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MAGELLAN PETROLEUM CORPORATION

*Company Report.*

GEOLOGICAL REPORT

ON

GRAVITY SURVEY OF SELECTED AREAS OF OP43

NORTHERN TERRITORY (AMADEUS AREA)

by H. I. Harris

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RANGES AREA

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**INTRODUCTION**

Magellan Petroleum Corporation was granted OP43 on June 24, 1960. This permit was renewed for a further year from June 24, 1961. The area of the permit and areas of gravity work are shown on Figure 1.

Magellan Petroleum Corporation maintains its registered offices at Bowman House, Edward and Adelaide Streets, Brisbane, Queensland. Field offices are in the Riverside Hotel, Alice Springs, Northern Territory. The contractor for the gravity work was International Resource Surveys, Inc., a wholly-owned subsidiary of Century Geophysical Corporation of Tulsa, Oklahoma, U.S.A.

The subsidized survey started June 1, 1961, and was completed about August 10, 1961. The results of a previous gravity survey, which was not subsidized, are included in this report and also in the report of the

contractor. The contractor's report was received in February, 1962.

Technical personnel employed by International Resource Surveys are:

E. P. Lane	-	Party Chief
J. Maddox	-	Surveyor
J. Sebels	-	Gravity meter operator

Final interpretation was made in Tulsa, Oklahoma, by Karl W. Abel.

#### SUMMARY OF GEOLOGY

An unmetamorphosed shelf sequence of late Proterozoic to late Ordovician marine rocks is preserved in the Amadeus area of Central Australia. These rocks are overlain unconformably by a post-Ordovician Paleozoic continental formation of greatly varying thickness. Figure 2, a compilation geologic map, indicates the outcrop pattern and summarizes the lithology of the mapped units.

The rocks have been folded into long, sinuous (chiefly) closed anticlines and synclines. Erosion has breached most of the anticlines to the mid-Cambrian or older rocks. However, there are large areas of synclinal structure in which the younger rocks have been preserved. These synclinal areas are deceptively simple in comparison with the exposures in the older rocks and it was proposed to run gravity lines across both anticlinal and synclinal

areas in hopes that gravity patterns derived from the exposed rocks would be echoed to some extent in the broad synclinal areas.

In particular, the structurally low area of Magellan's permit, the Missionary Plain, (see Figure 3) was of extreme importance. In this broad syncline are preserved all the marine sections which are exposed in the MacDonnell Ranges to the north and in the folded structures to the south, east and west.

Figure 4 is a generalized cross section through the MacDonnell Ranges, which shows the stratigraphic succession and provides some indication of facies changes in an east-west direction. The sections in the MacDonnell Ranges, although often described in print, are not representative in that some of the rocks have suffered low grade metamorphism which is completely absent in the rocks to the south.

Specific geologic areas were of interest as surface geology could not define certain unknowns. These were: Waterhouse Anticline, Palm Valley Anticline, Gosses Bluff, and Herb's Zilch (now known as Carnichael Prospect).

The Waterhouse Anticline (see Figure 3, Geographic Index) is a very large, long, closed anticline. The flanks of the structure have extremely high dips which

strongly suggested a diapiric core. It was hoped that the gravity method would shed light on this subject.

The Palm Valley Anticline (Krichauff Ranges of Figure 3) is a structurally low feature in which only weak closure could be demonstrated by measuring attitudes in the exposed Pertnjara formation. Because of the unconformity at the base of the Pertnjara it was desired to learn more of this structure at depth.

Gosses Bluff is a domal uplift about two miles in diameter, having vertical sides, with many radial faults. Theories of origin have been narrowed to (1) a salt dome or (2) an igneous plug at depth. Although previous gravity work had been done around the structure, Magellan did further work to see if more light could be shed on the problem.

Herb's Zilch (Carmichael Prospect) is an anomalous area in the western Missionary Plain in which Ordovician beds outcrop with an easterly strike and rather steep northerly dip. South-striking Pertnjara beds are in near-contact, separated only by an alluviated area. This small area was felt to be a "window" on relations which may exist in the more deeply buried portions of the Missionary Plain.

EQUIPMENT USED

A summary of gravity equipment used is found in the contractor's report (p.1) accompanying this report. In addition, it may be mentioned that surveying was carried out with a Zeiss automatic level mounted with a fluid, direct reading compass.

DENSITY DETERMINATIONS

Several surface samples were processed for density by the B.M.R. The following samples were collected at various localities in the Amadeus area and are representative:

<u>Formation</u>	<u>Density</u>
Jay Creek limestone	2.65
Horn Valley limestone	2.69
Pacoota sandstone	2.08
Areyonga sandstone	2.43
Stokes sandstone	2.02
Arumbera sandstone	1.85
Pertnjara sandstone	1.74

RESULTS OF THE GRAVITY SURVEY

Areas of control have been contoured by the contractor on a scale of one inch equals one mile. A compilation map on a scale of one inch equals eight miles was prepared from the larger scale maps.



The contractor's report indicates:

1. That insufficient data are available to determine whether the Gosses Bluff structure is a salt structure or not.
2. That the Bitter Springs formation, despite its low stratigraphic position, probably is a low density formation and that lateral density changes may be expected.
3. That the crest of James Range 'A' Anticline is a minimum superimposed on a broad maximum.
4. That the Missionary Plain Syncline is a maximum.
5. That the Waterhouse Range coincides with a "prominent local maximum feature".
6. That the Ooraminna Anticline is on a minimum, flanked by local maxima typical of a structure which is salt-controlled.
7. That to the northwest of Ooraminna is a feature similar to Ooraminna.
8. That Herb's Zilch (Carmichael Prospect) is a prominent minimum probably controlled by low density material.

The contractor concludes, in summary, that James Range Anticlines 'A', 'B', and 'C' and the Waterhouse Anticline are coincident with gravity maxima and the Wild Eagle Syncline with a gravity minimum. Thus all these

features indicate a normal increase in density with depth. On the other hand, he finds Ooraminna Anticline and Herb's Zilch to respond to gravity in a manner opposite to the normal, i.e. indicating low density material relatively near to the surface.

#### GEOLOGIC CONCLUSIONS

There is some disagreement with the conclusions reached by the geophysicists. This appears due to the fact that geophysicists are often prone to rely almost exclusively on the geophysical data available and to fail to take into account geological data which could be integrated.

However, there are certain areas of agreement. For example, the gravity interpretation indicates that the Bitter Springs formation is a low density formation and also that lateral density changes may be expected. On straight geological grounds such a result was anticipated. One reason was the evidence of fossilized salt springs in the Bitter Springs outcrop, especially near old Glen Helen homestead (Finke River area). Further is the fact that waters draining from the Bitter Springs outcrop are much more highly mineralized than elsewhere. But the strongest evidence for low density material is the highly incompetent folding which affects the Bitter Springs formation in

localities where the overlying and underlying beds are competently folded.

A rather clear case of flowage in the Bitter Springs is displayed at the Geyder Pass diapir (Figure 3) where subsequent tilting has turned a growing structure on end, stopping the growth and revealing the ancient cross sectional view in plan. In this diapir, the Bitter Springs formation has pushed up through some of the overlying formations, fracturing and turning them up on end. All formations up through the Geyder are affected and the continuing upward growth, while not causing further rupture, has caused thinning of the Pacoota and younger rocks across this ancient diapir. There is thus incontrovertible evidence that the Bitter Springs formation includes low density material such as salt, gypsum, etc.

It appears that the nearness of the Bitter Springs formation to the surface in such anticlines as Ooraminna and James Range 'A' accounts for the minima coinciding with the cores of these anticlines. The feature northwest of Ooraminna is thus considered to be a possible anticlinal area, with the possibility of a relatively thin Pertnjara cover over a rather deeply-eroded core.

The Herb's Zilch structure, on strict geological grounds, was hypothesized as a salt-controlled structure similar in origin to the Geyder Pass diapir. The gravity

minimum outlined by reconnaissance corroborates this idea to some extent.

The fact that the Missionary Plain Syncline is a maximum and the Wild Eagle Syncline a minimum was not unexpected and can be explained on geologic grounds. In both synclines there are tens of thousands of feet of section and, ordinarily, the thick "fill" of younger rocks would appear as a minimum on the gravity map. This "normal" situation prevails in the Wild Eagle Syncline where the Pertnjara formation is a sandstone with some shale. However, in the Missionary Plain, the Pertnjara near the MacDonnell front is a thick, well-consolidated conglomerate whose density is probably relatively high. This superior density at and near the surface explains the gravity maximum in a structurally low area.

Disagreements with the gravity interpretation commence with the Gosses Bluff structure. This circular structure has the size and shape of a salt dome and the contour map prepared from gravity readings suggests such an origin. However, the distinctive rim synclinal feature is based on only one or two stations and, indeed, much more detailed gravity work would be needed to satisfy an observer who draws his conclusions only from the gravity data. However, the geologic evidence, combined with the reconnaissance gravity add up to a much stronger case for

declaring Gesses Bluff to be a salt dome. There is the geologic evidence presented above for the presence of salt in the Bitter Springs as well as the evidence of diapirism displayed at Geyder Pass. In addition, at Gesses Bluff there is a broad circular valley surrounding the hills formed by the upturned, faulted beds of the Mercene formation. Such a topographic feature is common to many salt domes and supports the salt dome hypothesis.

It is not suggested that the origin of Gesses Bluff is unquestionably due to salt movement, but it is believed that there is, in total, enough evidence to warrant seismic work to further define the structure and its origins.

The Waterhouse Anticline coincides with a "prominent local maximum feature". The disagreement here lies in whether the maximum coinciding with the Waterhouse Anticline is as prominent as would be expected. In the contractor's report, profile E-E' shows two "humps". The northerly one is the Waterhouse Anticline; the southerly one is labelled "James Range 'B'". However, detailed plane table mapping in the area of James Range Anticlines 'B' and 'C' indicates that the southern "hump" on section E-E' is far removed from the effect of the James Range 'B' Anticline and is, in fact, coincident only with the north flank of James Range 'C' Anticline. It is thus difficult to agree that the two humps on section E-E'

represent anticlines, especially when James Range 'C' Anticline over which the section passes has no gravity expression. A further point is that the Jay Creek limestone which is exposed in the core of the Waterhouse Anticline, is buried under about 10,000 feet of sediment only about two miles from the centre of the structure. Under these circumstances one would expect much stronger gravity relief than that indicated. That fact that the gravity high across the Waterhouse is less than expected favors the possibility of some low density material in the core which is depressing the maximum.

The final conclusion that James Range Anticlines 'A', 'B', and 'C' are coincident with gravity maxima should be clarified. James Range 'B' was never surveyed with the gravity meter and the projection of the axis into the line of section is unwarranted since geologic mapping clearly indicates that the structure has died out before reaching the line of section. James Range 'C' cannot be evaluated in terms of gravity since the line in that area did not continue far enough to the south to demonstrate anything conclusive. Section E-E' indicates only slight fluctuations from the regional gravity gradient in the area of James 'C' and it does not appear that any statement can be made with regard to that structure without additional control. James Range Anticline 'A' appears to be the only

structure of these three which has fair gravity control. In this case the important point is not that the structure is basically a maximum, but that the core is indicated as a minimum. In crossing from the adjoining synclines high up onto the flank of the anticline a rise in gravity values is expected as only rocks of increasing density are being crossed. Under normal circumstances, the core of the structure would give the highest readings since here the meter would measure only the oldest, densest rocks plus basement. To observe lower readings here indicates that among the oldest rocks there exists a low density section. From geologic evidence we conclude that the shallowness of the Bitter Springs formation and the presence within it of evaporite and salt layers is causing the gravity minimum.

The contouring in the vicinity of the Palm Valley Anticline did not reveal any distinctive features. Gravity relief is very minor in this area and it is concluded that other methods will be necessary to further evaluate the deeper relations on the Palm Valley Anticline.

#### FINAL SUMMARY

This gravity survey appears to have rather conclusively shown that salt and associated minerals are present in the section in the Amadeus area. The assumption which then comes to mind is that salt is

possibly a key factor in the growth and localization of structures in the Amadeus area.

This gravity survey, in conjunction with intensive stratigraphic and structural work, has been of great aid in assuring a fuller understanding of the geology of the Amadeus area. While the gravity work in itself provides no ultimate information, it has provided extremely useful data which will be called upon in the future as further work is done.