CENTAMIN N.L.

GEOPHYSICAL SURVEY

AT MOUNT SKINNER (N.T.)
EL 786

October 1970 - January 1971

Mission No. 501-18-64

C.G.G.
26-28 Manning Street, SOUTH BRISBANE.
ABSTRACT

From October 1970 to January 1971, COMPAGNIE GENERALE DE GEOPHYSIQUE carried out a geophysical survey for CENTAMIN N.L. on a stratiform copper prospect at Mt. Skinner, 120 miles northeast from Alice Springs. Mineralizations are located in grey sandstone layers associated with siltstones in an Upper Proterozoic basin overlying a crystalline basement.

Seismic Refraction was tested and was found to yield much less structural and lithological data than electrical methods. Nine main conductive anomalies were detected on filtered total conductance profiles. The shapes of anomalies suggest that they are due to wide buried channels filled with conductive material, most probably siltstone, and that sediments came from the north. The edges of the buried channels may be favourable locations for sulfide mineralizations. Four drillholes have been recommended.
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INTRODUCTION

From the 1st of October 1970 to the 21st of January 1971, COMPAGNIE GENERALE DE GEOPHYSIQUE carried out a geophysical survey for CENTAMIN N.L. on the Mt. Skinner stratiform copper prospect approximately 130 miles north east of Alice Springs, Northern Territory.

Early in 1965, stratiform secondary copper mineralization was discovered by J. Nelson and S. Griffiths in the Central Mt. Stuart Beds, Mt. Skinner. Malachite, azurite and chalcocite surface showings are associated with grey sandstone and siltstone horizons.

In 1965 and 1966, exploration was carried out by Kennecott Exploration (Australia) Pty. Ltd. In 1968, Mines Branch, Northern Territory Administration, drilled four holes. They intersected chalcopyrite mineralizations in grey sandstone but the grade was not economic.

The drill holes proved that the mineralized horizons are continuous down dips of large extent, and thus higher concentrations of chalcopyrite may exist in places where lithology, structure and location are more favourable.

The Central Mt. Stuart Beds belong to the Upper Proterozoic - they overlie the Arunta Complex high grade metamorphics and granite. The Mt. Skinner "Basin" may be a syncline or a graben.

Stratiform copper deposits are often located on the flanks of smaller basins within a larger sedimentary basin. The mineralization
is also generally associated with sediments which were formed in a reducing medium, i.e. shales or siltstones rather than coarse sandstones. The drill holes show that the chalcopyrite mineralizations are located within grey sandstones associated with siltstones.

Siltstones and sediments formed in a reducing medium are generally more conductive than other sediments.

Consequently, favourable sites may appear as basins filled with conductive material, or a deepening of a particular resistant marker beneath a thickening of a conductive marker.

Moreover, sediments are generally more conductive than is a highly metamorphic basement - the morphology of the basement is often more or less reflected in the overlying sediments. Therefore, it seemed possible to detect favourable structures by resistivity methods.

Generally, the velocity of seismic waves is higher in the metamorphic basement than in the overlying sediments and it seemed worthwhile to try seismic refraction.

We wish to express our sincere gratitude to Mr. Jock Nelson, Mr. John Watts and Mr. Bob Barker for their close co-operation and invaluable assistance throughout the survey.
1. **FIELD AND GEOPHYSICAL CONDITIONS**

1-1. **Location - Access - Terrain:**

The Mt. Skinner copper prospect is located approximately 130 miles north east of Alice Springs (N.T.). Access from Alice Springs is via the Stuart Highway (bitumen), the Ammaroo Beef Road (gravel) and Mt. Skinner Homestead tracks (dirt).

Conventional vehicles can traverse the above-mentioned roads in dry conditions only. Four wheel drive vehicles are imperative for the unsealed roads after rain.

Access throughout the surveyed area was via bulldozed lines suitable only for four wheel drive vehicles.

Terrain was particularly rough on the Mt. Skinner Plateau, some parts necessitating the transport of equipment by foot. Maximum relief was 500 feet. Steep cliffs and valleys slowed the field work in this area. The rest of the area did not cause any undue difficulty, and good output was obtained.

1-2. **Geophysical Conditions:**

1-2-1. **Electrical Conditions:**

Acceptable values of current intensities (about 1 amp.) were obtained.

Measurements obtained were within the accepted accuracy for field measurements, namely 5%.
1-2-2. **Seismic Conditions**:

Seismic refraction tests were carried out on Line 1 and Line 2. Velocities ranged from 17,500 ft./sec. to 19,500 ft./sec. The records obtained were of exceptional quality with good energy transmission from surface or near surface shots. Noise was reduced to a minimum.
2. FIELD OPERATIONS AND STATISTICS

2-1. Electrical Operations:

For the gradient array coverage, an AB current electrode separation of 6,000 ft. and an MN potential electrode separation of 200 ft. were used on Line 7 and all lines to the north west of it. For lines to the south east of Line 7, an AB of 12,000 ft. and MN of 400 ft. was used.

Due to the semi-arid conditions of the area, it was necessary to water the electrodes prior to taking measurements. Water was obtained from New Bore. The high salinity of the water was ideal for reducing the contact resistance of the electrodes, although in some areas it was necessary to add copper sulphate to further reduce the contact resistance.

2-2. Seismic Operations:

A geophone spacing of 200 ft. was used. Each spread consisted of 24 geophones. Shots were fired at each end of the spread at distances equal to the length and twice the length of the spread. Charges ranged from 15 lbs. to 200 lbs. of gelignite fired on or near the surface.

A McCulloch Power Auger was used to drill holes to bury the charge where possible.

2-3. Statistics:

2-3-1. Composition of the Crew:

- one Party Chief: T. CREWS
- one Operator : K. HAZELGROVE
- one Surveyor
- four Helpers
- one Mechanic
- one Cook

2-3-2. Equipment Supplied by C.G.G. :

- one SERCEL AS604R seismic refraction set
- one SERCEL AE631 resistivity set complete with 25W, 200W and 1000W converters
- two Barometers
- two Toyota Landcruiser Utilities
- one Motor Cycle
- one 6 x 6 Toyota Truck
- one Wild Theodolite
- five Tokai 1W Walkie-Talkie Radios
- complete set of spares, cables, tools, geophones, etc. ....
- messing and camp facilities for ten men.

2-3-3. Equipment Supplied by Centamin :

- one Bulldozer
- one Eilco 7W Portable Outpost Radio.

2-3-4. Measurement Output :

Seismic Output :

8 spreads each with 48 shots were carried out on Lines 1 and 2.
Surveying and Pegging:

121.25 miles of line were surveyed and pegged every 200 ft. 30 miles of levelling with the Wild Theodolite and 107 miles of levelling with the barometers were carried out.

Electrical Output:

31 Electrical Soundings with an average AB line of 300 metres were carried out over the surveyed area.

2775 gradient array stations were carried out on 98 miles of resistivity profiles. This corresponds to 202 spreads with a spacing of 200 ft. between measurements.
3. **ELECTRICAL PROSPECTING**

3-1. **Electrical Soundings**

An Electrical Sounding does not define a unique solution with regard to the resistivities and thicknesses of the underlying layers.

It is simple to calculate an Electrical Sounding which corresponds to a given series of resistivities and thicknesses but, within certain limits, the shape of the calculated curve is not noticeably affected if

- the resistivity and thickness of a resistant layer are changed but its transverse resistance remains constant (Transverse Resistance = resistivity x thickness or TR = h x ρ)

- the resistivity and thickness of a conductive layer are changed but its longitudinal conductance remains constant (Longitudinal Conductance = Thickness/Resistivity or C = h/ρ).

N.B. The above rules make up the "Principle of Equivalence".

- a thin layer of intermediate resistivity is added to the series between two layers which have strongly contrasted resistivities ("Principle of Suppression").

To sum up the above considerations, it may be said that in most cases it is possible to determine Transverse Resistances and Longitudinal Conductances with the help of master curves from
experimental Electrical Soundings. It is not possible to
determine all thicknesses and resistivities - several different
solutions may satisfy the experimental curves.

Automatic processing of E.S. does not mean "automatic inter-
pretation"**. The automatic processing of an E.S. follows
the procedure mentioned below.

1. the ground is considered as made of a series of a
   large number of thin layers of equal thickness.

2. by presuming the thickness to be known, it is possible
to calculate the corresponding resistivities. This
"comprehensive solution" satisfies the experimental
curve but not the geological section.

3. from this particular solution, a Dar Zarrouk curve is
drafted, on which $\sqrt{RC}$ is plotted in abcissae and $\sqrt{R/C}$
is plotted in ordinate**. On the Dar Zarrouk curve an
angle corresponds to each interface between layers which
have different resistivities and it is therefore much
easier to determine the minimum number of layers which
satisfies the experimental curve. Figure 2 shows 3 E.S.,
Figure 3 gives the corresponding Dar Zarrouk curves obtained
from the "comprehensive solution".

* see "Automatic Processing of Electrical Soundings" by G. Kunetz
and J.P. Rocroi - 31st European Association of Exploration
Geophysicists Meeting - May 1969.

** R : cumulated Transverse Resistances
    C : cumulated Longitudinal Conductances
E.S. 7.2, 1.2, 1.5
E.S. 7.2, 1.2, 1.5
Dor Zarrouk curves
For example, it appears that the minimum number of layers for E.S. 7-2 is eight, for 1-5 it is seven and for 1-2 it is eleven. Figures 4, 5 and 6 present simplified solutions for each E.S. These solutions are the simplest which fit exactly with the Dar Zarrouk curves. No geological data has been taken into consideration.

The geological section of DDH3 shows only a series of thin layers of sandstones and siltstones, yet the proportion of sandstones and siltstones varies. Siltstones are more conductive than sandstones. From the relative proportion of sandstones and siltstones, it seems possible to distinguish the following resistivity units:

- **C1**: a complex conductive unit which comprises 4 layers. The third one is a 30 foot resistant intercolated layer.
- **R1**: a 340 foot resistant unit (resistivity 205 ohm-m).
- **C2**: a 403 foot conductive unit (resistivity 159 ohm-m).
- **R2**: a 811 foot resistant unit (resistivity 715 ohm-m).
- A very resistant basement below 1680 feet.

Thicknesses of C1, R1 and C2 were determined on the geological log. They were considered as electrically equivalent to the corresponding layers of the simplified solution (Figure 6). Consequently, their resistivities were determined.
Resistivities
in ohm.m

Fig. 4: ES 1-2: simplified solution
Fig. 5 : ES 1-5 : simplified solution
Fig. 6: ES 7-2 (on DDH3): simplified solution
It should be noted that section B, on Figure 7, is merely an acceptable solution; the hole did not reach the basement. The resistivity of R2 may differ from 715 ohm-m and therefore the depth of the basement may be other than 1680 feet.

E.S. 1-2 and E.S. 1-5 have been automatically processed according to the same rules as E.S. 7-2. All E.S., except E.S. 1-6 and 1-7, which are located on the nearly outcropping basement, have a shape similar to one of these three E.S.

Figures 3, 4, 5 and 6 show that all E.S. may be assumed to correspond to a series of layers similar to series B on Figure 7. Depths were determined according to the same procedure.

3-2. Conductance Profiles:

Electrical Soundings carried out on a sedimentary series overlying a very resistant basement present a rising asymptote on the right hand side. The slope of the asymptote is $45^\circ$. The coordinates, $\rho_a$ and $AB/2$, of any point on the asymptote, are related according to the following equation

$$\sum C = \frac{AB}{2} \rho_a^2$$  \hspace{1cm} (1)

where $\sum C$ is the sum of the conductances of the n layers.

$$\sum C = C_{AB} = \sum_{i=1}^{i=n} \frac{h_i}{\rho_i}$$  \hspace{1cm} (2)

Therefore, it is not necessary to carry out a complete E.S. to
E.S. 7.2 on DDH3

A: result of automatic processing
B: simplified section in agreement with result of automatic processing and geological section
determine the total conductance. An Apparent Resistivity measurement carried out with a sufficient current electrode separation allows the determination of $\Sigma C$ according to equation (1).

$$\Sigma C = C_{AB}$$

is an every rising function of depth. For a constant average resistivity of the sedimentary series it is actually proportional to the depth of the very resistant basement.

On the other hand, a buried basin filled with conductive material gives rise to an increase in the total conductance, as indicated on Figure 8.

As explained in the Introduction of this report, mineralizations may be located on the edges of such basins.

Apparent Resistivity measurements were carried out with a 6000 foot AB line in the northern half of the area (Plates 2 and 4) and with a 12000 foot line in the southern part (Plates 3 and 5). A longer line had to be used in the southern part because conductances increase southward and consequently the rising asymptote of the E.S. is shifted to the right.

Conductances mapped on Plates 2 and 3 were calculated according to equation (1).

The clayey overburden has a low resistivity - generally below 20 ohm-m. It has a slight influence on $C_{AB}$ variations, giving rise to sharp irregular variations of the total conductance (see Fig. 9 and Plates 4 and 5). Such anomalies are of no interest in the present case, and, moreover, they mask wide, smooth anomalies due to deeper structures and hinder correlations between profiles.
Total Conductance Anomaly due to a small basin filled with conductive material.

Total Conductance

Ground Surface

100 ohm.m

20 ohm.m

100 ohm.m.

Fault

resistant basement

Vertical Scale

1" : 300'

FIG. 8
Fig 9  Effect of non linear filtering on conductance profiles  
A: raw measurements  
B: filtered profiles  
□: conductance anomaly
In order to remove the influence of the overburden and shallow electrode effects, the conductance profiles were submitted to a non-linear filtering. Total conductance anomalies have properties similar to magnetic anomalies - their amplitudes add up linearly and their gradients decrease with increasing depths. The programme which was applied has been designed by H. NAUDY for aeromagnetic profiles * in order to avoid the inconveniences of linear filtering. The main fault in the linear filtering is that a given anomaly has a very wide "frequency spectrum" and filtering, for example, of "high frequencies" due to shallow causes distorts those anomalies which are to be preserved, and anomalies to be removed are not completely erased.

Figure 9 shows how non-linear filtering makes correlations much easier. A comparison of the total conductance contour maps (Plates 2 and 3) and the filtered profiles (Plates 4 and 5) shows how wide anomalies, clearly visible on the filtered profiles, are hard to distinguish on the unfiltered profiles. Actually the total conductance maps show only the general north-northwest/south-southeast trend of the Mt. Skinner basin.

Plates 4 and 5 show the anomalies numbered from B1 to B9 which are due to non-outcropping conductive basins or deepenings of the resistant basements. Correlations confirm the general north-northwest/south-southeast trend. Amplitudes of anomalies reach 2.5 mhos which is equivalent to a 150 foot thickness for a 20 ohm-m resistivity.

* see "Recent Development in the Acquisition Processing and Interpretation of High Sensitivity Aeromagnetic Data" by G. ROYER, H. NAUDY, J. THOMAS, H. DREYER- C.G.G. 1969
The elongated shapes of anomalies and their southward functions suggest that at least B1, B3 and B4 are wide buried channels and that sediments were carried from the north.

There is no constant correlation between surface elevation and conductances. Shallow anomalies have a larger amplitude in the flat areas because the clayey overburden is thicker.

Filtered conductances are smaller on the central plateau. Electrical Soundings confirm that the upper layers are more resistant in the central area. These facts suggest that the upper part of the Mt. Skinner series contains a higher percentage of coarse sandstone. It may lie unconformable on the lower part although it has not been possible to observe any unconformity in the field or on aerial photographs.

Strong conductive anomalies on the eastern and western edges of the area are probably due to shear zones associated with faults and filled with salt water. E.S. 1-4, 1-5, 1-6 and 1-7 support this interpretation (see Figure 10).

Electrical Soundings show that some smooth, wide, filtered anomalies are due to an extensive conductive overburden rather than deep structures (E.S. 1-2, 4-1 and 7-5).
E.S. 1.6, 1.5
Effect of a Fault on Electrical Soundings

Upper compartment: E.S. 1.6 - Total conductance: 12.3 mhos
Lower compartment: E.S. 1.5 - Total conductance: 55.5 mhos
4. **SEISMIC**

The quality of records was excellent and the energy arrivals clearly visible but the tests carried out on Profile 1 and on DDH3 showed that only one marker could be followed. This was the top of a layer characterized by seismic waves with a velocity of 19,000 ft./s. The velocity of seismic waves in the upper layer is about 16,000 ft./sec. Calculated depths of the 19,000 ft./s marker vary between 500 feet and 860 feet - well above the basement at DDH3.
CONCLUSIONS AND RECOMMENDATIONS

The resistivity survey carried out at Mt. Skinner detected nine main anomalies which are probably due to buried basins filled with conductive material or deepenings of the resistant basement.

Anomalies are elongated following a north-northwest/south-southeast trend. Some of them are composed of two axes which join in their southern region. These facts suggest that anomalies are due to wide buried channels and that sediments came from the north.

Faults follow the edges of the Mt. Skinner basin.

The true nature of all anomalies is unknown because no existing drill hole is located on an anomaly. As an initial step, we would recommend testing the main anomaly, B3, with three vertical drill holes.

- at the intersection of Line 12 with the base line
- at 1250 feet west from the base line on Line 12
- at 1800 feet east from the base line on Line 12

We recommend drilling a fourth hole on anomaly B6 on Line 7 at E.S. 7-3.

The Senior Geophysicist

W. FARABOLINI

The Chief Geophysicist

G. OMNES
