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REVIEW AND ANALYSIS OF NORTHEAST QUEENSLAND REGIONAL GRAVITY AND AEROMAGNETIC DATA TO 1982

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ABSTRACT

A review, further analysis and interpretation of regional gravity and aeromagnetic data for northeast Queensland throws new light on the deeper crustal and subcrustal structure in the area between latitudes 16°-21°S and longitudes 139.5°-148.5°E, and points out several problems which cannot be resolved without further geophysical data.

A major new phase of geophysical data acquisition in northeast Queensland was begun by BMR in late 1982. As the first stage of an ongoing program, 95,000 line-km of airborne magnetic and radiometric data were acquired and these are now in the processing stage. This report was prepared to assist interpretation of these data and also form the basis for possible further problem-solving ground geophysics.

The existing regional gravity data have been machine-contoured to 20 μms^{-2} contour interval. Upward-continuation processing has enabled display of long-wavelength effects such as Moho depth variations and density inhomogeneities in the lower crust and upper mantle. The main broad regional variations in the gravity field are attributed to crustal thinning out from the coastline, a slightly thinner than normal (~ 40 km) crust beneath the Mount Isa Inlier coupled with higher density upper crustal rocks, and thicker crust to the south of the Georgetown Inlier.

Contouring of residual gravity over the region has allowed enhancement of upper crustal density variations. Sediments in onshore basins are relatively thin (generally $\ll$ 1000 m) and their gravity effect is expected to be fairly small ($\ll$ about 150 μms^{-2}); most of the larger anomalies would be due to intra-basement density variations. Distinctive steep-sided gravity lows, often 20-40 km in width, are interpreted as large granitic intrusions within basement. These often correlate with

low intensity aeromagnetic anomalies. About 50% of the onshore area of NE Queensland is believed to be underlain by granitic rocks at shallow depth. Many of the linear or arcuate steep gradients in the gravity contours have been interpreted as major high-angle faults. These inferred faults are in some cases also evident as lineaments in the magnetic contours. Some geophysically mapped faults can be correlated with known geologically mapped faults. Faults not previously mapped have been identified, particularly where basement is concealed by sediment/volcanic cover. Several major structural zones have been delineated in the eastern part of the region.

Basement domains have been mapped on the basis of similarity in gravity and magnetic trend patterns; these trend patterns are believed to reflect fundamental structure. Strongly concordant N-S trends are characteristic for the Mount Isa domain. High intensity gravity and magnetic anomalies indicate continuation of the Mount Isa Inlier beneath shallow Mesozoic-Cainozoic sediment cover for considerable distances beyond its outcrop limits - as far as 60 km to the north and east.

There is no conclusive evidence in the gravity contours or trend patterns as to the subsurface eastern extent of the Precambrian craton. It probably continues eastward at least as far as the major structural zone which runs approximately N-S, following the western margin of Connors Arch and then the coastline further to the north.

1. INTRODUCTION

This report gives a review of northeast Queensland regional geology and recent geophysical results, and provides further analysis and interpretation of existing gravity and aeromagnetic data.

The area encompassed by the study is bounded by latitudes 16^{o}-21^{o}S and longitudes 139.5^{o}-148.5^{o}E (Figure 1). Thirty 1:250 000 map sheets are involved.

The geological history of the region spans about 2 billion years (to at least the Lower Proterozoic), and during this time various economically important metalliferous and petroleum/coal provinces have evolved. Commercially developed mineral deposits include Mount Isa (copper-lead-zinc-silver), Mary Kathleen (uranium), Greenvale (nickel), Herberton-Irvinebank and Mount Garnet (tin) and Wolfram Camp (tungsten). Though reconnaissance geological mapping at 1:250 000 scale is now complete, the geological evolution of the region is still poorly understood. The often intense structural, metamorphic and intrusive modifications (particularly of the older terrains) are partly responsible for this, though a major contributing factor must be the generally poor exposure - well over 50% of the basement geology is concealed by young sediments or volcanics, and ocean. Geophysical methods including gravity and magnetics provide the means for 'looking' through cover sequences, as well as providing deep structural information. With the gravity method it may be possible to extend the depth of investigation to the upper mantle; the depth of investigation of the magnetic method is limited to sub-Curie temperature depths (less than 20-30 km).

It is intended that this study provide a geophysical overview of the region and form the basis for more detailed and comprehensive research into its geological composition, structure and evolution, through acquisition of further field data. The results of BMR's recent (late 1982) magnetic and radiometric airborne transect survey of the area will become available in early 1983 and will constitute a major source of new data for the elucidation of local and regional structural detail. The survey achieved 95,000 line-km of coverage.

2. SOURCES AND DISTRIBUTION OF GRAVITY AND AEROMAGNETIC DATA

The principal contribution to gravity station coverage over the area was BMR's regional helicopter survey completed in 1966 on an 11 km grid (Shirley & Zadoroznyj, 1974). Additional data were the result of reconnaissance road traverses, petroleum exploration surveys, semi-regional and detailed metalliferous/structural investigations (e.g. Smith, 1966a, 1966b, 1968; Gibb, 1967, 1968; Darby, 1966, 1969; Watts, 1972; Watts & Brown, 1976). Details of gravity surveys of the Great Barrier Reef and adjacent coast are provided by Dooley (1965). Most of the offshore data were collected in 1971 as part of BMR's 1970-73 continental margins survey (Mutter, 1974). Figure 2 shows the gravity data distribution over NE Queensland. The data come from 27 surveys spanning the period 1950-78.

Airborne magnetic survey coverage, excluding BMR's late-1982 transects, is shown in Figure 3; also indicated are the survey flight heights. The surveys include those by BMR and also those flown by petroleum exploration companies (under the Petroleum Search Subsidy Acts). Reference to the survey parameters and completion reports can be found in the compilation by Gerula (1979).

Relevant BMR Records on the aeromagnetic acquisition and results include those by Dockery & Tipper (1965), Wells & Milsom (1966), Wells & others (1966), Waller (1968), Shelley & others (1971), Hsu (1974) and Tucker (1975).

Magnetic profiles recorded during a major survey over the area adjacent to the Gulf of Carpentaria (Hartman, 1962) have been redrawn in Figure 4 to provide an areal display of the data to facilitate correlation between profiles.

3. REGIONAL STRUCTURAL AND TECTONIC FRAMEWORK

The area studied straddles the boundary between two major and contrasting Australian basement terrains (Figure 5). The Proterozoic Arunta-Gawler cratonic province extends to the west of the N-S trending boundary, while the younger Phanerozoic Tasman Orogenic Zone lies to the east. The location and nature of the basement boundary is ill-defined along much of its inferred length due to concealment by superimposed sediment/volcanic cover or obliteration by invasion of large igneous intrusions. The Precambrian basement may in fact continue to some extent beneath the Tasman Orogenic Zone, terminating eastwards in a transition zone rather than a sharp lateral contact.

The Tasman Orogenic Zone of eastern Australia comprises a number of orogens (fold belts). The major orogens, identified in the NE Queensland region are the Cambrian-Carboniferous Thomson Orogen, the Ordovician-Early Carboniferous Hodgkinson-Broken River Orogen and the Silurian-Triassic New England Orogen (Murray & Kirkegaard, 1978; Day & others, 1978).

A lack of precise isotopic age determinations has led to some differences in opinion as to the mappable extent of the Precambrian craton to the east. The boundary shown in Figure 5 is that preferred by Leitch (1974), Rutland (1976), Scheibner (1976), Day & others (1978) and Murray & Kirkegaard (1978). Other workers, including Crook & Powell (1976) and Henderson (1980) consider that the Lolworth-Ravenswood Block is part of the Precambrian craton; some of the constituent rocks show similarities to those of the Georgetown Inlier in possessing high metamorphic grade and structural complexity. Henderson goes further by inferring that rocks of the Anakie Inlier are of Proterozoic age, and he suggests that the entire Thomson Orogen is underlain by Precambrian basement.

The geological development of the Precambrian terrains of the Mount Isa Inlier and the Georgetown/Yambo Inlier are outlined by Plumb & others (1980), and Blake (1983), and Withnall & others (1980), respectively. In his review of Australia's orogenic evolution, Rutland (1976) discusses both the Precambrian provinces and the Tasman Orogenic Zone.

Attempts have been made to explain evolution of the Tasman Orogenic Zone in terms of actualistic plate tectonic models of crustal accretion based on modern situations as typified by West Pacific island arcs and Andean-type continental margins. These attempts have not been altogether successful and unanswered questions remain (Crook & Powell, 1976). Rutland (1976) points out that interpretation of the Palaeozoic tectonics is complicated by the need for reassembly of the situation that existed before development of the present Tasman Sea marginal basin. The task of interpretation is simplified however by the fact that, instead of superimposition, there has been an episodic migration of the loci of deformation, metamorphism and orogenic magmatism away from the craton. A continental substrate for the Tasman Orogenic Zone is proposed by Rutland, though this is contrary to the views of a number of other workers including Scheibner (1973) and Crook (1980), who advocate an oceanic substrate.

4. LITHOSTRATIGRAPHIC AND STRUCTURAL DESCRIPTION OF MAIN GEOLOGICAL PROVINCES

The main structural components and basins of NE Queensland are indicated in Figure 6. More detail is provided in Figure 7 which shows the principal elements of surface geology, major mapped structure and sediment thickness within the more important Late Palaeozoic-Recent basins.

The following resumé, describing the principal geological features of the main provinces (as shown in Figure 6), has been drawn largely from Henderson (1980).

4.1 Mount Isa Inlier & Georgetown/Yambo Inliers

Mount Isa Inlier

Rocks of the Proterozoic inlier consist of thick sedimentary sequences with interlayered volcanics variously deformed and metamorphosed (in places to upper amphibolite facies) and intruded by substantial granitoid bodies and smaller plutons of more basic composition.

The basal part of the sequence, the Kalkadoon-Leichhardt Block, forms a broad belt striking N-S, separating younger successions to the east and west. Isotopic dating suggests a minimum age of 1865 m.a. for the K-L Block, which is characterised by acid, basic and intermediate metavolcanics with minor intervals of arenaceous sediments. Large granitoid bodies are also present.

The younger succession to the east, the Mary Kathleen Fold Belt, consists of tightly folded metasediments, generally of terrigenous clastic origin, and metavolcanics; the metamorphic grade is dominantly greenschist-lower amphibolite facies.

Georgetown/Yambo Inliers

The Proterozoic basement inliers appear to be part of a single structural unit, faulted to the east against Palaeozoic sedimentary terrains of the Hodgkinson and Broken River Provinces.

Three subprovinces - Croydon, Forsayth and Greenvale, which comprise the western, central and eastern parts of Georgetown Inlier (the Yambo Inlier being part of the Forsayth Subprovince) - have been recognised (Withnall & others, 1980). The Greenvale and Forsayth Subprovinces are partly separated by an extensive mylonite zone; a major unconformity separates the Forsayth Subprovince from the younger Croydon Subprovince.

Rocks of the Greenvale Subprovince consist of schist, phyllite, amphibolite and ultramafics. Sedimentation and emplacement of gabbro and ultramafic bodies (prior to 1100 m.a.) was followed by a metamorphic/ deformation event, and thereafter by an episode of basic and intermediate plutonism (older than 450 m.a.). The entire assemblage underwent later multiple deformation and metamorphism (to greenschist and amphibolite grade).

The central Forsayth Subprovince contains tightly interfolded multiply deformed metasediments and metavolcanics of variable metamorphic grade. Basic and intermediate intrusions pre-date most or all of the deformation. Granitoids were emplaced during two periods - Proterozoic and Siluro-Devonian. Metamorphic grade is highest to the east where amphibolite facies and locally granulite assemblages prevail; to the west the rocks are typically of greenschist grade. The oldest strata have a sedimentary age greater than 1570 m.a., with a complex deformation history extending into the Late Palaeozoic.

The Croydon Subprovince comprises gently folded ignimbrites and rhyolite flows intruded by granite and overlain by sandstone. The igneous rocks have been dated as 1420 m.a.

4.2 Lolworth-Ravenswood Block & Anakie Inlier

Lolworth-Ravenswood Block

Basement comprises metamorphics generally of amphibolite grade. Their age is uncertain; they may be either Precambrian or Lower Palaeozoic. The metamorphics are invaded by extensive batholiths of Middle Ordovician and Late Silurian age.

In the south and east of the Block, there are remnants of a thick (at least 6 km), once-continuous acid-intermediate volcanic and sedimentary assemblage. The rocks are of ?Late Cambrian-Early Ordovician age and believed to have been deposited in a marine environment. Though little deformation has occurred except in contact aureoles adjacent to granitoids, extensive disruption by faulting has taken place.

The Burdekin Basin is a thick sedimentary (terrigenous clastics and marine limestone) sequence of Middle-Early Carboniferous age unconformably overlying metamorphic basement. The strata are gently folded and highly disrupted by faulting.

Anakie Inlier

The Inlier is a NNW trending block of Early-Middle Palaeozoic rocks surrounded by Late Devonian-Permian sediments of the Drummond and Bowen Basins. Contained rocks are of at least five distinct ages: pre-Late Ordovician metamorphics, Late Ordovician sediments, Middle Devonian volcanics and sediments (of the transitional tectonic stage of the Thompson Orogen), Late Devonian granodiorite, and Late Carboniferous granite (Murray & Kirkegaard, 1978). The metamorphics include schists which appear to have been derived from basic volcanics; associated small lenses of serpentinised harzburgite are present.

The Drummond Basin comprises Late Devonian-Early Carboniferous covering strata which lap off the Anakie Inlier basement. The strata are almost entirely of continental deposition and include substantial intervals of acid volcanics and volcaniclastics. Open folding is present, following the trends of the basement core. To the west where the basin is best developed, outcrop extends across a 100 km zone and the sequence is up to 12 km thick.

4.3 Hodgkinson Province & Broken River Embayment

Hodgkinson Province

Thick, clastic marine sequences (mainly of flysch facies) predominate; however, near the western margin (Palmerville Fault) basic volcanics and fossiliferous limestones are more characteristic. The rocks are Siluro-Devonian.

Unconformably overlying are Permo-Carboniferous volcanic-sedimentary deposits (acid pyroclastics and lavas, subordinate andesite and minor basalt; interbedded sediments - conglomerate, arkose, micaceous sandstone, shale, siltstone, mudstone and coal seams) and isolated residuals of Mesozoic strata (sandstone and conglomerate). Both groups are of terrestrial origin.

The thickness of the Hodgkinson Province succession is unknown, but is expected to exceed 12 km (Arnold & Fawckner, 1980).

The Siluro-Devonian rocks were affected by a sequence of deformation and metamorphism - pre-slaty cleavage folding, large-scale folding associated with slaty cleavage development and regional metamorphism of predominantly greenschist grade, followed by a phase of refolding. The Barnard Metamorphics in the far eastern (coastal) sector are an exception, however. They have a more complex structural history and generally higher grade metamorphism and comprise schists, gneiss, gneissic granite, amphibolitised gabbro, migmatite and metamorphosed ultramafic bodies.

Broken River Embayment

This is a deformed, flysch-type sedimentary terrain bordered to the west and south by the Burdekin River Fault Zone and Clarke River Fault, respectively. The Gray Creek Fault Zone divides the Embayment into two subprovinces.

The Graveyard Creek Subprovince is confined to the southwestern end of the Broken River Embayment, and is considered as an anomalous, fault-bounded, relatively undeformed, Ordovician-Carboniferous basin. The Camel Creek Subprovince comprises mainly multiply-deformed Ordovician-Devonian flysch, thought to have been continuous with similar deposits in the Hodgkinson Province (Arnold & Fawckner, 1980).

Local basement within the Graveyard Creek Subprovince consists of the Gray Creek Complex, a small inlier of metamorphic Precambrian mafic and ultramafic rocks with affinity to the adjacent Georgetown Inlier. These rocks are overlain by (?) Ordovician quartzose flysch, which is in turn unconformably overlain by a very thick (maximum 12 km) marine mid-Silurian-Late-Devonian sequence of greywacke, pelite, limestone and conglomerate. Deformation of the sedimentary sequences has resulted in tight, large-scale folds to which the observed slaty cleavage is related.

Following is the 'upper' part of the Bundock Creek Formation (Wyatt & Jell, 1980), consisting of thickly bedded, lithic and arkosic arenite with interbedded mudstone, limestone, rhyolite, tuff and tuffaceous sandstone. The sequence is of Early Carboniferous age and at least 2.5 km thick.

4.4 Connors Arch & Campwyn Block

Connors Arch

This igneous belt is believed to be the remnant of a calcalkaline Andean-type volcanic arc (Day & others, 1978) active during the Late Devonian and Early Carboniferous. Massive andesite flows are the main rock types, with subordinate dacitic and rhyolitic lavas and pyroclastics. Post-orogenic granitic batholiths of Late Carboniferous, and Early Permian and Early Cretaceous age were emplaced. The Early Permian emplacement was related to a short episode of reactivation of the volcanic arc. The volcanic activity generated a thick sequence of dominantly andesitic volcanics on the western side of Connors Arch; these volcanics (ranging from basalt to rhyolite with only minor interbedded sediments) form the basal sequence of the Bowen Basin.

Campwyn Block

East of the volcanic chain, Late Devonian-Early Permian volcaniclastic sediments, limestone and calcalkaline volcanics were deposited in an unstable continental shelf environment; some terrestrial deposition took place in the Early Permian (Day & others, 1978).

4.5 Bowen, Galilee & Great Artesian Basins

Bowen Basin

The sediments are of Lower Permian-Middle Triassic age and were deposited in a broad synform which widens and deepens to the south.

Three distinctive terrigenous clastic suites are present - (i) mid-Permian Back Creek Group - predominantly marine; (ii) Upper Permian Blackwater Group - terrestrial coal-bearing sequence, and (iii) Triassic Clematis and Rewan Groups - of terrestrial, red-bed affinities lacking coal measures. The basin is structurally simple in the north.

Galilee Basin

The Basin consists of Upper Carboniferous-Middle Triassic strata of terrigenous, continental character and are undisturbed except for minor flexuring due to basement faulting. The Bowen and Galilee Basins are complementary downwarps on either side of the Anakie Inlier. Only the northern part of the Basin is within the study area - maximum sediment thickness here is estimated to be about 2500 m (Vine, 1976) - see Figure 7.

Great Artesian Basin

This consists of a vast Jurassic-Cretaceous basin (epeirogenic, intracratonic downwarp) occupying much of eastern Australia. In the NE Queensland, the Euroka Arch divides the basin into the Carpentaria Basin to the north and the Eromanga Basin to the south. The terrigenous strata comprise continental Jurassic and predominantly marine Cretaceous sediments. The beds are generally of low dip, except where draped over faulted basement. The basement appears to be mainly Precambrian, although in the north-east the Galilee Basin forms much of the underlying foundation. There is some evidence from seismic reflection results and petroleum exploration wells that basement to the Carpentaria Basin beneath the Gulf of Carpentaria in the extreme west of the study area may include Carpentarian rocks of the McArthur Basin. Drilling has also indicated the possible existence of several Palaeozoic-Triassic infrabasins, and Permian granite was intersected on Mornington Island (Smart & others, 1980).

Within the study area, the Carpentaria Basin attains a maximum thickness of about 1000 m beneath the Gulf, while the Eromanga Basin reaches a thickness of about 400 m at the southern margin of the area.

The extensive overlying Cainozoic Karumba Basin, dominantly of continental sand, with some silt and clay, attains a maximum thickness of 300 m.

4.6 Cainozoic flood basalts

As shown in Figure 7, Cainozoic flood basalts cover a considerable area (23,000 km^2) of the central NE Queensland region, and are clustered in seven volcanic provinces. Ages range from 44 m.a. to 10 000 b.p. (Stephenson & others, 1980). The basalt flows do not generally exceed 100 m in thickness.

4.7 Offshore area (Coral Sea)

This continental margin area is discussed by Pinchin & Hudspeth (1975), Mutter (1977), Taylor & Falvey (1977) and Mutter & Karner (1980). The submarine basement is believed to be a submerged and dissected extension of the Lachlan Orogenic Zone and consists of Palaeozoic meta-sediments.

Rifting in the mid-Cretaceous-Palaeocene led to development of the Queensland Trough which contains rift valley sequences to 3 km thick (see Figures 6 & 7). Sea-floor spreading in the Coral Sea Basin began in the Eocene, and its onset led to commencement of subsidence for the marginal Queensland Plateau. Between 500-1500 m of sediment now overlies basement of the Plateau.

5. PROCESSING AND DISPLAY OF REGIONAL GRAVITY DATA

The BMR gravity repository files were searched for data relating to the NE Queensland area by computer program LOCABA (Murray, 1974). These data were then reduced to Bouguer anomalies and contoured at 20 $\mu m.s^{-2}$ intervals (program CONTOR - Murray, 1977). The contouring process involved the generation of a square grid of gravity values (2 minutes of arc spacing) over the map area, and a certain amount of data smoothing (8 linear and 15 fast/slow iterations). Normal gravity was calculated on the 1967 reference ellipsoid and observed gravity values are compatible with the 1971 revised international standard. For reduction to Bouguer anomaly a density of 2.67 $t.m^{-3}$ was adopted because the relative precision of Bouguer anomalies is not expected to be better than 10 $\mu m.s^{-2}$ (Anfiloff & others, 1976), and considering the relatively flat topography of most of the region, terrain corrections were not applied. The Bouguer anomaly map is presented in Figure 8.

To suppress the near-surface gravity effects and to display the long wavelength variations in the field due to lateral density inhomogeneities at the base of the crust and in the upper mantle, the Bouguer anomaly map was upward-continued to a height of 22 km (Figure 9). The gravity data was translated to a 6 minute of arc square grid and processed by 2-D convolution to yield an upward-continuation of 2 grid spaces (approx. 22 km). The method is described by Henderson (1960) - the required coefficients are given in his paper. The processing was done by program REGRID (A.S. Murray, personal communication).

The residual Bouguer anomaly map of Figure 10, in which the near-surface density variations are enhanced by removal of long-wavelength field components, is the result of subtracting the upward continued gravity field (Figure 9) from the Bouguer anomaly field (Figure 8). The subtraction was done on a 2 minute of arc grid (the 6 minute of arc upward-continuation grid was first interpolated to yield a 2 minute grid).

To illustrate the effects of upward continuation on deep and shallow gravity sources, two simple models representing geological bodies with density contrast ($\Delta\rho$) have been selected and their gravity expression at the surface displayed (Figure 11). In the case of the 2-D rectangular slab (representing e.g. sedimentary basin, fault block, crustal thickening) the size of the anomaly (g_{max}) suffers a 5.9:1 reduction when the plane of observation is increased from the upper surface to a height of 20 km. In going from a height of 40 km (approx. crustal thickness) to 60 km, the reduction is only 1.5:1. The corresponding values for the (3-D) sphere (representing e.g. plutonic intrusions, local density inhomogeneity) are 25.0:1 and 2.1:1.

6. INFERENCE OF DEEP CRUSTAL AND SUB-CRUSTAL STRUCTURE FROM THE GRAVITY DATA

The large-scale Bouguer anomaly features displayed in Figure 9 reflect anomalous density distributions within the crust and upper mantle. Because of the major density discontinuity at the Moho (about 0.4 $t.m^{-3}$), relief in the Moho may be a major source of these anomalies.

The non-uniqueness of solutions in the gravity method makes interpretation of deep structure highly speculative. In the absence of additional constraints such as seismological data, there is no justification for adopting complex models, and the simple models of Airy, Pratt, Vening-Meinesz, or combinations of these, are adequate as first approximations for assessing basic parameters such as crustal thickness.

These simple models are based on isostatic compensation at the base of the crust. That such a situation commonly exists is evidenced by seismic confirmation of Airy 'crustal roots' and the fact that free-air anomalies averaged over large areas (approx. 200-250 km across) yield values close to zero (Woollard, 1969; Sazhina & Grushinsky, 1971 (Chapter XIII)). The depth to which interpretation of the gravity field needs to be extended is governed by the depth of isostatic compensation. As a generalisation regional compensation is effected at, or above, the asthenosphere (Falvey, 1977). Compensation at the base of the crust is a special case of this. Where there is evidence for deeper anomalous masses, such as lateral density variations in the upper mantle, interpretation needs to be modified accordingly.

Several analyses of crustal structure from the gravity data have been made for the NE Queensland region (Gibb, 1968; Wellman, 1976; Taylor & Falvey, 1977; Mutter & Karner, 1980; Shirley, 1979; Dooley, 1980). Different approaches to the problem have been employed - these and the conclusions drawn (relevant to the area under consideration) are discussed below.

Gibb (1968) examines the elevation versus Bouguer anomaly relationship for the principal gravity provinces over his study area (which overlaps the current study area at the southern boundary by 1° latitude), develops a pseudo-isostatic anomaly map based on Woollard's (1962) Bouguer anomaly/surface elevation function as representing crustal isostatic conditions, and looks at the regional distribution of free-air anomalies. The main conclusions are that (i) the crust beneath the Great Dividing Range (HUGHENDEN & CHARTERS TOWERS sheets) is under-compensated at its base, though some degree of crustal root development is evident, (ii) over the area to the east (to JULIA CREEK) conditions of near-complete isostatic compensation (at the base of the crust) appear to prevail.

Assuming $1^{\circ} \times 1^{\circ}$ areas are in complete isostatic equilibrium Wellman (1976a) has computed crustal thickness for Australia. His crustal model incorporates lateral variations in crustal density (essentially a combination of Airy/Pratt models). Crustal thickness estimates are made by treating gravity and topographic height as two independent variables (Strange & Woollard, 1964). Crustal thickness beneath the Mount Isa Inlier is shown as being relatively thick (approx. 40 km). Immediately to the east, and in the Cairns area, the crust is thinner (30-35 km). The Great Dividing Range area is shown as mostly underlain by a 35-40 km thick crust.

From a comparison of regional Bouguer and free-air anomalies, Shirley (1979) concluded that the eastern part of NE Queensland (including the Tasman Orogenic Zone and Georgetown Inlier) is isostatically adjusted. The Mount Isa Inlier is inferred to be an area of thin crust where under-compensation applies. Immediately to the east (southern Carpentaria Basin, Euroka Arch, northern Eromanga Basin) the opposite appears to be the case. Because of the opposite isostatic imbalances observed in these last two areas (Mount Isa Inlier/east of the Inlier), it may be that regional compensation (at the base of the crust) does apply when these areas are considered as an integral unit.

Using velocity and depth data from deep seismic soundings in the area obtained from CRUMP (Finlayson, 1968, and Cleary, 1973), Shirley derived a vertical density model with 2.7 $t.m^{-3}$ for the upper crust, 2.9 $t.m^{-3}$ for the lower crust and 3.25-3.45 $t.m^{-3}$ for the mantle, with density increasing east to west. A standard crustal thickness corresponding to zero Bouguer anomaly, of 40 km was adopted. 3-D modelling of crustal thickness over the region was then carried out to obtain the best match between theoretical and observed Bouguer anomaly. For the NE Queensland region (non-marine) the results of the interpretation indicated a Moho relief of about 4.4 km.

However, when the interpretations of Wellman and Shirley are compared they are found to produce some conflicting results in relation to crustal thickness. As discussed by Dooley (1980), this is due to the different approaches adopted. Because Shirley makes the choice of an invariant density model for the crustal layers and fixed density contrast between crust and mantle (within defined zones), his Moho relief follows the Bouguer anomalies. In Wellman's case a positive isostatic anomaly implies increased crustal density, and because the extra crustal mass has to be compensated there must be a deepening of the Moho beneath the anomaly.

The existing deep seismic data are insufficient in coverage and resolution to convincingly verify or disprove either of the proposed gravity models. The models necessarily incorporate much simplification and the actual crustal structure may be of such complexity that neither model is valid to any degree of accuracy.

Gravity modelling with the benefit of seismic refraction constraints has been done along two lines running out from the coast across the Queensland Trough and Plateau (Taylor & Falvey, 1977). The results indicate that depth to the Moho decreases from 30 km at the coastline to about 24 km beneath the Trough and increases again to about 28 km depth under the Plateau. The continent-ocean crustal boundary occurs at the outer slope of the Plateau. The interpreted continental crustal structure beneath the Trough and Plateau includes three main layers - a thin upper layer with average velocity 5.3 $km.s^{-1}$ (? metamorphosed and indurated sediments of the Tasman Orogenic Zone), a thick 6.0-6.8 $km.s^{-1}$ layer typical of continental crustal rocks, and a deep metamorphic layer (7.0-7.6 $km.s^{-1}$) of variable thickness. Densities of 2.85 $t.m^{-3}$ have been assigned to the first two layers, a density of 3.00 $t.m^{-3}$ for the metamorphic layer and 3.35 $t.m^{-3}$ for the underlying mantle.

Details of this structural model have been modified by Mutter & Karner (1980). They localise the deep metamorphic layer to a zone beneath the Trough; and also propose that the Moho beneath the Trough and Plateau lies at almost constant depth (24 km), deepening rapidly at the coastline to 30 km (as indicated by Taylor & Falvey).

6.1 Explanation of the main broad regional gravity features

The main features of Figure 9 are discussed below.

1. Large-scale gravity increase, from SW to NE.

Though barely perceptible in Figure 7, a broad regional gradient exists over the NE Queensland area due to its position between a geoidal anomaly high of +400 $\mu m.s^{-2}$ over New Guinea and a low of -400 $\mu m.s^{-2}$ just to the south of Western Australia. These global variations have been mapped from satellite data (Gaposchkin & Lambeck, 1971). The free-air anomaly variation across the study region would be about 100 $\mu m.s^{-2}$ with increase to the northeast.

Such global-scale gravity features have been attributed to convection currents in the asthenosphere or variations in mantle phase boundaries (Kaula, 1972; McQueen & Stacey, 1976).

2. Steep gradient along the northern part of the Coral Sea coastline, and gravity high over the Coral Sea.

This steep gradient corresponds to rapid crustal thinning - from about 30 km (onshore) to about 24 km beneath the Queensland Trough and Plateau. The Coral Sea high is due to the thinner crust.

3. Area of positive gravity values in the SE corner of the region.

Crustal thinning probably also occurs here but more gradually than in the area to the north.

4. Extensive area of gravity low in the central southern part of the region.

This is interpreted as an area of thicker crust (about 2-3 km relief on the Moho).

5. Area of positive gravity values on the NW margin of the region (Cape York Peninsula). Thinner crust probably occurs in the area.

6. Gravity high trending N-S in the western part of the area (Mount Isa Inlier) and adjacent gravity low immediately to the east.

These features are interpreted as resulting from a major N-S crustal flexure, with upwarp at the Mount Isa Inlier and downwarp beneath the Great Artesian/Eromanga Basins to the east. Evidence for an ancient E-W stress regime is preserved in the prominent N-S structural pattern of the Mount Isa Inlier. Measurements of present-day stress indicates a compressional regime with E-W major axes (Denham, 1979). In addition to the crustal thinning associated with the flexure some contribution to the observed gravity high over the Mount Isa Inlier must be the result of the relatively high density rocks (high grade metamorphics and basic intrusions) exposed in the eroded crest of the inferred upwarp.

7. UPPER CRUSTAL INTERPRETATION OF GRAVITY AND AEROMAGNETIC DATA

7.1 Gravity trend analysis

Wellman (1976b) has investigated the continental growth of Australia by examination of gravity trend patterns. A similar analysis has been applied to NE Queensland. Basement domains can be mapped on the basis of differing gravity trend patterns.

The structural and/or metamorphic grain imposed on an orogenic domain by the first major deformation tends to be preserved, and may even be accentuated by subsequent tectonism. Faulting and metamorphic foliation initially imprinted may act as planes of weakness for structural reactivation during later phases of tectonism. If such reactivation takes place after development of platform cover, the structure inherited by the oover sequences will reflect that of basement. Igneous intrusion is generally controlled by pre-existing structure, thus gravity anomalies produced by igneous bodies which have been emplaced with a structural bias will bear some expression of the structural pattern.

The gravity trend pattern for NE Queensland is presented in Figure 12. The trends are indicated by the axial orientation of elongate local gravity highs and lows, as well as the orientation of closely-spaced contours which reveal local gravity gradients. The gravity-trend map has been subdivided into areas(A-N) of similar trend characteristics.

Area	Situation in relation to principal geological provinces	Trend directions	Comments
A	Mount Isa Inlier	N-S	Strongly concordant trends
B	Georgetown Inlier	N-S, NNW-SSE, NNE-SSW	Trends in south of B & C appear to merge
C	Eastern part of Georgetown Inlier	NNE-SSW	As above
D	Area between Mount Isa and Georgetown Inlier	Approx. N-S	Moderately concordant trends
E	SW margin of Georgetown Inlier	NE-SW	Strongly concordant trends - but only small area involved
F	Western part of Georgetown Inlier and area adjacent to Gulf	Omnidirectional	Wavy pattern with locally concordant trends, but discordant overall

Area	Situation in relation to principal geological provinces	Trend directions	Comments
G	Area north of Georgetown Inlier and adjacent to Gulf	Omnidirectional	Trends completely discordant
H	Eromanga Basin	NNE	Very small area - may be considered as part of D or B
I	Southern Lolworth-Ravenswood Block, northern Galilee/Drummond Basins	E-W	Moderately-strongly concordant trends
J	Broken River Embayment, northern Lolworth-Ravenswood Block (including Burdekin Basin)	Mixed N-S & NE-SW; some NW-SE	Cross-cutting trends
K	Georgetown Inlier/ Hodgkinson Province boundary	WNW-ESE	Small area; moderately concordant trends
L	Hodgkinson Province	NNW-SSE	Moderate concordance
M	Northern Galilee/Drummond Basins	N-S	Fair concordance
N	Connors Arch, northern Bowen Basin & Campwyn Block	NNW-SSE	Moderately concordant trends

Coral Sea - no pronounced trend pattern is apparent, possibly due to the uneven distribution of the marine data. The most consistent trend direction is N-S; minor E-W cross-trends are probably due to contour bias along ship-tracks.

The more extensive basement domains exhibiting strongly concordant trends are A, B, C & I. These domains are associated with the oldest exposed basement terrains (Precambrian - ? Late Palaeozoic) - Mount Isa and Georgetown Inliers, and Loloworth-Ravenswood Block. Domains A and B (Mount Isa Inlier and Georgetown Inlier (part thereof), respectively) show similar trend directions and characteristics, suggesting possible early related structural history (? and evolution). A and B may be linked across domain D. The trends in the latter are not as strongly expressed as in A and B, though some resemblance exists.

There is some evidence for the hypothesis that the Broken River Embayment may have evolved through development of an aulacogen-type rift in a Late Palaeozoic continental margin, since the trends in domain C (eastern Georgetown Inlier) and domain I (southern Loloworth-Ravenswood Block) are consistent with initial juxtaposition of these domains followed by about 50° rotation of I away from C. The trend discordance across the northern part of the boundary between domains B and C suggests that some rotational displacement of C away from B may also have occurred, with approximately the same pole of rotation as for C and I.

The fairly strong trends in the relatively small domains E and K may be an expression of primary structure, which would indicate that these domains represent dislocated blocks derived from A or B. However, local late development of structure may be responsible for the observed trends.

Domains L and N largely coincide with the Hodgkinson Province and Connors Arch/Campwyn Block, respectively. The NNW-SSE trends within these domains are related to structural development associated with the orogenic evolution of the Tasman Orogenic Zone.

7.2 Magnetic anomaly character and regional variations

A 4-category classification scheme for qualitatively describing anomaly character has been adopted. According to this scheme, anomalies seen on contour or profile maps fall into one of the following relative subdivisions:

1. High amplitude, short wavelength.
2. Moderate-high amplitude, medium wavelength.
3. Low amplitude, medium-long wavelength.
4. Magnetically quiet.

Mapping of anomaly character has been done on the basis of the most predominant amplitude and wavelength features observed. In classifying anomalies over an area from maps produced from several different surveys, account must be taken of the filtering effects on the data of different flight heights and flight-line spacing. For NE Queensland the flight heights (Figure 3) range from 150 m to 760 m above ground (or sea) level. The information provided by a map of anomaly character as defined above is essentially a qualitative indication of depth to magnetic basement, or in some cases, depth to major supra-basement magnetic formations. A category 1 designation for an area would indicate surface or near-surface intermediate-basic igneous rock/metamorphics, while category 4 would suggest a thick sedimentary basin or extensive granitic terrain.

Figure 13 shows the anomaly character map for NE Queensland. The more obvious linear/curvilinear trends are also marked.

7.3 Interpretation

An interpretation map for NE Queensland (Figure 14) has been prepared showing structural and geological features as derived from the gravity and magnetic data. The map is based on results displayed in Figure 10 (residual Bouguer anomalies) and Figure 13 (character of aeromagnetic anomalies), and to a lesser degree Figure 12 (gravity trend analysis) - with cross-reference to the established geology resulting from field mapping and seismic surveys (Figure 7), and present concepts of the broad structural configuration of the region (Figure 6).

7.3.1 Granitic batholiths

Distinctive localised steep-sided gravity lows, often circular or elongate with widths of 20-40 km occur over much of the region. These anomalies are in the order of 200 μms^{-2} and frequently occur over, or are associated with, outcropping granitic rocks. The gravity lows have been interpreted as near-surface granitic batholiths. Gravity maps of the Lower Proterozoic metasedimentary terrain of the Pine Creek Geosyncline to the west also show similar gravity lows. These have been interpreted as granitic complexes; modelling suggests that the granite bodies slope outward and generally have a depth extent of less than 5 km (Tucker & others, 1980).

Areas underlain by granitic batholiths are expected to be characterised by gravity lows, and subdued magnetic response, since granites are usually only weakly magnetised. For NE Queensland this is generally found to be the case - areas of near-surface batholiths as deduced from evidence of gravity lows and surface geology are mostly associated with subdued aeromagnetic anomalies. There are some exceptions, and several explanations to account for this can be advanced -

(i) the presence of moderately-strongly magnetic rock overlying the batholith. For example (a) Cainozoic flood basalts, (b) co-magmatic volcanics with cauldron-collapse complexes, (c) metamorphics;

(ii) where the upper parts of the batholith have been eroded off, magnetic disturbance may be caused by - (a) inclusions of magnetic country-rock (including roof pendants), (b) rocks of the contact aureole magnetically upgraded by contact-metamorphism, (c) post-emplacement basic intrusions.

7.3.2 <u>Faults</u>

A number of the linear or arcuate steep gradients in the gravity contours and some magnetic anomaly character boundaries can be correlated with known major high-angle faults. The presence of such geophysical features has allowed the inference of major faults not detected in geological mapping, or where such structure in basement has been hidden by sedimentary or volcanic cover.

Normal or high-angle reverse faults tend to produce local monoclinal gradients (though this need not always be the case), while transcurrent faults are more likely to yield gravity gradients of alternating polarity along their length due to lateral displacement of density inhomogenieties in the subsurface. Not all geologically mapped faults are expected to be geophysically visible since fault displacement may not necessarily produce a spatially anomalous distribution of contrasting geophysical properties in the subsurface.

The interpreted faults shown in Figure 14 range from about 15 km to 120 km in length.

7.3.3 Sedimentary basins and basement

Some expression of sedimentary basins is expected in the gravity and magnetic maps as gravity lows and magnetically quiet areas. Assuming a sediment/basement density contact of 0.4 tm^{-3}, a 1000 m deep basin would produce a 170 μms^{-2} gravity low. The Mesozoic-Tertiary Great Artesian Basin sequence are believed to be less than about 1000 m thick in NE Queensland, to be relatively undeformed and to lie on a basement predominantly of gentle relief. Local anomalies of 100 μms^{-2} are observed however, which cannot readily be explained in terms of G.A. Basin sediment thickness variations. As interpreted by Smart and others (1980), these anomalies are attributed to intra-basement density variations; the presence of pre-Jurassic infra-basins (apart from the delineated Galilee Basin) may be contributing to the observed gravity variations.

The summary of measured/adopted rock densities for the Great Artesian Basin area (Table 1) gives some idea of the expected densities and density contrasts for the major rock units. Mean values for the major units are -

Mesozoic sediment	2.2-2.3 tm^{-3}
Granites	2.65
Precambrian basement	2.8

Even though the Galilee Basin at the southern margin of the map (latitude 21^{o}) is estimated to be 2500 m deep, the gravity expression is only about 200 μms^{-2} maximum. The sediment density is fairly high - 2.55 tm^{-3} (Gibb, 1968), which accounts for the relatively small anomaly. Basement beneath the deep part of the basin and to the northeast is probably Cambrian-Ordovician metamorphics of about 2.75 tm^{-3} density. To the west and northwest of the deep part of the basin, there is probably a change to lower density granitic basement (? 2.60 tm^{-3}) to account for the absence of a marked increase in gravity expected with sedimentary thickness decrease.

7.3.4 Major structural zones

That NE Queensland has undergone major and widespread structural modification over geological time is evidenced by the density and distribution of interpreted major faults as indicated in Figure 14. Within the structural patterns revealed by the gravity and aeromagnetics there are a number of broad lineaments of regional extent. They have been interpreted as major structural zones coinciding with large scale dislocations within the crust; the more notable of these are shown in Figure 14 (and marked A-D).

TABLE 1. Rock densities - Great Artesian Basin area

Precambrian rocks of Mount Isa Inlier	
Shale/siltstone	2.61-2.81 tm^{-3}
Silica-dolomite	2.91
Interbedded metabasalt/metasediments	2.85
	(Smith, 1966)
Granite/granodiorite	2.65 (range 2.60-2.75)
Calc-silicate rock, hornfels, granofels	2.76 (range 2.56-3.01)
Quartzite and siliceous metamorphic rock	2.69 (range 2.56-2.97)
Acid volcanics - rhyolite, dacite	2.63 (range 2.56-2.73)
Amphibolite, basic volcanics (metabasalt)	2.98 (range 2.80-3.11)
Basic igneous intrusives (metadolerite)	2.97 (range 2.71-3.05)
	(Mutton & Almond, 1979)
Data from area of pre-Mesozoic (? Precambrian) Inliers near Millungera	
Schist (Mount Brown)	2.9 tm^{-3}
Sandstone & conglomerate (Mount Fort Bowen)	2.7
Cretaceous sediment	2.2
	(Watts, 1972)
Regional data	
Mesozoic sediment	2.20 tm^{-3}
Upper-Middle Palaeozoic sediment	2.40
Precambrian metamorphics	2.80-2.85
Precambrian granite	2.65-2.70
Precambrian basic intrusives	2.90-2.95
	(Gibb, 1967)
Mesozoic sediment	2.3
Lower Mesozoic-Upper Permian	2.49) Lake Galilee No. 1
Lower Permian-Upper Carboniferous	2.55) well
Jurassic-Cretaceous	1.93-2.27 Wyaaba No. 1 well
Lower Palaeozoic metamorphics	2.65
Precambrian basement	2.8
	(Gibb, 1968)

Zone A corresponds with the N-S segment of the Palmerville Fault. Dense Precambrian metamorphics at shallow depth lie to the west, while the generally low-grade and extensively granitoid intruded metamorphic flysch and spillite sequences of the Hodgkinson Basin extend eastwards to the coast.

The Hodgkinson Province is apparently truncated to the southwest by structural zone B. Out from the coast, zone B is in alignment with the rift arm of the Townsville Trough; the zone marks the southern extent of thick sedimentary piles of rift-fill. The inferred Cainozoic Trough to the west of zone B (Figure 14) is subparallel with the zone, though slightly displaced to the south. Some structural relationship may exist, possibly associated with the rift development which commenced in mid-Cretaceous-Palaeocene. The WNW trending zone B may be a more major and fundamental structure than the largely inferred southern extension of the Palmerville Fault (Figure 6) which is believed to strike NW. The Hodgkinson Basin is thought to have been preserved (and also possibly developed) as a result of down-faulting of the block between zones A and B.

The Burdekin River Fault lies within structural zone C. The NNE trending Balcooma Mylonite Zone (Withnall & others, 1980) is also sub-parallel with, and spatially closely related to zone C. Age of mylonite formation is uncertain and may be Proterozoic, or possibly Siluro-Devonian or younger. The Burdekin River Fault was active during the mid-Palaeozoic.

Zone D follows the western margin of Connors Arch and may continue northward along the coastline. It coincides with the western side of the postulated Andean-type Connors-Auburn Volcanic Arc (Day & others, 1978) that occupied the western margin of the New England Orogen in the Late Devonian-Early Carboniferous. The onset of major structural development may have been in Late Carboniferous with uplift of the Arc in response to changes in the pattern of subduction.

8. CONCLUSIONS

Study of the regional gravity and aeromagnetics of NE Queensland has provided insight into the structural framework of the area and its broad geological aspects. The main results and conclusions are summarized below:

(i) The broad regional gravity field variations indicate, (a) thinning of the crust out from the coastline, (b) a crust beneath the Mount Isa Inlier that is slightly thinner and more dense than normal - which together with the dominant gravity/aeromagnetic trend patterns suggest a N-S trending crustal upwarp in the area, and (c) thicker crust to the south of the Georgetown Inlier.

(ii) The distributions of basement domains (A-N onshore) have been mapped on the basis of their gravity/aeromagnetic trend patterns (and to some degree, aeromagnetic anomaly character). These domains may represent fundamental crustal units.

(iii) Major high-angle faults have been delineated - some correlate with geologically mapped structure, others are inferred beneath sedimentary/volcanic cover.

(iv) Areas of high density basement, particularly beneath the Great Artesian Basin, have been mapped; some areas of thick sediment accumulation are also indicated by their relatively low gravity expression and often subdued aeromagnetic anomaly character.

(v) Areas believed to be underlain at shallow depth by granitic batholiths have been identified. Indications are that granitoids constitute about 50% of NE Queensland's onshore basement.

(vi) Four major structural zones (A-D) probably representing large scale dislocations in the crust have been delineated in the eastern part of the region.

9. REFERENCES

ANFILOFF, W., BARLOW, B.C., MURRAY, A., DENHAM, D., SANDFORD, R., 1976 - Compilation and production of the 1976 1:5 000 000 gravity map of Australia. BMR Journal of Australian Geology & Geophysics, 1: 273-276.

ARNOLD, G.O., & FAWCKNER, J.F., 1980 - The Broken River and Hodgkinson Provinces. In Henderson, R.A. & Stephenson, P.J. (Editors). The geology and geophysics of northeastern Australia. Geological Society of Australia, Queensland Division, Brisbane.

BLAKE, D.H., 1983 - Evolution of the Proterozoic Mount Isa Inlier, a review. In Abstracts (No. 9) - Lithosphere dynamics and evolution of continental crust: Sixth Australian Geological Convention. Geological Society of Australia.

CLEARY, J., 1973 - Australian crustal structure. Tectonophysics, 20: 241-248.

CROOK, K.A.W., & POWELL, C. McA., 1976 - The evolution of the southeastern part of the Tasman Geosyncline. 25th International Geological Congress Field Guide 17A.

CROOK, K.A.W., 1980 - Fore-arc evolution in the Tasman Geosyncline: the origin of the southeast Australian continental crust. Journal of the Geological Society of Australia, 27: 215-232.

DARBY, F., 1966 - North Bowen Basin reconnaissance gravity survey, Queensland, 1963. Bureau of Mineral Resources, Australia, Record 1966/209 (unpublished).

DARBY, F., 1969 - North Bowen Basin gravity survey, Queensland 1963. Bureau of Mineral Resources, Australia, Report 138.

DAY, R.W., MURRAY, C.G., & WHITAKER, W.G., 1978 - The eastern part of the Tasman Orogenic Zone. In Scheibner, E. (Editor), The Phanerozoic Structure of Australia and Variations in Tectonic Style. Tectonophysics, 48: 327-364.

DENHAM, D., 1979 - Earthquakes. BMR Earth Science Atlas of Australia. Bureau of Mineral Resources, Australia.

DOCKERY, B.A., & TIPPER, D.B., 1965 - Mount Isa detailed aeromagnetic survey, Queensland 1963. Bureau of Mineral Resources, Australia, Record 1965/25 (unpublished).

DOOLEY, J.C., 1965 - Gravity surveys of the Great Barrier Reef and adjacent coast, North Queensland 1954-1960. Bureau of Mineral Resources, Australia, Report 73.

DOOLEY, J.C., 1980 - A review of crustal structure in northeastern Australia. In Henderson, R.A. & Stephenson, P.J. (Editors), The geology and geophysics of northeastern Australia. Geological Society of Australia, Queensland Division, Brisbane.

FALVEY, D.A., 1977 - Isostatic constraints in 2-D gravity modelling. Bulletin, Australian Society of Exploration Geophysicists, 8: 106-110.

FINALYSON, D.M., 1968 - First arrival data from the Carpentaria Region Upper Mantle Project (CRUMP). Journal of the Geological Society of Australia, 15: 33-49.

GAPOSCHKIN, E.M., & LAMBECK, K., 1971 - Earth's gravity field to the sixteenth degree and station coordinates from satellite and terrestrial data. Journal of Geophysical Research, 76: 4855-4883.

GERULA, W.J., 1979 - Airborne magnetic and radiometric surveys up to December 1977. Bureau of Mineral Resources, Australia, Report 204 (MF78).

GIBB, R.A., 1967 - Western Queensland reconnaissance gravity surveys 1957-1961. Bureau of Mineral Resources, Australia, Report 129.

GIBB, R.A., 1968 - North Eromanga and Drummond Basins gravity surveys, Queensland 1959-1963. Bureau of Mineral Resources, Australia, Report 131.

HARTMAN, R.R., 1962 - Aeromagnetic survey of Carpentaria Basin, Karumba Area, AP 91P, by Aeroservice Ltd for Mid-Eastern Oil NL. Bureau of Mineral Resources, Australia, Petroleum Search Subsidy Acts Report 62/1721 (unpublished).

HENDERSON, R.A., 1980 - Structural outline and summary geological history for northeastern Australia. In Henderson, R.A. & Stephenson, P.J. (Editors), The geology and geophysics of northeastern Australia. Geological Society of Australia, Queensland Division, Brisbane.

HENDERSON, R.G., 1960 - A comprehensive system of automatic computation in magnetic and gravity interpretation. Geophysics, 25(3): 569-585.

HSU, M.D., 1974 - Aeromagnetic interpretation of northern Eromanga and Galilee Basins, Qld. Bureau of Mineral Resources, Australia, Record 1974/42 (unpublished).

KAULA, W.M., 1972 - Global gravity and mantle convection. Tectonophysics, 13: 341-359.

LEITCH, E.C., 1975 - Plate tectonic interpretation of the Paleozoic history of the New England Fold Belt. Geological Society of America Bulletin, 86: 141-144.

McQUEEN, H.W.S. & STACEY, F.D., 1976 - Interpretation of low degree components of gravitational potential in terms of undulations in mantle phase boundaries. Tectonophysics, 34, T1-T8.

MURRAY, A.S., 1974 - The Australian National Gravity Repository computer system. Bureau of Mineral Resources, Australia, Record 1974/68.

MURRAY, A.S., 1977 - A guide to the use and operation of program CONTOR. Bureau of Mineral Resources, Australia, Record 1977/17.

MURRAY, C.G., & KIRKEGAARD, A.G., 1978 - The Thomson Orogen of the Tasman Orogenic Zone. In Scheibner, E. (Editor), The Phanerozoic Structure of Australia and Variations in Tectonic Style. Tectonophysics, 48: 299-325.

MUTTER, J.C., 1974 - Geophysical results from the Coral Sea: continental margins survey report. Bureau of Mineral Resources, Australia, Record 1974/116 (unpublished).

MUTTER, J.C., 1977 - The Queensland Plateau. Bureau of Mineral Resources, Australia, Bulletin 179.

MUTTER, J.C., & KARNER, G.C., 1980 - The continental margin off northeast Australia. In Henderson, R.S. & Stephenson, P.J. (Editors), The geology and geophysics of northeastern Australia. Geological Society of Australia, Queensland Division, Brisbane.

MUTTON, A.J., & ALMOND, R.A., 1979 - Geophysical mapping of buried Precambrian rocks in the Cloncurry area, northwest Queensland. Bureau of Mineral Resources, Australia, Report 210 (MF95).

PINCHIN, J., & HUDSPETH, J.W., 1975 - The Queensland Trough: its petroleum potential based on some recent geophysical results. The APEA Journal, 15: 21-31.

PLUMB, K.A., DERRICK, G.M., & WILSON, I.H., 1980 - Precambrian geology of the McArthur River-Mount Isa region northeastern Australia. In Henderson, R.A. & Stephenson, P.J. (Editors), The geology and geophysics of northeastern Australia. Geological Society of Australia, Queensland Division, Brisbane.

RUTLAND, R.W.R., 1976 - Orogenic evolution of Australia. Earth-Science Reviews, 12: 161-196.

SAZHINA, N., & GRUSHINSKY, N., 1971 - GRAVITY PROSPECTING. MIR Publishers, Moscow.

SCHEIBNER, E., 1973 - A plate tectonic model of the Palaeozoic tectonic history of New South Wales. Journal of the Geological Society of Australia, 20: 405-426.

SCHEIBNER, E., 1976 - Definition of the Lachlan Fold Belt or Orogenic Belt. Australian Society of Exploration Geophysicists Bulletin, 7(1): 9.

SENIOR, B.R., MOND, A., & HARRISON, P.L., 1978 - Geology of the Eromanga Basin. Bureau of Mineral Resources, Australia, Bulletin 167.

SHELLEY, E.P., DOWNIE, D.N., & RRES, J.E., 1971 - Southern Cape York Peninsula airborne magnetic and radiometric survey, Queensland 1969. Bureau of Mineral Resources, Australia, Record 1971/124 (unpublished).

SHIRLEY, J., & ZADOROZNYJ, I., 1974 - Reconnaissance helicopter gravity survey, Northern Queensland, 1966. Bureau of Mineral Resources, Australia, Record 1974/140.

SHIRLEY, J.E., 1979 - Crustal structure of north Queensland from gravity anomalies. BMR Journal of Australian Geology & Geophysics, 4: 309-321.

SMITH, R.J., 1966a - Dobbyn gravity reconnaissance survey, Queensland 1963-1964. Bureau of Mineral Resources, Australia, Record 1966/41 (unpublished).

SMITH, R.J., 1966b - Mount Isa gravity test survey, Queensland 1963-1964. Bureau of Mineral Resources, Australia, Record 1966/50 (unpublished).

SMITH, R.J., 1968 - Dobbyn-Kamileroi geophysical survey, Queensland 1967. Bureau of Mineral Resources, Australia, Record 1968/78 (unpublished).

STRANGE, W.E., & WOOLLARD, G.P., 1964 - The use of geological and geophysical parameters in the evaluation, interpolation and prediction of gravity. Hawaiian Institute of Geophysics Report HIG-64-17.

TAYLOR, L.W.H., & FALVEY, D.A., 1977 - Queensland Plateau and Coral Sea Basin: stratigraphy, structure and tectonics. The APEA Journal, 17: 13-29.

TUCKER, D.H., 1975 - Cloncurry regional and prospector detailed airborne magnetic and radiometric surveys, Queensland, 1969. Bureau of Mineral Resources, Australia, Record 1975/74 (unpublished).

TUCKER, D.H., STUART, D.C., HONE, I.G., & SAMPATH, N., 1980 - The characteristics and interpretation of regional gravity, magnetic and radiometric surveys in the Pine Creek Geosyncline. In FERGUSON, J., & GOLEBY, A.B. (Editors), Proceedings of the International Uranium Symposium on the Pine Creek Geosyncline. International Atomic Energy Agency, Vienna.

VINE, R.R., 1976 - Galilee Basin. In ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA, Volume 3, PETROLEUM. Australasian Institute of Mining and Metallurgy, Melbourne.

WALLER, D.R., 1968 - Herberton airborne magnetic and radiometric survey, Queensland, 1967. Bureau of Mineral Resources, Australia, Record 1968/65 (unpublished).

WATTS, M.D., 1972 - Geological interpretation of a gravity survey over basement inliers near Millungera, north Queensland. In Geological Papers, 1969. Bureau of Mineral Resources, Australia, Bulletin 125: 17-22.

WATTS, M.D., & BROWN, F.W., 1976 - Gravity survey along seismic traverses in the northeastern part of the Eromanga Basin, Queensland, 1967. Bureau of Mineral Resources, Australia, Record 1976/73 (unpublished).

WELLMAN, P., 1976a - Regional variation of gravity, and isostatic equilibrium of the Australian crust. BMR Journal of Australian Geology & Geophysics, 1: 297-302.

WELLMAN, P., 1976b - Gravity trends and the growth of Australia: a tentative correlation. Journal of the Geological Society of Australia, 23(1): 11-14.

WELLS, R., & MILSOM, J.S., 1966 - Bowen Basin aeromagnetic and radiometric survey, Queensland 1961-1963. Bureau of Mineral Resources, Australia, Record 1966/208 (unpublished).

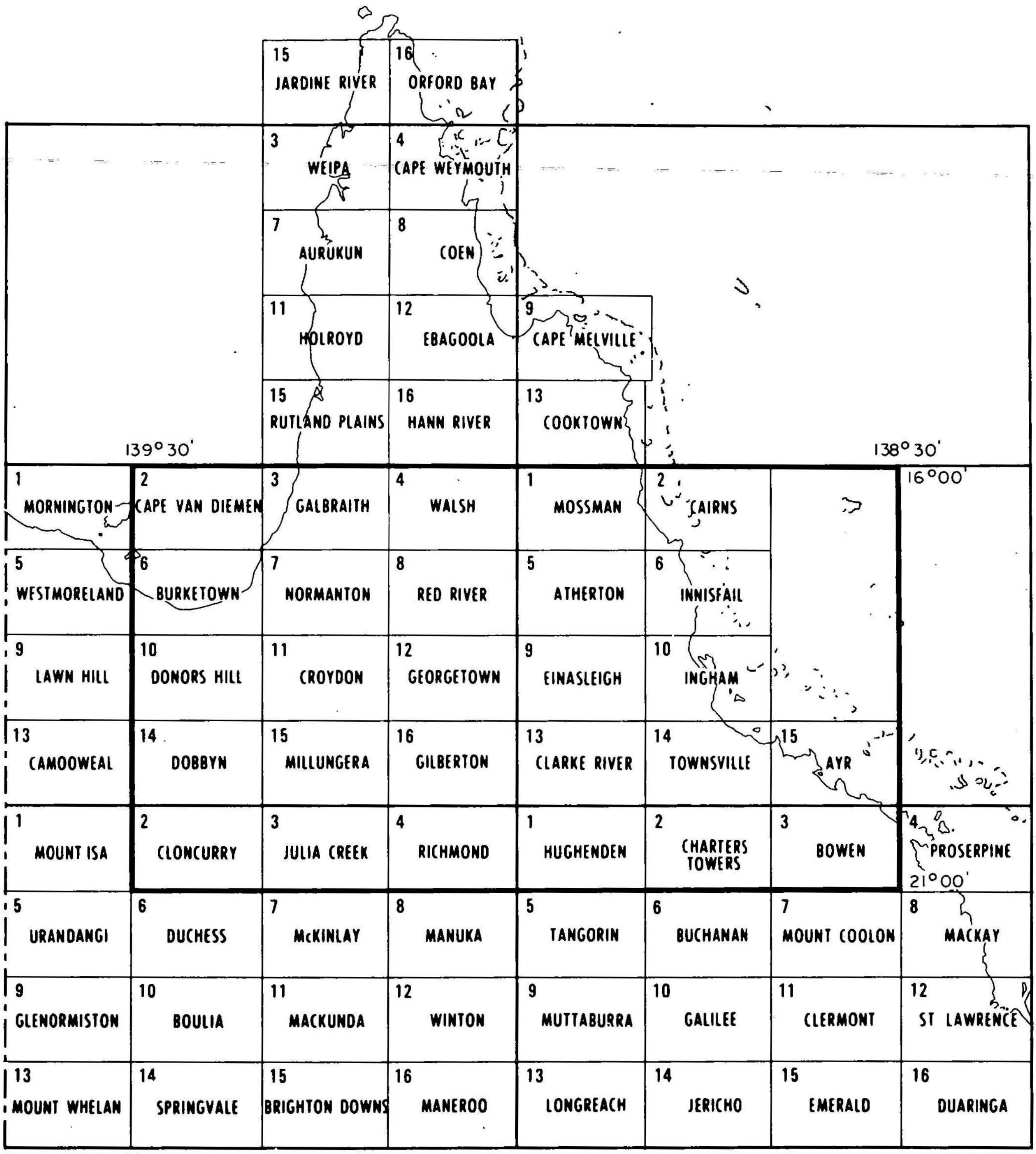
WELLS, R., MILSOM, J.S., & TIPPER, D.B., 1966 - Georgina Basin aeromagnetic survey, Queensland and Northern Territory 1963-1964. Bureau of Mineral Resources, Australia, Record 1966/142 (unpublished).

WITHNALL, I.W., BAIN, J.H.C., & RUBENBACH, M.J., 1980 - The Precambrian geology of northeastern Queensland. In Henderson, R.S. & Stephenson, P.J. (Editors), The geology and geophysics of northeastern Australia. Geological Society of Australia, Queensland Division. Brisbane.

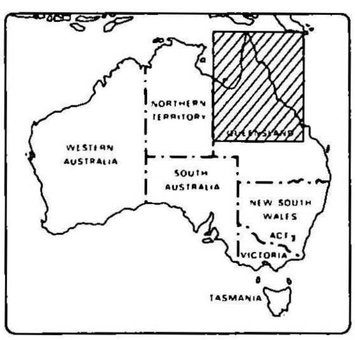
WOOLLARD, G.P., 1962 - The relation of gravity anomalies to surface elevation, crustal structure and geology. University of Wisconsin Geophysical and Polar Research Centre, Department of Geology Research Report Series 62-9.

WOOLLARD, G.P., 1969 - Regional variations in gravity. In Hart, P.J. & Beloussov, V.V. (Editors), THE EARTH'S CRUST AND UPPER MANTLE. American Geophysical Union Monograph 13, Washington D.C., 320-341.

WYATT, D.H., & JELL, J.S., 1980 - Devonian and Carboniferous stratigraphy of the northern Tasman Orogenic Zone in the Townsville hinterland, North Queensland. In Henderson, R.A. & Stephenson, P.J. (Editors), The Geology and geophysics of northeastern Australia. Geological Society of Australia, Queensland Division, Brisbane.



Record 1984/2 — 21/Q/25



— Boundary of study area

Fig. 1 Location of N E Queenland study area

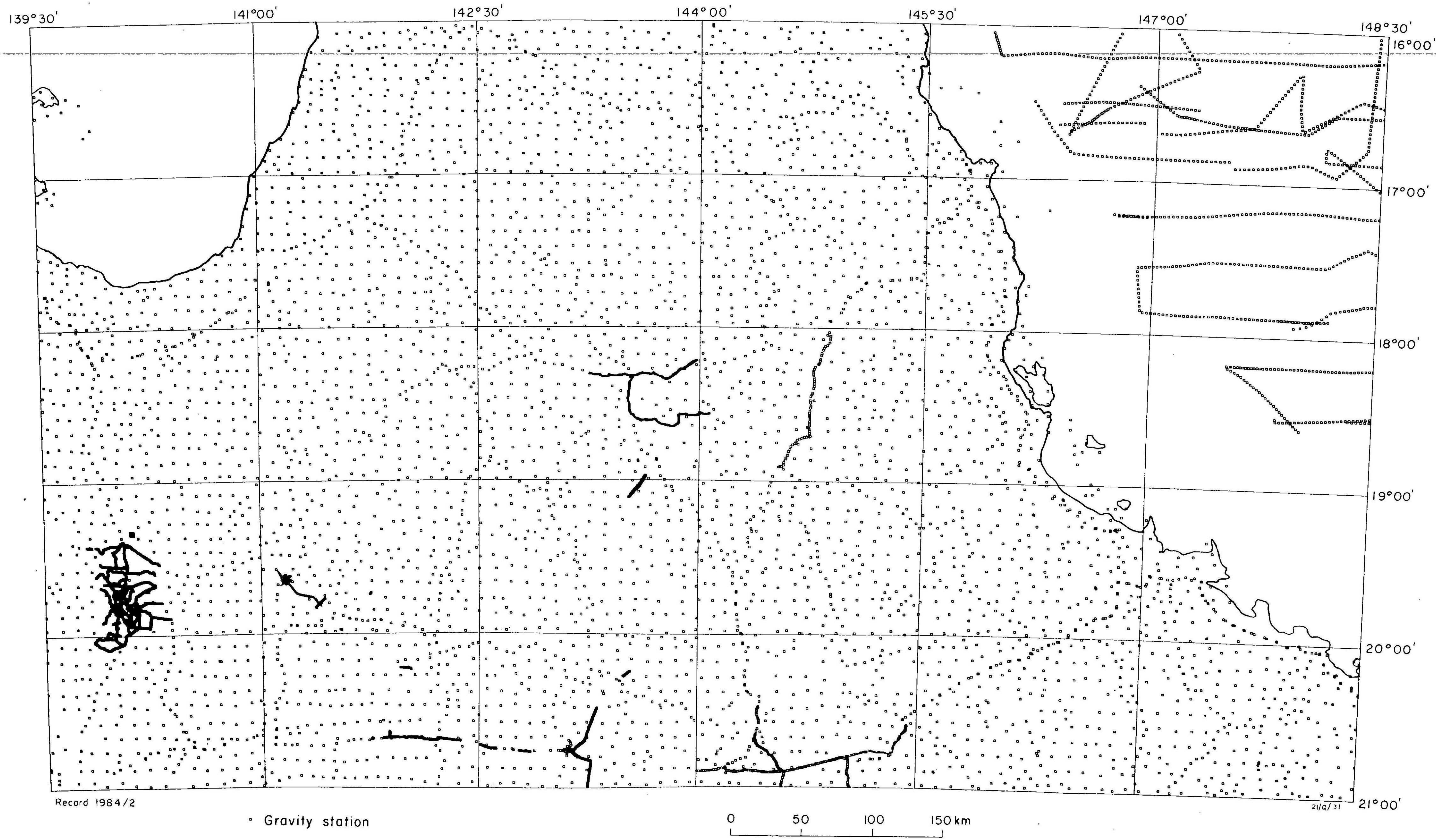
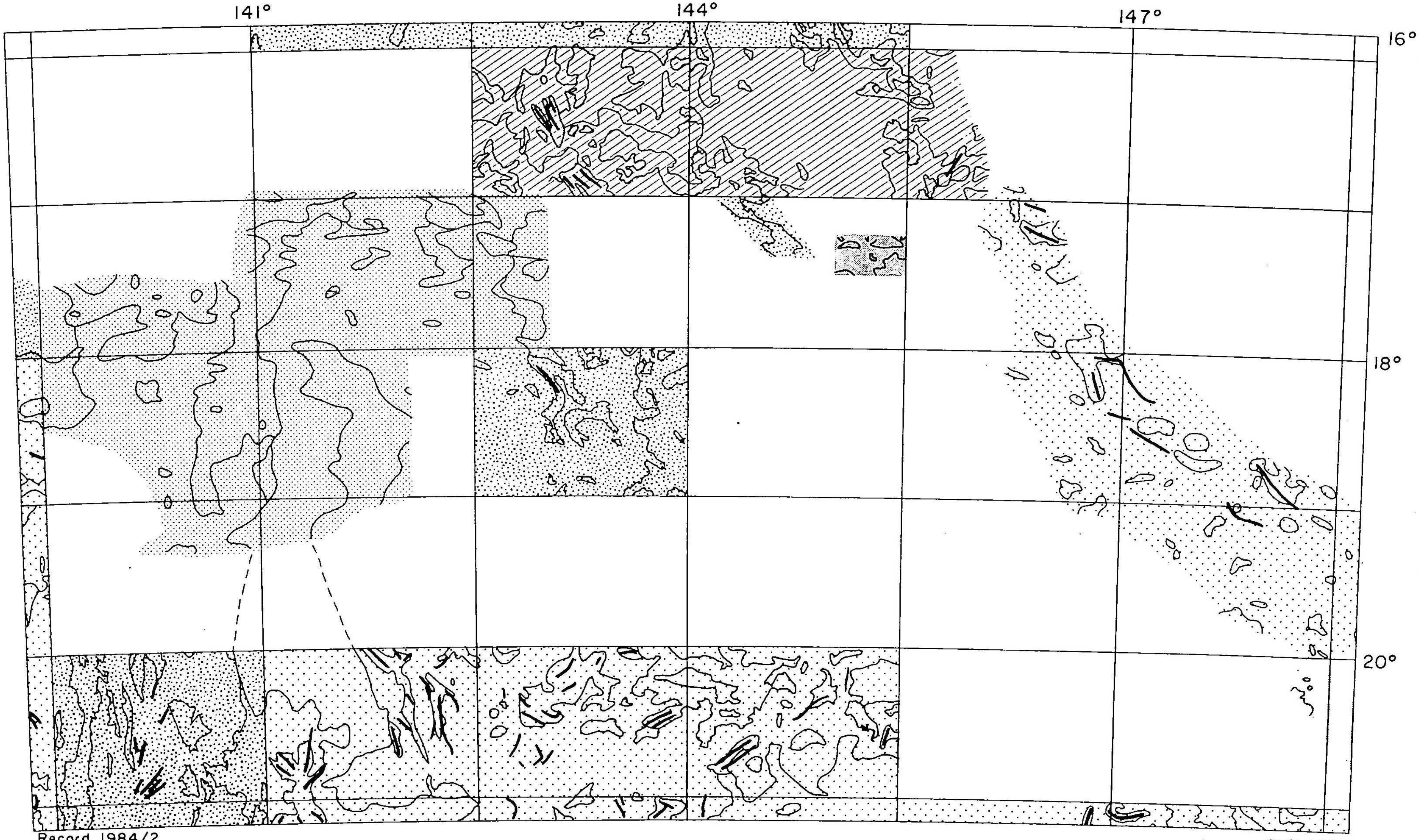


Fig.2 Gravity data distribution



FLIGHT HEIGHTS

150 m above ground level
250 m above ground level
300 m above ground level
460 m above sea level
600 m above sea level
760 m above sea level

Fig. 3 Aeromagnetic survey coverage

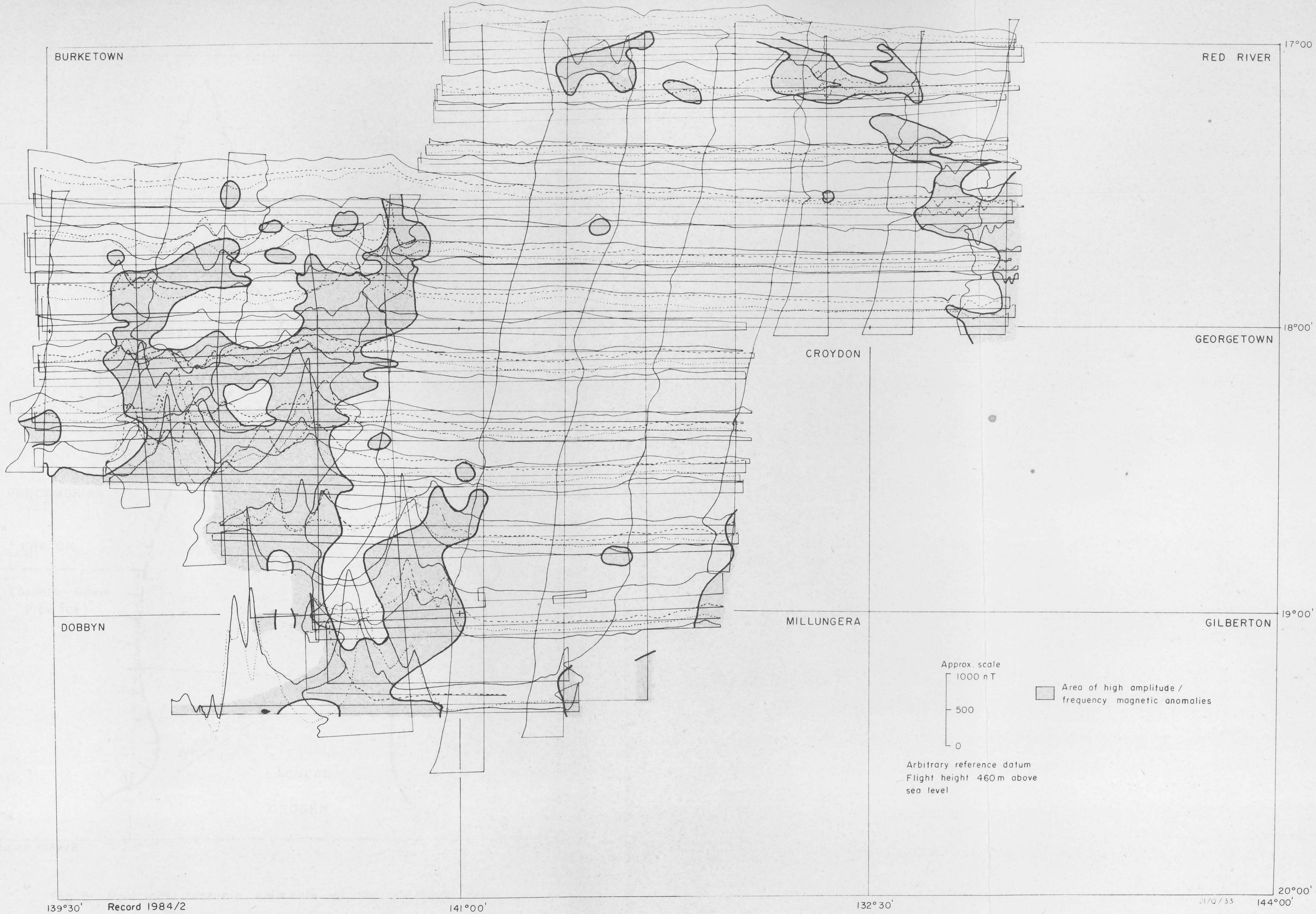


Fig. 4 Aeromagnetic profiles, Gulf of Carpentaria area

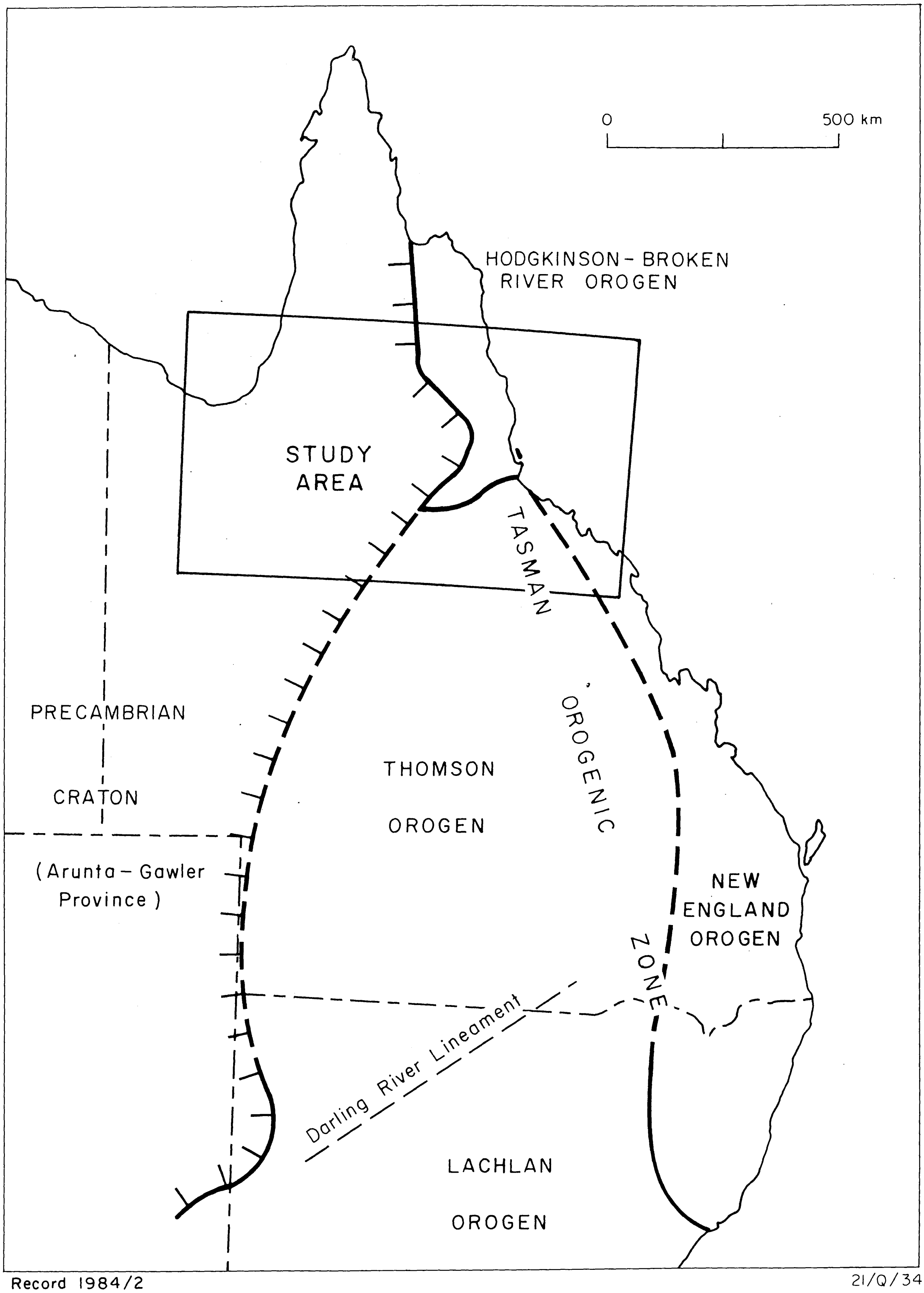


Fig. 5 Principal tectonic elements of the northern part of the Tasman Orogenic Zone

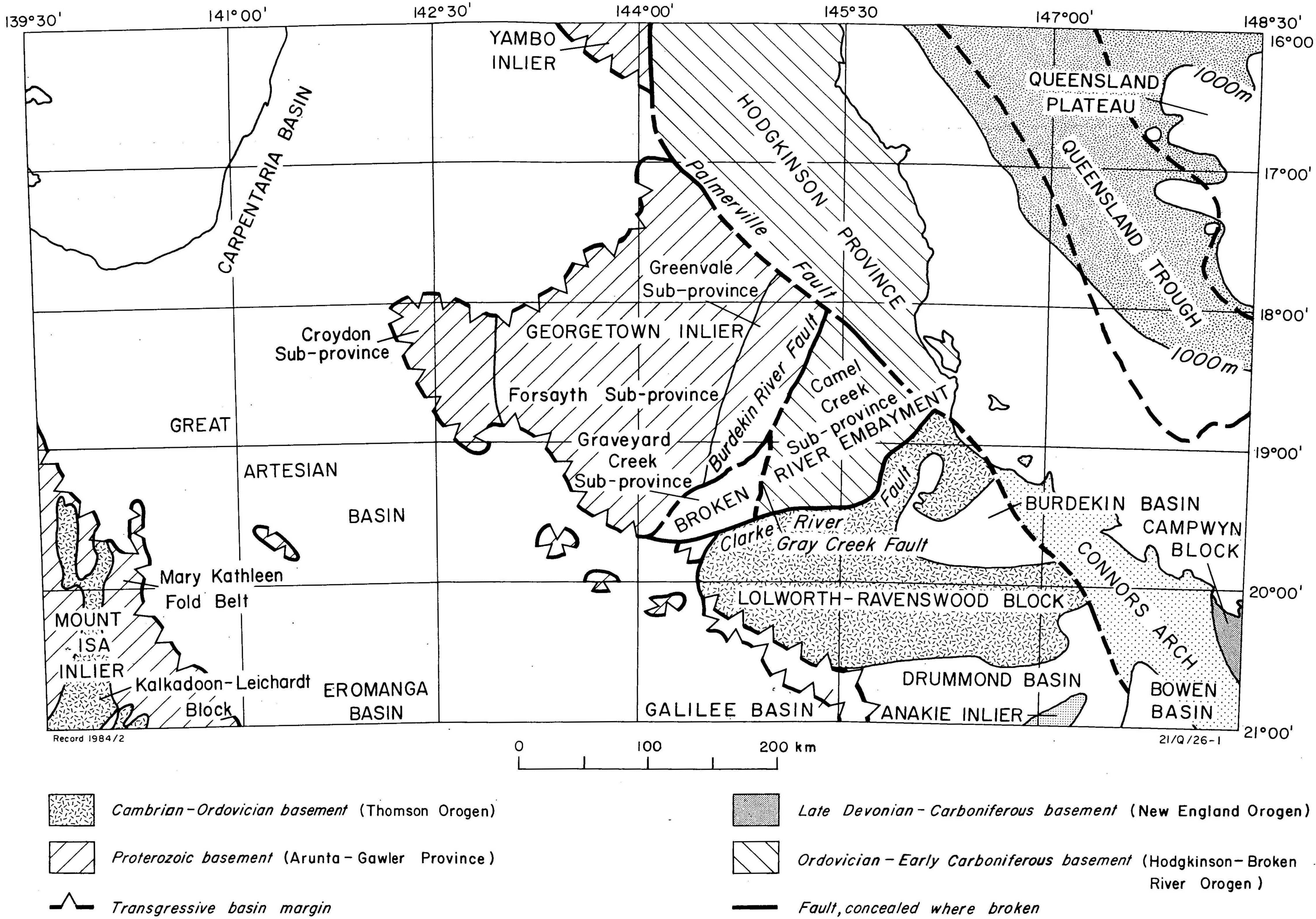


Fig. 6 Structural components of NE Queensland

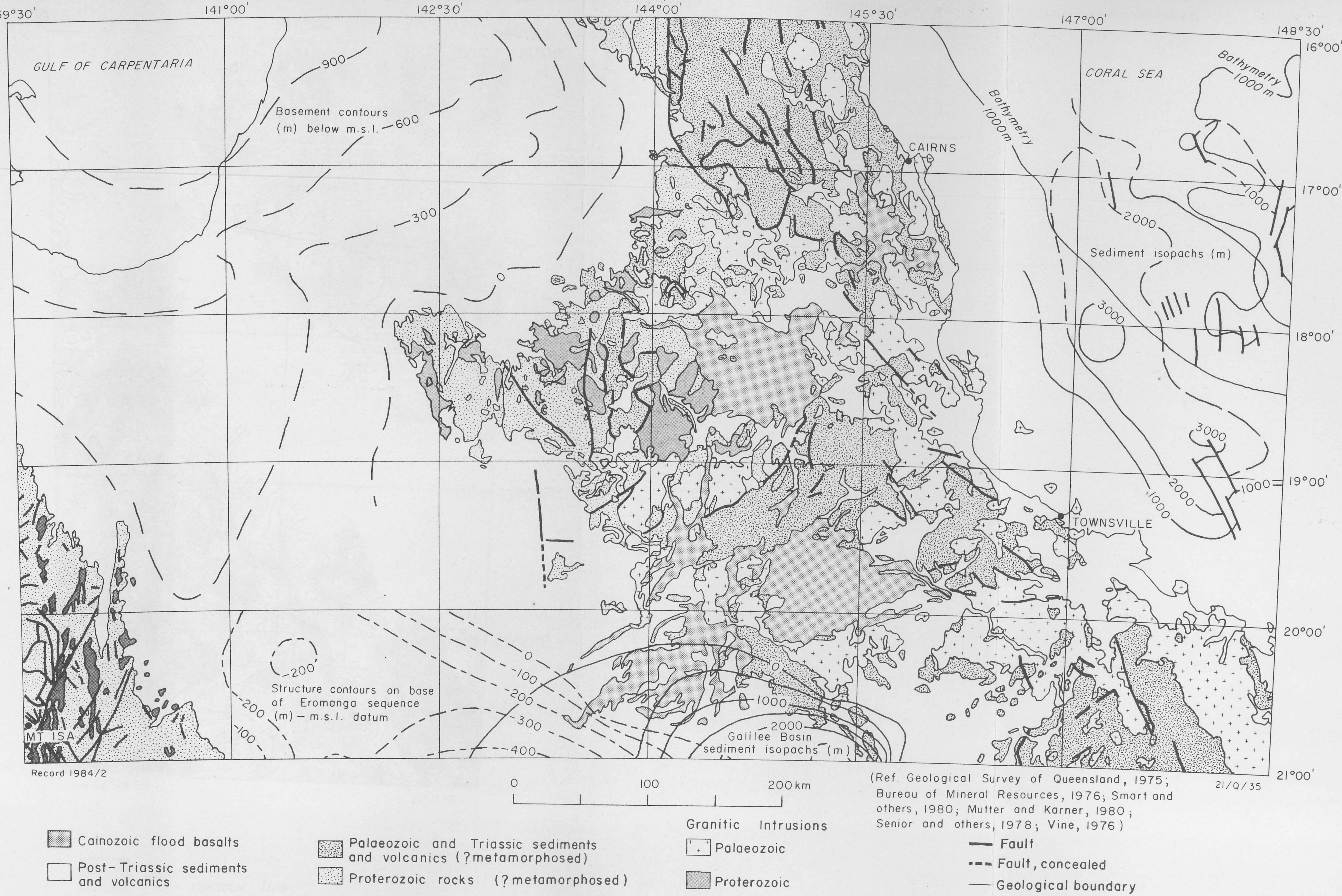
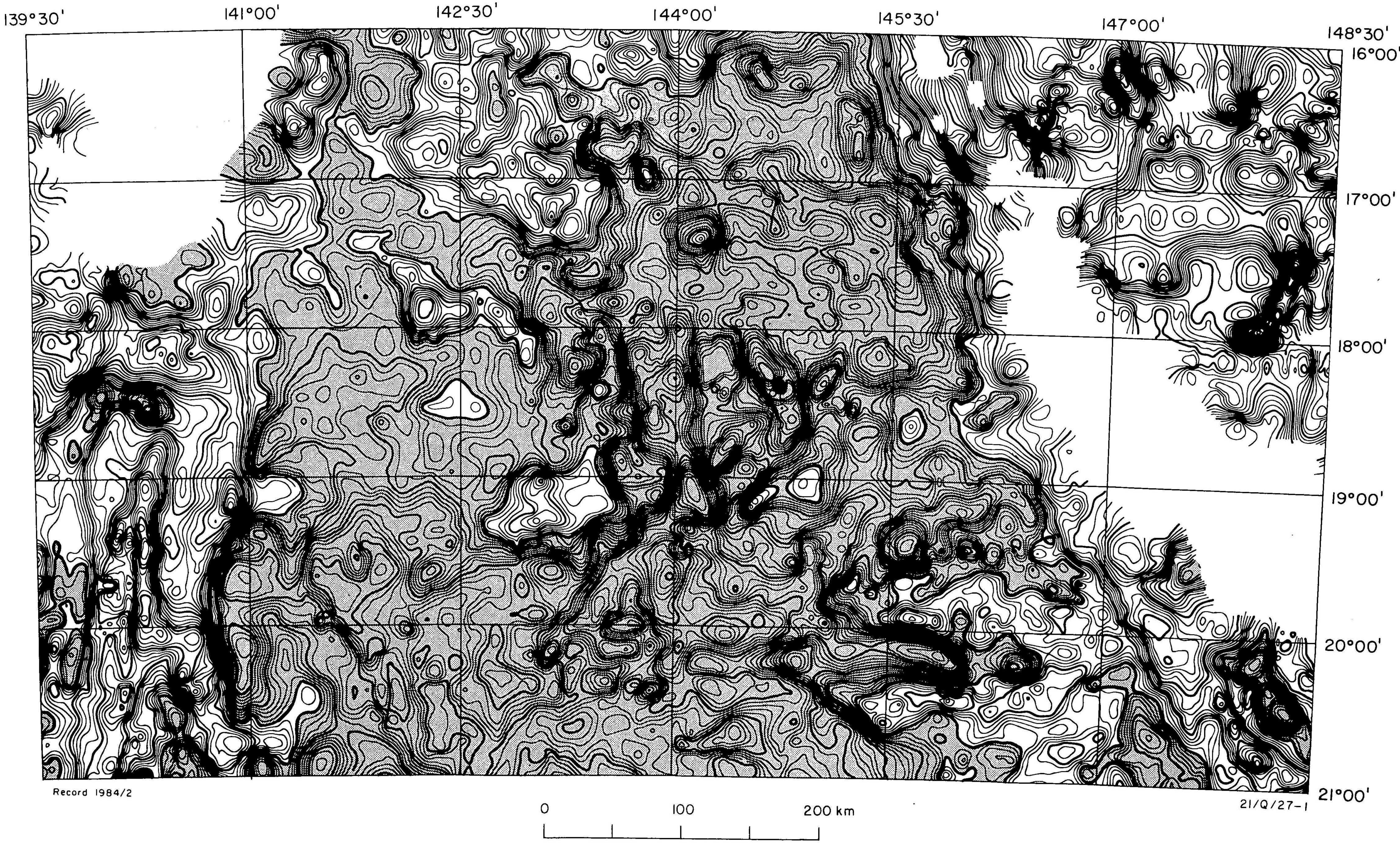


Fig. 7 Principal elements of NE Queensland geology



Negative anomaly

CONTOUR INTERVAL 20 $\mu m.s^{-2}$ (≡ 2 mGal)

For the calculation of Bouguer anomalies 2·67 $t.m^{-3}$ has been adopted as an average rock density.

Zero contour line

Fig. 8 Bouguer anomaly contours

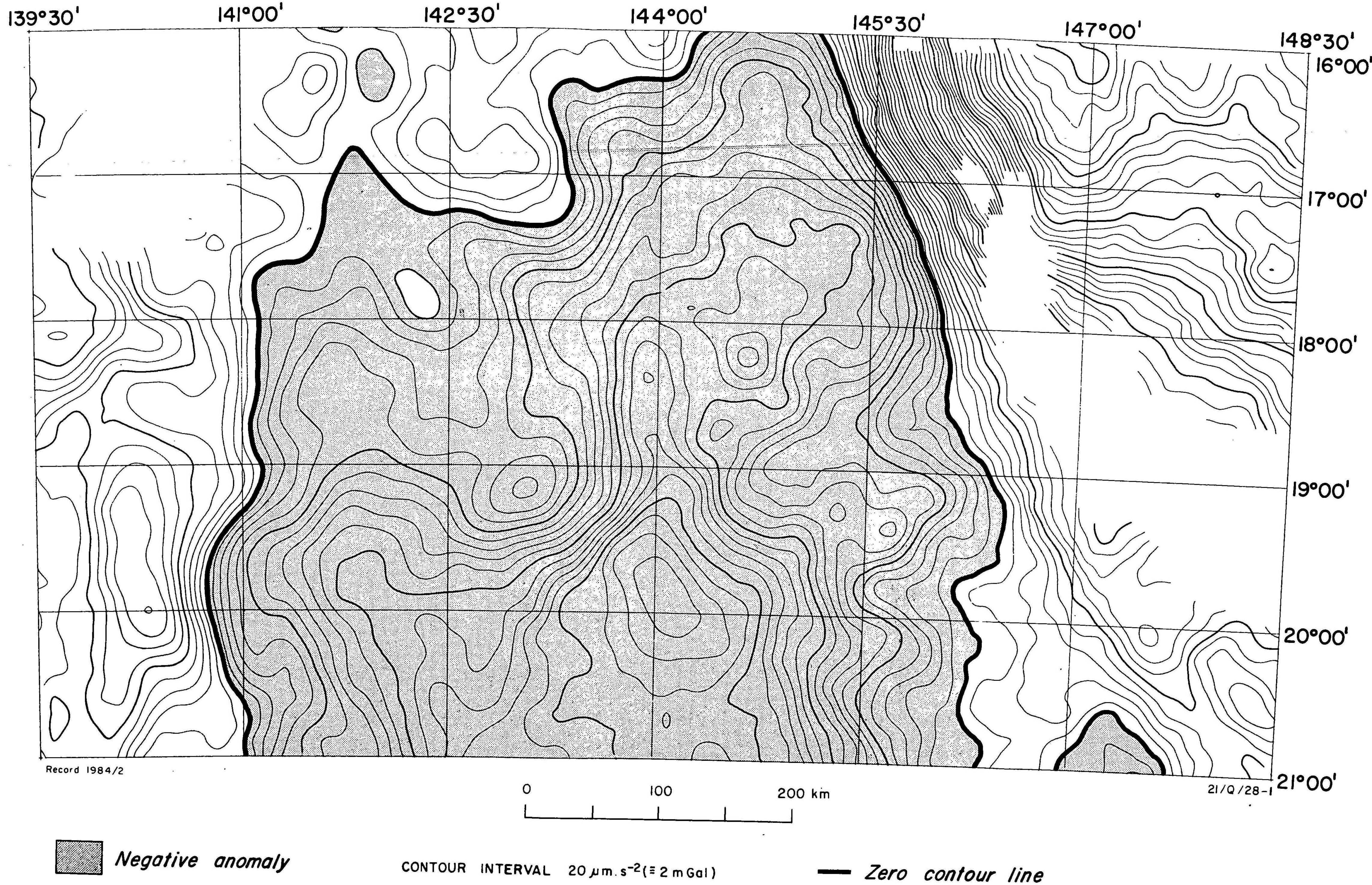


Fig. 9 Upward continuation (to 22 km) Bouguer anomaly map

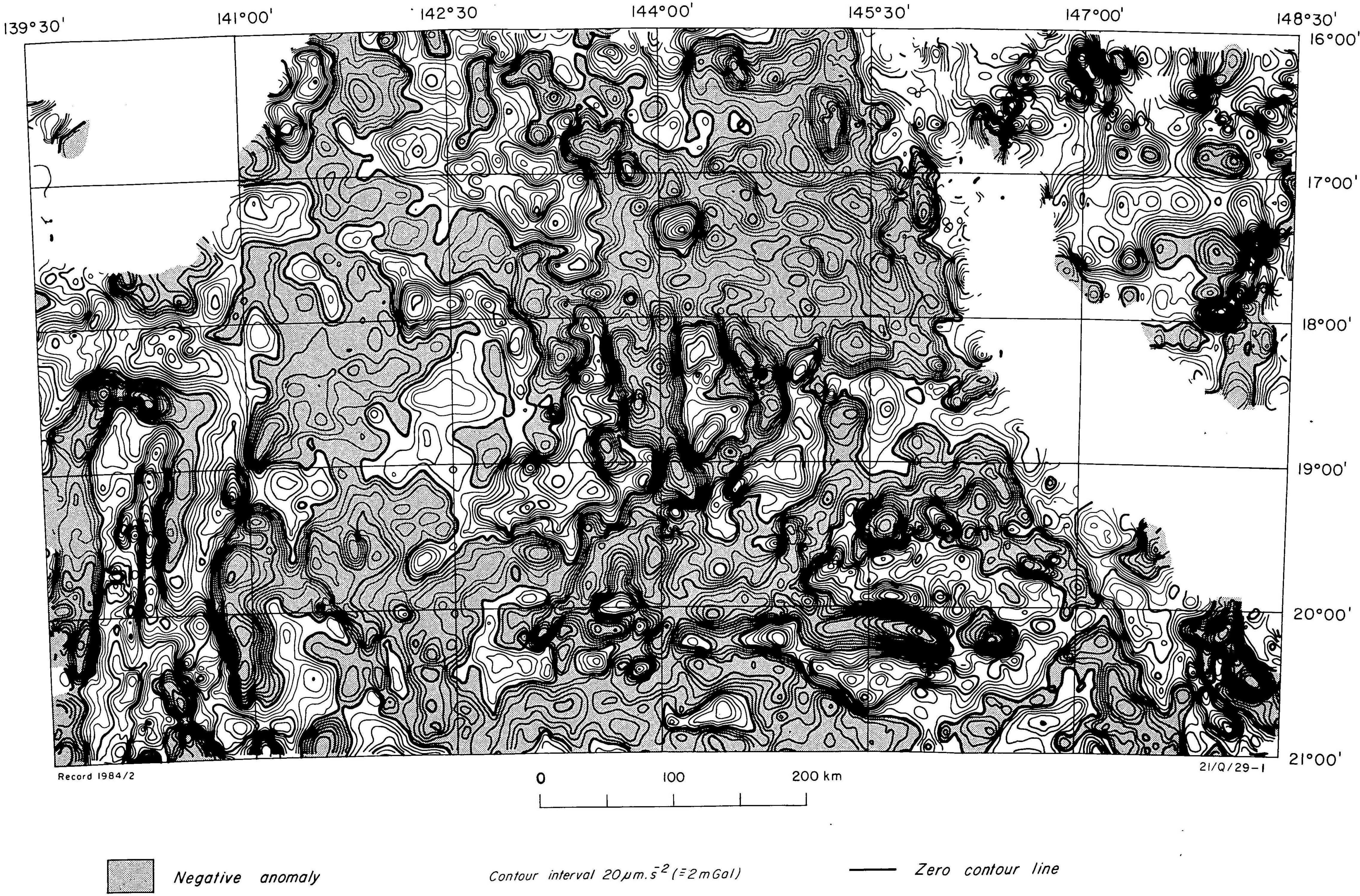


Fig. 10 Residual Bouguer anomaly contours

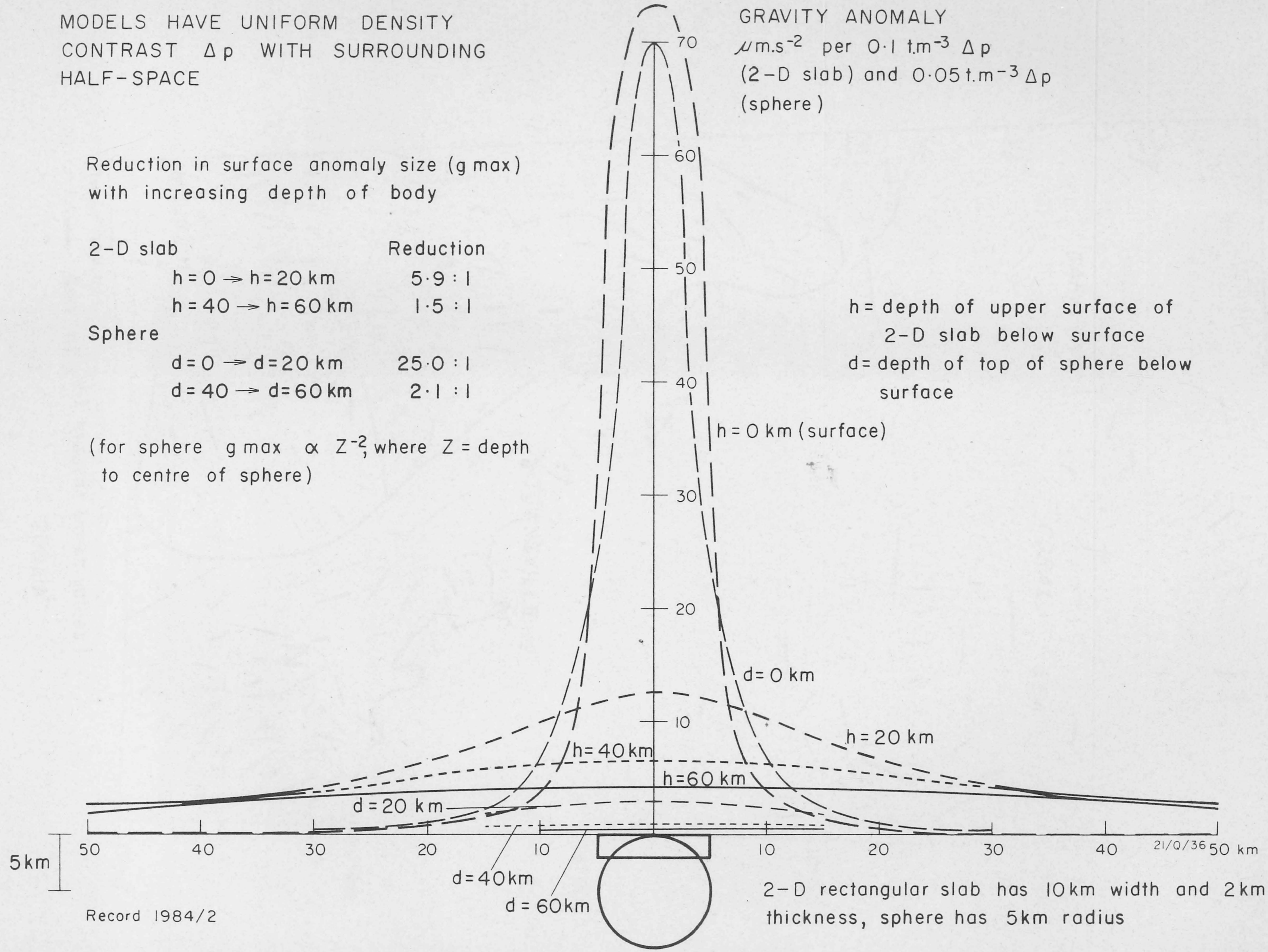


Fig. 11 Upward continuation effect for simple models

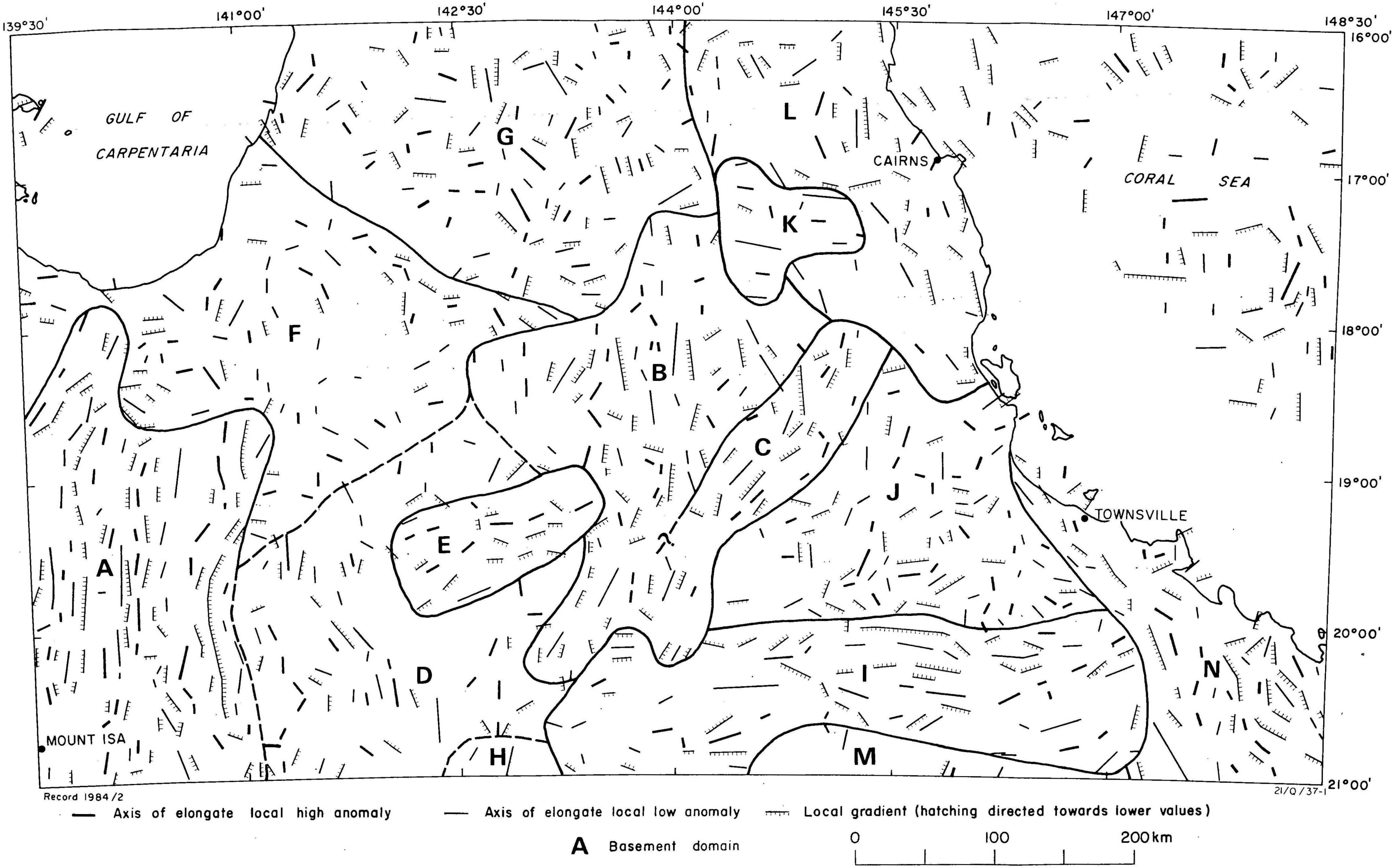


Fig. 12 Gravity trend analysis

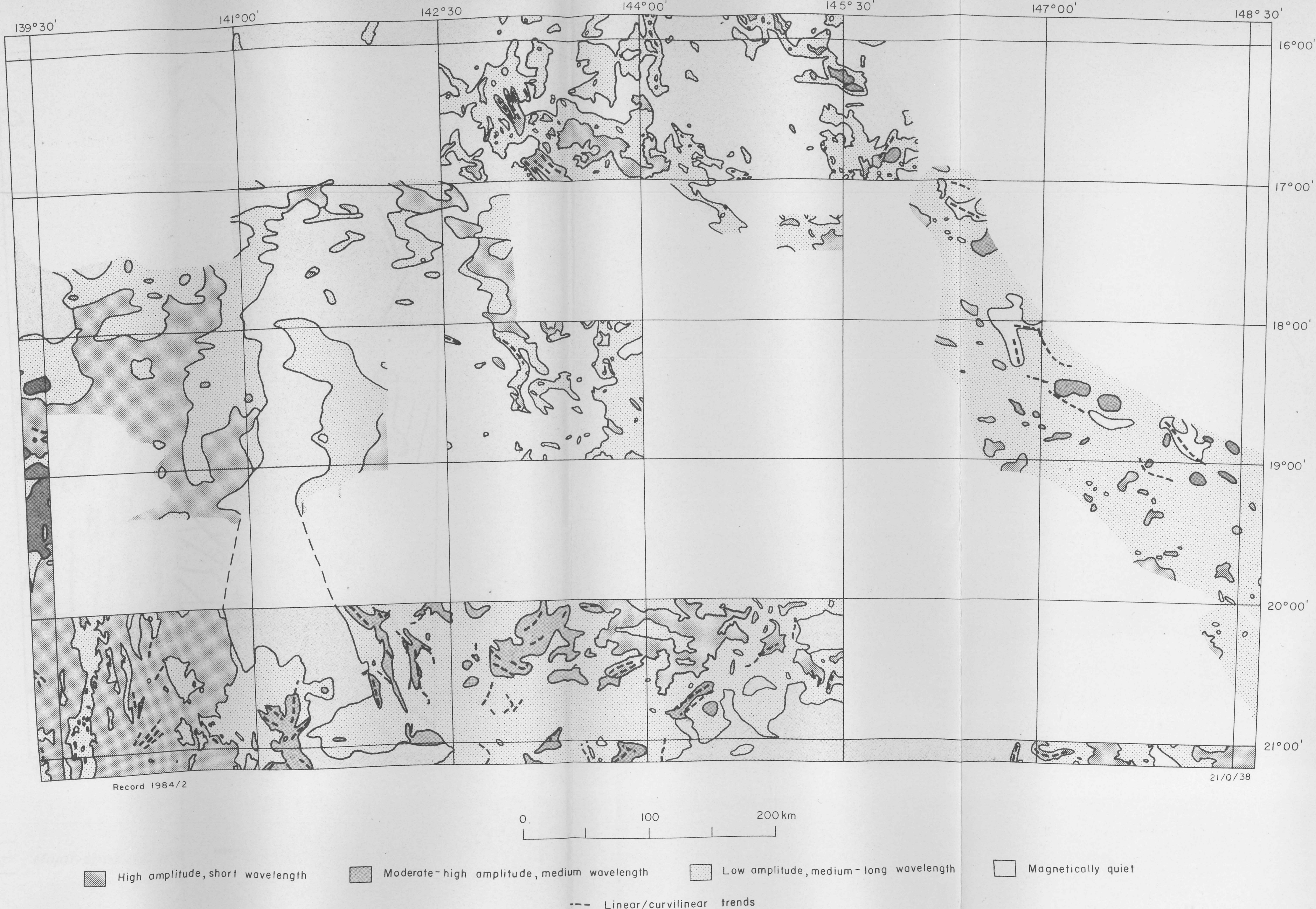


Fig. 13 Character of aeromagnetic anomalies over NE Queensland

Fig. 14 Interpretative upper-crustal geology / structure of NE Queensland from regional gravity and aeromagnetic results