Rep.Bk.No. 62/93
G.S. No. 3439

Author

DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY

REGIONAL SURVEYS DIVISION

REPORT ON RIFTS AND MAJOR SHEAR FAULTS
SOUTH AUSTRALIA

Questionnaire for Working Group on Tectonics

Upper Mantle Committee

by

B.P. THOMSON
SUPERVISING GEOLOGIST

D.M. 773/65

26th April, 1966

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ABSTRACT

The definition of rifts and major shear faults is discussed, A preliminary tectonic map of South Australia using available regional mapping, geophysical and subsurfaoe information has been prepared for this report. An outline of the tectonic framework of South Australia is presented emphasizing trends of major features. The second part of the report presents the information for the I.U.M.C. questionnaire on rifts and major shear faults in South Australia.

INTRODUCTION

The South Australian Divisional Sub-Committee of the Tectonic ~~Group~~ Map Committee was requested in September, 1965 to compile information on rifts and major shear faults in this state. This information was requested to be in the form of answers to a questionnaire circulated by Dr. J. Goguel, (Paris), who is Reporter of the Working Group on Tectonics of the I.U.M.C. (International Upper Mantle Committee).

The task of preparing the data was referred to the writer by the Deputy Director of Mines and Chief Geologist. It was found that preparation of a preliminary tectonic map of the state from scattered geological and geophysical data was necessary before the questionnaire could be answered. This initial work has delayed preparation of this report.

PART 1. PRELIMINARY STUDY

DEFINITIONS

1. <u>Rifts</u> The following definition is given in circular letter No. 14. International Union of Geological Sciences p.26 -

"rifts are considered elongated structural depressions, generally with one or two marginal faults, and of between 10 and 60km. width" - "synclinal" or "basin" and erosional depressions are excluded.

Interpretation of the definition in the broadest sense raises a number of problems in this state e.g. classification of the elongate features such as the largely concealed Officer Basin and the Kanmantoo Trough as either rifts or geosynclinal troughs. Likewise some of the elongate troughs of Mesozoic and Upper Palaeozoic basinal areas of sedimentation revealed by subsurface exploration in the Great Artesian Basin and elsewhere are in part fault controlled. It was decided owing to inadoquate data on these other areas to restrict description to the Torrens - St. Vincent Rift which clearly complies with the definition.

2. <u>Major Shear Faults</u> According to circular letter No. 14. (I.U.G.S.) page 27. - the term includes - "major faults several tens of hundreds of kilometers in length along which horizontal movement has been proved."

The writer has been unable to find a definition of shear fault in a number of standard texts which have been consulted.

It is assumed therefore that the definition is not restricted to wrench (strike-slip or transcurrent) faults which are vertical faults due to compressive stress on which predominant movement has been in the strike direction. De Sitter ("Structural Geology" - Chap. 12 - 2nd Ed.) describes "great fundamental faults" which may act in part as wrench faults. These are large features of great age belonging to major mountain chains and characterised by frequent movements along their contiguous faces. If this broader concept is adopted for the term major shear fault, it is possible to delineate a number of such features in South Australia which show evidence of having had horizontal components of movement.

METHOD OF COMPILATION AND STUDY OF DATA

Structural features of areas covered by regional mapping were assessed. Reports by government and petroleum exploration companies dealing with subsurface information in the younger basin areas were studied for evidence of faulting. In particular, regional gravity and aeromagnetic maps provided valuable information on broad basement configurations. A large number of air photo mosaics were scanned for evidence of regional lineaments.

A fact map (figure 1) was compiled on a scale of 1-inch to 120 miles showing known and probable fault lineaments. Further investigations would undoubtedly reveal much additional data since geophysical and geological mapping and subsurface data are incomplete. Numerous air photo lineaments in the Murray and Eucla Basins have not been shown on the fact map owing to difficulty in distinguishing between major joint systems and zones of faulting. The seismicity paper by Burke-Gaffney (1952), although now out of date, provided a useful guide to location of epicentres. Finally a tectonic sketch map (Fig.2) was compiled on the same scale as the fault fact map. This map is the basis for the following tectonic interpretation.

TECTONIC OUTLINE OF SOUTH AUSTRALIA

(1) The Tectonic Units

Seven tectonic features can be recognized.

1. The Gawler Platform* - A stable crystalline basement composed of sediments probably of Lower Proterozoic age (<2500m.) intruded and metamorphosed by granitic rocks of Carpentarian age (Middle Proterozoic 1500m. years to 1800m. years), mantled in part by Adelaidean, Palaeozoic, Mesozoic and Tertiary shelf sediments.

2. Mobile crystalline basement blocks of Median Belt - viz. Musgrave

* NOTE: The feature includes the Gawler ~~Granitic~~ Cratonic Nucleus(Sprigg,1953) and Shelf areas. c.f. East-European platform, ref. A. Bogdanoff. Explan.Note to Int.Tect. Map Europe 1964, pp.26-29 (Int. Geol. Congr.)

Block - Peake-Denison-Mount Painter-Mt. Babbage Block, Willyama Block. Age is pre-Adelaidean, intruded and metamorphosed by Carpentarian granitic rocks and later re-folded, faulted and intruded in places by granites during the Ordovician.

3. <u>Adelaide Geosyncline and Officer Basin</u> - The sediments are Adelaidean (Upper Proterozoic <1400m. years), Cambrian and in part of Ordovician age. These basinal areas separate the Median Belt and Gawler Platform. Pre-Adelaidean crystalline basement intruded by Ordovician granites is exposed in anticlines along the SE. flank of the Adelaide Geosyncline.

4. <u>Kanmantoo Trough</u> - Lower to Middle Cambrian geosynclinal belt which truncates Gawler Platform and flanking Adelaide Geosyncline and probably extends to south flank of the Willyama Block under cover of Tertiary marine sediments of the Murray Basin. Metamorphosed and extensively intruded particularly to the south and east by granites of Ordovician age. Floor of trough acted as tectonic unit and is possibly underlain by crystalline Precambrian Basement.

5. <u>Great Artesian Basin Region</u> - An extensive Mesozoic basin, mantling Palaeozoic fold belts which merge to the east into the Tasman Geosyncline (Wopfner, 1965).

6. <u>Gambier Embayment of Otway Basin</u> - A deep trench of Tertiary and Mesozoic sediments extending across the continental shelf and south-east into Victoria.

7. <u>Southern Ocean Region</u> - Three features are present:-

   a. Continental shelf.

   b. Continental slope

   c. Jeffery Deep (South Australian Basin)

   In the vicinity of $140^{\circ}30'$E the edge of Continental shelf is only 30 miles (50km.) from the coastline. The floor of the Jeffery Deep extends to the east-southeasterly so that at $140^{\circ}30'$E - 39°S it is only 55 miles (85km.) from the coastline. The ocean deep may be of great tectonic significance as it has probably influenced the evolution of the tectonic framework over a long period.

(ii) Tectonic Trends and Fault Patterns

South Australia is dominated by NW to WNW trending tectonic features. Crossing this set of ancient trends are NE, N and generally subordinate E-W trends which give rise to a fundamental pattern of polygonal basement blocks and wedges of varying mobility. The dominant stress relief appears to have been upwards and to have been controlled by deep movements below the crust as well as gravity phenomena. Block margins have been the loci of horizontal components of movements in some zones. Features can be grouped into the various trend directions as follows:-

1. N.W. and WNW Trends

a. Median Belt chain of basement rocks. These include many structural features commencing with Hinkley Fault on the Western Australia border and extending to the MacDonald Fault near the New South Wales border.

The Musgrave Block is shaped like a broad letter "V". The SW flank may be marginal to a concealed Proterozoic or Palaeozoic sedimentary basin extending WNW into Western Australia.

b. Deflection of northern portion of Adelaide Geosyncline along Norwest Fault trend. The Geosyncline is bounded to the north by a high gravity feature* which is interpreted as shallow basement. This is referred to as the Muloorinna Gravity Ridge.

c. Long axis of Gawler Platform, bounded on south west by the obscure Nuyts Lineament zone. This structural trend extends NW under the Eucla Basin. The geology of the continental shelf north of 35°30'S is at present unknown. The trend re-occurs SE on the northern hinge line margin of the Otway Basin. A major geophysical discordance occurs on the edge of the con-

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* NOTE: See Fig. 5 in La Ferrere, J. & Drayton, R.D. 1965. A.P.E.A. Journal 1965.p. 53. Some Geophysical Results across the Simpson Desert (pp. 48-58).

tinental shelf in this basin. The basin is also an area of seismicity and Cainozoic vulcanism. The Marmon Jabuk Fault is a parallel structure to the north which underwent minor movements in the Tertiary.

d. N.W. and WNW trends in edge of continental shelf and axis of Jeffery Deep.

e. Gairdner (aeromagnetic) Lineament which probably marks the western limit of Precambrian shelf sediments on this part of the Gawler Platform.

2. NE Trends

a. Kanmantoo Trough on the mainland, Aeromagnetic data links the Trough with the Anabama Fault on the northern margin of the Murray Basin. Intermittent minor subparallel faults follow the Anabama Fault trends across the southern end of the Adelaide Geosyncline.

b. Paralana Fault - a complex zone of steep faults controlling the western margin of the Frome Embayment. The Naryilco Lineament (Wopfner, 1966) represents in part an extension of this fault zone to the N.E.. To the S.W. it appears tobe taken up by block movements in the floor of the Adelaide Geosyncline. The Lincoln Fault - a geomorphic lineament-is the possible extension to the S.W. of this major zone of faulting.

c. Officer Basin - Trend is marked by folded Adelaidean and Ordo-*vician sediments. Extension to the N.E. is suggested by a gravity depression, the Abminga Gravity low. Extension to the S.W is suggested by geophysical data, and regional mapping along the southern edge of the Musgrave Block.

A parallel feature is the Ferdinand Fault which extends NE into the Northern Territory and influences the Amadeus Basin.

3. N-S Trends - The Torrens lineament is a marked feature in the tectonic framework of South Australia. Many fault structures occur in the southern and southwestern sector of the Adelaide Geosyncline which are parallel to the lineament.and extend south

NOTE: Canaple, J & Langdon-Smith, 1965. The Pre-Mesozoic Geology of the Western Great Artesian Basin. A.P.E.A. Journal,1965, discuss subsurface geology.

into the Kanmantoo Trough. This structural zone is outlined by the meridional alignment of many seismicity epicentres (Fig. 2). N-S features reappear farther north in the Peake & Denison Ranges. This region marks the known northern extension of the Geosyncline into the Median Belt. The Dalhousie gravity low* extends however from Oodnadatta northwards to latitude 26°. Farther north the low appears to combine with the Abminga gravity low and swing westward as a weak gravity trough to the Amadeus Basin. The Dalhousie low feature is known to contain Mesozoic and Palaeozoic sediments but may also include Adelaidean sediments in depth. This interpretation suggests the Adelaide Geosyncline may be terminated at about 25°30' south by the Musgrave Block.

4. E-W Trends - The Uno Fault controls the distribution of Gawler Range volcanics and was probably active during late Carpentarian (1500m. years). The Hampton Fault, a lineament at the head of the Great Australian Bight, may represent a reactivated extension of the Uno Fault. Intermittent E-W Faults appear in the Torrensian cores of anticlines in the Geosyncline to the east. The Faults were apparently active in Late Torrensian or Early Sturtian time (Upper Proterozoic). The E-W trend of the edge of the continental shelf west of 132°E may be related to the same major structural zone.

ACKNOWLEDGEMENTS

The writer has had the generous assistance of his colleagues in the Geological Survey. In particular Dr. H. Wopfner, I.B. Freytag and K. Rochow of the Petroleum Exploration Division have been helpful in supplying their interpretations and data on the configurations and tectonios of the younger basin areas. Papers by Hills, Sprigg, Campana, Webb and Thomson, listed in the bibliography attached to this report include appraisals of South Australian tectonics.

*NOTE: Incorporated in Pedirka Basin of Canaple & Langdon-Smith (op.cit.). Witcherrie No. 1 Well in the basin, bottomed at 1.47 km. in 300 meters of presumed Ordovician sandstone. Magnetic basement of unknown age at 2-3 km.

PART 2

I.U.M.C. QUESTIONNAIRE

SOUTH AUSTRALIA

Rifts

1.10 NAME: Torrens - St. Vincent Rift.

Includes "Pirie-Torrens Basin", "St. Vincent Basin" "Lake Torrens Sunkland."

1.11 POSITION (Fig.1) Southeastern South Australia.

Includes Gulf St. Vincent Area, Adelaide Plains, head of Spencer Gulf and Lake Torrens region. Southern extremity is N.E. coast of Kangaroo Island at 35°40'S to northern end of Lake Torrens at 30°15'S.

1.20 STRUCTURAL CHARACTERISTICS

The Structure is controlled by Precambrian and Palaeozoic fault systems which were reactivated during the Cainozoic. These systems include the Torrens Lineament and other meridional and northeasterly trending faults in the Adelaide Geosyncline. The rift is a meridional feature of variable width. Maximum width is about 70 kilometers (40 miles) in St. Vincent Basin to the south. Width may locally pinch to zero in the central area between Snowtown and Crystal Brook due to movements on the Templeton Fault on the east side of the Hummocks-Barunga Ranges. Total length of the rift is about 600 kilometers (380 miles). The marginal faults appear to have acted as normal gravity faults during the Cainozoic. Throw is greatest on the eastern flank of the St. Vincent Basin where a succession of step faults probably accounts for about 900 meters (3000 feet) of movement. In the Lake Torrens area, throw during the Cainozoic was at least 300 meters (1000feet).

1.30 AGE OF MOVEMENTS - The following sedimentary record indicates fault movements in the Cainozoic. Eocene Sands and coal measures in St. Vincent Basin were followed by marine Oligocene-Pliocene and Pleistocene terrestrial sediments (total thickness about 700 meters (2200 feet).

In the Lake Torrens area, Tertiary and Pleistocene terrestrial and lacustrine sediments are about 300 meters (1000 feet) thick.

1.50 VOLCANIC ACTIVITY RELATED TO RIFT - Local late Cainozoic basalt flows on Kangaroo Island.

1.60 SEISMIC ACTIVITY OR INDICATIONS OF RECENT MOVEMENT - The rift forms the western margin of a seismic zone of minor activity (Burke-Gaffney, 1952).

1.70 INDICATIONS FOR POSSIBLE PATTERNS OF ANCIENT MOVEMENTS OLDER THAN THE ACTUAL RIFTING - The western margin of the rift coincides with the Torrens Lineament. This will be discussed more fully below and evidence given for Proterozoic movements along this feature. The eastern fault zones of the rift were active as steep up-thrust fault structures during the Ordovician orogeny. The rift zone has been the site of much older sedimentation. This sedimentation probably began between 1,300 m. and 1,400 m. years, and continued intermittently until Middle Cambrian time.

I.U.M.C. QUESTIONNAIRE

SOUTH AUSTRALIA

Major Shear Faults

2.10 NAME: Mann Fault (important member of the Median Belt Fault System).

2.10 POSITION - Traceable for 250 kilometres (155 miles) from 26°S 129°25' to 26°30'S - 131°50'E. It probably extends as a single structure to the Indulkana Range area 27°S - 133°20'E.

2.20 NATURE OF OBSERVATIONS INDICATING HORIZONTAL DISPLACEMENT ETC. - The Fault dips S.S.W. at about 60 degrees. A possible north-block-east displacement is suggested by the distribution of the regional metamorphic zones. The dominant movement, however, appears to be north-block upward. These vertical movements were probably pene-contemporaneous with the emplacement of granitic bodies and mafic and ultramafic intrusions of the Giles Complex. Further indirect evidence for north-block east movements is suggested by the drag on Adelaidean and Ordovician and their truncation by basement rocks in the Indulkana Range area. The maximum possible movement is about 30 miles (20 kilometres). Similar wrench movements may be interpreted for the displacement of the Moorilyana conglomerate on parallel structures to the north, described by Coats (1962) these movements are now considered to be Pre-Adelaidean (Late-Carpentarian ?) in age. An apparent north-block-east displacement may be interpreted to occur between the Hamilton and Wintinna gravity highs farther east towards Oodnadatta. Farther to the southeast, north block east movements are suggested by the echelon fault patterns and drag structure in the Adelaidean sediments in the McDonald Fault zone. Wopfner (1966) described a north-block west displacement of the Paralana Fault by the Lake Blanche Fault lineament.

2.30 SEISMIC ACTIVITY OR INDICATIONS OF RECENT OR SUB RECENT MOVEMENT - No seismic activity reported. Geomorphological evidence and distribution of Quaternary sediments and surfaces suggest Quaternary movements ~~to the~~ North block up were ~~made~~ in the Mann Range area.

2.40 RELATION TO FOLDED CHAINS, OTHER FAULTS - The Mann Fault may continue to the southeast as the Lake Eyre Lineament (Wopfner, 1964). This Lineament appears to cut the shallow block crystalline basement flanking the eastern margin of the Adelaide Geosyncline. East-west faults in the Adelaidean sediments west of the Paralana Fault suggests a southerly direction of movement of basement in this region. Likewise, the Willyama Block fold structures both in the basement and Adelaidean cover rocks shows that the block as a whole has moved to the southeast. The central part of the Willyama Block in New South Wales is cut by the W.N.W. trendingThackaringa Fault with apparent north-block ~~west~~ east movement (King & Thomson 1953) which may represent a regional extension of the Mann Fault. The Thackaringa Fault like the Mann Fault and Hinkley Fault is an ancient feature within the basement and is associated with intrusive mafic and ultra mafic rocks.

Adjoining the Mann Fault to the south and west is the important Hinkley Fault. This is a steep dipping structure associated with basic and ultramafic Giles Complex. It extends far into Western Australia.

1.10 NAME: Torrens Lineament.

1.11 POSITION: - This complex fault system strikes approximately North-South and extends from 30°S - 147°5'E to 35°45'S - 137° 45'E.

2.2. NATURE OF MOVEMENTS INDICATING HORIZONTAL DISPLACEMENTS ETC. - The pattern of folding in the Adelaidean sediments suggests a relative southerly component of movement of the Gawler Platform block The lineament marks a hinged zone of rapid thickening of the Adelaidean sediments on the western flank of the Adelaide Geosyncline. The section thickens from west to east across the lineament from a few thousand to tens of thousands of feet in the Geosyncline. The evidence of thickening east of the lineament is supported by evidence of a low gravity trough in the St. Vincent Gulf Area and S.W. margin of central and southern Flinders Ranges. The lineament also marks the western limit of strong folding of Adelaidean and Cambrian sediments. (Ordovician Orogeny). Moderate folding of these sediments has occurred in the Yorke Peninsula area however.

2.3 SEISMIC ACTIVITY - Minor epicentres are relatively abundant (Fig. 2) east of the lineament. One epicentre occurs on the lineament in the Warooka area at the heel of Yorke Peninsula.

2.4 RELATION TO FOLDED CHAINS, OTHER FAULTS, POSSIBLE EXTENSION - The lineament forms the western boundary of a zone of important faults and shears up to 80 miles (130 km.) wide in the southern part of the Adelaide Geosyncline which intermeshes with the margin of the Kanmantoo Trough. At about 30° south the northern extension of the lineament is interrupted by the northwesterly trend of the Median Belt. To the south, available evidence indicates that the lineament is terminated by the Cygnet Fault margin of the Kanmantoo Trough.

I.U.M.C.

QUESTIONNAIRE

Shear Faults

2.10 NAME: Cygnet Fault.

2.11 POSITION: - It probably extends from the edge of the continental shelf at about 35°45'S, 135°45'E to the northwest coast of Kangaroo Island and is connected by the linking Snelling Fault to the main Cygnet Fault (Sprigg, 1954, Kingscote 4-mile sheet). From there it appears to extend east-northeast on the seaward side of Fleurieu Peninsula. The fault crosses the coast at about 35°28'S and there connects with the Meadows-Kitchener Fault systems which form the structural background of the Mount Lofty Ranges (Thomson, 1965).

2.12 DIRECTION OF MOVEMENT - In Kangaroo Island a south block-west movement is indicated. In the Mount Lofty Ranges the movement on the eastern flank was probably south and west.

2.21 NATURE OF OBSERVATIONS INDICATING DIRECTION OF MOVEMENT ETC. - Evidence of south block-west movement of the Kanmantoo Trough region west of Kangaroo Island is suggested by the re-entrant feature in the edge of the continental shelf to the west.

In Kangaroo Island the pattern of E.N.E. trending fold structures in the Cambrian geosynclinal sediments (Kanmantoo Group) support a south block-west movement interpretation. In Kangaroo Island the fault forms the northern limit of the high grade metamorphism and granite intrusions, it also marks the hinge line of the Kanmantoo Trough in which the Kanmantoo Group may attain a thickness of some 15,000 meters (50,000 feet). A similar relationship between metamorphism and Kanmantoo Group sedimentation is observed along the Meadows-Kitchener Fault system of the Mt. Lofty Ranges. In the Mt. Lofty Ranges the enechelon pattern of folding in the Kanmantoo Group is outlined by a right handed arrangement of north-south striking synclines which show marked lineations and minor fold structures plunging southeast of south-southeast. Movements which developed these structures occurred during Kanmantoo Group sedimentation and were apparently continued during the Ordovician orogeny.

2.3 SEISMIC ACTIVITY - Several minor epicentres occur in proximity to the Kitchener-Meadows Fault.

2.40 RELATION TO FOLDED CHAINS ETC.- The fold pattern described in 2.21 contrasts with the left handed anticlinal en echelon system of folding in the Adelaidean and older rocks of the central Mount Lofty Ranges and to the north. It is suggested that evolution of this pattern commenced before the onset of Kanmantoo Group sedimentation and may extend back into Proterozoic time before the onset of the shear faulting that appears to have controlled the margin of the Kanmantoo Trough.

2.41 RELATION TO OTHER FAULTS AND POSSIBLE EXTENSIONS ETC. - The northeast trending Encounter Fault, which was active in the Tertiary appears to be parallel to the complex margin of the Kanmantoo Trough developed in the Mount Lofty Ranges. Northeast of the Mount Lofty Ranges the east block south and west movements were taken up by the complex fault systems of the Palmer, Florieton and Morgan Faults on the west side of the Murray Basin. These faults finally linking with the Anabama Fault system, interpreted from the aeromagnetic data. The Redan Fault* on the southeast margin of the Willyama Block in New South Wales appears to be the equivalent of the Anabama Fault offset to the east by movements on the McDonald Fault. The Redan Fault is part of the Darling Lineament system of N.S.W.

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* NOTE: Interpretation based largely on aeromagnetic data. ref. B.P. Thomson, 1953. Geology & Ore Occurrence in Cobar District p. 866. Geology of Aust. Ore Deposits. 1st Ed. (5th Emp. Min. Met. Congr: Melbourne.)

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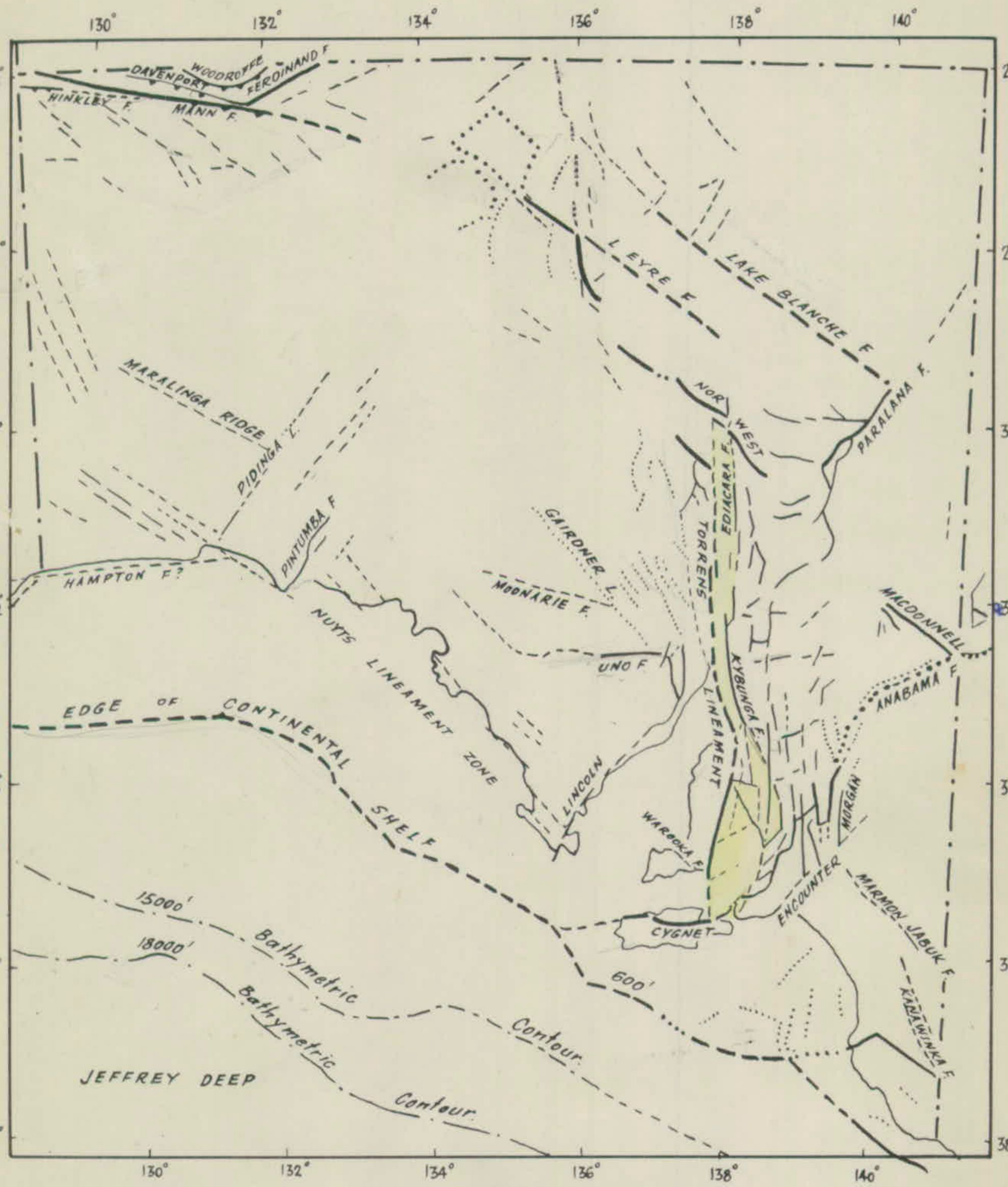

Faults & Major Shear Zones, Observed

" " " " , Inferred

" " " " , Geophysical Interpretation

Torrens - St Vincent Rift

To accompany report by B. P. Thomson.

FIG. 1

DEPARTMENT OF MINES — SOUTH AUSTRALIA

	Drn.	MAP SHOWING MAJOR FAULTS & SHEAR ZONES IN SOUTH AUSTRALIA	SCALE: 120 Miles to 1 inch
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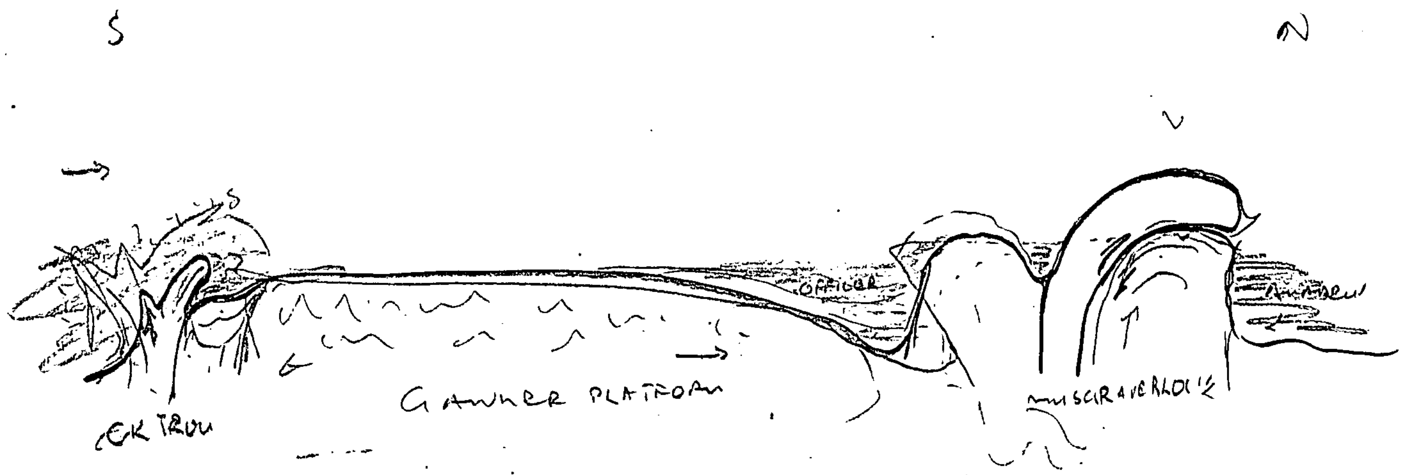
	Ckd.		
	Exd.		DATE: 19. 4. 66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GAWKER PLATFORM
OFFICER

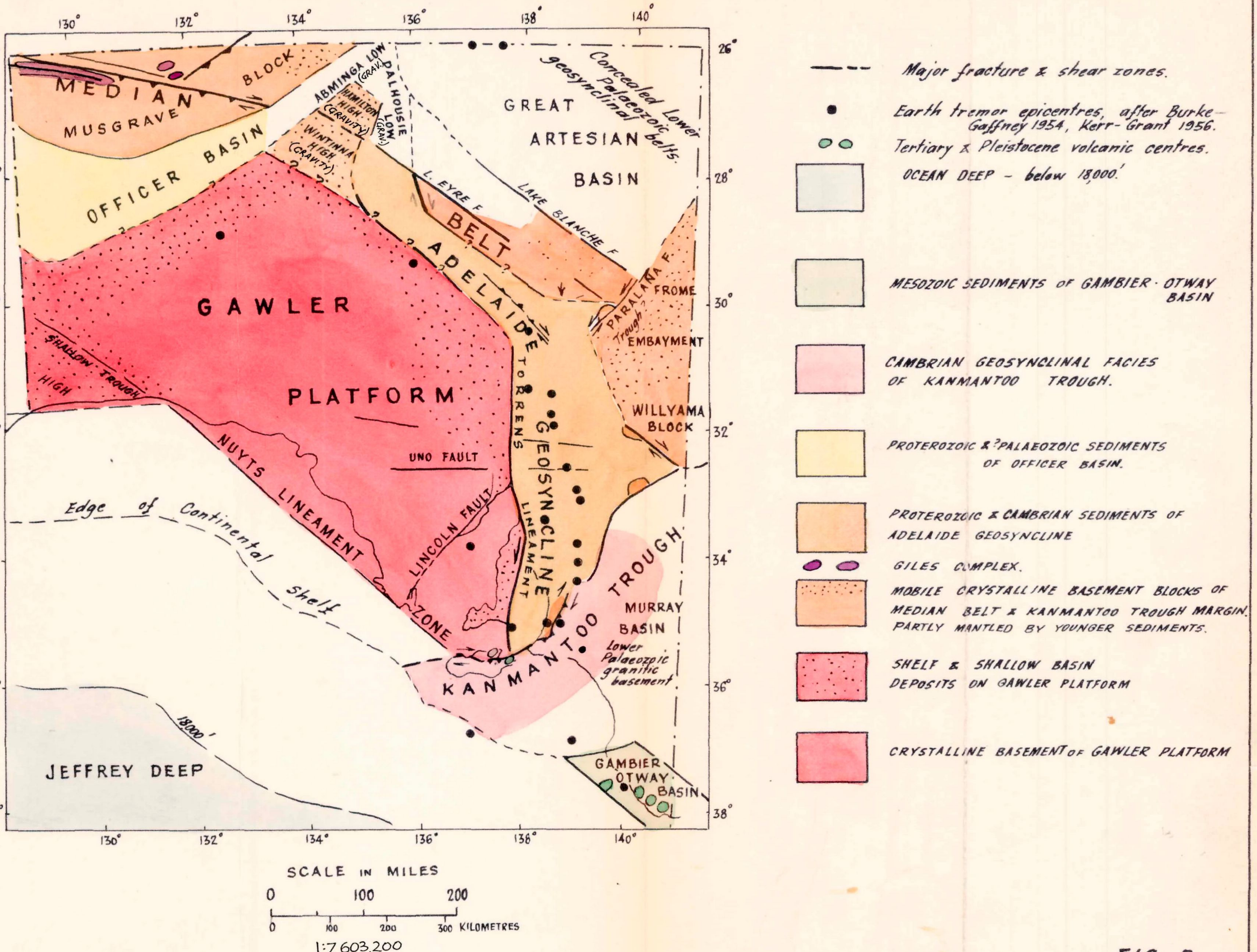

FIG 2

DEPARTMENT OF MINES — SOUTH AUSTRALIA

MAP SHOWING

MAJOR TECTONIC UNITS & FRACTURE SYSTEMS IN SOUTH AUSTRALIA

		Drn.	SCALE: 120 Miles to 1 inch.
		Tcd.	66 - 277
		Ckd.	994·2
	Director of Mines	Exd.	DATE: 19. 4. 66.

To accompany report by B. P. Thomson.