DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

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PETROPHYSICAL DATA ON WILKINSON STRATIGRAPHIC DRILL HOLE NO. 1

GEOLOGICAL SURVEY

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ABSTRACT

Petrophysical measurements undertaken on core between depths of 210 m and 710 m from S.A.D.M.E. Stratigraphic Well Wilkinson No. 1 show five or six major petrophysical subdivisions within the Observatory Hill Beds (?) of Early Cambrian age. Sulphide minerals appear to be the main cause of magnetic effects. The presence of non-magnetic fine sulphides provides a geochemical marker and requires further examination as a possible lead to mineralization of economic significance.

PURPOSE

Petrophysical data for core samples of Wilkinson No. 1, a S.A.D.M.E. stratigraphic well drilled in 1978, provide information to supplement geophysical logs for this important drill hole.

These data provide bases for:

(i) the subdivision of the lithological units and possible petrophysical parameters for future correlations between drillholes;

(ii) the geophysical interpretation of Bouguer gravity and magnetic data in the Tallaringa Trough.

LOCATION

Wilkinson No. 1 has co-ordinates 29.8672°S, 132.5653°E and is located approximately 150 m south of shot point 65 on seismic traverse FR in TALLARINGA. The drillhole core has been assigned a unique number of 5438-003-00007, and is stored in the S.A.D.M.E. Core Library, Glenside.

AVAILABLE IN-SITU GEOPHYSICAL LOGS

In-situ geophysical logs recorded are gamma and temperature to a depth of 575 m, and a neutron log to a depth of 384 m. These logs do not extend to the total depth of 710 m penetrated in the hole. The reason for this limited coverage is due to a drill rod being stuck in the hole at a depth of 575 m, and to the neutron probe becoming jammed in the hole at 384 m.

METHOD OF MEASUREMENT AND REDUCTIONS OF THE PETROPHYSICAL DATA

Three petrophysical parameters were recorded from the diamond drill core: total count radiometric, magnetic susceptibility and specific gravity measurements. The sampling interval was one metre. The samples used, marked with a red textacolour (dot), were located at the end of each core tray farthest from the tray labelling.

The radiometric data were rejected as there were no means available of adequately shielding the core from extraneous high background radiation levels in the core laboratory, nor of obtaining a reliable background level to standardise the measurements.

1. Magnetic Susceptibility

Measurements were recorded using a Bison Instrument, Model 3200, auto-phase balance high sensitivity magnetic susceptibility meter. Corrections for cross-sectional area and different size coils were made as required.

2. Specific Gravity

The specific gravity was determined by Archimedes method in a supersaturated salt (NaCl) solution and then normalised by allowing for the specific gravity of the salt solution. The supersaturated salt solution was used to reduce the possibility of dissolving any of the salts from the evaporite section of the core, and to avoid contamination of the core, by the introduction of organic material from solvents, e.g. kerosene. These sediments contain a small percentage of hydrocarbons, and constitute high-quality source rocks for petroleum.

The conductivity was measured on a conductivity bridge. The specific gravity of the saturated solution varied, due to an accidental addition of a quantity of tap water during the course of measurement. Spot checks of these parameters, which were undertaken to provide quality control on the solution, are summarised below.

The original supersaturated NaCl solution had a density of 1.1760 gm/cm^3 and an estimated salinity of 225 000 ppm. This solution was used for all measurements on core samples between depths of 210 m and 534 m. The contaminated supersaturated solution (tap water added) had a density of 1.1600 $gm.cm^3$ and an estimated salinity of 215 000 ppm. This solution was used for the remainder of the core.

Samples of the solution submitted for contamination analysis to check the operating procedure were:

(i) the original supersaturated solution,

(ii) samples after the reading at a depth of 534 m,

and (iii) samples at the completion of measurements.

These samples are retained by the S.A.D.M.E. Oil and Gas Division for future analysis, if required.

INTERPRETATION OF PETROPHYSICAL RESULTS

Logs of specific gravity and magnetic susceptibility were compared with the other geophysical and lithological logs, and showed a five-fold subdivision of the interval between depths of 210 m and 710 m, mainly defined by the susceptibility log (Figure 1). These five major units may be further subdivided into minor units, based on the combined petrophysical data.

A summary of the major petrophysical units and their subdivisions compared with both the lithological and petrological data is given hereunder.

Four definitions are required, for ease of reference to Figure 1, in this report, to describe the regular increases or decreases of magnetic susceptibility and specific gravity with depth. These were used to subdivide units and identify them on the petrophysical logs.

A regular gradient showing an increase or decrease of magnetic susceptibility with depth over a particular interval is called a susceptibility zone. The increasing and decreasing gradients are called the susceptibility positive gradient zone (S.P.Z.) and susceptibility negative gradient zone (S.N.Z.). The specific gravity has similar positive and negative zones, called density zones, e.g. D.P.Z. for a positive gradient with increasing depth and D.N.Z. for a negative gradient with increasing depth.

1. UNIT 1, situated between depths of 210 m and 295 m.

This major petrophysical unit contains some ferromagnetic minerals clearly indicated by three subunits becoming thicker with depth, and each showing a characteristic reduction in susceptibility with depth (S.N.Z.). The upper boundary of each subunit shows a sharp increased susceptibility contrast with the overlying subunit. There is an increase with depth in the mean susceptibility values of these subunits, being 10, 30 and 55 x 10^{-6} cgs. units respectively.

The specific gravity values of Unit I do not show this three fold subdivision, but show a series of less than 10 m thick D.P.Z.'s. The rolling mean plot showed three possible subdivisions. These zones are characterised by a sharp microdensity contrast at the base of each such D.P.Z. There are two thin D.N.Z.'s.

The lower boundary of this unit is defined best by the susceptibility log, but there is a corresponding microchange in the specific gravity log. This is shown by a change from a monovariant population to a divariant population, having a mean contrast of 0.1 gm/cm^3.

Unit I is a sandy to silty dolomitic limestone with minor sandy and limestone bands. Twelve petrological samples, (RS 34-44 and RS 50) from this unit have been described.

1.1. SUBUNIT 1A is situated between depths of 210 m and 230 m.

The specific gravity values appear to be a function of the dolomite percentage and possibly opaque mineral content. The latter shows a 2% to 5% increase with depth, which is the reverse to the change in susceptibility values and suggests that most of the opaque minerals are highly oxidized, and do not represent the major ferromagnetic mineral present in this subunit.

Lydyard (1979) observed a sulphide band at 210.26 m, and the corresponding susceptibility value at a depth of 210 m is 14×10^{-6} cgs. units. This susceptibility could explain the prime susceptibility response, if these sulphide bands are frequent or the sulphide is disseminated within the subunit. The presence of biotite in the dolomitic micrite may also affect the susceptibility.

1.2. SUBUNIT 1B is situated between depths of 230 m and 254 m.

This subunit has a similar lithology to Subunit 1A, but shows a considerable amount of goethite or limonite staining of the calcite, and the presence of detrital biotite may explain in part the higher susceptibility background of the subunit, compared with Subunit 1A. This interpretation is based on some biotite observed during petrological examination of RS 38 (Steveson, 1979). The corresponding susceptibility value of this specimen is 35 x 10^{-6} cgs. units, which is the average value for this unit.

The higher susceptibility "spikes" (Figure 1) probably relate to thin sulphide bands, one of which was observed at 242.7 m depth (Lydyard, 1979), with a susceptibility of 161 x 10^{-6} cgs. units. This value is comparable with, but slightly less than the accepted susceptibility value for pyrite, and is considerably less than values recorded for pyrrhotite. This suggests that the sulphide present is probably pyrite.

The specific gravity log shows two D.P.Z.'s, with a thinner D.N.Z. at the top. The overall increase in density with depth of this unit may reflect an increasing percentage of anhydrite, as reported in the petrological description for RS 40, (Steveson, 1979).

1.3. SUBUNIT 1C is situated between depths of 254 m and 295 m.

The upper boundary of this subunit as defined by susceptibility data correlates with the carbonate colour change from red-brown to green or light grey, which is considered by Lydyard (1979) to be the top of a carbonate sequence.

The susceptibility data shows a thick S.N.Z. for this subunit. There are two possible ferromagnetic materials reported within this unit:

(i) a thin sulphide band at 254 m depth, with an approximate susceptibility value of 75 x 10^{-6} cgs. units;

(ii) a band of heavy minerals approximately 5 cm thick at 269.64 m (Lydyard, 1979), within a zone having a susceptibility value of 59 x 10^{-6} cgs. units.

These are suggested as the source of the main background value of the observed susceptibility with the major susceptibility "spikes" (Figure 1), which probably correlate with thin bands of pyrite as in Subunit 1B.

The specific gravity log shows a slight increase in base level and higher gradient (D.P.Z.) than observed in Subunits 1A and 1B. The higher background level reflects an increase in dolomite content, and the maximum and minimum values of the D.P.Z. reflects variations in the anhydrite and gypsum content. This variation is interpreted to represent a possible alternation of the proportion of each evaporite minerals present within these carbonates.

The expected magnetic response of Unit 1, assuming a thickness of 85 m and maximum dip of 5^{o} would be small, and not detectable at the surface even if these sediments cropped out.

2. UNIT II situated between depths of 295 m and 369 m.

This unit is relatively poor in ferromagnetic material and is characterised by layers of zero susceptibility, correlating with diamagnetic evaporite minerals, (halite and gypsum). The higher susceptibility values at 358 m (Figure 1) probably correlate with a sulphide band.

The specific gravity log shows a predominance of D.P.Z.'s, which in the upper 52 m have thicknesses of about 10 m, and below 347 m thicknesses of up to 20 m. The coincidences of lower density and zero susceptibility values are interpreted to be associated with concentrations of gypsum rather than halite in this calcareous sequence.

3. UNIT III situated between depths of 369 m and approximately 573 m.

This unit is characterised by a relatively low magnetic susceptibility sequence containing both S.P.Z. and S.N.Z.'s having variable thicknesses, (Figure 1). Thick D.N.Z., with thickness of about 40 m, predominate in the upper portion of the unit and at depth, changes to thinner high frequency D.P.Z.'s. The section between 505 m and 535 m compares petrophysically with Subunit 1B. It is possible to subdivide this unit into four subunits as shown in Figure 1.

The zero susceptibility values within this unit coincident with high density values correlate with anhydrite. This is based on the occurrence of anhydrite at 451 m, petrological description of RS 48 (Steveson, 1979), and the corresponding high density and zero susceptibility in the hole. Anhydrite is a diamagnetic mineral with a specific gravity of 2.9. The other zero susceptibility values located at 499 m and 504 m (Figure 1), may also correlate with anhydrite.

Bands of sulphides, observed at 391 m, occur in a narrow S.N.Z., and two sulphide occurrences, reported at depths of 458.3 m and 465.8 m, relate to a boundary between an S.P.Z. and an S.N.Z. A high geochemical zinc value at 390 m (Shackleton, 1979) occurs in an S.N.Z. within the upper portion of a thick D.N.Z. The sulphides present are pyrite and marcasite (Steveson, 1979). The minerals containing the Pb and Zn ions have not been reported. Some of the higher susceptibility values may correlate with either disseminated pyrite or possibly, with pyrite intermixing with and/or in exsolution with marcasite.

The zinc mineralisation may be either stratabound, relating to the boundary between Units II and III, or stratiform relating directly to the thin S.N.Z. zones situated between depths of 388 m and 405 m, or, to the distinctive change and/or boundary between the thin D.P.Z. to the thicker underlying D.N.Z. Other similar zones are present in this hole, and by the combination of these zones and the distinctive gamma ray response between 367 m and 417 m, they may be useful in defining a distinctive geophysical characteristic for future geochemical sampling. A systematic geochemical analysis for Pb, Zn and associated elements, characteristic of stratabound and/or stratiform mineralisation is warranted over the whole core and particularly the interval specified by the gamma response, to test if these petrophysical methods can be used as a guide to geochemical exploration in other drill holes in the region. In addition, a comparison of these geochemical and geophysical parameters with those from classical "Mississippi Valley" and/or "Kupferschiefer" sequence is warranted.

4. UNIT IV, situated between depths of 573 m and 678 m.

This unit is predominantly a halite sequence, characterised petrophysically by an alternating sequence of low density and low susceptibility bands (correlating with the main evaporites), and higher density and susceptibility bands (siltstone).

The halite beds show zero susceptibility, characteristic of diamagnetic minerals, and the specific gravity data show a predominance of halite, (standard density is 2.2 gm/cm^3) over gypsum (standard density is 2.3 gm/cm^3). The published density ranges reported for halite (rock salt) and gypsum, show ranges, e.g. 2.1 to 2.4 and 2.2 to 2.6 gm/cm^3 respectively. However, most of the zero susceptibility bands have densities less than the range published for gypsum.

The sample located at a depth of 623 m has a density comparable in magnitude with anhydrite (standard density is 2.9 gm/cm^3). Therefore, based on the specific gravity log, the evaporite is mostly halite and is deficient in anhydrite.

The higher susceptibility bands correlate with siltstone interbeds, and the source of the ferromagnetic mineral is probably magnetite and/or martite within these red beds.

5. UNIT V, situated between 678 m depth and the total depth of the well at 710 m.

This unit is characterised by relatively high susceptibility values comparable with those of siltstone interbeds in Unit IV. There is an increase in the mean specific gravity relative to Unit IV, and any evaporitic minerals present within this sequence are probably gypsum and halite. Lithologically this unit is a sandstone-siltstone sequence with a minor amount of gypsum (Gatehouse, 1979).

The specific gravity log shows a decrease over the last 5 m of core, reflecting a minor change to sandstone lithology. There is a corresponding decrease in magnetic susceptibility over the same interval.

CONCLUSIONS AND RECOMMENDATIONS

The petrophysical logs for Wilkinson No. 1 (Figure 1) show that there are five or possibly six major petrophysical units below 210 m depth. The possible sixth major unit is 1C. The main magnetic susceptibility units correlate with disseminated pyrite and minor biotite. The other sulphide mineral present is marcasite. The rolling mean plot of the specific gravity data showed this six-fold subdivision, but produced some pseudo-bands due to isolated peaks in the original.

The expected magnetic response determined for the combined major Units IV, and V, assuming a width to depth ratio of unity for a near horizontal sheet, would be 1.6 gammas. This magnitude anomaly may be marginally detectable with good quality fluxgate data, but would be clearly resolved if a caesium vapour magnetometer or squid gradiometer magnetic system were used, which have a corresponding increase in sensitivity of 10 and 100 respectively. These data could provide information on the depth and distribution of these evaporitic sediments.

Based on the specific gravity data, micro-gravity and high resolution reflection seismic methods may be used in mapping the extent of the evaporite sequence, as there is a density contrast (and a corresponding negative seismic reflection coefficient) between Units III and IV. A synthetic seismogram should be constructed from the specific gravity data of Wilkinson No. 1 to determine the expected response, before further gravity or seismic methods are applied to map this sequence within the Tallaringa Trough.

This petrophysical data should be useful for future stratigraphic correlations with other wells, and may provide information in the search for stratabound and/or stratiform lead-zinc deposits.

Priority should be given to a combined petrophysical and geochemical study of all available cores from the Tallaringa Trough, and also those from the Officer Basin. A study of the distribution of prospective facies should be made to enable areas with higher probability for economic mineral exploration to be defined more accurately, providing geophysical and drilling targets.

RAG:ZV

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REFERENCES

Gatehouse, C.G., 1979. Well completion report. Wilkinson No. 1. S. Aust. Dept. Mines and Energy report No. 79/88 (unpublished).

Lydyard, A.J., 1979. Brief Litholog descriptions of sulphide-bearing strata in Wilkinson No. 1. Appendix VI in Gatehouse, C.G., 1979. Well completion report - Wilkinson No. 1.

Shackleton, W.G., 1979. Wilkinson No. 1. Stratigraphic well trace metal analysis. Appendix IV in Gatehouse, C.G., 1979. Well completion report - Wilkinson No. 1.

Steveson, B., 1979. Petrography of thin sections and polished sections from Wilkinson No. 1. Appendix VII in Gatehouse, C.G., 1979. Well completion report - Wilkinson No. 1.

PETROPHYSICAL LOG
OF
WILKINSON No 1

STATE : SOUTH AUSTRALIA   PETROLEUM TENEMENT: NONE   1:250000 SHEET: TALLARINGA   BASIN: OFFICER

WELL STATUS: PLUGGED AND ABANDONED.

LOCATION: LAT: 29°52'02"S.
LONG: 132°33'55"E.
Near S.A.D.M.E. seismic line shot point FR 65.

ELEVATION: FR 65 ground 162·1m.

TOTAL DEPTH 710 m

WELL SYMBOLS

- No 3 — CORE INTERVAL AND NUMBER
- PLUGGED INTERVAL
- CASING SHOE
- Fl — FLUORESCENCE
- CUT WITH CCl_4

LITHOLOGY BY C. G. GATEHOUSE
COMPILED BY R. A. GERDES
DRAFTED BY N. R. SANDERCOCK
DRAWING NUMBER: 79-532
(ALSO REFER TO 79-412)

TYPE OF LOG	TEMPERATURE	64 IN NORMAL	8 FT LATERAL	VELOCITY	NEUTRON	GAMMA RAY
DATE OF RUN						
FIRST READING	576			0	542	576
LAST READING	1				0·5	
INTERVAL MEASURED	576				541·5	576
CASING: LOGGER						
CASING DRILLER						
DEPTH REACHED						
BOTTOM DRILLER	710				710	710
MUD TYPE						
DENSITY/ VISCOSITY						
Ph/ FLUID LOSS cc						
MUD RESISTIVITY						
RECORDED BY	B P TAYLOR.			B.P.TAYLOR	B P.TAYLOR	B P TAYLOR.
WITNESSED BY						

LITHOLOGICAL REFERENCE

Shale claystone	Sandstone	K Kaolinitic
Sandy shale	Halite	Glauconitic
Silty shale	Pebble	G Garnet
Siltstone	Li Lithic	Calcareous
Argillaceous siltstone	A Anhydrite	Dolomitic
Sandy siltstone	Py Pyrite	O Oolite
Calcite	Vi Micaceous	F Fossiliferous Fragmental or Indeterminate
Dolomite	Carbonaceous	f Feldspathic
Coal	Fe Ferruginous	Gy Gypsum Gypsiferous
Quartzite	ca Carbonate Fragments	Mn Manganese
Quartz grains	D Dolomite pebbles	

GRADIENT ZONE REFERENCE

- Positive,
- Negative,
- Large cycle,