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NORTH WEST SHELF PROJECT

A lineament tectonic study of the basement architecture of northwestern Australia

Catherine I. Elliott
Songfa Liu, Barry Willcox & Peter Petkovic

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Foreword

This report is presented as the product from a consultancy contract with Dr Catherine I. Elliott of Minoil Exploration, as part of AGSO's North West Shelf Project. The plates showing computer generated potential field images were prepared by Songfa Liu.

Maps of the gravity provinces and the section of text dealing with gravity fabric analysis were part of an independent study carried out by Barry Willcox and Peter Petkovic.

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Abstract

Gravity and magnetic data sets were compiled for northwestern Australia and interpreted for lineaments exceeding 100km in length. A regional network of large-scale gravity and offshore magnetic lineaments was identified as linear zones (corridors) of concentrated, aligned basement disruptions. The regional lineaments were generally identified as corridors approximately 100km in width and often exceeding 1000km in length. Many of the regional lineaments could be traced from onshore Precambrian terrains into the younger, offshore sedimentary basins.

The regional lineaments, especially the gravity trends, consistently correlate with major tectono-depositional boundaries, regional faults, ancient suture zones and mobile belts, and craton margins. In many cases the corridors could be correlated with continental-scale lineaments identified in earlier onshore studies.

Correlation of deep-seismic reflection profiles with the regional gravity lineaments helps to understand the three dimensional geometry of the geophysical anomalies. Our studies indicate that the regional lineaments correlate with zones of basement structure whose depth of influence often exceeds 20km. The structural style of the regional gravity lineaments is variable both between lineaments, and between provinces along individual lineaments. The regional trends reflect a diverse range of styles including thrust, extension, wrench, and possible mantle underplating.

Detailed studies of the architecture of the Petrel Sub-basin (O'Brien et al., 1996) suggest that basement structures behave as discontinuities across which extensional faults relay and flip polarity. The basement discontinuities, perpendicular to the extension direction, are not necessarily expressed as faults in the syn-rift sequence but often form topographic highs. Our study shows that regional gravity and magnetic lineaments coincide with the predicted basement disruptions in the Petrel Sub-basin, and that topographic highs separating major depocentres is commonly associated with the large-scale corridors at the regional scale.

Identification of regional geophysical lineaments provides a framework within which the evolution of offshore northwestern can be understood in the context of the ancient onshore terrains. Importantly, it appears that corridors of pre-existing basement structure are fundamental to the Phanerozoic tectonic and sedimentary history of the Northwest Shelf.

Introduction

This report comprises an integrated investigation into the basement architecture of the Northwest Shelf of Australia. The method utilized in this study involves the integration of geophysical, geological and morphological data sets as a method of identifying the regional crustal framework. The approach, more specifically, is to identify regional zones of basement discontinuity, described herein as lineaments, using geophysical data sets. The objectives of this study are:

- To compile the regional gravity and magnetic data sets for northwestern Australia, and to use these to identify regional basement structures which may provide clues to the distribution and nature of the basement to the offshore provinces.
- To investigate whether there is a relationship between the ancient cratonic basement of onshore Australia and the offshore sedimentary basins.
- To integrate the interpretations of geophysical data with geo-tectonic maps of northwestern Australia in order to examine the potential relationship between the deep crustal structures and the tectono-depositional history of the offshore domains.
- To integrate deep-seismic reflection profiles that transect several of the regional gravity lineaments in order to investigate the seismic response of these zones of basement disruption.

This report is designed as a pilot study to investigate the role of basement structure in the tectonic evolution of offshore northwestern Australia. It takes the form of identification of lineaments from numerous raw data sets, compilation to define a regional network of basement structures, and integration of this framework with geo-tectonic maps and deep-seismic reflection profiles of northwestern Australia. Empirical correlations have been made between data sets, and especially between the identified regional lineament framework and published compilations of crustal structure and tectonic elements. The raw data sets used for the interpretation of the regional lineaments are included here at a reduced scale (1:10 000 000) to that of the original interpretation (1:5 000 000) for presentation purposes. The digital version of the data, together with the interpretation, is available for purchase through the AGSO on request.

The lineaments, identified as part of this study, are hundreds of kilometres in length, and are generally interpreted as zones or 'corridors' often exceeding 100km in width. In several cases the gravity corridors can be correlated with those that have been described in earlier publications (see 'Historical Aspects'), and can be reconciled with well documented crustal structures (eg. G5 corridor with the Halls Creek Mobile Zone). Several previously unpublished regional lineaments are also identified and importantly, these are clearly seen to transect geological terrain boundaries.

This study has demonstrated that regional lineaments can be traced, with apparent lateral continuity, from onshore Proterozoic terrains to the offshore Westralian sedimentary sequence of the Northwest Shelf. The lineaments are often seen to frame the sedimentary basins and coincide with major province boundaries. The implications of these observations are that pre-existing structural weaknesses have, through reactivation, influenced the tectonostratigraphic history of the offshore depositional sequence. Identifying and understanding the timing relationships and structural style of these regional lineaments is of paramount importance to the petroleum industry in the sedimentary basins, and to the minerals industry in the onshore basins and older basement terrains. As discussed later in "Historical Aspects", exploration successes such as Olympic Dam Cu-Au-U and Century Ag-Pb-Zn, are intimately associated with basement lineaments.

Deep-seismic studies in the North Sea (Blundell, 1990) have highlighted the importance of reactivation of ancient, regional basement lineaments in the depositional history of the British petroleum fields. Reflection profiles have demonstrated that basin geometry and depositional history are related to the reactivation of major basement faults, and that these structures transect the entire lithosphere.

Correlation with deep-seismic reflection profiles in this study have demonstrated that in several cases, the gravity lineaments coincide with deep crustal structures and appear to be associated with strike-slip displacement. There is also evidence that in some cases, the gravity lineaments reflect structures that may continue at depth to the Moho. Through comparison of several deep-seismic profiles, it appears that the gravity lineaments reflect zones of complex structures and that the structural style is not consistent between lineaments and may show variation between lines that transect the same gravity corridor. This is consistent with the author's earlier findings (Elliott, 1994a) which demonstrated variations in structural style between continental-scale lineaments in northwestern, central and eastern Australia.

Historical Aspects of lineament tectonic studies and previous work

The significance of ancient basement architecture to the tectonic history of the Australian continent was first discussed by Hills in 1953. Hills documented a systematic network of continental-scale morphotectonic lineaments which he described as "zones of yielding" in the earth's crust, and suggested that they acted as preferential pathways for ore-bearing fluids. Hills observed that major mineral accumulations tended to be preferentially located along regional morphological lineaments and, more specifically, at the lineament intersections.

The work of Hills was further developed by detailed lineament investigations of O'Driscoll (1983, 1886, 1990), whose extensive publications on the subject date back to early 1960'. O'Driscoll has clearly demonstrated the lineament–ore relationship and his lineament-based tectonic models were fundamental to the discovery of the Olympic Dam Copper–Gold–Uranium (Cu–Au–U) deposit at Roxby Downs in 1975 (Woodall, 1994; O'Driscoll, 1985). Other significant Australian mineral deposits, including the Century Pb–Zn target in northern Australia (Woodall, 1992) and the Boddington, Kanowa Bell and Plutonic Au deposits in Western Australia, lie on previously defined lineaments (Woodall, 1991).

Interpretation of new computer processed gravity data (Elliott, 1994a, 1994b) revealed large-scale, linear crustal discontinuities which were considered, by the author, to be continental-scale lineaments. These basement discontinuities appear to be hundreds to thousands of kilometres in length and to cross terrains of variable age and tectonic history. Generally the lineaments appear as corridors (zones along which two parallel edges could be identified), with some exceptions, while the strength of each individual edge varies along the length of the lineament.

In 1980 O'Driscoll published a sequence of 10 major gravity corridors, each being hundreds to thousands of kilometres in length, which he interpreted as continuous zones (Fig. 1). Hills (1956) on the other hand chose to portray the regional lineaments as segments which he tentatively joined in recognition of their aligned nature over vast distances. Studies by Elliott (1994a) have indicated that the continental-scale corridors are concentrated zones of aligned tectonic activity and that, though manifest as corridors at a continental scale, can be broken down into individual linear segments (Fig. 2). This process of segmentation can be seen progressively from the continental-scale down to the field scale. As a result, the style of deformation and sense of movement will be variable along the length of the corridor.

Earlier lineament researchers, including Hills (1956) and O'Driscoll (1980), have suggested that continental-scale lineaments are ancient features that have undergone long histories of reactivation. Results from the integration of new computer-processed imagery in recent studies (Elliott, 1994a) supports these earlier observations (Fig. 3).

Little research in Australia, aside from that of Elliott, O'Driscoll and Hills, has investigated the implications of large-scale lineaments. Additional studies of interest include the lineament–hydrocarbon investigations of Campbell (1989) in southern Australia and Boucher (1996) in the Cooper-Eromanga Basin, east-central Australia. The lineament-ore relationship includes the Victorian gold studies of Cozens (1986), the more localized lineament tectonic discussions of Katz (1976) in South Australia, and lateral propagation studies of Scheibner (1974) in the Lachlan Foldbelt.

The continuity between onshore lineaments and offshore bathymetric anomalies in eastern Australia has been discussed by Fairbridge (1989), O'Driscoll and Keenihan (1980) and Scheibner (1974). Leach *et al.* (1987) also recognized an onshore–offshore continuity in eastern Australia surmising that pre-existing continental lineaments played a role in the opening of the Coral Sea. O'Driscoll (1989, 1982, 1980) correlated major gravity lineaments in Western Australia with bathymetric lineaments in the adjacent continental shelf, suggesting that the ancient, onshore basement structure had influenced the offshore configuration (Fig. 4).

The continental-scale lineament framework for northwestern Australia—previous work

The Australian continent is transected by a network of systematic continental-scale lineaments that have undergone a series of reactivation events that date back to the earliest Proterozoic. Several continental-scale lineaments are identified to transect northwestern Australia where they can be related to aligned zones of structural activity (Fig. 5). The G5 (Halls Creek Mobile Zone–HCMZ) and G3 (King Leopold Mobile Zone–KLMZ) corridors are examples of such lineaments and have been shown to have undergone a complex, interactive reactivation history from the earliest Proterozoic through to the Holocene (White & Muir, 1989).

The west–northwest G3 corridor is a continental-scale lineament that is identified as a west-northwest structural zone from the gravity (Fig. 1; Fig. 3), and the Australian aeromagnetic splice (Tarlowski *et al.*, 1996). In northwestern Australia, the G3 corridor coincides with the west–northwest linear distribution of Proterozoic lithologies and major faults within the KLMZ (Fig. 5). The KLMZ has a recorded history comprising rifting, wrenching, thrusting and concentrated igneous activity over a period in excess of 1800 Ma (White & Muir, 1989). During its reactivation history, the G3 has behaved as a transfer zone to the Late Palaeozoic–Mesozoic rifting of Gondwanaland along the northwest margin of the continent (White & Muir, 1989). The distribution of north–south Permo–Triassic faulting supports a dextral sense of shear under a reidel system during this period (Elliott, 1994a).

The G5 corridor is a major gravity discontinuity that can be traced as a continuous north–northeast zone through northwestern and northern Australia (Fig. 1; Fig. 3). The corridor coincides with the HCMZ and its lateral equivalent, the Fitzmaurice Mobile Zone (FMZ), both ancient zones of basement reactivation (Plumb, 1990). The eastern edge of the G5 corridor approximates the linear eastern margin of the Bonaparte Basin. Further north, the western edge of the corridor aligns with the Lyndoch Bank Fault Zone along the margin of the offshore Arafura Basin (Fig. 5). The fault zone is documented as a Pre-Cambrian structure with a reactivation history extending through to at least the Mid Tertiary (McLennen *et al.*, 1990).

The northern edge of the northwest G11 corridor aligns with the southwestern, faulted margin of the offshore Bonaparte Basin (Lacrosse Terrace), and with the Sahul Syncline, a major basement discontinuity (O'Brien, 1993). The corridor can be sub-divided into two equidistant zones based on the gravity signature, the G11A and the G11B (Fig. 5). The G11A/B boundary coincides with the linear coastline of the Kimberley Craton and offshore, with a major lineament in the magnetic basement (O'Brien, 1993). The magnetic lineament has been interpreted by O'Brien (1993) as a accommodation zone to the Late Palaeozoic–Mesozoic northeast rifting of the Australia's northwest margin during the break-up of Gondwanaland.

The north–south G12 corridor is a double-edged linear zone that can be traced from the Bonaparte Basin in northwestern Australia to the southern coastline of western Australia (Fig. 3; Elliott, 1994b).The gravity discontinuity coincides with an alignment of north–south faults, mantle-derived intrusives and depocentre margins across Australia (Elliott, 1994a). In southern Australia, the lineament is coincident with a north–south continental-scale fault clearly seen in the magnetic basement (Tarlowski *et al.*, 1996) to exceed 300km in length.

The west-northwest G13 lineament transects northern Australia (Fig. 3) where it coincides with the Proterozoic Mallupunyah Fault for a distance of approximately 1600km. In eastern Australia the lineament coincides with a remarkable alignment of Palaeozoic and Mesozoic depocentres from the Mt Isa Inlier to the east Australian coastline (Elliott, 1994a).

Suture zones between cratonic blocks such as the Pilbara and Yilgarn are identified as the intervening mobile belts formed when the cratons came together in the Proterozoic (Elliott, 1994a). These can be correlated to continental-scale gravity and magnetic trends, and support the antiquity of the lineaments.

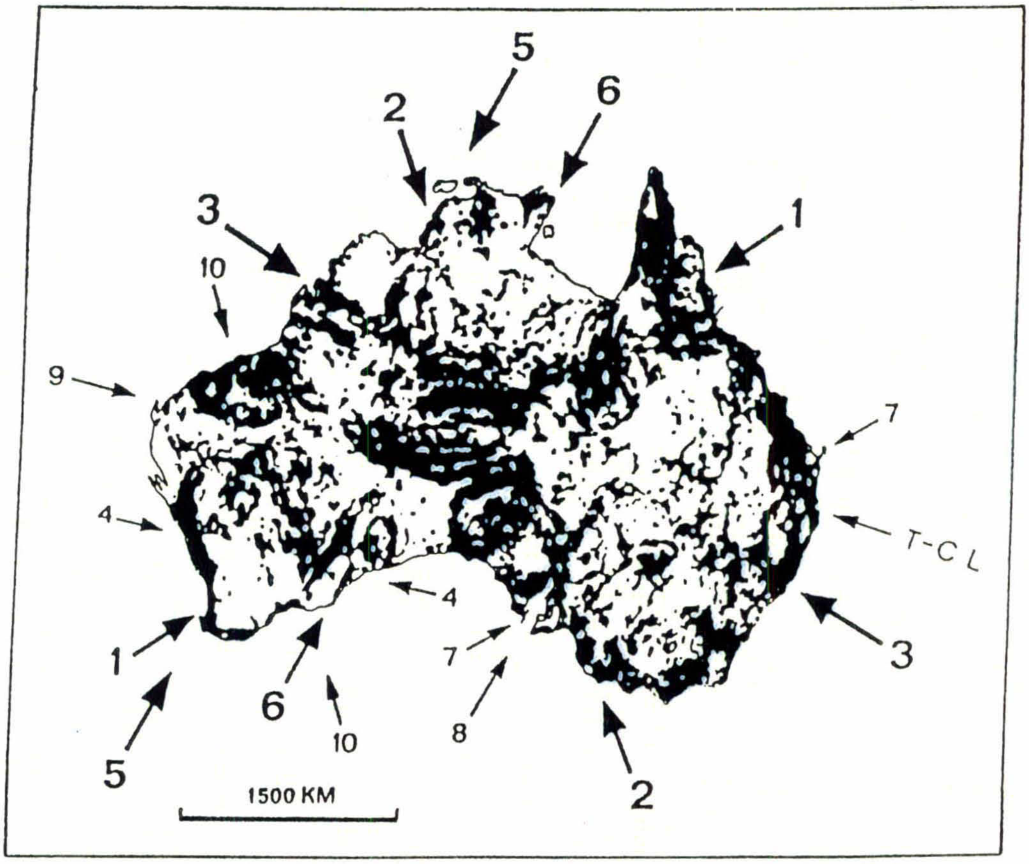

Figure 1: Diffused Bouguer gravity map of Australia showing the major gravity lineaments as identified by O'Driscoll (after O'Driscoll, 1982).

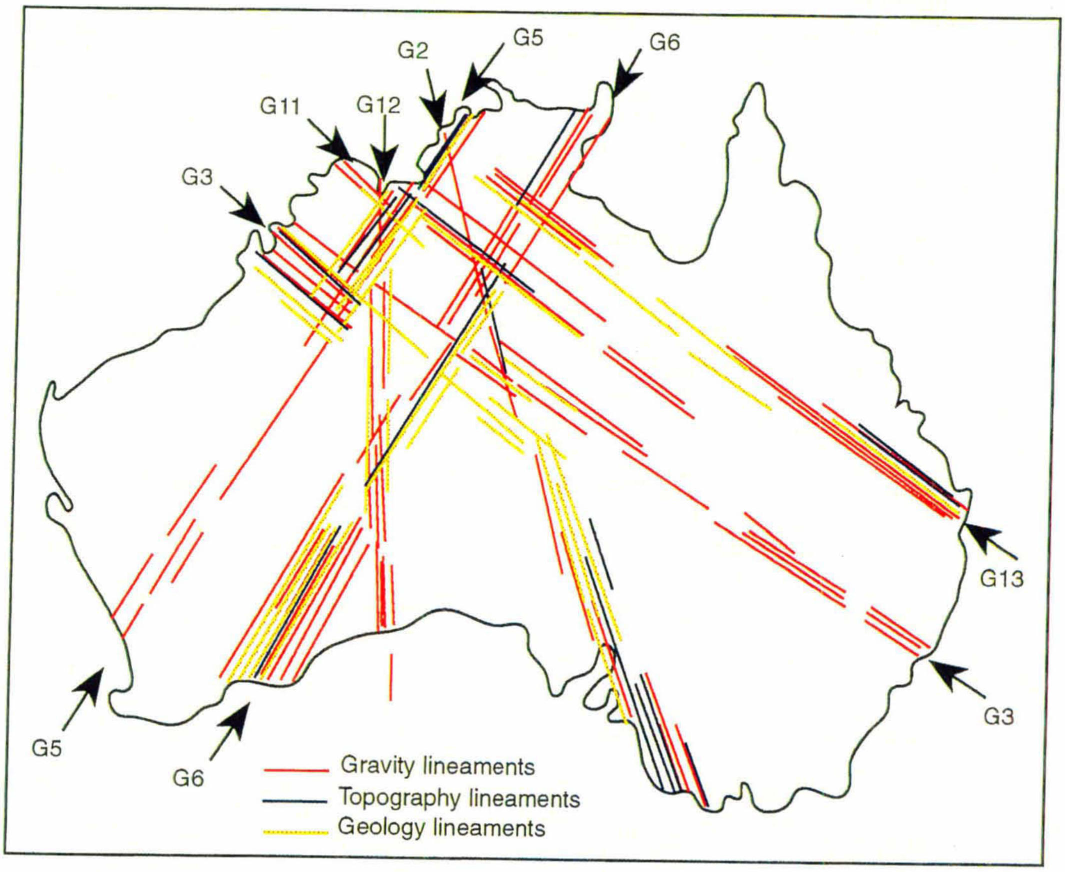

Figure 2: Schematic diagram showing the concentration of aligned lineament segments along several of the continental-scale corridors. The corridors are zones of concentrated gravity, magnetic and topographic alignments giving the appearance of continuity over vast distances, often in the order of thousands of kilometres (Elliott, 1994a).

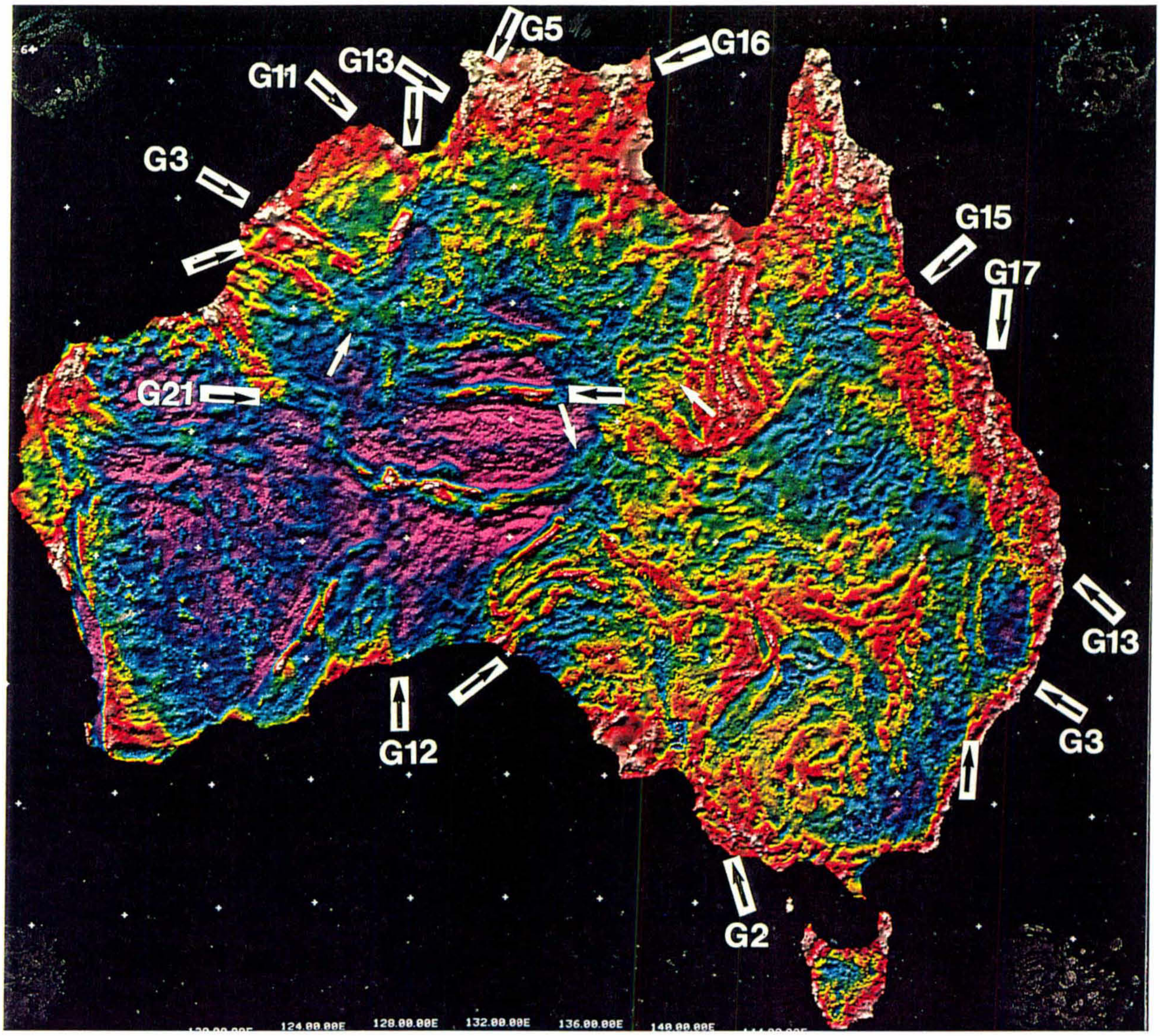

Figure 3: A pseudocolour, computer-processed gravity image (BHP Minerals) of Australia showing several continental-scale lineaments. Several of these lineaments are also recognized in this study (from Elliott 1994a, 1994b).

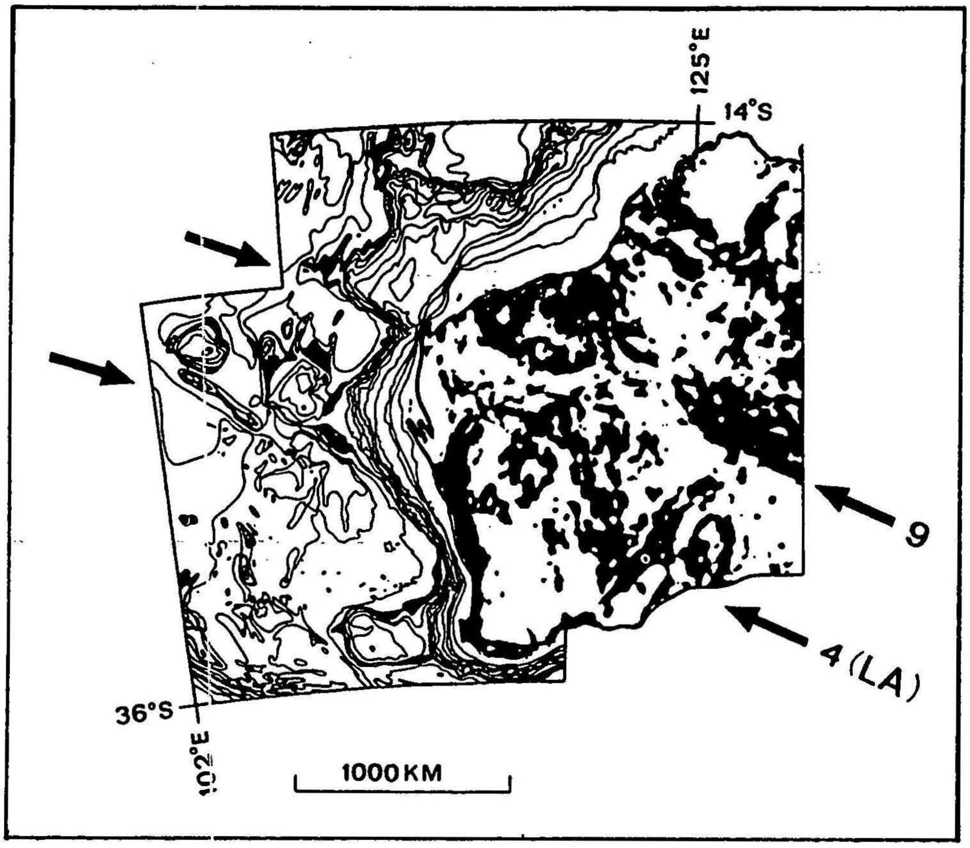

Figure 4: A mosaic of the diffused gravity map of western Australia and the bathymetry showing the alignment of the onshore gravity lineaments with the morphology of the Northwest Shelf (after O'Driscoll, 1982).

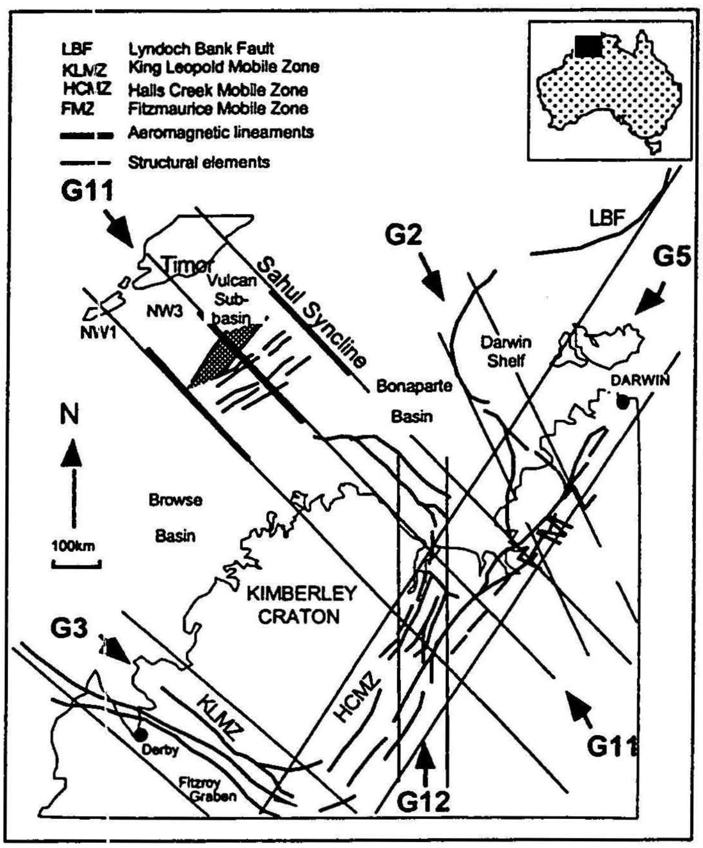

Figure 5: Schematic diagram showing the alignment of several gravity corridors with the major tectonic elements of northwestern Australia

Method

Personnel

This study is primarily a compilation and interpretation of a large variety of data sets gathered from many different sources covering both onshore and offshore northwestern Australia. The identification of a regional framework of large-scale gravity and magnetic lineaments, together with the documentation of their potential significance to the tectono-depositional history of northwestern Australia, was undertaken by C. Elliott. The majority of technical production of this report, maps for interpretation and for final presentation, was carried out by S. Lui. Barry Willcox and Peter Petkovic provided a significant contribution in the form of the Gravity Province map (Plate 33) which was fundamental to Plates 34 & 35.

Map scale

This project was designed to be a regional investigation of the tectonic fabric of onshore and offshore northwestern Australia. With this in mind, the study was carried out using data sets at 1:5 000 000 scale. This proved to be the optimum scale which allows for a regional perspective yet large enough to incorporate some of the intra-basin elements for correlation with the large-scale trends. The images reproduced in this report are done so at 1:10 000 000 scale for presentation reasons. The original data and interpretations are available from AGSO in digital format upon request.

Data representation

Different lineaments are best shown in different images, partly because processing techniques can have a profound effect on the enhancement or diminishing of those contrasts which lead to lineament identification. This lineament investigation has drawn upon as many data-sets and image-processing techniques as were available. The gravity data, for example, was interpreted from Free Air, Bouguer and Geosat, and within these categories, as colour fill anomaly and horizontal first derivatives with sun-shading from both the northwest and northeast. This comprised a total of 8 gravity images which contributed to the identification of the regional lineament pattern of the Northwest Shelf. The offshore regional magnetic pattern was derived from a total of 4 shipborne magnetic images—black and white contour, colour fill contour, and two sun-shaded horizontal first derivatives.

Basic processing of the shipborne magnetics was undertaken by Ark Geophysics. Details of this method, and the gravity processing by AGSO, are discussed in Petkovic (1995). The Geosat gravity data set was down-loaded from the Internet, locality reference *baltica.ucsd.edu/pub/global_grav_2min*. Theories and details of the computations used to create version 7.2 of the global gravity, from which the Geosat data used in this report was taken, are given in Sandwell & Smith (1996).

Where possible and practical, descriptions of data sets are included on the relevant Plate. Those descriptions whose length exceeds the space available, are found on the page immediately preceding their Plate.

The "Crustal Elements" map of northwestern Australia is reprinted, with permission, from the 1:5 000 000 "Crustal Elements Map of Australia" by Shaw *et. al.*, (1996a). The "Aeromagnetic" map of northwestern Australia is reprinted, with permission, from the 1:5 000 000 "Aeromagnetic Map of Australia" by Tarlowski *et. al.*, (1996). The "Depth to Basement" map of northwestern Australia is reprinted, with permission, from the 1:5 000 000 "Australian Depth to Basement Map" by Borissova (1994). The "Tectonic Elements" map of northwestern Australia is reprinted, with permission, from the 1:2 500 000 "Tectonic Elements of the Northwest Shelf, Australia" by Stagg (1993). The Free Air and Bouguer gravity images are available as montages for the Northwest Shelf, Petkovic *et al.*, (1996a) and (1996b), respectively.

Method of interpretation

Each of the raw gravity and magnetic data sets presented in this report were interpreted for lineaments using a selection criteria of a minimum length of one hundred kilometres. When defining the generalized pattern, the regional trends were restricted to those zones within which aligned lineaments were concentrated, and where lineaments were identified to coincide on at least two images of the individual data sets. This resulted in a regional pattern involving 20 intersecting gravity lineaments (6 'G', 11 'GL' and 3 'B' lineaments), and 10 regional magnetic lineaments ('ML'), most of which are identified as linear zones or 'corridors'.

This approach to lineament identification differs from that used by Willcox and Petkovic in their gravity province maps (included in this report, Plates 33 to 35), and to many earlier lineament studies such as those by Etheridge *et al.*, (1994) included in the "Tectonic Elements" map of northwestern Australia (Plates 23 to 25). Their approach identifies high-frequency linear trends in the data sets which are generally of lengths less that 100km, and confined to individual provinces or terrains. They do not take their interpretation further than this stage. This report attempts to identify the regional lineament framework, defined here as through-going trends which transect province boundaries, and consist of a number of aligned, not necessarily visually connected in the data, high-frequency lineaments. This method identifies the basement discontinuity to which the individual linear trends can be attributed, and is based on the model that basement structures transect province boundaries and may pre-date, and influence, the formation of the sedimentary basins.

The lineament framework identified in this report is regional in perspective. Readers, with a more detailed knowledge of their particular area of interest, may identify additional trends of significance.

The regional gravity and offshore magnetic lineament framework, derived from the compilation of individual raw data set interpretations, was then combined with several pre-existing maps of northwestern Australia, and the correlations documented.

Map Projection

The map projection consistently used throughout the study was simple conic. The central meridian was set at 132 00E for data sets of northwestern Australia and 135 00E for the data set constructed to include the entire continent (ie. Depth to Basement). As a result there was a slight variation in the location of the lineaments interpreted on the northwestern data sets when transposed onto the Australian data sets. This error was considered when correlating the data sets.

The majority of lineaments are portrayed in this study as straight lines. This is because at the scale of interpretation used in this study (1:5 000 000 and 1:10 000 000), the lineament corridors manifest as zones, boundaries of which are not fixed between images, and which at this scale appear to be linear. If plotted over the whole of Australia, or at larger scales, they would generally occur as gentle curves.

Terminology

Terminology such as "corridor" and the use of the prefixes 'G' and 'M' to denote lineaments identified from gravity and magnetic data sets respectively, are used in this report to maintain consistency with the publications of O'Driscoll (1980, 1983, 1986, 1990) and Elliott (1994a, 1994b). The G3, G5 and G2 discussed in this report are consistent with those described by O'Driscoll (1980). The G11, G12, and G13 are adopted from Elliott (1994a). The ML3 corridor in this report is spatially associated with an offshore projection of the M3 magnetic lineament described in Elliott (1994a) but in this report, is identified as a northwest zone within the regional west-northwest trend.

Lineament annotation 'GL' and 'ML' denote gravity and magnetic lineaments respectively. They have been identified specifically as part of this study. The numbering system of these two sets of lineaments is designed, where possible, to maintain consistency between data sets, ie. GL2 is spatially associated with the ML2. This does not necessarily imply a genetic relationship unless otherwise stated. To maintain consistency with the gravity annotation, magnetic lineaments are not necessarily numbered sequentially. Three lineaments annotated B1, B2 and B3 are not of the same regional extent or significance as the 'G' and 'GL' lineaments but are, nonetheless, well defined and of importance in the Bonaparte Basin.

Data reliability

Gravity

Correlation of interpreted lineament corridors was good between the Free Air and Bouguer versions, and the Geosat source. This suggests a high degree of reliability. The influence of bathymetry in the offshore regions however, was considered during interpretation.

Magnetics

The regional magnetic lineament pattern was derived from the shipborne magnetic data for the offshore region and was of poor resolution and very regional in distribution. Correlation of the shipborne magnetic data with the geology was therefore less reliable than the correlation of the gravity data with the geology.

Deep-seismic correlations with the regional lineaments

Deep-seismic reflection profiles included in this report are all from the AGSO database and have been interpreted by AGSO personnel on a preliminary basis. The lineament edges (eg. east and west) plotted onto the seismic profiles are approximate only as they have been taken from the 1:5 000 000 regional lineament compilation where the lineaments were identified as zones or "corridors". The accuracy of the edges is low given that the corridors tend to represent a zone of structural disruption along which the local position of the edge will vary. This potential inaccuracy should be considered when comparing the approximate edge, as plotted from the regional compilation, with the interpreted structures that affect the basement and therefore the gravity response.

Gravity province map

The gravity anomaly field has been divided into several regional gravity provinces, each of which is characterised by uniformity of trend, anomaly intensity, or degree of disturbance. In general, the gravity signature is considered to correspond to major crustal elements; however, a common gravity response does not necessarily imply a common source. The process was carried out using both the Free Air and Bouguer anomaly maps, and also maps of the maximum horizontal gradients. The gradient maps have a tendency to more clearly define the block and basin boundaries, and to accentuate the mobile belts and other regional linear structures.

The provinces (Plate 33) are best defined on the map of Bouguer anomaly maximum horizontal gradient, with a northwest illumination and 45 degree sun-angle. Six categories of anomaly amplitude and alignment have been recognised:

	Colour	Amplitude	Alignment
1	Blue	Zero	None
2	Yellow	Low	Low
3	Green	Medium	Low
4	Purple	Medium	High
5	Orange	High	Low
6	Magenta	High	High

A basic interpretation of these provinces is:

Type 1: characterised by a low amplitude / featureless gravity signature, corresponds almost precisely with the oceanic crust of the Argo, Gascoyne and Cuvier Abyssal Plains.

Type 2: with low amplitude / low alignment signature, seems to be generated by a variety of sources, but in general corresponds to basinal areas overlying the more stable platforms. These range from the Proterozoic Kimberley Basin to the Palaeozoic / Mesozoic basins of the outer Northwest Shelf.

Type 3: the medium amplitude / low alignment anomalies in the offshore region, are generated by the largely volcanic margin of the Exmouth and Scott Plateaus.

Type 4: medium amplitude / high alignment anomalies, relate to the basinal areas which underwent northwest–southeast directed extension in the Late Devonian–Early Carboniferous. The lineaments correspond broadly to the boundaries of the elevated areas and sub-basinal troughs which are aligned approximately perpendicular to the extensional direction.

Type 5: high amplitude / low alignment characteristics, occur over the complex terrain of the Pilbara Block.

Type 6: high amplitude / high alignment provinces, correspond to the elongate Jurassic depocentres of the Exmouth, Barrow and Dampier Sub-basins as well as some of the basins of central Australia.

Geophysical lineaments of northwestern Australia

The following series of Plates can be divided into four sections. The first sequence, **Plates 1 to 3**, are designed as a series of locality diagrams so that the reader can familiarize themselves with the location of the regional lineaments identified later in this study. The regional lineaments are often referred to when discussing the lineament-interpreted raw data images. **Enclosures 1 and 2** in the back pocket of this report, are clear copies of the regional gravity and offshore magnetic lineament framework which can be overlain onto the raw data sets for easy location of the trends referred to in the Plate cations.

Plates 4 to 15 are computer processed versions of the gravity and magnetic data sets onto which the individual lineament interpretations have been annotated.

Plates 16 to 25 are a selection of geophysical, tectonic and stratigraphic maps of northwestern Australia with which the regional gravity and offshore magnetic lineaments have been correlated. Individual sedimentary basins and tectonic provinces are constantly referred to in the Plate captions but are not always annotated on the map. The "Tectonic Elements" map of northwestern Australia (Plates 23 to 25) provides a good reference for the locality of the provinces referred to in this report.

Plates 26 to 32 provide examples of the correlation of three regional gravity lineaments with several deep-seismic reflection profiles. A locality diagram for the seismic lines, and the lineaments discussed, is included as Plate 26.

Plates 33 to 35 demonstrate the relationship between the gravity province map (constructed using the gravity signature of individual provinces by Willcox and Petkovic) and the regional gravity and offshore magnetic lineaments of northwestern Australia.

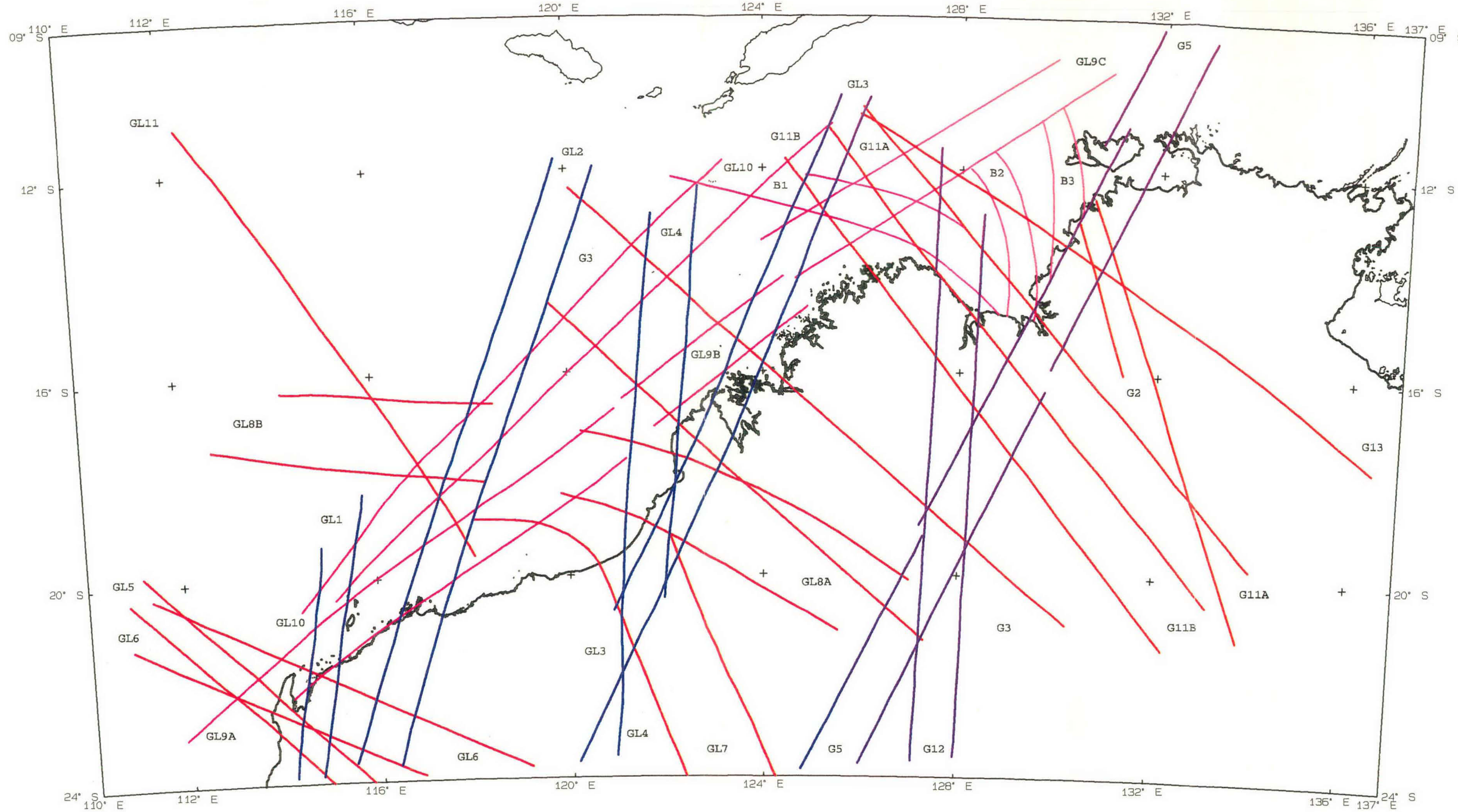

Plate 1a: Compilation map of the regional gravity lineament framework of northwestern Australia.

A compilation map of the regional gravity lineament framework of the NW Shelf. The lineaments, generally identified as zones or "corridors", were derived through the compilation of interpretations of the Bouguer, Free Air and Geosat gravity images included in this report. Processing of the gravity data was carried out by Ark Geophysics. See Petkovic (1995) for processing details. The lineaments or "corridors" have been numbered as a means of reference for the descriptions in the following plates. This compilation can be used as a locality reference diagram for the lineaments discussed in the gravity data descriptions which follow. A clear overlay of this Plate is included in the back pocket of this Record as Enclosure 1.

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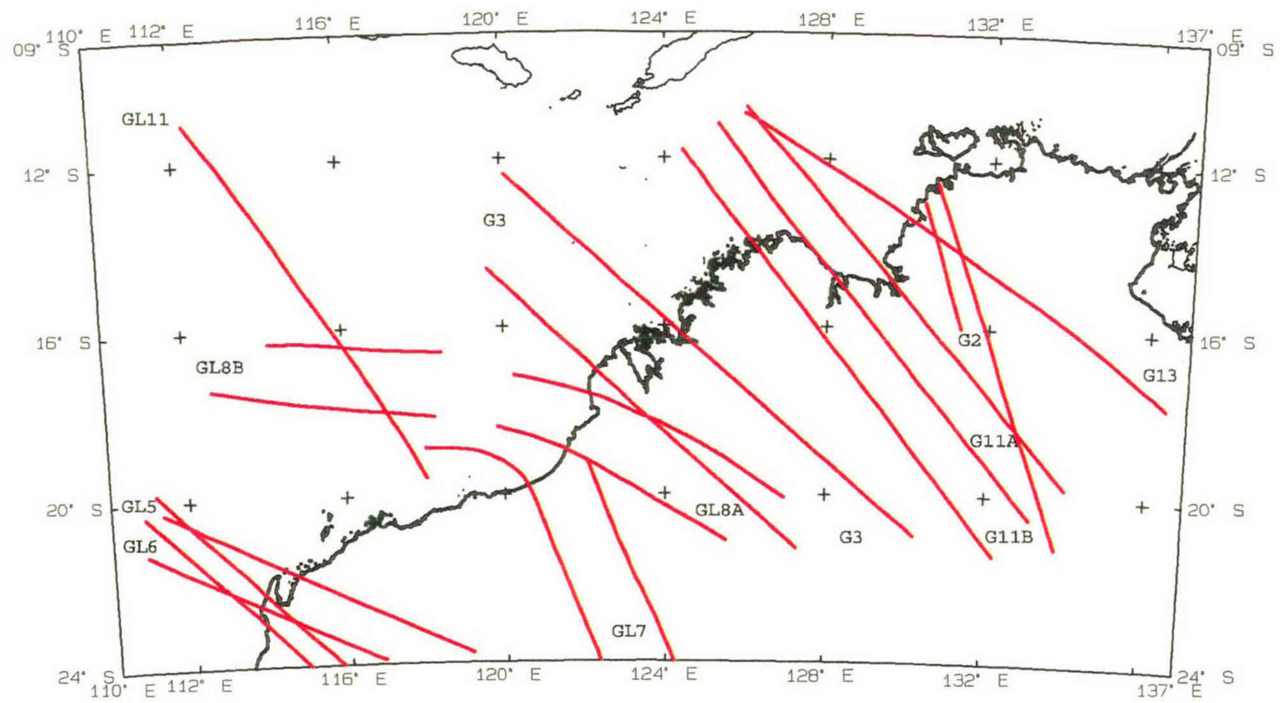
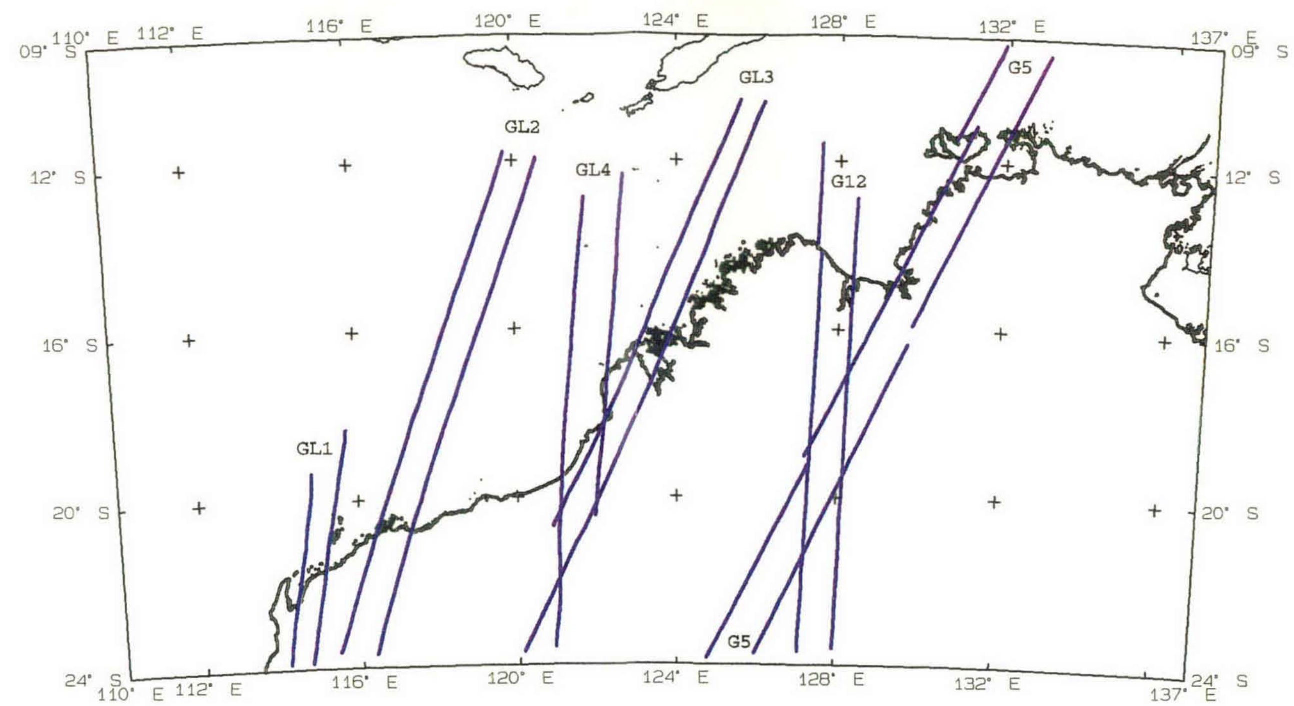
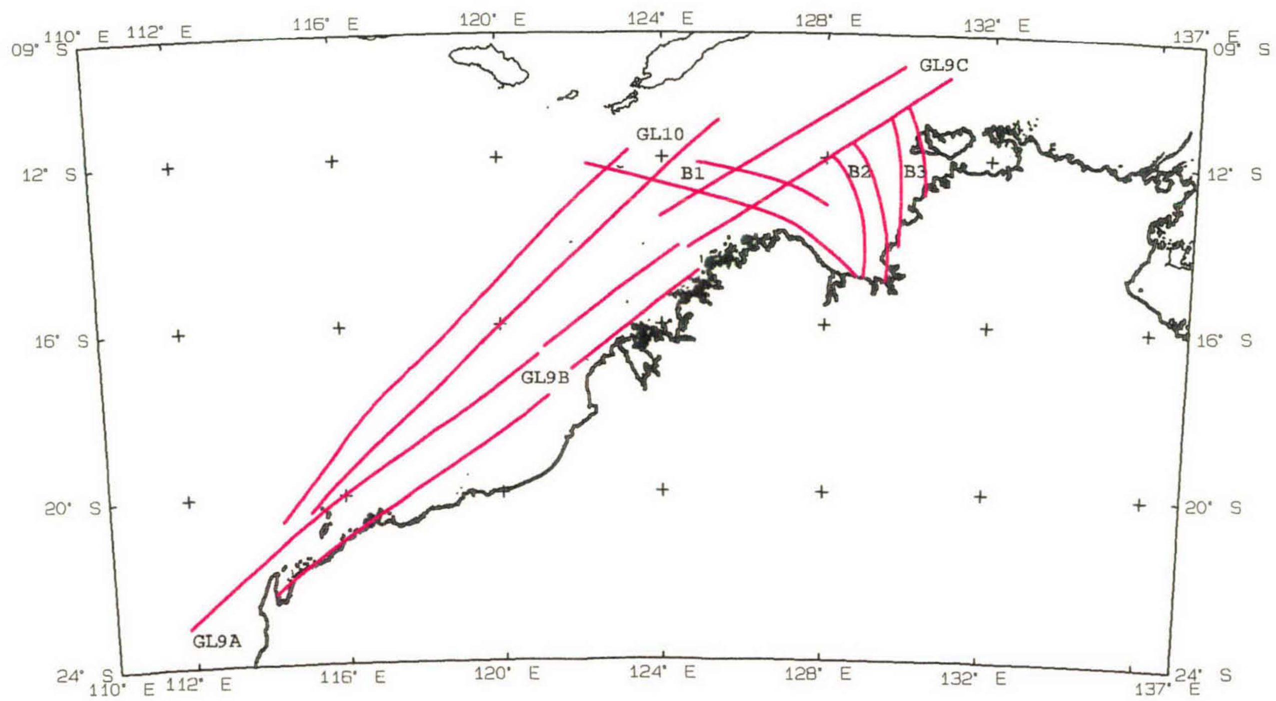


West-northwest to north-northwest regional lineaments.



North-south to north-northeast regional lineaments.



Northeast regional lineaments and the Bonaparte Basin 'B' trends.

Plate 1b: Locality diagram of the regional gravity lineaments of northwestern Australia

A locality diagram of the regional gravity lineaments for the NW Shelf derived from the compilation of the interpreted Bouguer, Free Air and Geosat gravity data sets. This plate is a simplification of Plate 1a. The lineaments are subdivided according to their orientation.

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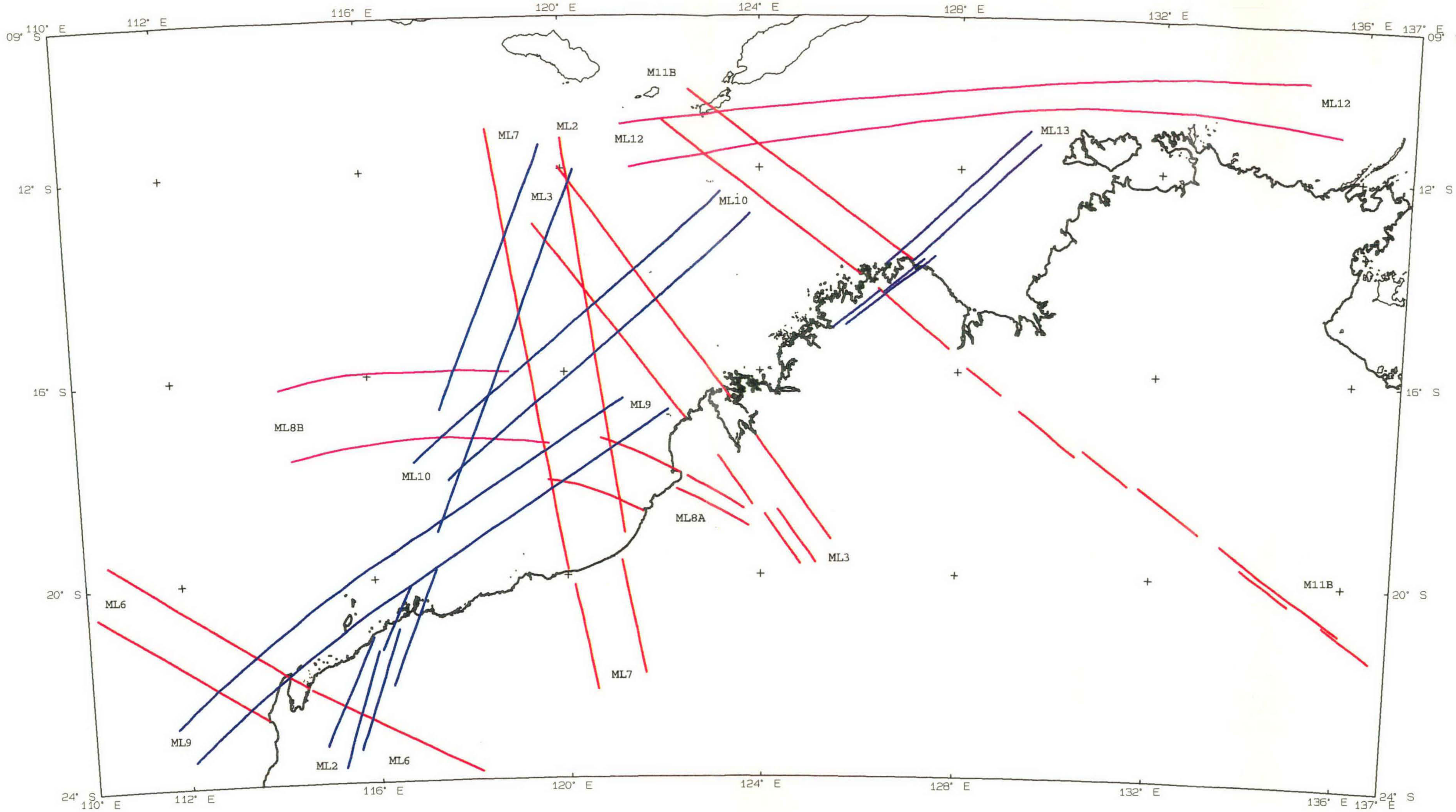

Plate 2a: Compilation map of the regional offshore magnetic lineament framework of northwestern Australia.

A compilation map of the regional magnetic lineament framework of the NW Shelf. The lineaments, generally identified as zones or "corridors", were derived through the compilation of interpretations of the shipborne magnetic images included in this report. Preliminary correlations with onshore magnetic trends (identified from the aeromagnetic map of Australia; Tarlowski et al., 1996) are also shown.

Processing of the magnetic data was carried out by Ark Geophysics. See Petkovic (1995) for processing details. The lineaments or "corridors" have been numbered as a means of reference for the descriptions in the following plates. This compilation can be used as a locality reference diagram for the lineaments discussed in the magnetic data descriptions which follow. A clear overlay of this Plate is included in the back pocket of this Record as Enclosure 2.

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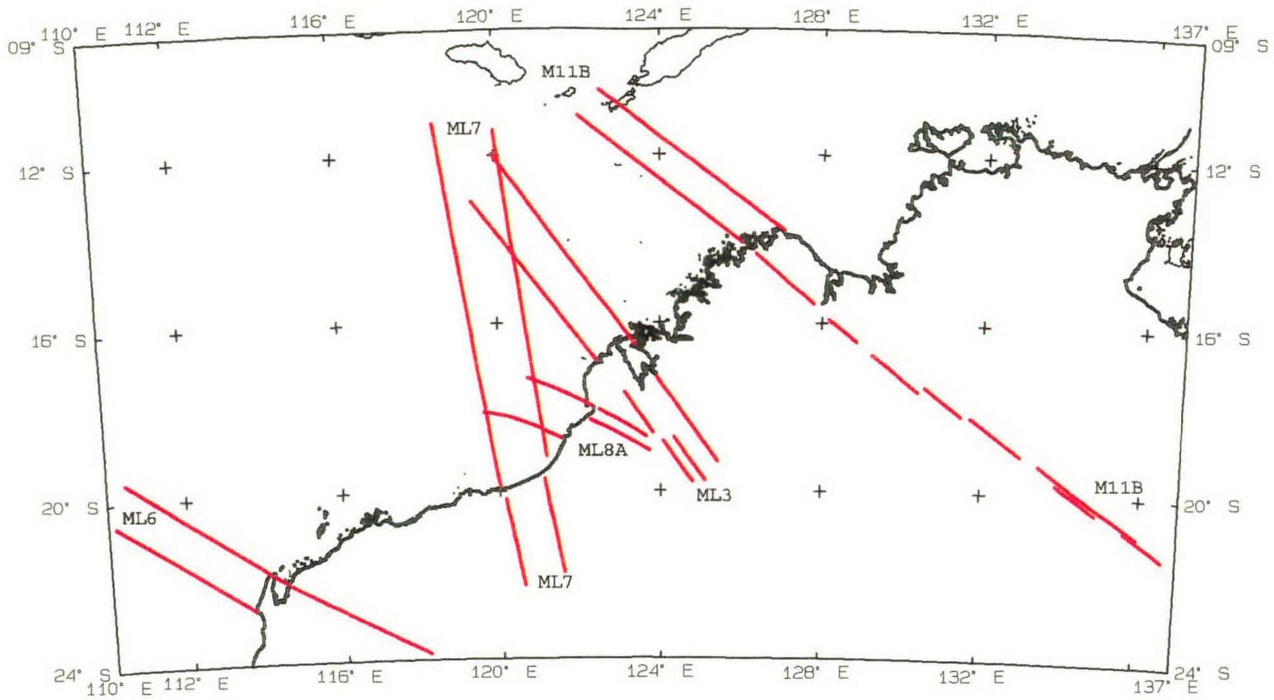
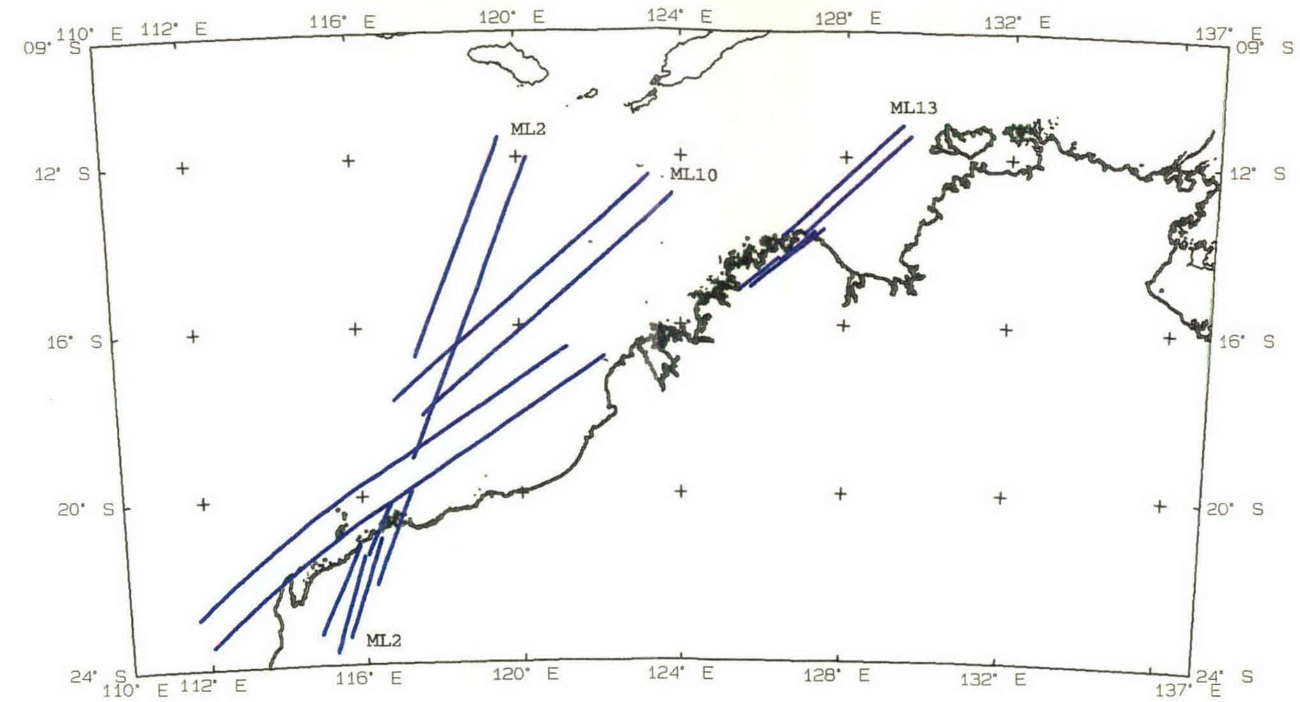
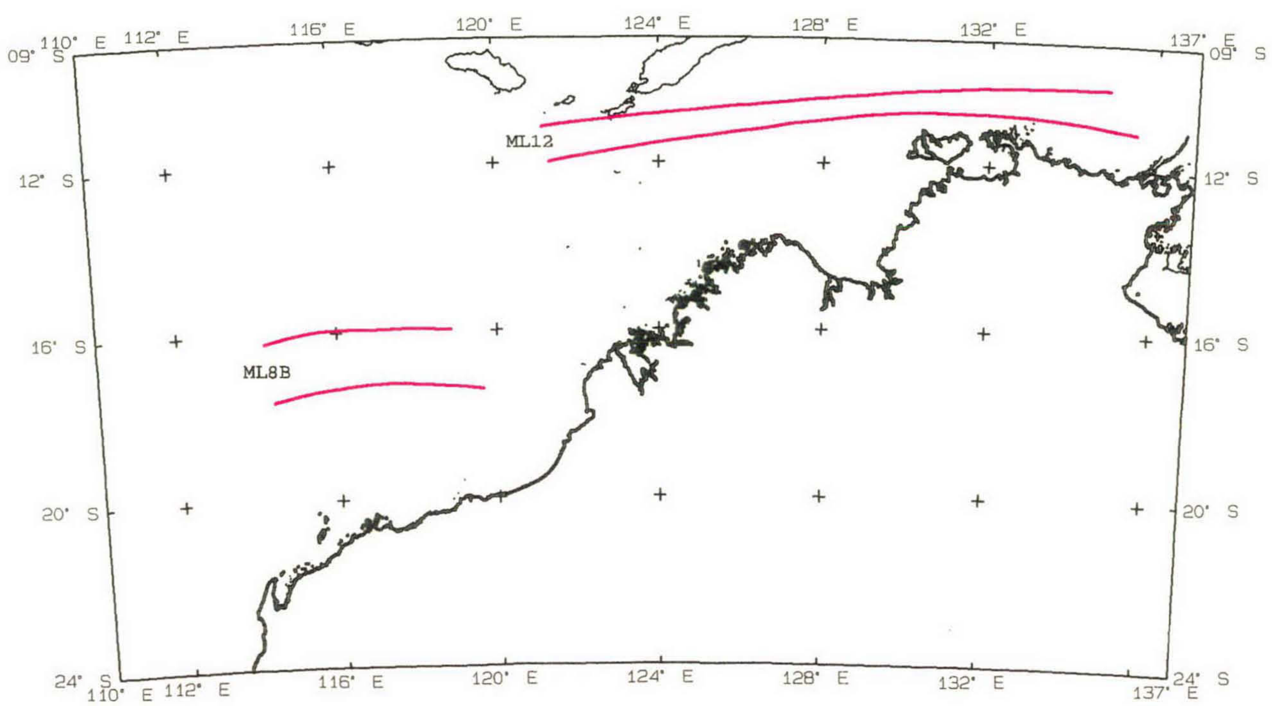


Northwest to west-northwest regional lineaments.



North-northeast to northeast regional lineaments.



East-west to east-northeast regional lineaments.

Plate 2b: Locality diagram of the regional offshore magnetic lineaments of northwestern Australia

A locality diagram of the regional magnetic lineaments for the NW Shelf derived from the shipborne magnetic data set. This plate is a simplification of Plate 2a showing the lineaments sub-divided according to their orientation.

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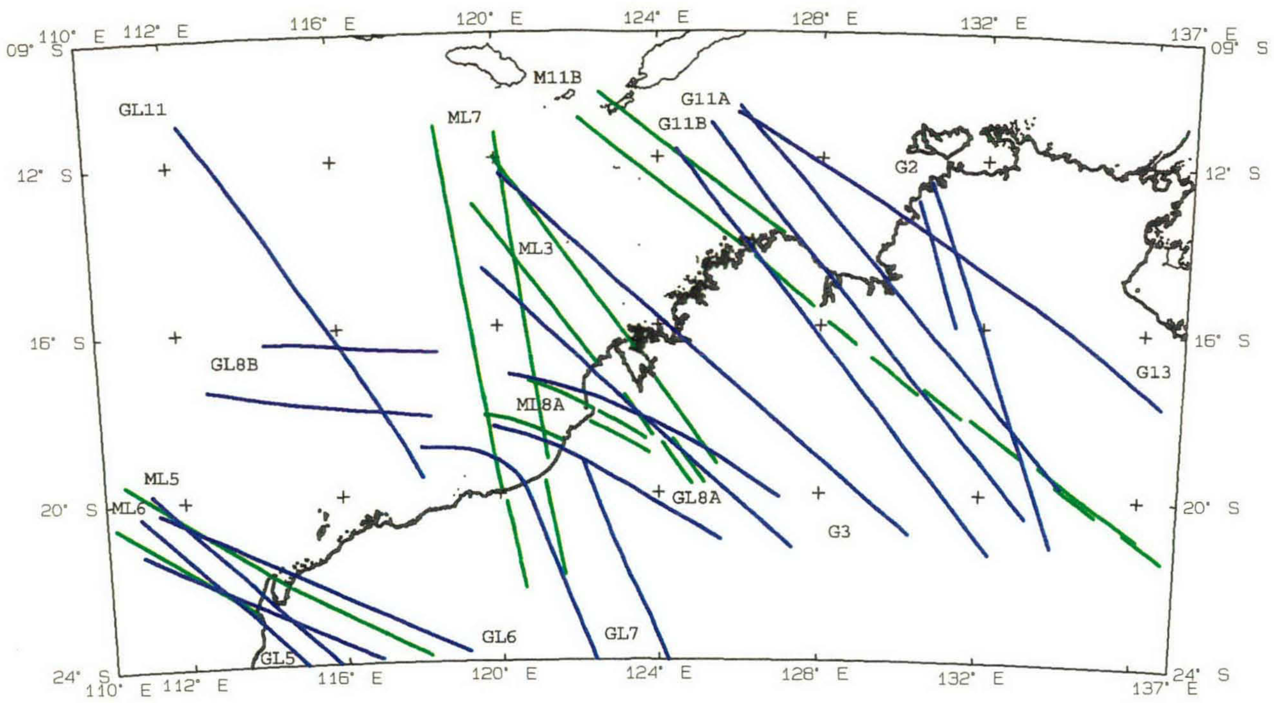
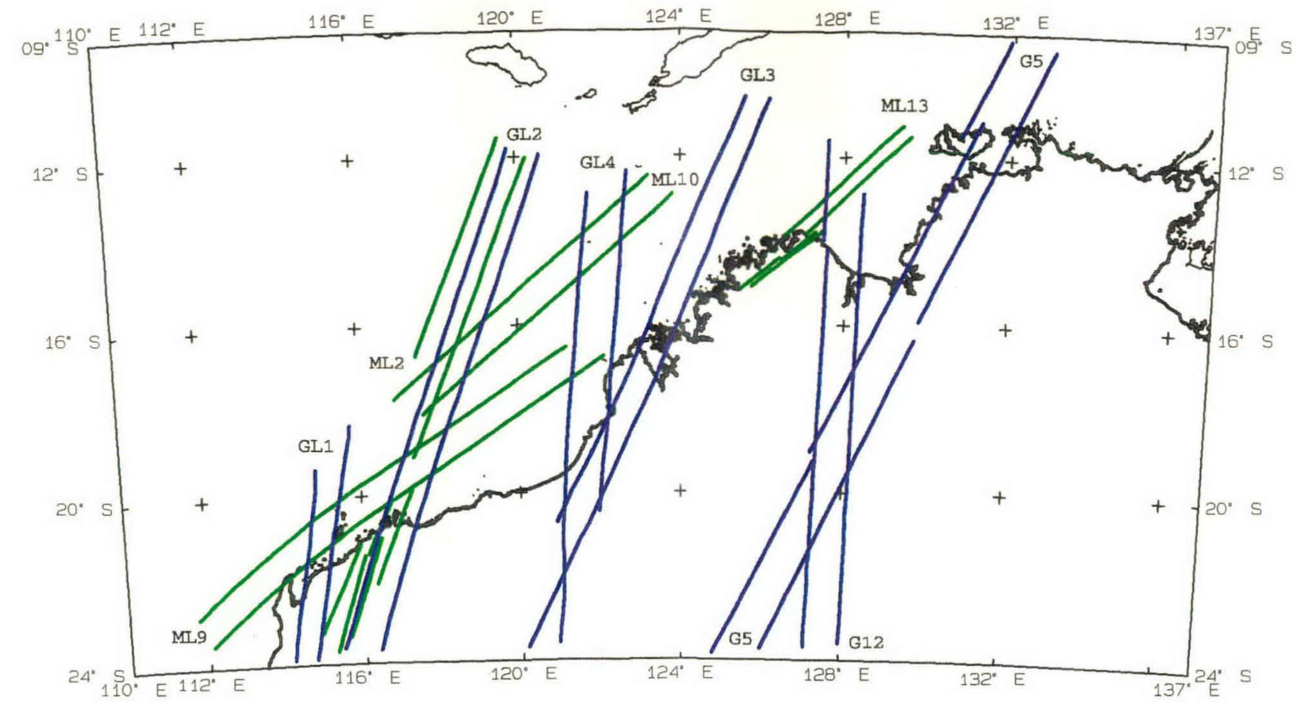
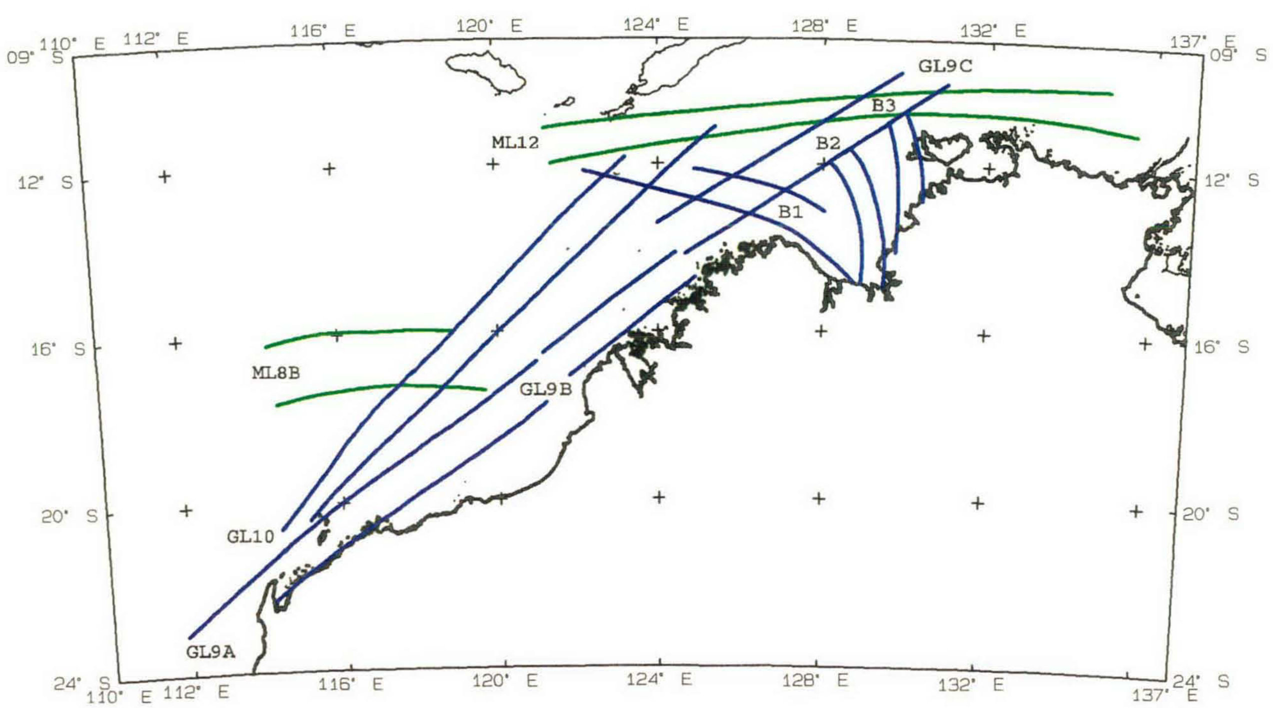


West-northwest to north-northwest regional lineaments.



North-south to east-northeast regional lineaments.

Plate 3: Correlation of the regional gravity lineament framework with the regional, offshore magnetic lineaments



Northeast and east-west regional lineaments and the Bonaparte Basin 'B' trends.

This plate is a combination of the regional gravity (blue) and regional offshore magnetic (green) lineament frameworks derived from the compilation of the raw data sets shown in the following Plates. The lineaments are separated into three maps based on orientation, and both the gravity and magnetic trends, within that range of orientations, shown together.

The primary observation that can be made regarding this correlation is that offshore, several of the gravity and magnetic corridors are spatially similar but divergent in their trends. The GL2 / ML2. GL6 / ML6, GL7 / ML7, GL8 / ML8 and G11B / M11B are of particular note.

The divergent GL9 and GL10 trends, clearly defined in the gravity, are not reflected in the magnetics. The ML9 and ML10 lineaments are consistently NE and parallel. The ML8A closely resembles the GL8A in spatial distribution and orientation. The ML8B is identified to be slightly more ENE in comparison to the EW GL8B corridor.

There are several notable instances in which there is no apparent correlation between the two geophysical data sets. There is no consistent regional magnetic expression of the G2, G5, G12, GL1, GL3, GL4, GL5 and the linear GL11. The ML13 aligns with the NW termination of the B2 and B3 gravity lineaments, and the change in orientation of the B1 from NW to WNW. The absence of a gravity expression correlating with the EW ML12 (which cross-cuts the general NE to ENE gravity trend), is also noted.

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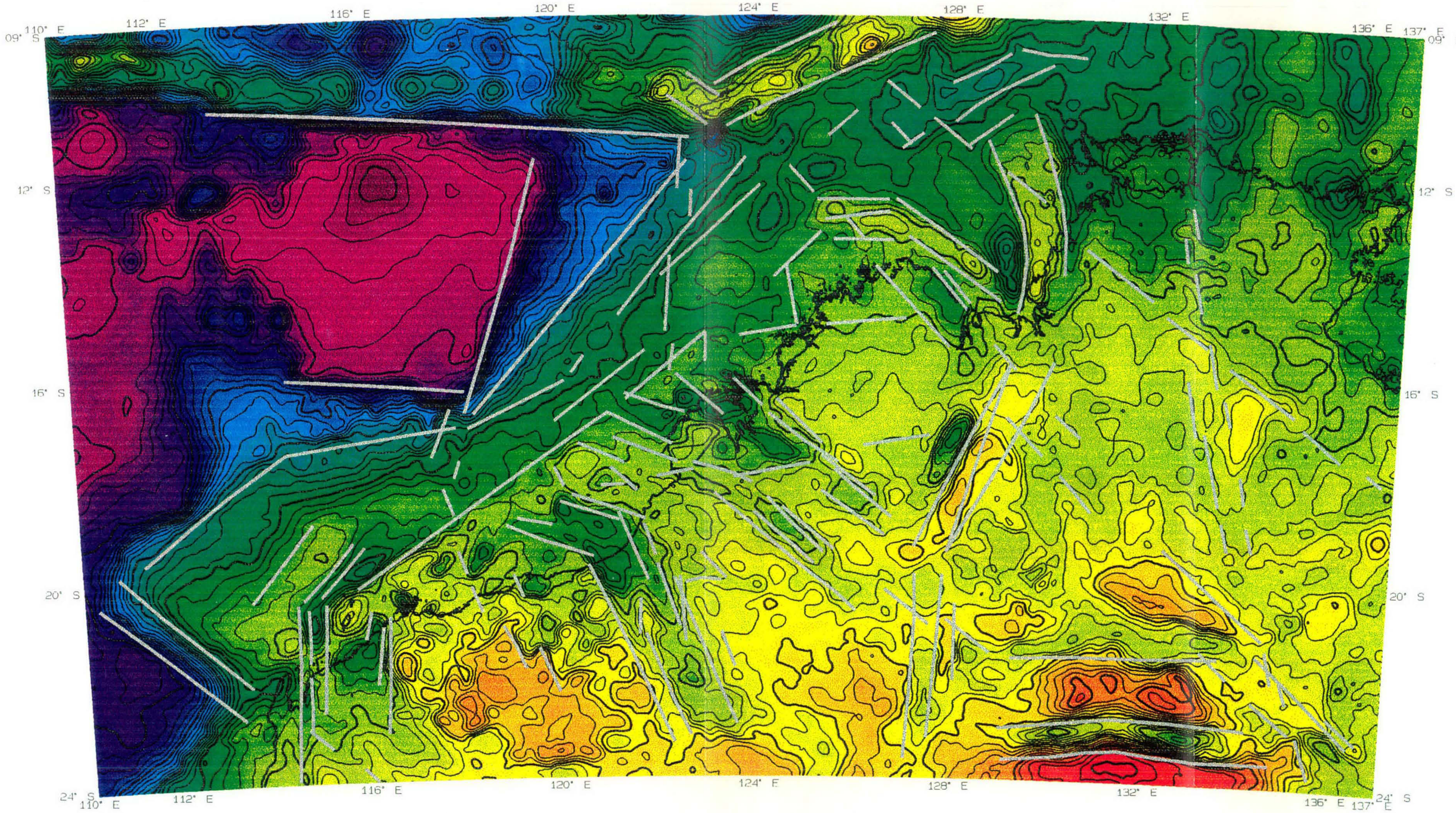
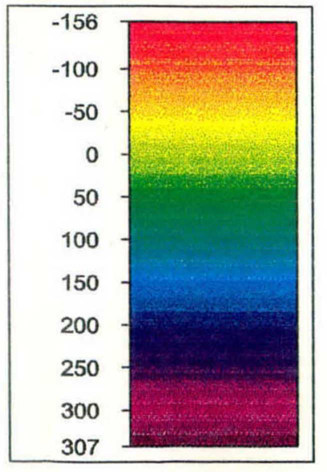


Plate 4: Colour map of the Bouguer gravity contour anomaly

A Bouguer anomaly image with a range of values from -156 to 307 mgal represented with colour fill and contours. Several corridors are well defined including the WNW G3, NW G11, WNW G13, NNW GL7, NS GL1, NE GL9, and the NNW GL11. A left-lateral swing of the offshore extension of the G3 and GL7 corridors, and the Bonaparte trends (B1 and B2), are of note. The B1 trend coincides with the northern section of the G11 corridor, although in this image the B1 is at an angle to the G11. The EW central Australian trend is seen to terminate against the NS G12. West of the corridor the dominant regional trend is WNW to NW.



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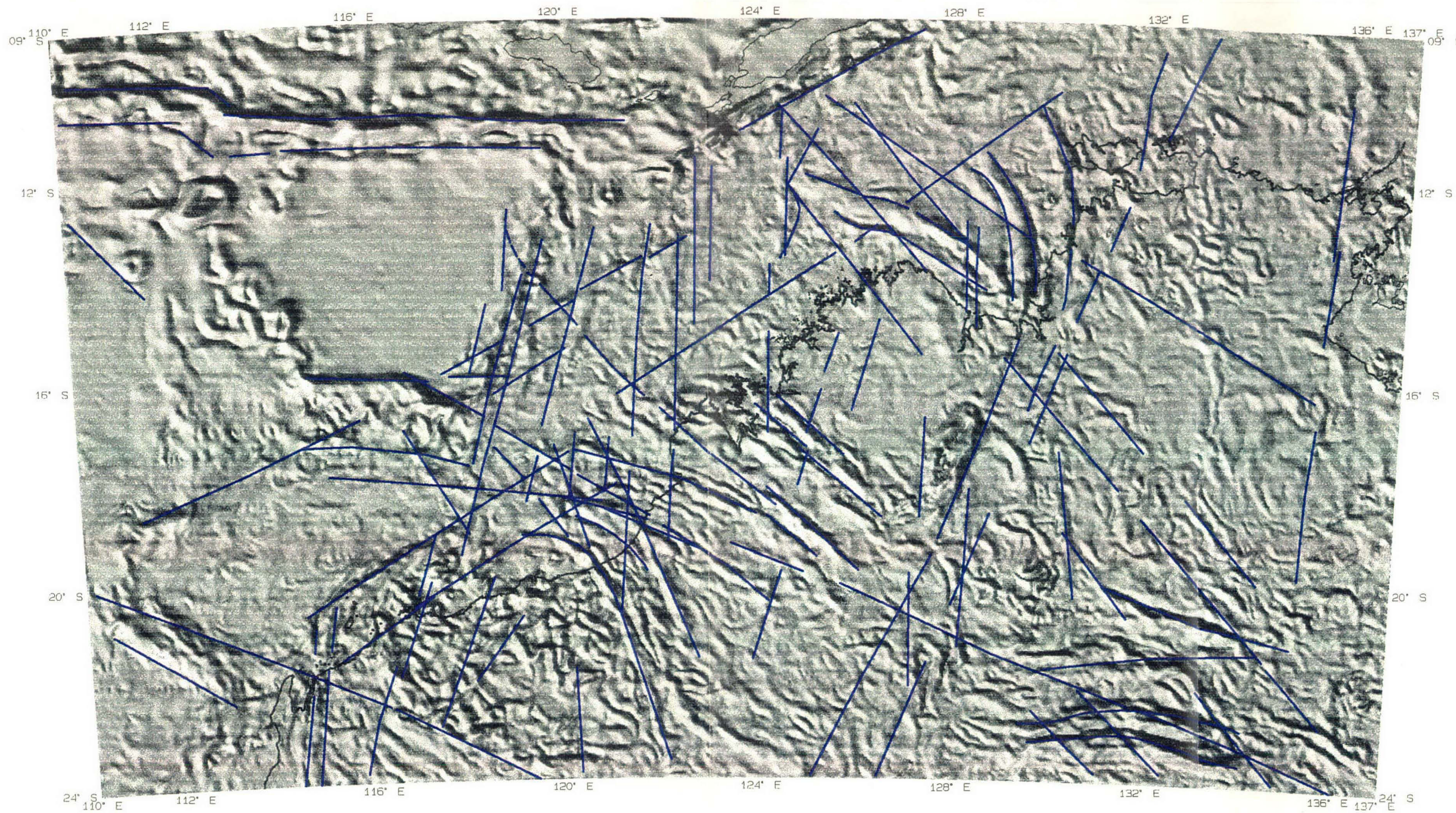

Plate 5: Horizontal gradient of the Bouguer gravity anomaly, northeast illumination

A horizontal gradient of the Bouguer anomaly map represented as sun-shaded relief with sun elevation 45 degrees and azimuth 45 degrees. Several corridors are identified in this image but of special note is the NNE GL2 and NS GL4 which show apparent onshore/offshore continuity. The intersection zone of the offshore extension of the GL7 and GL8, with the NE GL9, is of interest. Smaller scale NS trends appear to overprint the dominant NNW GL7 and WNW GL8A corridors in this region. The NW end of GL8A, and the GL8B, show a similarity in gravity signature and are transected by the NNE GL2 corridor. This image also shows the coincident yet divergent G11 and B1 corridors in the southern Bonaparte region. The intersecting G5 and G12 corridors are also clearly seen, as is the WNW GL6 and the eastward extension of the G11.

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Plate 6: Horizontal gradient of the Bouguer gravity anomaly, northwest illumination

A horizontal gradient of the Bouguer anomaly map represented as sun-shaded relief with sun elevation 45 degrees, azimuth 315 degrees. Several corridors are identified in this image but of special note are the NNE trends which can be correlated with the GL2, and the NS trends in the Canning Basin region of which the GL4 is a component. The NNE GL3 is also identified in this image and is seen to parallel the G5. The GL4 is seen to parallel the NS G12. The GL6, G3 and the divergent corridors of the GL9 and GL10, are also clearly identified.

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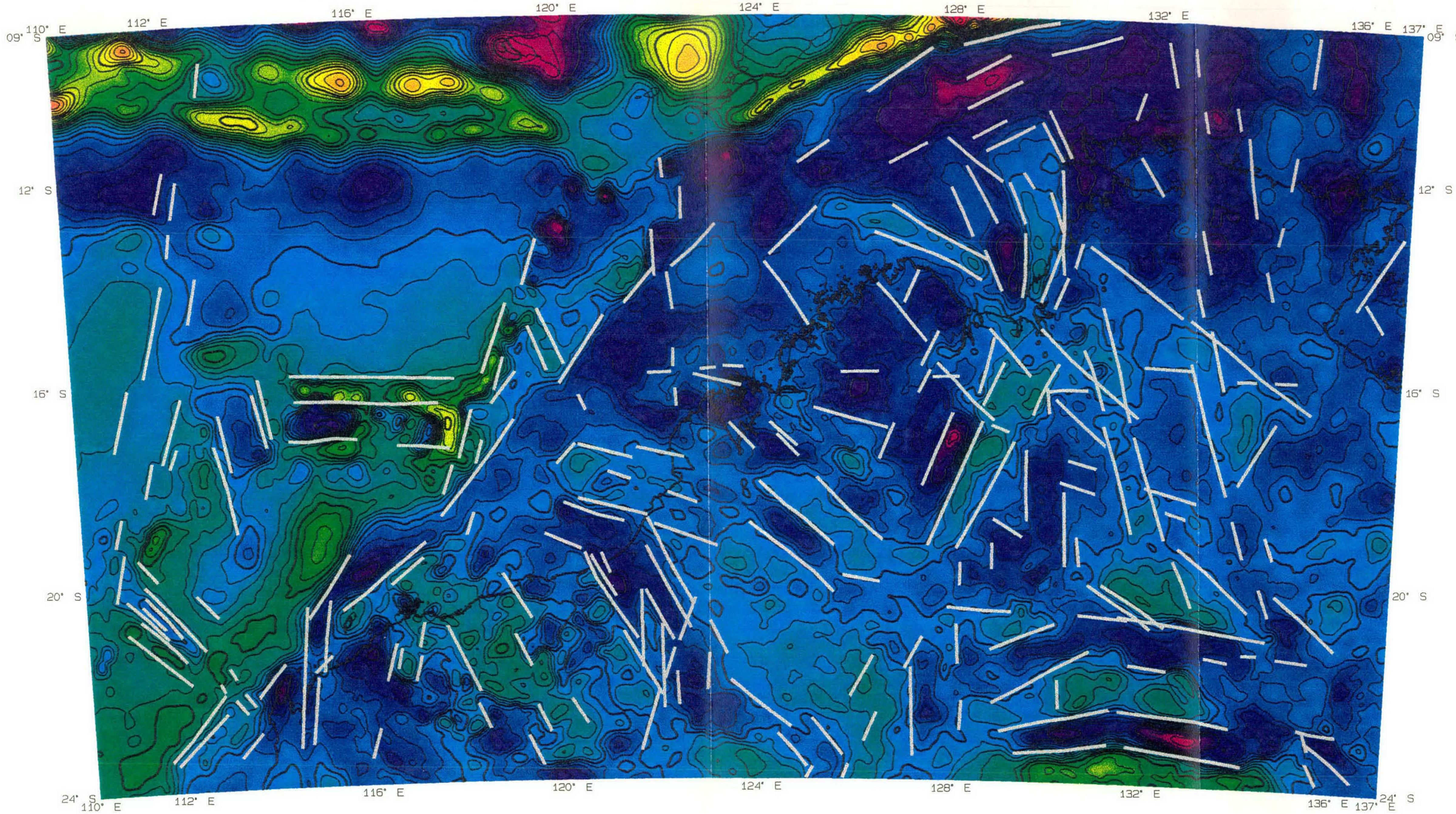
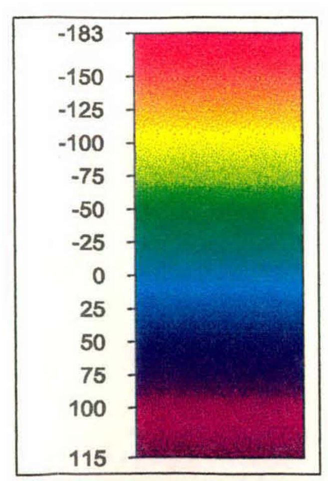


Plate 7: Colour map of the Free Air gravity contour anomaly.

A Free Air anomaly image with a range of values from -156 to 307 mgal represented with colour fill and contours. The trends in this image tend to be of shorter length but can still be related to the corridors defined in the Bouguer images. Those of note are the three Bonaparte trends, the B1, B2 and B3, the GL2, GL4, GL7, and the offshore extension of GL8 where it swings into a more EW orientation. Lineaments consistent with the G2, G11 and G13 gravity corridors can be identified in this image. The GL8B and the GL5 (which intersects the GL6 offshore), and the GL11, are also seen.



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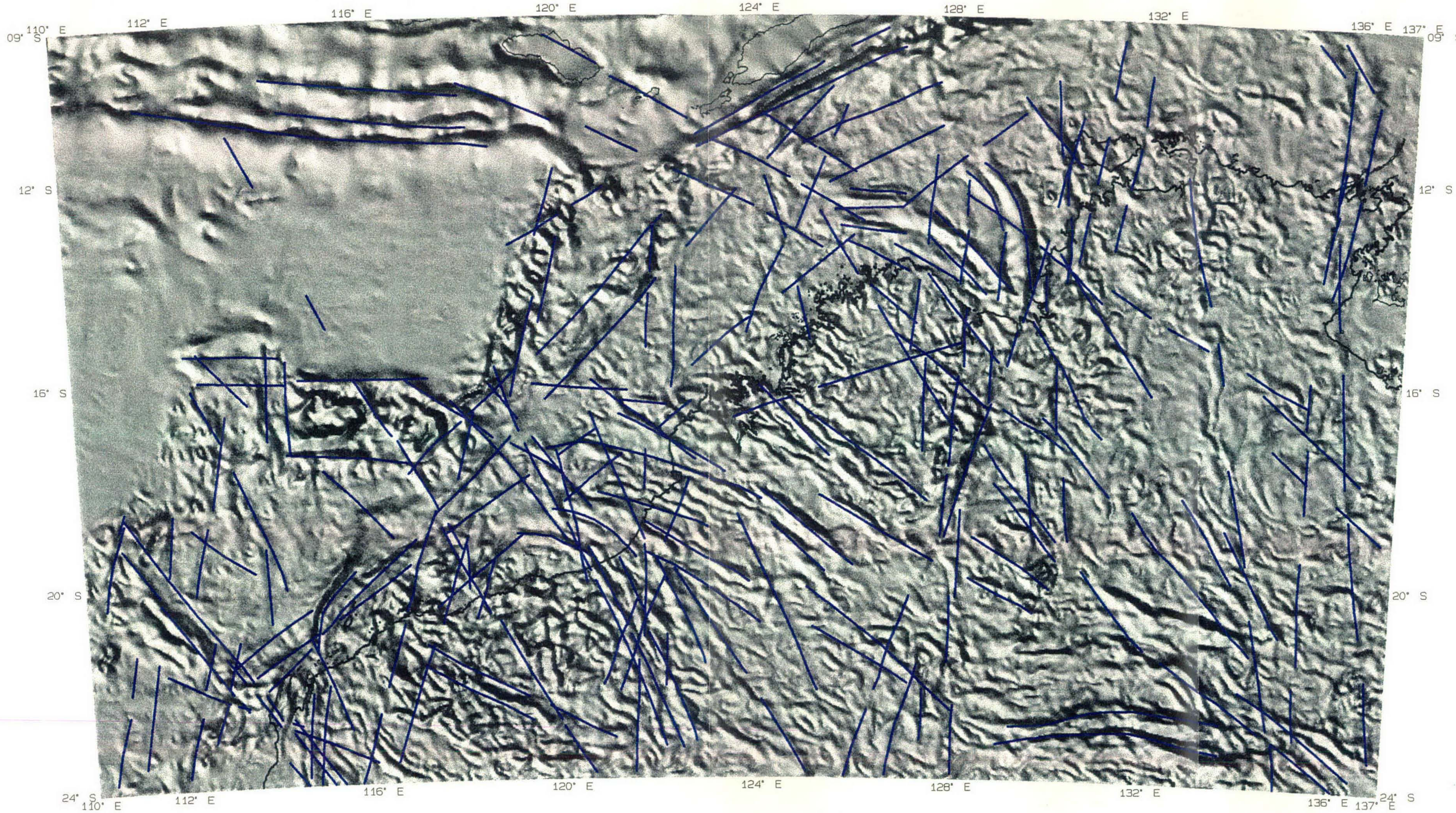

Plate 8: Horizontal gradient of the Free Air gravity anomaly, northeast illumination.

A horizontal gradient of the Free Air anomaly represented as sun-shaded relief with a sun elevation 45 degrees and an azimuth 45 degrees. The offshore intersection of the GL7 and GL8 are clearly seen in this image together with the crosscutting G5 and G12 corridors, and the crosscutting GL5 and GL6 corridors. The NNE GL2, and divergent GL9 and GL10 corridors, are also of note. An offshore extension of the G5 corridor into the Arafura Basin is suggested by the alignment of NNE lineaments in this region. A possible extension of the NW GL7 corridor across the WNW GL8 is also suggested. A WNW swing in the NW G11/B1 trend supports the observations of the Bouguer images.

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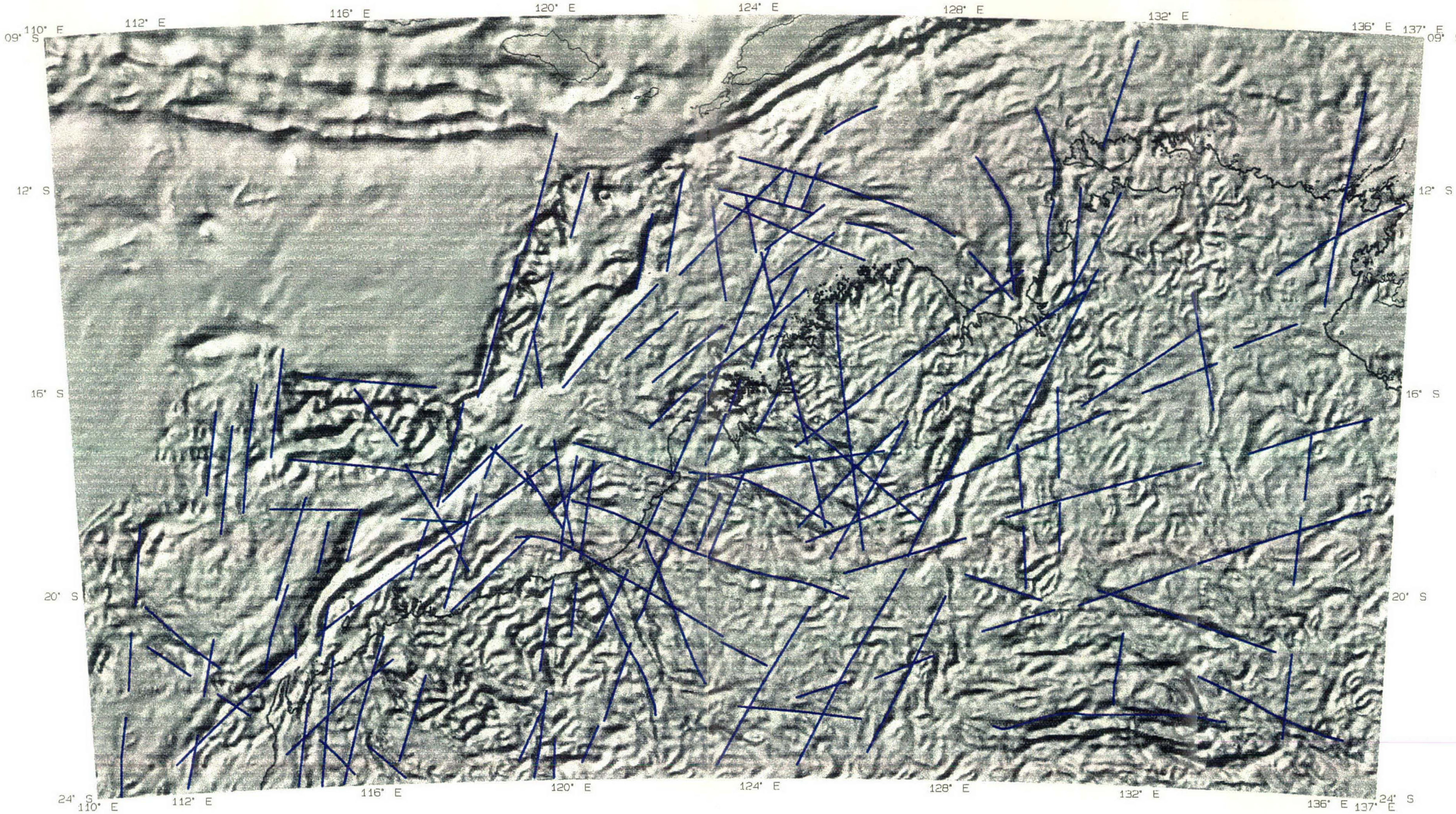

Plate 9: Horizontal gradient of the Free Air gravity anomaly, northwest illumination.

A horizontal gradient of the Free Air anomaly represented as sun-shaded relief with a sun elevation of 45 degrees and an azimuth of 315 degrees. The offshore convergence of the GL7 and GL8 are again seen in this image, as are the NNE corridors GL2, GL3 and G5. The NS GL1, WNW GL6 and NE GL9, are again clearly visible. The WNW swing of the B1 trend is also apparent.

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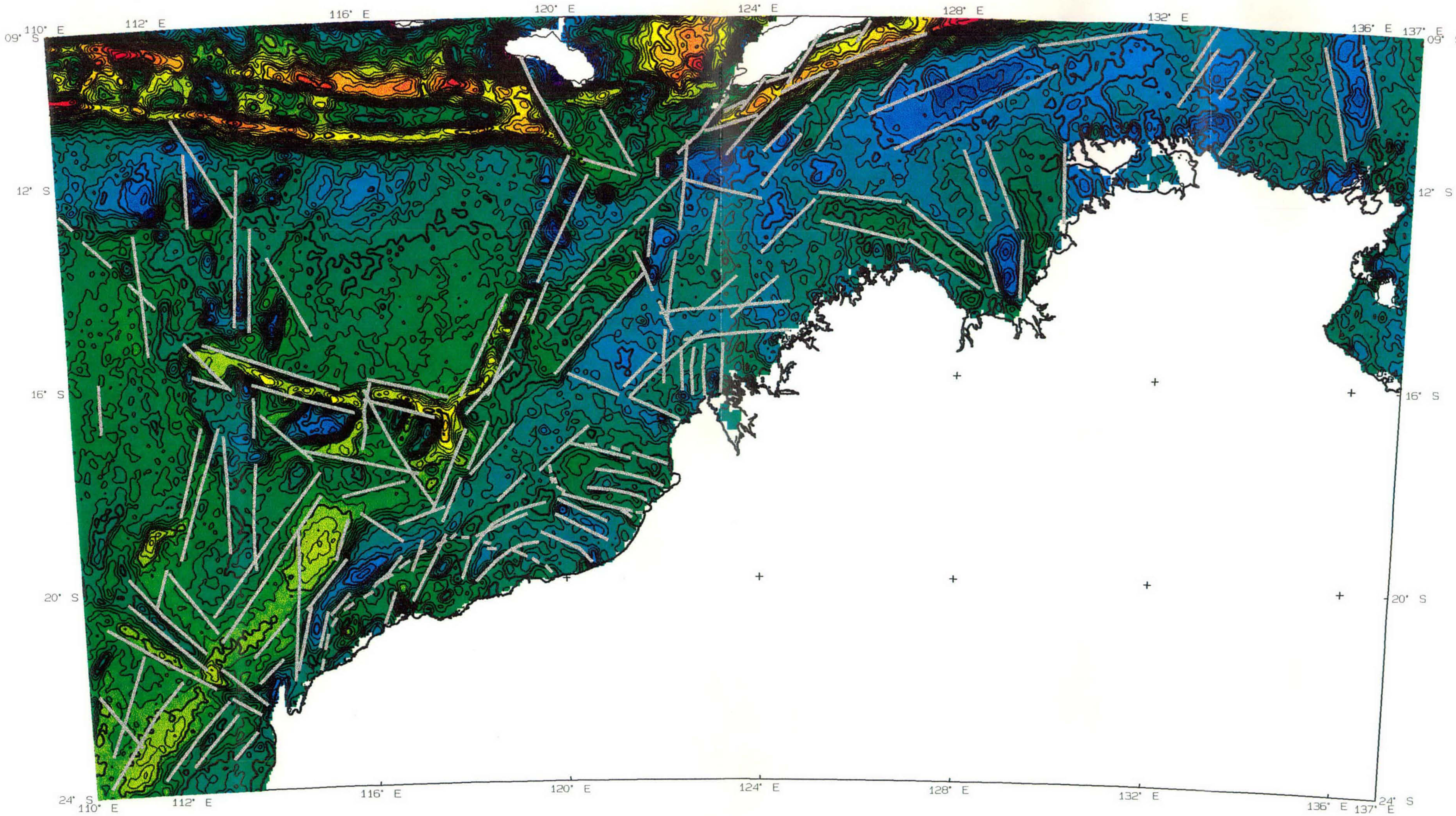
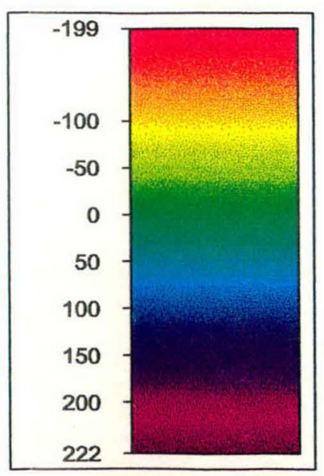


Plate 10: Colour map of the Free Air gravity contour anomaly from the Geosat data set

A portion of the Geosat Free Air world-gravity-7.2 displayed as colour fill and contour with a 10 mgal contour interval. This image reveals the same trends as identified on the previous images, especially the GL2, GL4, and the B1, B2 and B3 lineaments. The divergent GL9 and GL10 corridors are also seen. Of interest is the termination of the GL8 against the NE GL9 corridor, and the apparent swing of the GL7 corridor back towards the Pilbara Craton. NNE lineaments support an offshore extension of the G5, and the B1 trend again shows a swing into a WNW orientation.



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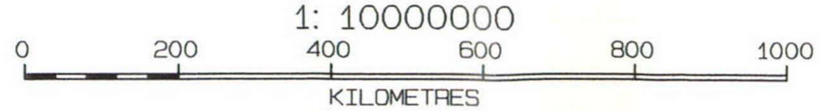

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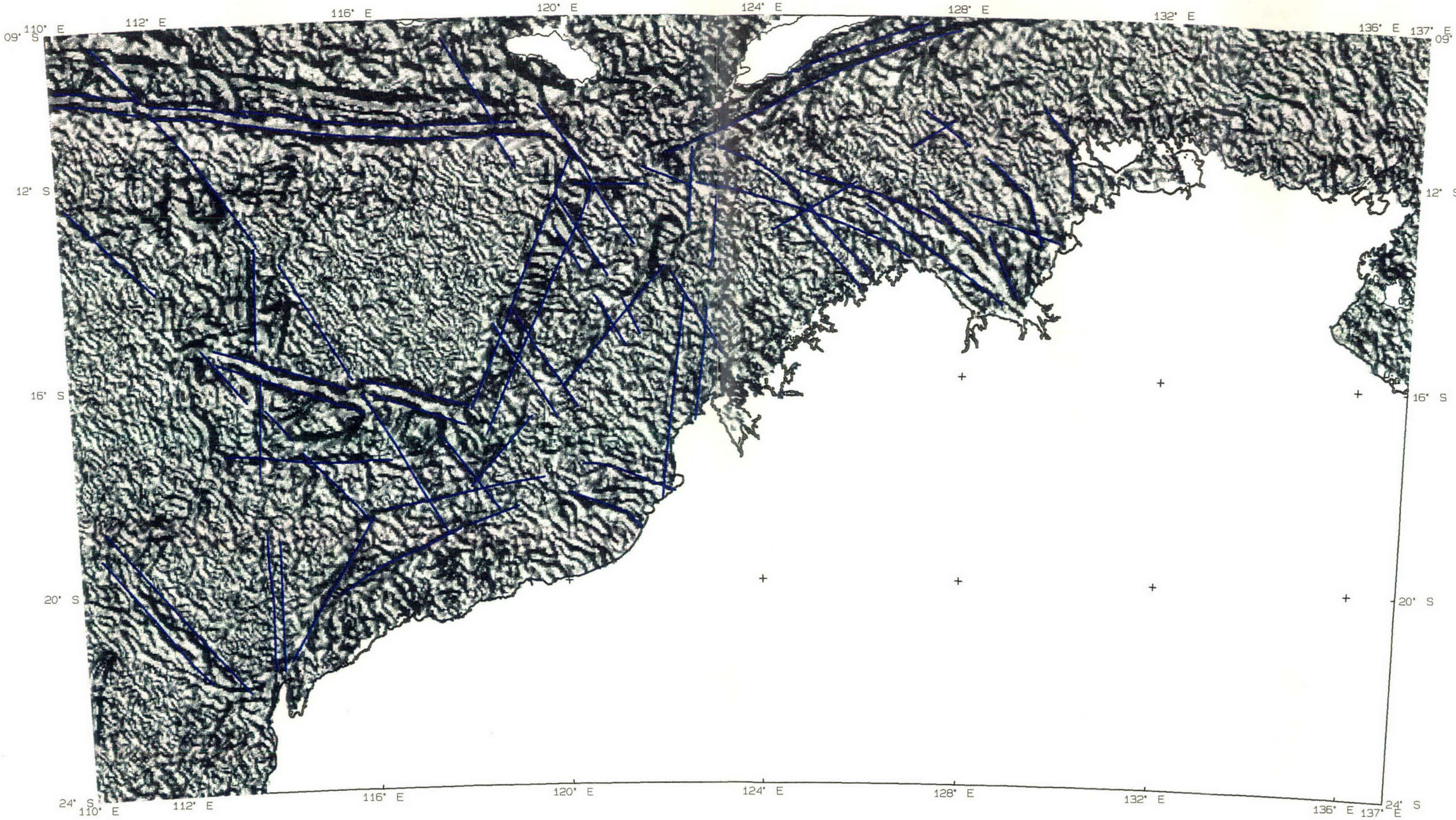

Plate 11: Horizontal gradient Free Air Geosat gravity anomaly, northeast illumination

A portion of the Geosat Free Air world-gravity-7.2 displayed as sun-shaded relief and horizontal gradient with a sun elevation 45 degrees and azimuth 45 degrees. The most notable feature on this image is the NW lineament GL11 which transects the offshore Carnarvon Basin and Argo Abyssal Plain. There appears to be sinistral offset of the southern margin of the Argo Abyssal Plain and possible dextral displacement of the Timor trench across this lineament. The cross-cutting relationships of this lineament suggests that it has undergone very recent movement. The NW lineaments aligning with the onshore G3 corridor suggest a possible extension of this gravity lineament that may extend as far as the edge of the Australian Plate. The GL4, B1 and GL2 gravity zones are clearly seen.

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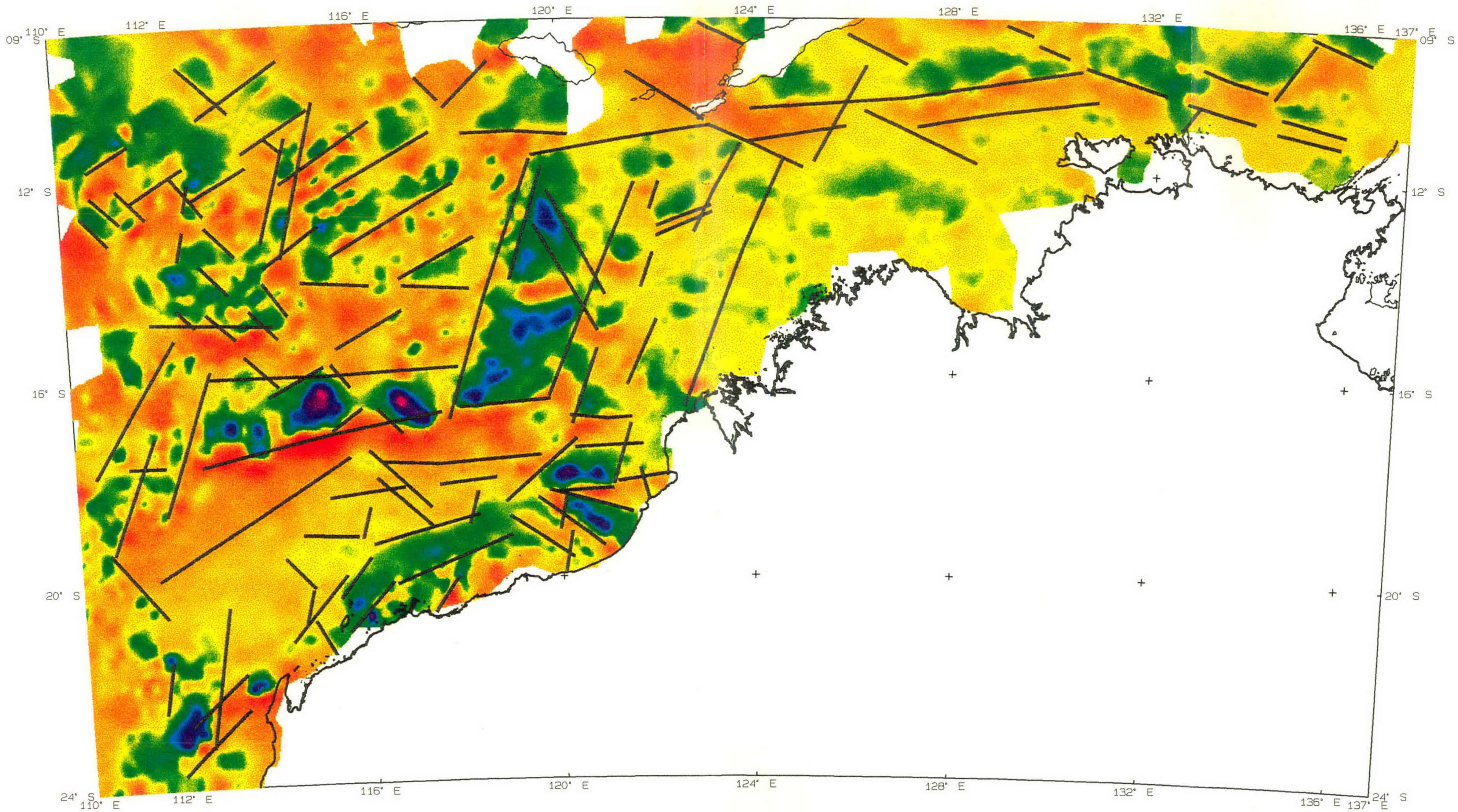
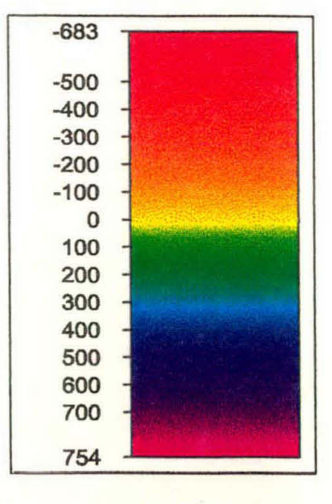


Plate 12: Color contour map of shipborne magnetic anomaly

A shipborne magnetic anomaly represented by colour fill. Although the lineaments are less well-defined than in the gravity data sets, there are several notable trends. These include the EW ML8B, NNE ML2, NNW ML7 and the ENE ML12 corridors.



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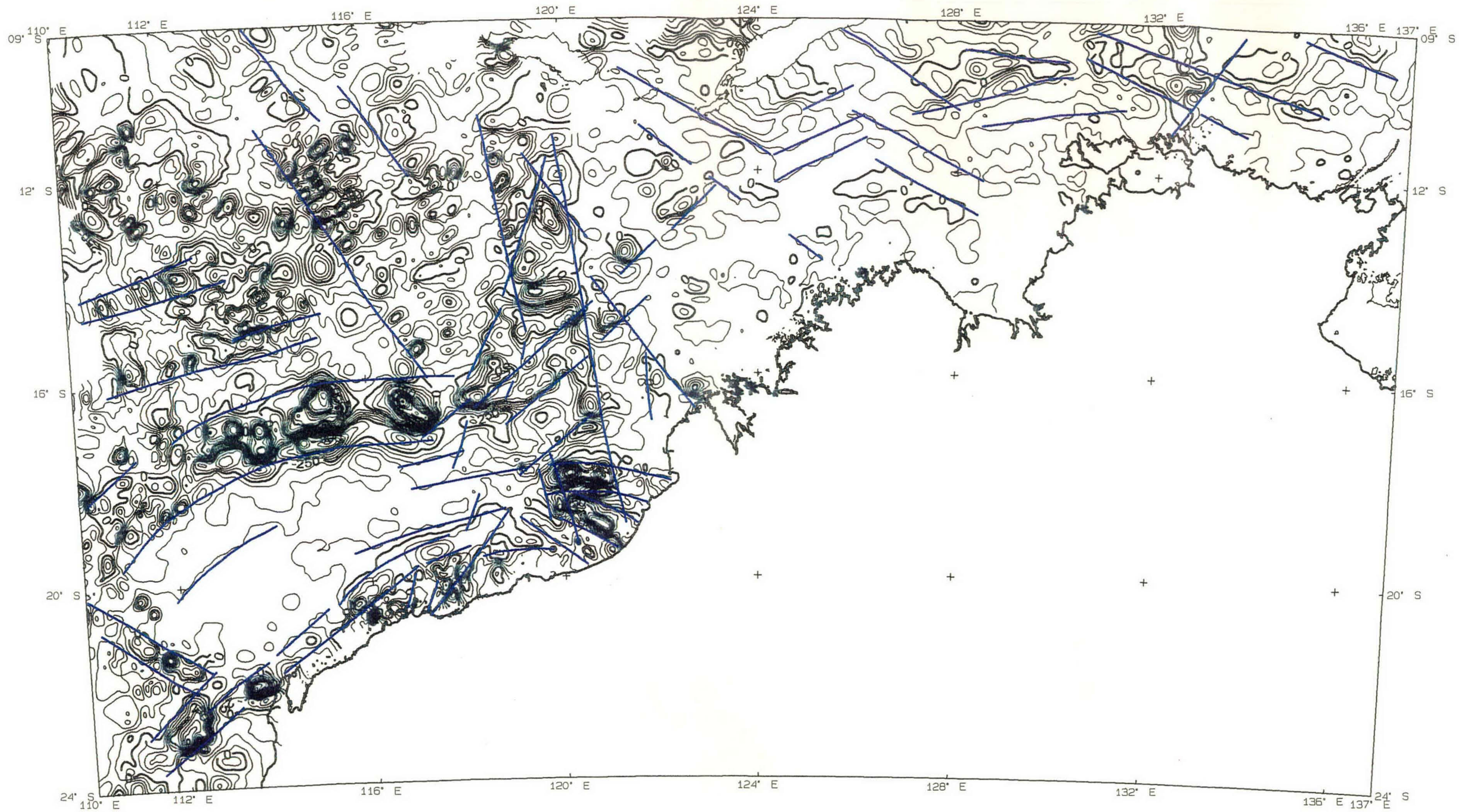

Plate 13: Contour map of the shipborne magnetic anomaly data set

A shipborne magnetic anomaly represented by a 50nT contour interval. This image shows several trends including the ML8B seen in the colour version, and the ML2. A corridor of interest is the NNW ML7 which approximates the NW onshore aeromagnetic lineament zone, and the onshore gravity corridor GL7. The ML7 is interpreted to lie at a slight angle to the orientation of its onshore counterparts which could suggest that it is reflecting magnetic units in the offshore Broome Platform and Scott Plateau, the latter which is situated to the NNW of the Broome Platform. A curvature of lineaments around the Pilbara Craton is a marked feature of this image. The linear western termination of the offshore extensions of the ML7 and ML8A can be related to the Broome Platform and Paterson Suture Zones.

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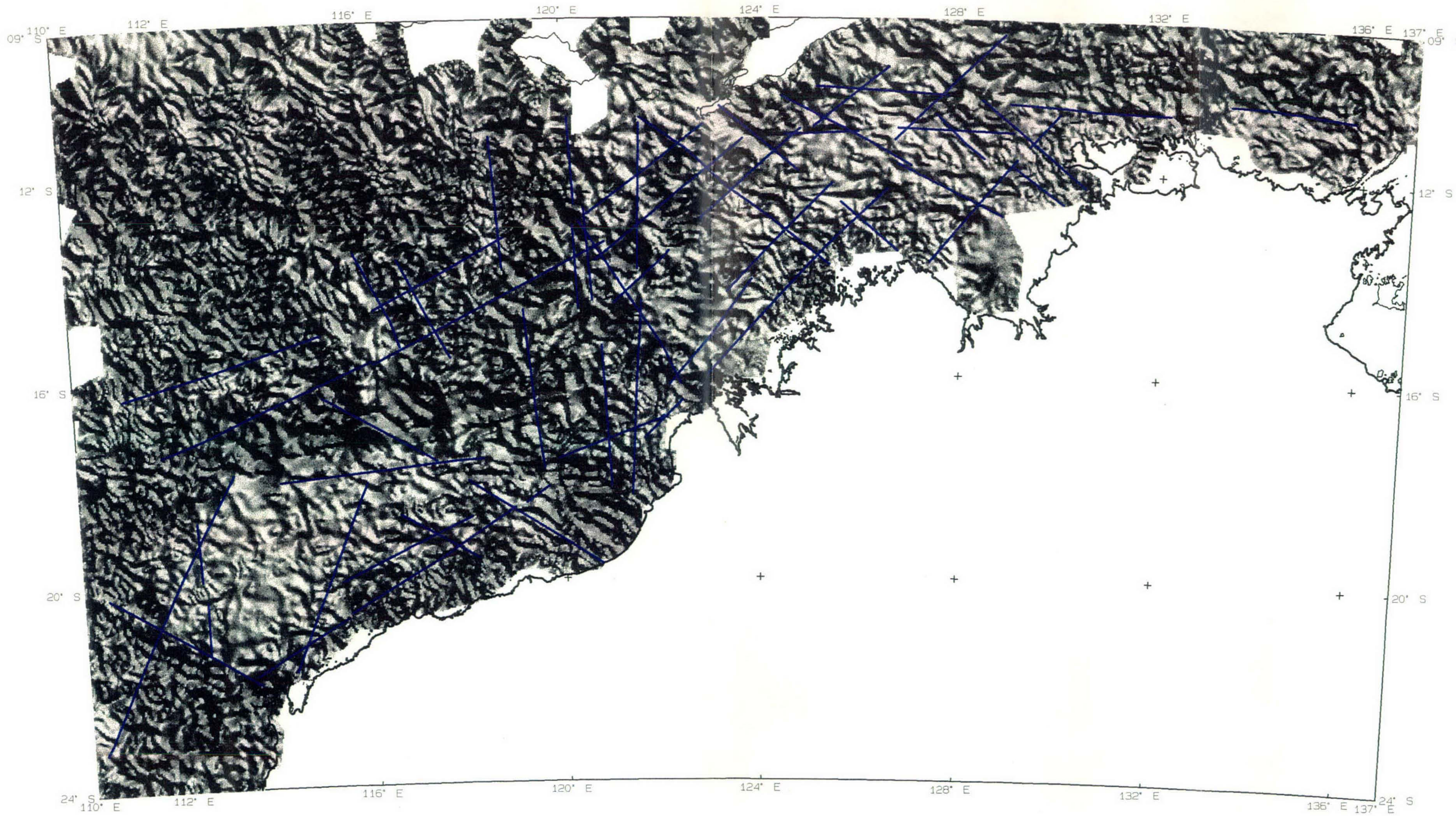

Plate 14: Horizontal gradient of the shipborne magnetic contour anomaly, northeast illumination.

A shipborne magnetic anomaly displayed as a sun-shaded relief, horizontal gradient with sun elevation of 45 degrees and an azimuth of 45 degrees. Magnetic lineament trends were poorly defined in this image however several, consistent with those described above, were observed. These include the offshore extension of the GL6, an alignment with the western edge of the GL4, the ML7, ML12 and ML13.

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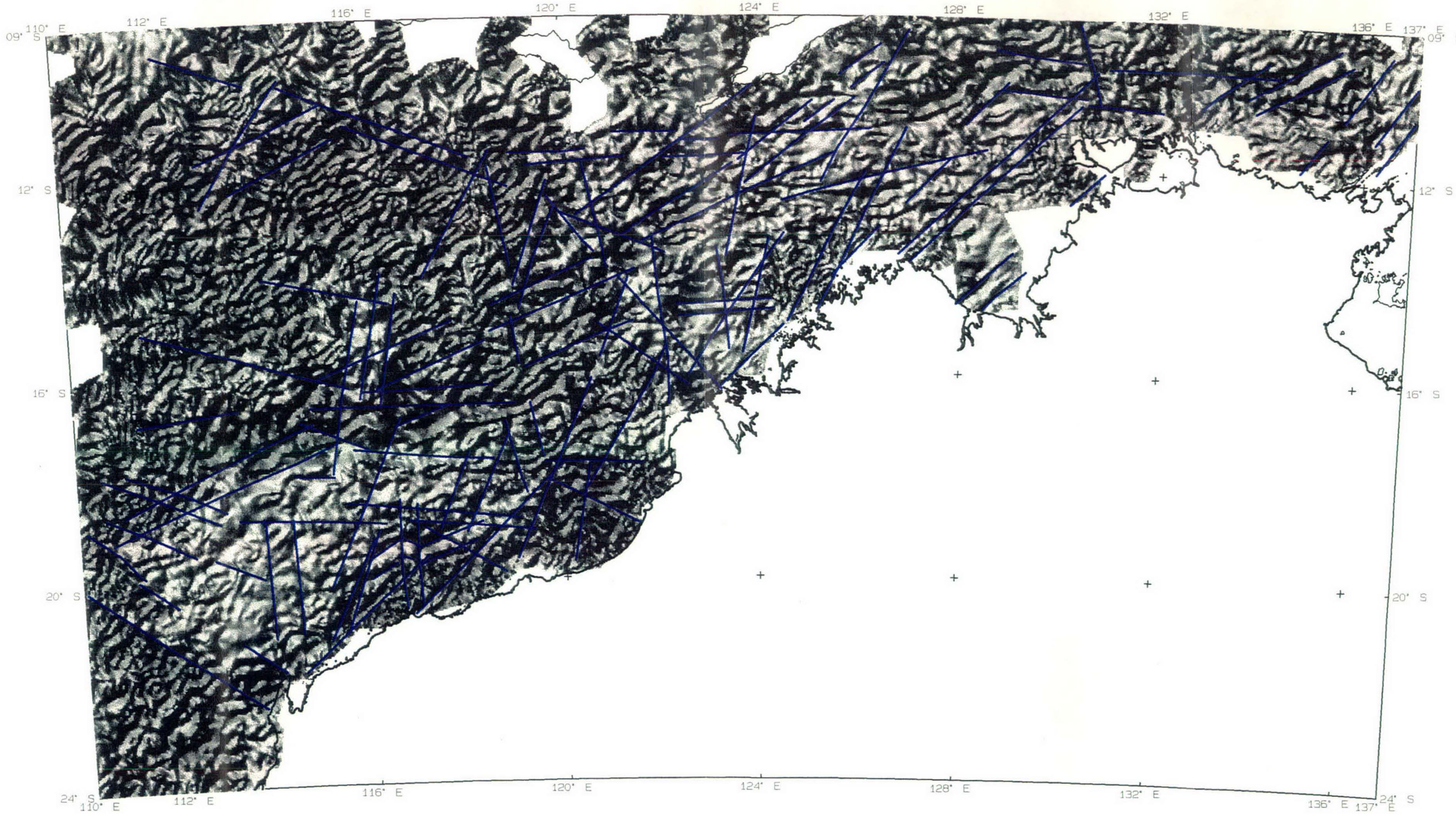

Plate 15: Horizontal gradient of the shipborne magnetic contour anomaly, northwest illumination

A shipborne magnetic anomaly displayed as a sun-shaded relief horizontal gradient with a sun elevation of 45 degrees and an azimuth of 315 degrees. Lineaments were again poorly defined in this image. Several familiar trends could be recognized including a magnetic alignment with the offshore extension of the GL6, GL3 and GL4 corridors. The NNE ML13 (aligning with the western margin of the Kimberley Craton coastline) the EW ML12 (which approximates the northern edge of the Money Shoals Platform) and a possible offshore extension of the ML3, are of interest.

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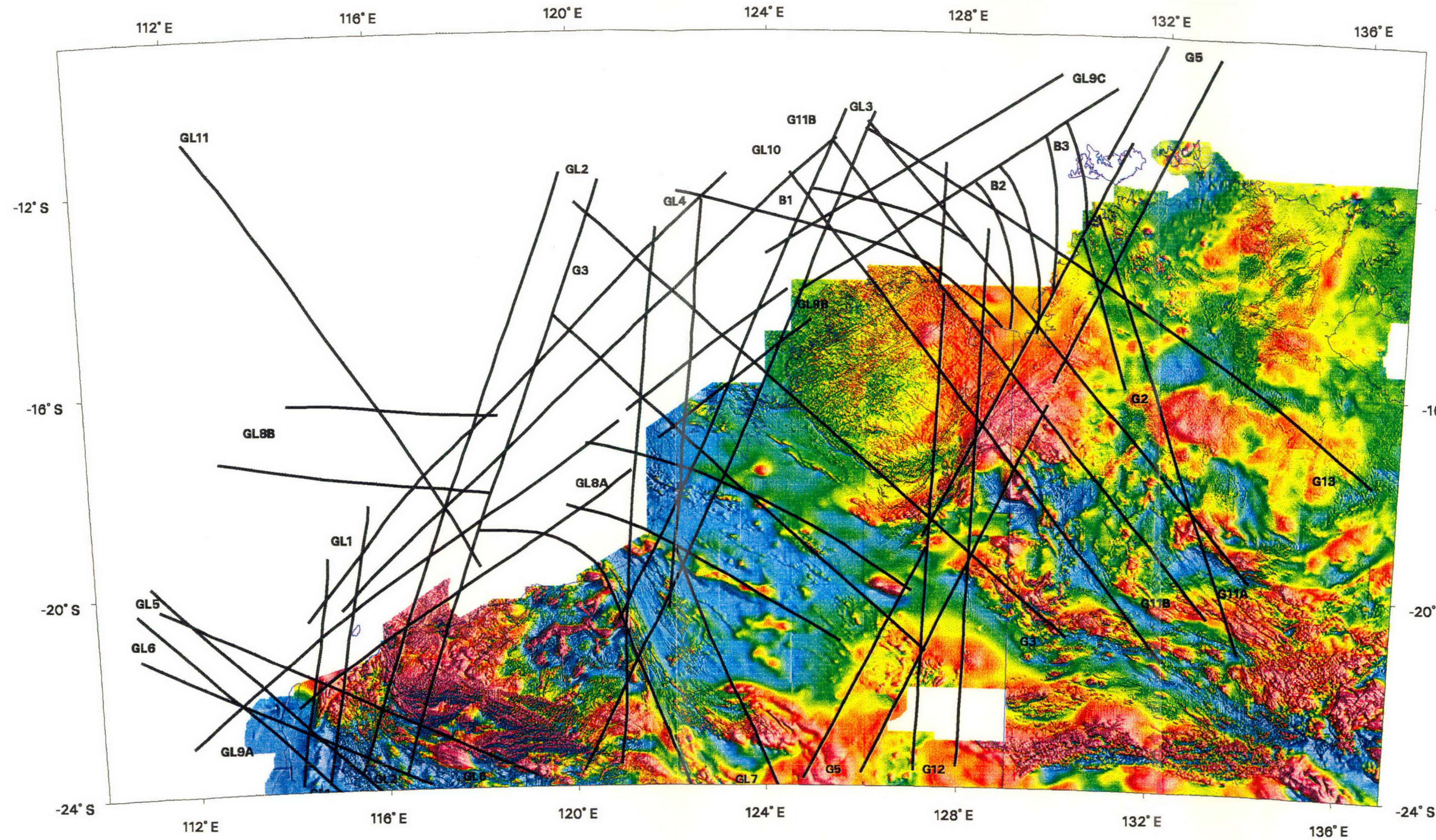

Plate 16: Correlation of the regional gravity lineaments with the onshore aeromagnetic anomaly map of northwest Australia

(portion of the Magnetic Anomaly Map of Australia by Tarlowski, Milligan and Mackey (1996))

The correlation of the regional gravity lineaments with the onshore aeromagnetic map of northwestern Australia demonstrates that there is a magnetic response consistent with the expression of the deeper gravity trends. Of special note is the north-northeast magnetic alignment along the western edge of the G5, and the north-south magnetic pattern consistent with the GL1 corridor. North-northeast magnetic lineaments (probable dykes or faults) are concentrated in the northwestern Pilbara, both onshore and offshore. The concentration is anomalously within, and parallel to, the GL2 gravity corridor.
A north-south magnetic alignment, consistent with the G12 and GL4 corridors, crosscuts the dominant regional structural grain of the G5 (Halls Creek Mobile Zone) and the GL7 (Paterson Suture Zone) corridors respectively.

The west-northwest trend of the G3 corridor, and the strong northwest magnetic alignment coincident with the GL7 corridor, are also of interest. The west-northwest GL8A (Broome Platform) magnetic grain is convergent with the northwest GL7. A west-northwest magnetic alignment also coincides with the GL6 gravity corridor in the southern region of the Pilbara.

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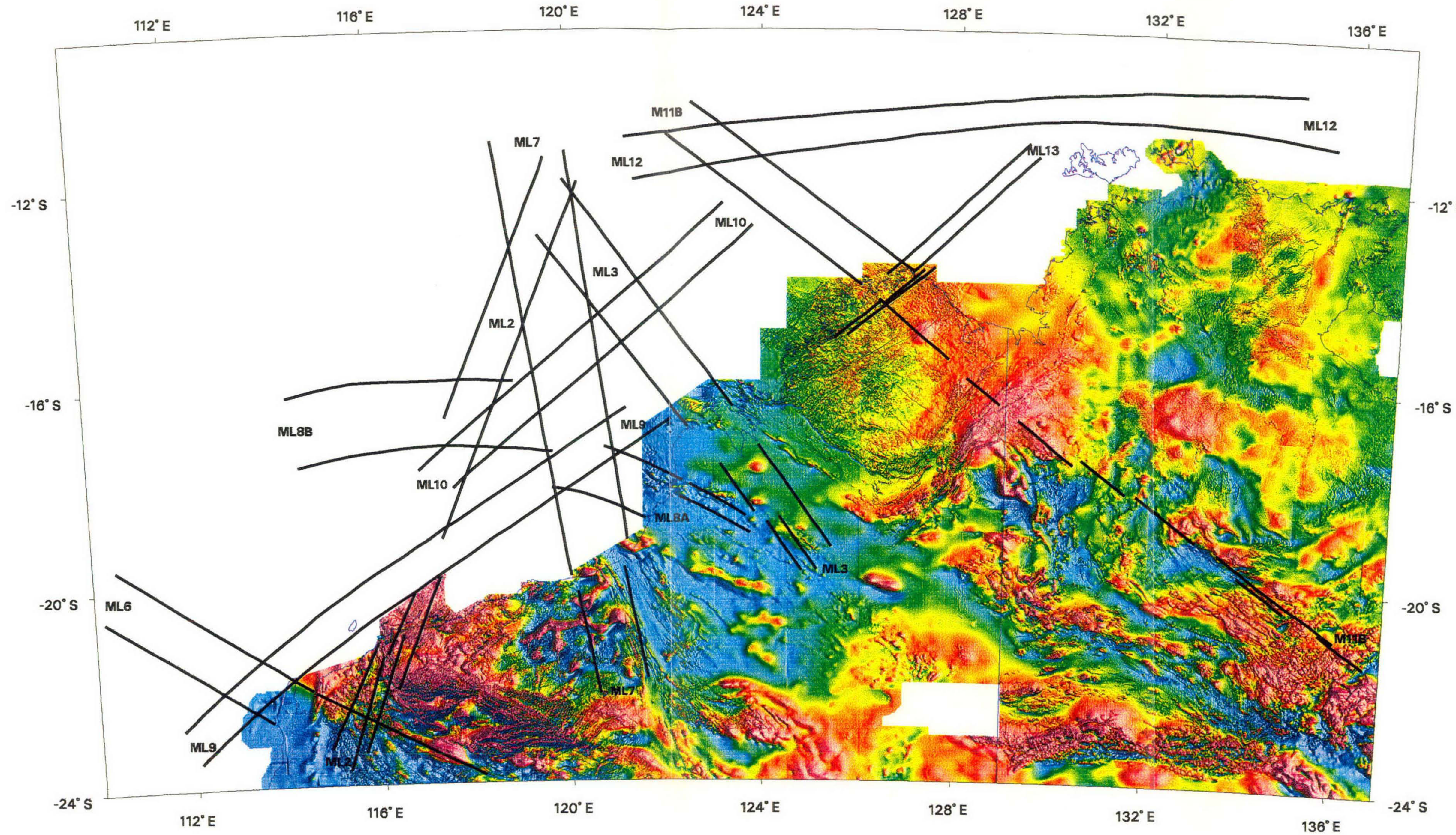

Plate 17: Correlation of the regional offshore magnetic lineaments with the onshore aeromagnetic anomaly map of northwest Australia

(portion of the Magnetic Anomaly Map of Australia by Tarlowski, Milligan and Mackey (1996))

The correlation of the offshore shipborne magnetic lineaments with the onshore aeromagnetic map shows some correlation between the two data sets. The ML2 and ML6 corridors both align with magnetic lineaments clearly seen to transect the Archaean/Proterozoic Pilbara Craton and Bangemall Basin.
The ML3 and ML7 both align with a weak magnetic expression onshore which cross-cuts the magnetic expression of the onshore gravity corridors (described earlier), at a slight angle. Both edges of the M11B closely correlate with the magnetic expression of the gravity G11B corridor but again at a slight angle. The magnetic expression of the southern edge of the M11B can be traced as aligned northwest lineaments for a distance exceeding 1400km. The ML13 corridor aligns with the western edge of the Kimberley craton. The eastern edge of the corridor is sub-parallel to, and aligns with, a prominent set of magnetic dykes in the western part of the Kimberley Craton. The ML8A aligns with a strong magnetic lineament response onshore which coincides the GL8A corridor and the Palaeoproterozoic Broome Platform.

0 200 400 600 800 1000 km

Scale 1:10 000 000

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Plate 18: Correlation of the regional gravity lineaments with the "Crustal Elements" map of onshore northwestern Australia

A correlation of the regional gravity lineaments with the northwestern portion of the Australian "Crustal Elements" map (Shaw *et. al.*, 1996a 1996b) shows that there is a marked coincidence between many of the corridors and the crustal boundaries as depicted by Shaw *et al.*, (1996). The legend for the "Crustal Elements" map is included on the page immediately following this Plate.

North-south to northeast regional lineaments

G5 Corridor:

The G5 corridor coincides with the linear north–northeast belt of Palaeoproterozoic rocks known as the Halls Creek Mobile Zone (HCMZ) and Fitzmaurice Mobile Zone (FMZ) in northern and northwestern Australia. The FMZ rocks are contained within the corridor whereas further to the south–southwest, the western edge of the G5 corridor aligns with the eastern edge of the HCMZ. The change in relative location of the Palaeoproterozoic rocks is seen as a sinistral deflection of the belt across the northwest G11A & B corridors. Further south, the eastern edge of the G5 coincides with the linear eastern edge of the Palaeoproterozoic basement ('R') underlying the Kidson Sub-basin. A swing in orientation of the Mesoproterozoic 'RU' unit from east-west to north–south, occurs across the western edge of the corridor.

G12 Corridor:

The G12 corridor cross-cuts the north–northeast trend of the HCMZ where it coincides with a sinistral deflection of the Palaeoproterozoic HCMZ in a north–south orientation. Further south, the G12 aligns with a swing in orientation of the west–northwest 'BR' terrain which becomes the north-south 'AG' terrain. In the Kimberley region, the eastern edge of the corridor coincides with the north-south Cambridge Gulf inlet.

GL1 Corridor:

The north–south GL1 gravity corridor correlates with the north–south extension of the Darling Fault boundary between the Archaean 'CPG' terrain on the margin of the Pilbara Craton, and the late Mesoproterozoic 'NH' terrain.

GL2 Corridor:

The north–northeast GL2 corridor aligns with a general swing in orientation of crustal elements within the Pilbara Craton region from west–northwest to north–south. Further south, and not included in this section of the map, a projection of the GL2 corridor coincides with a dextral deflection in the north-south trending Darling Fault.

GL3 Corridor:

The north–northeast GL3 corridor crosscuts the dominant northwest and west-northwest regional trend of the Paterson–Fitzroy province and is poorly expressed in the crustal elements. There are, however, several small alignments that may reflect this gravity discontinuity. These include the north–northeast swing of the eastern edge of the late Neoproterozoic 'PA' terrain, and linear north–northeast alignments of the Archaean 'P' crustal zone which coincides with two edges of the GL3.

GL4 Corridor:

The north–south GL4 gravity corridor crosscuts the dominant northwest regional trend of the Paterson Province ('PA' & 'RU'). The lineament aligns with a general north–south trend to the eastern margin of the Archaean Pilbara Craton. This includes the linear north-south, possibly fault related, boundary of the Pilbara which coincides with the western edge of the corridor.

West–northwest to north–northwest regional lineaments

G3 Corridor:

The northwestern section of the west–northwest G3 corridor coincides with Palaeoproterozoic rocks of the King Leopold Mobile Zone (KLMZ), annotated on this map as 'KL'. Toward central Australia, the northern edge also aligns with the southern margin of the west–northwest trending 'AHR' Palaeoproterozoic province. The southern edge of the G3 gravity corridor, as identified from the maps included in this report, coincides with the northern margin of the 'BR' Palaeoproterozoic province known as the Broome Platform. The underlying, and older basement of

'R', is also postulated on this map to terminate against this southern margin.

G11 Corridor:

In the Kimberley region, the northwest GllA/B boundary coincides with the linear Kimberley coastline and parallels the linear crustal boundary between the Mesoproterozoic Kimberley Basin sequence ('K'), and the early Palaeozoic Bonaparte sequence ('BN'). An apparent dextral offset of the HCMZ / FMZ occurs primarily across the G11A corridor. A younger north-northeast Mesoproterozoic sequence ('HCA'), within the linear mid Palaeoproterozoic HCMZ trend, is concentrated within the G11B corridor. Toward central Australia, the 'TC' crustal element associated with the Tennent Creek Inlier, which is of the same age group as the HCMZ, is also dextrally deflected, this time across the northern edge of the G11A corridor.

G13 Corridor:

The west–northwest G13 corridor approximates the northern edge of the late Palaeoproterozoic basement to the Wiso Basin ('W'), and with a crustal change within the 'MA' province. The lineament also sub-parallels the southern edge of the Archaean 'CU' block and coincides with the northern edge of the Mesoproterozoic 'WEL' province.

G2 Corridor:

The north–northeast G2 corridor aligns with north–northeast crustal boundaries within the late Palaeoproterozoic 'HM', 'BU' and 'W' provinces. A possible extension of the corridor, which is supported by Elliott's earlier work (Elliott, 1994a, 1994b) and that of O'Driscoll (1980, 1986), coincides with the western edge of the 'CYS' late Palaeoproterozoic terrain, south of the Arunta Craton.

GL6 Corridor:

The GL6 corridor coincides with the west–northwest Archaean 'MV' province. The northern edge of the corridor aligns with the southern margin of the older Archaean basement of the Pilbara Craton. Further southeast, and not included in this section of the map, the corridor also coincides with the west-northwest boundary between the Palaeoproterozoic 'NBB' Basin on the northern margin of the Yilgarn Craton, and the Mesoproterozoic 'CPB' province.

GL7 Corridor:

The northwest GL7 corridor coincides with the Neoproterozoic 'PA', and the northern part of the Mesoproterozoic 'RU' terrains, which are generally known as the Paterson Province or Paterson Suture Zone. The linear north–eastern margin of the 'P' Archaean terrain parallels, and coincides with, the GL7 corridor.

GL8 Corridor:

The GL8 corridor swings from a west–northwest orientation onshore into a more east-west trend offshore. The corridor broadly correlates with the Neoproterozoic 'LA' sequence, and the more linear Palaeoproterozoic 'BR' terrain, which also shows a swing in trend similar to the gravity expression.

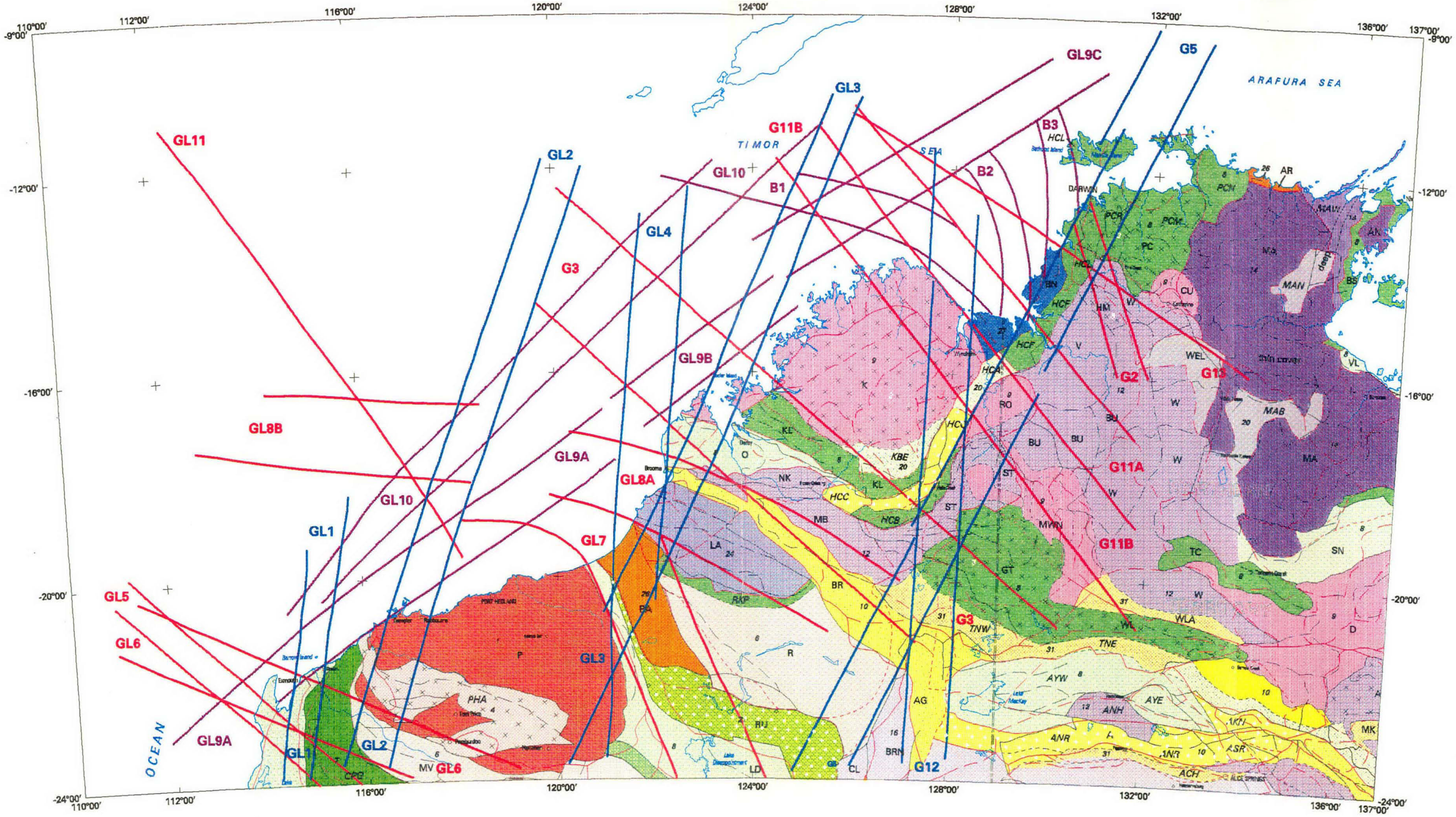

Plate 18 : Correlation of the regional gravity lineaments with the "Crustal Elements" map of onshore northwestern Australia

(portion of "Australian Crustal Elements" map by Shaw, R.D. et al, 1996)

SCALE 1:10 000 000

0 100 500 1000 Kilometres

SIMPLE CONIC PROJECTION WITH TWO STANDARD PARALLELS AT 12°S AND 21°S
AUSTRALIAN NATIONAL SPHEROID
CENTRAL MERIDIAN 123°E

AGSO
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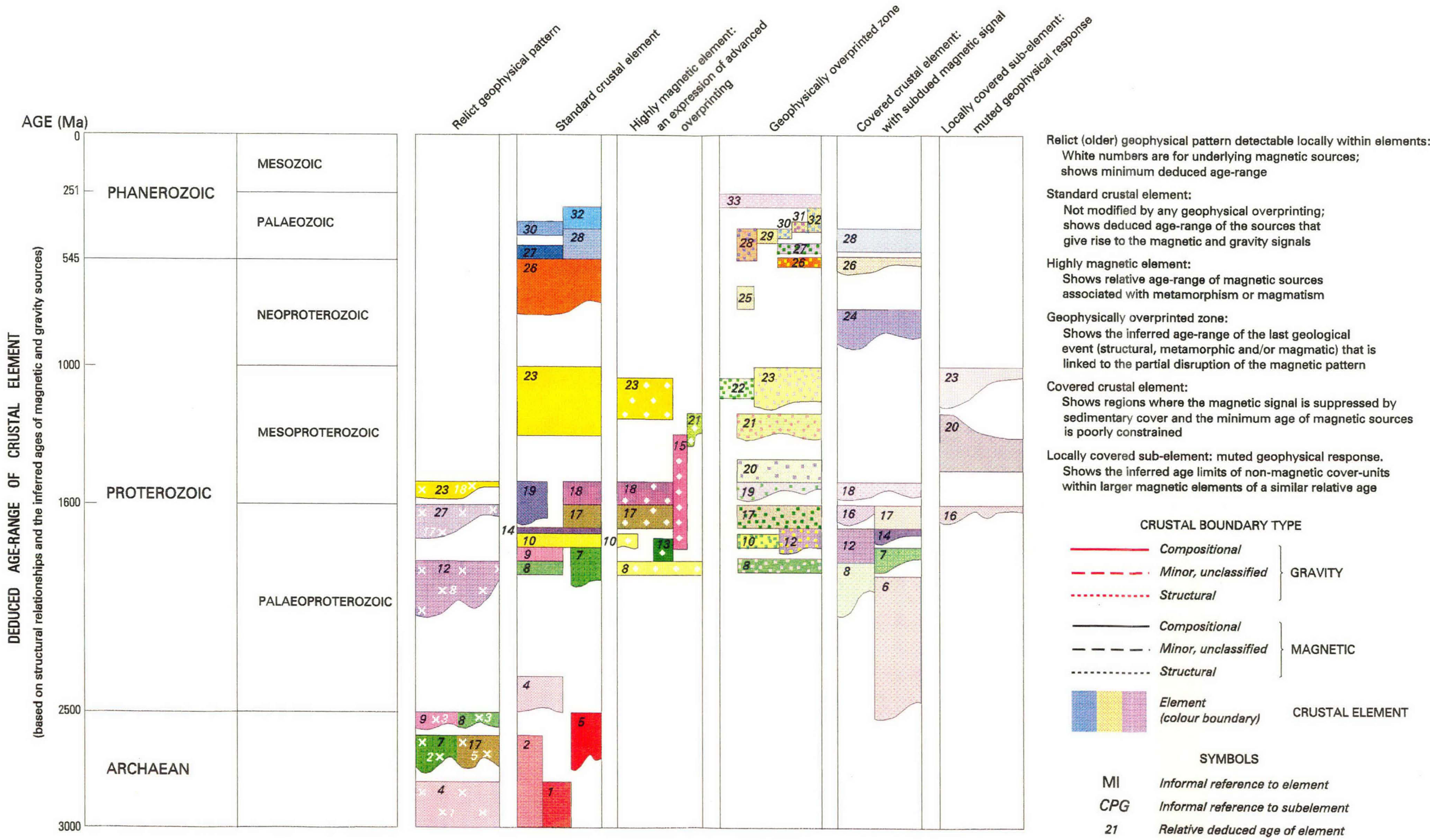
AGE (Ma)
0
251
545
1000
1600
2500
3000
PHANEROZOIC
PROTEROZOIC
ARCHAEAN
MESOZOIC
PALAEOZOIC
NEOPROTEROZOIC
MESOPROTEROZOIC
PALAEOPROTEROZOIC
DEDUCED AGE-RANGE OF CRUSTAL ELEMENT
(based on structural relationships and the inferred ages of magnetic and gravity sources)
Relict geophysical pattern
Standard crustal element
Highly magnetic element: an expression of advanced overprinting
Geophysically overprinted zone
Covered crustal element: with subdued magnetic signal
Locally covered sub-element: muted geophysical response
Relict (older) geophysical pattern detectable locally within elements:
White numbers are for underlying magnetic sources;
shows minimum deduced age-range
Standard crustal element:
Not modified by any geophysical overprinting;
shows deduced age-range of the sources that
give rise to the magnetic and gravity signals
Highly magnetic element:
Shows relative age-range of magnetic sources
associated with metamorphism or magmatism
Geophysically overprinted zone:
Shows the inferred age-range of the last geological
event (structural, metamorphic and/or magmatic) that is
linked to the partial disruption of the magnetic pattern
Covered crustal element:
Shows regions where the magnetic signal is suppressed by
sedimentary cover and the minimum age of magnetic sources
is poorly constrained
Locally covered sub-element: muted geophysical response.
Shows the inferred age limits of non-magnetic cover-units
within larger magnetic elements of a similar relative age
CRUSTAL BOUNDARY TYPE
Compositional
Minor, unclassified
Structural
GRAVITY
Compositional
Minor, unclassified
Structural
MAGNETIC
Element
(colour boundary)
CRUSTAL ELEMENT
SYMBOLS
MI
Informal reference to element
CPG
Informal reference to subelement
21
Relative deduced age of element

Plate 19: Correlation of the regional offshore magnetic lineaments with the "Crustal Elements" map of Northwestern Australia

Of the six regional offshore magnetic corridors that can be projected to intersect the coastline (ML6, ML7, ML8A, ML3, M11B and ML13), four show correlation with the crustal elements as mapped by Shaw *et al.,* (1996a, 1996b).

The ML6 aligns with the Palaeoproterozoic 'MV' province, and the ML7 sub-parallels the Proterozoic 'LD', 'RU' and 'PA' terrains. The ML3, which is within and at an angle to, the regional west-northwest G3 trend, aligns with northwest offsets in the west-northwest Palaeoproterozoic 'BR' province (which aligns with the ML8A corridor).

The northeast ML13 aligns with the Kimberley coastline, and with inter-provincial boundaries as mapped by Shaw *et al.,* (1996a). They map a northeast boundary, aligning with the ML13, in the Mesoproterozoic 'K' terrain of the Kimberley Craton. The western termination of the Archaean 'KL' province (correlating with the King Leopold Mobile Zone) against the Mesoproterozoic 'K' terrain, also aligns with the projected extension of the ML13 lineament. Further southwest, a northwest inter-provincial boundary within the Palaeoproterozoic 'O' domain is seen to align with the projection of the ML13.

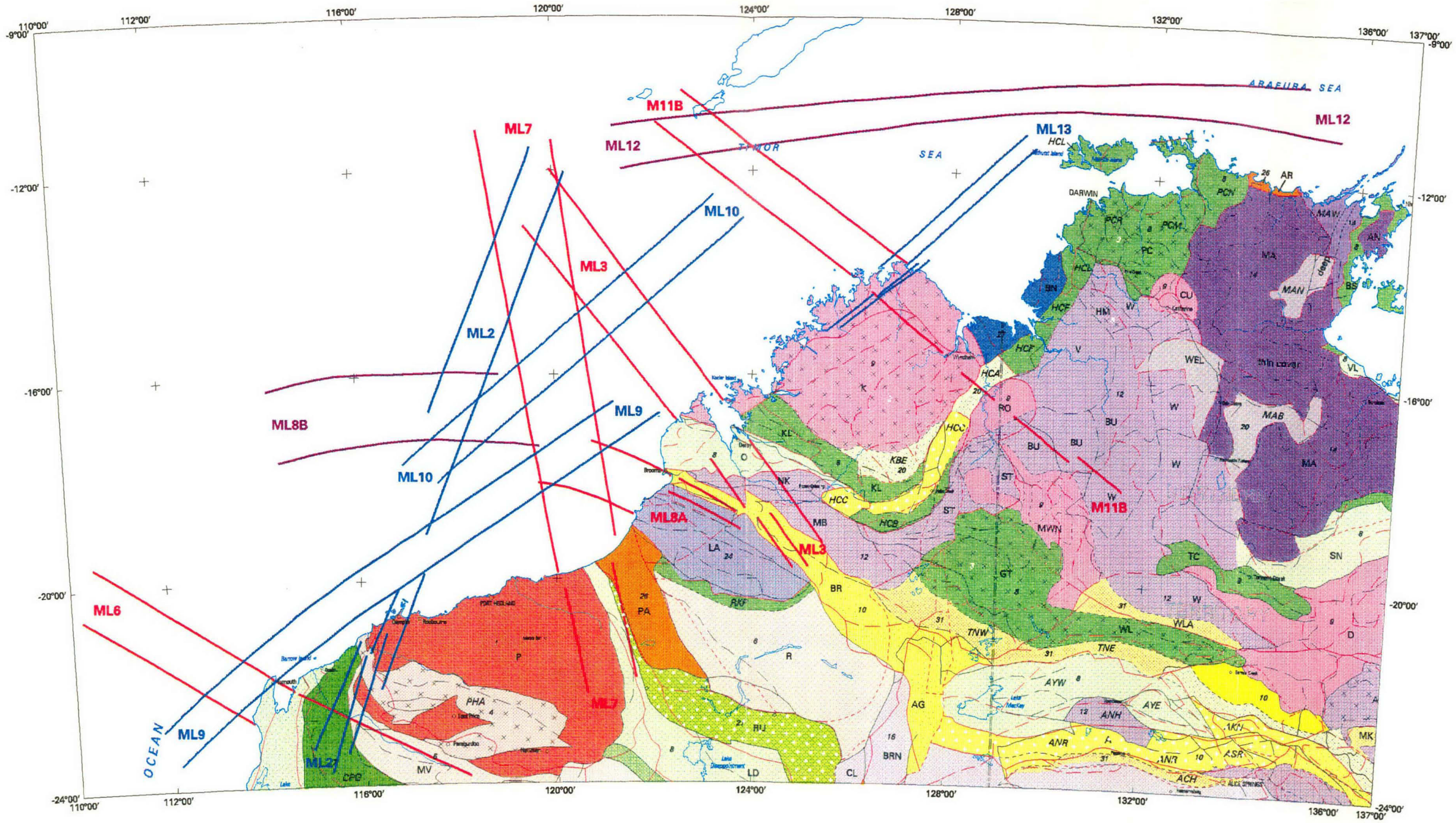

Plate 19 : Correlation of the offshore magnetic lineaments with the "Crustal Elements" map of onshore northwestern Australia

(portion of "Australian Crustal Elements" map by Shaw, R.D. et al, 1996)

SCALE 1:10 000 000

0 100 500 1000 Kilometres

SIMPLE CONIC PROJECTION WITH TWO STANDARD PARALLELS AT 12°S AND 21°S
AUSTRALIAN NATIONAL SPHEROID
CENTRAL MERIDIAN 123°E

AGSO
AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

Plate 20: Correlation of the north-south to northeast regional gravity lineaments with the "Depth to Basement" map of northwestern Australia

Correlation of the north–south to northeast regional gravity lineaments with the northwestern section of the Australian "Depth to Basement" map (Borissova, 1994). This map shows that there is a consistent correlation between the major depocentres, the regional basement 'highs', and the gravity corridors. The north-south to north-northeast regional lineaments are depicted in this map by short-dashed lines. The northeast lineaments and Bonaparte Trends are depicted by long-dashed lines.

G5 Corridor:

Onshore, the G5 corridor correlates with several sedimentary provinces. These include the western margin of the Proterozoic Victoria River Basin along the eastern edge, and the boundary between the Halls Creek Mobile Zone (HCMZ), and the Ord depocentre along the western margin. The dextral deflection of the HCMZ and Fitzmaurice Mobile Zone (FMZ) is again apparent across the G11A corridor. Further south, the eastern edge of the G5 corridor coincides with the eastern edge of the Fitzroy Trough and Canning Basin Phanerozoic depocentres.

G12 Corridor:

The dominant sedimentary feature of the G12 corridor is the north–south terminations of the northwest and west–northwest Canning and Fitzroy basins respectively. North–south deflections of the otherwise north–northeast HCMZ, within the G12, are also apparent. Offshore, a postulated extension of the G12 coincides with a localized depocentre near the intersection of the orthogonal Malita Graben and Sahul Syncline.

GL1 Corridor:

Onshore, the GL1 corridor coincides with a series of regional north–south faults. Offshore, the western edge aligns with the coastline and a northeast basement high that swings into a north–south orientation within the corridor, separating the Exmouth Sub-basin from the Barrow Sub-basin. The eastern edge of the corridor separates the Barrow Sub-basin from the Dampier Sub-basin with a sinistral deflection of the northeast depositional hinge across the lineament.

GL2 Corridor:

The dominant feature of the offshore GL2 corridor is its alignment with the eastern edge of the Argo Abyssal Plain. The corridor also coincides with north-northeast trending faults separating the Carnarvon from the Rowley Basin, and a sinistral offset of the major Northwest Shelf depocentre. A deflection of the depocentre from northeast to north-northeast, and parallel to the corridor, occurs on the eastern margin of the lineament zone. An elongation of the basement of the Scott Plateau in a north-northeast orientation also coincides with the eastern edge of the corridor.

GL3 Corridor:

Offshore, the GL3 corridor coincides with a swing in the orientation of the Kimberley Shelf from northeast, and parallel to the major depocentre axis, to north-northeast and parallel to the corridor. The corridor also coincides with a north–northeast basement high that separates the Bonaparte Basin to the northeast, from the Browse Basin to the southwest.

GL4 Corridor:

Offshore, the GL4 corridor coincides with the westward extension of the Kimberley shelf and to the north, with a change in orientation of the depocentre axis from northeast to north-northeast. The western edge of the corridor aligns with the eastern margin of the Scott Plateau.

GL9 Corridor:

The GL9 corridor extends for a distance of approximately 2400km on a northeast orientation and based on the gravity images used in this study, can be divided into three components, the GL9A, GL9B and GL9C. The three components maintain a consistent orientation but each are progressively offset in a left-lateral orientation.

The GL9A aligns with the Barrow and Dampier depocentres of the Carnarvon Basin with northern edge of the lineament coinciding with the southeastern edge of the Exmouth Sub-basin, and the northwestern edge of the Barrow Sub-basin. The southern edge coincides with the northeast Australian coastline for a distance exceeding 300km and parallels the shelf margin offshore from the Pilbara Craton.

The GL9B shows a minor left-lateral displacement from the GL9A across the eastern edge of the north–south GL4 corridor. The corridor sub-parallels the offshore margin of the Kimberley Craton.

The GL9C corridor is displaced approximately 100km with the southern edge aligning with the northern edge of the GL9B. The displacement occurs across the GL3 corridor and coincides with a change in orientation of the basement trend from northeast to north–northeast / north–south. The corridor aligns with the northwestern margin of the Petrel Sub-basin, and with the linear Malita Graben. The northwestern edge approximates the northwestern edge of the Malita Graben. The B2 and B3 corridors terminate at the southeastern edge of the GL9C reflecting the termination of the Bonaparte Basin depocentre.

GL10 Corridor:

The more northeasterly GL10A corridor forms a bifurcating trend with the GL9 corridor and aligns with the depocentre of the Rowley Sub-basin, and with the northwest margin of the Browse Basin depocentre. To the north, the corridor coincides with the basement high associated with the southern region of the Ashmore Platform. In the southern region, the corridor coincides with a change in orientation of faults from north–south to northeast, and the northeast Exmouth Sub-basin.

B1 Corridor:

The B1 corridor is identified in this study as a component of the more regional G11A corridor which swings off in an east–west orientation coinciding with the southern margin of the Bonaparte Basin. Further west, the southern edge of the corridor aligns with the southern margin of the Ashmore Platform.

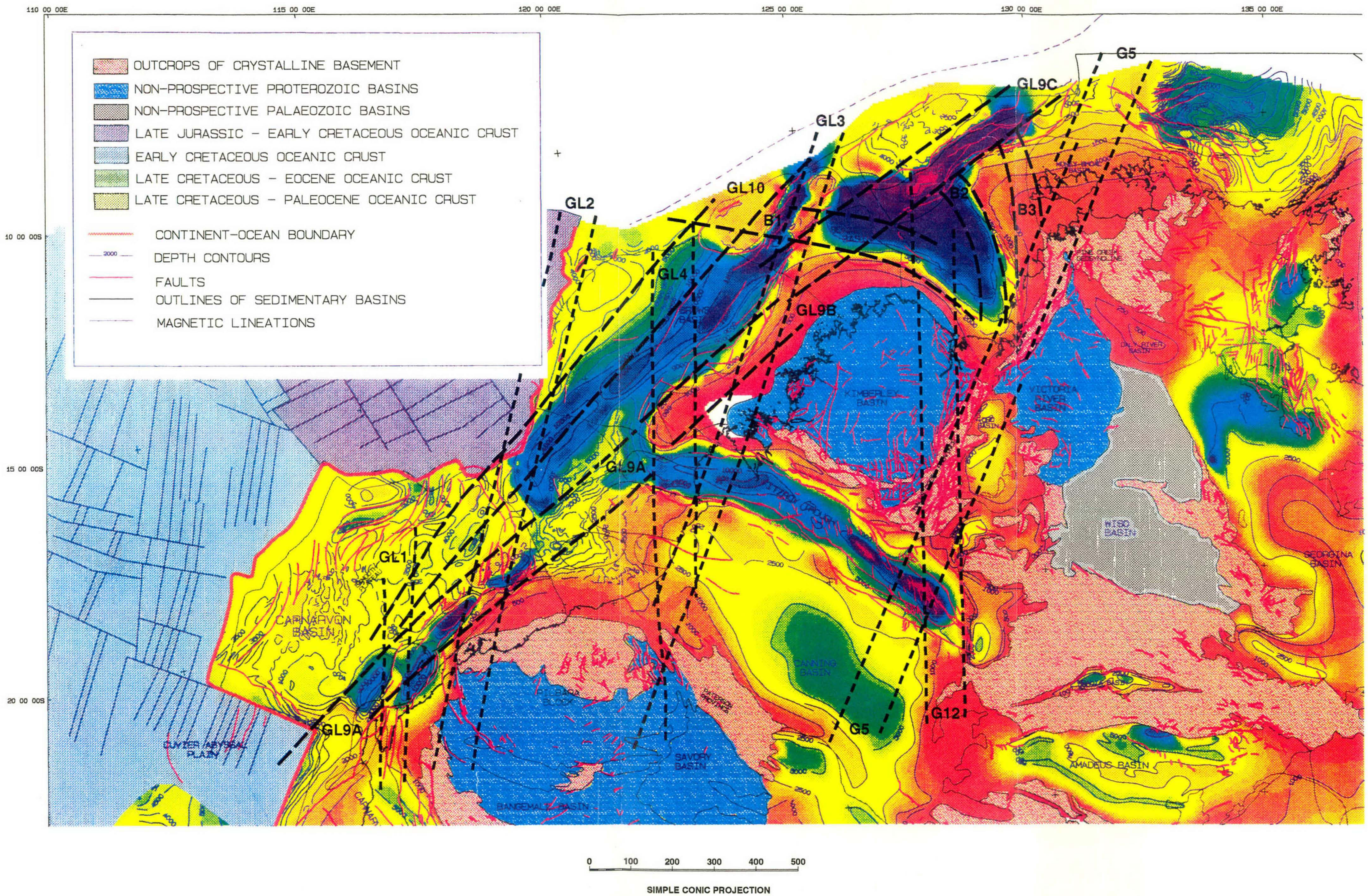

Plate 20: Correlation of the north-south to northeast regional gravity lineaments with the "Depth to Basement" map of northwestern Australia

Plate 21: Correlation of the west–northwest to north–northwest regional gravity lineaments with the "Depth to Basement" map of northwestern Australia

Correlation of the west–northwest to north-northwest regional gravity lineaments with the northwestern section of the Australian "Depth to Basement" map (Borissova, 1994). This map shows that there is a consistent correlation between the major depocentres, regional basement 'highs', and the gravity corridors. The regional lineaments are depicted in this map by solid black line.

G3 Corridor:

The gravity images herein suggest that the G3 gravity corridor reflects the west–northwest King Leopold Mobile Zone (KLMZ) along the southern edge of the Mesoproterozoic Kimberley Craton, and the linear Fitzroy Trough. The southern edge of the corridor coincides with the transition from the Fitzroy depocentre to the basement high of the Broome Platform. In central Australia, the northern edge of the G3 corridor aligns with the west-northwest margin of the Arunta Craton. Offshore, the extension of the northern edge of the G3 corridor (based on the gravity images) coincides with a dextral deflection of northeast depocentres within the Browse Basin. The basement high of the Scott Plateau is situated primarily within the offshore extension of the G3 corridor.

Earlier work (Elliott, 1994b) has shown that the offshore extension of the G3 corridor correlates with a dextral deflection in the southern Browse Basin Jurassic depocentre. This is consistent with structural data (faults and folds) in the onshore Fitzroy Graben and Lennard Shelf that suggests dextral shear within the G3 corridor during the Permo–Triassic (Elliott, 1994a, 1994b). This region had undergone north-northwest compression during the Late Palaeozoic–Mesozoic (Willcox, *pers. comm.*, 1996). A west-northwest zone of basement weakness (ie. G3 lineament) would be expected to undergo dextral shear in response to north–northwest compression.

G2 Corridor:

The eastern edge of the G2 corridor coincides with the linear boundary of the Proterozoic Victoria River Basin with the Phanerozoic Daly River and Wiso Basins, a distance exceeding 400km. Offshore, the western edge aligns with the B3 gravity lineament and coincides with the western margin of the Money Shoals Basin (now known as the Goulburn Graben).

G11 Corridor:

This map clearly shows the northwest orientated southern margin of the Bonaparte Basin aligning with the northwest G11A corridor. The northern edge of the G11A aligns with the northern edge of the Wiso Basin depocentre, and offshore, with the southerly termination of localized depocentres near the Malita Graben / Sahul Syncline intersection. A northwest linear trend, approximating the G11A/B boundary, is evident from the margins of the Proterozoic Kimberley and Victoria River Basins. A southeast extension of that alignment coincides with the long axis of the Wiso Basin and the west–northwest to north-west depositional arm of the Georgina Basin. The dextral deflection of the Proterozoic Halls Creek and Fitzmaurice Mobile Zones, occurs just south of the northern edge of the G11A.

G13 Lineament:

The west–northwest G13 lineament coincides with the depositional axis of the Daly River Basin and the Georgina Basin. Offshore, the lineament correlates with a swing in depocentre trend from east–northeast in the Malita Graben, to northwest in the Sahul Syncline.

GL5 Corridor:

Offshore, the GL5 corridor coincides with west–northwest faults in the Carnarvon Basin and a west–northwest trend of the basement margin. Onshore, the corridor aligns with the Carnarvon Basin depocentre and parallels the southern margin of the Proterozoic Bangemall Basin south of this mapsheet.

GL6 Corridor:

The GL6 cross-cuts the GL5 corridor in the offshore Carnarvon Basin and appears to dominate the gravity signature. Onshore, the GL6 coincides with the Palaeoproterozoic Bangemall Basin and offshore, with the northern margin of the Cuvier Abyssal Plain.

GL7 Corridor:

The GL7 corridor coincides with the northwest basement high associated with the Proterozoic Paterson Province with the eastern edge of the corridor aligning with the margin of the Canning Basin depocentre. The western edge coincides with, at least in part, the linear northwestern boundary between the Pilbara Craton and the Paterson Province. Offshore, the corridor swings into an east-west orientation following the margin of the Broome Platform and the basement high associated with the offshore extension of the Pilbara Craton. The east–west trending Bedout depocentre coincides with the postulated extension of the corridor until its termination against the north–northeast GL2.

GL8 Corridor:

The GL8 corridor, segmented into the GL8A and GL8B, reflects a possible genetic relationship between the two components. Onshore, the west–northwest corridor coincides with the basement high of the Broome Platform which separates the Canning Basin depocentre from the Fitzroy Basin as an intra-basin high. The northern edge of the gently curving corridor appears to be truncated by the west–northwest G3 as the Fitzroy Trough swings from an east-west trend offshore, to a west–northwest trend onshore. The corridor terminates to the east against the north–south G12. Offshore, the GL8A extends as an east–west trend along the western edge of the GL9 forming a triangular shaped basement high within this intersection. The anomalous 'Bedout High' is situated on the southern edge of the GL8A at its intersection with the western edge of the GL9 and the northern margin of the GL7.

The GL8B coincides with a series of anomalous east–west basement high blocks along the southern margin of the Argo Abyssal Plain. A dextral deflection of north–south faulting is clearly seen across the southern margin of the corridor. The GL8A is separated from the GL8B by the northerly trending Rowley Sub-basin, and the north-northeast GL2 corridor.

GL11 Corridor:

The GL11 corridor, most clearly seen in the Geosat gravity data to transect the Argo Abyssal Plain, appears to cross-cut the regional structural trend of the Carnarvon Basin. The lineament is identified as a single linear feature which differs from the more common expression at this scale, the double edged corridor. The GL11 lineament coincides with an offset in the southern margin of the Argo Abyssal Plain (identified in the gravity as a possible dextral displacement), and a possible sinistral offset in the Java Trench to the north.

The lineament also coincides with a change in orientation of the most northeasterly depocentre of the Barrow–Dampier Trend in the Carnarvon Basin. The depocentre swings from a north-south orientation within the GL2 corridor, and southwest of the GL11, to a northeast orientation northeast of the GL2 and GL11 in the Roebuck Basin.

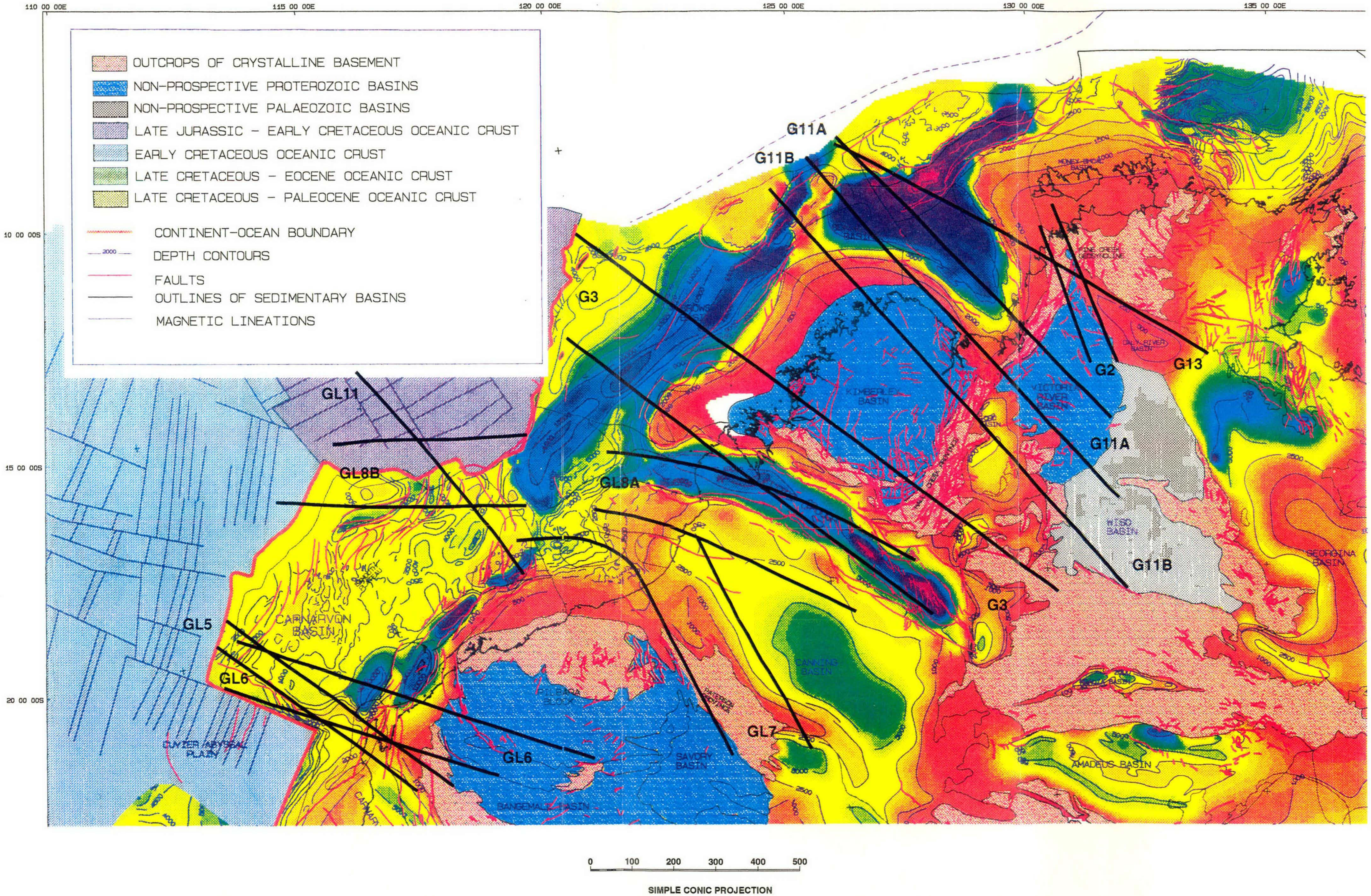

Plate 21: Correlation of the west-northwest to north-northwest regional gravity lineaments with the "Depth to Basement" map of northwestern Australia

Plate 22: Correlation of the regional offshore magnetic lineaments with the "Depth to Basement" map of northwestern Australia

Correlation of the regional offshore magnetic lineaments with the northwestern section of the Australian "Depth to Basement" map (Borissova, 1994) shows that several of the regional magnetic trends can be related to major depocentres. The west–northwest to northwest regional lineaments are depicted by solid black line. The north–south to northeast are depicted by short-dashed line, and the east–west by long-dashed line.

The ML2, ML6 and ML8B corridors reflect the margins of the Abyssal Plains. The ML8B corridor also coincides with the dextral deflection of major north–south faulting, and aligns with the southern edge of the Rowley Sub-basin depocentre. The northern edge of the ML8A coincides with the southern margin of the offshore extension of the Fitzroy Graben, and the southern edge approximates the southern edge of the basement high of the Broome Platform.

The east–west trending ML12 corridor cross-cuts the regional northeast structural and gravity trends. The lineament can be related to sinistral deflection of faulting in the Arafura Basin across its southern edge, and with the northern margin of the Bonaparte depocentre, including a dextral deflection of the Malita Graben.

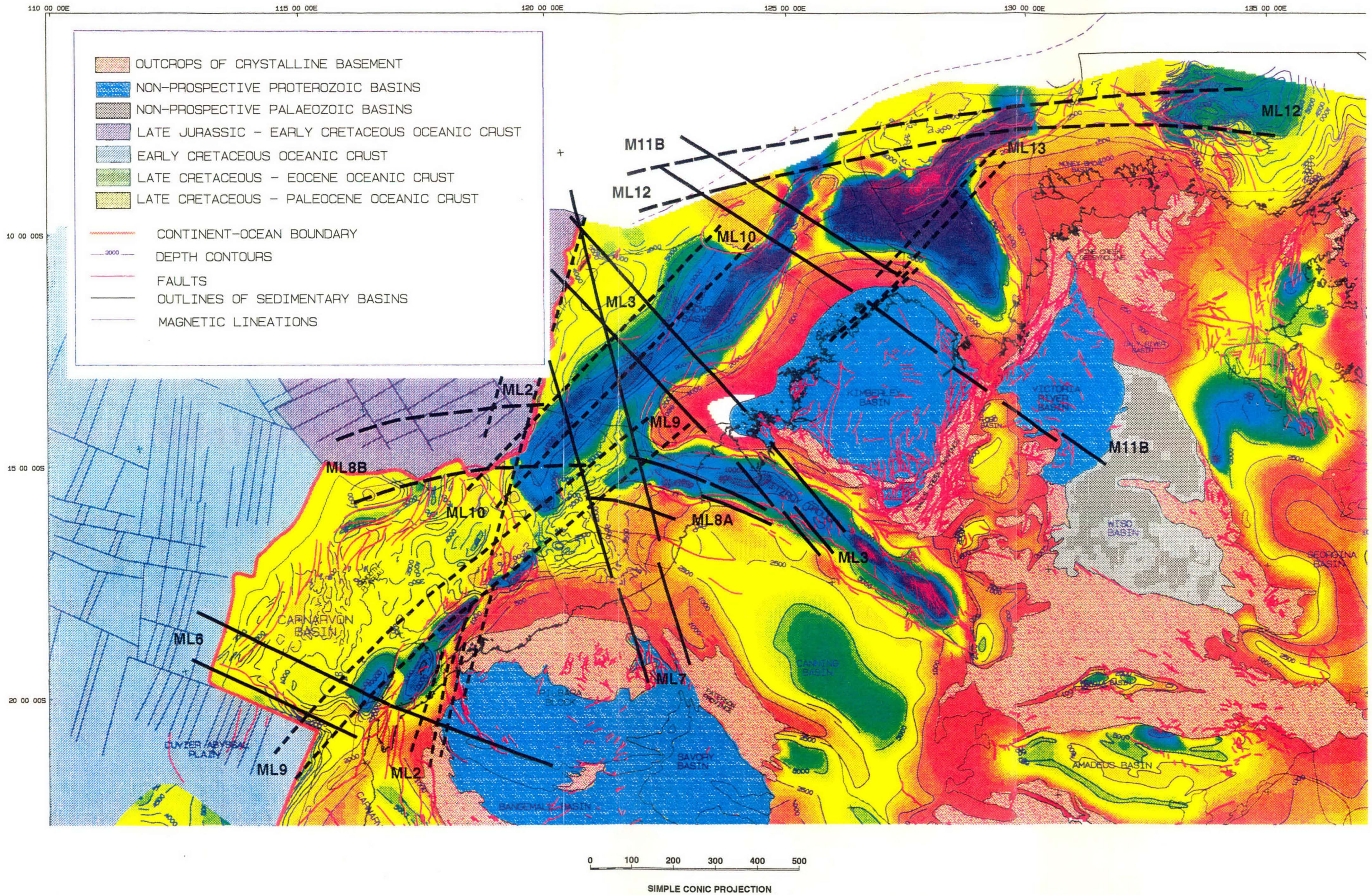

Plate 22: Correlation of the regional offshore magnetic lineaments with the "Depth to Basement" map of northwestern Australia

Plate 23: Correlation of the north–south to northeast regional gravity lineaments with the "Tectonic Elements" map of northwestern Australia

Correlation of the north–south to northeast regional gravity lineaments with the "Tectonic Elements" map of northwestern Australia (Stagg, 1993) shows that the lineaments consistently coincide with structural trends and tectono-depositional boundaries.

G5 Corridor:

The G5 corridor coincides with the north-northeast Halls Creek Mobile Zone (HCMZ), Fitzmaurice Mobile Zone (FMZ), Ord Basin, and approximates the eastern margin of the Fitzroy Trough, Broome Platform and the Kidson Sub-basin. Offshore, the eastern edge of the corridor aligns with a western margin of east–northeast faults in the Arafura Basin, and a sinistral displacement of the major graben bounding fault.

G12 Corridor:

A prominent feature of the G12 corridor is that it coincides with the eastern margins of the northwest and west-northwest Canning and Fitzroy basins respectively. North–south deflections in the otherwise north-northeast structures of the HCMZ, are also apparent. Offshore, a speculated extension of the G12 coincides with the major depocentre of the southwest Malita Graben.

GL1 Corridor:

The eastern edge of the GL1 corridor coincides with a sinistral offset in the Mesozoic depositional axis, and with a major sinistral deflection of the 200m bathymetric contour. This reflects a north–south orientation of the shelf break within this corridor. The eastern edge also coincides with the sinistral deflection of several northeast faults to a north–south orientation, parallel and aligning with, the corridor edge.

GL2 Corridor:

The GL2 corridor also coincides with a sinistral deflection in the Mesozoic depositional axis, and with a sinistral deflection in the 2000m bathymetric contour. The northeast structural trend of the Barrow–Dampier depocentre (especially anticlinal axes) swing into a north-northeast to north-south orientation within the corridor and near its margins. The corridor also coincides with a linear north-northeast belt of volcanics along the eastern margin of the Argo Abyssal Plain.

GL3 Corridor:

Onshore, the GL3 is seen to approximately parallel the western margin of the Bangemall Basin where it abuts the Hamersley Basin in the Pilbara region. This is a Proterozoic depocentre margin. Offshore, the corridor aligns with the north–northeast trend of the Yampi Shelf along the Kimberley margin. Further north, the corridor coincides with a series of sinistral *en echelon* depocentres which make up the Vulcan Graben.

GL4 Corridor:

Onshore, the GL4 corridor crosscuts the northwest structural trend of the GL7 and the west–northwest trend of the GL8, but coincides with many north–south deflections of the northwest basement trends. The north–south trend (aligning with the eastern edge of the corridor), is identified as an important basement orientation within the dominant northwest structural grain of the Paterson Province in the region of the Telfer goldmine. Offshore, the western edge coincides with a north–south deflection of the 200m and 2000m bathymetric contours, and the north–south termination of many east–west folds in the offshore Fitzroy Trough.

The corridor also coincides with an anomalous narrowing of the west–northwest Broome Platform and Browse Basin, and approximates the outer shelf break of the Leveque Platform. The narrowing of the Browse Basin, coinciding with the GL4 corridor, also correlates with a marked change in structural style of the Browse Basin. A regional change from landward-dipping (southeast) normal faults east of the corridor, to basin-dipping faults (northwest), west of the corridor has been demonstrated by Symonds *et al.*, (1994).

GL9 Corridor:

The GL9A corridor primarily aligns with the regional Mesozoic depocentre axis in the greater Carnarvon Basin. At its intersection with the GL2 corridor, however, the trend of the depocentre swings into a north–south orientation, within and sub-parallel to, the GL2 corridor. The northern edge of the GL9A coincides with a change in structural orientation from northeast within the corridor, to more north–northeast to north–south outside the corridor. The postulated offshore margin of the Pilbara Craton parallels the GL9A.

The offshore margin of the Kimberley Craton parallels the GL9B corridor, as does the regional trend of the Kimberley coastline.

The most notable feature of the GL9C corridor is that it coincides with the structural trend of the Malita Graben. The northeast depocentre is primarily contained within the gravity response of the corridor, with the gravity signature terminating at its intersection with the north–northeast Lyndoch Bank Fault System. Previous studies (Elliott, 1994a, 1994b) have shown that the western margin of the east–northeast G5 gravity corridor may be situated further west than indicated by this study and coincide with the east–northeast Lyndoch Bank Fault Zone. In this scenario, the GL9C would terminate against the north-northeast G5 lineament.

GL10 Corridor:

The southern edge of the GL10 corridor in the Carnarvon Basin coincides with a change in structural trend from north–south between the GL9 and GL10, to northeast within the GL10 lineament zone. In the southern Browse Basin, the corridor aligns with the regional Mesozoic depocentre axis and the 2000m bathymetric contour. The gravity response, like that of the GL2, GL3, GL4 and GL11, appears to terminate at the edge of the Australian Plate.

B1 Corridor:

The southern edge of the B1 corridor coincides with the basement margin of the Kimberley Craton and further offshore, with an almost east–west deflection of the 200m bathymetric contour. The swing in trend of the corridor from northwest within the G11A, to almost east–west in the G11B and further west, aligns with the change in orientation of the southern margin of the Bonaparte Basin which also swings from northwest to east–west.

B2 Corridor:

The B2 corridor coincides with the north-eastern basement margin of the Petrel Sub-basin with the curve of the lineament reflecting the curve of the basin margin.

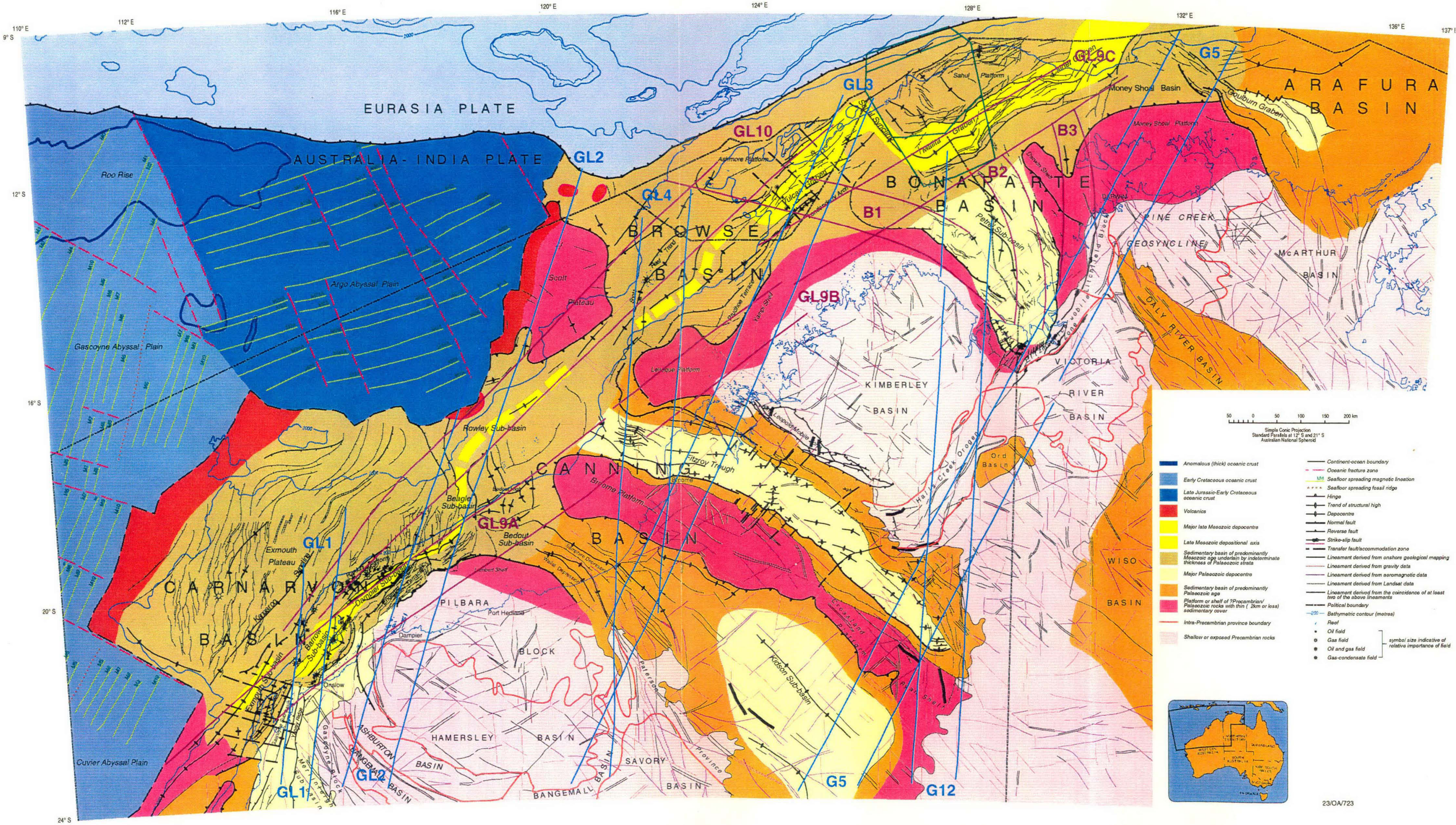

Plate 23: Correlation of the north-south to northeast regional gravity lineaments with the "Tectonic Elements" map of northwestern Australia

Plate 24: Correlation of the west–northwest to north–northwest regional gravity lineaments with the "Tectonic Elements" map of northwestern Australia

Correlation of the west–northwest to north–northwest regional gravity lineaments with the "Tectonic Elements" map of northwestern Australia (Stagg, 1993) shows that the lineaments consistently coincide with structural trends and tectono-depositional boundaries.

G3 Corridor:

The G3 corridor coincides with the Proterozoic thrust terrain of the west–northwest King Leopold Mobile Zone (KLMZ), the Fitzroy Graben and offshore, with the Leveque Platform and greater part of the Scott Plateau.

G11 Corridor:

Offshore, the northern edge of the G11A corridor aligns with the Sahul Syncline. The G11A/B boundary, (southern edge of the G11B corridor), coincide with compartment boundaries within the northern Browse Basin.

GL5 Corridor:

Offshore, the GL5 corridor approximately parallels the 2000m bathymetric contour and onshore, aligns with the Proterozoic Merlinleigh Sub-basin.

GL6 Corridor:

Onshore, the northern edge of the GL6 corridor aligns with the Hamersley / Ashburton depocentre margin, and the southern edge with the Proterozoic Bangemall Basin. Offshore, the northern edge coincides with the northern margin of the Gascoyne Sub-basin and a change in orientation from north–northeast to northeast. Further offshore, a west–northwest regional anticline aligns with the corridor before swinging into a northwest trend, parallel and within, the GL5 corridor.

GL7 Corridor:

The northwest orientation of the GL7 gravity corridor is reflected by the northwest structural grain within the onshore Paterson Province. The structural grain swings into a west–northwest orientation offshore reflecting the change in trend of the gravity corridor. The southern edge of the GL7 coincides with a concentration of regional folds separating the Wallal and Samphire Depressions. Although the eastern edge of the GL7 appears to terminate at the southern boundary of the GL8A, the gravity data suggests the possibility of a through-going northwest trend cross-cutting the GL8A. This projection aligns with a dextral deflection in the Broom Platform, and a northwest deflection in the 200m bathymetric contour. The west-northwest trend of the GL7 aligns with regional west–northwest folds and faults in the southern Bedout Sub-basin, and parallels the speculated margin of the Pilbara Craton.

L8 Corridor:

The GL8A corridor coincides with the Broome Platform which swings from a west–northwest into a more east–west orientation offshore. The southern edge of the GL8B corridor aligns with the east–west 2000m bathymetric contour, the northern edge with the southern east-west trending margin of the Argo Abyssal Plain. A sinistral deflection of major north-south faulting across the southern edge of the GL8B is clearly seen.

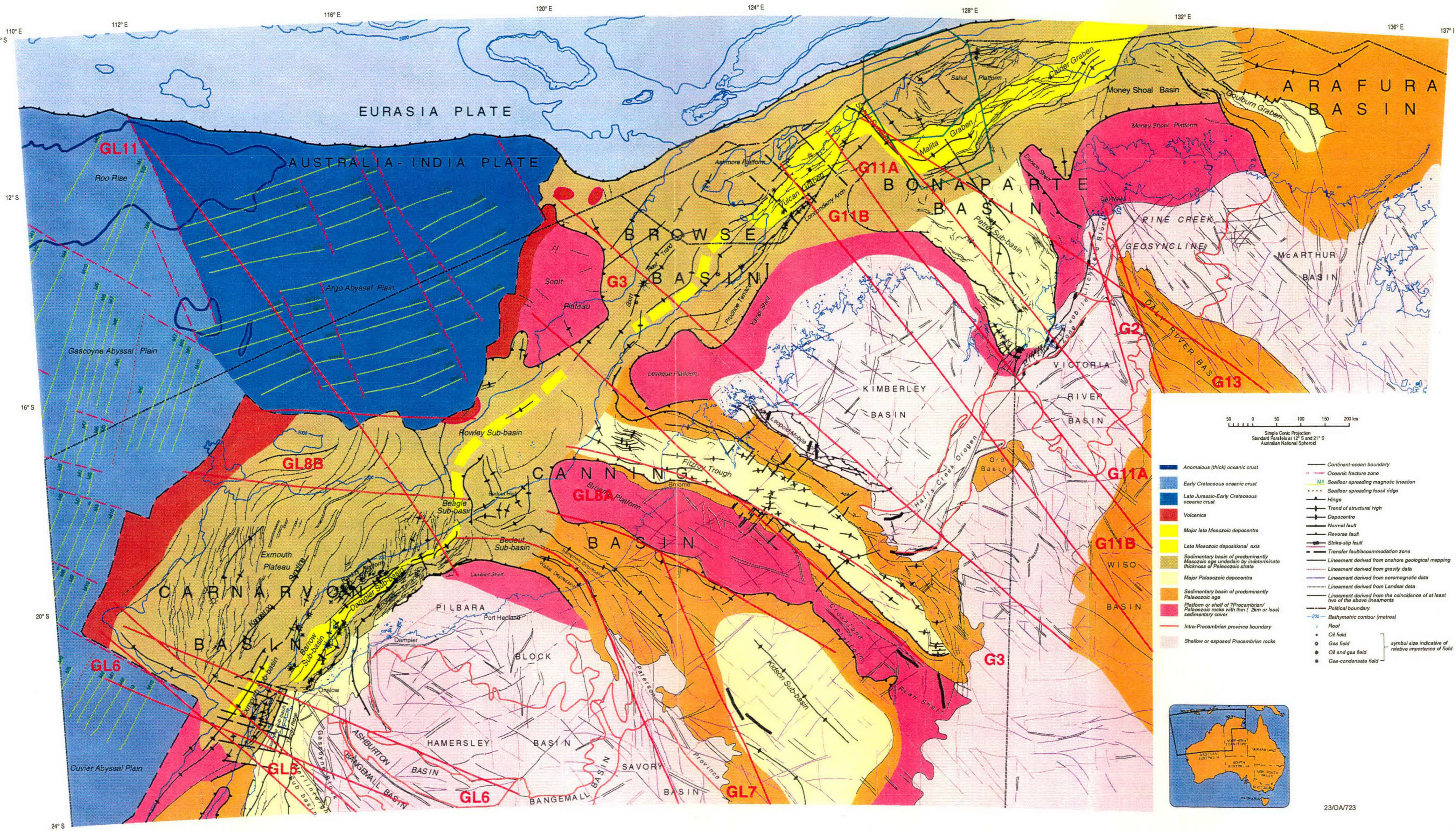

Plate 24: Correlation of the west-northwest to north-northwest regional gravity lineaments with the "Tectonic Elements" map of northwestern Australia

Plate 25: Correlation of the regional offshore magnetic lineaments with the "Tectonic Elements" map of northwestern Australia

Correlation of the regional offshore magnetic lineaments with the "Tectonic Elements" map of northwestern Australia clearly shows that the magnetic lineaments are expressed in the geology, although less well-defined than their deeper gravity counterparts.

The eastern edge of the ML2 corridor, which lies slightly to the west of the GL2 position, coincides with the volcanic sequence that forms the eastern margin of the Argo Abyssal Plain, and with a sinistral deflection in the 2000m bathymetric contour.

The southern edge of the ML6 corridor aligns with the north–northeastern edge of the Cuvier Abyssal Plain, with a major synclinal axis, and with the approximate margin of the north–south faults of the Exmouth Plateau.

The ML8B corridor approximates the southern edge of the Argo Abyssal Plain although the curvature of the magnetic lineament is not reflected in the margin of the oceanic crust.

The basement high of the Scott Plateau is situated at the junction of four magnetic corridors (ML2, ML7, ML3 and ML10), and the margins of the Plateau can be related to the intersection pattern of these lineaments. Interestingly, the eastern and western margins of the Leveque Platform are parallel to the ML3 corridor which is more northwestern in orientation than its west–northwest G3 gravity counterpart. The ML10 aligns with the 2000m bathymetric contour, the southern margin of the Scott Plateau, and the northwest margin of the Vulcan Graben depocentre.

The southern edge of the ML9 corridor coincides with the offshore margin of the Pilbara Craton. The corridor correlates with the general northeast fault trend of the Barrow–Dampier Trend in the Carnarvon Basin until a north–south swing in orientation which is concentrated within a projection of the ML2 corridor. Further northeast in the Bedout Sub-basin, the ML9 corridor coincides with a structural zone that separates the northwest trend of the Paterson Suture Zone (Paterson Province) in the south, from north-northwest structures in the Rowley Sub-basin to the north.

The east–west ML12 corridor is clearly seen in this map to align with sinistral deflections, across both edges, of major north-northeast faults, and the Goulburn Graben depocentre. Further west, the southern edge of the corridor coincides with a change in orientation of the northwestern edge of the Malita Graben and bounding faults to the Sahul Platform, from northeast to east–west. Further west again, the southern edge of the corridor aligns with the irregular 200m bathymetric contour corresponding to the northern edge of the Ashmore Platform.

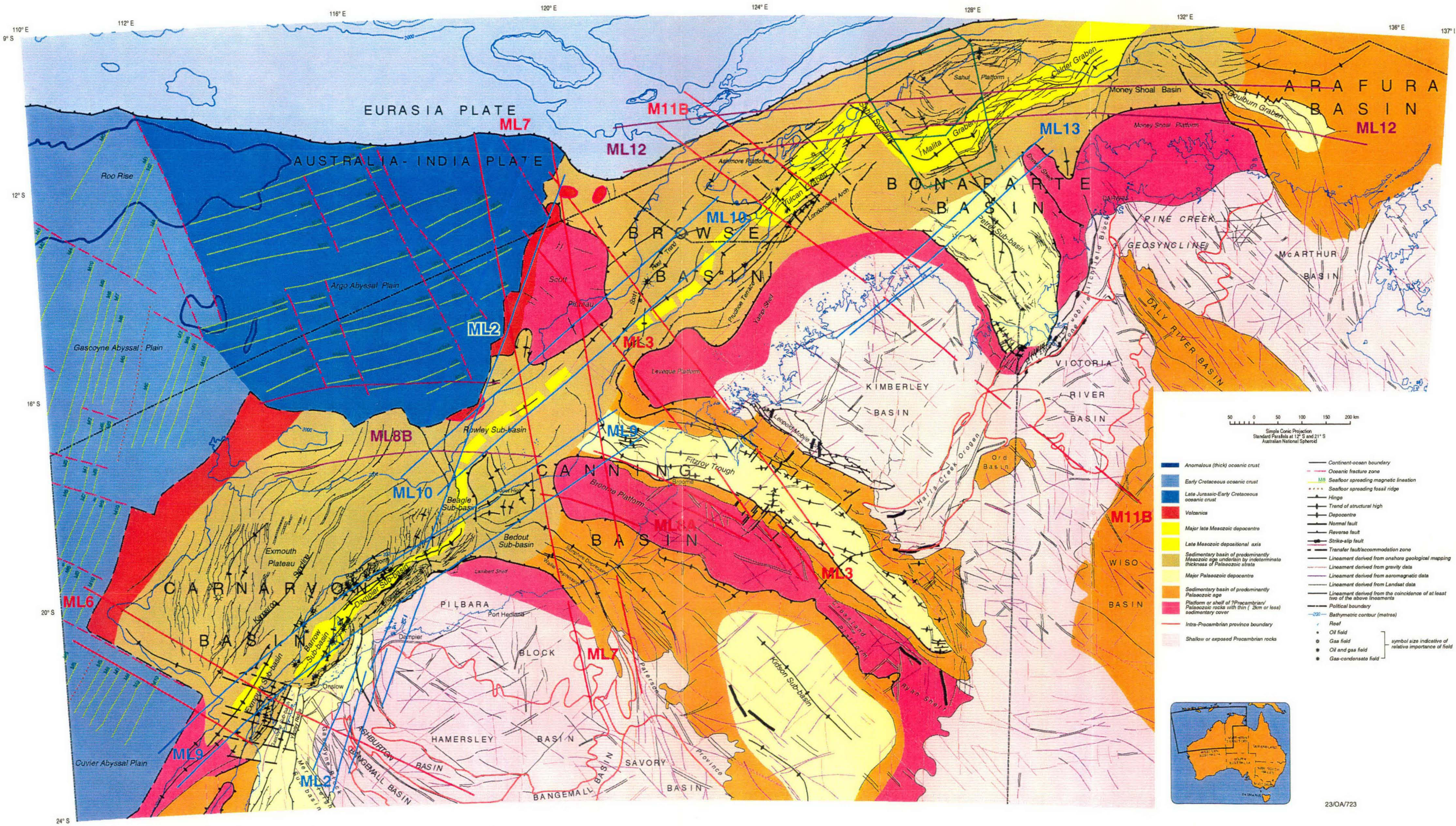

Plate 25: Correlation of the regional offshore magnetic lineaments with the "Tectonic Elements" map of northwestern Australia

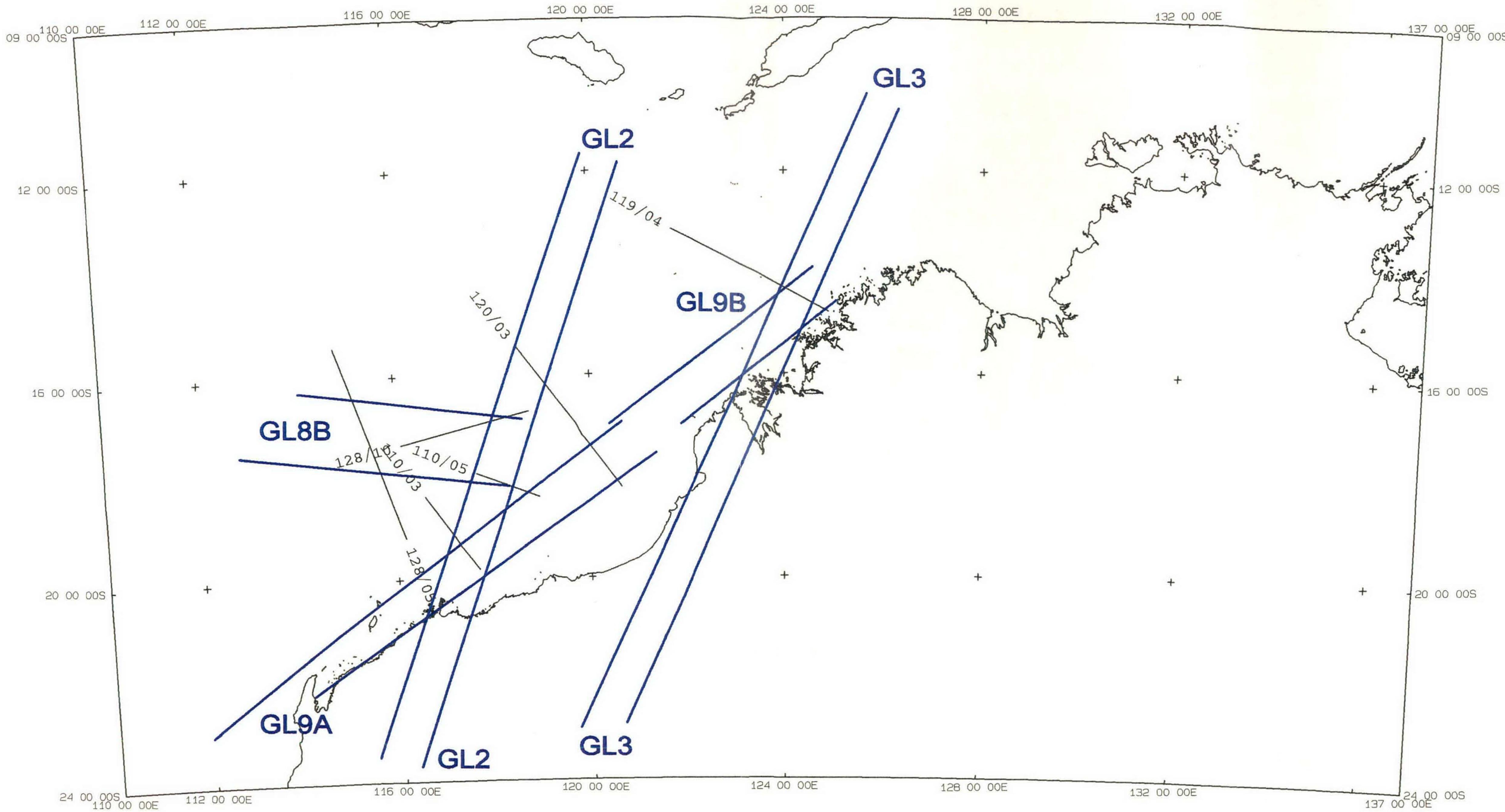

Plate 26: Location map for the deep-seismic reflection profiles.

A shot-point location map of the Northwest Shelf showing the location of the deep-seismic reflection profiles and the regional lineaments they intersect. All deep-seismic reflection profiles included in this report are from the AGSO database and have been preliminarily interpreted by AGSO personnel.

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Plate 27: GL2 gravity corridor, Carnarvon Basin: Deep-seismic reflection profile 128–10

A reproduction of the section of the east-northeast trending 128–10 deep-seismic line which transects the regional gravity corridor GL2 in the Carnarvon Basin. The preliminary interpretation, shown here, was carried out by H. Stagg at AGSO. The interval included is between shot points 2477 and 5552, and the approximate edges of the GL2 corridor, transcribed from the regional 1:5 000 000 data set, are annotated. Selected faults (black) and basement horizons (red and blue) are also annotated.

At this locality the correlation shows that the western part of the GL2 gravity corridor coincides with a change from basement showing little disruption, to a zone of numerous north–south oriented wrench, reverse and normal faults. This deep seismic line suggests that the GL2 corridor correlates with the north-south to north–northeast orientated wrench zone which separates the Carnarvon and Roebuck depocentres.

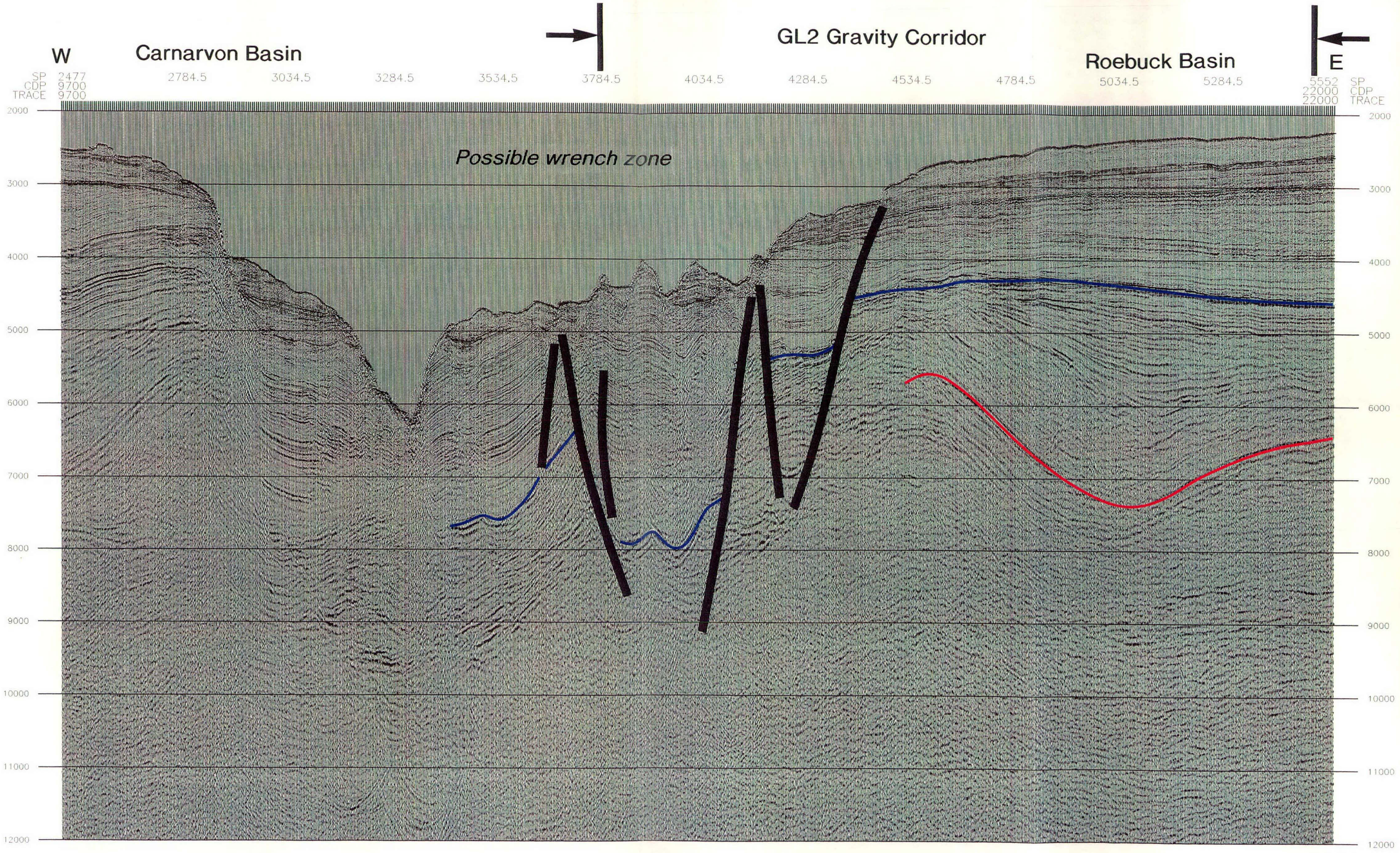

Plate 27: GL2 gravity corridor, Carnarvon Basin: Deep-seismic reflection profile 128-10

Plate 28: GL2 gravity corridor, Carnarvon Basin: Deep-seismic reflection profile 110–05

A reproduction of the section of the west-northwest trending 110–05 deep-seismic line which transects the eastern part of the regional gravity corridor GL2 in the Carnarvon Basin. The western edge of the corridor is not shown on this section. The preliminary interpretation, shown here, was carried out by H. Stagg at AGSO. The interval shown is between shot points 160 and 1536, and the approximate eastern edge of the GL2 corridor, transcribed from the regional 1:5 000 000 data set, is annotated. Selected faults (black) and basement horizons (red and blue) are also annotated.

At this locality, the deep-seismic profile shows that the GL2 corridor coincides with the north-south trending Thouin Graben. The Graben is interpreted to have resulted from north-south wrenching (Stagg, *pers. comm.*, 1996) which, similar to the line 128–10, aligns with the GL2 gravity corridor. The Graben shows both normal and reverse faulting, and has displaced the basement from approximately 10km (6.5sec. twt) to 17km (9sec. twt). This equates to approximately 7km of offset of the basement across a distance of 6km.

The eastern edge of the corridor, plotted from the regional data, is located east of the main structural change. At this locality, it is probable that the gravity response is a reflection of the graben structure and increased thickness of sedimentary section above the basement. The deep-seismic line again supports the interpretation that the GL2 corridor correlates with a north-south oriented accommodation zone which separates the Carnarvon and Roebuck depocentres.

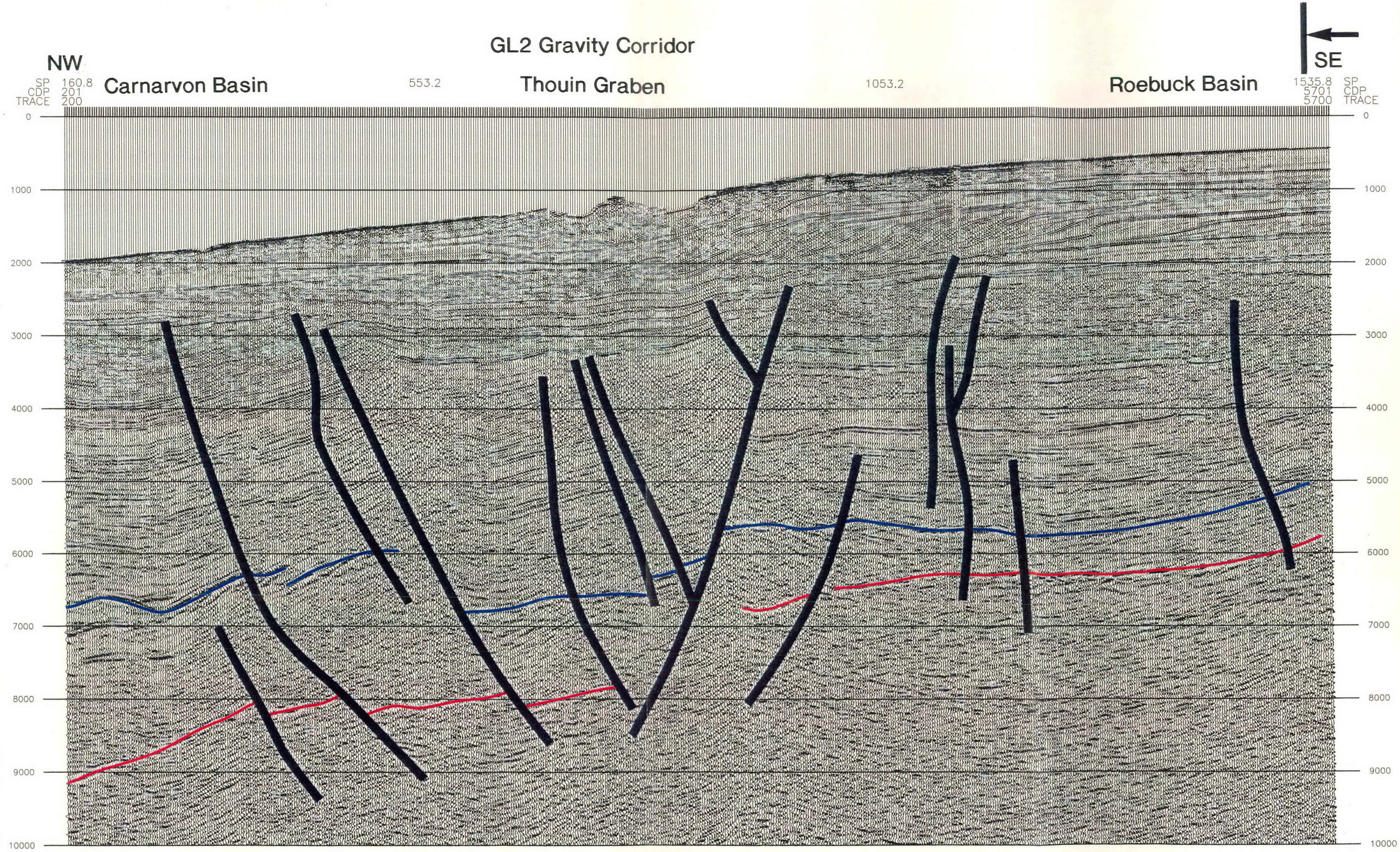

Plate 28: GL2 gravity corridor, Carnarvon Basin: Deep-seismic reflection profile 110-05

Plate 29: GL2 gravity corridor, Carnarvon Basin: Deep-seismic reflection profile 110–03

A reproduction of the section of the northwest trending 110–03 deep-seismic line which transects the regional gravity corridor GL2 in the Carnarvon Basin. The preliminary interpretation, shown here, was carried out by H. Stagg at AGSO. The interval shown is between shot points 1030 and 3480 and the approximate western edge of the GL2 corridor, transcribed from the regional 1:5 000 000 data set, is annotated. The eastern edge of the GL2 gravity corridor lies just off this section. Selected faults (black) and basement horizons (red and blue) are also annotated.

This section shows that the GL2 corridor coincides with a major basement fault, interpreted by Stagg (*pers. comm.*, 1996) to be a possible extension of the basement structure of the Rankin trend to the west. The fault shows evidence of strike-slip reactivation resulting in local reverse faulting at this locality. This again supports the north–south strike-slip accommodation model of the GL2 corridor. The corridor also coincides with major downstepping of the basement from the Lambert Shelf in the northwest, to the Beagle Sub-basin in the southeast. The corridor coincides with a change in basement depth from 0.5sec(twt) on the eastern edge, to 9sec(twt) on the western edge. This equates to an overall displacement of 18–20km across the gravity corridor.

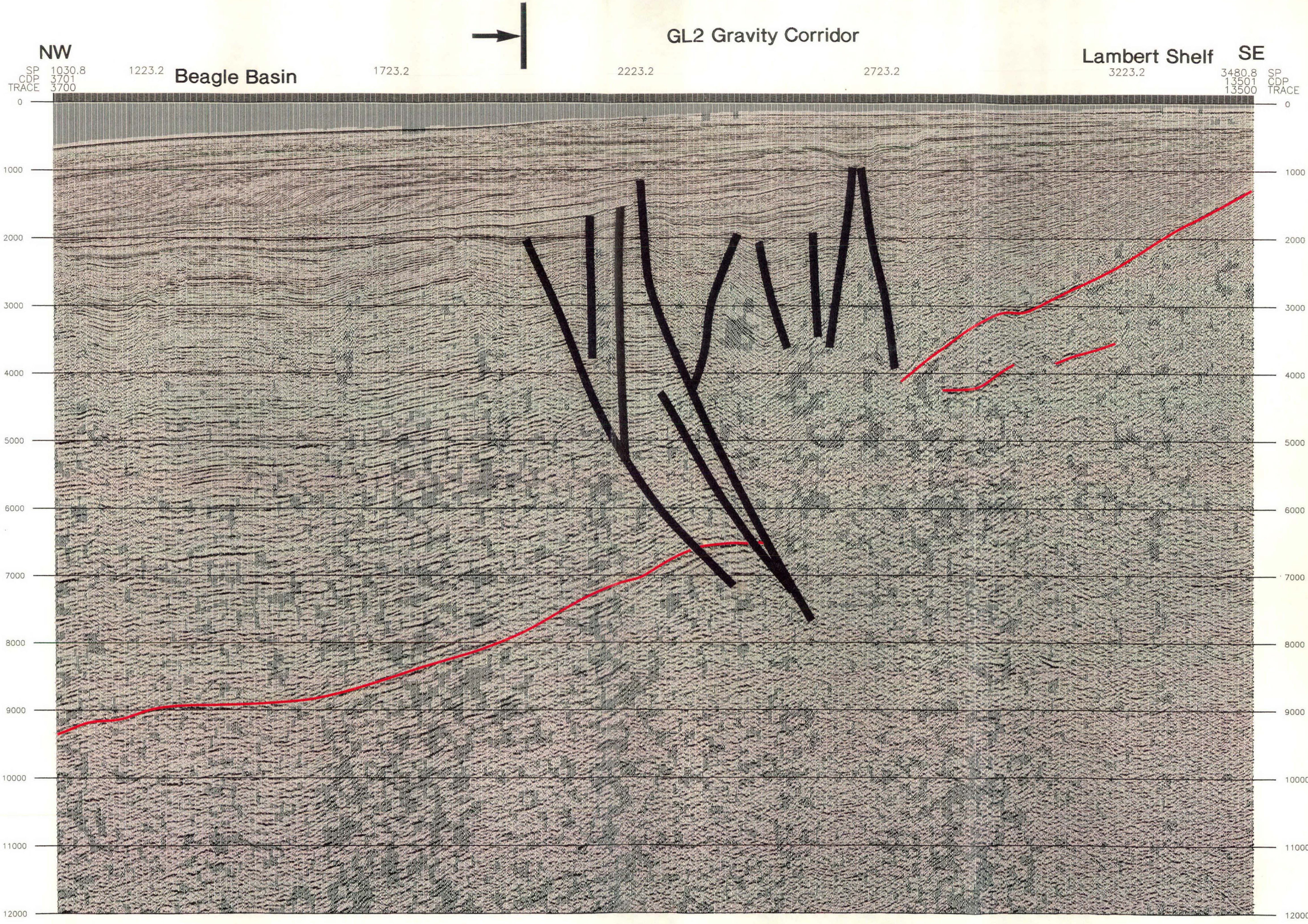

Plate 29: GL2 gravity corridor, Carnarvon Basin: Deep-seismic reflection profile 110-03

Plate 30: GL2 gravity corridor, Carnarvon Basin: Deep-seismic reflection profile 120–03

A reproduction of the section of the 120–03 deep-seismic line which transects the regional gravity corridor GL2 in the Carnarvon Basin. The western edge of the corridor is not shown on this section. The preliminary interpretation shown here was carried out by H. Stagg at AGSO. The seismic interval shown is between shot points 0 and 2041, and the approximate eastern edge of the GL2 corridor, transcribed from the 1:5 000 000 data set, is annotated. Selected faults (black) and basement horizons (red and blue) are also annotated.

This correlation shows that the GL2 gravity corridor coincides with a zone of structured and eroded blocks adjacent to the margin of the Argo Abyssal Plain. The approximate eastern edge, as plotted from the regional trend, lies to the northwest of a major fault which has significant basement offset. It is possible that the gravity response, identified as part of the GL2 corridor, is a product of this basement fault or the eastern margin of the volcanic sequence. The fault, which trends northeast-southwest (Stagg, 1993; Plate 23) is primarily situated within the corridor. The zone of irregular bathymetry, resulting from probable Mesozoic faulting, is possibly a zone of volcanics adjacent to the margin of the Australian Continental Plate. This zone of structured volcanic geology is situated within the GL2 corridor at its intersection with the northeast trending GL10 corridor.

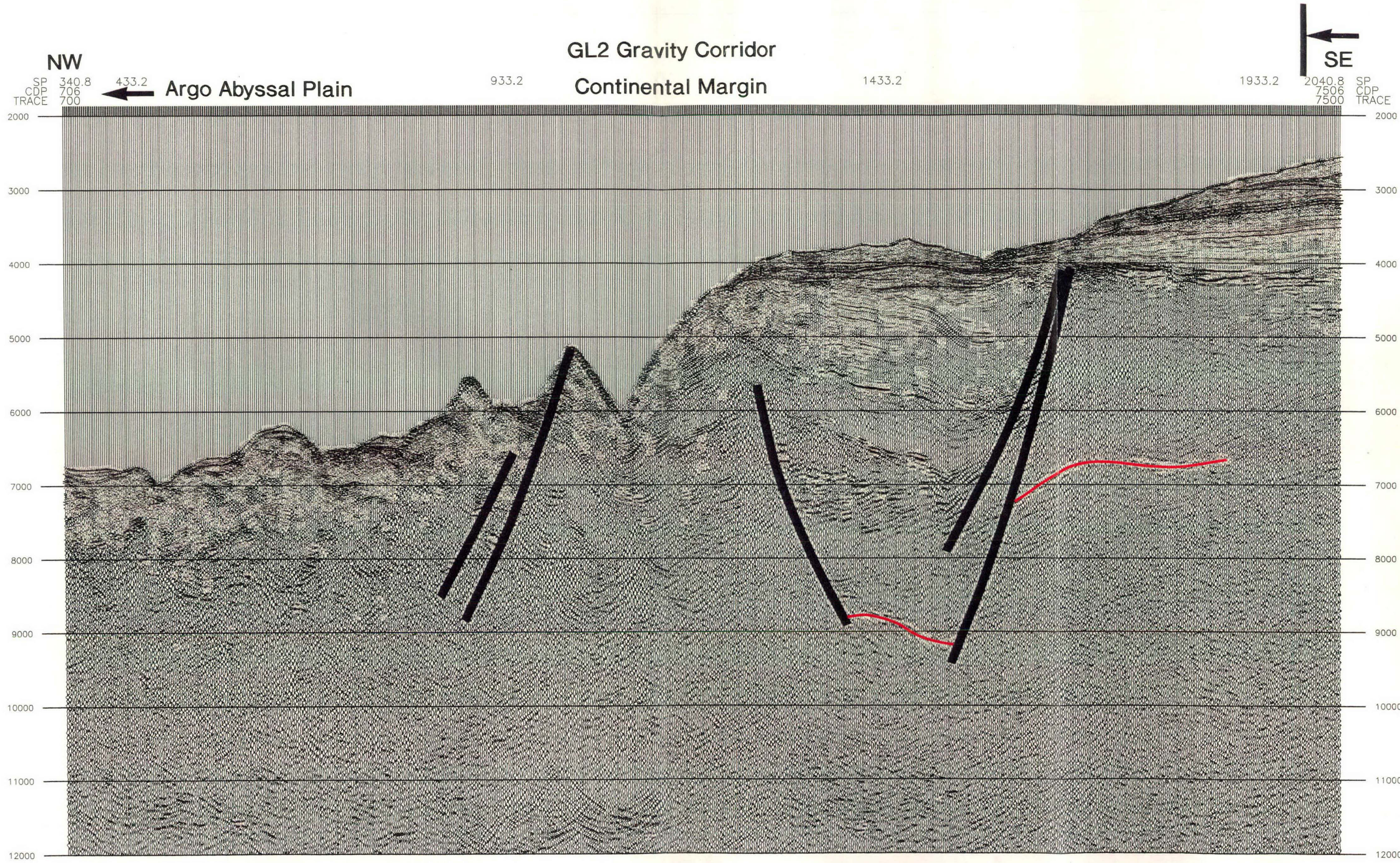

Plate 30: GL2 gravity corridor, Carnarvon Basin: Deep-seismic reflection profile 120-03

Plate 31: GL8B gravity corridor, Carnarvon Basin: Deep-seismic reflection profile 128–05

A reproduction of the section of the north-northwest trending 128–05 deep-seismic line which transects the regional gravity corridor GL8B in the northern Carnarvon Basin. No preliminary interpretation was available for this line. The interval shown is between shot points 3277 and 6302. The southern edge of the GL8B corridor, transcribed from the regional 1:5 000 000 data set, is annotated. The northern edge lies just off this section. Selected faults (black) and basement horizons (red and blue) are also annotated.

This section shows that the GL8B corridor coincides with a basement high adjacent to the boundary between the Australian Continental Plate and the oceanic crust of the Argo Abyssal Plain. The basement high is one of several that strike in an east-west direction, parallel to and within, the GL8B corridor. The basement highs show extensive peneplanation which probably resulted from Mesozoic structuring associated with the Gondwanaland "break-up" event. The GL8B gravity corridor is possibly a response to the anomalous string of east-west basement "highs", and the transition from continental to oceanic crust along the margin of the Plate.

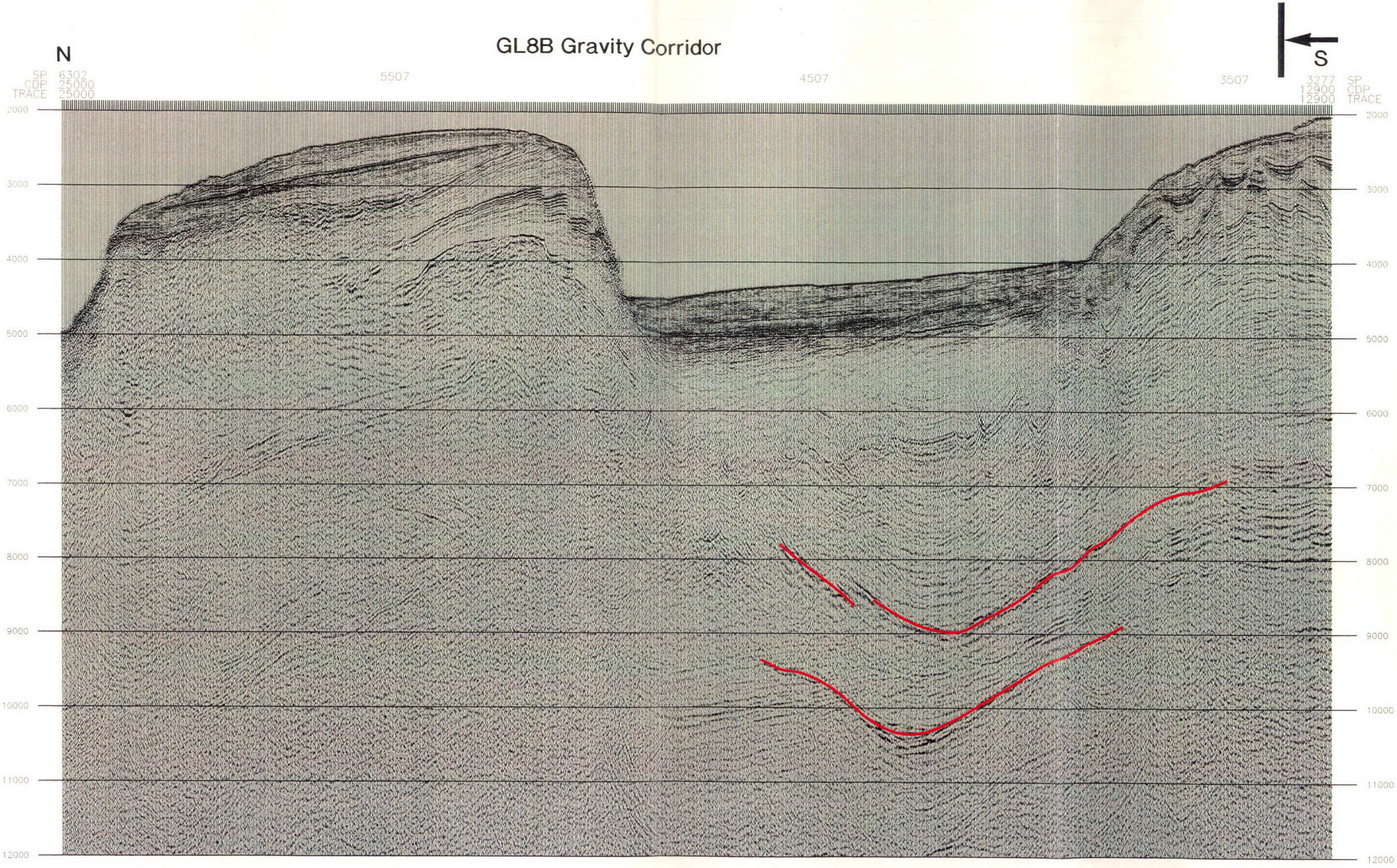

Plate 31: GL8B gravity corridor, Carnarvon Basin: Deep-seismic reflection profile 128-05

Plate 32: GL3 Gravity Corridor, Browse Basin: Deep-seismic reflection profile 119–04

A reproduction of the section of the northwest trending 119–04 deep-seismic line which transects the western part of the regional gravity corridor GL3 in the southeastern Browse Basin. The preliminary interpretation, shown here, was carried out by P. Symonds at AGSO. The interval shown is between shot points 4975 and 6975, with the approximate edges of the GL3 corridor, transcribed from the regional 1:5 000 000 data set, annotated. The northwestern edge of the GL9C corridor is also annotated. This section does not extend far enough to include the southeastern edge of the GL9C. Selected faults (black) and basement horizons (red and blue) are also annotated. The seismic section included here extends to 10sec. (twt). This is shallower than the original data set on which the Moho is clearly seen between 10 and 11sec. (twt). A more detailed description of this deep-seismic profile is given in Symonds *et al.,* (1994).

This section shows that the GL3 gravity corridor coincides with the Yampi Shelf and the western margin of the Kimberley Craton. The corridor coincides with western edge of the shelf, and the transition from cratonic basement of the Kimberley province to extended basement which underlies the Browse Basin.

The corridor also coincides with a sequence of prominent, shallow-dipping lower-crust to upper-mantle reflectors. These reflectors, which may represent underplating of the crust in the form of igneous dykes and sills, appear to cross-cut the Moho (established from the deep-seismic reflections and refraction data) within the corridor. These dipping reflectors are situated within the basement (possibly Archaean) which underlies the relatively homogeneous sediments of the Mesoproterozoic Kimberley Basin sequence. Although not shown on this section, the Moho shallows across the corridor from approximately 35km beneath the Kimberley Craton to approximately 23km below the Browse Basin (Symonds *et al.,*1994).

The corridor also correlates with a major, easterly dipping basement fault (possible thrust structure—Symonds, *pers. comm.,* 1996) within the Mesoproterozoic and Archaean(?) basement of the Yampi Shelf. This basement fault is situated within the intersection of the GL3 with the northeast trending GL9B gravity corridor. The basement fault can also be identified on deep-seismic lines 119–05 and 119–06 to the south which parallel the 119–04. This suggests that the basement fault trends northeast, parallel to the craton margin, within and parallel to the northeast trending GL9B corridor. Therefore the GL9B corridor may be reflecting, at least in part, a major basement fault which parallels the margin of the Kimberley Craton.

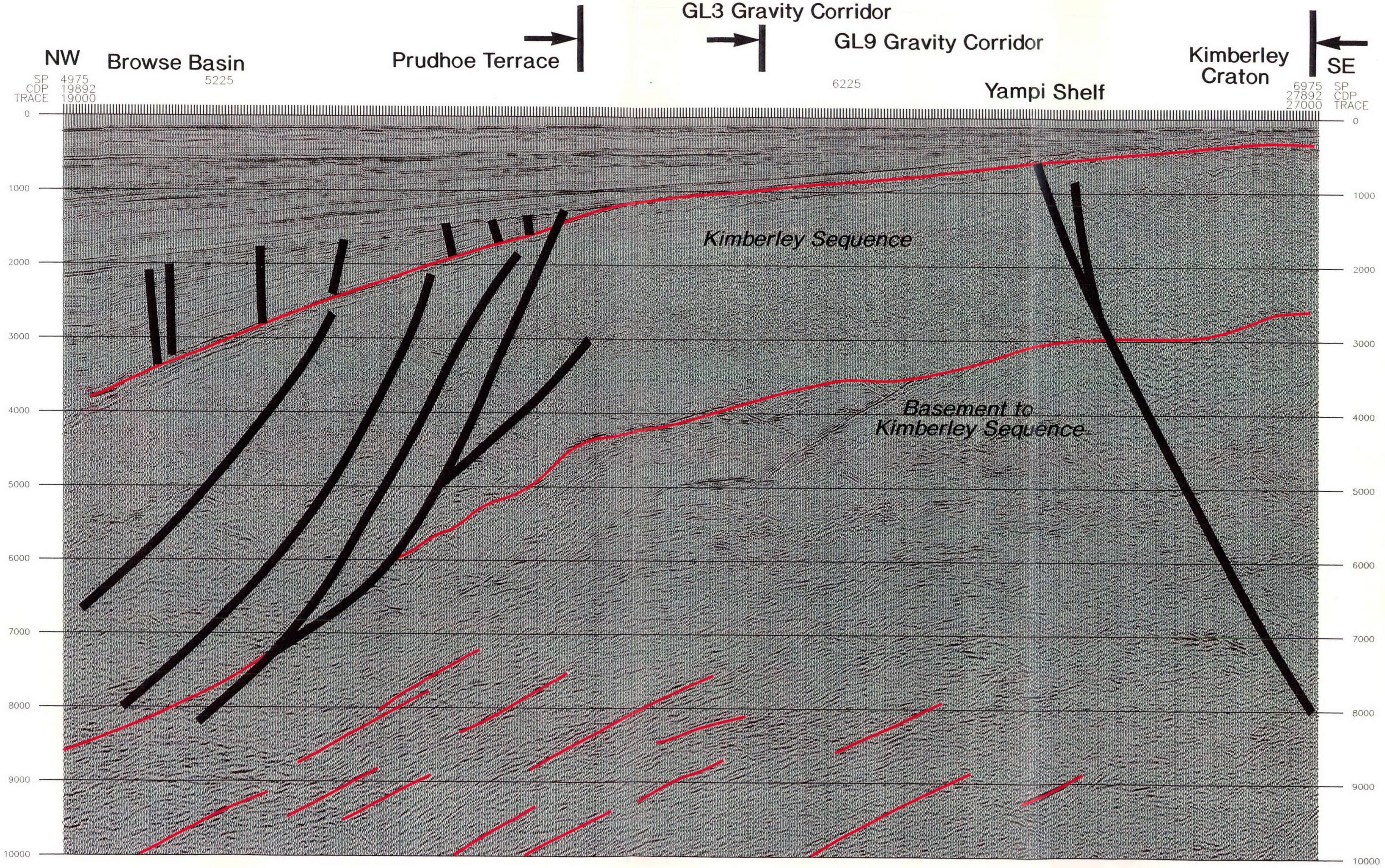

Plate 32: GL3 gravity corridor, Browse Basin: Deep-seismic reflection profile 119-04

Plate 33: Gravity provinces based on the Bouguer gravity anomaly, northwest illumination

The gravity province map gives a general indication of the offshore extent of the gravity / tectonic features of northwest Australia. These appear to terminate, or to undergo abrupt deepening, along the GL10/ML10 gravity and magnetic lineaments which form a well-defined northeast trend (Plates 34 & 35). This trend is probably by a feature termed the Northwest Shelf Megashear by the AGSO Northwest Shelf Study Group (1994). It is interpreted as a complex accommodation structure associated with Late Devonian–Early Carboniferous extension, and is related to a range of flower-like structures seen on the deep seismic profiles. Potential field corridors along the eastern flank of the major tectonic units (eg. G10/G5) correspond broadly with the eastern flank of this extensional system. They overlie features such as the Halls Creek Mobile Zone and may be a representation of the Lasseter Shear Zone (Etheridge *et al.*, 1991).

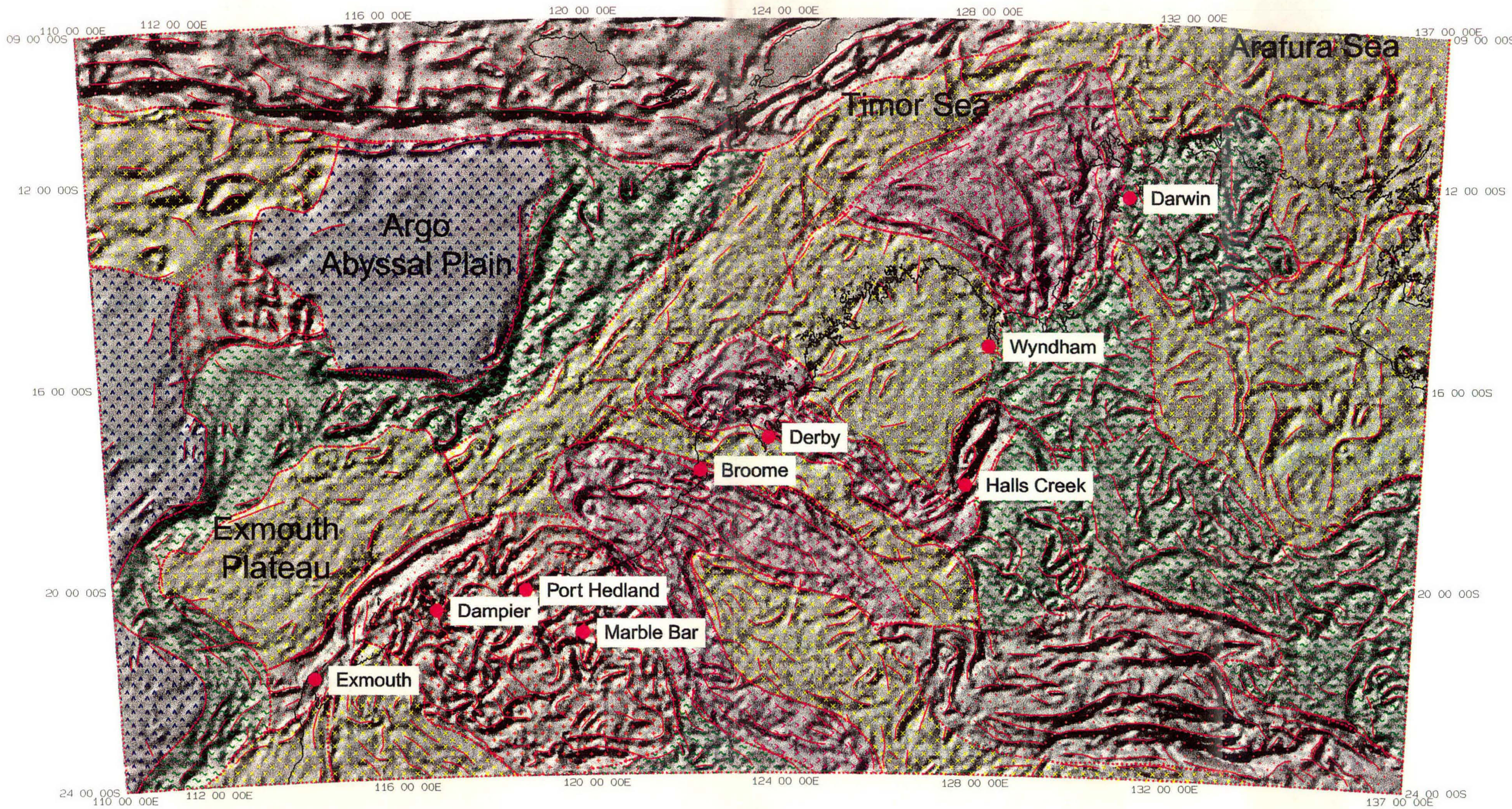

Plate 33: Gravity provinces based on the Bouguer gravity anomaly, northwest illumination.

The absolute value of the maximum horizontal gradient of Bouguer anomaly was classified according to the amplitude and alignment of trends.

The colours show this classification, using the following scheme:

Colour	amplitude	alignment
^ blue	zero	none
x yellow	low	low
~ green	medium	low
> purple	medium	high
+ orange	high	low
. magenta	high	high

1: 10000000

0 200 400 600 800 1000

KILOMETRES

SIMPLE CONICAL PROJECTION
AUSTRALIAN NATIONAL SPHEROID
PARALLELS 12 00 00S AND 21 00 00S, CENTRAL MERIDIAN 123 00 00E

The trend lines represent alignments of maximum horizontal gradient, which may be interpreted to be structural boundaries or lines along which subsurface density changes occur.

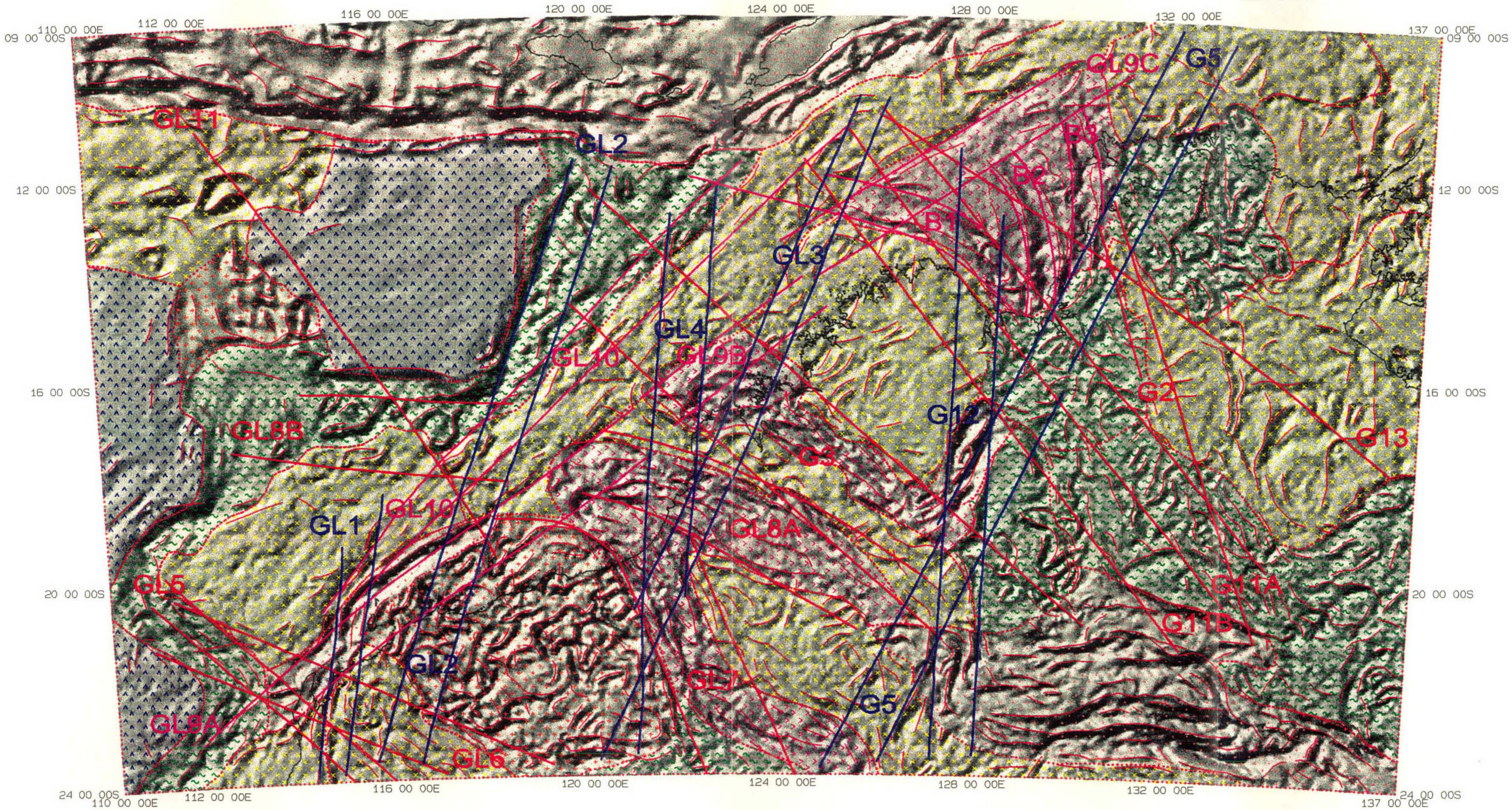

Plate 34: Correlation of the gravity province map with the regional gravity lineaments of northwestern Australia.

Correlation of the gravity province map with the regional gravity lineaments shows a consistent spatial relationship between the corridors of concentrated and aligned linear gravity disruptions, and the province boundaries defined by more mathematical parametres. Of particular note are the province boundaries which coincide with the G2, G3, GL7 and the GL8A. The western edges of the GL9A, GL9B and GL9C lineaments, coincide with the western edges of Pilbara (GL9A), Paterson Suture Zone and Broome Platform (GL9B), and the Bonaparte Basin (GL9C) gravity domains. Spatial relationships between the province boundaries and the GL2, GL5, GL6, GL8B, G11 and B1 corridors, are also of interest.

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KILOMETRES

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PARALLELS 12 00 00S AND 21 00 00S, CENTRAL MERIDIAN 123 00 00E

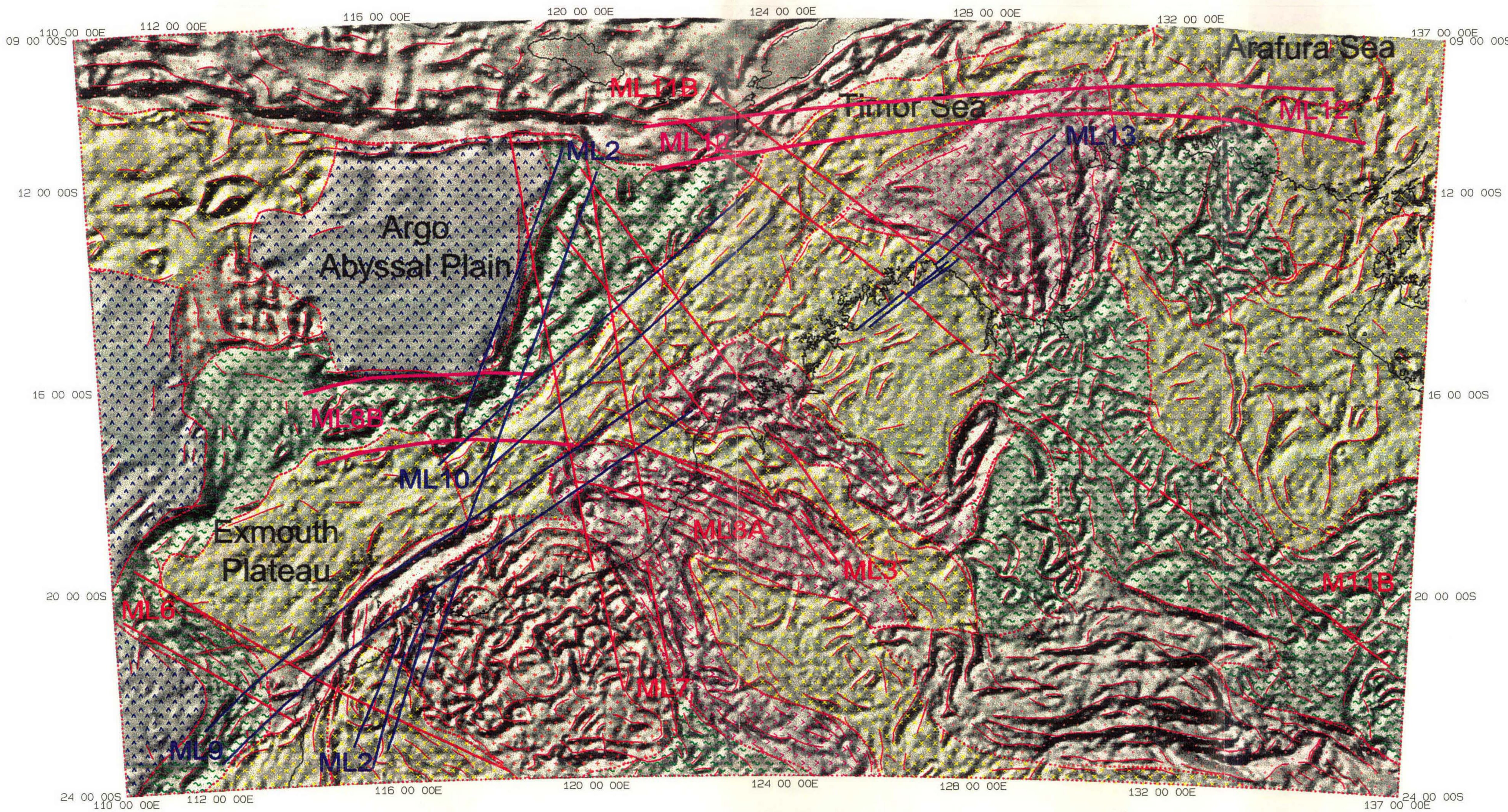

Plate 35: Correlation of the gravity province map with the regional offshore magnetic lineaments of northwestern Australia.

Correlation of the gravity province map with the regional offshore magnetic lineaments shows a consistent spatial relationship between the corridors identified from the shipborne magnetic data sets, and the province boundaries defined by more mathematical parametres. In several cases the correlation between the magnetic corridors and the gravity province boundaries shows a better alignment than the gravity province boundaries with the gravity corridors. Examples of this are the ML2, ML6, ML9 and ML10 magnetic lineaments.

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AUSTRALIAN NATIONAL SPHEROID

PARALLELS 12 00 00S AND 21 00 00S, CENTRAL MERIDIAN 123 00 00E

Discussion of results

This study has drawn together several sets of regional gravity and magnetic data, and from these, a regional pattern of intersecting basement discontinuities has been identified. Through integration of raw data sets with compiled geological and tectonic maps, and deep seismic reflection profiles, observations regarding the significance of these regional lineaments to the tectono-depositional history of northwestern Australia, have been documented.

Regional lineament framework of northwestern Australia

Gravity lineaments:

Gravity data sets can be used to identify local concentrations of linear disruptions in the geophysical response which align over vast distances to form regional lineaments or "corridors". These corridors transect terrain boundaries and show lateral continuity between the ancient onshore geological terrains, and the younger offshore sedimentary basins. Correlation of the regional gravity lineaments with geo-tectonic maps of northwestern Australia show that the gravity disruptions often align with major changes in depocentre loci, structural style, and often frame offshore sedimentary basins. This suggests that the gravity lineaments reflect major crustal changes which predate and have influenced the tectono-depositional style of the Northwest Shelf.

The regional gravity lineaments were approximately 100km in width and often exceeded 1000km in length. The width of the corridors was generally fairly consistent at this regional scale. Using large-scale higher resolution data, more accurate plotting of the gravity disruptions suggests that locally, the correlation is variable in width and that the edges of the corridors change in location as a reflection of the changing structural style at depth.

Magnetic lineaments:

The shipborne magnetic data set can also be used to identify regional lineaments which can in turn be related to the geology and tectonic configuration of offshore northwestern Australia. Despite the low resolution of the data, in many cases the magnetic lineaments align with major tectono-depositional changes.

The fact that the regional magnetic trends are often oriented at a slight angle to their gravity counterparts (eg. GL7 and ML7; G3 and ML3), has also been noted by O'Driscoll (*Pers. Comm.*, 1996) in his analysis of onshore geophysical data sets in western Australia. This may be due, in part, to the two data sets reflecting features at different crustal levels. Magnetic signatures probably reflect shallower level features than the gravity signatures. The offset in orientation between the two data sets may also be due to the lower degree of accuracy in locating the magnetic data during processing.

Deep-seismic reflection data:

Deep-seismic reflection profiles suggest that structural style of large-scale lineaments is variable between lineaments and along their length. For example, the GL2 corridor demonstrates strike-slip activity where it coincides with the boundary between the Carnarvon / Roebuck Basins. Further north the corridor coincides with the oceanic / continental margin along the eastern edge of the Argo Abyssal Plain.

In some cases, evidence from deep-seismic reflection profiles supports that large-scale gravity lineaments may be zones of complex structures rather than reflect a single fault plane, at least in the middle to upper crust. The GL2 is such an example. This corridor, in the south, aligns with the Carnarvon / Roebuck Basins where the gravity expression can be correlated to a wide zone of wrench faulting. In the north, the zone of gravity disruption coincides with a linear belt of volcanics along the continental / oceanic margin.

The GL9B corridor is an example of gravity response which possibly reflects a major thrust in the basement. The thrust dips steeply to the east (opposite direction to the extensional faults on the Yampi Shelf). It is situated within, and parallel to GL9B, and can be traced through the Mesoproterozoic Kimberley Basin sequence into the underlying, probably Palaeoproterozoic to Archaean, basement. The thrust trends northeast and sub-parallel to the Halls Creek Mobile Zone on the eastern margin of the Craton. Further work is now required to establish how this structure relates to the other major bounding sutures of the Kimberley Craton.

Spatial distribution:

This study suggests that the spatial distribution of regional lineaments in northwestern Australia, especially the gravity ones, is not random. Plates 1b and 2b show that the gravity and magnetic lineaments can be sub-divided into several orientation groups, ie., sets of approximately parallel lineaments. For example, the north-northeast gravity lineaments appear to be regularly spaced across northwestern Australia (eg. G5, GL3 and GL2). The north-south trending G12, GL4 and GL1 gravity lineaments are also regularly spaced. The G5/G12 and GL3/GL4 gravity lineament pairs form a remarkably similar intersection pattern with an angle of intersection of approximately 25°, which is almost identical for the two pairs. The north–south / north–northeast intersection pattern has also been noted in onshore northern Australia (C. Simpson, *Pers. Comm.*, 1996). The west-northwest / north-northeast couple (ie., G3 & G5) were found in earlier research (Elliott, 1994a) to be the most common continental-scale lineament orientation across Australia. The north–south (eg. G12) orientation are the most common second order lineaments. This suggests that the west–northwest couple is a stable stress-relieving relationship, and that the north–south / north–northeast pair may also be a stable stress-relieving couple.

The northwest to west–northwest lineaments are common regional corridors in northwestern Australia. GL5, GL6, GL7, GL8A, G3, G11 and G13 can be traced from the onshore Proterozoic / Archaean terrains into the younger offshore sedimentary basins.

Cross-cutting relationships:

The GL9 regional gravity lineaments show a regular orientation along the margin of the Australia continent and appear to be offset across the north–south GL4 and north-northeast GL3 lineaments. This may suggest that the northeast to north–northeast lineaments (ie., GL9, GL10) are younger, or have undergone more recent reactivation than the northwesterly and northerly trending lineaments that can be traced from the onshore terrains. The younger extensional activity could be related to the extensional processes forming the sedimentary basins during the Gondwana break-up.

Generally, regional lineaments cross-cut each other with no apparent offset. This may suggest that regional corridors undergo oscillatory movement so at the scale investigated in this study (1:5 000 000 to 1:10 000 000), there is little net offset. This is consistent with earlier observations of Australian continental lineaments (Elliott, 1994a, 1994b; O'Driscoll, 1980, 1990; Campbell, 1989) which also demonstrated little offset across the large-scale corridors.

Several of the regional gravity corridors appear to cross-cut well-defined structural trends. The northwest GL7 and the west-northwest GL8A, for example, coincide with the Palaeoproterozoic Paterson Suture Zone and Broome Platform respectively. Both of these corridors show a well-defined structural grain and are transected by the north-south to northeast GL3 and GL4 corridors. The northerly trends cross-cut the dominant northwesterly structural grain and, like the G12 cross-cutting the G5, the northerly trends are relatively subtle in the geology. The importance of the northerly trend at the Telfer ore deposit (in the GL7/GL4 intersection zone) suggests that the subtle trends may be of significance during the process of fluid migration and entrapment.

Lineament terminations:

The GL7 and GL8 are examples of corridor terminations. The northwest GL7 appears to terminate, or possibly swing into alignment, where it intersects the GL8A in the offshore Roebuck basin. The magnetic signature (ML7), however, suggests that the northwest basement trend may continue offshore, possibly as far as the edge of the continental plate.

The B2 and B3 Bonaparte gravity trends are also examples of lineament termination. These pronounced northwest trending lineaments terminate at the southeastern edge of the northeast GL9C. This correlates with the northwestern margin of the Bonaparte Basin where it terminates against the Malita Graben.

Reactivation:

Onshore, many of the regional lineaments coincide with terrains that have undergone complex reactivation histories, some since the Archaean (eg. G5–Halls Creek and Fitzmaurice Mobile Zones, G3–King Leopold Mobile Zone, GL7–Paterson Suture Zone). The G3 and G5 corridors, for example, have undergone a complex oscillatory and resurgent tectonic history beginning in the earliest Proterozoic (White & Muir, 1989) and yet are still seismically active today. The onshore / offshore continuity of many of the resurgent lineaments, including the G3 and G5, leads us to the possibility that a zone of structural weakness could be maintained in the basement to the sedimentary basins, and through reactivation, influence their geometry and tectonic history. Understanding anomalies, such as the Bedout High at the intersection of the offshore Proterozoic GL7 and GL8A with the GL9A, may be furthered by examining the geological history of terrains where they are exposed, onshore.

Correlation of large-scale lineaments with recent analogue modelling

Recent studies by O'Brien *et al.*, (1996) have utilized analogue models to understand the role of deep-seated basement structures during extension processes of basin formation. Their models have shown that pre-existing basement discontinuities such as faults, fractures, dykes etc., form a "hard-link" over which faults parallel to the direction of extension (ie., basin margin faults), will die out and form *en echelon* relay systems. They suggest that the basement fractures do not initiate through-going transfer faults (which implies a measurable break or offset) but do relay the extensional faults or flip their polarity forming intra-basinal highs.

These modelling results are consistent with the general observations of our study where results of the local studies can be applied at regional scale. Our study has shown that geophysics can be used to identify the linear zones of basement fracture, and that these zones consistently relate to major changes in depocentre geometry. This may indicate that the gravity lineaments represent deep basement structures which act as "hard links" during the basin forming processes at the regional scale, and why the lineaments are often related to the basin margins and intra-basin highs, than the depocentres themselves.

The research of O'Brien *et al.*, (1996) demonstrates that the basement structures were not always easily seen in seismic and do not necessarily manifest in the upper sedimentary sequence as faults. These are useful observations to bear in mind when examining the regional framework. The manifestation of a fundamental basement structure, therefore, may simply be recognized as subtle topographical changes associated with a change in depositional loci.

The Bonaparte Basin: An example of the "hard link / soft link model, and its relationship to the regional lineament framework.

O'Brien *et al.*, (1996) use the Petrel Sub-basin, within the Bonaparte Basin of northwestern Australia, as an example of the "hard link / soft link" model. They propose that the Sub-basin can be sub-divided into the Tern and Curlew extensional compartments. The extensional faults forming these compartments show flip in polarity and *en echelon* offset across a postulated offshore extension of a northeast trending Proterozoic dyke/fracture zone in the basement of the adjacent Kimberley Craton. According to their model, the offshore extension of the dyke swarm forms a basement fracture zone or "hard link" (HL0), which has resulted in the soft linked relay and polarity flip of the extensional faults in the offshore Petrel Sub-basin. *En echelon* (soft link) offset of extensional faults in the southeastern corner of the Petrel Sub-basin is also modelled by O'Brien *et al.*, (1996) to occur across northeast trending hard links (HL2 & HL3).

Our work shows that the ML13 regional magnetic lineament (Plates 2a, 17) coincides with O'Brien's predicted HL0 hard link and aligns with the magnetic dyke and fracture zone in the Kimberley Craton. The ML13 magnetic lineament is clearly seen in the data as a zone approximately 50km wide which extends for a distance exceeding 300km. The regional magnetic lineament, as identified in our study, coincides with the *en echelon* fault relay and polarity flip but is wider and longer than the basement zone predicted by O'Brien. The shipborne magnetic response (ML13) suggests that the magnetic basement dyke / fracture zone (Plate 17) of the Kimberley does extend offshore and supports the identification of regional lineaments as important indicators of basement structure. The western edge of the regional north-northeast G5 corridor (Plates 1a, 23) again supports the alignment of a regional lineament with basement structure and fault relaying in an extensional system. O'Brien *et al.*, (1996) have also identified two hard links (HL2 & HL3) which trend northeast and align with the western margin of the G5 gravity lineament.

Implications for exploration

Earlier research has shown that regional lineaments, especially their intersections (O'Driscoll, 1986), and their edges (Elliott, 1994), are spatially associated with mineral occurrences. Within western Australia, seventy percent of all gold deposits are situated within 20km of the edge of a continental-scale lineament, over ninety-five percent are within 50km (Elliott, 1994a). This suggests that lineaments, and especially their edges, are zones of enhanced favourability for ore-bearing fluid migration and entrapment. The lineament-ore relationship, as discussed in the introduction, was a fundamental component of the model which led to the Olympic Dam Cu–Au–U discovery in South Australia. Major petroleum provinces show a similar distribution, especially at the regional scale. This is seen in the Northwest Shelf where the Barrow–Dampier fields are situated at the intersection of the northerly GL1 and GL2, with the northeast GL9A. Further north, the Scott Reef gas discovery is located at the intersection of the west-northwest G3 and north-south GL4, with northeast GL10. The Timor Sea fields (eg. Jabiru and Challis) are situated at the intersection of the northwest G11B, west–northwest B1, and the north-northeast GL3.

Given that lineaments are zones of energy release (ie., igneous activity, faulting etc., and zones of fluid flow), intersections and edges appear to be favoured sites for the formation or entrapment of resource commodities. This may be because lineaments are active through time. As such, they are zones of increased fracture porosity, conduits for deep crustal and mantle fluids, and potential mixing zones for fluids of differing chemistries. In hydrocarbon exploration, lineament intersections will be areas of increased fracture porosity (migration pathways), tectonically active sites of erosion and deposition (reservoir formation), areas of higher heat flow (maturation), and zones of enhanced structural activity (trap formation). The lineament/hydrocarbon association along Australia's Northwest Shelf, and the analogue modelling of O'Brien *et al.*, (1996) supports the view that they are enhanced zones of favourability, with respect to the petroleum habitat.

Correlation of lineaments with those in earlier publications

Lineaments identified in this study generally correlate well with those identified in previous work by O'Driscoll (1980, 1986, 1990) and Elliott (1994a, 1994b). Often, however, the edges of the corridors identified in this study did not directly coincide with the edges identified in the earlier work. This suggests that although different data sets continue to show basement disruptions, the actual location of zones, at the continental-scale discussed in this report, will be variable. Identification of the lineament corridors may be restricted, at this scale, to their general location. At a more detailed scale, the individual structures or lineaments (when concentrated and aligned form a regional trend), can be accurately mapped. Comparisons between the location of the 'G' gravity lineaments identified in previous studies, and their location based on the data in this study, are described below:

G5 Corridor:

The western edge of the G5 gravity corridor, as identified by Elliott (1994a) from gravity images of the Australian continent, lies to the west of the Proterozoic Halls Creek Mobile Zone (HCMZ) and passes through the Cambridge Gulf to run parallel to the coastline in the offshore Bonaparte Basin (Fig. 5). Further offshore, the western edge coincides with the Lyndoch Bank Fault Zone where the east-northeast Malita Graben swings into the north-northeast Calder Graben. This previously identified edge is approximately 75km west of the position identified in this study.

The eastern edge of the G5 corridor, as identified in this study, is situated in the same position as previous studies, on the eastern border of the Fitzmaurice Mobile Zone (FMZ).

G3 Corridor:

The northern edge of the G3 corridor is situated in approximately the same position in this study as in previous studies, along the northern margin of the King Leopold Mobile Zone (KLMZ). The southern edge, identified in this study, is approximately 25km to the south of the position identified by Elliott (1994a). In this study, the edge is reflecting the northern margin of the Broome Platform basement whereas in the earlier work reflected the Fenton Fault, a major basin bounding fault to the Fitzroy Trough.

G2 Corridor:

The G2 corridor was less well-defined in northern Australia in both this and earlier studies than many of the other large-scale gravity corridors. The location of the eastern edge of the lineament, in this study, is to the north-east of the earlier position. The southern edge (this study) approximates the northern edge from earlier work (Elliott, 1994a).

G11 Corridor:

The G11 corridor is compartmentalized into the G11A and G11B and is consistent with earlier work (Elliott, 1994a). The corridor edges directly correlate with those identified in earlier studies with the addition of the B1 lineament. The B1 lineament coincides with the northwest G11A in the southern Bonaparte Basin, and then swings into a west–northwest trend further offshore.

G12 Corridor:

The G12 corridor is identified as a wider zone than in previous work (Elliott, 1994a). The eastern edge of the corridor is coincident in both studies, lying just to the east of the Cambridge Gulf. The western edge, however, is approximately 35km to the west of the position based earlier results.

G13 Corridor:

The G13 lineament is situated approximately 40km south of its position from earlier work (Elliott, 1994a). In this study, the gravity lineament is reflecting the depocentre margin of the Daly River and Georgina Basins whereas in earlier work, the lineament correlates with the shallow basement margin of the Proterozoic Pine Creek Geosyncline.

G9 Corridor:

The G9 corridor was identified by O'Driscoll (1990) as a sequence of four west-northwest lineaments that cross-cut the Pilbara Craton between Cape Range and Port Hedland. The two edges of the GL6 gravity corridor correlate with the two southern-most lineaments of O'Driscoll's G9 sequence, the G9A and G9B.

Although in many cases the lineament edges were coincident, the discrepancies between the edges identified in this study, and those of the earlier work, were less that 75km, and generally less than 35km. These discrepancies may be a function of the scale of interpretation. The earlier studies identified these lineaments as continental-scale features that in some cases could be traced for distances exceeding 3000km using 1:20 000 000 to 1:40 000 000 data sets. In this study, the scale of data-sets was 1:5 000 000 which allowed a greater resolution and therefore accuracy within the Northwest Shelf region.

The image processing algorithms and resolution of the original data-sets also varied between this and earlier studies which may have influenced the apparent location of the corridor edges. The horizontal derivative was a useful gravity data set for lineament identification. The horizontal derivative produces an anomaly over the maximum gravity gradient resulting in a double linear anomaly for each true single anomaly in the crust. Therefore, accuracy in placing the actual edge of a zone can be significantly altered depending on which of the horizontal gradient anomalies is selected to represent the crustal anomaly. Considering this, the corridors are represented in this study as zones whose edges are approximate and may vary in position with the addition of new data-sets and processing techniques.

Recommendations for future work

The significance of basement structure to the tectono-stratigraphic history of hydrocarbon provinces is rapidly gaining attention. Studies, such as those of Blundell (1990) in the North Sea, have shown the influence of ancient, reactivated basement structures on the depositional history, and highlighted the importance of incorporating deep seismic into the basin analysis method.

Australia has the most comprehensive deep seismic data sets over a series of proven hydrocarbon provinces. These seismic lines are being incorporated, with great success, into the mapping of individual basins. There is, however, great potential to utilize these lines, in conjunction with the regional gravity and magnetic data, in a more regional geological context. The objective of this would be to develop a further understanding of the fundamental tectonic controls that have governed the depositional history and Gondwana breakup along the Northwest Shelf.

The current study leads us to propose several projects that work towards understanding that basement architecture of northwestern Australia:

1. *To develop a crustal elements / tectonic elements map for the Northwest Shelf*

Using the geometry of the crustal boundaries identified in the current study, and the offshore geophysical data, interpretations can be made with regard to offshore spatial relationships between the cratons, mobile belts, and the sedimentary basins. The objective of this would be to produce an offshore crustal elements map that defines the sedimentary basins and shows their relationship to the onshore basins and ancient cratons and mobile zones.

2. *To further define the offshore sedimentary basins*

Our study reveals that the Northwest Shelf is transected by a sequence of large-scale basement discontinuities. In many cases these zones are identified as lower crustal, possibly upper mantle, structures using the deep-seismic. Further work is now required to understand the geometry of the basement discontinuities and therefore the geometry of the offshore sedimentary basins. Using geophysical data, maps have been produced as part of this study to show the horizontal 2D arrangement of these large-scale structures. A great deal of information is now available through the mapping of seismic reflection profiles, ie., in the vertical 2D. Integration of the horizontal 2D geophysical data (ie., gravity and magnetics) with the vertical 2D seismic data will provide a basis for 3D modelling of sedimentary basins.

3. *To develop an offshore geological map for the Northwest Shelf*

Geological mapping is being carried out by individual groups on the several basins along the Northwest Shelf. A compiled geological map, which incorporates the major geological features and detailed documentation of the relationships between the onshore Proterozoic and Palaeozoic terrains, would significantly contribute to the understanding of the offshore basin forming processes, and the timing of structural events. Such a geological map would be a very useful guide in the exploration for petroleum resources.

4. *Structural studies within an individual basin*

Regional structural studies should be incorporated with detailed structural analysis at smaller scales. Timing and style of trap formation, oil maturation and migration, and predictive models within a basin, may all be related to the reactivation of basement structure.

Work by O'Brien and others (1996) has indicated that "hard-links" are responsible for structural changes which may lead to the formation of potential hydrocarbon traps. This is an exciting model which highlights the importance of understanding the basement structure and especially the timing of movement. Previous research by Elliott (1994a) has suggested that lineaments are self-similar and occur in a 'fractal-like' pattern. This suggests the possibility that basement structures which affect prospectivity ("hard-links") will occur within structures of a more regional nature that affect the basin forming processes. Relating these structural zones, both regional and local, to the onshore geology and tectonic history, is of paramount importance to understand favourable structures.

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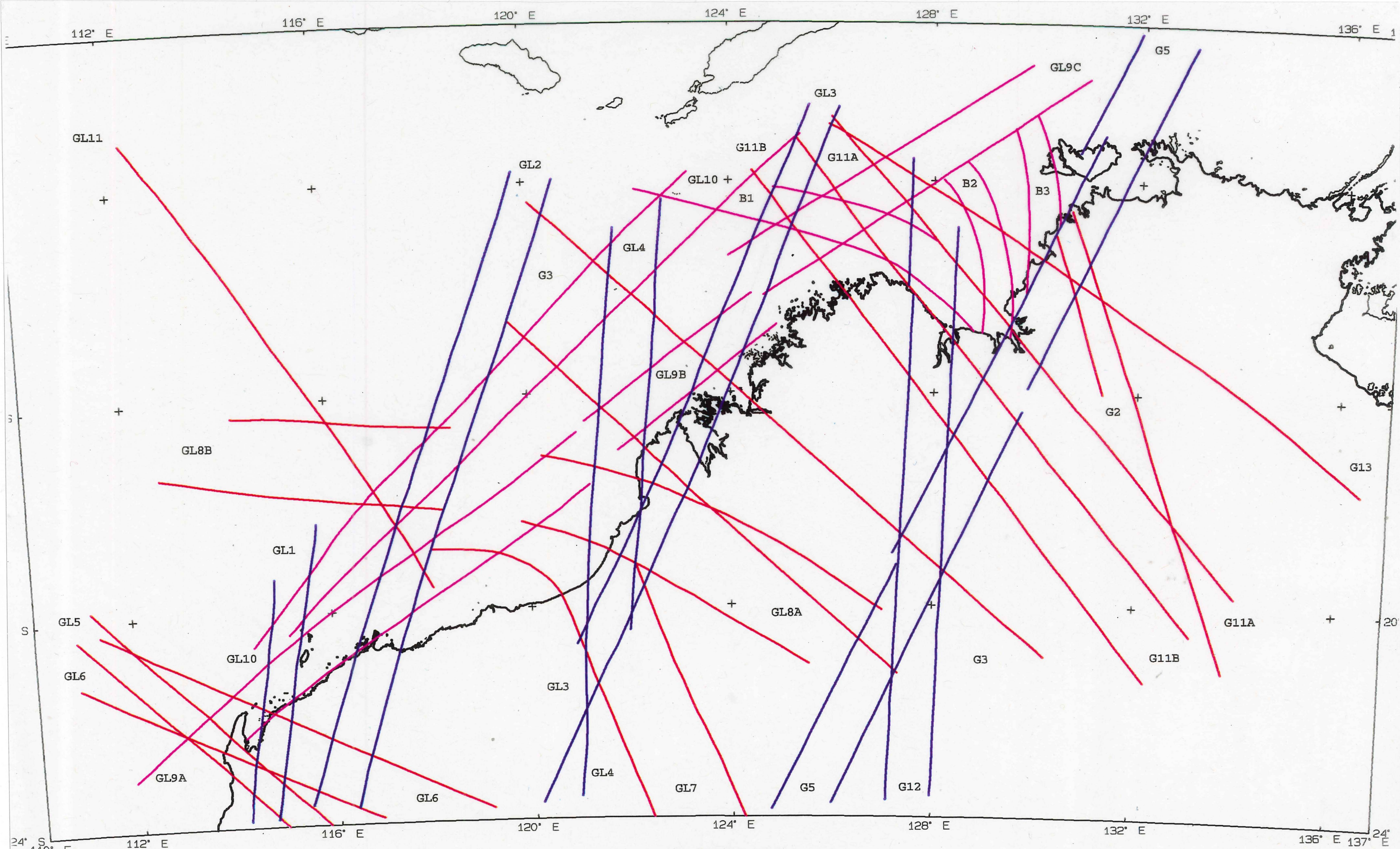
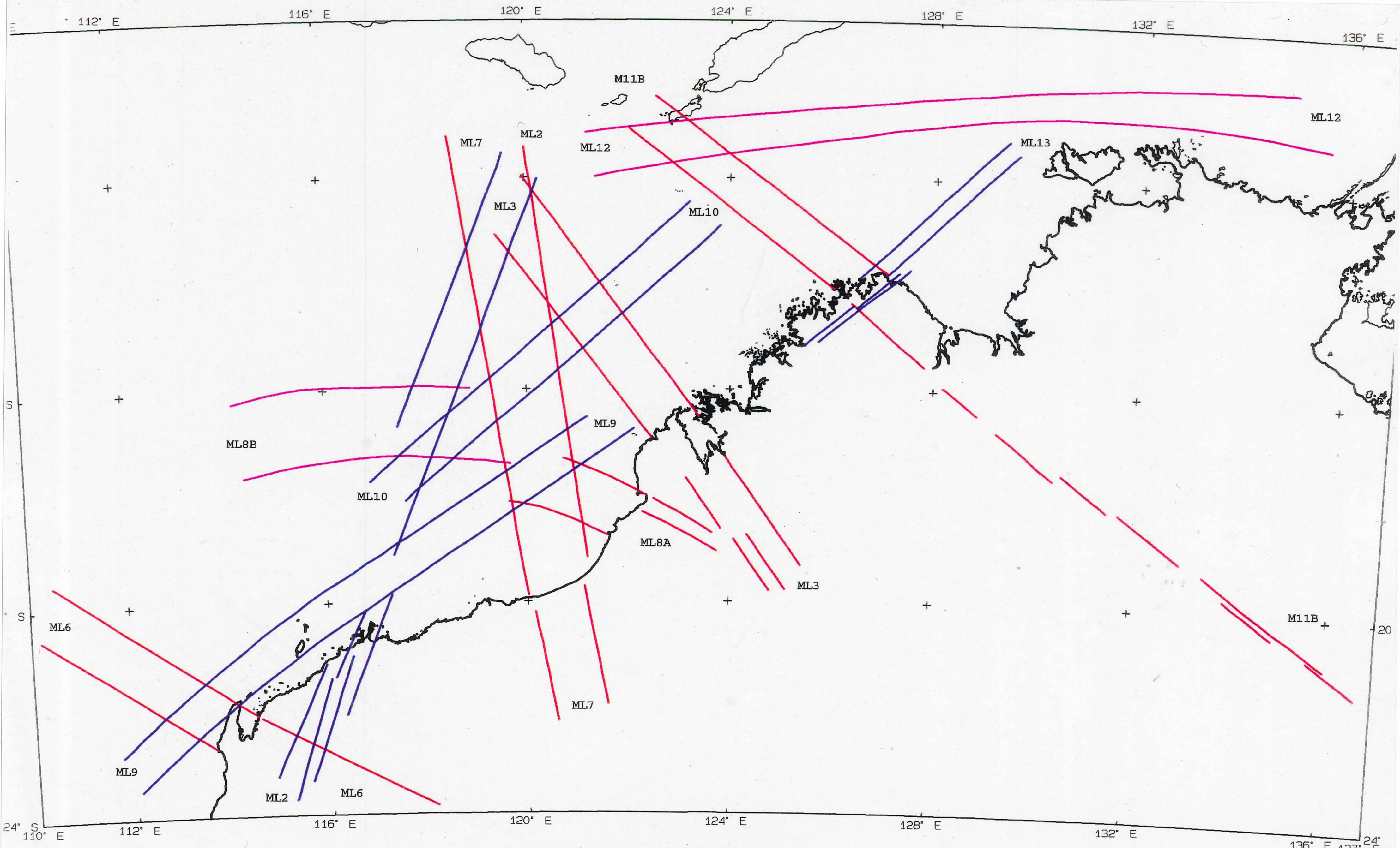


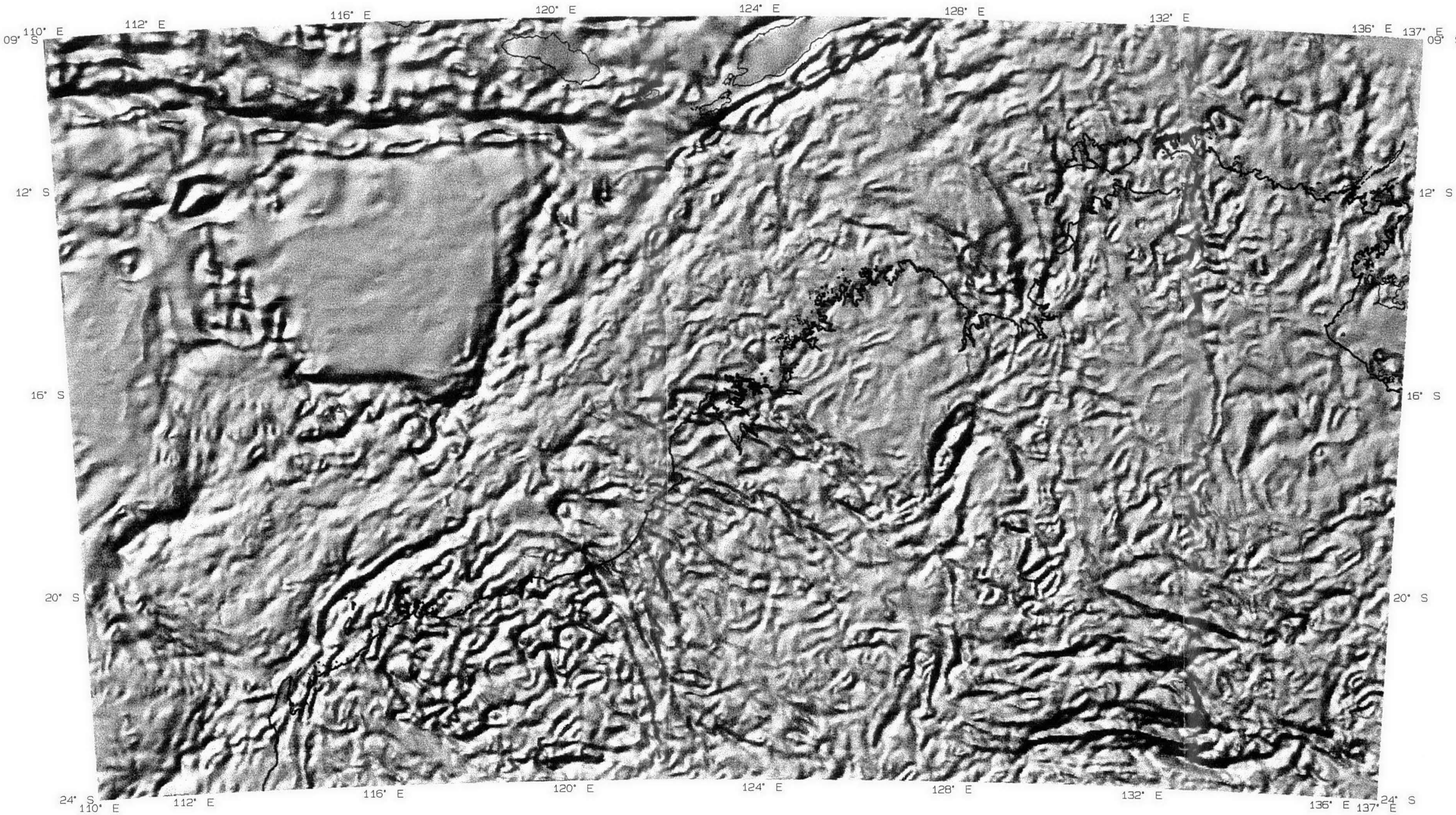
ENCLOSURE 1:

REGIONAL GRAVITY LINEAMENTS OF NORTHWESTERN AUSTRALIA.



ENCLOSURE 2:

REGIONAL MAGNETIC INEAMENTS OF OFFSHORE NORTHWESTERN AUSTRALIA.



Horizontal gradient of the Bouguer gravity anomaly, northwest illumination

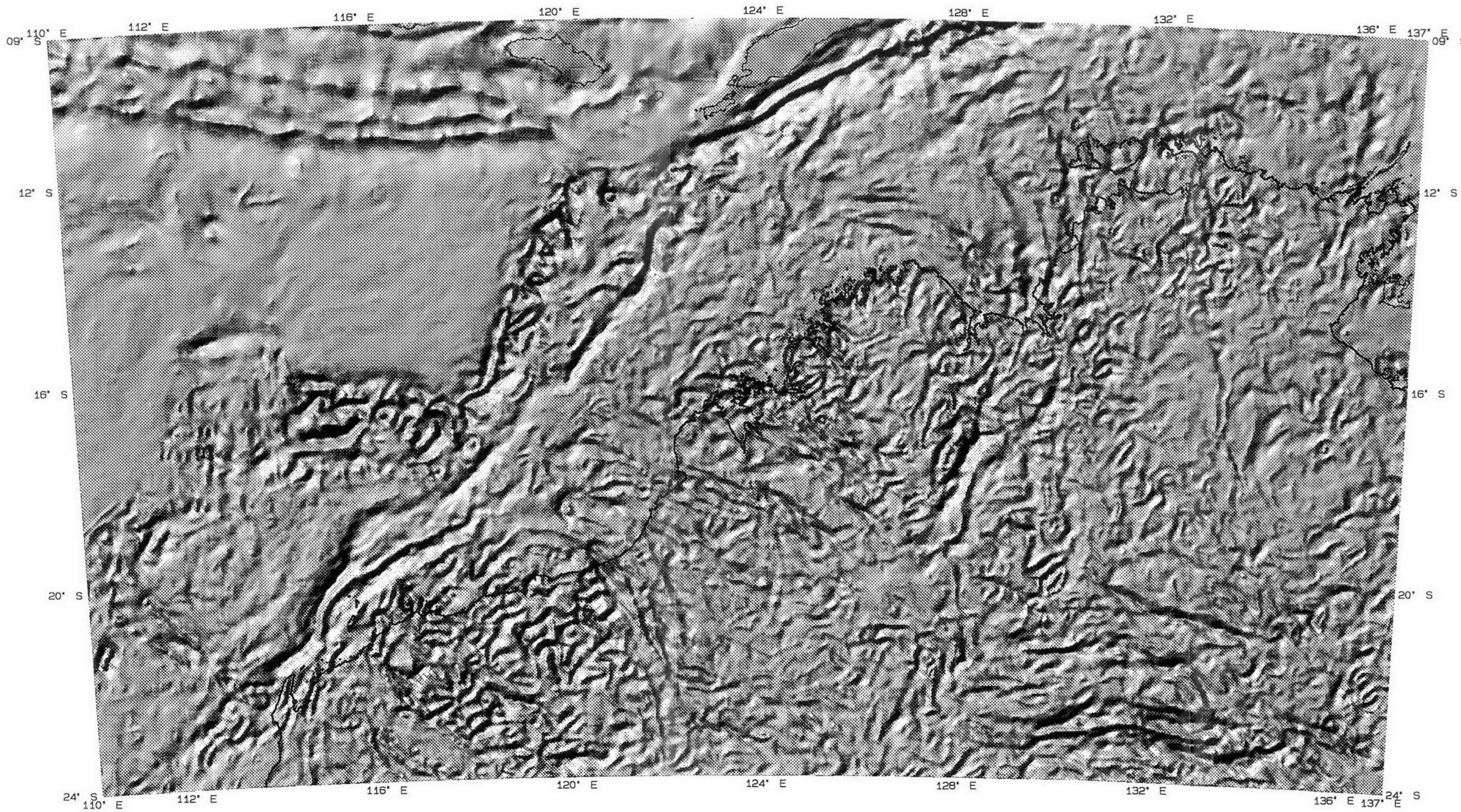
1: 10000000

0 200 400 600 800 1000

KILOMETRES

SIMPLE CONICAL PROJECTION
AUSTRALIAN NATIONAL SPHEROID
PARALLELS 12° S AND 21° S, CENTRAL MERIDIAN 123° E

AGSO
AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION



Horizontal gradient of the Free Air gravity anomaly, northwest illumination

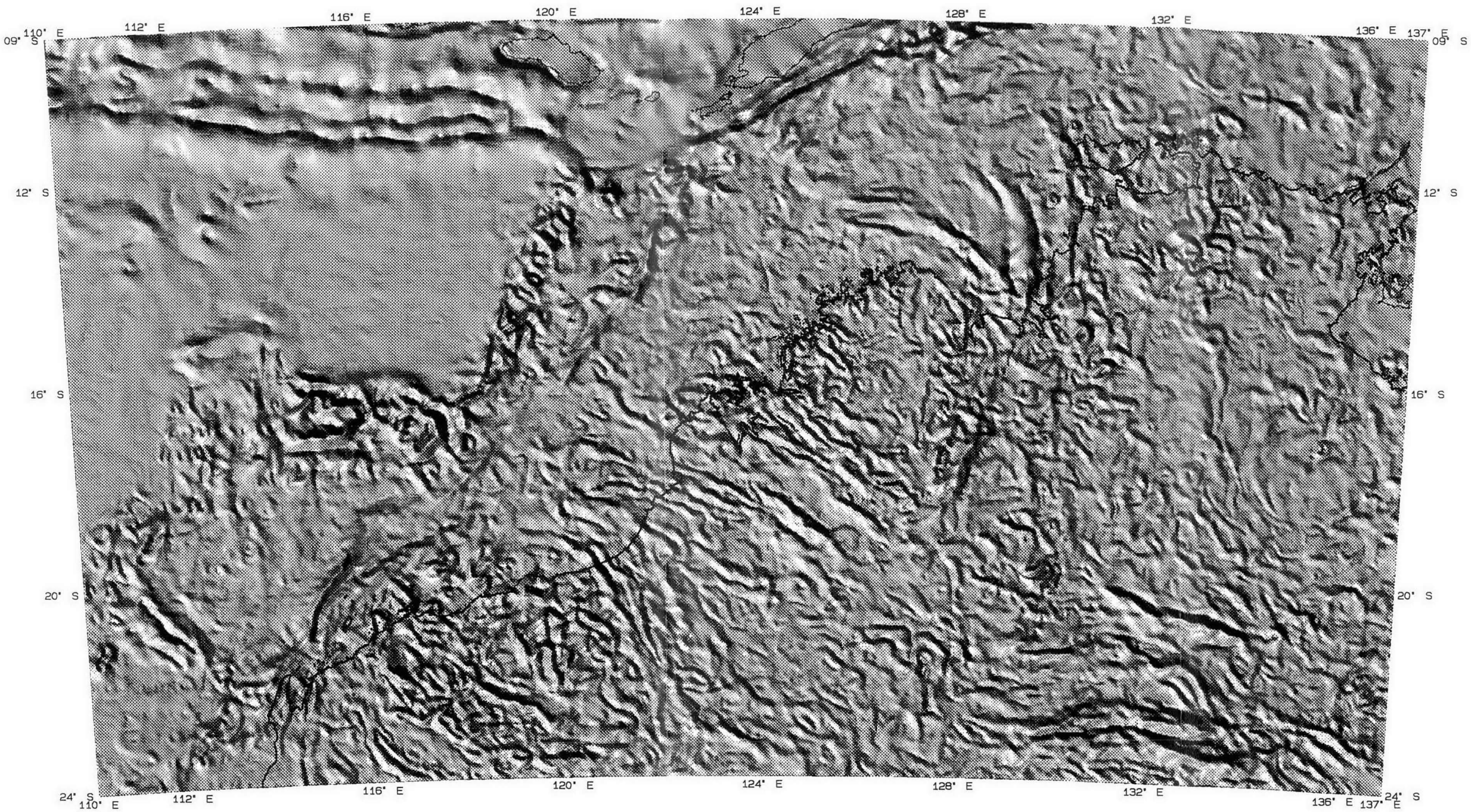
1: 10000000

0 200 400 600 800 1000

KILOMETRES

SIMPLE CONICAL PROJECTION
AUSTRALIAN NATIONAL SPHEROID
PARALLELS 12° S AND 21° S. CENTRAL MERIDIAN 123° E

AGSO
AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION



Horizontal gradient of the Free Air gravity anomaly, northeast illumination

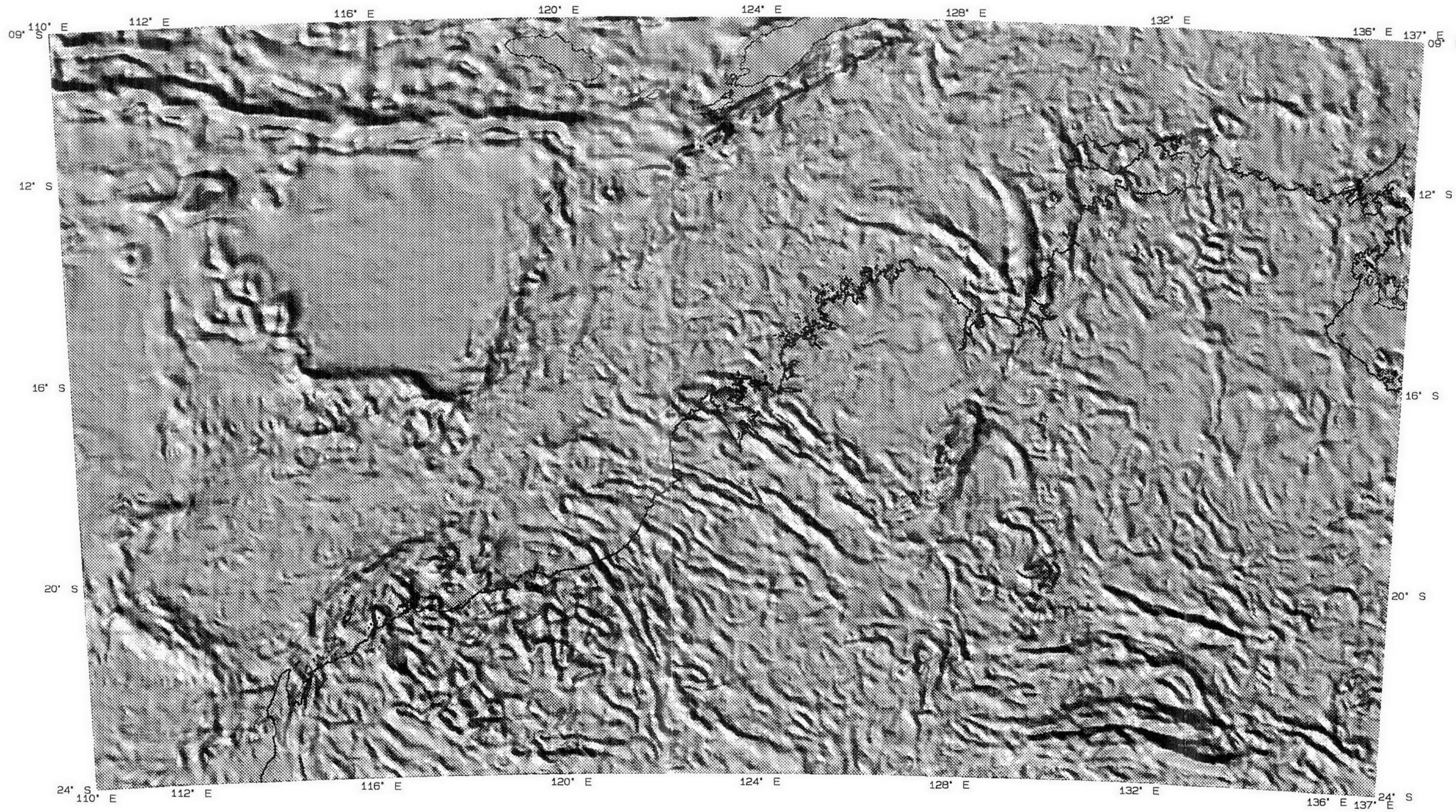
1: 10000000

0 200 400 600 800 1000

KILOMETRES

SIMPLE CONICAL PROJECTION
AUSTRALIAN NATIONAL SPHEROID
PARALLELS 12° S AND 21° S, CENTRAL MERIDIAN 123° E

AGSO
AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION



Horizontal gradient of the Bouguer gravity anomaly, northeast illumination

1: 10000000

0 200 400 600 800 1000

KILOMETRES

SIMPLE CONICAL PROJECTION
AUSTRALIAN NATIONAL SPHEROID
PARALLELS 12° S AND 21° S, CENTRAL MERIDIAN 123° E

AGSO
AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION