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GEOPHYSICAL REVIEW
of
GEL97
for
GEODYNAMICS LIMITED

This report on the South Australian Permit GEL97 is a review of the existing seismic, gravity and magnetic data to assess its future use in the investigation of the morphology of the granite basement including any lineations and/or faulting that may exist. This information about the granite body is required as part of the input for the assessment of the integrity of the granite and to assist in the selection of sites for the development of future geothermal reservoirs.

MAGNETICS

Regional magnetic data has been compiled by AGSO and these maps have been reviewed several times by various investigators for Geodynamics. The clear consensus is that there is little possibility of recovering anything of interest with respect to basement depth from these data. Equally the possibility of extracting any lineament information relative to the basement is unlikely due to the interference from magnetic units in the sedimentary section. The low pass (5000 m) filtering to remove near surface effects (AGSO, 1999) is interesting in that there are clearly magnetic bodies in the sedimentary section. These bodies while not of interest in the interpretation of magnetic basement will almost certainly have a density variation from the surrounding rocks and hence will affect the gravity interpretation. These anomalies appear to have also been filtered from the gravity data.

Subject to the emergence of a new processing technology or data acquisition system that is an advance on those existing I consider that magnetics can be excluded from active consideration for the geothermal investigations in the South Australian permits. This in no way detracts from its use in other areas or indeed as an adjunct to other forms of investigation where its effectiveness can be demonstrated.

GRAVITY

Summary

The basic gravity data for the area consists of regional syrveys on an approximate 4 km to 7 km grid undertaken by SADME / BMR in the 1960-70's. This has been supplemented by traverses along seismic lines most probably during or immediately after the seismic surveys. This existing data was presented in the documentation for the GEL Applications by PIRSA and has subsequently been the subject of an analysis by CSIRO (2002). Approximately 300 additional stations were acquired by Geodynamics during a 2003 survey (DSS, 2003).

To provide a general assessment of how the gravity picture has developed it is useful to compare the PIRSA map available at the time of tendering for the area with subsequent maps. The subsequent maps to which I refer are those resulting from

a) The 2003 CSIRO report; and from
b) the DSS survey in 2003.

These maps are available from earlier reports.

The later work has significantly improved the reliability of the gravity field, but it has not changed the overall picture

This re-affirms my contention that high resolution traverses in specific locations designed for a specific result are now the only useful application for gravity in this project.

ACCURACY

There are two significant outcomes from the CSIRO, (2002) work and the DSS, (2003) survey and both concern the data accuracy.

Firstly the accuracy of the early work over the area is now incompatible with the accuracy of modern surveys and hence it is a nonsense to attempt to incorporate one with the other. **Secondly**, the precision available and utilized in the analysis needs to be appropriate to the data. [I must note here that I confine my comments to the accuracy of commercial survey gravity measurements and not those of the more scientific based studies associated with absolute gravity determinations and the establishment of datum networks.]

Relative accuracy

For many years increases in the accuracy of gravity data were incremental and occurred over a relatively long time frame. This allowed the sequential addition of new data to databanks and the integration of new data with that already obtained. The principal order of magnitude leap in precision has been the availability of GPS technology for the location determination, particularly the elevation, of gravity stations. Elevation accuracy has for many years been the Achilles heel of gravity work and this is now no longer the case. It is now in my opinion incorrect to utilize the Bouguer anomaly values at “old” regional stations with new data as the elevations of “old” stations have most likely been obtained barometrically and the standard deviation of the height may be up to a metre (or more!) which is equivalent to about 0.3 mgal.

CSIRO has drawn attention to the ”punctuation mark” that some stations resemble in the AGSO, (1999) study and this “punctuation mark” appearance is the classic “one station anomaly”. Having regard to the date of the data acquisition this anomaly is most commonly due to elevation measurement errors.

A study of the recent DSS report shows that the Bouguer data are presented as mgal to three decimal places suggesting that a 0.3 mgal (or larger) standard deviation as in the regional data is massive in comparison.

DSS accuracy

The DSS (2003) report is disappointing in that nowhere in the report is there any substantive assessment of accuracy of the field data.

If for example we look at the data for station 200 in the DSS Appendix B we see no accuracy assessment for the data and note that 24 of 25 readings are **identical** and have a value of 979,125.960 and one differs by 0.019. This may be a random tare but when we look at the other data in the appendix the mis-ties vary significantly. In some cases the mis-tie is zero but another is up to 0.081. Also noticeable is the fact that several stations occupied many times have identical values e.g. stations 1742, 9015 . This suggests that the output device on the gravity meter has an accuracy in excess of the instrument capability and hence the numbers quoted to three decimal places could be misleading without some assessment as to their accuracy.

A report on data acquisition without an assessment of accuracy is not acceptable. The accuracy should be part of the survey specifications and is the basic assessment for the acceptability or otherwise of the data acquisition.

MODELS

CSIRO (2002) has developed a model using the gravity data pre the DSS survey.

The CSIRO modelling is excellent in its execution however the input is over-relied on in that the digitised profiles are obtained from the existing old data that is probably accurate to 1 to 2 mgal. If we look at the data locations with respect to the CSIRO digitized profiles the problem is immediately apparent. The control on the contours of the Bouguer anomalies is inadequate for attempting to work at a resolution of better than several milligals. A consequence of using the accuracy of digitized data is that the accuracy of the modeling usually far exceeds that of the actual field data (as opposed to the data presented on a contour map). The final model may well be (and probably is) a best approximation to the origin of the Bouguer anomaly however little credence can be attributed to it because the data are so inaccurate and widely spaced compared to the modeling data. The attached figure shows the approximate location of the CSIRO lines used in the interpretation which were obtained by digitization from the Bouguer anomaly map. The figure also shows the spatial distribution of the gravity data on which the contours were drawn and it is readily apparent that the profiles digitized for modeling are nowhere near as precise as the accuracy of the computational model. In fact there are only 9-10 gravity stations throughout the GEL97 area except for some detailed E-W lines which do not effectively add to the coverage. This is a common error and usually totally overlooked.

Basic data should always be presented for a report of this type.

Being aware of this the CSIRO model while somewhat short on geology and not recognizing the data accuracy issue is probably a reasonable representation of the geology. However the reliability of the result is not such that a development decision should be based on it.

SEISMIC

Seismic data has been acquired over regional lines by Santos over the period 1972 to 1994 and the latest of this is now several generations old. In general the data is multifold and was acquired with short offsets designed to enhance the interpretation of the basin sediments. The section contains a number of coal measures and this has resulted in a massive multiple presence in the sections. The interpretations have focused on the structuring in the sediments together with attempts to map basement, this not being of prime interest in the petroleum search. The basement mapping has been largely driven by loss of signal coherence below the last reflector and extrapolation from well depths using the general form of the overlying reflector. In fact if there were no wells to basement in the region the basement selection would be totally indeterminate.

The seismic information has been reviewed by a number of consultants including an extensive scientific review by CSIRO (undated) and a report by Jensen-Schmidt 2002.

CSIRO have gone to extreme lengths to attempt to recover a basement signal from the data. The report is presented as reprocessed sections with little commentary. CSIRO made no attempt to map basement and the interpretative certainty from the reprocessed sections indicate that this would not have been a useful option. Extensive and complex processing has been applied to the data starting from the surface with a recalculation of static corrections and velocities on the original traces using later well velocity data. The processing sequence was varied using a range of different deconvolution algorithms, filter processes and velocity analyses. The extensive velocity analyses resulted is a significant clean up of some sections however this detailed analysis also shows that the basement is at the same time-depth as various multiples and hence any basement signals get processed out together with the multiples. This is a consequence of the small moveout of the basement signal due to the small offsets used in the data acquisition. The geometry of the data acquisition cannot be ameliorated by subsequent processing.

The final stacked and migrated signals were presented in two formats for line 83-NCA. There is a wide range of basement morphology in the two possible solutions proposed however I am unconvinced as to the correctness of either possibility. The deeper and highly structured basement is considered the most likely of the two possibilities however I find this unconvincing. I consider that there is little point in any further regional analysis of the existing seismic in order to obtain a regional basement map. Even if there could be some reliability attached to the CSIRO processing such as to make it worthwhile the cost would be fairly formidable.

The CSIRO processed sections should be revisited if a future well is drilled on one of the reprocessed lines. This may provide further insight into the desirable processing sequence. The acquisition of a VSP in a future well should be considered both for the information it could provide not only for reprocessing of existing data but also for use with any new seismic acquisition associated with field development.

CSIRO (undated) provide basic recommendations for future seismic data acquisition. These recommendations could form the basis for acquisition specifications that should be developed in consultation with an expert processing and interpretation team prior to seeking tenders from industry.

The interpretation by Jensen-Schmidt (20023) has been carried out in an area within six kilometers of the Burley and McLeod structures using a simple two-way-time depth conversion based on the Burley #2 and McLeod #1 wells and a depth conversion convolved with the two-way-time. These two basic approaches to depth conversion produced results with similar topology and were interestingly similar to the CSIRO analysis in that one interpretation produced a fairly low relief basement whereas the other produced a more structured basement relief, both controlled at the wells. As the well had similar granite depths there was no control for the highs and lows, hence the different structuring. Jensen-Schmidt also includes in his report a depth to Top of the Big Lake Suite. A comparison of his depth maps reveals a basement morphology highly correlated to the sediments above it. This is not unexpected having regard to the depth conversion method used. Interestingly Jensen-Schmidt on the basis of his experience in the area prefers the flatter (low relief) interpretation to the high relief interpretation in contrast to CSIRO which opts for its high relief version.

The Jensen-Smith approach produces a basement map that in general terms probably bears some resemblance to actuality. In my view however it will not be an effective tool to define basement morphology and lineation in the detail necessary for the geothermal project without further data. It would really require a well in one of the depressions with a depth to granite substantially different to that at McLeod #1 – say the depression approximately 2km north east of McLeod #1. In the event that a later well in the development program is drilled in the area of this depression it could be worthwhile revisiting the seismic interpretation.

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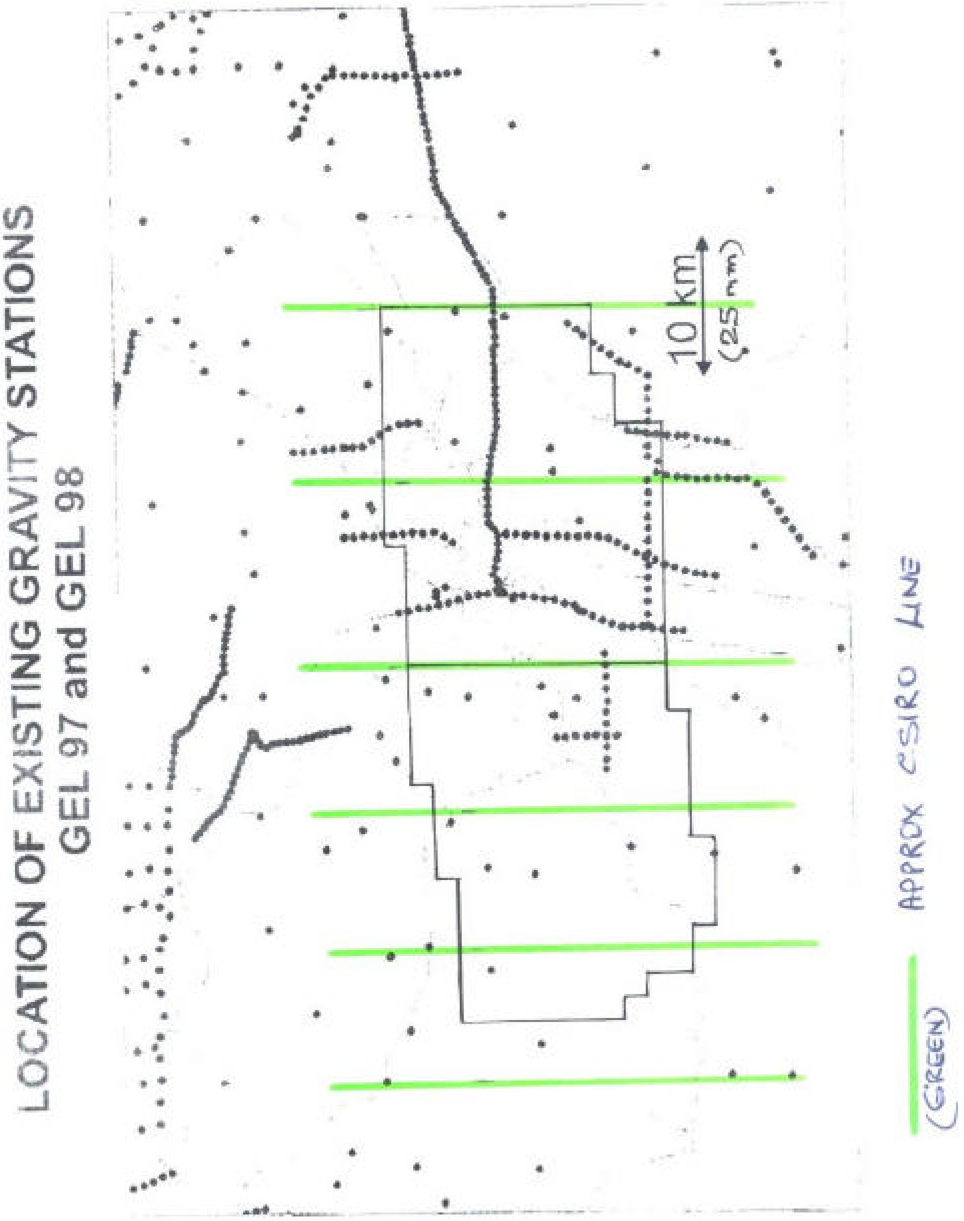
LOCATION OF EXISTING GRAVITY STATIONS
GEL 97 and GEL 98
10 km
(25 nm)
APPROX CSIRO LINE
(GREEN)