MINES and ENERGY RESOURCES SOUTH AUSTRALIA

REPORT BOOK 97/39

LINEAMENT TECTONIC DATA, SOUTH AUSTRALIA WITH A FOCUS ON THE COOPER BASIN

by

R.K. Boucher
Petroleum Division

OCTOBER 1997

CONTENTS **PAGE**

FIGURES

APPENDIXES

DEPARTMENT OF MINES AND ENERGY RESOURCES
SOUTH AUSTRALIA

REPORT BOOK 97/39

LINEAMENT TECTONIC DATA, SOUTH AUSTRALIA WITH A FOCUS ON THE COOPER BASIN

R K Boucher

Lineament analysis by E. S. T. O Driscoll was a crucial factor in the discovery of Olympic Dam the world s largest copper-uranium-gold-silver deposit. Further such work should have led to the discovery of Century, the world s largest lead-zinc deposit in Queensland and could have led to the discovery of Boddington, Plutonic and Kanowna Belle gold deposits in Western Australia. These mapping techniques have been applied to a portion of South Australia.

INTRODUCTION

This report provides the essential background information and the data of the lineament tectonic study underway at MESA. The background information is the most important part of the project, describing the potential of lineaments as an exploration tool. This is relatively unknown to many geoscientists and misunderstood. A second report is in progress which will discuss the interpretation of the data presented in this report for the Cooper Basin area.

Much of this report is from research for a doctoral thesis at the Gartrell School of Mining, Metallurgy and Applied Geology (University of South Australia) under the guidance of Dr. J. B. Jago. This report must not be reproduced without permission of the author.

Workshops related to this report were held at MESA in December 1996 and contained many figures not included in this report. Notes from this workshop are held in MESA file 96/00455

It is important to recognise that this study exclusively utilises the term lineament with respect to the work of Dr. E. S. T. O'Driscoll's concepts. These differ from many others concepts of a lineament that have varying degrees of relevance to O'Driscoll's work.

REASON FOR THIS STUDY

E. S. T. (Tim) O'Driscoll must statistically be the most successful exploration geoscientist in Australia. Woodall has certified that it is doubtful that the world's largest copper-uranium-gold-silver deposit at Olympic Dam would have been found if it had not been for the input of O'Driscoll's lineament analysis (Woodall 1995). Other examples of ore bodies discovered on lineaments pre-defined by O'Driscoll are given below.

It is explained below that Tim's methods are unique and that no Geologist was practiced and practising his technique when the project began.

The initiation of this project was therefore twofold, to utilise the successful exploration technique Tim has developed to encourage further exploration in South Australia and because the most senior expert in this field has retired and it is necessary for on the job training to ensure the skills can be adequately passed on.

R. Boucher is currently completing a PhD on lineament tectonics. However, it was recognised that individual techniques were being developed that were not the same as O'Driscoll's and there was a need to be taught O'Driscoll's methods.

It takes approximately a year to adequately learn O'Driscoll's techniques. Given this, the study exclusively is based on the work of O'Driscoll. This is not to say that other lineament techniques do not have merit, just that time constraints limit this study to the one method.

STUDY AREA

The study area was in part designed by the nature of the project, rather than specific to a certain region. In order to be initially trained in lineament analysis, an area with outcrop was required where lineament mapping was easier. The northern Adelaide Geosyncline was chosen and lineament mapping began here, then moving northwards towards the Cooper Basin area. The Andamooka and Torrens sheets were included as published by Woodall (1994) and O'Driscoll (1986) and recent work by O'Driscoll on the Gairdner sheet was also included. The Otway Basin photo mosaics were interpreted in addition to the area to the north. In total, almost 20% of the state has now been covered (Appendix 1, Map 2). The Otway Basin area was similarly mapped however, no further analysis or interpretations were made beyond the initial air photo lineament plot.

DATA AVAILABILITY

The final lineament data as well as other data used in this project were composited in Arcinfo and have been made available on CD-ROM in ArcView and Mapinfo formats. Details of the metadata are provided in Appendix 2. The CD-ROM contains all of the digital data used in the project, the associated metadata and this geological report.

THE NATURE OF LINEAMENT PUBLICATIONS AND HOW THIS EFFECTS THE SCIENCE OF LINEAMENT TECTONICS

The term 'lineament' has been used virtually since the birth of Geology (Hodgson 1974). And despite thousands of publications with 'lineament' in the title, there is little consensus on a definition. Typically, Geologists are familiar with the term, yet utilise their own individual definitions and concepts. As a way of demonstrating this, I asked Departmental Geologists at the beginning of workshops presented in December 1996 to map lineaments for a given landsat image without prior explanation of the task. The results from the first workshop are given in Figure 1.

It can be seen in Figure 1 that no two authors consider a lineament to be the same thing as they all mapped differing features. The locations, lengths, azimuth's and even the straightness differ. In contrast, if the drainage were required to be identified, all interpretations would be similar. Of interest, all were the width of the pencil used - implying lineaments are the width of a pencil at 1:250 000 scale. Would they have remained the width of a pencil if 1:1 000 000 or 1:50 000 were used? From this example, it can be shown that all attendees of the workshop believed they could map lineaments, yet all had differing opinions.

Indeed, the same is true world wide. There is no shortage of lineament publications. In the last few decades, there have been thousands of publications written with the term 'lineament' in the title. Single authors (Fig. 2a) wrote the majority of the publications. This suggests that the authors merely contributed their own ideas without consulting others or furthering the work of others. Consequently, a great variety of definitions exist. For example, if the author were working on a 1:250 000 scale landsat image, a lineament would be described as being a certain length, the width of a pencil and best seen in Landsat imagery. The definition would differ for someone working in the field, where a lineament may be a joint, evident by an alignment of vegetation.

The majority of lineament authors only contribute a single publication (Fig. 2b). Consequently, few experts exist in the field (assuming the number of publications can be used as a guide). With so many authors contributing individual and differing definitions, it is no wonder that the science has such poor credibility.

The human eye is very good at picking alignments within random data. Consequently, it is possible to map artefacts within the data and not true lineaments. There are examples in the literature which can easily be shown to be artefacts, where linear features are published on small scale, non-Mercator base maps. If these features were true loxodromes, they would plot to curve accordingly with the map projection. It would be fortuitous for such published 'lineaments' to curve to exactly conform to the projection, so it is safe to assume these features are random alignments and therefore have no geological significance. If such errors can be found in small scale maps, it would be safe to assume that artefacts are commonly picked in large scale maps yet remain undetected.

W. H. Hobbs is considered to be one of the earliest observers of lineaments. Numerous studies refer to Hobbs' work in the early 1900's as the benchmark for lineament analysis. Hobbs typically mapped small, linear surface features that were attributed to faults, joints. etc. Others map lineaments hundreds or thousands of kilometres long. These cannot be expected to be of the same significance as the smaller ones described by Hobbs and others. The problem arises when the definition of a lineament does not even consider the size of the feature, let alone its origin or significance. The use of the term 'lineament' in the literature has been applied in a careless manner and discrepancies on fundamental properties like the size of a lineament need to be established. Cox & Power (1997) critically reviewed the use of the term 'lineament' in Australia and came to many conclusions similar to those reported in this report. A copy of the report of Cox & Power (1997) can be found in MESA file 96/00455.

The use of the term 'lineament' to describe known geological features is poor practice. Faults, joints etc. should be referred to as what they are known to be, and not given a collective, unrestrained term. This practice can result in the exclusion of non-linear features. It is possible, therefore, for a linear fault and a linear joint to be both referred to as a 'lineament' whilst a non-linear fault remains known as a fault. This terminology would imply the linear features are genetically related whilst the faults are not.

From the above, poor scientific method and practice has resulted in the science of lineament tectonics not progressing despite being older than many branches of Geology. Wise (1989) provided an excellent summary of the pitfalls of lineament mapping that is recommended reading.

DO LINEAMENTS EXIST?

Given claims that nature abhors straight lines and that the practices of Geologists in the field has not resulted in the science progressing, it could be possible to be misled into thinking lineaments did not exist. However, there is good circumstantial evidence to suggest that they do - in that their application to exploration resulted in the discovery of several ore bodies (see below). Given that lineaments can be used to find ore bodies, they therefore must exist.

LINEAMENT - DEFINITION

Despite the fact that lineaments must exist, still does not aid the definition of a lineament. Boucher (1995) proposed that the lineaments used in the discovery of Olympic Dam could be considered type examples, allowing several conclusions to be drawn:

- Lineaments can be identified at the surface as expressions of deep seated features
- Lineaments and their intersections provide access for metalliferous fluids
- The lineament intersection at Olympic Dam is a site of intense brecciation, initiated or intensified by structural movements.
- Aggregate lineaments, having an overall linear trend, are composed of segregate features of varying orientation
- Aggregate lineaments of various sizes appear to produce their own structural features. For example, if a lineament were a basement strike-slip fault, extension, compression and further strike slip-faulting will be anticipated. The degree to which these structures develop will depend upon:
  - the depth to the source of the lineament and the rock type in which it occurs
  - the style of deformation
  - the rock types above the lineament through which the structures propagate
  - the frequency and direction of reactivation along each lineament
  - Furthermore, 'bottlenecks' of structures will occur at lineament intersections.
- The lineaments at Olympic Dam are presumably as old as the ore deposit (1600My, Johnson & Cross 1991) and continue to be seen in the present day surface geology
- The presence of lineaments is also recognised in aeromagnetic, gravity, air-photo etc data sets indicating they are represented at various depths and can be defined in multiple data sets.
- Lineaments are extracted from the same data used for exploration and appraisal of minerals and petroleum.

These concepts remain a long way from defining lineaments. For this study, a definition is not essential. We know that lineaments can be used to locate ore bodies and this study is designed to utilise these techniques. Therefore, for this study, the concepts and practices of O'Driscoll have been used exclusively. This is not to say that no other significant work exists on lineaments.

POTENTIAL STRUCTURES RELATED TO LINEAMENTS

It is probably safe to assume that lineaments are structural features. If so, several models exist that could be applied to lineaments to attempt to get an understanding of them.

The simplest of these models would assume lineaments were a discrete fault, either dip slip or strike slip. A lineament cannot be a dip slip fault, either extensional or compressional because no dramatic topographic change occurs across the lineaments where they are known to exist (eg. Olympic Dam). Strike slip faulting has more potential, yet is more difficult to prove. A deep seated strike slip fault will produce a deformation ellipse in cover rocks above it, producing extensional, compressional and further strike slip faulting (depending on the rheology of the cover) which may be difficult to relate to the lineament below, particularly when field mapping.

Pure shear models result in an overall compressional regime. Bell (1981) developed the concept of progressive bulk inhomogeneous shortening (PBIS) which explains that extensional and strike slip faulting can occur in an overall compressional regime.

Simple shear models probably have the most demonstrative power and the use and significance of such models have probably been underestimated in geology. If an incompetent medium undergoes simple shearing, folds will develop at approximately 45 degrees to the shearing direction with the remaining stress absorbed by the medium. If the deformation were restored, instead of unfolding the original folds, a new set of folds will overprint the originals. In brittle media, fracturing and faulting will occur in preference to folding. If pre-existing fractures were assumed (Fig. 3a), simple shearing will produce extensional, compressional and strike slip faulting (Fig. 3b). Again, these blocks will not be returned to their original position when the deformation is reversed. More appropriately, erosion off the highs and sediment deposition in the rifts will further complicate any future deformations.

All models will become further complicated when cross cutting lineaments overprint or deform existing lineaments.

The potential structural relationships of lineaments need to be further considered, but are outside the realm of this project.

THE DISCOVERY OF OLYMPIC DAM AND OTHERS

Western Mining Corporation began the search for a Proterozoic hosted copper deposit in Australia in the 1950's after similar occurrences were noted on other continents. The search began in Western Australia and had been unsuccessful until they moved to South Australia. Prospective areas were established on part of the Stuart Shelf based on the conceptual model developed by Haynes (1972) that oxidised, tholeiitic basalts can act as a source of sufficient copper to form a major sediment-hosted orebody. Woodall (1994) explains that 'by October 1973 Haynes had recognised oxidised basalts in outcrop and in drill core. He was joined by Hugh Rutter who began working on aspects of regional geophysics. The study was complete by June 1974 and areas of interest nominated... by June 1974 the search for stratiform ore based on the oxidised basalt model was focused on areas north and south of Port Augusta. By July two locations, Tower Hill and Uro Bluff, on the Torrens and Port Augusta sheets respectively, were recommended for stratigraphic drilling' from within an area of interest (Fig 4a). Post discovery reports of Haynes (1979), Smith (1985), Rutter and Esdale (1985) and Lalor (1987) have the area extended to include the Olympic Dam deposit (Fig. 4b). O'Driscoll (1988) has confirmed that the WMC report K/1990 records that 'the Andamooka sheet received a low score in the ranking table' from the geological investigations.

Woodall (1994) continues, 'by July 1974 Rutter had completed an interpretation of the Andamooka airborne magnetics and highlighted the importance of Zone IX... and nominated prospective areas for drilling around Andamooka, Trig Bluff, Edge Hill and Cowan Ridge' (Fig. 5). Of the geophysical anomalies, 'Bills Lookout was selected as the most promising geophysical target... the second choice of geophysical target was on the eastern flank of Andamooka Island, southeast of Bill's Lookout' (O'Driscoll, 1988), these are shown in Figure 6.

The lineament tectonics input into the Olympic Dam discovery was prescribed by the work O'Driscoll had completed in Broken Hill 1966 and 1967. The discovery of copper at Mt. Gunson by CSR in 1972 was then found to be located at the intersection of two of these original lineaments. Additional lineament maps were then compiled from air-photo mosaics. Gravity and aeromagnetic data were similarly analysed and by August 1974 tectonic targets were proposed. 'Eleven targets were selected on the Andamooka sheet' (O'Driscoll, 1988). Six of these are shown in Lalor's (1987) publication (Fig. 6). O'Driscoll (1983b) states that 'a structural signature for Mount Gunson emerged which was found to be strongly repeated on the Andamooka sheet to the north in the vicinity of Olympic Dam'. This, combined with the nature of the WNW corridor and with features of the gravity anomaly (Fig. 7) gave the tectonic target at Olympic Dam highest priority from a lineament perspective. The target was positioned slightly off centre from the lineament intersection because the same structural signature was seen at Mt Gunson where the new ore discovery was seen to be offset from the NNE lineament along the WNW lineament. The sinistral deflection of the gravity anomaly along the WNW lineament, further indicated the target should be offset. The lineament signature at Appendicitis Dam (later renamed as Acropolis) lay on the same NNE lineament which passed through Olympic Dam and was similarly intersected by a WNW lineament. The targets at Olympic Dam and Acropolis were the only two displaying the same structural signatures seen at Mount Gunson (O'Driscoll, 1983b, 1985, 1986). These two targets lay on the western edge of the NNW corridor (G2) extending through Mt Gunson, which further emphasised the potential of these targets.

Initially, work planned to focus on the southern part of the Stuart Shelf, where the occurrence of appropriately altered lavas have been documented (Lalor, 1987), however, when competitor activity restricted exploration south of Port Augusta and on the southern part of the Stuart Shelf, exploration focussed on the Andamooka sheet which was favoured by the lineament tectonics study.

In September 1974, the exploration strategy was to '(i) nominate potentially favourable geological environments using the basalt alteration model; (ii) define the geophysical elements of the environment using regional gravity and magnetics; (iii) define tectonic targets using lineament analysis; and (iv) chose a portion of the environment with the greatest coincidence of interpreted favourable features' (Woodall, 1994). It can be seen, however, that the two principal targets chosen respectively from each of the three disciplines, geology, geophysics and tectonics (Fig. 6) are not coincidental. The targets chosen, as prescribed, were those with the greatest degree of coincidence. The geological environment, the Stuart Shelf, covers the entire Andamooka map sheet area, hence geophysical and tectonic targets were required to locate the ore body within the geological environment. 'Four of the eight geophysical targets on the Andamooka sheet coincided with tectonic targets' (Woodall, 1994). The areas with the greatest overlap of gravity, magnetics and tectonics were chosen, which can be recognised in Figure 6. The 'sites for stratigraphic diamond drill holes on two of the targets, at Olympic Dam and Acropolis' (Lalor, 1987) were chosen.

'In June 1975 the first drillhole (RDD 1) was sited on a combined gravity-magnetic-tectonic target at Olympic Dam. The drillhole was targeted to intersect near the edge of the body producing the magnetic anomaly and within the tectonic target and corridor' (Woodall, 1994). It can be seen in Figure 7 that RDD 1 was not cited in the tectonic corridor as prescribed by the management, but about a kilometre south of it. The majority of the ore lies within the corridor, hence it was not until drilling moved to the north and within the lineament corridor that the real ore body was discovered in RDD 17 (Smith 1985).

The second drill hole was sited on the Acropolis target. This, along with the Wirrda Well deposit which lies to the east on the same WNW lineament, are smaller deposits.

The oxidised basalts that Haynes (1972) prescribed for his model were not found. The host rock is instead a huge body of hematite-rich breccias (Woodall, 1994) which are believed to be the source of the gravity anomaly. Regardless, the absence of oxidised basalts does not reflect on lineament tectonics as the tectonic targets do not require the presence of such lithologies. Such brecciated lithologies occur at lineament intersections shown in elsewhere in the region (eg. Mount Painter) as well as at Olympic Dam, hence, lineament intersections possibly are sites of fault brecciation.

THE DISCOVERY OF OTHER ORE BODIES

Further examples exist of ore deposits discovered on pre-recognised lineaments. The Century (Pb-Zn) deposit in northwest Queensland lies on a lineament target (Woodall 1992) which in 1974 was the highest ranked target on the Lawn Hill 1:4-mile map sheet of Carter and Opik (1960). Woodall (1991) has stated that ore deposits at Boddington, Plutonic and Kanowna Belle lay on previously defined lineaments and that such deposits were overlooked because Western Mining's Geologists 'failed to take Tim O'Driscoll's work seriously'.

LINEAMENT WORK SINCE OLYMPIC DAM

Since lineament tectonics successfully targeted Olympic Dam, Acropolis Wirrda Well which all lie on lineament intersections (O'Driscoll & Campbell 1997) it would reasonably be expected that lineament tectonics would have a prosperous future in exploration. Initially, the role of lineament tectonics in the Olympic Dam discovery was held confidential by Western Mining for two years following the discovery and it was not until after the geological and geophysical contributions had been made public that the first belated, detailed account of the lineament contribution was authorised and given in 1983. (O'Driscoll, 1983b).

Haynes (1979) acknowledged the role of lineaments in the exploration of Olympic Dam, stating 'one of the conceptual model exploration parameters was the requirement for lineament analysis as a target defining tool' and that drilling was made on the geophysical targets 'with a priority for drilling those targets associated with lineament-analysis targets.

Numerous misleading and untrue statements (some examples follow) led to various versions of the discovery history characteristically omitting any reference to lineament tectonics or the key publications of Lalor (1987), Woodall (1993, 1994) and O'Driscoll (1983b).

Rutter & Esdale (1985) explained that 'the process of ground elimination and target selection required the use of all the available geological and geophysical information' and go on to state that 'RD 2 was sited at Appendicitis Dam... using only regional gravity and airborne magnetics'. No mention of lineaments is made throughout this publication. It is also stated that 'the regional gravity and magnetic data provided the basis for the original study which located the site of RD 1'. This may explain why RD 1 was not located within the tectonic corridor and it does indicate a reluctance to acknowledge lineaments. Indeed Rutter (pers. comm.) stated that RD 1 was sited purely on geophysical information and that he personally placed the peg in the ground to site the hole.

Haynes (1996) and in an interview with The Independent Monthly, August 1991, makes no reference to the use of lineaments in the exploration discovery, stating '"what I found really interesting was that on the Stuart Shelf there were two gravity highs... one was at Mount Gunson and the other was at this place called Olympic Dam"... Haynes showed the map to Western Mining geophysicist Hugh Rutter, who compared it with the magnetic signature for the area'. This contradicts data in figures 4 and 6 which outlines Haynes' areas of interest south and east of Mount Gunson. Haynes emphasises that the discovery was a team effort, yet makes no mention of the lineament tectonic team led by O'Driscoll.

Other authors who were not in the exploration team for Olympic Dam do not publish the full extent to which lineaments were used in the discovery of Olympic Dam. For example, passing references to lineaments have been made by Reeve et al, (1990), Selby (1990), Smith (1985). None of these workers elaborates on the importance of the role of lineaments. Selby (1990) and Reeve et al, (1990), do not refer at all to the then available significant publications of Lalor (1987) or O'Driscoll (1983b). Selby published a paper in 1987 exclusively highlighting the regional tectonic work of Tim O'Driscoll: no mention is made of the actual application of lineaments in the Olympic Dam discovery. It must be assumed that he was not aware of this, otherwise it surely would have been the main point of his article.

Cox (pers comm.) stated that the Cox and Power (1997) report was instigated by Haynes of Western Mining Corporation, who was closely linked to setting the content of this work. One statement which was not included in the body of the report but added as a conclusion stated that 'some of the claims for the association of mineralisation with lineaments are apparently supported by judicious revision of targets as more data become available.'

This sentence directly follows criticism of three authors, including O'Driscoll. Similar allegations about O'Driscoll have previously been made, when it was claimed that he had moved his targets to take in ore not previously within. These allegations were subsequently categorically refuted by Woodall (1977).

The above data shows that few publications have acknowledged the true significance of O'Driscoll's tectonic contributions to the discovery of Olympic Dam and there has been little effective use of his lineament concepts as an exploration tool since the discovery of Olympic Dam. Given that deposits were overlooked and many remain untested by WMC and others, this would appear to be a miscarriage of opportunity. And as a result the applicability and success of the science of lineament tectonics continues to remain unknown to many explorers.

THE USE OF LINEAMENTS IN PETROLEUM PROVINCES

APPLYING THE LINEAMENT-ORE RELATIONSHIP TO PETROLEUM

Work has been done relating continental scale lineaments to basin controlling features (eg. O’Driscoll 1982, 1983a, Campbell & O’Driscoll 1989) however, the targeting techniques used for exploration of ore bodies has not been tested in petroleum provinces.

It is probable that the same lineament-ore association will not apply directly to petroleum accumulations. Lineaments at Olympic Dam are related to areas of intense brecciation, access to hydrothermal fluids and high heat flow. None of which are necessarily good for petroleum. Brecciation can result in leaking seals, secondary mineralisation associated with hydrothermal fluids can reduce porosity and high heat flow can overcook the hydrocarbons. Boucher (1995) showed that no hydrocarbon occur along the Fly Lake - Burruna lineament as possible example but instead are aligned on either side of the lineament. Traditionally, some authors have curiously tended to align economic occurrences and assume these were "lineaments". This may not necessarily be the case. Nevertheless, in immature areas, high heat flow may locally mature hydrocarbons and brecciation of tight reservoirs could give rise to localised fracture porosity.

FACIES DISTRIBUTIONS RELATED TO LINEAMENT STRUCTURES

It is not unreasonable to assume that lineaments will control facies distributions, just as any structure would. For example, late Carboniferous to Permian glacial movements in the Cooper Basin would be likely to exploit existing zones of weakness produced by the lineaments. Fluvial systems will be similarly influenced, for example where slight topographic changes may occur along lineaments (Fig. 8). In such cases, potential reservoirs may be offset from the lineament. This would result in parallel ‘shadow’ lineaments where facies alignments, fault alignments and petroleum alignments will be displaced from the mappable lineament seen in differing data.

DATA IN PETROLEUM TERRAINS

When studies of this nature have been undertaken in ‘hard rock’ provinces, the data are of a differing nature from those applied to petroleum provinces. ‘Basement’ is at or closer to the surface relative to petroleum terrains. Consequently, geological, aeromagnetic, gravity, air-photo, landsat, topographic etc. data can be more easily related to ‘basement’ features in ‘hard rock’ terrains. For the Cooper Basin area in particular, flat or near flat lying sediments have little geological expression. Instead, dune systems and ephemeral lakes dominate which typically have little relationship to the ‘basement’ several kilometres below. Similarly topographic, air-photos and landsat imagery do not show these features as obviously. The depths to ‘basement’ further result in loss of diagnostic magnetic and gravity signatures.

Petroleum provinces do have data that are unique, for example depth structure maps and reflection seismic which provide sources of data that are not particularly relevant to ‘hard rock’ regimes. Integration of these data with surrounding ‘hard rock’ data does assist in defining regional trends that transect petroleum basins.

DATA SOURCES

Essentially any mappable feature is useful for lineament analysis. In particular, data used in this study include (Appendix 1, Maps 2-30):

- Geological maps
- Aeromagnetic maps
- Gravity maps
- Depth structure maps
- Drainage maps
- Topographic maps
- Economic occurrence maps (petroleum and mineral distributions)

In addition, Departmental data not included in Appendix 1 include:

- Air-photos
- Interpretative geological and fault maps
- Landsat
- Earthquake epicentres

DATA PREPARATION

O'Driscoll's mapping techniques are certainly unique, as can be seen in any of his publications. Over several decades, O'Driscoll has refined map preparation to be of most use in assisting lineament viewing. Traditionally, this has meant the reduction of non-essential data, such as colour, shading, sun illumination, labels, symbols, survey boundaries, cultural features (roads, railways, towns etc.) and at times drainage which are distractions to the eye. In particular colour maps, which have become increasing popular for presentation of aeromagnetic, gravity and depth structure maps, are of limited use. The eye is typically attracted to broad expanses of colour, whereas lineaments tend to be related to regions of gradient changes. Coloured or grey scale vertical derivative maps, regardless, are of limited assistance in lineament interpretation. This could be due to problems of interpreting coloured or sun illuminated imagery, or simply a matter of not being trained and experienced in using these data.

As a general rule, data have to be reduced to an uncluttered black and white image. The best example of this is the use of contour maps (refer Appendix 1). These maps, in their simplest forms are the contours only, without colour or labels and no reference or cultural features aside from a grid and latitude/longitude labels outside the data area. A well known map of O'Driscoll's is the geological ingredient map which simply consists of all the geological boundaries replotted without any other data. Except for the grid and sheet boundaries, each data set (Appendix 1) is reduced to the bare minimum data only. This allows for easiest viewing. Data sets can then be combined for further investigation.

It is important to use an appropriate line thickness that can involve a degree of experimentation and is related to data density and map scale. Lines need to be very bold as thinner lines are not as easy to see, but not too thick to clutter the image. Good examples are the aeromagnetic images provided in Appendix 1. In the southeastern part of the image, data are too dense to be of use, where the contours are so closely spaced that the entire area is black. A differing larger scale needs to be used to free up these data. In contrast, the contours in the northern area are too sparse. Some of the areas in between are more suitable for lineament interpretation. At times it is useful to add differing data sets to area of sparse data to fill in the holes. Alternatively, each area can be contoured individually to maximise the data density.

When data are combined, it is particularly important to use appropriate line thickness to maximise its use. Ideally, no data should dominate and a balance needs to be found to that the eye can easily see both data types equally as well. This may require relatively heavier lines in sparse data to provide the balance.

DATA SCALES

It is important to jump from differing scales to interpret lineaments. Within any single data set, differing features become evident at differing scales. For example, discrete lineaments are more evident on large scale (enlargement of small area) maps, whereas corridors are more easily identified in small scale (reduction of large area) maps. Similarly it is important to utilise maps of differing scales and areas to relate features at differing scales.

DIGITAL DATA PREPARATION

Traditionally, O'Driscoll has prepared his data manually, mainly due to the development of the techniques prior to the availability of digital data. Much of the data used in this study already did exist in a digital format. It was decided to generate all data digitally to capitalise on this to save regenerating each data set manually. This further aims to reduce problems of differing map projections between data sets that can provide errors. Unfortunately, generating these data digitally took longer than anticipated and it was necessary to compile some manual data to continue the project. In particular, generating digital photo lineament data required a great deal of work and was a time consuming process. The high frequency photo lineaments (see below) had been mapped by June 1996, however it was not until June 1997 that they were all made digital. The photo lineaments were identified on uncontrolled 1:63 360 air photo mosaics. The process to make these data digital was lengthy and time consuming. At times, major discrepancies existed in the photo overlaps. It was necessary to produce a transparent Landsat overlay at the same scale to re-plot the data. The Landsat image was juxtaposed on the photo's and the linear features transposed to the overlay. The overlay had to be continually moved and rotated to fit the photos. At times it took three times as long to re-plot these data as is did to originally map them. Interestingly, it was common for the data to fall into alignment when re-plotted as they were offset accordingly with the photos. Finally these data were digitised. This process resulted in the data being handled three times. It is understandable, therefore that this process is lengthy considering almost 50 000 linear elements had been identified in the mosaics.

Of the remaining data, most was available digitally and was then reprocessed and plotted accordingly to the guidelines mentioned previously. See Appendix 2 for metadata descriptions.

LINEAMENT MAPPING METHODS

The majority of O'Driscoll's publications are related to continental scale lineaments. These are mapped in a differing manner to the ore defining lineaments. These methods have not been adequately covered in the literature, primarily because a great deal of insight, experience and practice is required to be able to map such features. Such lineament mapping techniques cannot easily be self-taught. In the final analysis, the resulting ore-targeting lineaments are similar if not the same as regional or continental lineaments. However, it is the initial detailed air-photo interpretations that are the critical process.

HIGH FREQUENCY PHOTO LINEAMENTS (HFPL)

High frequency photo lineaments are often colloquially known as 'chicken track' lineaments. These data are generated in a differing manner to the regional or continental scale low frequency lineaments (LFL) although HFPL are combined to assist generating them.

Almost 50 000 HFPL were generated for this project. It is important to note that an individual HFPL is not necessarily significant on it's own. It is the combination of all these features that are used to discriminate the final LFL. The process of mapping HFPL is an interpretation that aids the final interpretation and is not to be taken as a result in itself.

The process of mapping HFPL is an intensive and requires a great deal of insight and experience to master. Indeed, O'Driscoll recently found he required some practice before regaining his former skill. The first step involves recognising regional trends that entirely or in part transect the 1:63 360 scale air-photo mosaic. These trends are then 'sampled' by the HFPL. Fortuitously, quality control was enabled where either O'Driscoll or myself would recognise the trends, then swap mosaics and the HFPL were added. This was done to enable O'Driscoll to verify my recognition of these features and I was able to ensure I was identifying the correct features by analysing O'Driscoll features. The interpreted mosaics are held within the Department if any future interested person would like to follow up on this study and get an understanding of what features had been mapped.

A scale of 1:63 360 was used partly from tradition, but mainly because it best represents the best interpretative scale. At 1:100 000, detail is lost and 1:50 000 mosaics do not cover a large enough area to enable easy recognition of regional trends. In addition, mosaic availability determined which scale were used. 1:63 360 scale mosaics were available for the study area in the northern part of the state. The Andamooka and Torrens maps sheets had be similarly mapped at this scale in the 1970's. The Gairdner sheet was mapped from 1:100 000 scale mosaics and the Otway Basin utilised 1:50 000 scale mosaics.

The 1:63 360 scale mosaics were compiled in the early 1960's and the quality of the mosaics may not be as good as some of the more recent compilations. The age of the mosaics did prove to be useful in the Cooper Basin area where they pre-date almost all exploration. This meant no culture obscured interpretation or biased the interpretation by revealing where the fields were located.

The HFPL are on average 2 miles (3 km) long but range from 1 km up to 10 km in length. The 2 mile length was decided by O'Driscoll in the 1960's as a length relevant to the size of the ore body being sought.

It is important to note that not every identifiable feature within the mosaic has been added. Predominantly, the HFPL are designed to 'sample' the regional trend and are restricted to features along or in close proximity to that trend. These features were recognised predominantly as tonal contrasts within the photos. Stratigraphy was consciously repressed, primarily because it would be seen when the HFPL were overlain with the geological data. Randomly mapping HFPL will not necessarily bring out the regional trends of interest and tends to add noise which hinders later interpretation.

The necessity to be adequately trained in HFPL interpretation is evident in Figure 9. During the data collection of my PhD, I attempted an HFPL with effectively no training from O'Driscoll. I failed to recognise and highlight the regional features (Fig. 9a) subsequently mapped by O'Driscoll (Fig. 9b). This need for training has similarly been highlighted by the work of Lyle Burgess who was trained by O'Driscoll in the early 1970's. Burgess was trained in HFPL interpretation on the Cloncurry 1:250 000 map sheet. Initially he watched an interpretation being made by O'Driscoll and he then repeated the exercise. Burgess' data was then used to complete the final interpretation and select targets for drilling. None of these targets coincided with the subsequently found Earnest Henry deposit. O'Driscoll reverted to his own original HFPL data and pointed out a strong WNW corridor which contained mineralisation to the west where there was outcrop and an intersecting NNE orthogonal lineament. This lineament intersection could have picked the exact location. With more practice, Burgess moved to the Lawn Hill 1:250 000 map sheet and identified targets. His first priority target in 1974 was the location of the Century (Pb-Zn) deposit found over a decade later. Therefore, the necessity of practice in addition to training is highlighted.

The HFPL mapped by one author will not necessarily be the same as those mapped by another. This is not important as the dominant trends will inevitably be revealed on both interpretations in the final analysis. In this context, each individual HFPL is not necessarily important or a significant feature.

Given that HFPL are mainly designed to sample regional trends, it is still necessary to map all HFPL rather than focus on the regional trend by itself. The HFPL will highlight the width of the feature. HFPL will recognise zones of intensification where they are crossed by another feature. At times, these may not have been recognised and can then be added.

A duration of approximately 20 minutes has estimated to best represent the time taken for an interpretation of a 1:63 360 scale mosaic. Any less than this will mean the mosaic is not adequately covered and features are likely to be overlooked. Any more than this will mean that the data become too dense. A mistake is to continually add HFPL. There are always more to be found. It has to be remembered, that it is the regional trends that are being mapped and once these are covered the interpretation must be considered complete. Once the feature has been mapped, it is common to 'identify' another one parallel and adjacent to it. Restraint is needed not to overvalue this as if it were dominant in the initial interpretation, it should have been identified.

A skill I was never able to master was to identify HFPL that were not parallel to the regional trend. Typically, I would only map HFPL parallel to the feature of interest and failed to identify HFPL of differing azimuths. This does not necessarily mean the final interpretation will differ. However, some cross cutting features may not be emphasised as strongly as they otherwise should be. It is not difficult therefore, to distinguish my interpretations from O'Driscoll's who has HFPL of all orientations, whereas mine are 'anisotropic'.

Circumstantial evidence to suggest that the HFPL trends are real can be seen when interpretations are mosaiced together. Each sheet was mapped independently of the next. When trends align across two or more sheets, then they must be considered to be real. If a trend does not continue onto an adjacent sheet, then either the feature does not exist and instead was an unrealistic alignment within the data, or it had not been recognised on the adjacent sheet. A second pass is then made to establish if things had been missed. Such occurrences are relatively common on sheet corners where insufficient data are available to justify including the feature without the supporting data. It was rare, however, to add a feature which passed through the centre of a sheet.

COMBINING HFPL S WITH OTHER DATA TO PRODUCE LFL S

VIEWING LINEAMENTS

It is important, when extracting lineaments to look for the appropriate features and more importantly to view the data in the correct manner. Knowing exactly what features to look for comes only with an insight into the science and a great deal of practice. Basically, lineaments are seen either as pattern breaks within the data, or as broader zones of either intense or negligible data (lineament corridors). Corridors, in particular are not easily identifiable unless they are specifically searched for. It is essential to view data at a low angle to the page to enable the lineaments to become obvious.

An example from the study is provided in Figures 10. The necessity of correct data preparation is evident within these examples. If any distractive data remained in these examples, the pattern breaks would not be evident. Figure 10 is a WNW trending lineament seen in a combination of aeromagnetic and HFPL data.

DATA COMBINATIONS

As shown in Figure 10, lineaments are most easily extracted and verified by combining data. This is particularly true when data density varies. Figure 10, for example, shows the data density varies form being dominated by aeromagnetic data to the east and HFPL data to the west. It can be seen in Appendix 1, however, that the lineament shown in Figure 10 cannot be easily seen in HFPL or TMI data alone and certainly cannot be seen in the greyscale TMI. It would be difficult to pick the lineament without combining the data (Fig. 10).

Of the twenty-one versions of the nine sets of data used in this project, millions of data combinations using two data sets could be interpreted. Triple data set combinations typically become too cluttered to be of use, but any use of these will significantly add to the available combinations. With HFPL as the primary data source, their combination with the remaining data sets was integral to the project. Similarly, aeromagnetic and economic occurrence maps are integral data sources which are intensively used in combination with other data. Some combinations, for example gravity with aeromagnetics, have been found in the past to be of little use.

ALIGNMENTS AND LINEAMENTS

As previously mentioned, the human eye is especially good at picking linear elements out of random data. Regardless, the first step in identifying lineaments is to recognise linear elements within the data. At this stage, these features are termed alignments. An alignment does not become a lineament until it is verified in other data to have significance to the geology of the area. In this context, all lineaments are alignments, but not all alignments are lineaments.

VERIFYING ALIGNMENTS

To determine the geological significance of an alignment, an investigation of the features along that alignment are undertaken. The first step in this is to filter random alignments by establishing the alignments strength in differing data. Alignments that are represented in various data sets are more likely to be significant than those only seen in a single data set. The majority of the alignments recognised in several map sets need no more verification to justify their existence. The remainder may require significantly more work. However, if an alignment cannot be recognised in multiple data, it most likely does not exist or is not significant. Alternatively, the data may be poor or sparse.

It is a lengthy and relatively unproductive process to verify alignments. It takes a considerable amount of time to translate an alignment to differing data. For this project, twenty versions of data were compared with the original in addition to combinations at differing data scales and for differing data areas. It can take several hours to verify an alignment as a lineament. In the final analysis, the line plotted as the alignment, after several hours of scrutiny, remains as a line albeit with the term lineament awarded to it. This is not a psychologically rewarding process, where weeks of work will result in a map that looks little different to the original.

DANGERS IN USING ECONOMIC OCCURRENCES TO VERIFY LINEAMENTS

Traditionally, an author wishing to justify their work has related economic occurrences to lineaments. It is difficult to prove any lineament exists; they cannot be assayed or thin sectioned. Often, the lineament is purely in the eye of the beholder and it can be difficult to justify on faith alone. Authors commonly justify their work by relating the lineaments to economic occurrences, for this is the ultimate way to prove their significance. It is rare to find a lineament publication that does not include correlations with economic occurrences. The conclusions drawn from this are that lineaments are of profound significance, yet enigmatic.

Once an author defines a lineament-economic occurrence relationship, they will feel obliged to account for all occurrences in the area. This leads to an over-interpretation of the data where lineaments are added to account for all occurrences. Others are excluded if they do not coincide with an economically significant feature. Yet these may be of utmost importance. And it has been explained earlier that occurrences may occur alongside the lineament and not actually on it. In this context, an author may add a lineament to account for the economic occurrences and leave out the real one. It is therefore extremely important to honour the data and only plot the lineaments as they are seen. Regardless, it is difficult to overlook a weak trend that coincides with an economic occurrence.

RANKING LINEAMENTS AND CRITERIA FOR TARGET SELECTION

It is important to note that not all lineaments are the same and that a heirachy exists. From empirical studies, O'Driscoll (1972) outlined a paradigm for target selection (Fig. 11). It was statistically determined that ore bodies tend to lie on west-northwest (Tethyan) lineaments, in particular lineament corridors. The most prospective portions of the WNW lineaments occur when intersected by an NNE orthogonal trend. It was determined that ore bodies in Western Australia lay within 2.5 miles of such lineament intersections and a tectonic target of this radius was drawn around prospective lineaments to reflect this. It should be noted that the entire area within the target circle is not the target area, the target area is the portion of the WNW lineament encompassed by the tectonic target, in particular to the west of the intersecting orthogonal.

The targeting paradigm was developed to assist nickel exploration in Western Australia. Here, host rocks (ultramafics) have recognisable aeromagnetic signatures. One of the key criteria, therefore, was to have a favourable host rock at the lineament intersection, in particular where known nickel occurred elsewhere along strike. Prospective lineament intersections occurred where these host rocks displayed evidence of sinistral deflections - known as a Tethyan Twist. This signature has been recognised elsewhere in Australia and around the world (eg. O'Driscoll 1982, 1984, 1986, 1990).

Finally, lineament targets would ideally have an additional intersecting ENE lineament. This, in theory represents the propagation of an ENE trending extensional fault initiated from sinistral movement along a WNW lineament. Similarly, such movements would produce folding in a NNW direction.

CONCLUSION AND RECOMMENDATIONS FOR FUTURE WORK

The lineament mapping methods used to define the Olympic Dam and several other ore bodies has been applied to the eastern South Australia area.

This project was still uncompleted when the author resigned from the Department and final interpretations are not complete. Investigations focussed on the Cooper Basin area to relate petroleum distribution to the lineaments are continuing and will comprise a separate report.

ACKNOWLEDGEMENTS

This project would not have been possible if it were not for the assistance of many people. Firstly to Bob Laws for providing the authority and encouragement to undertake the study. Dragan Ivic dedicated months to preparing and producing data. Sam Harvey and drafting staff digitised the HFPL data.

REFERENCES

Bell, T. H., 1981. Foliation development - the contribution, geometry and significance of progressive, bulk, inhomogeneous shortening. *Tectonophysics.* 75:273-296.

Boucher, R. K., 1995. Some examples of lineaments from the Cooper and Eromanga Basins in South Australia and their relevance to hydrocarbon occurrences. *PESA Journal*. 23:69-75.

Campbell, I. B. & O'Driscoll, E. S. T., 1989. Lineament- Hydrocarbon Associations in the Cooper and Eromanga Basins. In: O'Neil, B. J, (ed.) The Cooper and Eromanga Basins, Australia. *Proceedings of the Petroleum Exploration Society of Australia, Society of Petroleum Engineers, Australian Society of Exploration Geophysicists (S.A. Branches), Adelaide*. pp295-313.

Carter, E. K. & Opik, A. A., 1968. LAWN HILL map sheet. *BMR Geology and Geophysics. Geological Atlas 1:253,440 Series,* sheet SE54-9

Cox, S. J. D. & Power. W. L., 1997. Significance of linear tectonic features in the Australian continent. *Australian Geodynamics Cooperative Research Centre.* Project 3001MO Report.

Haynes, D. W., 1972. Geochemistry of altered basalts and associated copper deposits. *Australian National University. Ph.D. thesis.* (Unpublished).

Haynes, D. W., 1979. Geological technology in mineral resource exploration. *In:* Kelsall, D. F. & Woodcock, J. T. (eds). *Mineral resources of Australia.* Australian Academy of Technological Sciences. 73-95.

Haynes, D. W., 1996. Proterozoic copper deposits: the discovery of the Olympic Dam and the Nifty copper deposits. *In:* 13th Australian Geological Convention, Canberra 1996. *Geological Society of Australia. Abstracts,* 41:185.

Hodgson, R. A., 1974. Review of significant early studies in lineament tectonics. *In:* Hodgson, R. A., Gay, S. P. & Benjamins, J. Y. (eds.) *Proceedings of the first international conference on the new basement tectonics.* Utah Geological Association Publication 5:1-10.

Johnson, J. P. & Cross, K. C., 1991. Geochronological an Sm-Nd isotopic constraints on the genesis of the Olympic Dam Cu-U-Au-Ag deposit, South Australia. *In:* Pagel & Leroy (eds), *Source, Transport and Deposition of Metals.* Balkema.

Lalor, J. H., 1986. The Olympic Dam discovery. *Western Mining Corporation Limited. Report*. K/2972. Unpublished.

Lalor, J. H., 1987. The Olympic Dam Copper-Uranium-Gold deposit, South Australia. *In:* Horn, M. K. (Ed.) Transactions of the fourth circum-Pacific energy and mineral resources conference. pp. 561-567. *The Circum-Pacific Council for Energy and Mineral Resources.*

O'Driscoll, E. S. T., 1972. Area selection based on lineament studies. Memorandum to R. H. Mazzucchelli, 18-10-72. Western Mining Corporation Ltd, Exploration Division.

O'Driscoll, E. S. T., 1982. Patterns of Discovery - The Challenge for Innovative Thinking. *PESA Journal* 1:11-31.

O'Driscoll, E. S. T., 1983a. Deep Tectonic Foundations of the Eromanga Basin. *APEA Journal* 23(1):5-17.

O'Driscoll, E. S. T., 1983b. Broken Hill at the cross roads. *Australasian Institute of Mining and Metallurgy, Conference series 12.* p.29-47.

O'Driscoll, E. S. T., 1984. Structural signatures to mineralisation. *Geological Society of Australia, Abstract Series 11.* p.38-41.

O'Driscoll, E. S. T., 1985. The application of lineament tectonics in the discovery of Olympic Dam Cu-Au-U deposit at Roxby Downs, South Australia. *Global Tectonics and Metallogeny.* 3(1):43-57.

O'Driscoll, E. S. T., 1986. Observations of the lineament-ore relation. *Philosophical Transactions of the Royal Society of London.* A317:195-218.

O'Driscoll, E. S. T., 1988. Lineament tectonics in ore search, with examples including Olympic Dam. *Notes for Australian Mineral Foundation course 563/88.*

O'Driscoll 1990. Lineament tectonics of Australian ore deposits. *In:* Hughes, F. E. (Ed.), Geology of the mineral deposits of Australia and Papua New Guinea. *Australiasian Institute of Mining and Metallurgy.*

Reeve, J. S., Cross, K. C., Smith, R. N. & Oreskes, N., 1990. Olympic Dam Cooper-Uranium-Gold-Silver deposit. *In:* Hughes, F. E. (ed.) *Geology of the mineral deposits of Australia and Papua New Guinea.* Australian Institute of Mining and Metallurgy. 1009-1035.

Rutter, H. & Esdale, D. J., 1985. The geophysics of the Olympic Dam discovery. *Exploration Geophysics.* 16(2/3):273-276.

Selby, J., 1987. Patterns in the crust: a key to ore discovery. *Geology Today.* 160-164.

Selby, J., 1991. Olympic Dam: A giant Australian ore deposit. *Geology Today.* 24-27.

Smith, R. J., 1985. Geophysics in Australian mineral exploration. *Geophysics* 50(12): 2637-2665.

Wise, D. U., 1989. Linesmanship and the practice of linear geo-art. Geological Society of America Bulletin. 93:886-888.

Woodall, R. W., 1977. Written communication to E. S. T O'Driscoll, 13 June 1977.

Woodall, R. W., 1984. Success in mineral exploration: A matter of confidence. *Geoscience Canada.* 11(1):41-46.

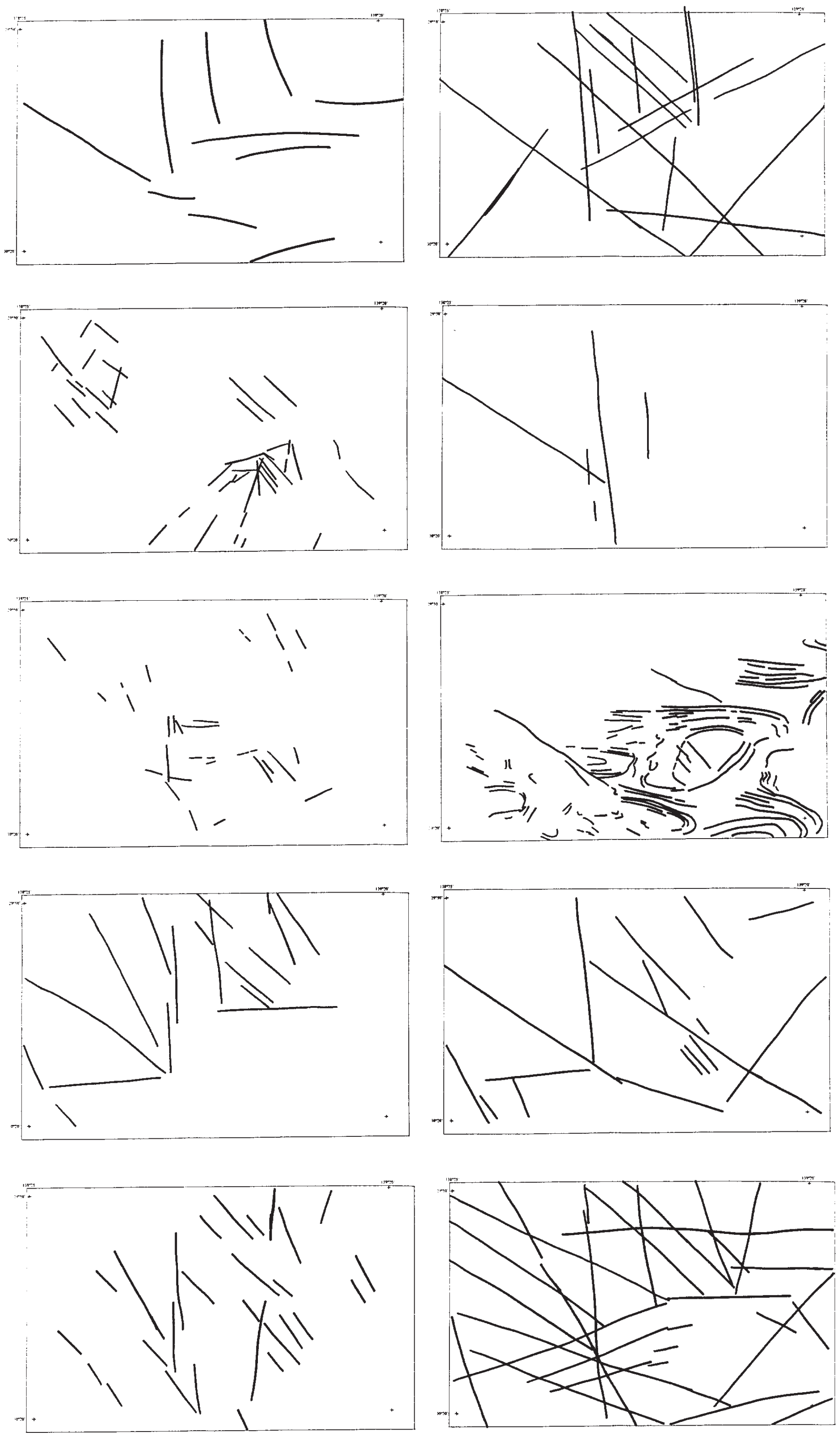
Woodall, R., 1991. WMC's Australian mineral exploration: Yesterday, today and tomorrow. *Western Australian Geoscientific Technical Conference.*

Woodall, R., 1992. Empiricism and concept in successful exploration. *11th Australian Geological Convention. Geological Society of Australia Abstracts.* 32:49-51.

Woodall, R. W., 1993. The multidisciplanary team approach to succesful mineral exploration. *Society of Economic Geologists Newsletter.* 14:1-6.

Woodall, R. W., 1994. Empiricism and concept in successful mineral exploration. *Australian Journal of Earth Sciences.* 41(1):1-10.

Woodall, R. W., 1995. Written communication to P. Mazzoni, 5 September, 1995.



98-0084

Fig. 1 *'Lineaments' produced by MESA staff. See text for details.*

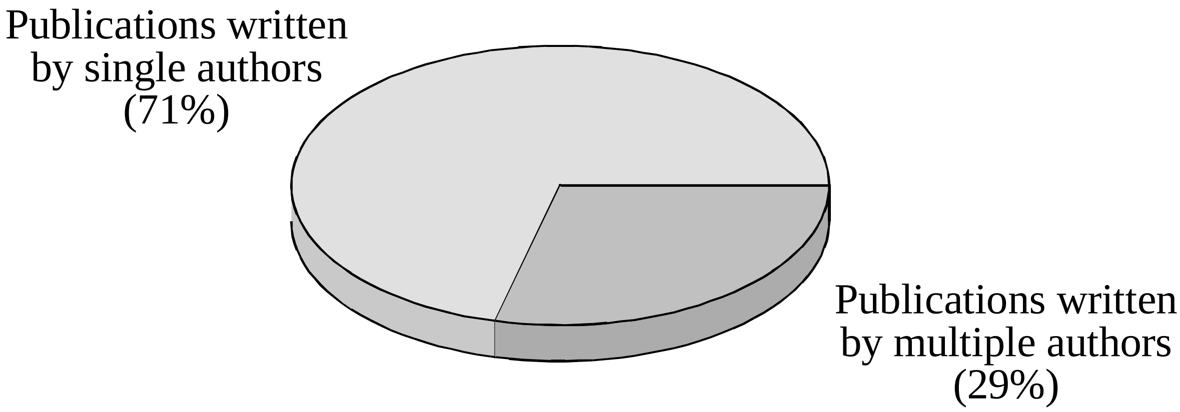


Fig. 2a *Comparison between the number of authors contributing to each lineament publication. The data is from almost 1,000 publications and indicates a reluctance for authors to work together and presumably to further the work of others.*

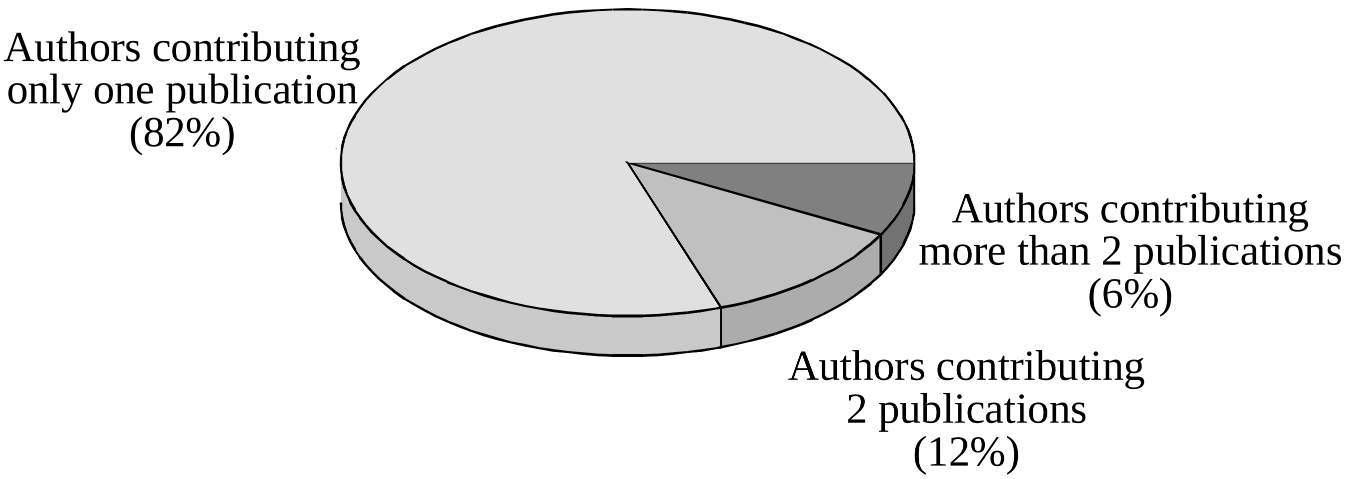


Fig. 2b *Pie graph indicating the number of authors who have contributed to one or multiple publications on lineaments. This graph indicates that few authors are either able or willing to continue lineament studies and therefore few experts have emerged.*

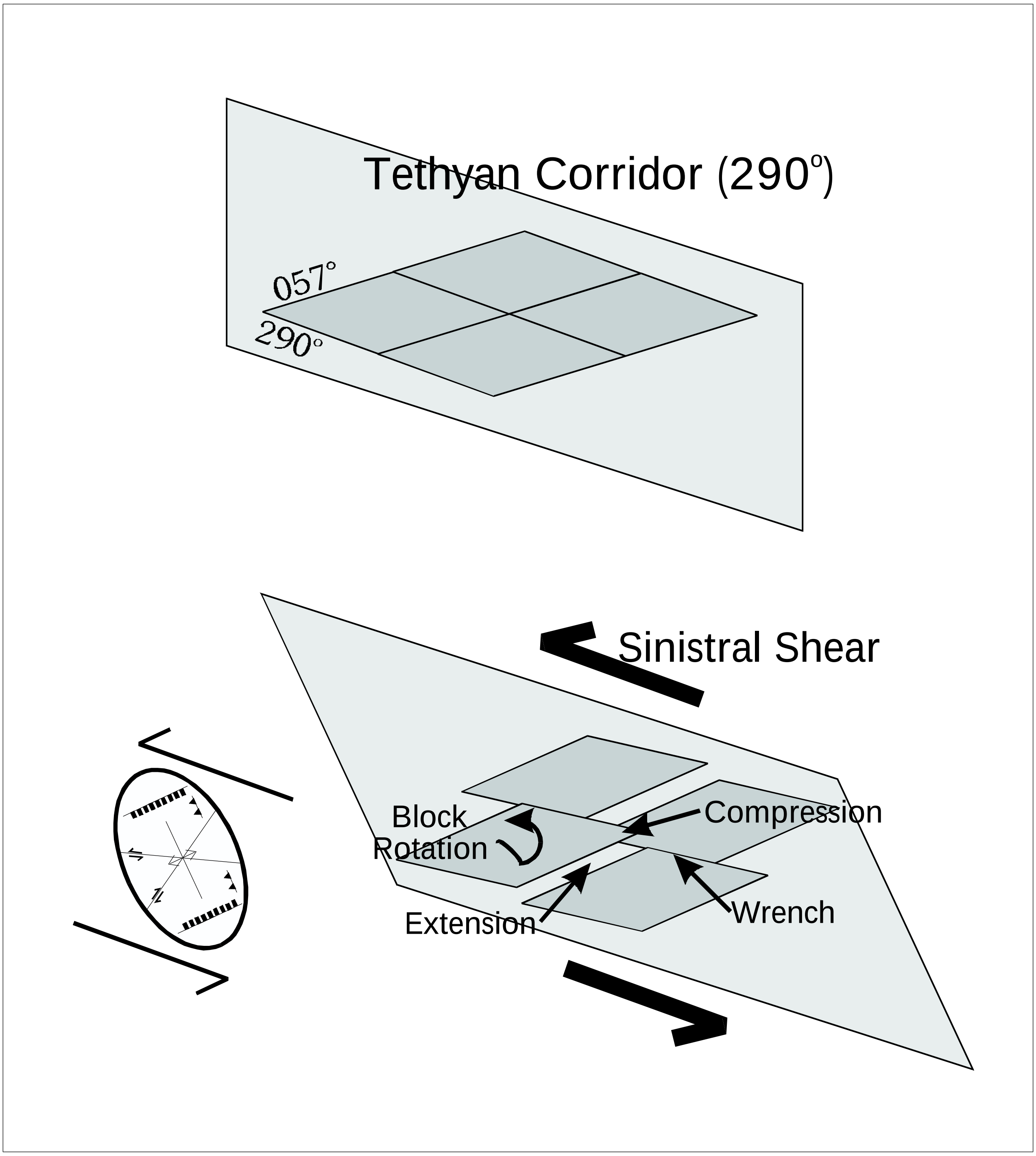


Figure 3. Example of simple shearing.

98-008

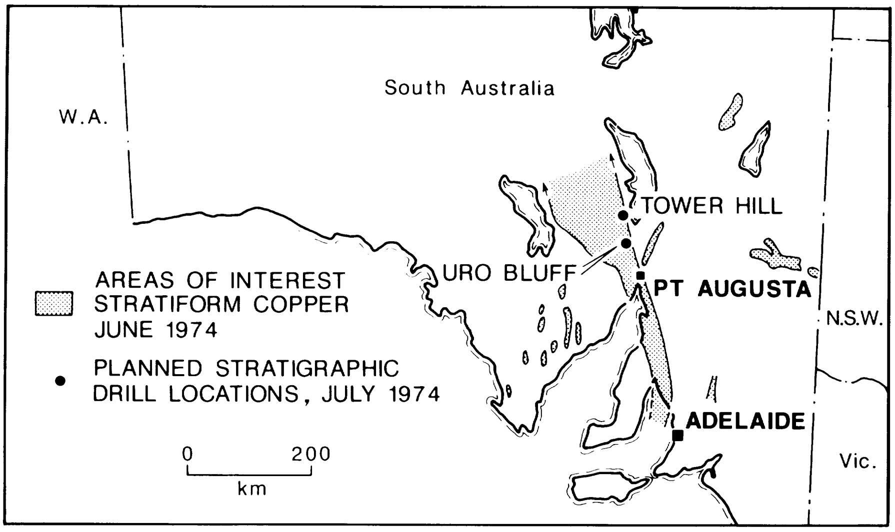


Figure 4a. The geological environment (Woodall 1994) which does not extend as far northward as that given in Figure 4b.

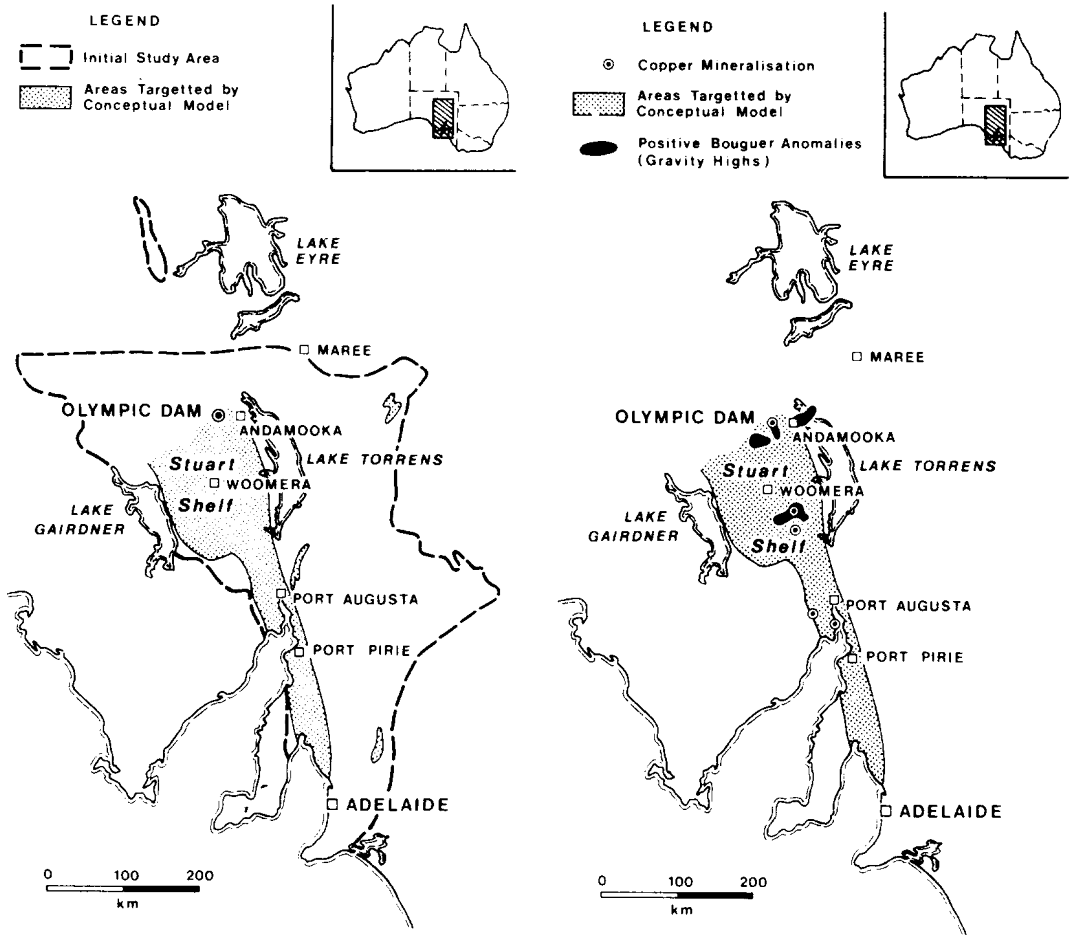
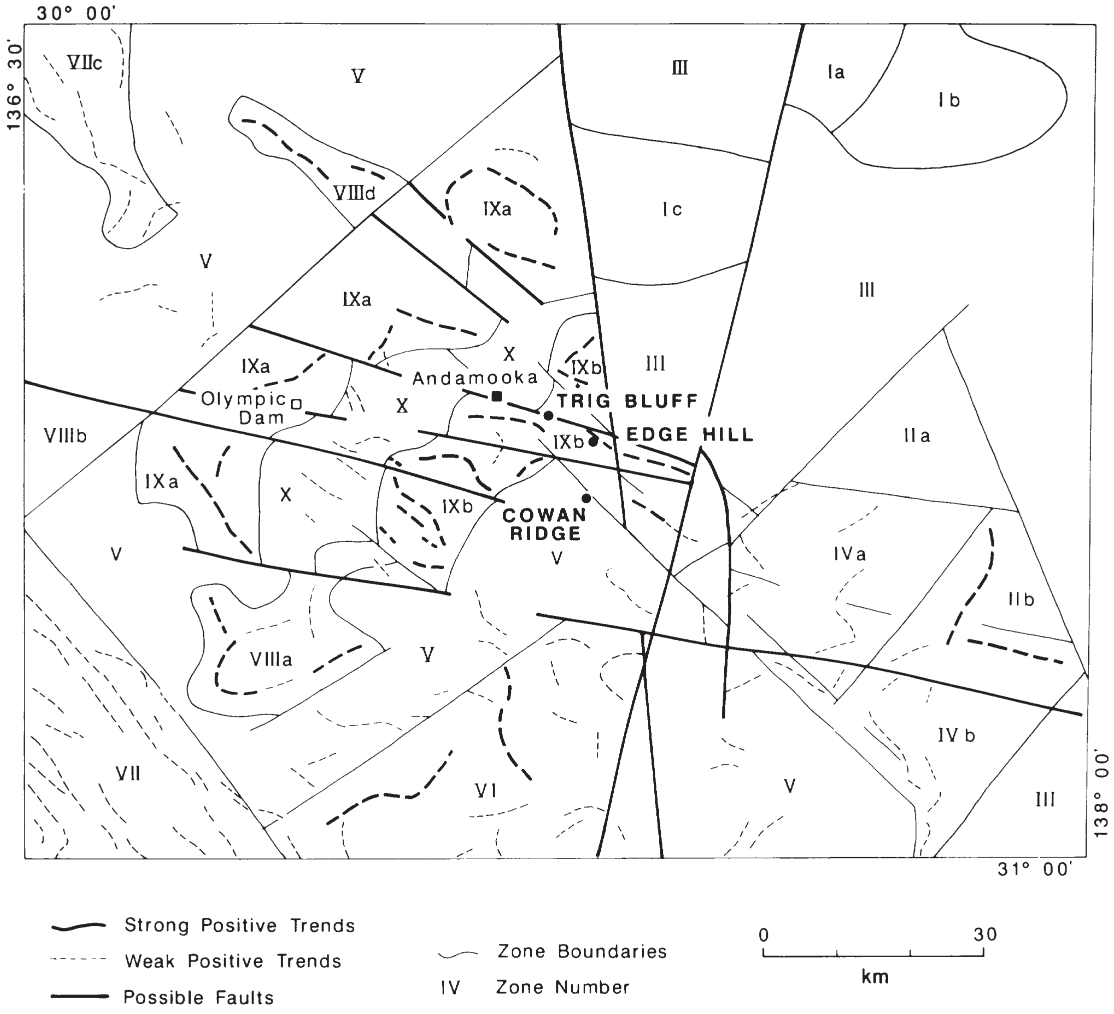


Figure 4b. The geological environment recommended for stratigraphic drilling during the exploration of Olympic Dam (Haynes 1979). In this figure, the stippled area extends to cover the Olympic Dam deposit.


30° 00'
136° 30'
VIIc
V
III
Ia
Ib
VIIId
IXa
Ic
V
III
IXa
X
IXb
III
IXa
Andamooka
Olympic Dam
X
TRIG BLUFF
VIIIb
IXb
EDGE HILL
IIa
IXa
X
IXb
COWAN RIDGE
V
V
IVa
IIb
VIIIa
V
IV b
VII
VI
V
III
138° 00'
31° 00'
Strong Positive Trends
Weak Positive Trends
Possible Faults
Zone Boundaries
IV Zone Number
0
30
km

98-0088

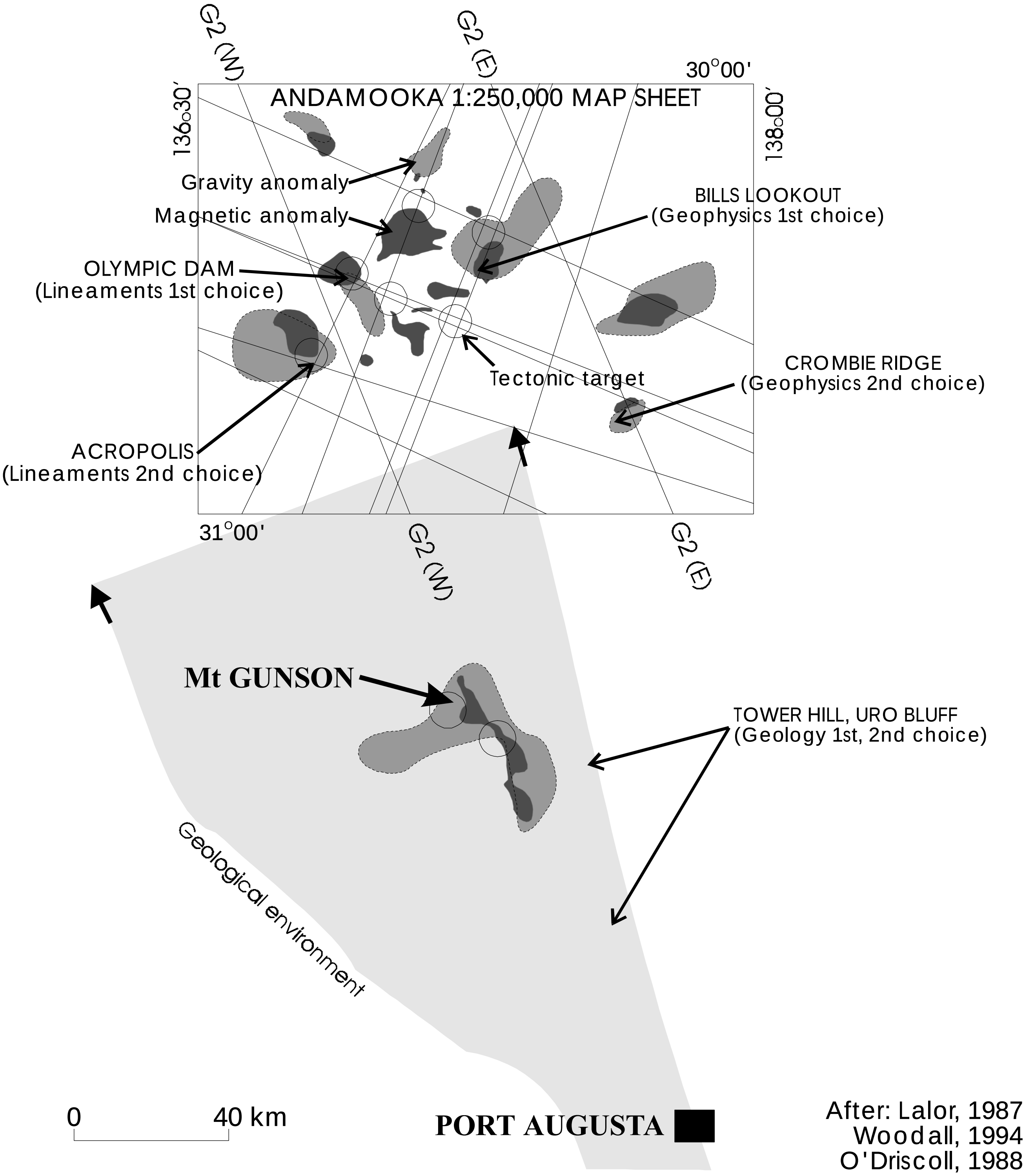


Figure 6. Geological, geophysical and lineament tectonic elements used to define the location of drilling targets which led to the discovery of the Olympic Dam deposit. The geological environment defined areas likely to contain a sedimentary hosted, basalt sourced copper deposit (Haynes 1979). Geophysical anomalies were to define areas representing the basalt model. Six of the eleven tectonic targets on the Andamooka 1:250,000 map sheet are from Lalor (1987). Tectonic targets were based on an earlier paradigm (O'Driscoll 1972) and similar structural signatures at Mt. Gunson. The top two elements from each discipline are given (after O'Driscoll 1988). Siting of the first drillhole was chosen where maximum overlap occurred between all three disciplines. Despite being outside the geological environment, the entire Stuart Shelf (Fig. 4) was considered favourable. Three areas existed where gravity, magnetics and lineament targets coincided within the Stuart Shelf: at Olympic Dam, Acropolis and a small area at Bills Lookout. The site of the first drill hole was chosen at Olympic Dam where the maximum overlap occurred, and the second at Acropolis.

98-0089

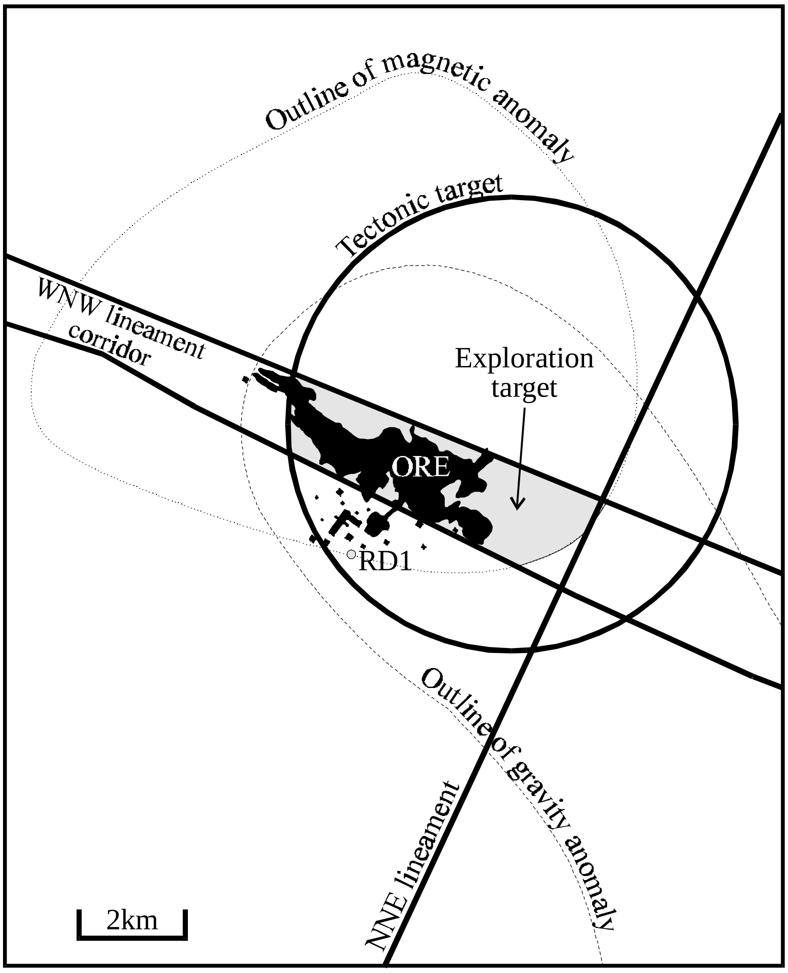


Figure 7. Location of the Olympic Dam orebody within the gravity and magnetic anomalies and lineament tectonic target (after O'Driscoll 1982, in prep.). The tectonic target was to define the portion of the WNW lineament corridor considered most favourable. The exploration target, therefore, was the area over overlap between the gravity and magnetic anomalies and in the lineament corridor within the tectonic target. The first drillhole (RD1), however, was not sited in this exploration target. If it were, the main body of the ore would almost certainly have been drilled. Instead, RD1 almost missed the orebody entirely.

98-0090

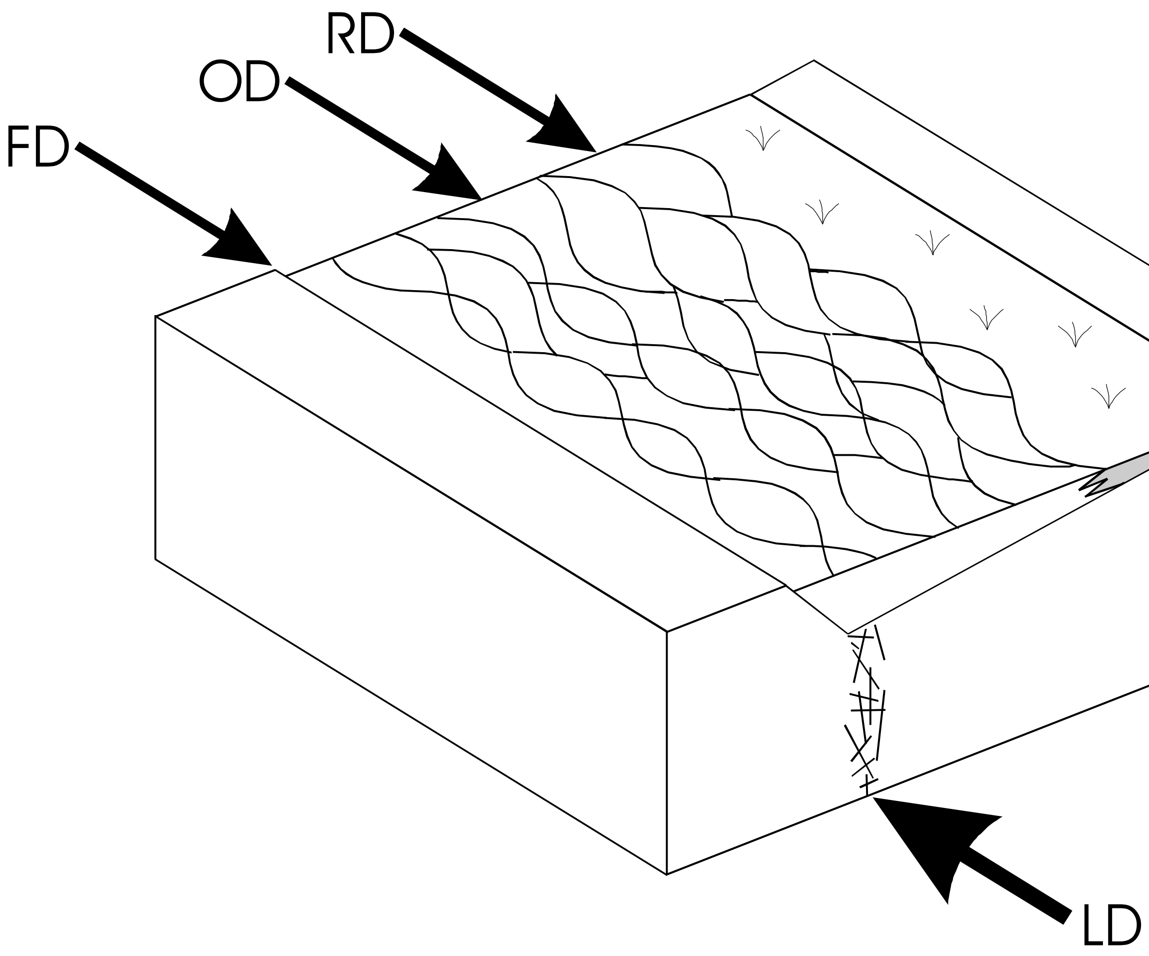


Figure 8. Schematic diagram showing that alignments may not necessarily coincide with a lineament (LD). Features shown include facies (rock) discontinuity (RD), a potential oil field alignment (OD) and a fault zone (FD)

98-009

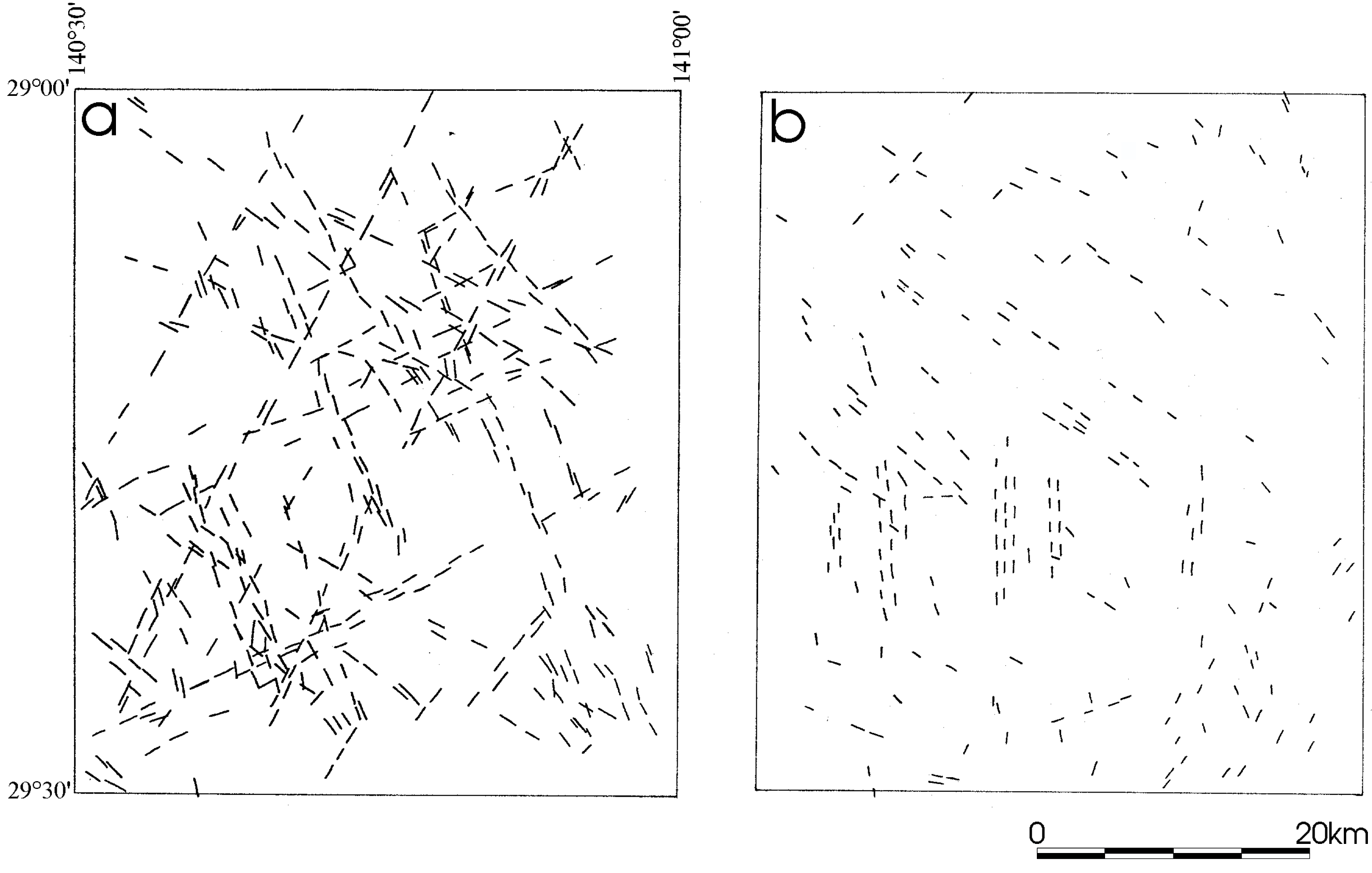
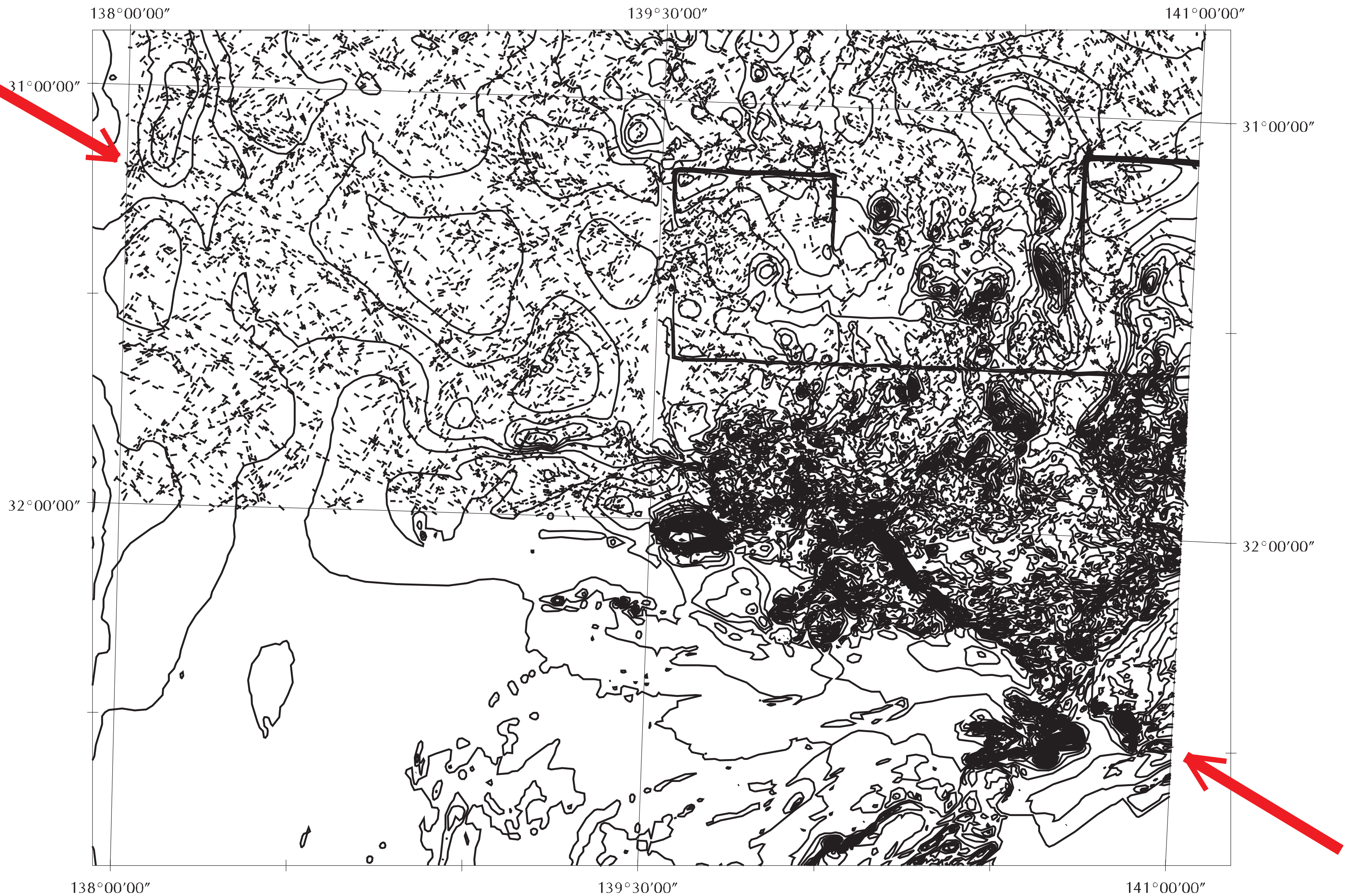


Figure 9. Comparison of HFPL for the Burruna 1:100,000 map sheet area mapped E. S. T. O'Driscoll (Fig. 9a) and those done by R. Boucher (Fig. 9b).

98-0092

Lineament Tectonics - South Australia

High Frequency Photo Lineaments + TMI (200nT contours)



Authors: E.S.T O'Driscoll & R.K. Boucher

MINES and ENERGY RESOURCES

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources
For further information contact MESA on (08) 8274 7500

SCALE 1:1500000

10 0 10 20 30 40 50

KILOMETERS

Fig 10: WNW trending lineament seen in HFPL and aeromagnetic data

98-0093

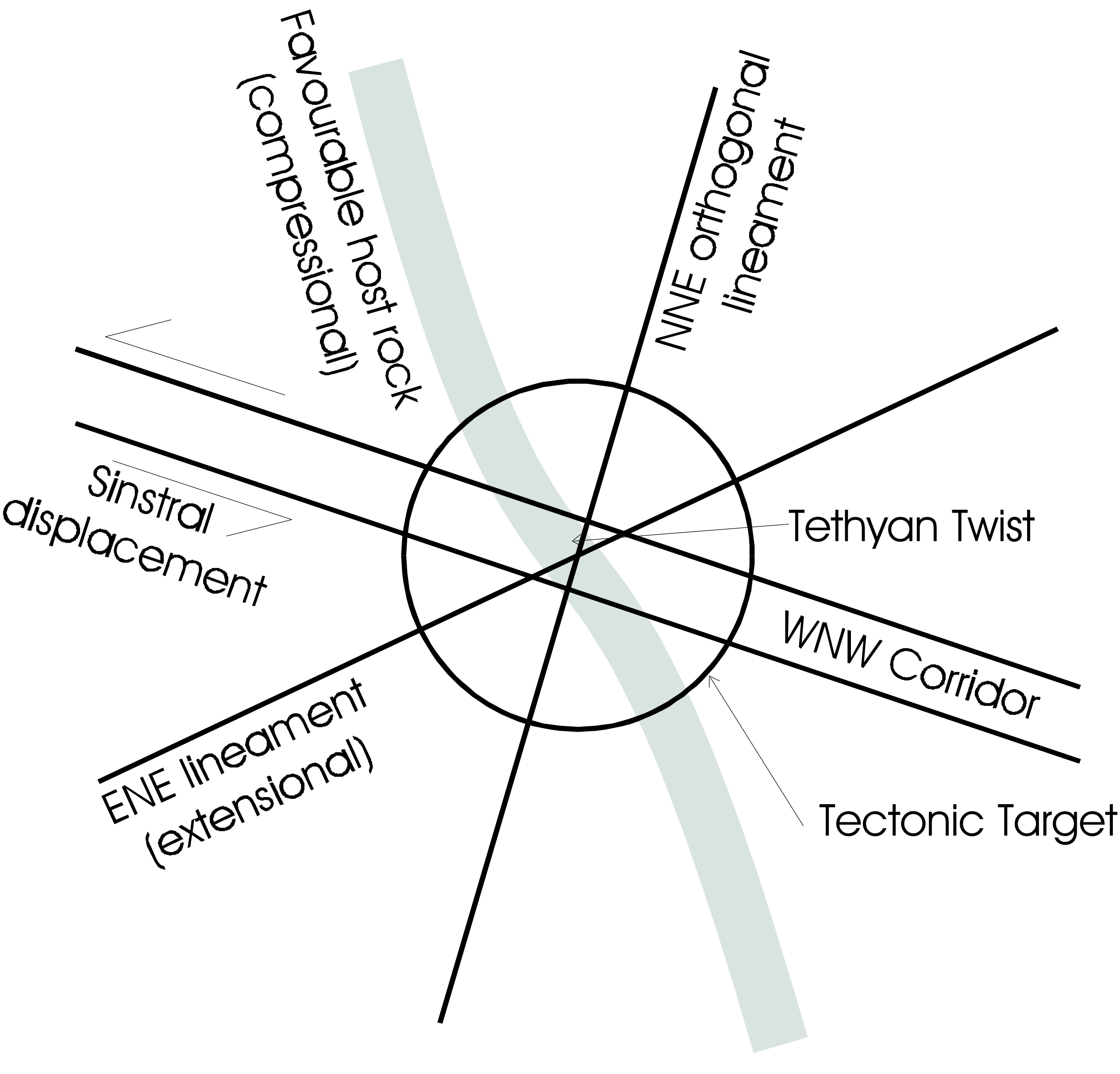


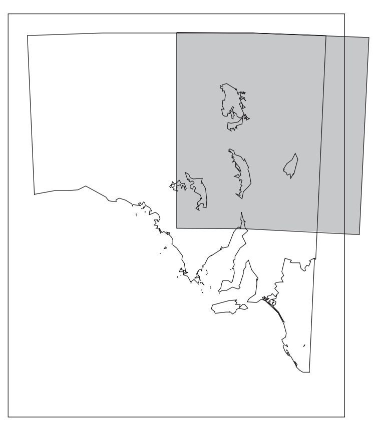
Figure 11. Paradigm for lineament targeting (after O'Driscoll 1972) developed for nickel exploration in Western Australia. A favourable nickel host rock displaying sinistral deflection (Tethyan Twist) is required where it is intersected by a WNW lineament or lineament corridor. Targets required an intersecting NNE trending orthogonal lineament and preferably an ENE trending lineament. Sinistral movement on the WNW lineament will theoretically produce compression in the host rock and extension at approximately 45 degrees to the corridor which can be exploited. A radius of 2.5 miles for the tectonic target was used as it was determined ore bodies in the area lay within this distance from the lineament intersection. It should be noted that the actual target area is the portion of the WNW lineament within the tectonic target and not the entire area within the circle.

98-0094

APPENDIX 1

Lineament Tectonics - South Australia

1:250,000 map sheet reference



Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200
KILOMETERS

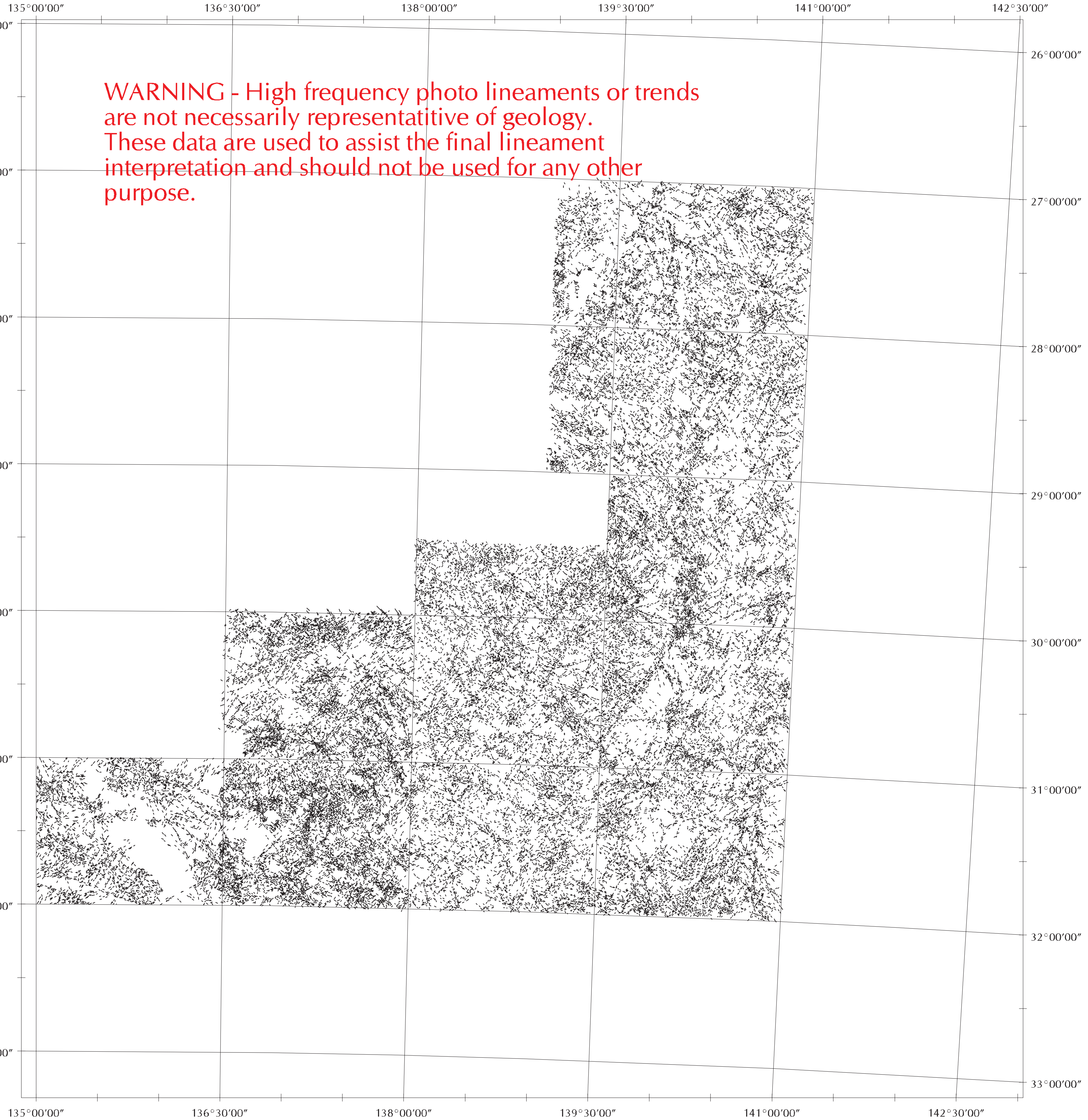
MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Department of Mines and Energy Resources,
South Australia, 1997

Map 1
98-0054

Lineament Tectonics - South Australia

High Frequency Photo Lineaments



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200

KILOMETERS

High Frequency Photo Lineaments interpreted by E.S.T O'Driscoll and R.K.Boucher from 1:63,360 air photo mosaics, and geo-referenced using RGB:542 Landsat TM imagery plotted at 1:63,360.

Produced from Arcinfo databases by Dragan Ivic, Petroleum Geophysics

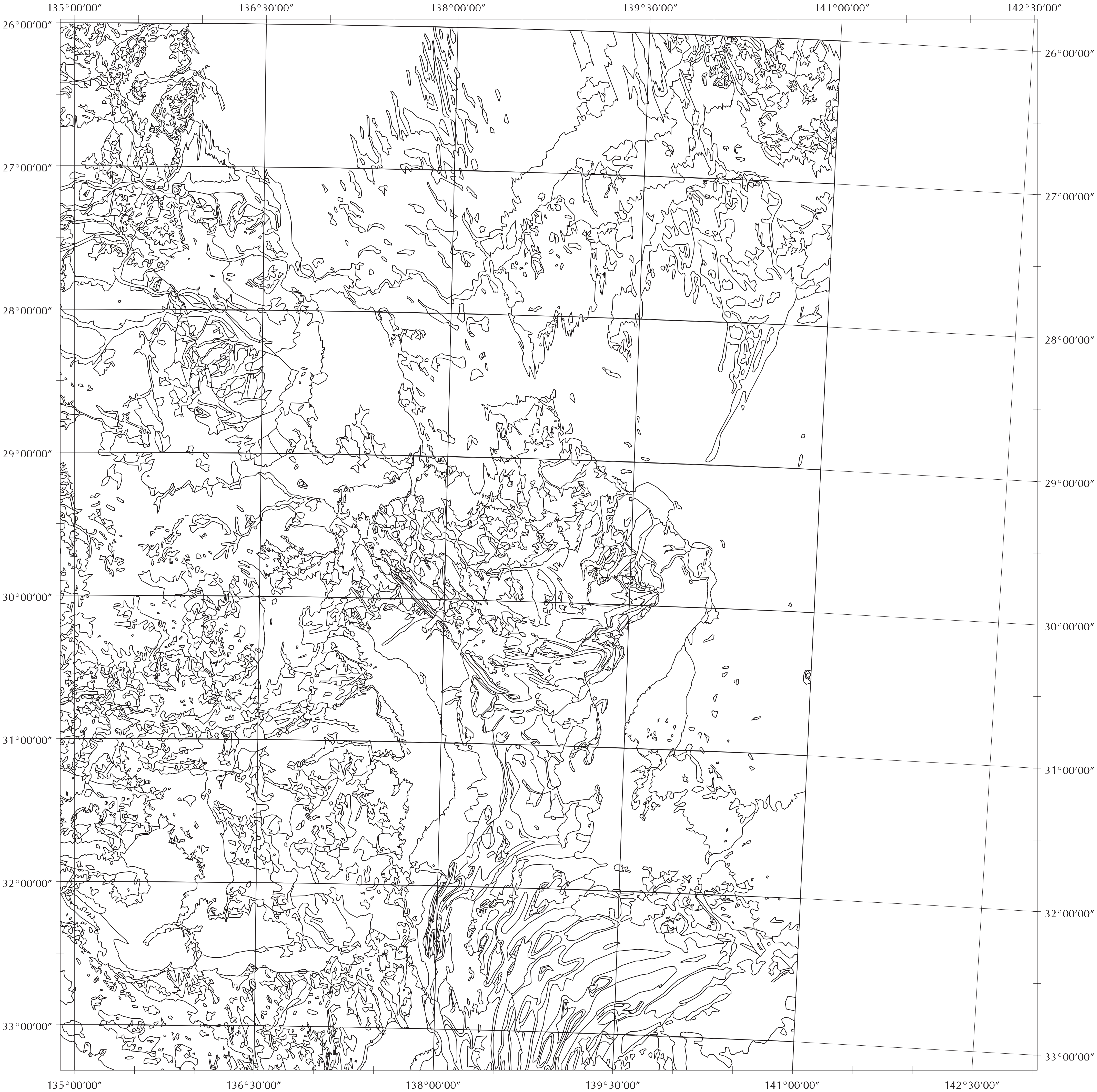
Plotted July 1997

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Map 2
98-0055

Lineament Tectonics - South Australia

Generalised Geology



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200

KILOMETERS

Generalised (1:1M) Geological Boundries derived from MESA's PC based ArcView GIS dataset.

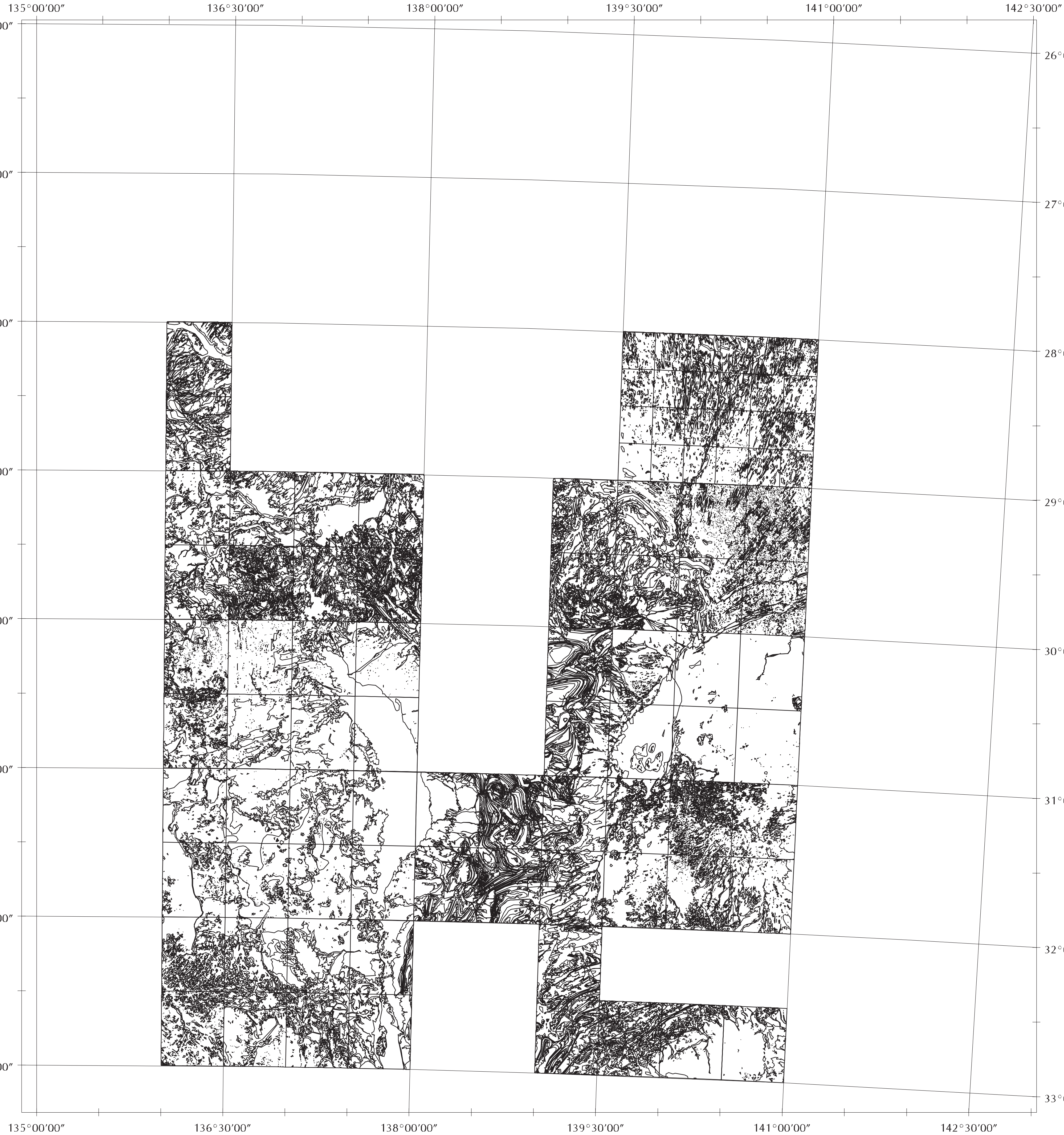
Plotted July 1997

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Map 3
98-0056

Lineament Tectonics - South Australia

Detailed Geology



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200
KILOMETERS

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

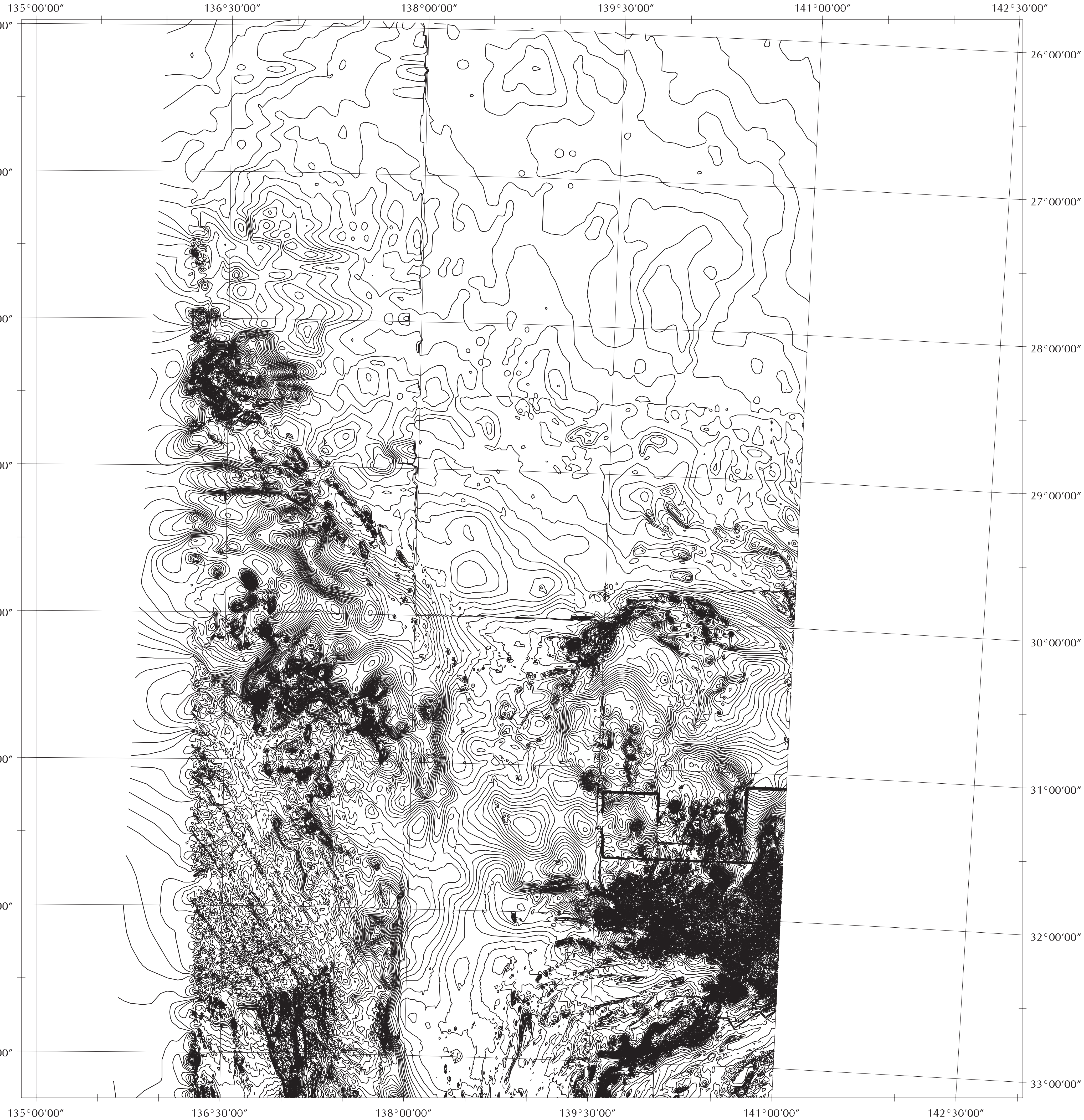
100K Geological Boundaries derived from the SA-Geology database.

Plotted July 1997

Map 4
98-0057

Lineament Tectonics - South Australia

TMI - 50nT contours



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200
KILOMETERS

Total Magnetic Intensity contour interval = 50 nTesla.
Data gridded using 200m x 200m mesh.
The data range displayed is -2359 to 6970 nTesla.
This merged TMI data was sourced from Mineral Geophysics Section, Mineral Provinces Division, MESA, for the Petroleum Geology Section, Petroleum Division, MESA.
It has been compiled from a number of sources, including MESA South Australian Exploration Initiative data, AGSO and MESA Broken Hill Initiative data, and open-file company surveys.

The data exhibits gaps and levelling errors. Interpretations of this data should be made with due diligence.

Airborne survey paramaters:
Line spacing 100m - 400m.
Terrain clearance 60m - 150m.

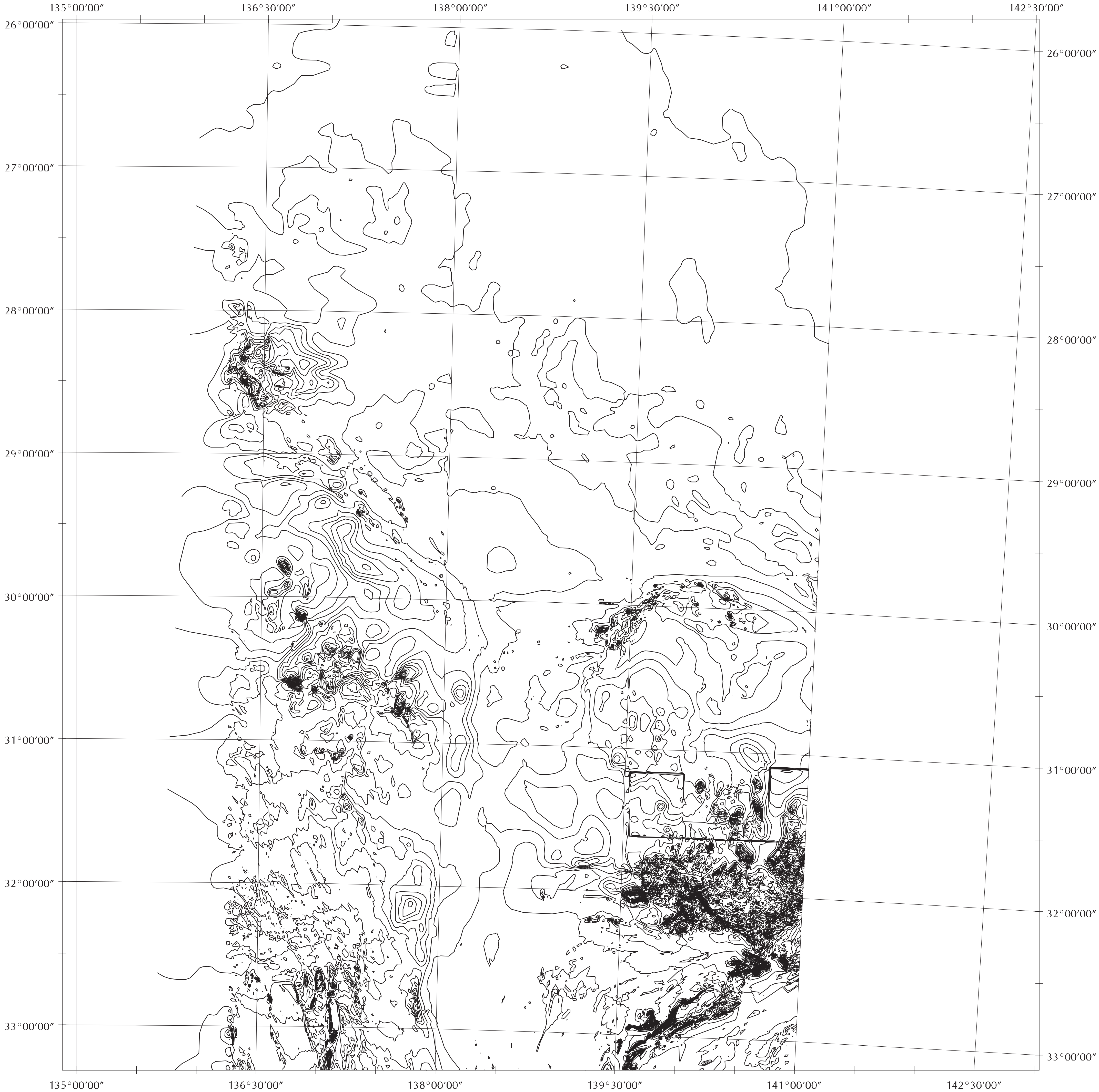
MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Plotted July 1997

Map 5
98-0058

Lineament Tectonics - South Australia

TMI - 200nT contours



Total Magnetic Intensity contour interval = 200 nTesla.
Data gridded using 200m x 200m mesh.
The data range displayed is -2359 to 6970 nTesla.
This merged TMI data was sourced from Mineral Geophysics Section, Mineral Provinces Division, MESA, for the Petroleum Geology Section, Petroleum Division, MESA.
It has been compiled from a number of sources, including MESA South Australian Exploration Initiative data, AGSO and MESA Broken Hill Initiative data, and open-file company surveys.

The data exhibits gaps and levelling errors. Interpretations of this data should be made with due diligence.

Airborne survey paramaters:
Line spacing 100m - 400m.
Terrain clearance 60m - 150m.

Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200
KILOMETERS

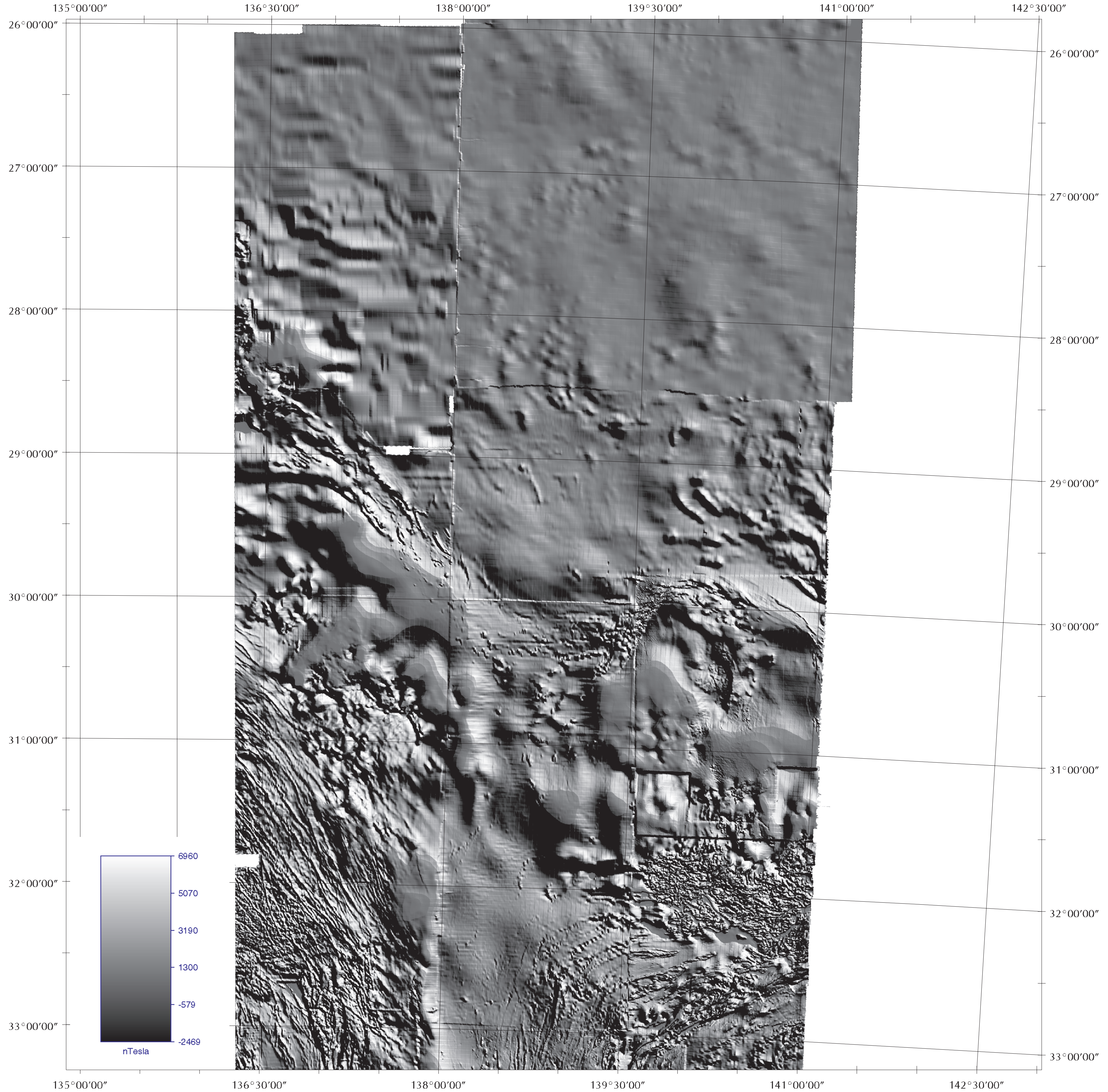
MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Plotted July 1997

Map 6
98-0059

Lineament Tectonics - South Australia

Total Magnetic Intensity Image



This is a Total Magnetic Intensity grey scale image with sun shading:
azimuth = 45 degrees,elevation = 10 degrees.
The grey scale was produced using a linear transform to a greyscale LUT.
The intensity histogram has been clipped to 99% of histogram and a linear transform applied.
Data gridded at 200m.
The data range displayed is -2359 to 6970 nTesla.
The data has not been smoothed.
This merged TMI data was sourced from Mineral Geophysics Section, Mineral Provinces Division, MESA.
It has been compiled from a number of sources, including MESA South Australian Exploration Initiative data, AGSO and MESA Broken Hill Initiative data, and open-file company surveys.
The data exhibits gaps and levelling errors. Interpretations of this data should be made with due diligence.
Airborne survey paramaters:
Line spacing 100m - 400m.
Terrain clearance 60m - 150m.

Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200
KILOMETERS

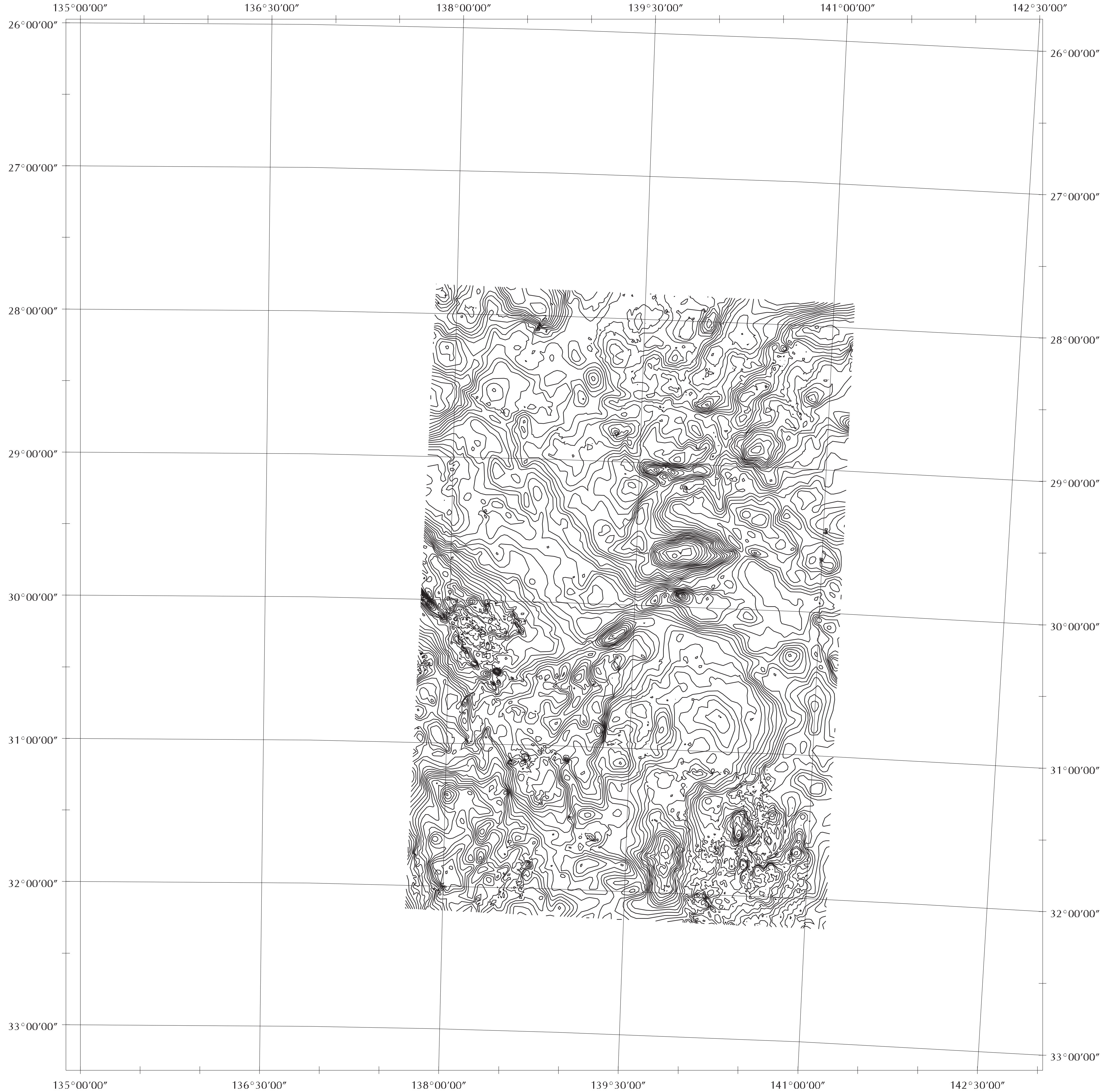
MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Plotted August 1997

Map 7
98-0060

Lineament Tectonics - South Australia

Bouguer Gravity - 300m grid,2mgal contours



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200
KILOMETERS

The Bouguer Gravity was gridded at 300m grid spacing and contoured at 2mgal interval.
Gravity data was sourced from SA Gravity Database. This data is unevenly distributed over the area of interest, with points ranging between 400m and 7km spacing.
The Bouguer value was calculated using an average density of 2.67 g/cm3.

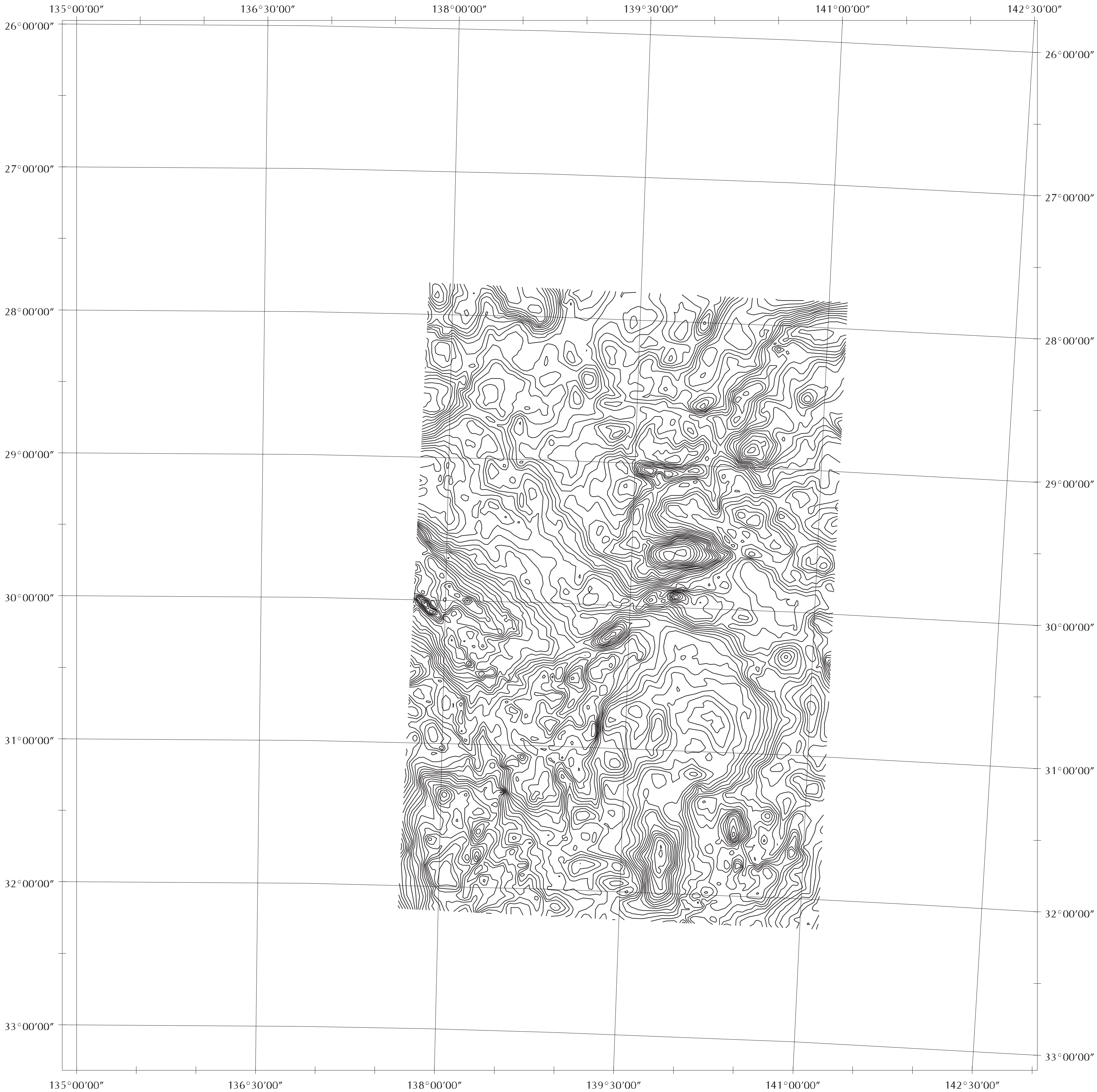
Plotted July 1997

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Map 8
98-0061

Lineament Tectonics - South Australia

Bouguer Gravity - 3500m grid,2mgal contours



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200

KILOMETERS

The Bouguer Gravity was gridded at 3500m grid spacing and contoured at 2mgal interval.
Gravity data was sourced from SA Gravity Database. This data is unevenly distributed over the area of interest, with points ranging between 400m and 7km spacing.
The Bouguer value was calculated using an average density of 2.67 g/cm3.

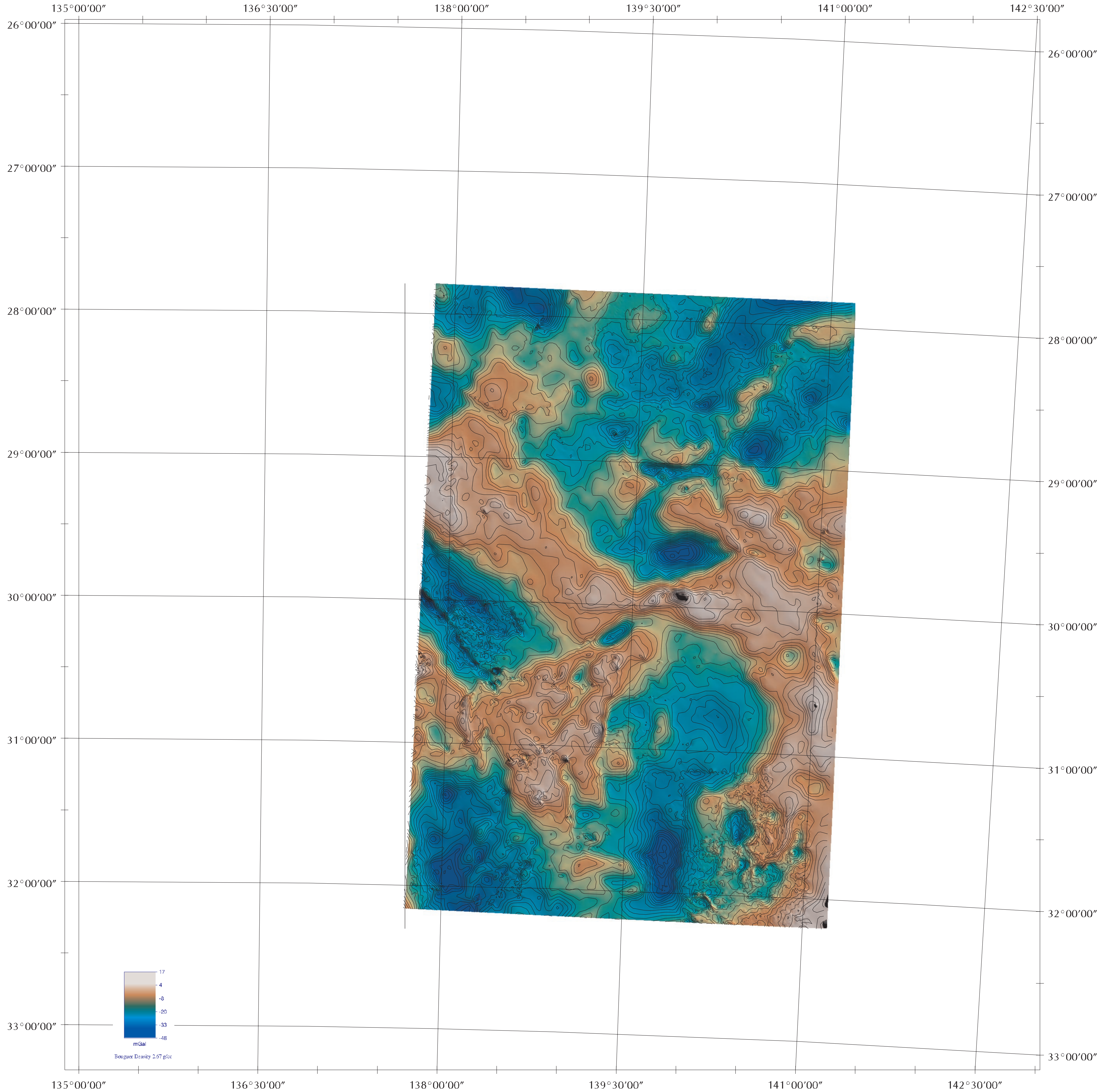
MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Plotted July 1997

Map 9
98-0062

Lineament Tectonics - South Australia

Bouguer Gravity Image



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200

KILOMETERS

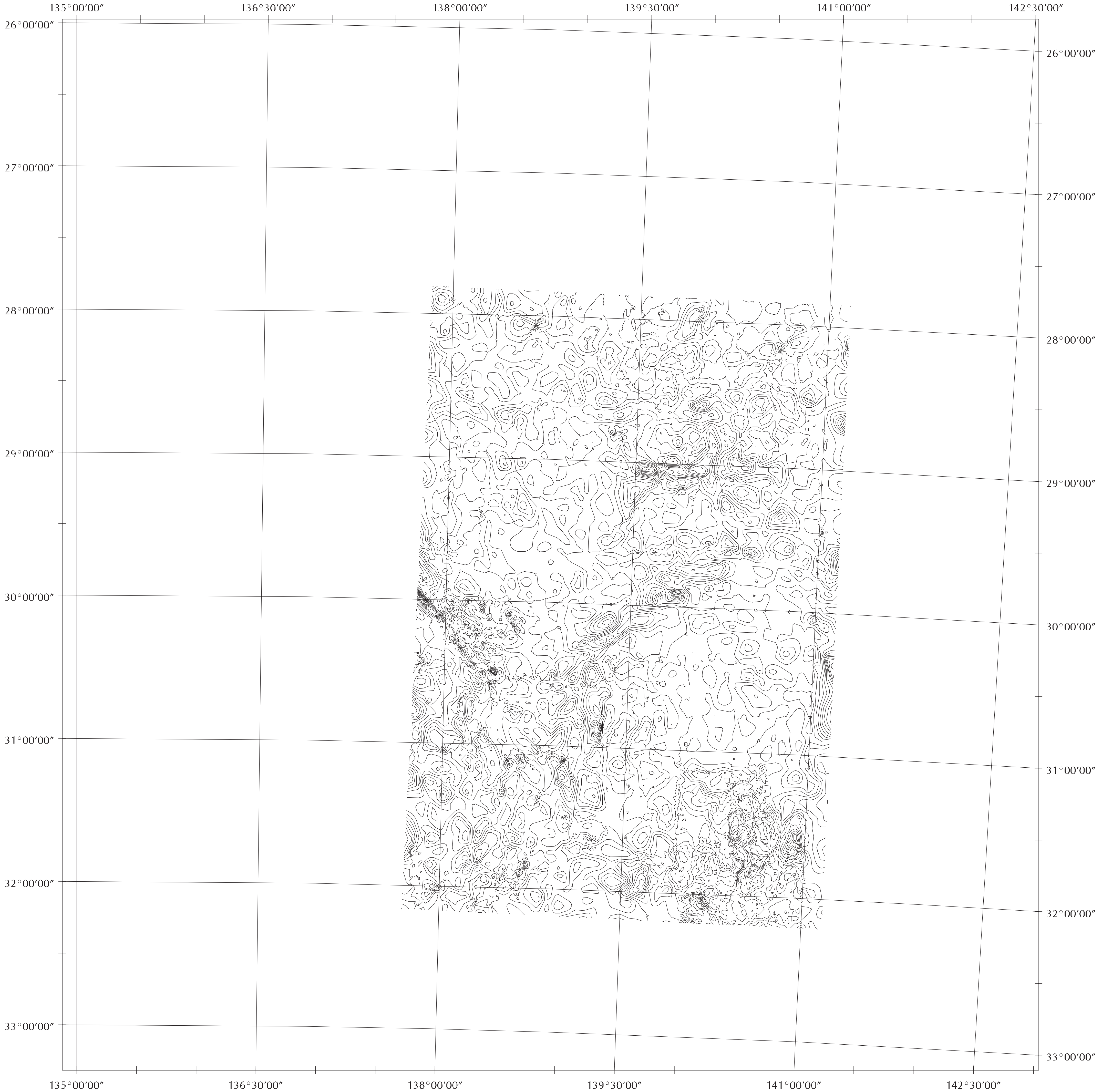
This is a pseudocolour image of the Bouguer Gravity with sun shading applied:
sun elevation = 45 degrees
sun azimuth = 45 degrees
The Bouguer value was calculated using an average density of 2.67 g/cm3.
The data was gridded at a grid spacing of 300m.
The data range displayed is -46.7 mgal dark blue to 16.3 mgal dark red.
Bouguer Gravity contours are displayed at a 2mgal contour interval.
Gravity data was sourced from SA Gravity Database. This data is unevenly distributed over the area of interest, with points ranging between 400m and 7km spacing.

Plotted August 1997

Map 10
98-0063

Lineament Tectonics - South Australia

Residual Gravity - 2mgal contours



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200

KILOMETERS

Residual Gravity generated by resampling original Bouguer 300m grid to 20k. The 20k grid was then resampled to 300m and subtracted from the original 300m grid. This grid was then contoured at a 2mgal interval. Gravity data was sourced from SA Gravity Database. This data is unevenly distributed over the area of interest, with points ranging between 400m and 7km spacing.
The Bouguer value was calculated using an average density of 2.67 g/cm3.

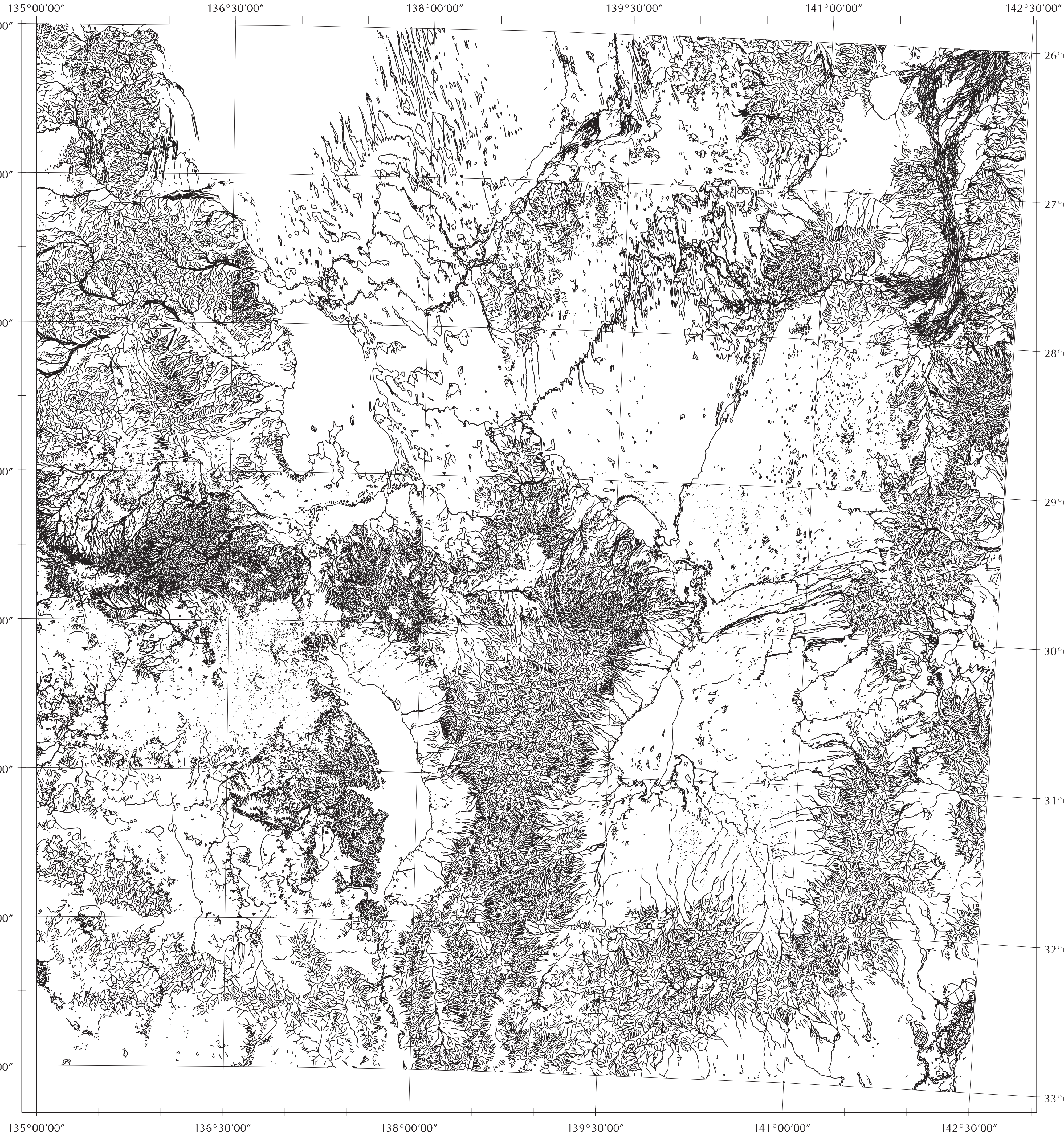
Plotted July 1997

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Map 11
98-0064

Lineament Tectonics - South Australia

Drainage and Waterbodies



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200
KILOMETERS

Drainage patterns derived from
Auslig TOPO 250K Geodata Product - DRAINAGE

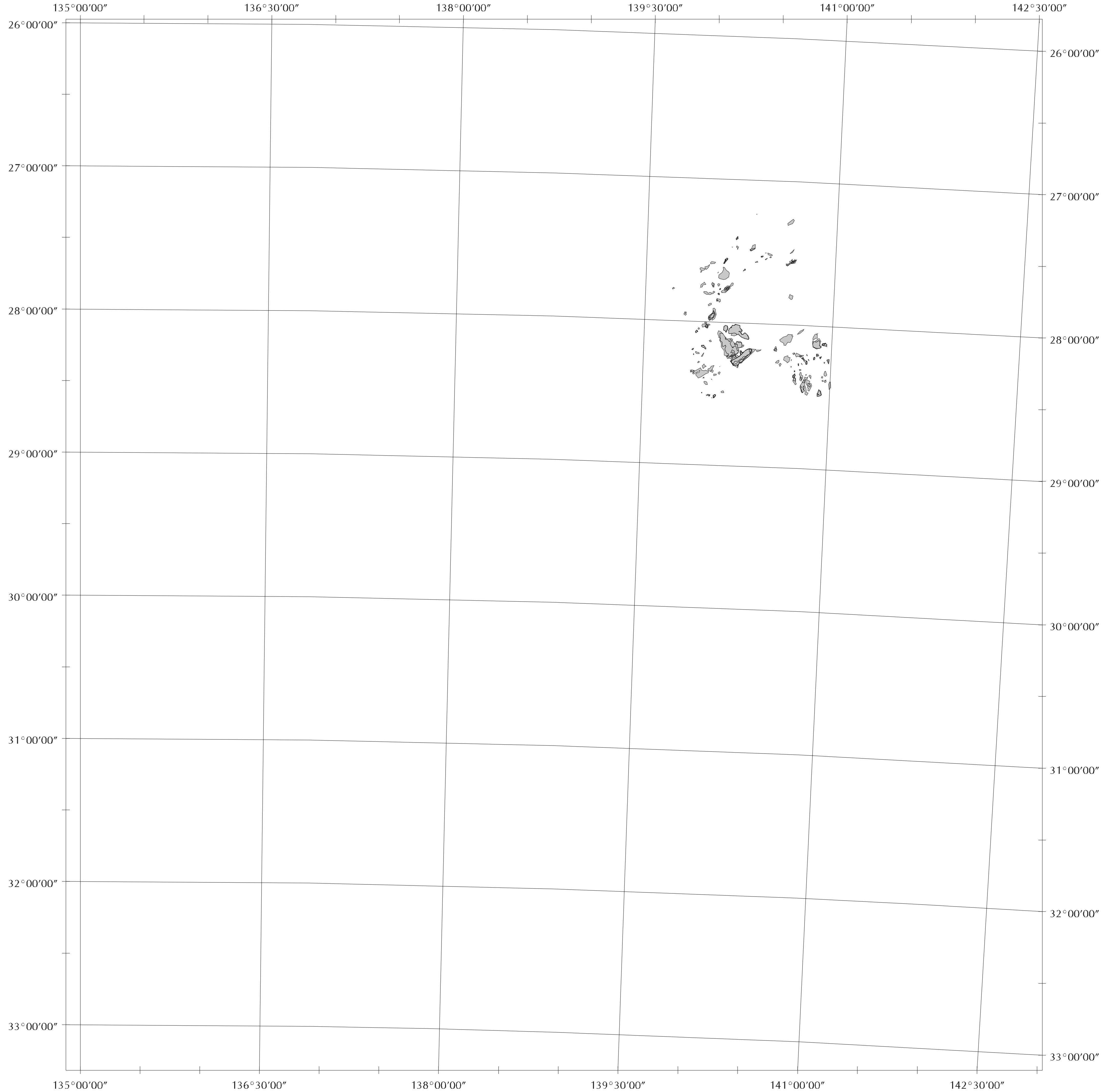
Plotted July 1997

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Map 12
98-0065

Lineament Tectonics - South Australia

Gas Fields - Cooper Basin



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200
KILOMETERS

Gas Fields from ALL geological formations in the Cooper Basin area are displayed on this map.
These data were derived from the ArcInfo coverage /garnet/usr4/petrol/fields/fields.
At the time of producing this plot the database was preliminary and incomplete.

Plotted July 1997

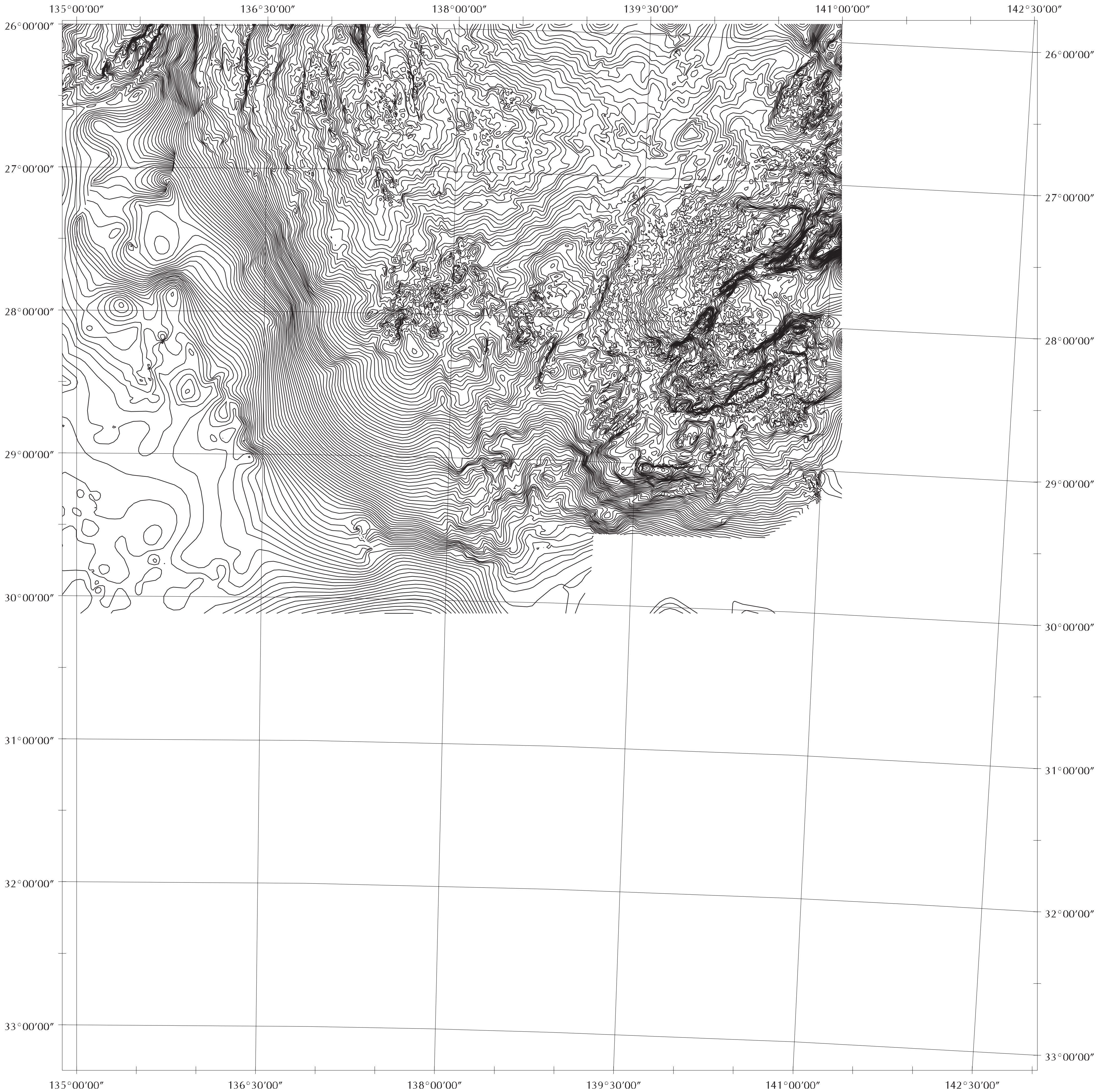
MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Map 13
98-0066

Lineament Tectonics - South Australia

Depth Structure

Top Cadnaowie ('C' horizon - 20m contours)



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200

KILOMETERS

Top Cadnaowie ('C' Horizon) Depth Structure Contours plotted at 20m interval.
Data gridded using 200m x 200m mesh.
The data range displayed is -1956 to 404 metres relative to MSL.

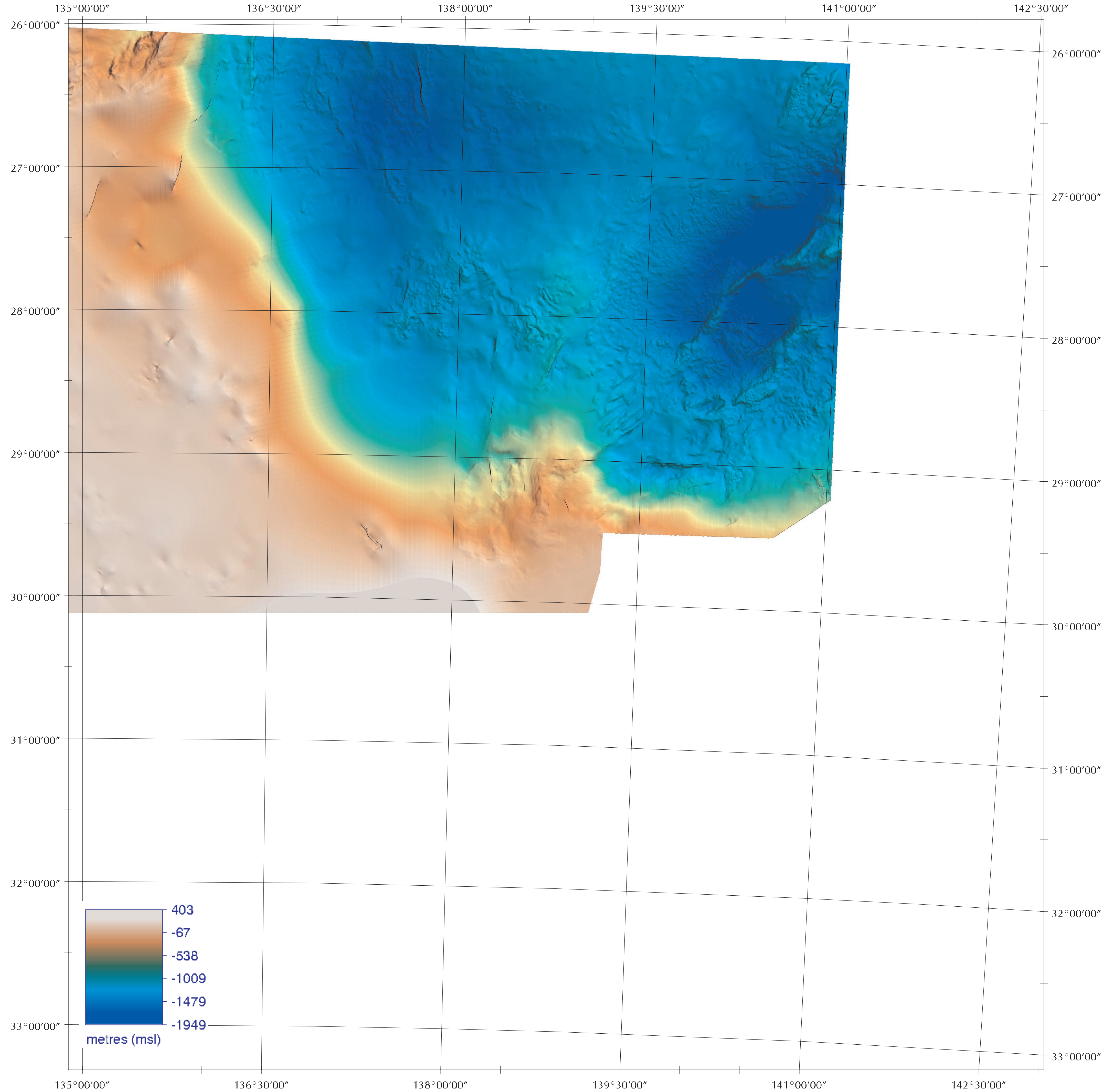
The depth structure contours have been provided by Petroleum Geophysics from the Seismic Mapping Database which forms a component of the South Australian Exploration Initiative data set.
The contours were compiled from existing open-file company time, velocity and depth structure contour maps which were digitised and gridded.
Independent seismic horizon interpretations of selected seismic sections were incorporated in the final gridding and contouring.

Plotted July 1997

Map 14
98-0067

Lineament Tectonics - South Australia

Top Cadnaowie ('C' Horizon) Depth Structure Image



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200
KILOMETERS

This is a Depth Structure pseudocolour image of the seismic horizon Top Cadnaowie ('C' Horizon).
Sun shading has been applied: azimuth = 45 degrees, elevation = 60 degrees.
Data was gridded using a 200m x 200m mesh.
The data range displayed is -1952 to 403 metres relative to MSL.

The depth structure grid has been provided by Petroleum Geophysics from the Seismic Mapping Database which forms a component of the South Australian Exploration Initiative data set.
The data were compiled from existing open-file company time, velocity and depth structure contour maps which were digitised and gridded.
Independent seismic horizon interpretations of selected seismic sections were incorporated in the final gridding and contouring.

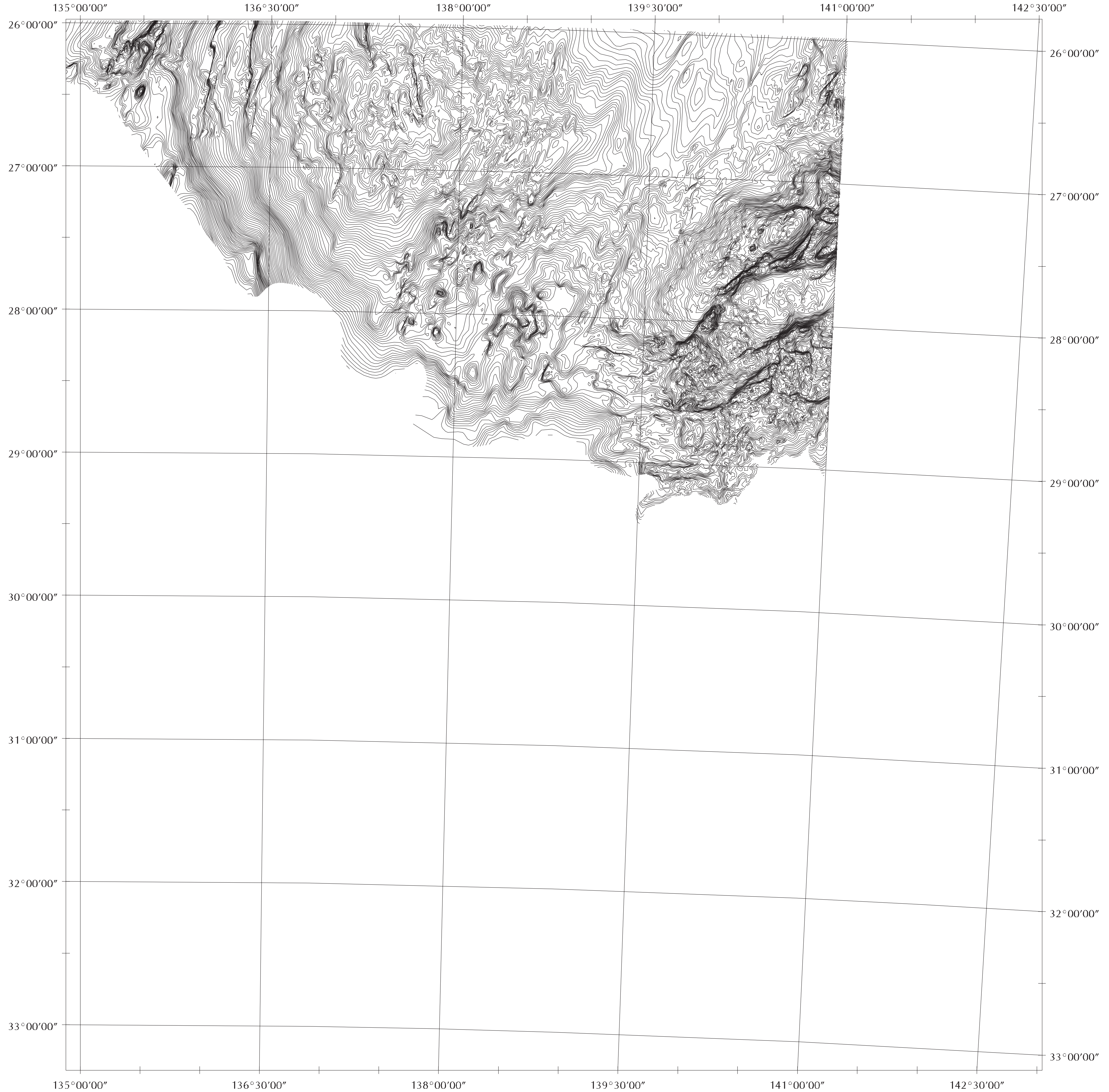
Plotted August 1997

Map 15
98-0068

Lineament Tectonics - South Australia

Depth Structure

Base Eromanga ('BE' horizon - 20m contours)



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200
KILOMETERS

Base Eromanga ('BE' Horizon) Depth Structure Contours plotted at 20m interval.
Data gridded using 200m x 200m mesh.
The data range displayed is -3240 to -60 metres relative to MSL.

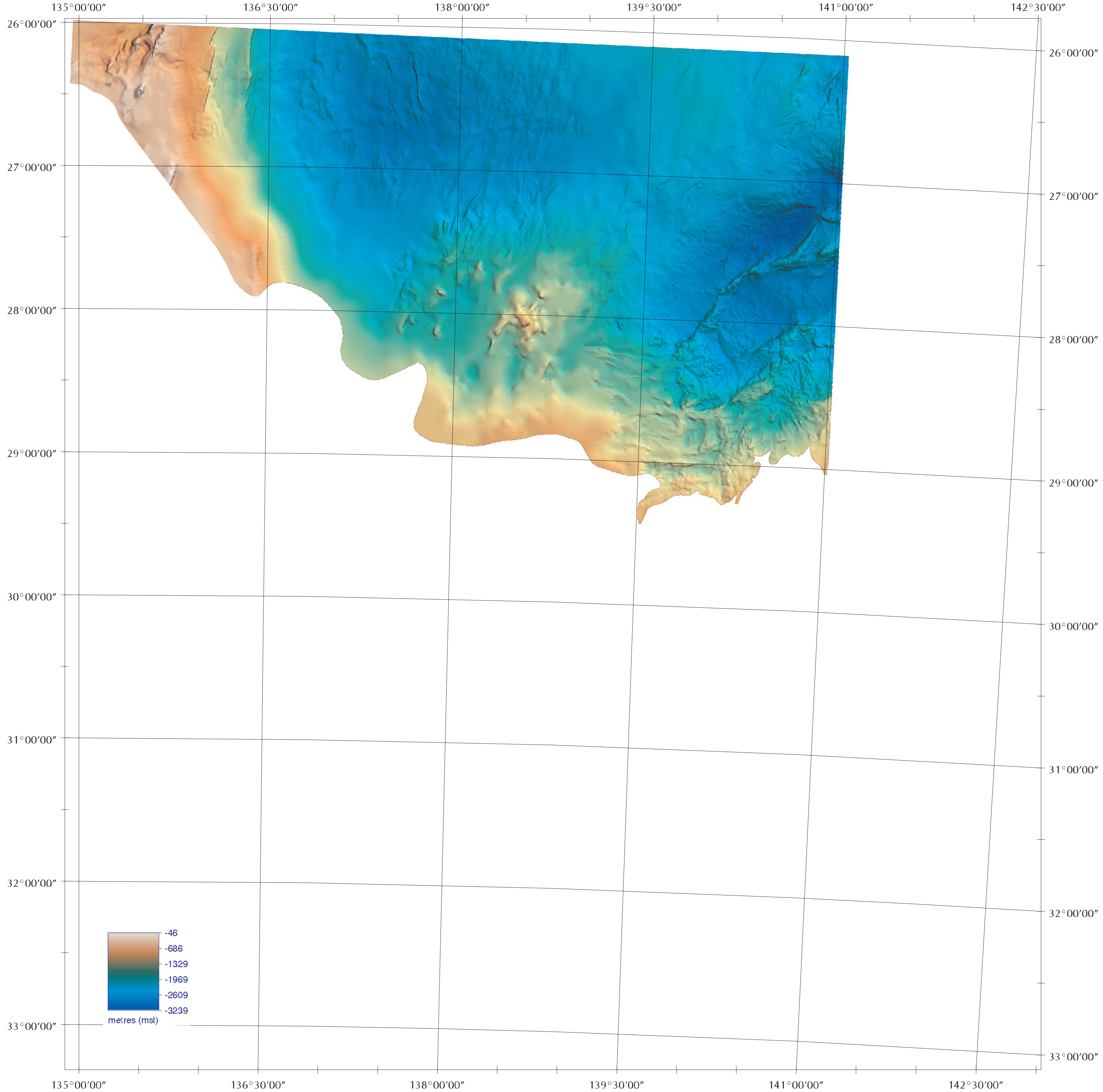
The depth structure contours have been provided by Petroleum Geophysics from the Seismic Mapping Database which forms a component of the South Australian Exploration Initiative data set.
The contours were compiled from existing open-file company time, velocity and depth structure contour maps which were digitised and gridded.
Independent seismic horizon interpretations of selected seismic sections were incorporated in the final gridding and contouring.

Plotted July 1997

Map 16
98-0069

Lineament Tectonics - South Australia

Base Eromanga ('BE' Horizon) Depth Structure Image



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200
KILOMETERS

This is a Depth Structure pseudocolour image of the seismic horizon Base Eromanga ('BE' Horizon).
Sun shading has been applied: azimuth = 45 degrees, elevation = 60 degrees.
Data was gridded using a 200m x 200m mesh.
The data range displayed is -3240 to -60 metres relative to MSL.

The depth structure grid has been provided by Petroleum Geophysics from the Seismic Mapping Database which forms a component of the South Australian Exploration Initiative data set.
The data were compiled from existing open-file company time, velocity and depth structure contour maps which were digitised and gridded. Independent seismic horizon interpretations of selected seismic sections were incorporated in the final gridding and contouring.

Plotted August 1997

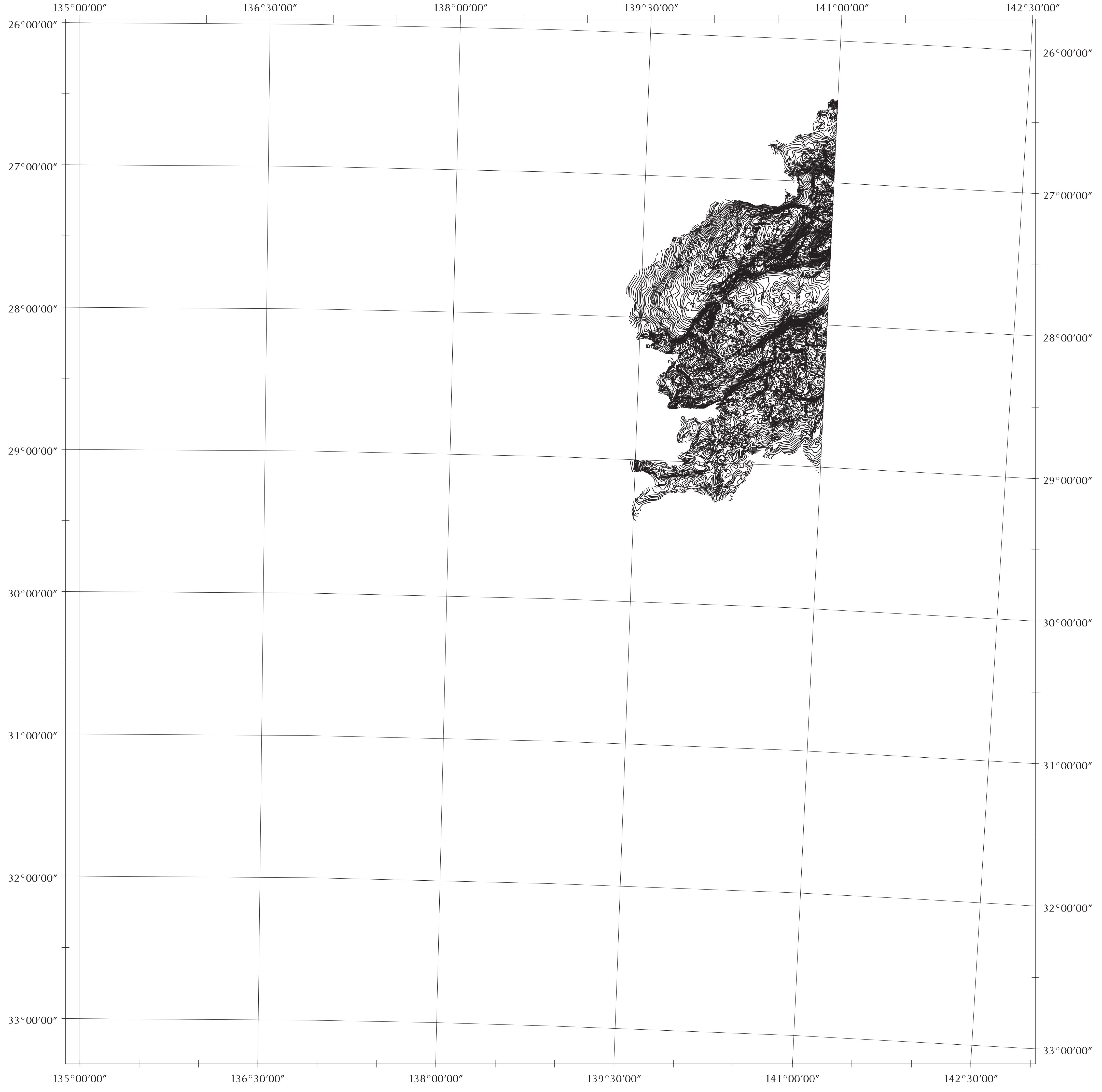
MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Map 17
98-0070

Lineament Tectonics - South Australia

Depth Structure

Top Permian ('P' horizon - 20m contours)



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200
KILOMETERS

Top Permian ('P' Horizon) Depth Structure Contours plotted at 20m interval.
Data gridded using 200m x 200m mesh.
The data range displayed is -3260 to -940 metres relative to MSL.

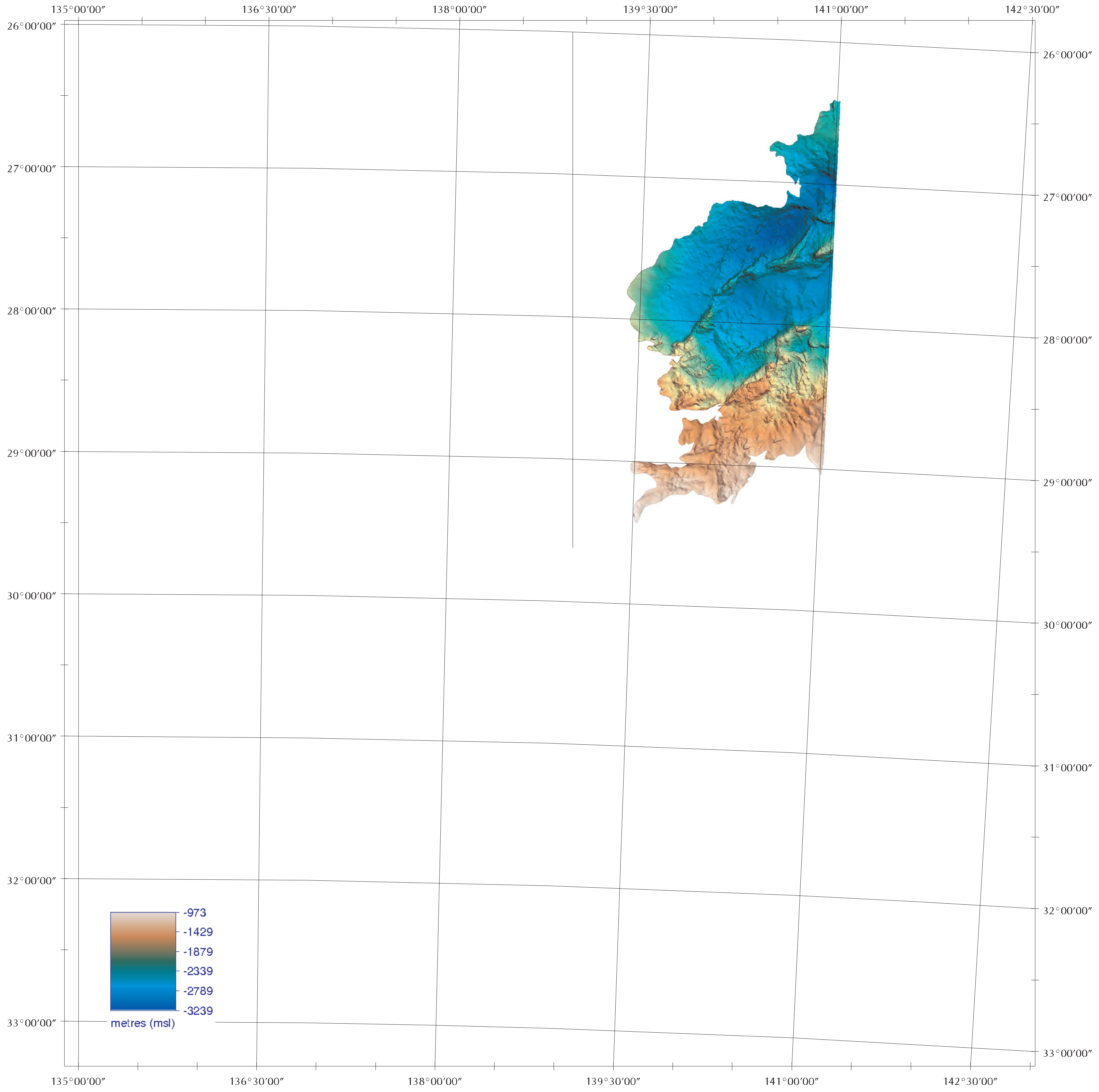
The depth structure contours have been provided by Petroleum Geophysics from the Seismic Mapping Database which forms a component of the South Australian Exploration Initiative data set.
The contours were compiled from existing open-file company time, velocity and depth structure contour maps which were digitised and gridded.
Independent seismic horizon interpretations of selected seismic sections were incorporated in the final gridding and contouring.

Plotted July 1997

Map 18
98-0071

Lineament Tectonics - South Australia

Top Permian ('P' Horizon) Depth Structure Image



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200

KILOMETERS

This is a Depth Structure pseudocolour image of the seismic horizon Top Permian ('P' Horizon).
Sun shading has been applied: azimuth = 45 degrees, elevation = 60 degrees.
Data was gridded using a 200m x 200m mesh.
The data range displayed is -3245 to -974 metres relative to MSL.

The depth structure grid has been provided by Petroleum Geophysics from the Seismic Mapping Database which forms a component of the South Australian Exploration Initiative data set.
The data were compiled from existing open-file company time, velocity and depth structure contour maps which were digitised and gridded. Independent seismic horizon interpretations of selected seismic sections were incorporated in the final gridding and contouring.

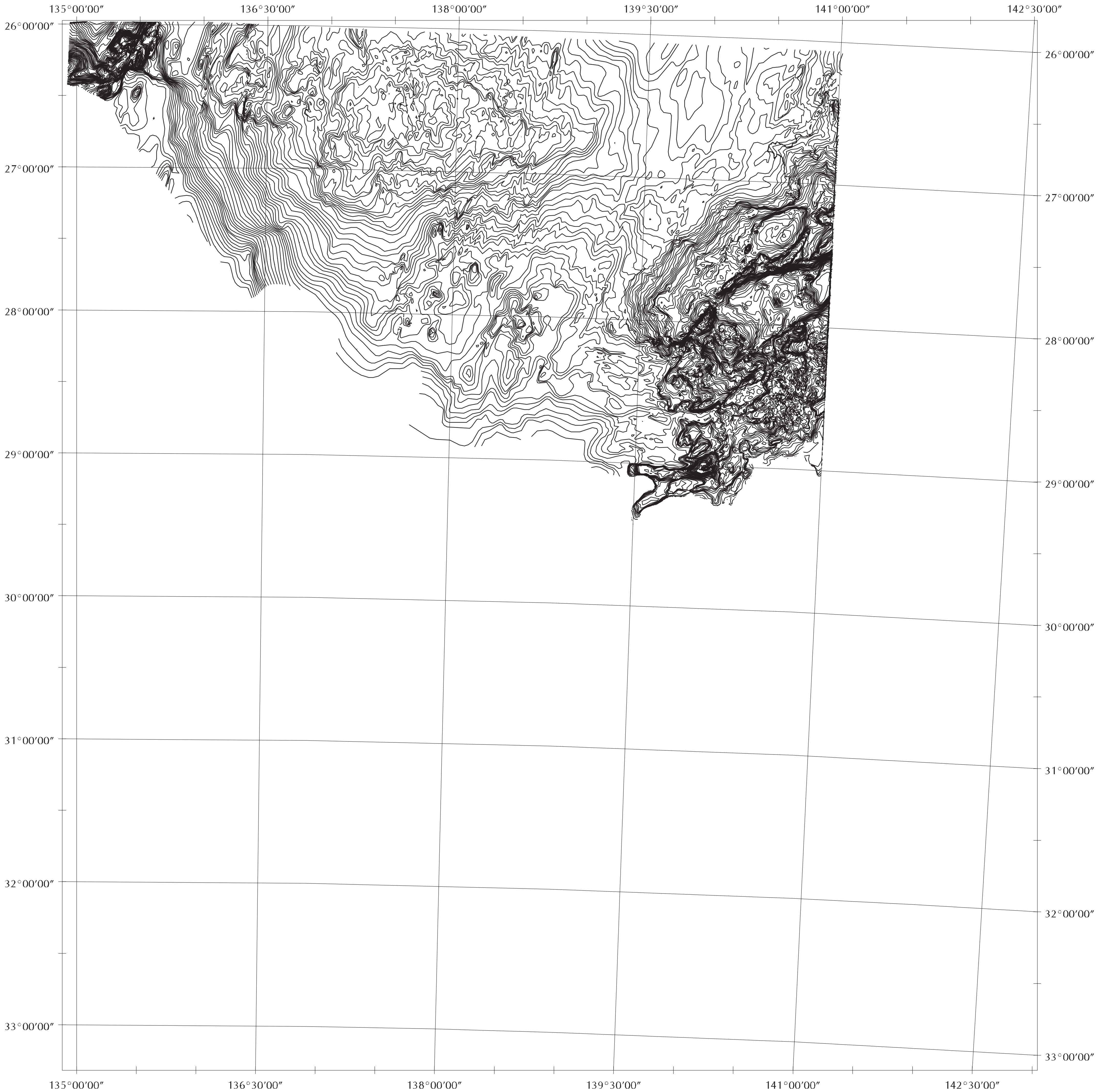
Plotted August 1997

Map 19
98-0072

Lineament Tectonics - South Australia

Depth Structure

Top Warburton ('Z' horizon - 50m contours)



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200
KILOMETERS

Top Warburton ('Z' Horizon) Depth Structure Contours plotted at 50m interval.
Data gridded using 200m x 200m mesh.
The data range displayed is -4650 to 2200 metres relative to MSL.

The depth structure contours have been provided by Petroleum Geophysics from the Seismic Mapping Database which forms a component of the South Australian Exploration Initiative data set.
The contours were compiled from existing open-file company time, velocity and depth structure contour maps which were digitised and gridded.
Independent seismic horizon interpretations of selected seismic sections were incorporated in the final gridding and contouring.

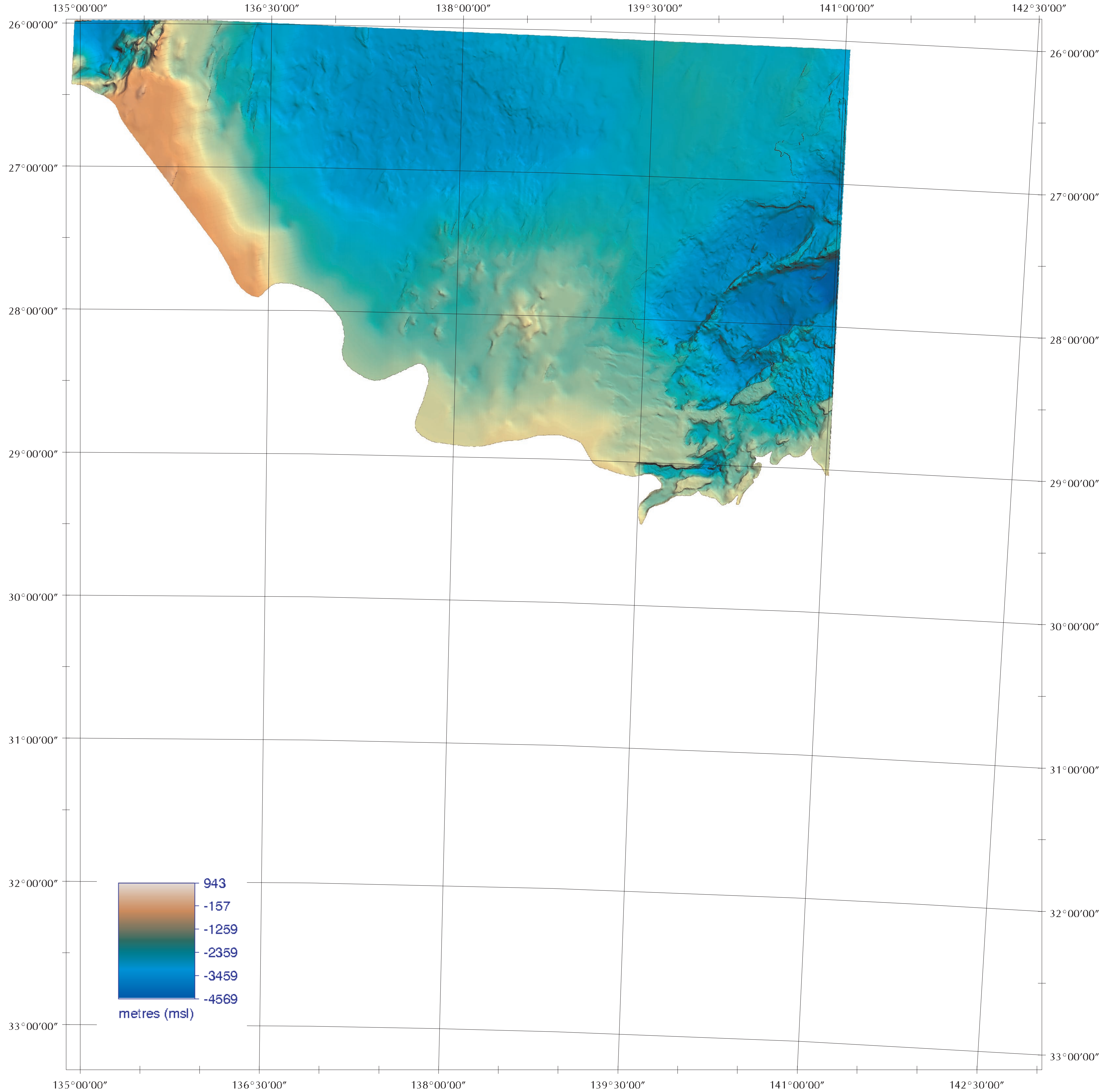
MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Plotted July 1997

Map 20
98-0073

Lineament Tectonics - South Australia

Top Warburton ('Z' Horizon) Depth Structure Image



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200
KILOMETERS

This is a Depth Structure pseudocolour image of the seismic horizon Top Warburton ('Z' Horizon).
Sun shading has been applied: azimuth = 45 degrees, elevation = 60 degrees.
Data was gridded using a 200m x 200m mesh.
The data range displayed is -4565 to -943 metres relative to MSL.

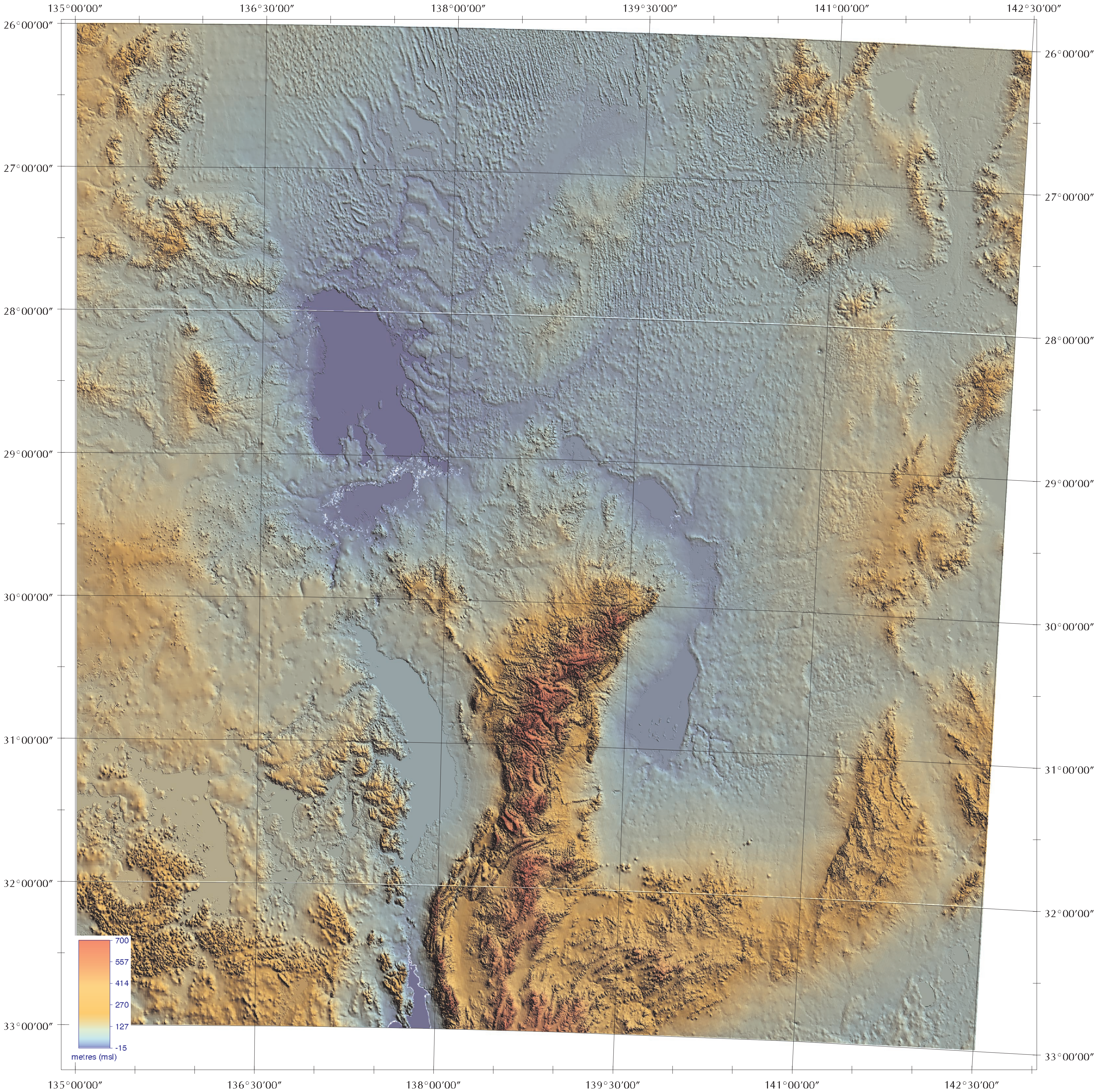
The depth structure grid has been provided by Petroleum Geophysics from the Seismic Mapping Database which forms a component of the South Australian Exploration Initiative data set.
The data were compiled from existing open-file company time, velocity and depth structure contour maps which were digitised and gridded. Independent seismic horizon interpretations of selected seismic sections were incorporated in the final gridding and contouring.

Plotted August 1997

Map 21
98-0074

Lineament Tectonics - South Australia

Digital Elevation Model



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200

KILOMETERS

This is a Digital Elevation Model pseudocolour image.
Sun shading has been applied: azimuth = 45 degrees, elevation = 45 degrees.
Data was gridded using a 200m x 200m mesh.
The data range displayed is -15 to 700 metres relative to MSL.

The DEM is a model of the terrain in which each data point represents the average elevation for the respective 200m by 200m cell.
The DEM has a standard deviation of 25m.
This DEM is derived from AUSLIG's GEODATA 9 SECOND DEM.

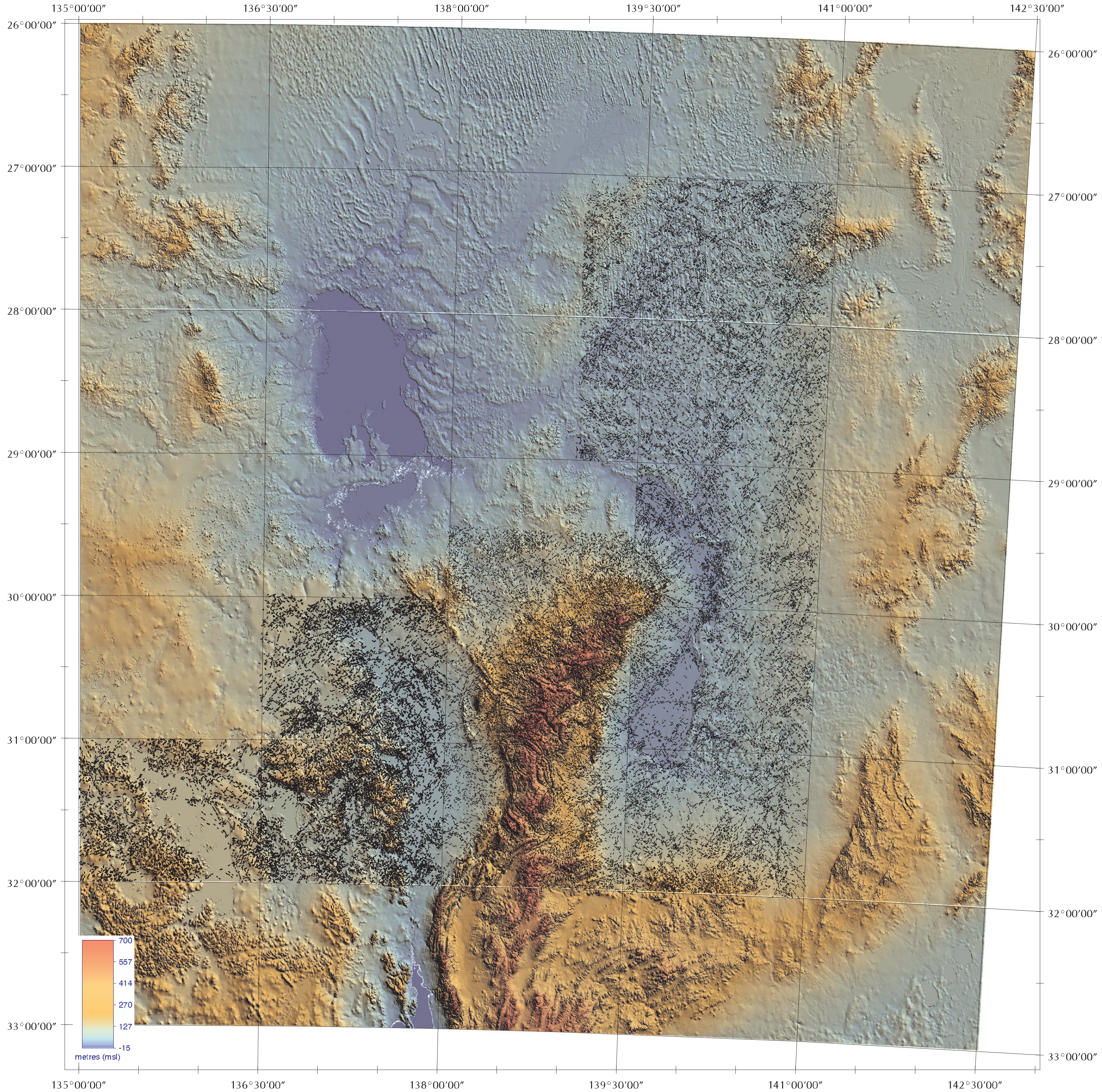
The source data for the DEM was national spot height elevation data taken from 1:100,1000 scale topographic mapping as well as river and waterbody information from 1:250,000 topographic mapping.
These data are components of AUSLIG's GEODATA TOPO-250K digital map product.

Plotted August 1997

Map 22
98-0075

Lineament Tectonics - South Australia

Digital Elevation Model + High Frequency Photo Lineaments



This is a Digital Elevation Model pseudocolour image.
Sun shading has been applied: azimuth = 45 degrees, elevation = 45 degrees.
Data was gridded using a 200m x 200m mesh.
The data range displayed is -15 to 700 metres relative to MSL.

The DEM is a model of the terrain in which each data point represents the average elevation for the respective 200m by 200m cell.
The DEM has a standard deviation of 25m.
This DEM is derived from AUSLIG's GEODATA 9 SECOND DEM.

The source data for the DEM was national spot height elevation data taken from 1:100,1000 scale topographic mapping as well as river and waterbody information from 1:250,000 topographic mapping.
These data are components of AUSLIG's GEODATA TOPO-250K digital map product.

High Frequency Photo Lineaments interpreted by E.S.T O'Driscoll and R.K.Boucher from 1:63,360 air photo mosaics, and geo-referenced using RGB:542 Landsat TM imagery plotted at 1:63,360.

Plotted September 1997

Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

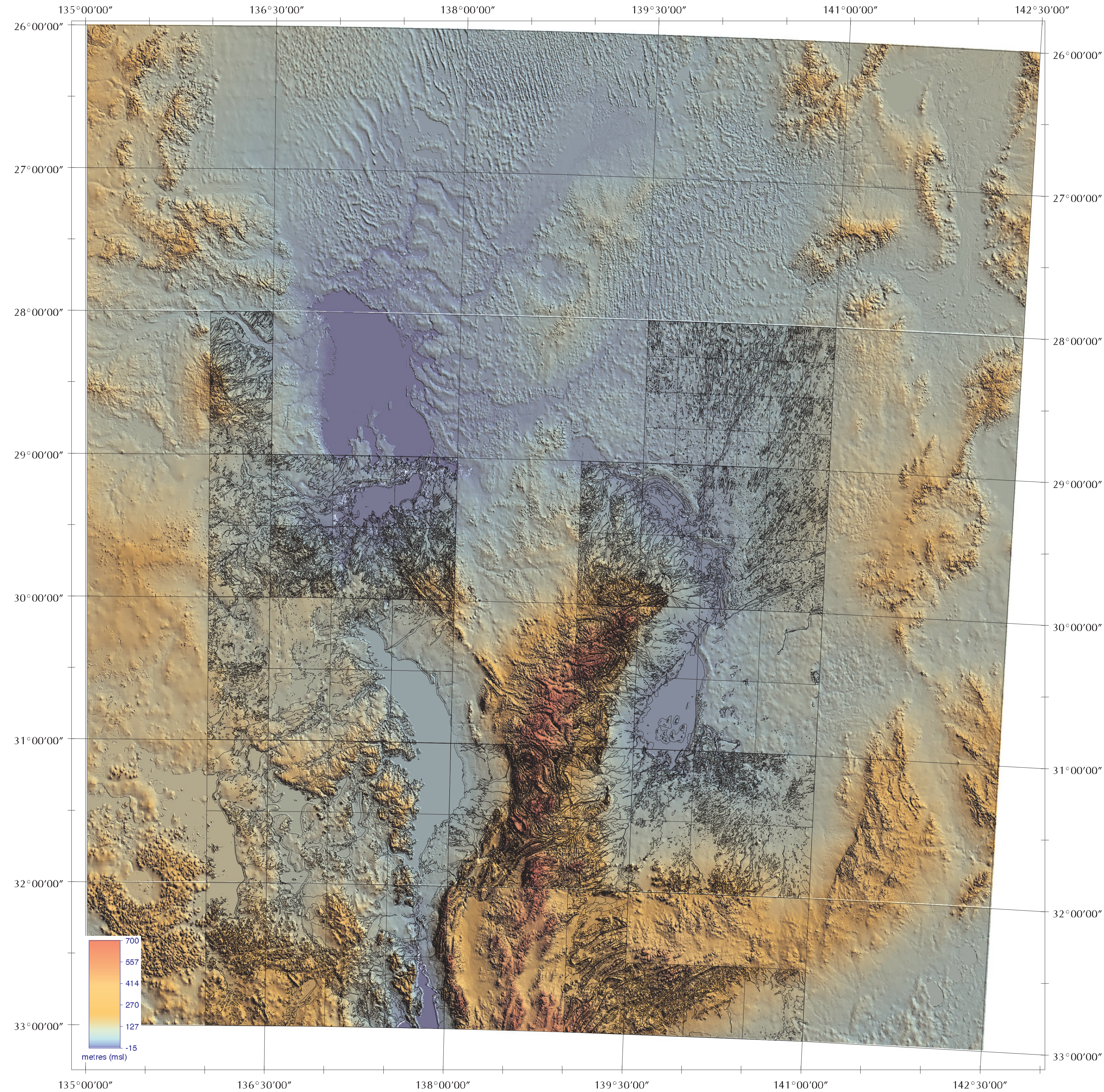
SCALE 1:3000000

50 0 50 100 150 200
KILOMETERS

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Lineament Tectonics - South Australia

Digital Elevation Model + Geological Boundaries



This is a Digital Elevation Model pseudocolour image.
Sun shading has been applied: azimuth = 45 degrees, elevation = 45 degrees.
Data was gridded using a 200m x 200m mesh.
The data range displayed is -15 to 700 metres relative to MSL.

The DEM is a model of the terrain in which each data point represents the average elevation for the respective 200m by 200m cell.
The DEM has a standard deviation of 25m.
This DEM is derived from AUSLIG's GEODATA 9 SECOND DEM.

The source data for the DEM was national spot height elevation data taken from 1:100,1000 scale topographic mapping as well as river and waterbody information from 1:250,000 topographic mapping.
These data are components of AUSLIG's GEODATA TOPO-250K digital map product.

100K Geological Boundaries derived from the SA-Geology database.

Plotted September 1997

Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

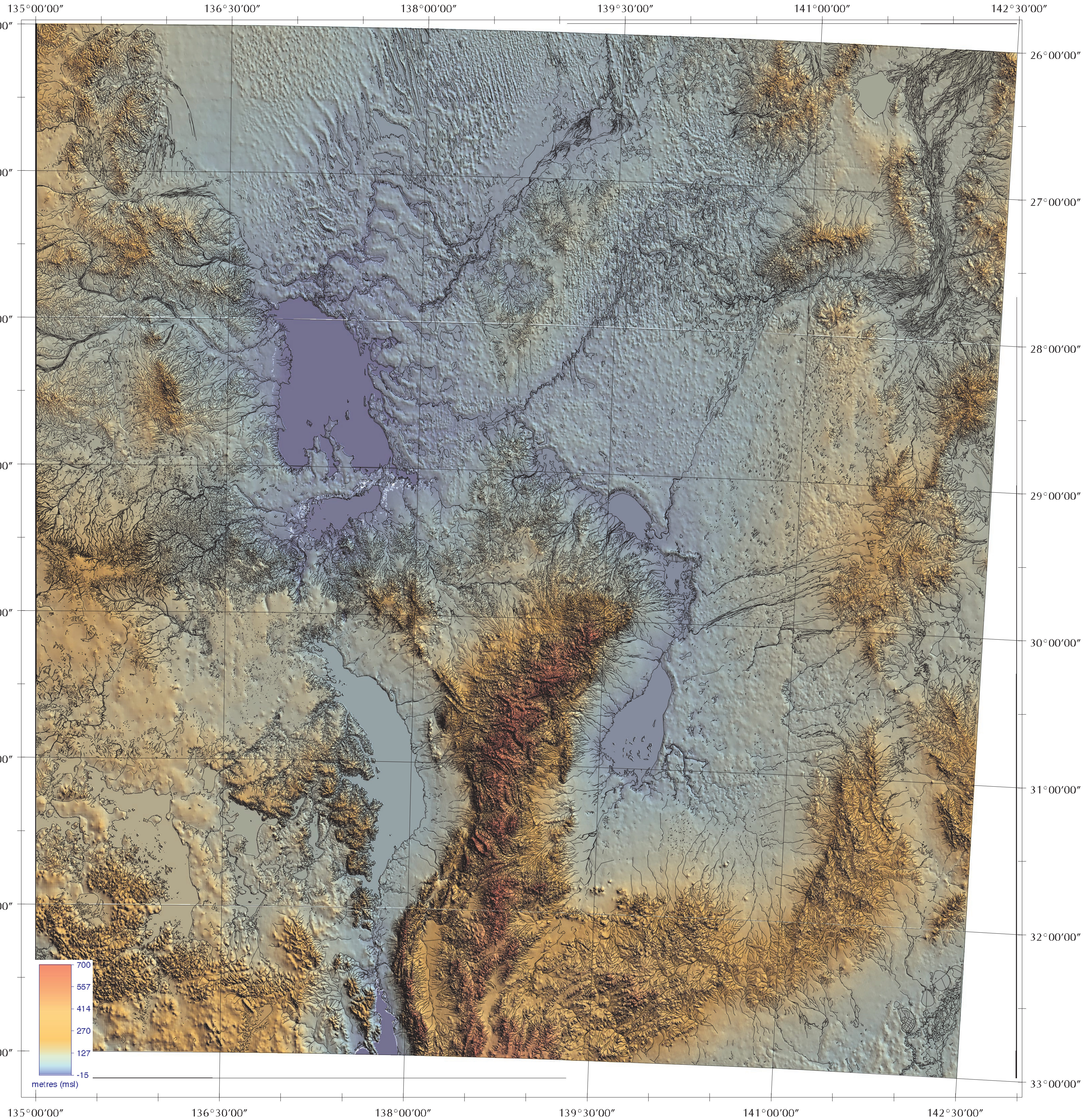
50 0 50 100 150 200
KILOMETERS

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Map 24
98-0077

Lineament Tectonics - South Australia

Digital Elevation Model + Drainage



This is a Digital Elevation Model pseudocolour image.
Sun shading has been applied: azimuth = 45 degrees, elevation = 45 degrees.
Data was gridded using a 200m x 200m mesh.
The data range displayed is -15 to 700 metres relative to MSL.

The DEM is a model of the terrain in which each data point represents the average elevation for the respective 200m by 200m cell.
The DEM has a standard deviation of 25m.
This DEM is derived from AUSLIG's GEODATA 9 SECOND DEM.

The source data for the DEM was national spot height elevation data taken from 1:100,1000 scale topographic mapping as well as river and waterbody information from 1:250,000 topographic mapping.
These data are components of AUSLIG's GEODATA TOPO-250K digital map product.

Drainage patterns derived from
Auslig TOPO 250K Geodata Product - DRAINAGE

Plotted September 1997

Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

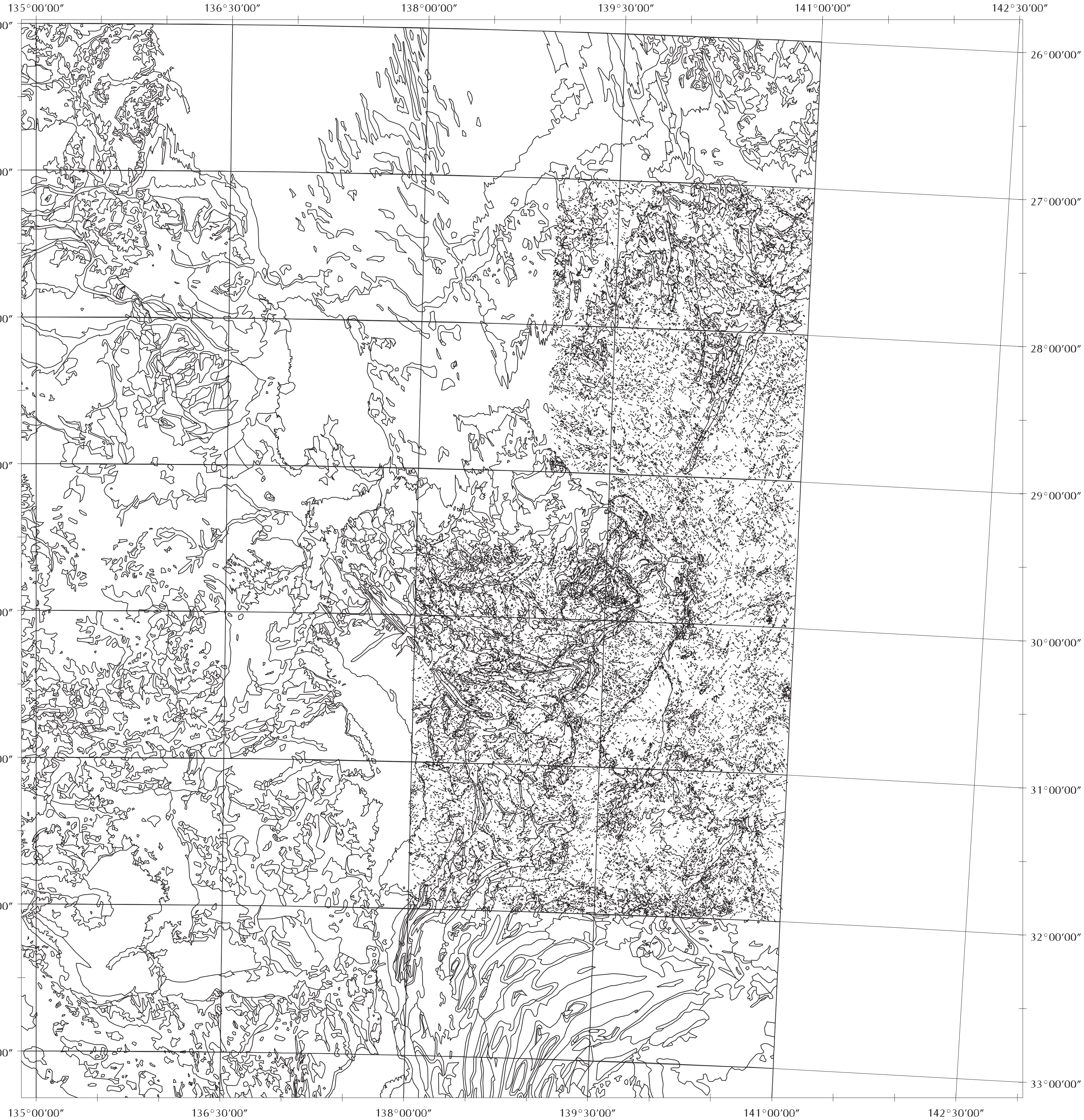
50 0 50 100 150 200
KILOMETERS

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Map 25
98-0078

Lineament Tectonics - South Australia

High Frequency Photo Lineaments + Generalised Geology



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

50 0 50 100 150 200
KILOMETERS

High Frequency Photo Lineaments interpreted by E.S.T O'Driscoll and R.K.Boucher from 1:63,360 air photo mosaics, and geo-referenced using RGB:542 Landsat TM imagery plotted at 1:63,360.

Generalised (1:1M) Geological Boundries derived from MESA's PC based ArcView GIS dataset.

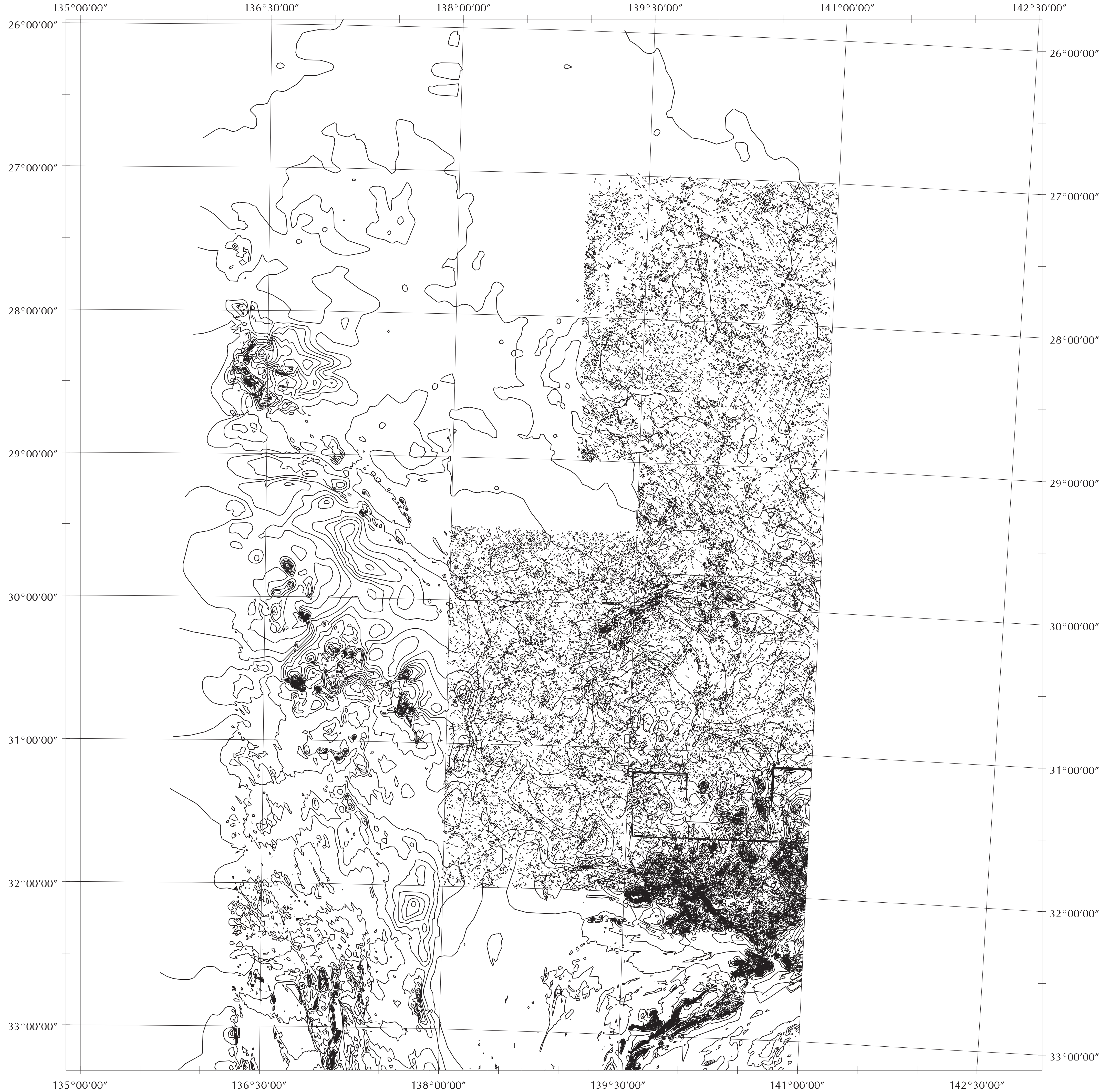
Plotted July 1997

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Map 26
98-0079

Lineament Tectonics - South Australia

High Frequency Photo Lineaments + TMI (200nT contours)



High Frequency Photo Lineaments interpreted by E.S.T O'Driscoll and R.K.Boucher from 1:63,360 air photo mosaics, and geo-referenced using RGB:542 Landsat TM imagery plotted at 1:63,360.

Total Magnetic Intensity contour interval = 200 nTesla.
Data gridded using 200m x 200m mesh.
The data range displayed is -2359 to 6970 nTesla.
This merged TMI data was sourced from Mineral Geophysics Section, Mineral Provinces Division, MESA, for the Petroleum Geology Section, Petroleum Division, MESA.
It has been compiled from a number of sources, including MESA South Australian Exploration Initiative data, AGSO and MESA Broken Hill Initiative data, and open-file company surveys.

The data exhibits gaps and levelling errors. Interpretations of this data should be made with due diligence.

Airborne survey paramaters:
Line spacing 100m - 400m.
Terrain clearance 60m - 150m.

Plotted July 1997

Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

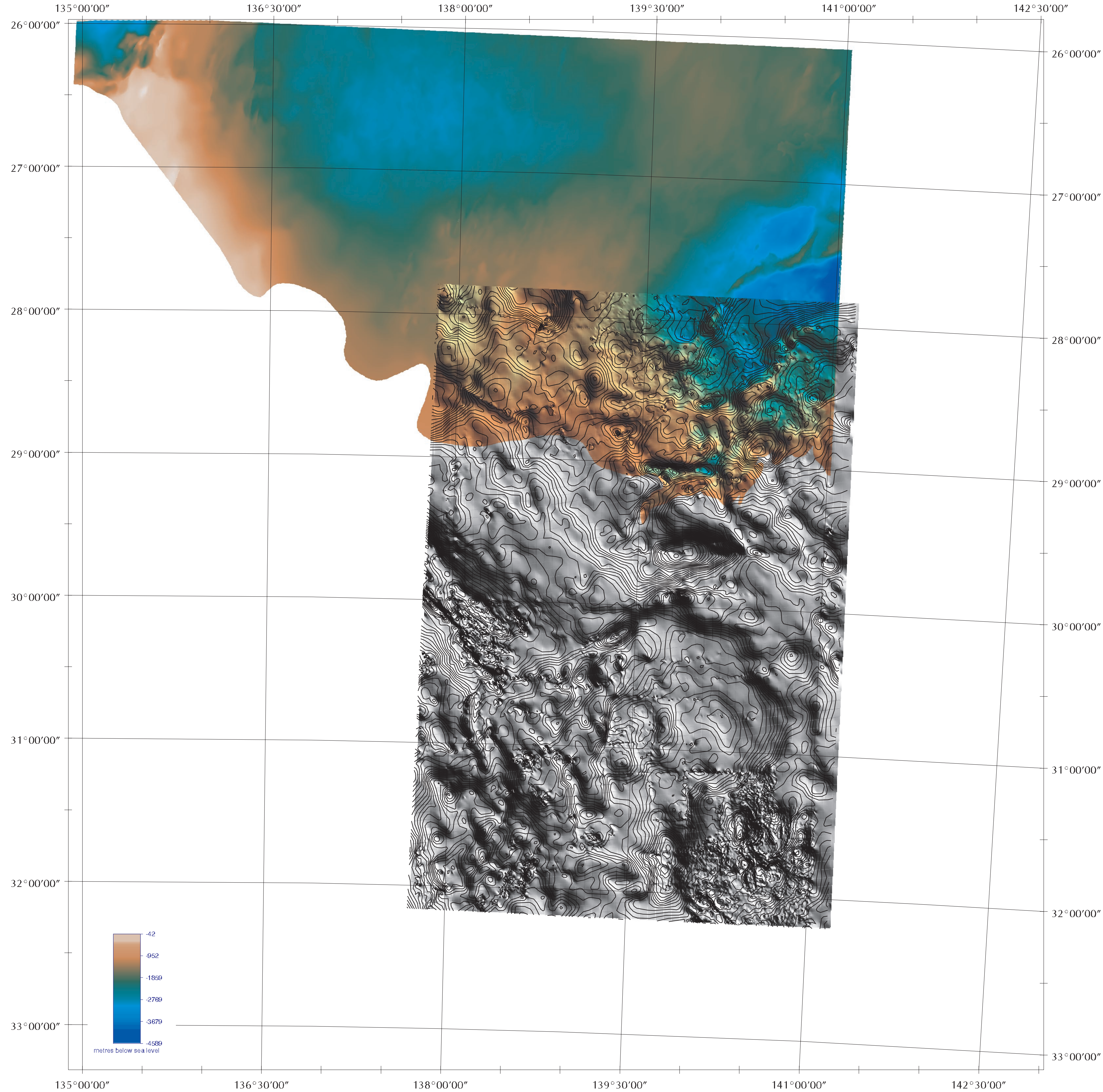
50 0 50 100 150 200
KILOMETERS

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Map 27
98-0080

Lineament Tectonics - South Australia

Top Warburton ('Z' Horizon) Depth Structure pseudocolour image draped over Bouguer Gravity greyscale image and contours



This is a Depth Structure pseudocolour image of the seismic horizon Top Warburton ('Z' Horizon) draped over a greyscaled Vouguer Gravity image with sun shading applied:
sun elevation = 45 degrees;sun azimuth = 45 degrees.

Seismic data were gridded using a 200m x 200m mesh.
The data range displayed is -4592 to -43 metres relative to MSL.
The depth structure grid has been provided by Petroleum Geophysics from the Seismic Mapping Database which forms a component of the South Australian Exploration Initiative data set.
The data were compiled from existing open-file company time, velocity and depth structure contour maps which were digitised and gridded.
Independent seismic horizon interpretations of selected seismic sections were incorporated in the final gridding and contouring.

The Bouguer value was calculated using an average density of 2.67 g/cm3.
The data was gridded at a grid spacing of 300m.
The data range displayed is -46.7 to 16.3 mgal.
Bouguer Gravity contours are displayed at a 2mgal contour interval.
Gravity data was sourced from SA Gravity Database. This data is unevenly distributed over the area of interest, with points ranging between 400m and 7km spacing.
Plotted September 1997

Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

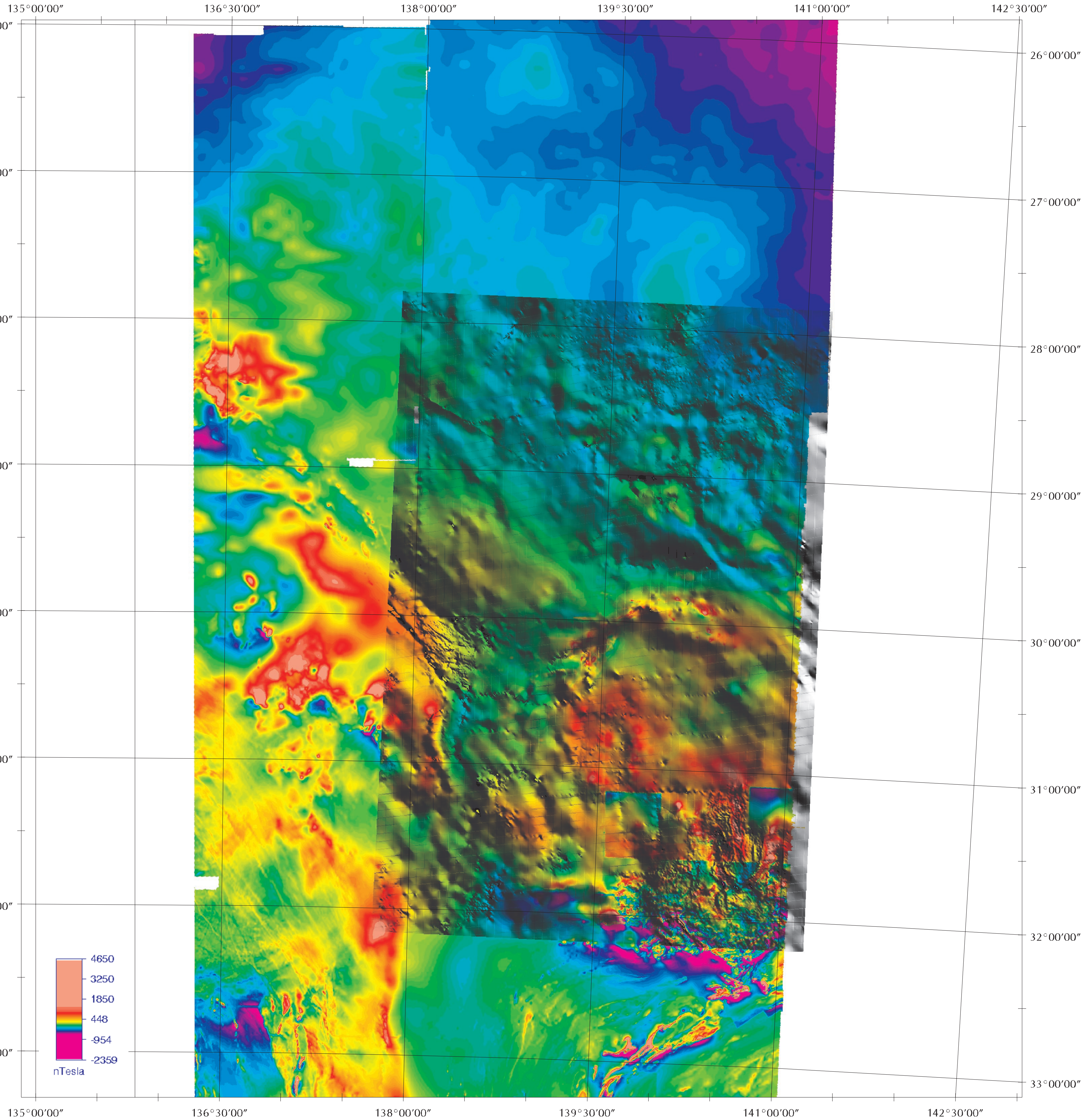
50 0 50 100 150 200
KILOMETERS

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Map 28
98-0081

Lineament Tectonics - South Australia

Total Magnetic Intensity pseudocolour image draped over Bouguer Gravity greyscale image



This is a Total Magnetic Intensity pseudocolour image draped over a greyscaled Bouguer Gravity image with sun shading applied:
sun elevation = 45 degrees;sun azimuth = 45 degrees
The pseudocolour was produced using a gaussian equalize transform applied to the full TMI data range using a pseudocolour LUT.
The full TMI data range displayed is -2359 to 6970 nTesla, however 99% of the values occur within the range -522 to 976 nTesla.
Magnetic data were gridded at 200m. The data has not been smoothed.
This merged TMI data was sourced from Mineral Geophysics Section, Mineral Provinces Division, MESA. It has been compiled from a number of sources, including MESA South Australian Exploration Initiative data, AGSO and MESA Broken Hill Initiative data, and open-file company surveys.
The data exhibits gaps and levelling errors. Interpretations of this data should be made with due diligence.
Airborne survey paramaters: Line spacing 100m - 400m
Terrain clearance 60m - 150m.
The Bouguer values were calculated using an average density of 2.67 g/cm3.
The data were gridded at a grid spacing of 300m.
The gravity data range displayed is -46.7 to 16.3 mgal.
Gravity data was sourced from SA Gravity Database. This data is unevenly distributed over the area of interest, with points ranging between 400m and 7km spacing.
Plotted September 1997

Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:3000000

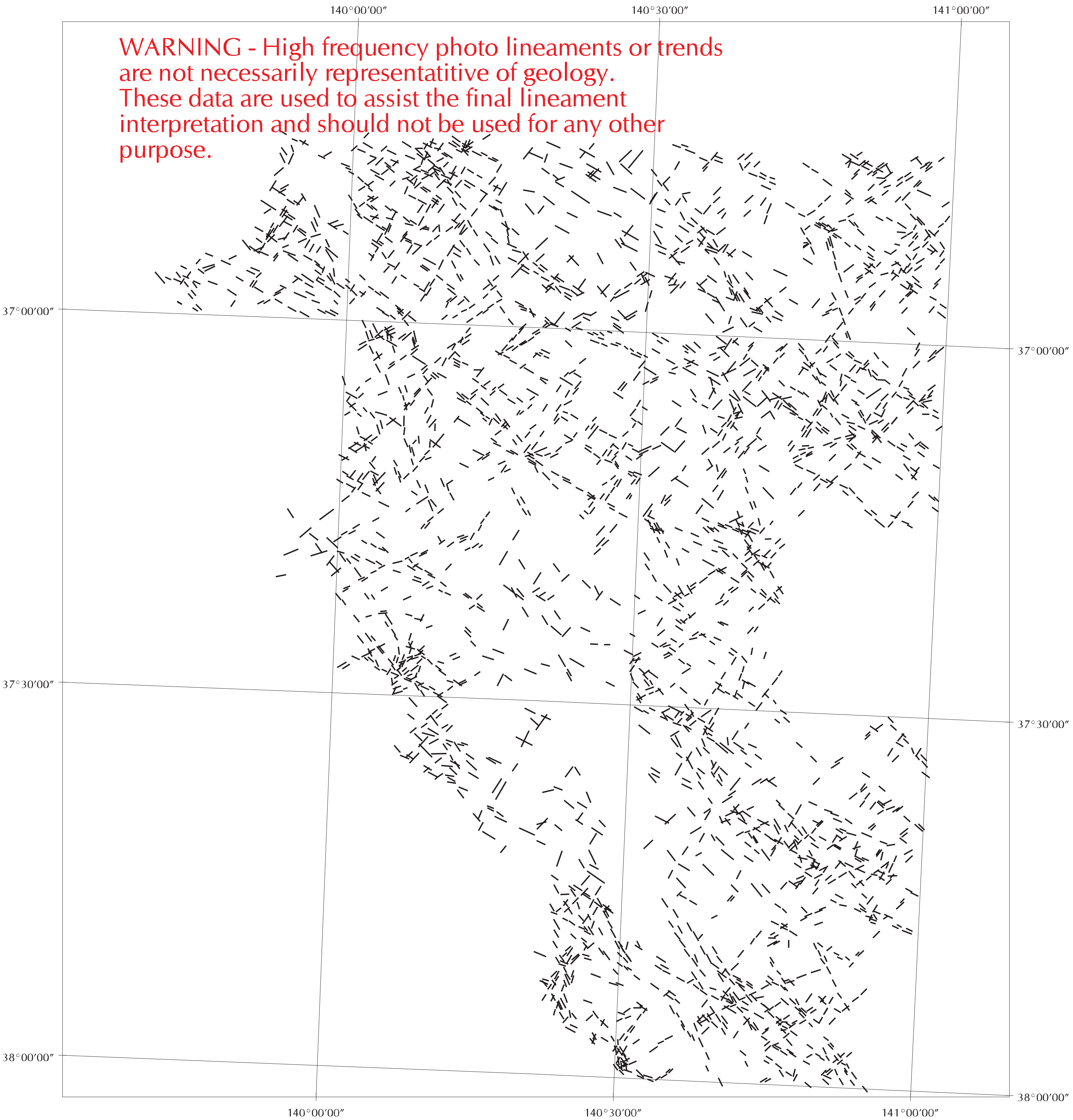
50 0 50 100 150 200
KILOMETERS

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Map 29
98-0082

Lineament Tectonics - South Australia

High Frequency Photo Lineaments - Otway Basin



Authors:
E.S.T O'Driscoll - Lochina Pty. Ltd.
R.K. Boucher - Petroleum Geology, MESA

Digital Data:
Dragan Ivic - Petroleum Geophysics, MESA

Published by, and with the authority of,
the South Australian Department of Mines and Energy Resources

For further information contact MESA on (08) 8274 7500

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Equidistant Simple Conic
Central Meridian 135 degrees
Standard Parallels 18S and 36S
Latitude of Origin 18S
Australian National Spheroid

SCALE 1:600000

10 0 10 20

KILOMETERS

High Frequency Photo Lineaments interpreted by E.S.T O'Driscoll and R.K.Boucher from 1:63,360 air photo mosaics, and geo-referenced using 1:100,000 topographic maps.

Plotted July 1997

Map 30
98-0083

APPENDIX 2

METADATA FOR THE DIGITAL GEOSCIENTIFIC DATA REFERRED TO IN REPORT "LINEAMENT TECTONIC DATA, SOUTH AUSTRALIA WITH A FOCUS ON THE COOPER BASIN"

Prepared by Dragan Ivic, November 1997
Primary Industries and Resources South Australia (PIRSA)

This document contains metadata information pertaining to data used for lineament analysis. In particular, data used in this study include:

- Geological maps
- High Frequency Photo Lineaments
- Aeromagnetic maps
- Gravity maps
- Seismic depth structure maps
- Drainage maps
- Topographic maps
- Economic occurrence maps (petroleum and mineral distributions)
- 1:250 000 map sheet boundaries

Metadata is information about data, presented in a consistent way. It is a description of the characteristics of the geographically referenced datasets that have been collected for this study. It enables the data in this study to be better understood, the limitations realised and thereby be used more effectively.

The metadata, although representative of datasets held by PIRSA, is restricted to the datasets used in this project. These have generally been clipped spatially and pruned thematically.

NOTE:

The original GIS data sets used in the study are available for purchase on a separate CD-ROM. Specific licensing is required for use of AUSLIG's data ie hydrography and DEM themes. The only data which is distributed with the report are the (.pdf) maps used in Appendix 1.

The additional CD-ROM contains all of the digital data used in the project as well as the geological report and this metadata documentation. The geological report is a Word 6.0c document in the '\report' directory. The metadata file is a Word 6.0c document in the '\metadata' directory.

The data on CD-ROM contains point, line and polygon features as well as images. It is supplied in ArcView or Mapinfo formats (depending on what you have ordered) and band interleaved by line (BIL) for the imagery. Individual data themes are stored in separate directories.
Due to the regional nature of this study all datasets are provided in the Equidistant Simple Conic Projection where:

Central Meridian = 135 degrees
Standard Parallels = 18 degrees South and 36 degrees South
Latitude of Origin = 18 degrees South
Spheroid = Australian National Spheroid

SUMMARY OF THE METADATA FORMAT

(based on "ANZLIC Guidelines: Core Metadata Elements" version 1 July 1996)

Category	Element	Comment
Dataset	Title	The ordinary name of the dataset.
	Custodian	The organisation responsible for the dataset.
	Jurisdiction	The state or country of the Custodian.
Description	Abstract	A short description of the contents of the dataset.
	Geographic Extent	Describes the geographic extent in a way that reasonably indicates the spatial coverage of the dataset.
Data Currency	Beginning Date	Earliest date of data in the dataset.
	Ending Date	Last date of information in the dataset.
Dataset Status	Progress	The status of the process of creation of the dataset
	Maintenance and Update Frequency	Frequency of changes or additions made to the dataset.
Access	Stored Data Format	The format(s) in which the dataset is stored on the CD-ROM including size, projection, coordinate system and record count.
	Data Dictionary	Description of the feature attributes
	Access Constraint	Any restrictions or legal prerequisites applying to the use of the dataset eg. licence, re-distribution.
Data Quality	Lineage	A brief history of the source and processing steps used to produce the dataset including capture scale and capture method.
	Positional Accuracy	A brief assessment of the closeness of the location of spatial objects in the dataset in relation to their true position on the Earth.
	Attribute Accuracy	A brief assessment of the reliability of values assigned to features in the dataset in relation to their real world values.
	Logical Consistency	A brief assessment of the logical relationships between items in the dataset. It is a measure of the degree to which data complies with the technical specification.
	Completeness	A brief assessment of the completeness of coverage, classification and verification.
Contact Information	Contact Organisation	Ordinary name of the organisation from which the dataset may be obtained.
	Contact Person	The relevant position in the Contact Organisation.
	Mail Address	Postal Address of the Contact Position.
	Telephone	Telephone of the Contact Person.
	Facsimile	Facsimile of the Contact Person.
	Electronic Mail Address	Electronic Mail Address of the Contact Person.
Metadata Date	Metadata Date	Date that the metadata record for the dataset was created.
Additional Metadata	Additional Metadata	Reference to other directories or systems containing further information about the dataset.

DETAILS OF THE DATASETS INCLUDED ON THE CD

The following datasets are described below:

- Geological Boundaries - detailed
- Geological Boundaries - generalised
- High Frequency Photo Lineaments
- Seismic Depth Structure
- Gravity
- Airborne Magnetics
- Hydrography
- Digital elevation Model
- Gas Fields - Cooper Basin
- Mineral Deposits/Occurrences
- 1:250 000 map sheets

Category	Element	Comment
Dataset	Title	**Geological Boundaries - detailed**
	Custodian	Primary Industries and Resources South Australia
	Jurisdiction	South Australia
Description	Abstract	Detailed mapping of geological boundaries of outcrop geology.
	Geographic Extent	136E-141E;28S-33S
Data Currency	Beginning Date	?
	Ending Date	October, 1997
Dataset Status	Progress	1/3 of the detailed State Geology has been captured digitally.
	Maintenance and Update Frequency	Continuous
Access	Stored Data Format	Arcinfo file name: geol_det Data type: ArcInfo arcs Projection: Equidistant Conic File size: 69.5 Mbytes (ArcInfo directory) Record Count: 116659 arcs
	Data Dictionary	*Arc attributes*: **symbol**:-colour code assigned to arcs in the PIRSA database. **description**:-description of the geological features represented by arcs.
	Access Constraint	none
Data Quality	Lineage	Geological data was derived from published Primary Industries and Resources South Australia (PIRSA) geological map series, aerial photography mapping and PIRSA report books and investigations. Data was captured at 1:100 000 and 1:50 000 by manual digitising.
	Positional Accuracy	Generally accepted as 1:100 000 accurate.
	Attribute Accuracy	Accepted as representative of observations
	Logical Consistency	Data is topologically correct.
	Completeness	The spatial data provided is all that was available at the time or in the process of being compiled for the area of study. Attributes for this dataset have been limited to only one field - ‘description’, as the primary interest in the study was to reveal spatial relationships between geological boundaries in general and high frequency photo lineaments.

Contact Information	Contact Organisation	Primary Industries and Resources South Australia
	Contact Person	Graham Young
	Mail Address	191 Greenhill Rd. PARKSIDE 5063 SA
	Telephone	08 8274 7535
	Facsimile	08 8272 7597
	Electronic Mail Address	gyoung@msgate.mesa.sa.gov.au
Metadata Date	Metadata Date	18 November 1997
Additional Metadata	Additional Metadata	none

Category	Element	Comment
Dataset	Title	**Geological Boundaries - generalised**
	Custodian	Primary Industries and Resources South Australia
	Jurisdiction	South Australia
Description	Abstract	Generalised mapping of geological boundaries of outcrop geology.
	Geographic Extent	South Australia
Data Currency	Beginning Date	?
	Ending Date	October, 1997
Dataset Status	Progress	Data for the whole State is available.
	Maintenance and Update Frequency	Continuous
Access	Stored Data Format	Arcinfo file name: geol_gen Data type: ArcInfo arcs Projection: Equidistant Conic File size: 11.2 Mbytes (ArcInfo directory) Record Count: 9737 arcs
	Data Dictionary	<u>*Arc attributes*</u>: **glcode**:**-** MESA drafting stratigraphic identification code **mapunit**:**-** Stratigraphic code **name**:**-** Formation name **comment**:**-** Description of the stratigraphic unit **comment2**:**-** Description of the stratigraphic unit **comment3**:**-** Description of the stratigraphic unit
	Access Constraint	none
Data Quality	Lineage	Geological data was derived from published Primary Industries and Resources South Australia (PIRSA) geological map series, aerial photography mapping and PIRSA report books and investigations. Originally data was captured at 1:500 000 and 1:1 000 000. As more of the detailed geological mapping is digitised, subsequent generalisations are derived from this data.
	Positional Accuracy	Generally accepted as 1:1 000 000 accurate.
	Attribute Accuracy	Accepted as representative of observations
	Logical Consistency	Data is topologically correct.
	Completeness	The spatial data is the best available at this time. It is refined continuously based on the detailed geological mapping. Only selected attributes are provided for this dataset as the primary interest in the study was to reveal spatial relationships between geological boundaries in general and high frequency photo lineaments.
Contact Information	Contact Organisation	Primary Industries and Resources South Australia
	Contact Person	Graham Young
	Mail Address	191 Greenhill Rd. PARKSIDE 5063 SA
	Telephone	08 8274 7535
	Facsimile	08 8272 7597
	Electronic Mail Address	gyoung@msgate.mesa.sa.gov.au
Metadata Date	Metadata Date	18 November 1997
Additional Metadata	Additional Metadata	none

Category	Element	Comment
Dataset	Title	**High frequency Photo Lineaments (HFPL)**
	Custodian	Primary Industries and Resources South Australia
	Jurisdiction	South Australia
Description	Abstract	The HFPL represent mappable features observed on 1:63,360 air-photo mosaics which sample the regional or continental scale lineament trends.
	Geographic Extent	135E - 141E;27S - 32S
Data Currency	Beginning Date	1960's
	Ending Date	July 1997
Dataset Status	Progress	The data presented is the current status of air photo interpretations. No further work is currently planned.
	Maintenance and Update Frequency	Last update was in July 1997.
Access	Stored Data Format	Arcinfo file name: HFPL Data type: ArcInfo arcs Projection: Equidistant Conic File size: 4.9 Mbytes (ArcInfo directory) Record Count: 46805 arcs
	Data Dictionary	*Arc attributes*: No attributes are stored for this data set
	Access Constraint	none
Data Quality	Lineage	The HFPL lineaments are the result of detailed air-photo interpretations from 1:63,360 air-photo mosaics. These interpretations were designed to map or sample the continental/regional scale lineament trends. The HFPL are restricted to features along or in close proximity to these regional trends. These features were recognised predominantly as tonal contrasts within the photos. Stratigraphy was not mapped. The average length of HFPL of 3km is related to the size of the ore body being sought. The HFPL are used to assist the final lineament interpretation and should not be used for any other purpose.
	Positional Accuracy	The exact positions are subjective and not important as the important dominant trends are revealed in the final analysis.
	Attribute Accuracy	not applicable
	Logical Consistency	All arcs are generally 2 node arcs.
	Completeness	100% of interpreted HFPL's are included in the dataset. There is no HFPL classification. The mapping of HFPL's was verified by comparing the results of two independent interpreters. Furthermore, alignment of HFPL trends across adjacent air-photo mosaics was used to confirm the interpretations.
Contact Information	Contact Organisation	Primary Industries and Resources South Australia
	Contact Person	Rodney Boucher and E.S.T O'Driscoll
	Mail Address	191 Greenhill Rd. PARKSIDE 5063 SA
	Telephone	08 8274 7612
	Facsimile	08 8373 3269
	Electronic Mail Address	lineament@bigfoot.com
Metadata Date	Metadata Date	18 November 1997
Additional Metadata	Additional Metadata	none

Category	Element	Comment
Dataset	Title	**Seismic Depth Structure Maps**
	Custodian	Primary Industries and Resources South Australia
	Jurisdiction	South Australia
Description	Abstract	This dataset depicts depths below sea level to key seismic horizons that have been mapped. The data is presented as pseudo-colour images and contours.
	Geographic Extent	135E - 141E;27S - 32S
Data Currency	Beginning Date	1963
	Ending Date	1994
Dataset Status	Progress	The dataset represents the latest compilations and interpretations available in October, 1997.
	Maintenance and Update Frequency	Last update was in October 1997.
Access	Stored Data Format	File names: **Images** be_depth.(bil,hdr,tif) c_depth.(bil,hdr,tif) p_depth.(bil,hdr,tif) z_depth.(bil,hdr,tif) Arcinfo file names: **Contours** be_depth_edc c_depth_edc p_depth_edc z_depth_edc Data type: Depth structure images are in .bil format. Image header files are in .hdr format. Legends for the images are in .tif format. Contours are ArcInfo arcs. Projection: Equidistant Conic File sizes: **Images** be_depth.(bil,hdr,tif) - 20.9 Mbytes,,143 Kbytes c_depth.(bil,hdr,tif) - 26.4Mbytes,,13 Kbytes p_depth.(bil,hdr,tif) - 6.9Mbytes,,136 Kbytes z_depth.(bil,hdr,tif) - 21.1Mbytes,,175 Kbytes **Contours** be_depth_edc - 19.8 Mbytes (Arcinfo directory) c_depth_edc - 16.1 Mbytes (Arcinfo directory) p_depth_edc - 8.7 Mbytes (Arcinfo directory) z_depth_edc - 13.5 Mbytes (Arcinfo directory) Record Counts: **Contours** be_depth_edc - 4082 arcs c_depth_edc - 3765 arcs p_depth_edc - 3164 arcs z_depth_edc - 5442 arcs
	Data Dictionary	<u>*Arc attributes*</u>: **betop_depth**:- depth (metres) below sea level to seismic horizon 'BE' **ctop_depth**:- depth (metres) below sea level to seismic horizon 'C' **ptop_depth**:- depth (metres) below sea level to seismic horizon 'P' **z50_depth**:- depth (metres) below sea level to seismic horizon 'Z'
	Access Constraint	none

Data Quality	Lineage	Depth structure maps represent interpretations of the sub-surface structure of geological formations. For this study four mapped seismic horizons were selected as being the most representative of the subsurface structural control on the observed lineament trends. These horizons are, starting from the deepest:Top Warburton Basin (Z horizon), Near Top Permian (P horizon), Top Cooper Basin (BE horizon), and Top Cadnaowie formation (C horizon). The dataset represents compilations from seismic data, well data and adapted industry interpretations. These data were gridded at a 200 metre mesh and contoured at either 20 or 50 metres for the 'Z' horizon. The pseudo coloured images have been sun shaded with an azimuth of 45 degrees and an elevation of 60 degrees. Each image has an associated legend in .tif format.
	Positional Accuracy	This is related to the mesh size used to grid the dataset. In this case 200 metres.
	Attribute Accuracy	not applicable
	Logical Consistency	not applicable
	Completeness	100% complete at October 1997. As additional seismic and well data are recorded and become available these interpretations will be refined.
Contact Information	Contact Organisation	Primary Industries and Resources South Australia
	Contact Person	Dave Cockshell
	Mail Address	191 Greenhill Rd. PARKSIDE 5063 SA
	Telephone	08 8274 7671
	Facsimile	08 8373 3269
	Electronic Mail Address	dcockshell@msgate.mesa.sa.gov.au
Metadata Date	Metadata Date	18 November 1997
Additional Metadata	Additional Metadata	none

Category	Element	Comment
Dataset	Title	**Gravity Maps**
	Custodian	Primary Industries and Resources South Australia
	Jurisdiction	South Australia
Description	Abstract	These maps represent the Bouguer Gravity and Residual Gravity fields over a portion of the study area. The data are displayed as contours and pseudo-coloured images.
	Geographic Extent	137:50E - 141:10E;27:47S - 32:12S
Data Currency	Beginning Date	1940's
	Ending Date	1996
Dataset Status	Progress	The dataset represents the latest compilations available in 1996.
	Maintenance and Update Frequency	Last update was in 1996.
Access	Stored Data Format	File names: **Images** bouguer.(bil,hdr,tif) residual.(bil,hdr,tif) Arcinfo file names: **Contours** bouguer residual Data type: Gravity images are in .bil format. Image header files are in .hdr format. Legends for the images are in .tif format. Contours are ArcInfo arcs. Projection: Equidistant Conic File sizes: **Images** bouguer.(bil,hdr,tif) - 5.8 Mbytes,,520 Kbytes residual.(bil,hdr,tif) - 5.8 Mbytes,,762 Kbytes **Contours** bouguer - 7.1 Mbytes (Arcinfo directory) residual - 5.8 Mbytes (Arcinfo directory) Record Counts: **Contours** bouguer - 1840 arcs residual - 2076 arcs
	Data Dictionary	*Arc attributes*: **Bouguer_value**:- strength of the gravity field in milliGals.
	Access Constraint	none
Data Quality	Lineage	The gravity data is sourced from the South Australian Gravity database. This data is unevenly distributed over the area of interest, with points ranging between 400 metre and 7 kilometre spacing. The Bouguer value was calculated using an average density of 2.67 grams per cubic centimetre. The data was gridded at a 300 metre mesh and contoured at 2 milligal interval. The Residual gravity was generated by resampling the original Bouguer 300 metre grid to 20 kilometres which was in turn resampled to 300 metres and subtracted from the original 300 metre grid. Artificial sun shading has been applied to the pseudo-coloured image of the Bouguer Gravity and Residual Gravity images. The sun illuminates the Bouguer scene from the North East (45 degrees) at an elevation of 45 degrees above the horizon. The residual scene is illuminated directly from above (90 degrees).
	Positional Accuracy	This is related to the mesh size used to grid the dataset. In this case 300 metres.
	Attribute Accuracy	not applicable
	Logical Consistency	not applicable
	Completeness	The gravity data used in this study represents the latest data available. Gravity data is collected continuously across the State as the need arises.

Contact Information	Contact Organisation	Primary Industries and Resources South Australia
	Contact Person	Andrew Shearer
	Mail Address	191 Greenhill Rd. PARKSIDE 5063 SA
	Telephone	08 8274 7730
	Facsimile	08 8373 3269
	Electronic Mail Address	ashearer@msgate.mesa.sa.gov.au
Metadata Date	Metadata Date	18 November 1997
Additional Metadata	Additional Metadata	none

Category	Element	Comment
Dataset	Title	**Total Magnetic Intensity Maps**
	Custodian	Primary Industries and Resources South Australia
	Jurisdiction	South Australia
Description	Abstract	The Total Magnetic Intensity data represent the strength of the Earth's magnetic field over the study area. The data are displayed as contours and a pseudo-coloured image.
	Geographic Extent	136:30E - 141E;26S - 33S
Data Currency	Beginning Date	1950's
	Ending Date	1996
Dataset Status	Progress	The dataset represents the latest compilations available in 1996.
	Maintenance and Update Frequency	Last update was in 1996.
Access	Stored Data Format	File names: **Images** tmi.(bil,hdr,tif) Arcinfo file names: **Contours** mag200 mag50 Data type: TMI images are in .bil format. Image header files are in .hdr format. Legends for the images are in .tif format. Contours are ArcInfo arcs. Projection: Equidistant Conic File sizes: **Images** tmi.(bil,hdr,tif) - 34.8 Mbytes,,818 Kbytes **Contours** mag200 - 14.9 Mbytes (Arcinfo directory) mag50 - 63.1 Mbytes (Arcinfo directory) Record Counts: **Contours** mag200 - 6074 arcs mag50 - 23740 arcs
	Data Dictionary	*Arc attributes*: **tmi_value**:- strength of the magnetic field in nanoTesla.
	Access Constraint	none
Data Quality	Lineage	The Total Magnetic Intensity dataset has been sourced from the South Australian Airborne Magnetics database. It has been produced by compiling and merging datasets from a variety of surveys including MESA South Australian Exploration Initiative, AGSO and MESA Broken Hill Initiative and open-file company surveys. Airborne survey parameters are: line spacing from 100 metres to 400 metres; terrain clearance 60 metres to 150 metres. The data exhibits gaps and levelling errors and due diligence should be exercised when performing interpretations. The data was gridded at a 200 metre mesh and contoured at intervals of 200 metres and 50 metres. Artificial sun shading has been applied to the pseudo-coloured TMI image. The sun illuminates the scene from above (90 degrees). The pseudo-colour was produced by applying a histogram equalise transform to the full data range using a pseudo-colour lookup table.
	Positional Accuracy	This is related to the mesh size used to grid the dataset. In this case 200 metres.
	Attribute Accuracy	not applicable
	Logical Consistency	not applicable
	Completeness	The airborne magnetic data used in this study represents the latest data available. Airborne magnetic data is collected continuously across the State as the need arises.

Contact Information	Contact Organisation	Primary Industries and Resources South Australia
	Contact Person	Gary Reed
	Mail Address	191 Greenhill Rd. PARKSIDE 5063 SA
	Telephone	08 8274 7638
	Facsimile	08 8373 3269
	Electronic Mail Address	greed@msgate.mesa.sa.gov.au
Metadata Date	Metadata Date	18 November 1997
Additional Metadata	Additional Metadata	none

Category	Element	Comment
Dataset	Title	**Hydrography**
	Custodian	Primary Industries and Resources South Australia
	Jurisdiction	South Australia
Description	Abstract	Surface drainage patterns including streams, rivers, swamps and lakes.
	Geographic Extent	135E - 142:30E;26S - 33S
Data Currency	Beginning Date	?
	Ending Date	1992
Dataset Status	Progress	Data derived from AUSLIG's TOPO 250K geodata Product - HYDROGRAPHY theme
	Maintenance and Update Frequency	Last update was in 1992.
Access	Stored Data Format	Arcinfo file names: **Contours** drainage waterbdy Data type: Contours are ArcInfo arcs. Projection: Equidistant Conic File sizes: **Contours** drainage - 24 Mbytes (Arcinfo directory) waterbdy - 9.3 Mbytes (Arcinfo directory) Record Counts: **Contours** drainage - 140,662 arcs waterbdy - 17,718 arcs
	Data Dictionary	*Arc attributes*: not applicable
	Access Constraint	The hydrographic data is provided as it is a valuable component to understanding the nature of lineament trends. However, the data as provided on the CD-ROM must not be used without first obtaining a licence to use the data. Please contact AUSLIG Data Sales (tel. 06 2014 339) or visit their web site (http://www.auslig.gov.au) to obtain further information or discuss your requirements.
Data Quality	Lineage	The AUSLIG topographic mapping data (TOPO-250K) was derived from the 1:250 000 scale National Topographic Map Series.
	Positional Accuracy	Better than 125 metres
	Attribute Accuracy	not applicable
	Logical Consistency	Varies from 0% to 5%
	Completeness	More than 95%
Contact Information	Contact Organisation	Primary Industries and Resources South Australia
	Contact Person	Stephen Bell
	Mail Address	191 Greenhill Rd. PARKSIDE 5063 SA
	Telephone	08 8274 7737
	Facsimile	08 8373 3269
	Electronic Mail Address	sbell@msgate.mesa.sa.gov.au
Metadata Date	Metadata Date	18 November 1997
Additional Metadata	Additional Metadata	none

Category	Element	Comment
Dataset	Title	**Digital Elevation Model (DEM)**
	Custodian	Primary Industries and Resources South Australia
	Jurisdiction	South Australia
Description	Abstract	The DEM is a model of the terrain in which each data point represents the average elevation for the respective mesh point.
	Geographic Extent	135E - 142:30E;26S - 33S
Data Currency	Beginning Date	?
	Ending Date	July 1996
Dataset Status	Progress	Data derived from Auslig TOPO 250K geodata Product - 9 SECOND DEM theme
	Maintenance and Update Frequency	?
Access	Stored Data Format	File names: **Images** dem.{bil,hdr,tif} Data type: **Images** DEM images are in .bil format. Image header files are in .hdr format. Legends for the images are in .tif format. Projection: Equidistant Conic File sizes: **Images** dem.{bil,hdr,tif} - 44.3 Mbytes,,155 Kbytes
	Data Dictionary	<u>*Arc attributes*</u>: not applicable
	Access Constraint	The DEM data is provided as it is a valuable component to understanding the nature of lineament trends. However, the data as provided on the CD-ROM must not be used without first obtaining a licence to use the data. Please contact AUSLIG Data Sales (tel. 06 2014 339) or visit their web site (http://www.auslig.gov.au) to obtain further information or discuss your requirements.
Data Quality	Lineage	The DEM is derived from AUSLIG's GEODATA TOPO-250K digital map product - 9 SECOND DEM. This is a grid of elevation points covering the area of the study with a grid spacing of 9 seconds in latitude and longitude (approx. 250 metres). The source for the DEM was national spot height elevation data taken from 1:100 000 scale topographic mapping as well as river and waterbody information from 1:250 000 topographic mapping. For this study the data was gridded at a 200 metre mesh. Artificial sun shading has been applied to the pseudo-coloured DEM image. The sun illuminates the scene from the North East (45 degrees) at an elevation of 45 degrees above the horizon.
	Positional Accuracy	The standard deviation is 25 metres.
	Attribute Accuracy	not applicable
	Logical Consistency	?
	Completeness	100%
Contact Information	Contact Organisation	Primary Industries and Resources South Australia
	Contact Person	Stephen Bell
	Mail Address	191 Greenhill Rd. PARKSIDE 5063 SA
	Telephone	08 8274 7737
	Facsimile	08 8373 3269
	Electronic Mail Address	sbell@msgate.mesa.sa.gov.au
Metadata Date	Metadata Date	18 November 1997
Additional Metadata	Additional Metadata	none

Category	Element	Comment
Dataset	Title	**Gas Fields - Cooper Basin**
	Custodian	Primary Industries and Resources South Australia
	Jurisdiction	South Australia
Description	Abstract	Boundaries of gas fields in the Cooper Basin.
	Geographic Extent	139:30E - 141E;27S - 29S
Data Currency	Beginning Date	?
	Ending Date	July 1997
Dataset Status	Progress	Data is being updated with more accurate representations of the gas field boundaries
	Maintenance and Update Frequency	In progress
Access	Stored Data Format	Arcinfo file names: fields Data type: Data is stored as arcs and regions Projection: Equidistant Conic File sizes: fields - 660 Kbytes (Arcinfo directory) Record Counts: fields - 1144 arcs and 158 regions
	Data Dictionary	*Arc attributes*: not applicable
	Access Constraint	none
Data Quality	Lineage	The gas field boundaries have been derived from information obtained from various geological formations in the Cooper basin area. The database is preliminary and incomplete.
	Positional Accuracy	?
	Attribute Accuracy	not applicable
	Logical Consistency	?
	Completeness	Preliminary and incomplete
Contact Information	Contact Organisation	Primary Industries and Resources South Australia
	Contact Person	Alan Sansome
	Mail Address	191 Greenhill Rd. PARKSIDE 5063 SA
	Telephone	08 8274 7672
	Facsimile	08 8373 3269
	Electronic Mail Address	asansome@msgate.mesa.sa.gov.au
Metadata Date	Metadata Date	18 November 1997
Additional Metadata	Additional Metadata	none

Category	**Element**	**Comment**
Dataset	Title	**Mineral Deposits/Occurrences**
	Custodian	Primary Industries and Resources South Australia
	Jurisdiction	South Australia
Description	Abstract	Point locations of mineral deposits.
	Geographic Extent	135E - 141E;26S - 33S
Data Currency	Beginning Date	not known
	Ending Date	not known
Dataset Status	Progress	Dataset is not complete. Updates are in progress.
	Maintenance and Update Frequency	Currently being upgraded.
Access	Stored Data Format	Arcinfo file names: minocc Data type: Data is stored as points Projection: Equidistant Conic File sizes: minocc - 572 Kbytes (Arcinfo directory) Record Counts: minocc - 499 points
	Data Dictionary	*Arc attributes*: Easting - map coordinate on AMG 54 in metres Northing - map coordinate on AMG 54 in metres Zone - Australian Map Grid zone Id_deposit - unique identifying number for the deposit Major_commodity - list of major commodities to be found in the deposit Minor_commodity - list of commodities found in lesser amounts Show_commodity - list of commodities detected in trace amounts in the deposit Name_site - name of the deposit Name_synonym - an alternative name for the deposit Orebody - description of the site and orebody Mineralisation - Nature and style of mineralisation Author - author of reference document Year - year of document publication Title - document title Publication - publication details
	Access Constraint	none
Data Quality	Lineage	Quality of spatial data is variable. The attribute data quality is estimated at 80%. The source of the data are field surveys. Point coverage captured at 1:100,00-1:50 000 scale. Attribute subset of Mines and Energy Resources MINDEP database, not all 1:250 000 mapsheets have been covered to date.
	Positional Accuracy	?
	Attribute Accuracy	not applicable
	Logical Consistency	?
	Completeness	Under review
Contact Information	Contact Organisation	Primary Industries and Resources South Australia
	Contact Person	Michelle Bullock
	Mail Address	191 Greenhill Rd. PARKSIDE 5063 SA
	Telephone	08 8274 7719
	Facsimile	08 8373 3269
	Electronic Mail Address	mbullock@msgate.mesa.sa.gov.au
Metadata Date	Metadata Date	18 November 1997
Additional Metadata	Additional Metadata	none

Category	Element	Comment
Dataset	Title	**1:250 000 map sheet boundaries**
	Custodian	Primary Industries and Resources South Australia
	Jurisdiction	South Australia
Description	Abstract	Boundaries of 1:250 000 map sheets
	Geographic Extent	135E - 141E;26S - 33S
Data Currency	Beginning Date	?
	Ending Date	?
Dataset Status	Progress	All map boundaries and names have been defined.
	Maintenance and Update Frequency	All map boundaries and names have been defined.
Access	Stored Data Format	Arcinfo file names: maps250k Data type: Data is stored as arcs and polygons Projection: Equidistant Conic File sizes: minocc - 68 Kbytes (Arcinfo directory) Record Counts: maps250k - 81 arcs, 36 polygons
	Data Dictionary	*Arc attributes*: map-num - 1:250 000 map number map-name - 1:250 000 map name
	Access Constraint	none
Data Quality	Lineage	1:250 000 mapsheet boundaries and names are the responsibility of the Australian Survey and Land Information group (AUSLIG).
	Positional Accuracy	Mapsheet boundaries are defined along particular latitude/longitude lines.
	Attribute Accuracy	100%
	Logical Consistency	100%
	Completeness	Complete
Contact Information	Contact Organisation	Primary Industries and Resources South Australia
	Contact Person	Stephen Bell
	Mail Address	191 Greenhill Rd. PARKSIDE 5063 SA
	Telephone	08 8274 7737
	Facsimile	08 8373 3269
	Electronic Mail Address	sbell@msgate.mesa.sa.gov.au
Metadata Date	Metadata Date	18 November 1997
Additional Metadata	Additional Metadata	none