep, which reduces water retention capacity of rocks with high porosity. These topographic and ground conditions lead to lowering groundwater tables and hence expanding an ambient of ground unsaturated with pore water. This may be another reason for the high resistivity.

In the plain extending from east to south, resistivity is low in the shallower part and tends to become higher with depth. This suggests that unconsolidated sedimentary rocks of Tertiary or Quaternary is developed near surface and is underlain by Cretaceous rocks mainly consisting of limestone. The high resistivity zone to the plain side of the low resistivity zone tends to become shallower between the lines B 3 and B 5 where surface mineralization such as the Bou K'hil ore deposit is located. Similarly, the gravity basement also rises in this part (Figure s. 3.3-14, to -16). These characteristics

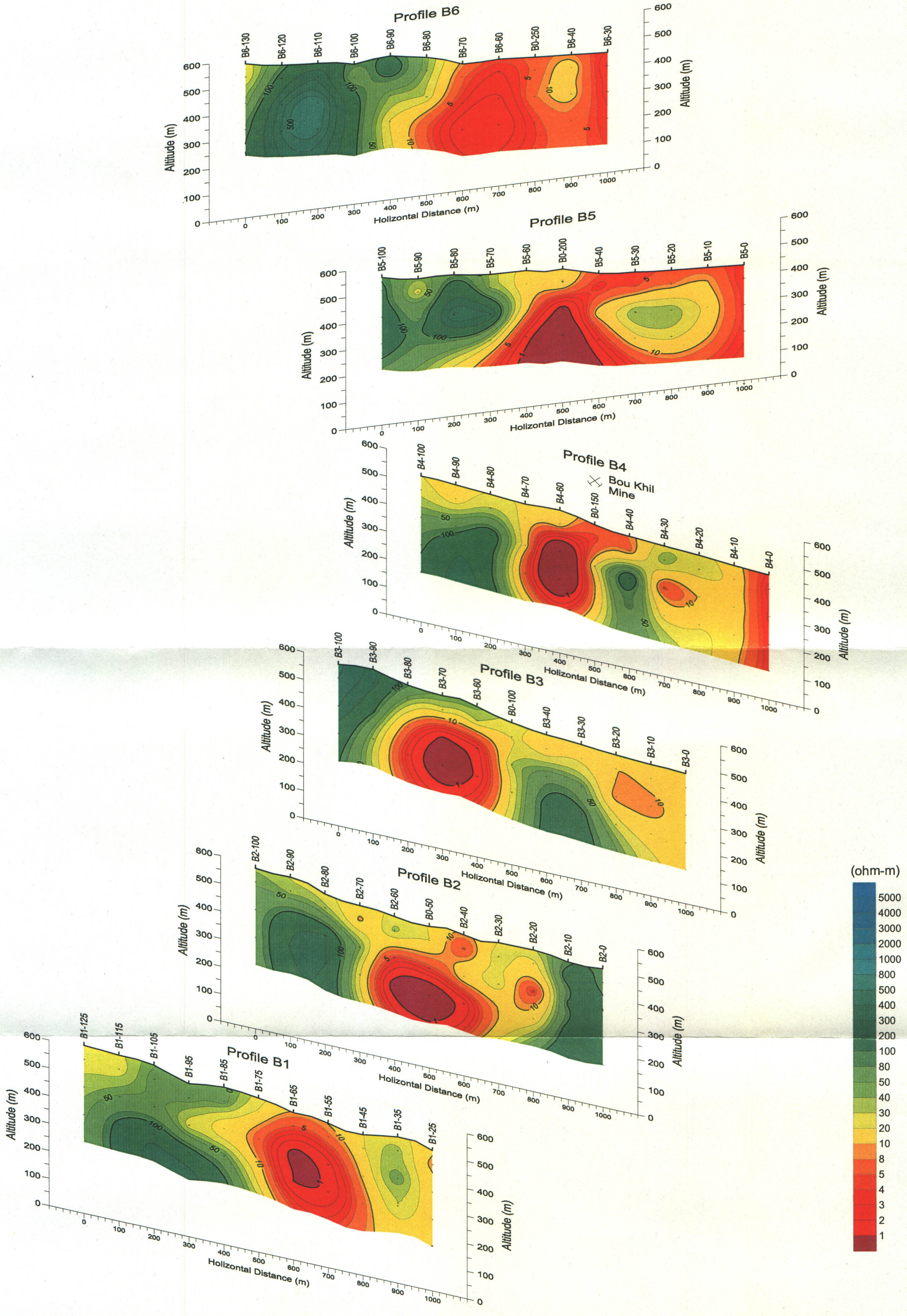


Figure 20 Panel diagram of modeled resistivity section in Bou Khil prospect

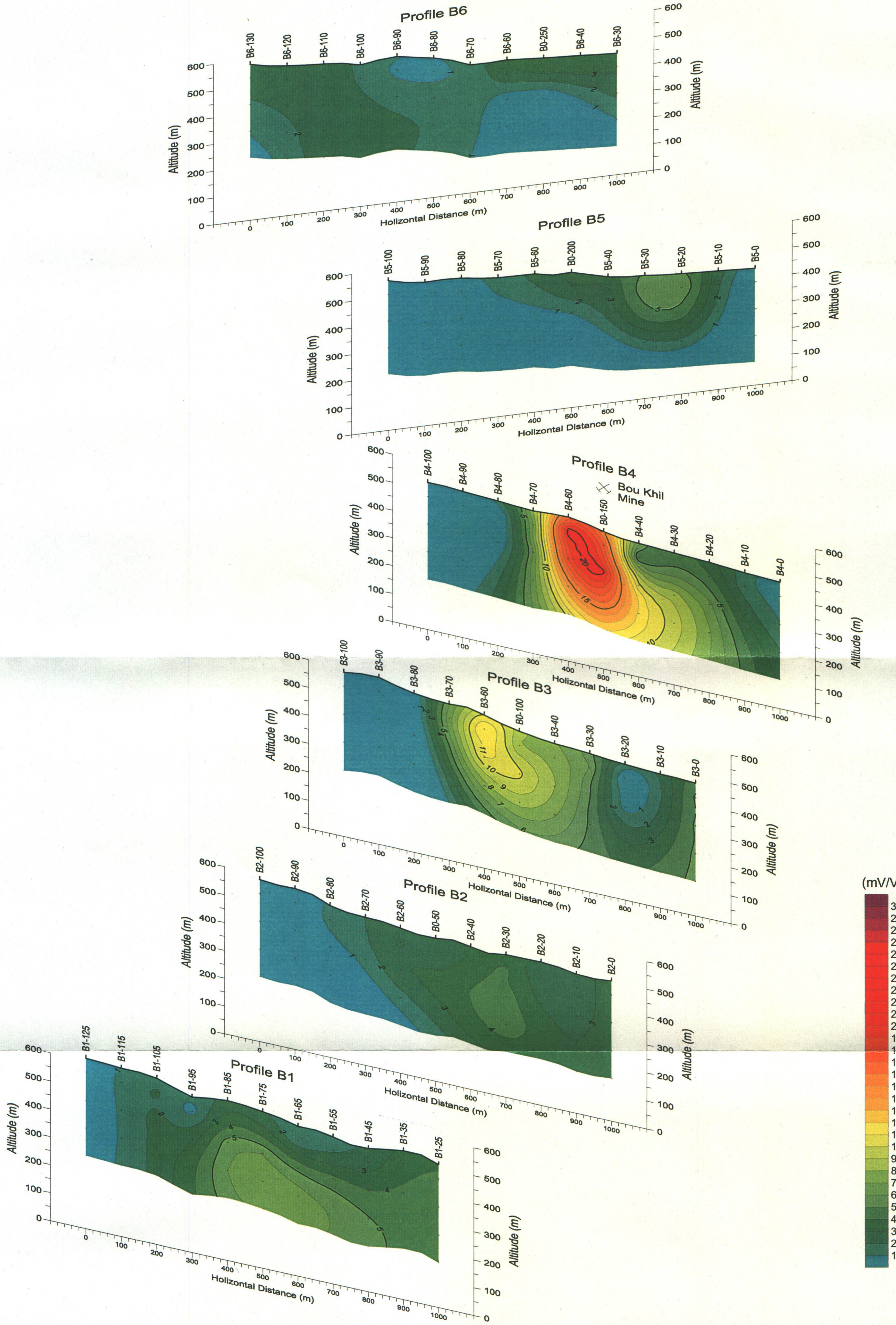


Figure 21 Panel diagram of modeled chargeability section in Bou Khil prospect

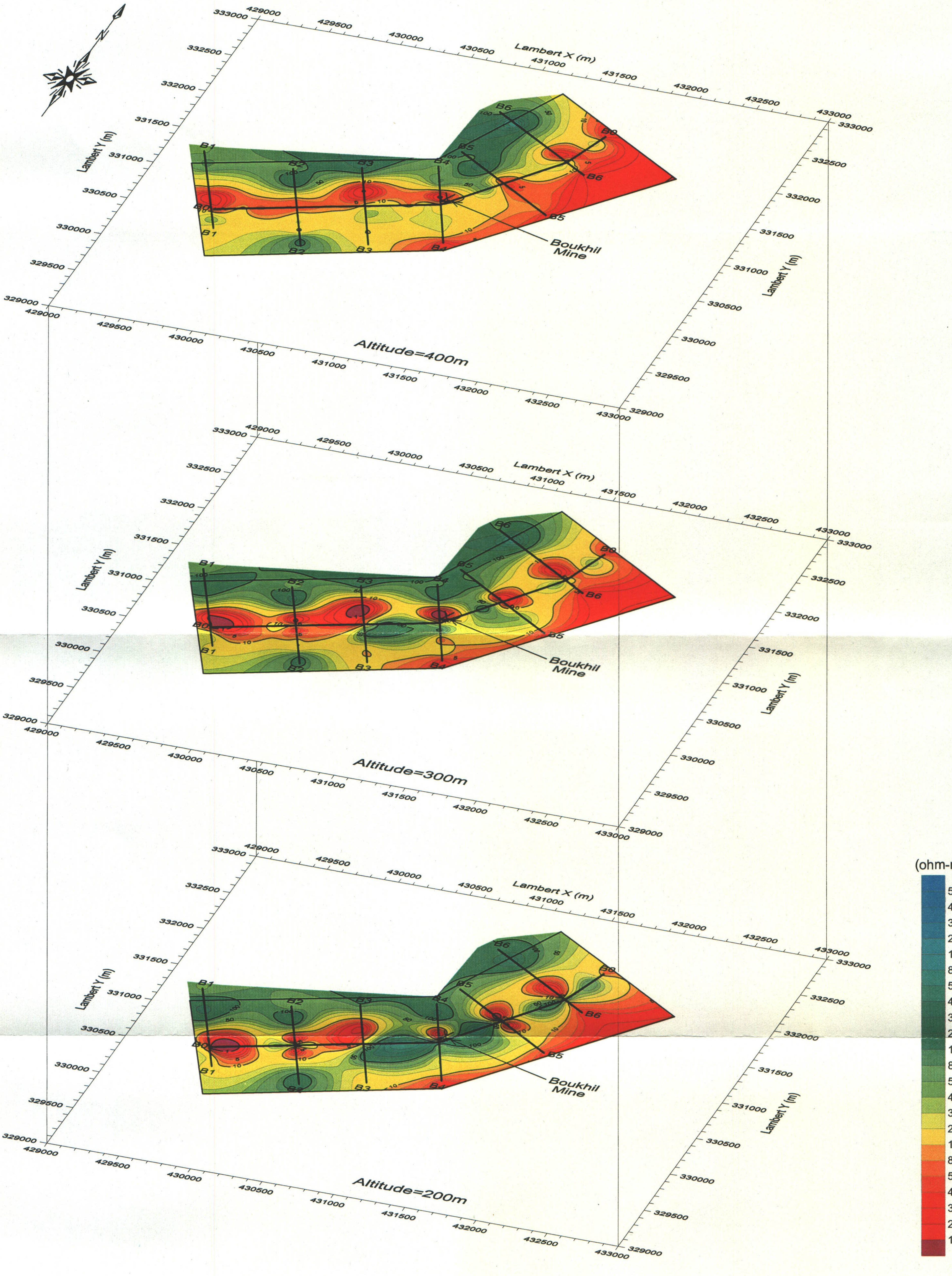


Figure 22 Panel diagram of modeled resistivity plan map in Bou Khil prospect

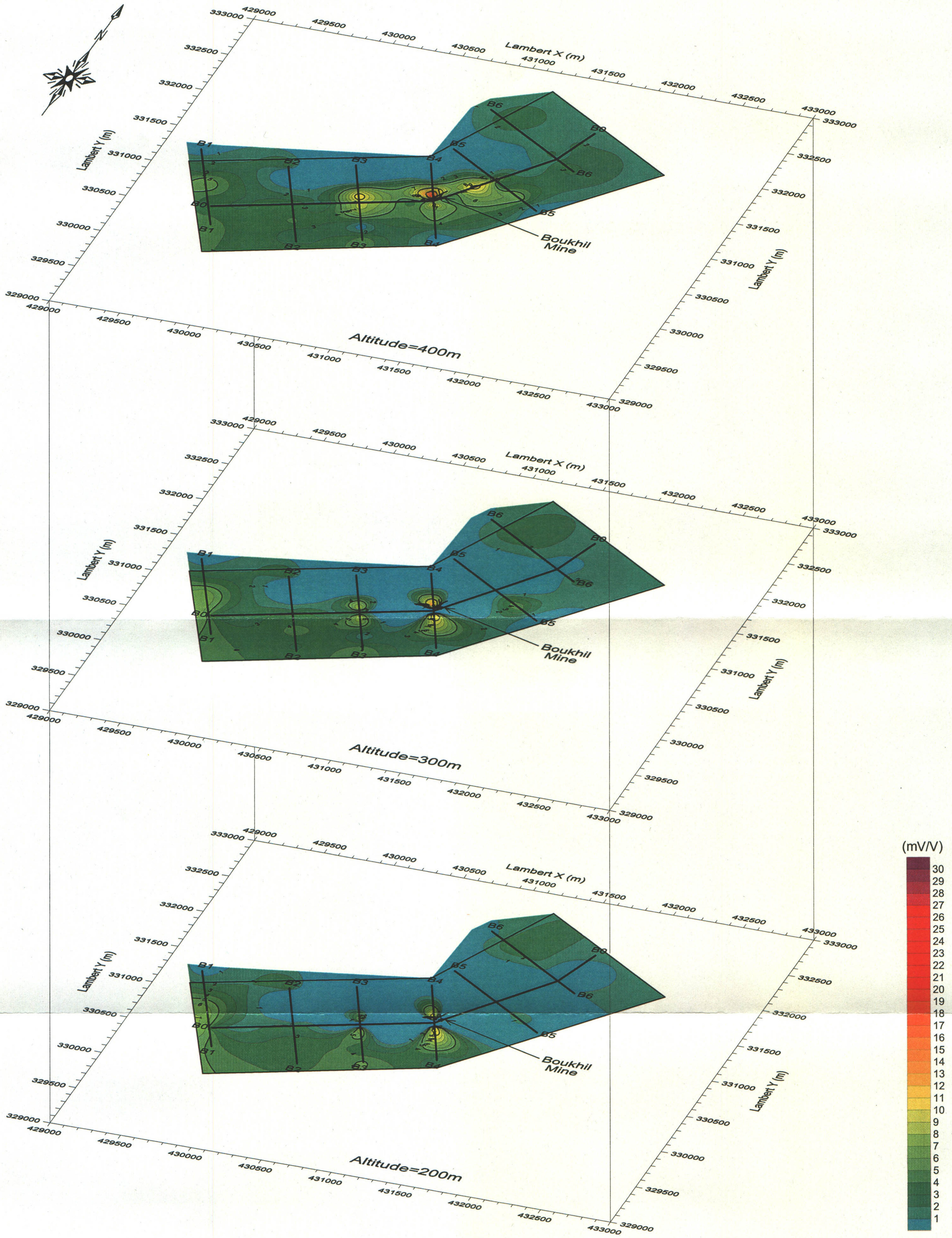


Figure 23 Panel diagram of modeled chargeability plan map in Bou Khil prospect

in resistivity and gravity may be used as one of exploration indices, if not directly related to the mineralization.

The chargeability obtained by the modeling based on the field measurement is low as a whole, indicating the maximum of 21 mV/V and averaging at approximately 1 mV/V. Besides, negative chargeability is estimated in part where it is virtually impossible to measure valid chargeability. Chargeabilty anomalies, unlike resistivity anomalies, are spatially in close association with the known mineralization such as the Bou K'hil deposit and the celestite alteration, and are limited near surface. Therefore, they can be regarded as direct indications of mineralization. Strangely, however, no high chargeability is detected for any minerals other than galena, a lead sulfide, according to the result of laboratory test. For example, samples containing abundant celestite indicate chargeability equal to or lower than that for unmineralized samples. Although pyrite is generally high in chargeabilty, its content in the mineralization is not particularly high to explain the high chargeability observed in the field measurement.

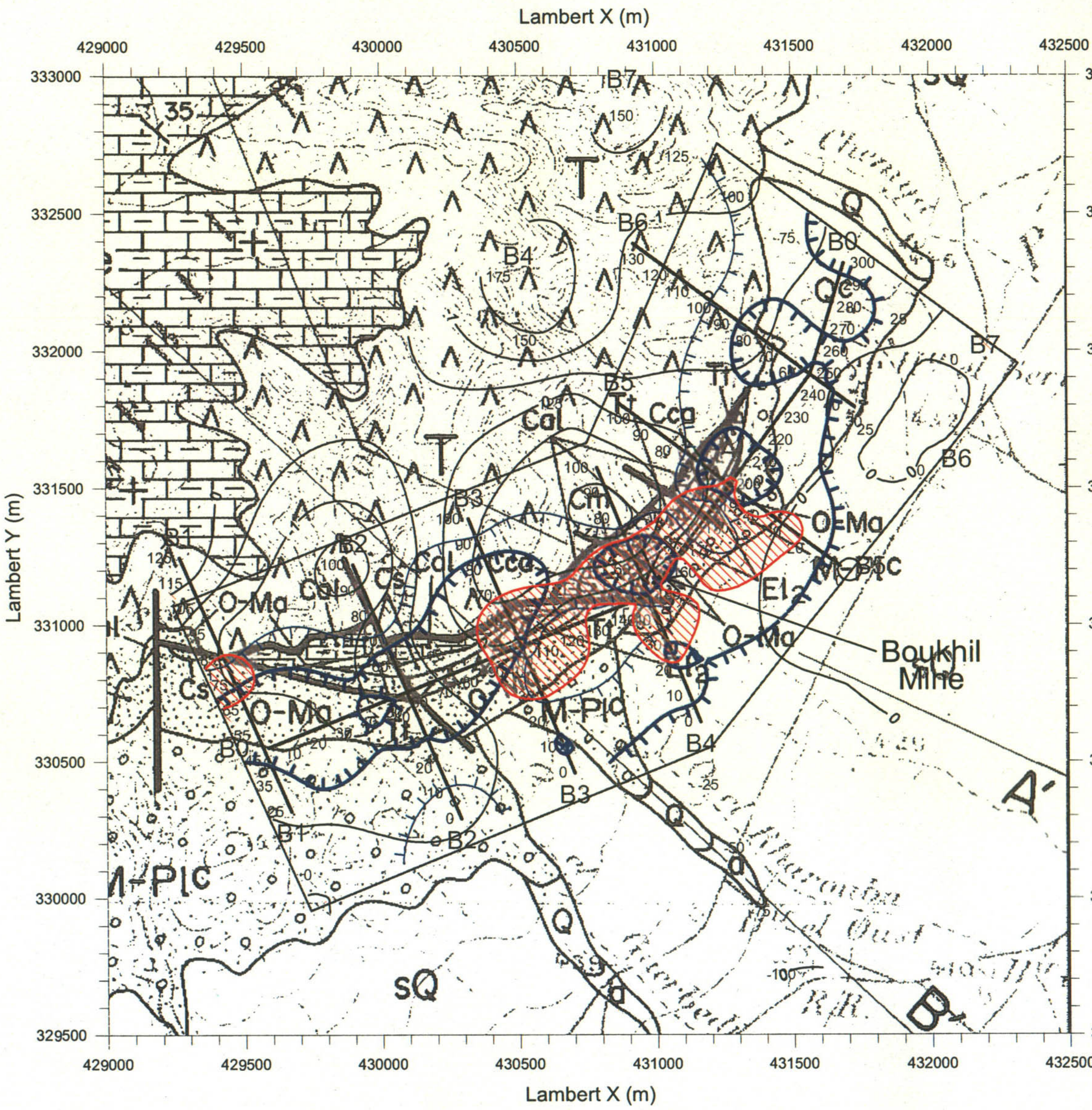
At the present stage, galena is the only mineral that is responsible for high chargeability. The high chargeability anomalies are broader than the extents of mineralization that can be estimated according to the field observation. Further investigation will be required to verify causes of chargeability anomalies.

(2) Interpreted Geophysical Survey Map

Chargeability zones higher than 5 mV/V are superimposed over the locations of known mineralizations, resistive zones and conductive zones as shown in Figure 24.

The old Bou K'hil mine is around the crossing point between the line B0 and B4 in the central part of the prospect. Triassic diapir in the northwestern hill area, the Cretaceous syetem, the narrow Triassic system and the Tertiary system are lined up towards the southeastern plain area. The mine locates around the narrow Triassic system between the Cretaceous system and the Tertiary one. The Cretaceous system is represented by resistive limestone. The Tertiary system consists of porous sedimentary rocks indicating low resistivity. The Triassic system between the Cretaceous system and the Tertiary system is extremely conductive and thrusts down into the resistive Cretaceous system towards the northwestern sides. These conductive anomalies are distributed along the base line B0. In the southeastern side of known mineralization zones of the Bou K'hil ore deposit and the celestite alteration around the crossing point between the line B3 and B0, the resistive basement become partly shallower towards the upper conductive layer correlated the Tertiary system. These characteristics in resistivity are consistent with the results of cross section analysis from the residual gravity.

The valid Chargeability zones concentrate around the The Bou K'hil ore deposit and the celestite alteration. The highest chargeability is indicated in the vicinity of the old Bou K'hil working. It is supposed that galena is responsible for high chargeability



Legend

: IP survey Line

: Survey Area

: Closed Mine

Residual Gravity (0.5 mgal interval)

Resistive zone > 50 Ωm (Altitude: 300m SL)

Conductive zone < 10 Ωm (Altitude: 300m SL)

High Chargeability > 5 mV/V (Altitude: 400m SL)

Figure 24
Interpreted geophysical survey map in Bou Khil prospect
1 : 25,000
February, 2002

around the mine. The cause of valid chargeability in the vicinity of the celestite alteration has not identified yet. The results from the current survey suggest that chargeability is useful in order to identify mineralizations in the prospect. No unknown mineralization is discovered from the results of the current Gravity and IP field observations.

3.2.4 Laboratory Test

Enforced wet densities of 21 rock samples collected in and around the prospect are resulted in the range between 2.02 through 3.82 g/cm^3 from density measurement in laboratory. The estimated average density of 2.67 g/cm^3 is higher than the correction density of 2.33 g/cm^3 adopted in the current gravity survey. Two celestite samples higher density than 3.5 g/cm^3 raise the average density. Hard rock samples with better property are measured in the many case of laboratory test, although many fragile rocks possibly disintegrated during shaping or immersion are lying in the field. In the current test, the four fifths of samples indicate less porosity than 10 %. Average density of rock samples decreases in order of the Cretaceous system of 2.65 g/cm^3 in, the Triassic system of 2.59 g/cm^3 and the Tertiary system 2.50 g/cm^3. The highest average density of 2.92 g/cm^3 is indicated in the rocks collected in the transition zone around the ore deposits.

The results from resistivity and chargeability measurement of 20 rock samples measured density, except for a sample disintegrated during immersion. Resistivities ranging from 80 to 11,000 Ωm are extremely higher than the measured resistivities from the field survey of which many indicating less than 10Ωm. Rock resistivity is affected by resistivity of pore water and porosity.

Rock samples indicating lower porosity than rocks lying in fields produce the difference of results between in field survey and in laboratory test. However, extreme low resistivity resulted from the current field survey cannot be explained by only high porosity. Pore water as conductive as sea water indicating less than 1 Ωm is suggested. Measured chargeability of rock samples is low except for two samples of sandstone indicating higher than 10mV/V. The sample 12 of limestone collecting around the old Bou K'hil working is measured relative high chargeability of about 8mV/V. The samples of celestite collecting in the high chargeability zone characterized from the current field survey indicate low chargeability lower than 3.5 mV/V. Another sample collected in a waste deposit of the old Bou K'hil mine indicates chargeability considerably higher than 20 mV/V. The fact that the sample includes sulfide lead suggests that sulfide lead like galena generates high chargeability.

3.3 Drilling Investigation

3.3.1 Summary of the Drilling Operation

The geological summary plan of the Bou Khil prospect is shown in Figure 25, incorporating the drill hole locations. As shown in the figure, the geology of the prospect comprises the Triassic diapir, the Cretaceous carbonates (limestone and limestone-marl alternations), the transition zone consisting of brecciated dolomitic carbonates, sedimentary rocks (marl, sandstone, argillite and conglomerate) of the Tertiary system (Eocene, Oligocene and Miocene) and the Quaternary system. The Cretaceous system contains the Bou Khil ore deposit that was mined in the past and produced some 400 thousand tons of ores with the average grade of combined lead and zinc at about 10 %. Celestite deposits, such as Chantier 2 and Saint-Pierre, have been located in the transition zone trending in the NE-SW direction.

Two drill holes, MJTK-B 1 and B 2, were put down along the two geophysical survey lines, B3 (A-A') and B5 (B-B'), of the 1st Year Campaign in this prospect, in order to explore the Chantier 2 deposit and to verify the IP anomaly outlined by the geophysical survey. The columnar section of each hole is shown in the appendix 1 to 2.

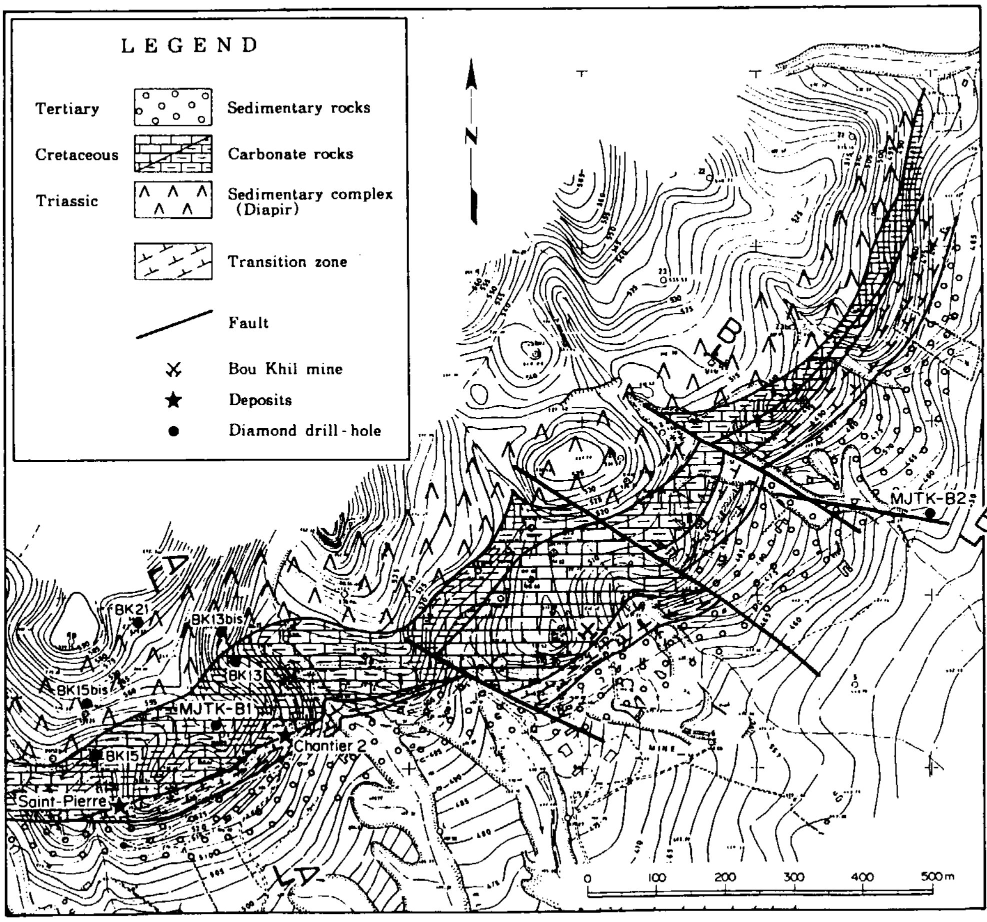


Figure 25 Geology and Drill Hole Location of the Bou Khil Prospect

3.3.2 Result of Drilling Operation

(1) MJTK-B 1

This hole was drilled along the geophysical survey line B3 (A-A'), as shown in Figure 25, to verify the IP anomaly outlined in the course of the 1st Year Campaign and to explore the southwestern extension of the Chantier 2 deposit. The columnar section of the hole and the geological profile along the survey line are presented in Appendix 3 and Figure 26 respectively.

The IP survey in the 1st Year Campaign identified an IP anomaly along the survey

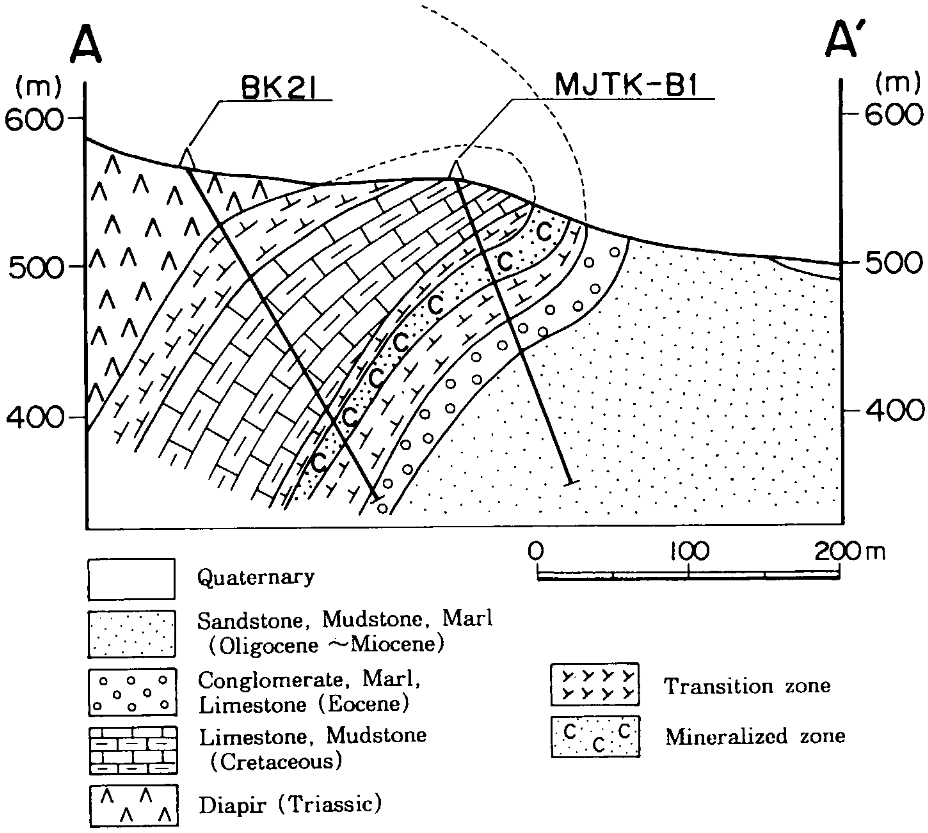


Figure 26 Geological Profile along the Hole, MJTK-B1

line B3 where the transition zone distributed. Since celestite mineralization had been known to occur associated with the transition zone, a celestite ore sample was collected and submitted for laboratory testing. The test result indicated that the celestite ore was very low in its chargeability at around 3.5 mV/V or less, which made it difficult to effectively interpret the field measurement in terms of the relationship between the celestite mineralization and its chargeability. It is, therefore, one of the purposes of this hole to clarify the ground nature that produced the IP anomaly, specifically for its relationship with the celestite mineralization.

The Chantier 2 deposit had been explored by 5 drill holes with the total length of 970.85 m (Figure 137 and Table 15) in the past. A probable reserve of 3 million tons with an average grade of 70 % $SrSO_4$ had been estimated based on the drilling result. Of the five, drill holes, the hole, BK13bis, intersected a celestite ore zone of 22m in width with an average grade of 72 % $SrSO_4$ as shown in Table 15. However, the exploration to the southwest of the section BK13bis-BK13 had been very much limited with a scarce number of drill holes. In addition, the celestite ore zone had been intersected by only two of the five holes, BK13bis and BK21. Taking account of these past exploration results, the southwest of the section BK13bis-BK13 was selected for the drilling target in the current operation.

Table 15 Ore Intersections of Past Drill Holes in the Bou Khil Prospect

Drill Hole	Depth (m)	Thickness (m)	Grade (%)		Length (m)	Direction (°)	Inclination (°)	Elevation (m)
			Pb+Zn	$SrSO_4$				
BK13	87.00-96.00	9.0	8.3	-	169.50	160	-65	530.66
BK13bis	138.00-160.00	22.0	-	72.64	209.50	160	-65	538.44
BK15	66.55-71.55	5.0	18.7	-	127.20	170	-70	540.18
BK15bis	-	-	-	-	210.00	170	-70	559.23
BK21	194.00-207.00	13.0	-	38.01	254.65	160	-60	572.38

The geology of this hole is composed of a unit of limestone-argillite alternation (Cretaceous) from 0.00 to 33.00m, the transition zone from 33.00 to 103.10m, a unit of conglomerate-marl-limestone (Eocene) from 103.10 to 121.80m and a unit of semi- or non-consolidated sandstone interbedded with adhesive argillite layers (Oligocene -Miocene) from 121.80 to 216.80m. The transition zone consists mainly of gray to dark gray dolomite, being occasionally brecciated and including pyrite, marcasite and celestite mineralization in places. Under microscope, dolomite (<0.2 mm), calcite (<0.2mm), quartz (<0.8mm), wollastonite (<1.0mm) and opaques are observed in rock specimen of the transition zone.

Celestite mineralization occurs in breccias and veins in the interval between 47.50 and 73.80m. The brecciated celestite contains a minor amount of sphalerite and is inter-fragmentally filled with black and compact dolomite accompanying abundant euhedral pyrite. The celestite mineralization of vein-form comprises celestite and calcite as major constituents, accompanying such ore minerals as pyrite, marcasite and sphalerite. Celestite forms euhedral to subhedral crystals with sizes up to 0.05mm. Pyrite occurs as subhedral crystals with sizes of ±0.02mm. Marcasite also forms euhedral to subhedral crystals with sizes ranging from 0.05 to 0.2mm and indicates framboidal textures. Sphalerite occurs as subhedral crystals with sizes of ±0.05mm. The analytical results of the celestite section are indicated in Table 16.

The IP anomaly that was outlined by the geophysical survey in the 1st Year Campaign is correlated to the transition zone intersected between 40 and 120m of this hole. Pyrite-marcasite mineralization is intense in the transition zone, which may be attributed to the cause of the IP anomaly. The investigation results to date and the celestite intersection of this hole suggest that the celestite mineralization of the

Chantier 2 continues southwestward for a distance of at least 75m from the BK13bis-BK13 section.

Table 16 Analytical Results of the Celestite Section in MJTK-B1

Drill Hole	Depth (m)	Thickness (m)	Type of Ore	Grade (%) $SrSO_4$
MJTK-B1	47.5-58.5	11.0	Brecciated, Vein	16.89
	59.5-65.5	6.0	Brecciated	20.33
	67.8-73.8	6.0	Brecciated, Vein	7.80

(2) MJTK-B 2

This hole was drilled along the geophysical survey line B5, as shown in Figure 25, to verify the IP anomaly outlined in the course of the 1st Year Campaign. The columnar section of the hole and the geological profile including the hole are presented in Appendix 2 and Figures 27 respectively.

The geology of this hole is composed of a unit of non-/semi-consolidated sandstone from 0.00 to 40.10m, a unit of conglomerate interbedded with sandstone layers from 40.10 to 109.70m and a unit of non-consolidated sandstone interbedded with adhesive argillite layers from 109.70 to 142.10m, all of which are sedimentary rocks of the Tertiary Oligocene to Miocene ages, as shown in Figures 139 and 145.

The IP anomaly that was outlined by the geophysical survey in the 1st Year Campaign is correlated to the conglomerate unit interbedded with sandstone layers that is intersected between 70.00 and 110.00m of this hole. The calcareous sandstone layers are intensely mineralized with pyrite, which is considered the main cause of the IP anomaly.

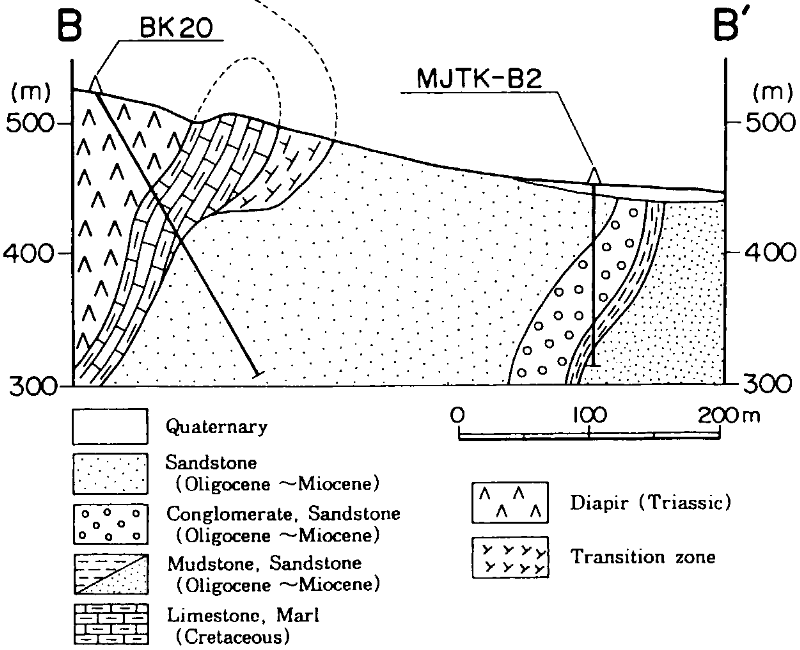


Figure 27 Geological Profile along the Hole, MJTK-B2