Report 253

Geological interpretation of geophysical results, Glenormiston special airborne survey, Queensland, 1977

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Bureau of Mineral Resources, Geology and Geophysics

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

REPORT 253

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GEOLOGICAL INTERPRETATION OF GEOPHYSICAL RESULTS, GLENORMISTON SPECIAL AIRBORNE SURVEY, QUEENSLAND, 1977

by

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ABSTRACT

A semi-detailed airborne magnetic and gamma-ray spectrometer survey was flown over part of the GLENORMISTON 1:250 000 Sheet area in 1977 by the Bureau of Mineral Resources. The principal aims of the survey were: to define relief, structure and composition of the basement which may have controlled early Palaeozoic sedimentation; to define the distribution of non-outcropping granite; and to define the western margin of the Mount Isa Orogen.

Interpretation of the magnetic data indicates that the Proterozoic-Palaeozoic unconformity forms a broad ridge which extends roughly north-south through the survey area. This ridge deepens from about 100 m below the surface at the survey's northern boundary to over 400 m below the surface at the southern boundary. The thickest Palaeozoic sections occur in the southwest and southeast corners of the survey area, where section thicknesses of 800 m and 700 m respectively are interpreted.

Analysis of both magnetic and Bouguer gravity data indicate that the Proterozoic basement can be divided into four principal rock units. Granite has been interpreted to form a fifth basement rock unit in the extreme southwest of the survey area, and to underlie the axial region of the broad basement ridge.

A series of lineaments oriented N40^{o}E is evident in the magnetic data. These lineaments are interpreted as faults, some of which show displacements of up to 3 km in a dextral sense. A major fault mapped a few kilometres north of the survey area, in the southern part of the Ardmore 1:100 000 Sheet area, appears to extend southwards through the survey area.

The western boundary of the Mount Isa Inlier is interpreted to lie outside the survey area west of the Georgina River.

INTRODUCTION

In September 1977 the Bureau of Mineral Resources (BMR) flew a semi-detailed airborne magnetic and gamma-ray spectrometer survey over part of GLENORMISTON* (Fig. 1). Data were acquired along a 1 km x 6 km grid of flight lines at a height of 100 m above ground level over an area of 70 km x 70 km. The aims of the survey were: to define relief, structure, and composition of the basement which may have controlled early Palaeozoic sedimentation; to assist the search for favourable environments for the formation of stratabound Pb-Zn deposits; to define the distribution of non-outcropping granite; and to define the western margin of the Mount Isa Orogen.

Maps showing the magnetic data in contour, profile, and surface profile form, at a scale of 1:250 000, were released to the public in July 1981. Copies of these maps are available from:

Copy Service
Government Printer (Production)
GPO Box 84
CANBERRA ACT 2600

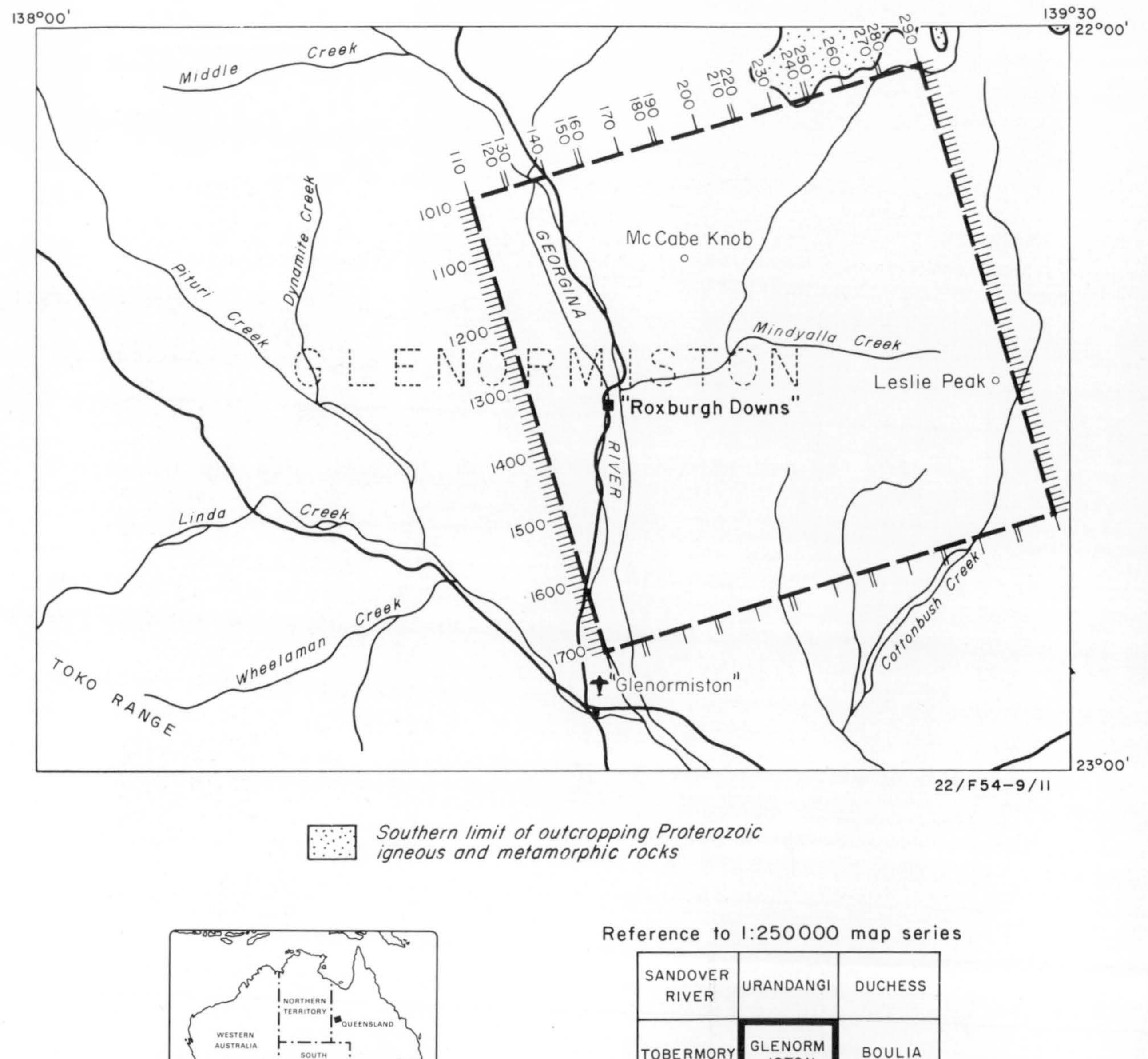
Figures 2,3, and 4 are small-scale reproductions of these maps.

Radiometric results are not included in this Report as they did not provide useful information in terms of meeting the aims of the survey.

GEOLOGY

Stratigraphy. The oldest rocks exposed in the survey area are interbedded metasediments and metavolcanics of the Proterozoic Eastern Creek Volcanics, which crop out near the northern boundary of the survey area (Fig. 5). Similar rocks previously mapped as Eastern Creek Volcanics north of the

* Names of 1:250 000 Sheet areas are printed in capitals.



Southern limit of outcropping Proterozoic igneous and metamorphic rocks

Reference to 1:250000 map series

SANDOVER RIVER	URANDANGI	DUCHESS
TOBERMORY	**GLENORM -ISTON**	BOULIA
HAY RIVER	MOUNT WHELAN	SPRINGVALE

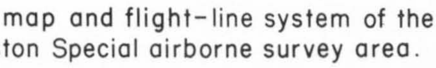


Fig. 1. Location map and flight-line system of the Glenormiston Special airborne survey area.

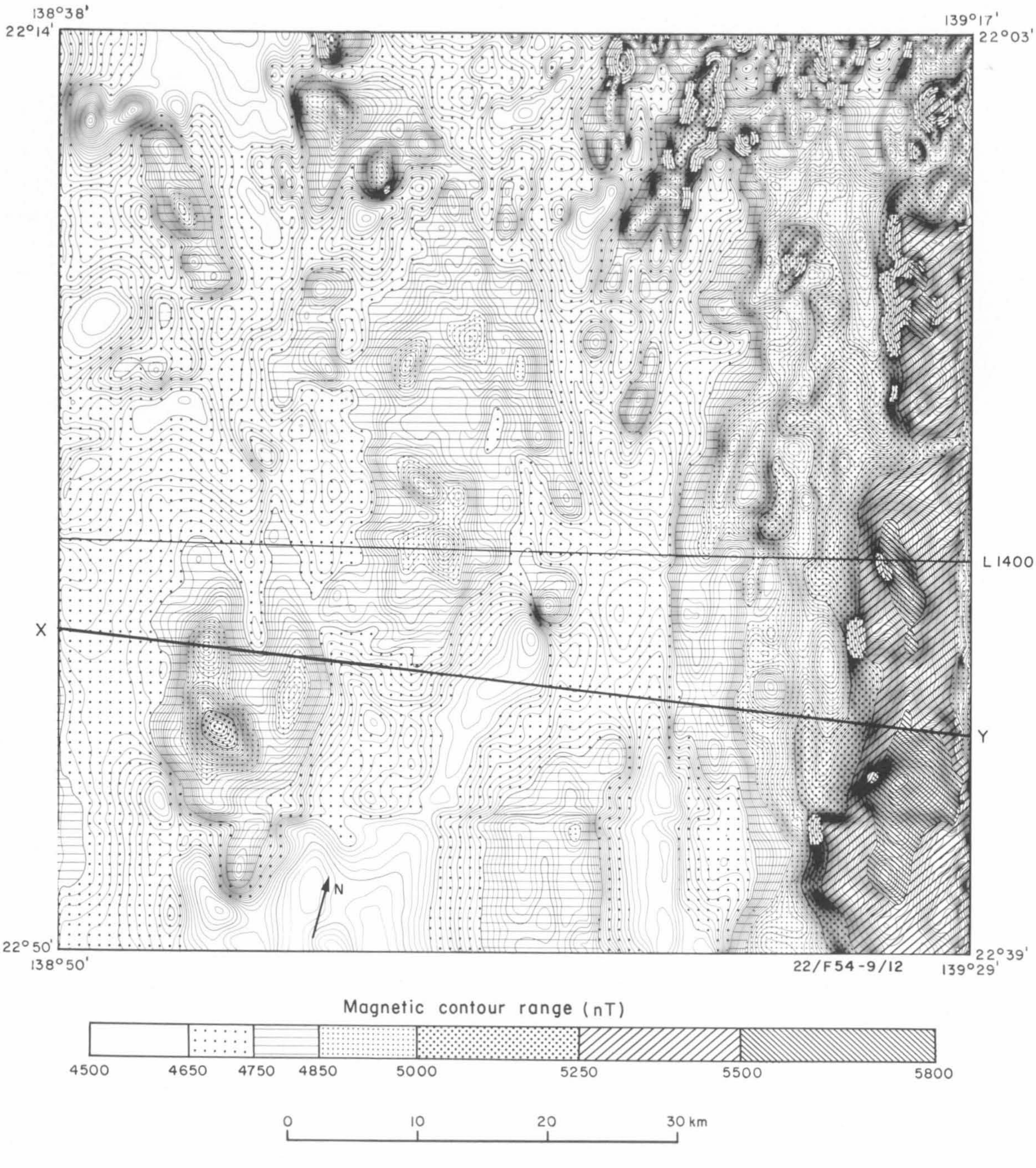


Fig. 2. Total magnetic intensity contours.

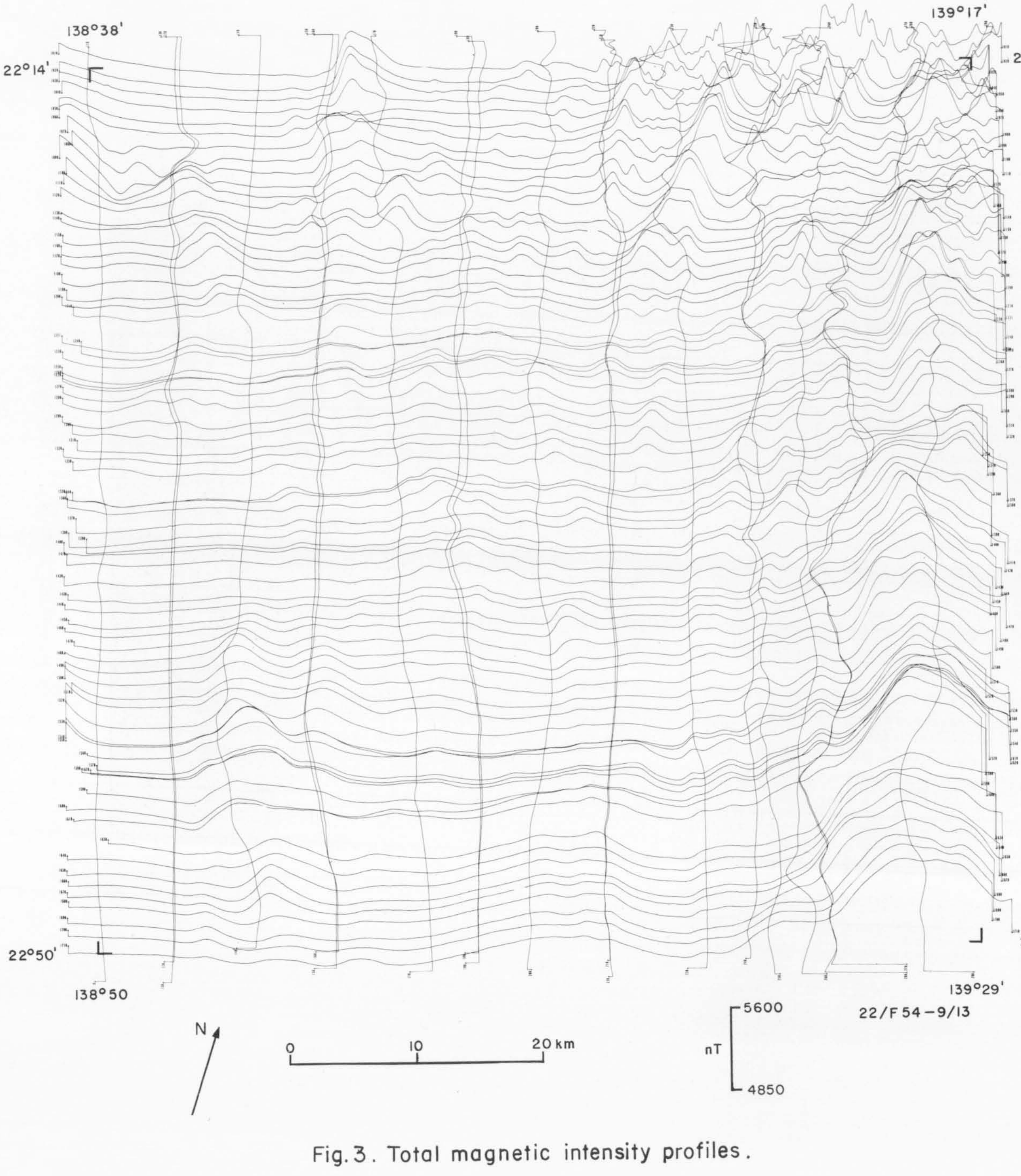


Fig. 3. Total magnetic intensity profiles.

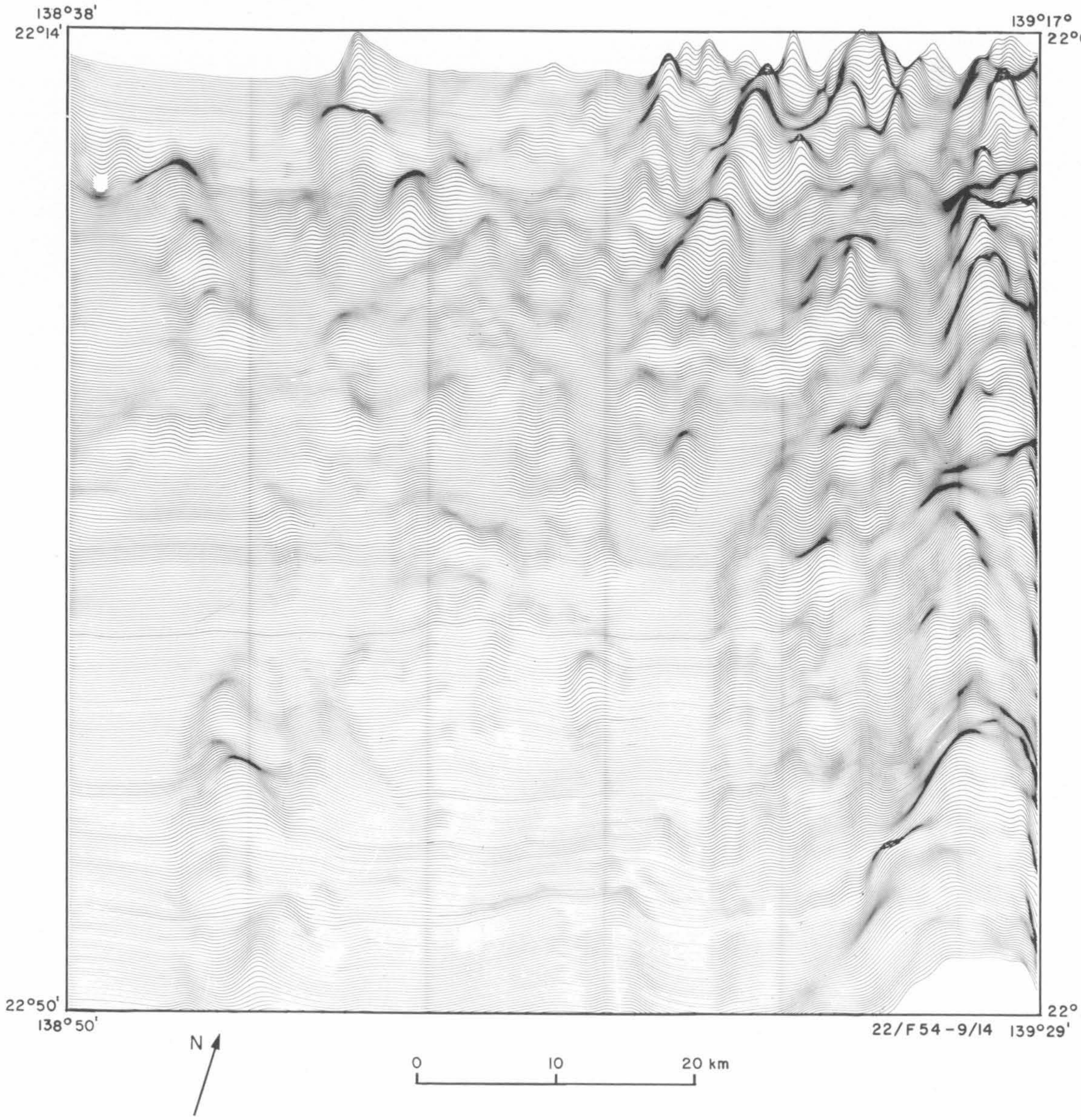


Fig. 4. Total magnetic intensity surface profiles.

survey area have been remapped as separate units - the Oroopo Metabasalt, Jayah Creek Metabasalt, Eastern Creek Volcanics, and Sulieman Gneiss (Bultitude, 1982). Younger units, probably totalling about 500 m thick near Roxburgh Downs, are flat-lying, and consist mainly of calcareous and quartzose sediments.

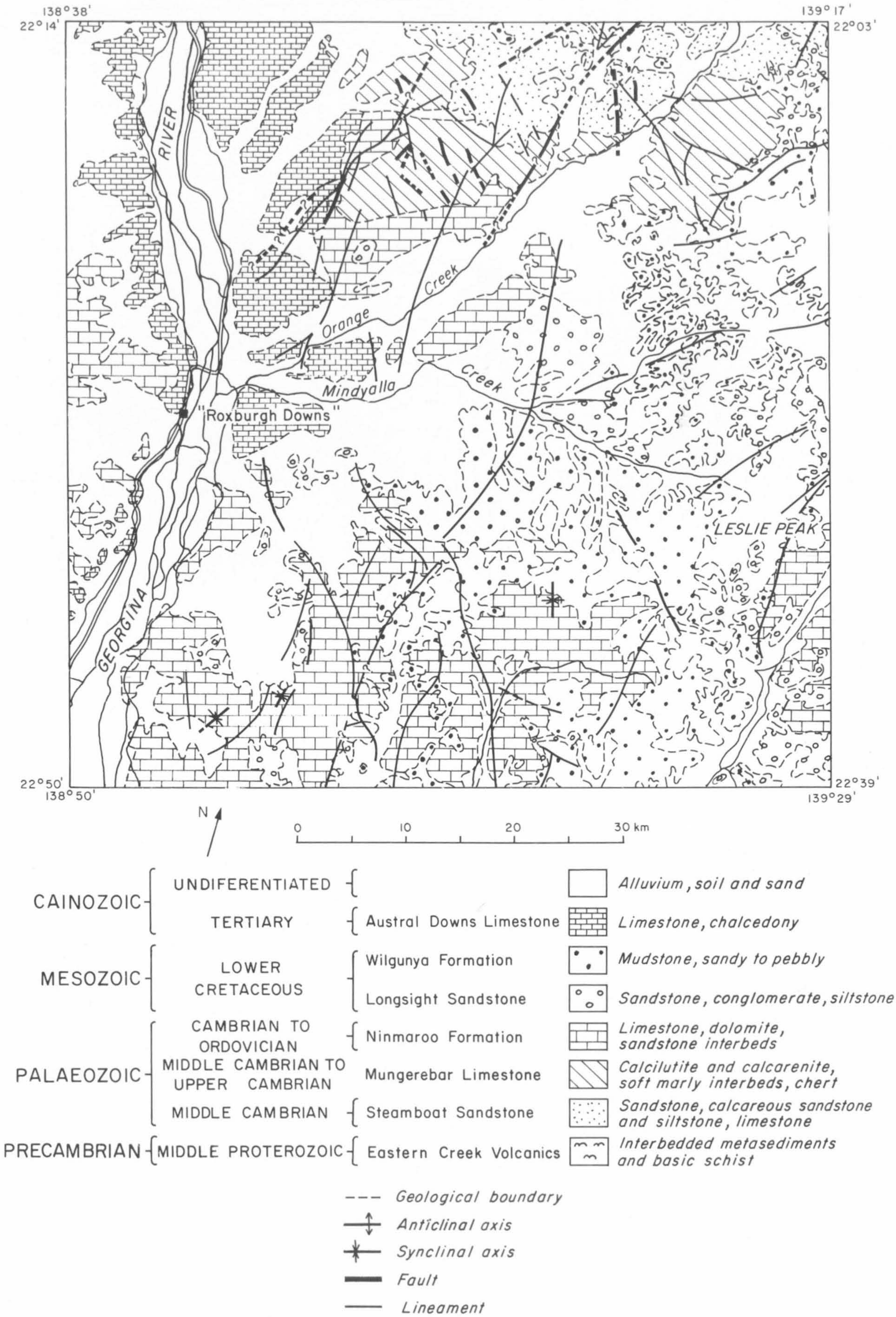
Structure. According to Reynolds (1965), Precambrian structural trends are commonly reflected in the Palaeozoic rocks to the south and southwest of the Precambrian rock outcrop, and the most prominent lineaments may also be apparent in the overlying Mesozoic rocks. Minor structures include prominent east-northeasterly lineaments (Fig. 5) shown by lower Palaeozoic rocks and by streams, and minor faults.

PREVIOUS GEOPHYSICAL INVESTIGATIONS

BMR has completed extensive regional gravity and aeromagnetic surveys over the late Adelaidean to Palaeozoic Georgina Basin and the Precambrian Mount Isa Inlier, which included coverage of GLENORMISTON. This work was done mainly in the early 1960s, and has been reported by Gibb (1967) and Wells & others (1966). Bouguer anomaly contours for the survey area (Fig. 6), and aeromagnetic contours for a region including the survey area (Fig. 7, which shows the most prominent lineaments in the magnetic data relating to the survey area), are derived from the regional survey data.

Tucker & others (1979) completed a reinterpretation of all available geophysical and geological information, to provide a better understanding of the basement structure and history of the Georgina Basin (see Figs. 8 and 9).

Hone & others (1982) completed a reinterpretation of the geophysical data over the Mount Isa Orogen, to provide a better understanding of the principal geological factors which control the size and distribution of gravity, magnetic, and radiometric anomalies. Their interpretation (Fig. 10)



Where location of boundaries, faults and folds is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted; faults are shown by short dashes

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Fig.5. Geology (modified from Reynolds, 1965).

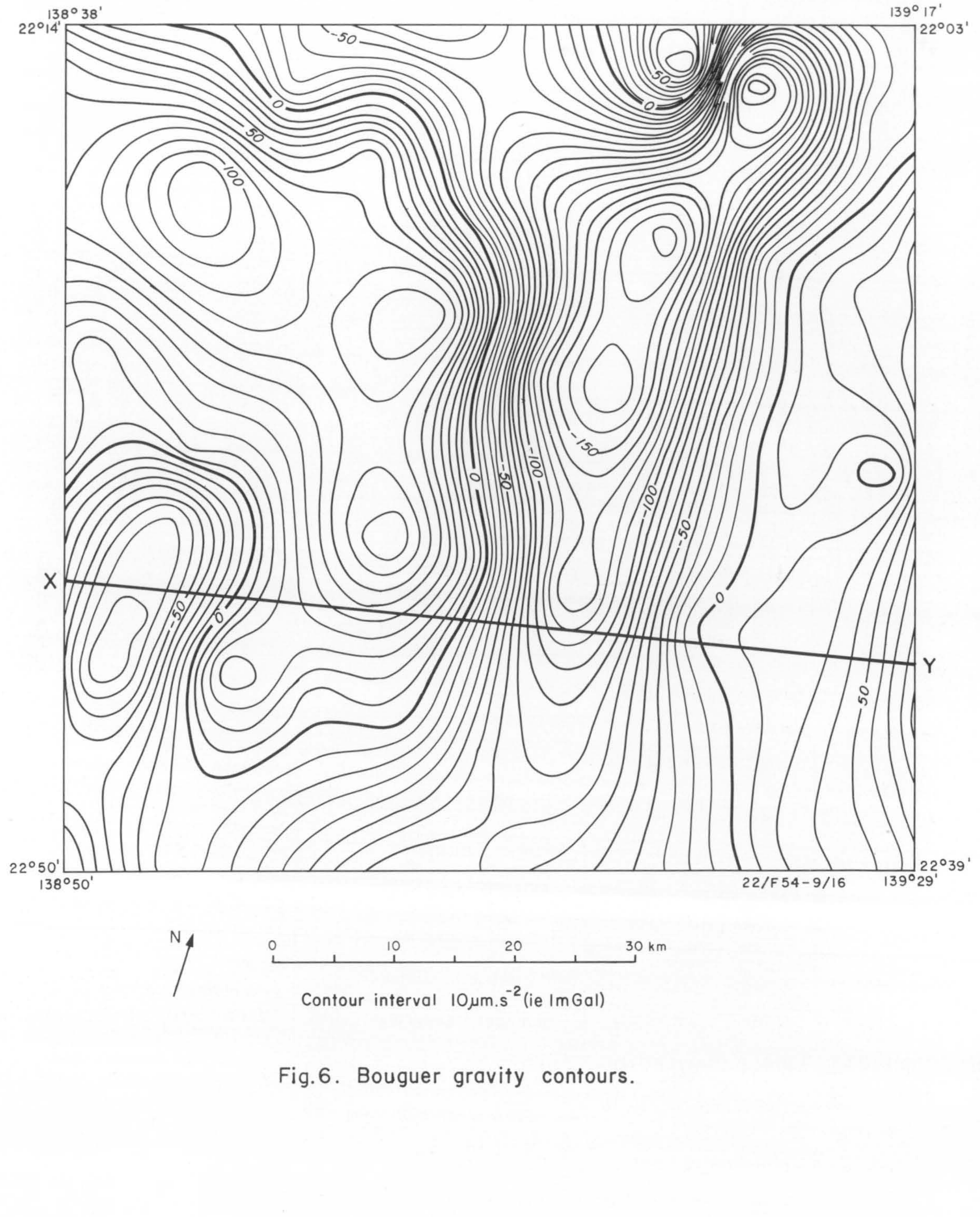
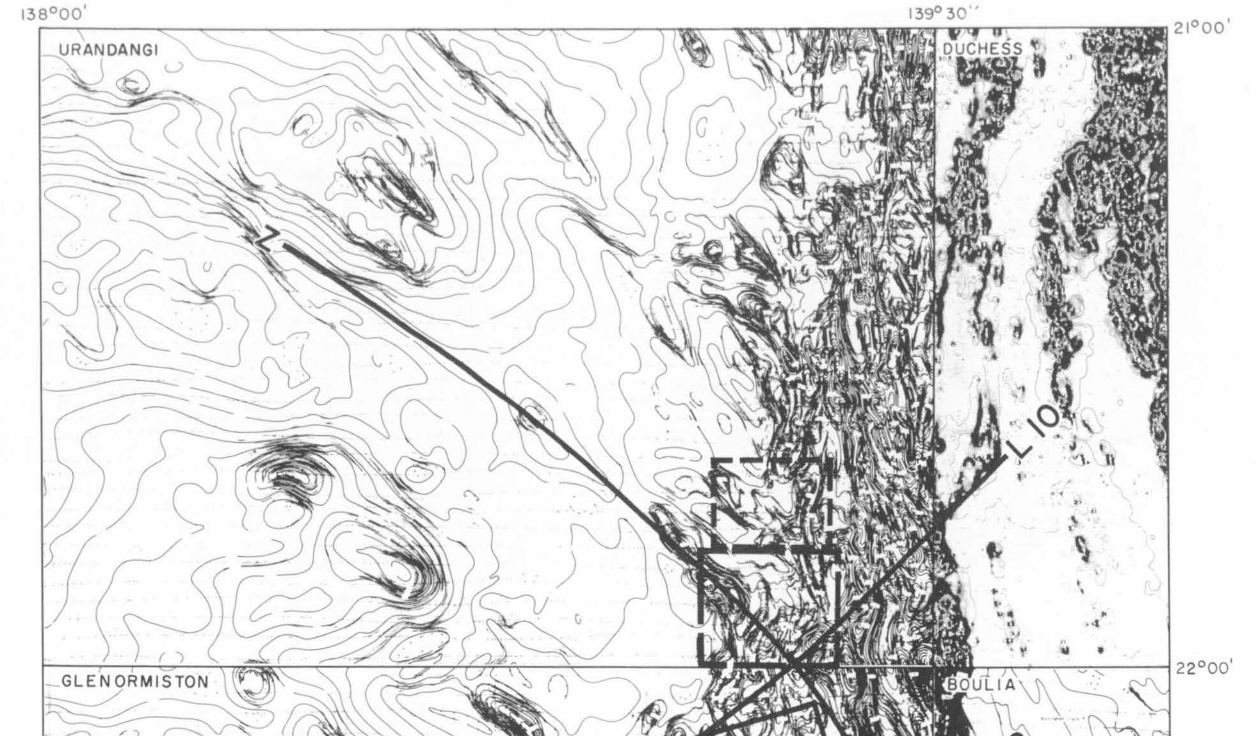


Fig.6. Bouguer gravity contours.



(Based on F54/BI-120,1:1000 000 TMI map)

22/F54-9/17

0 50 km

—— *Genormiston Special survey boundary*

— — *Area referred to in Figure 13*

- - - *Area referred to in Figure 14*

Z—— *Lineaments in magnetic data*

Fig.7. Total magnetic intensity contours of a region around the Glenormiston Special survey area.

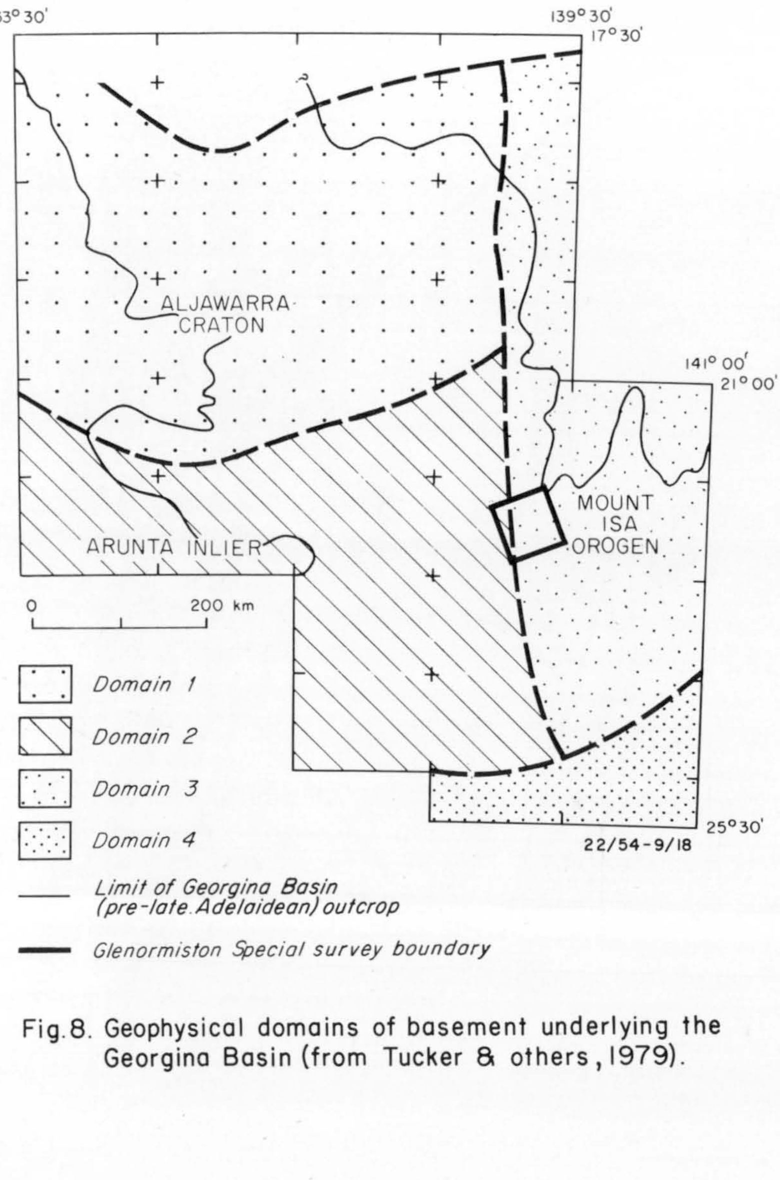


Fig. 8. Geophysical domains of basement underlying the Georgina Basin (from Tucker & others, 1979).

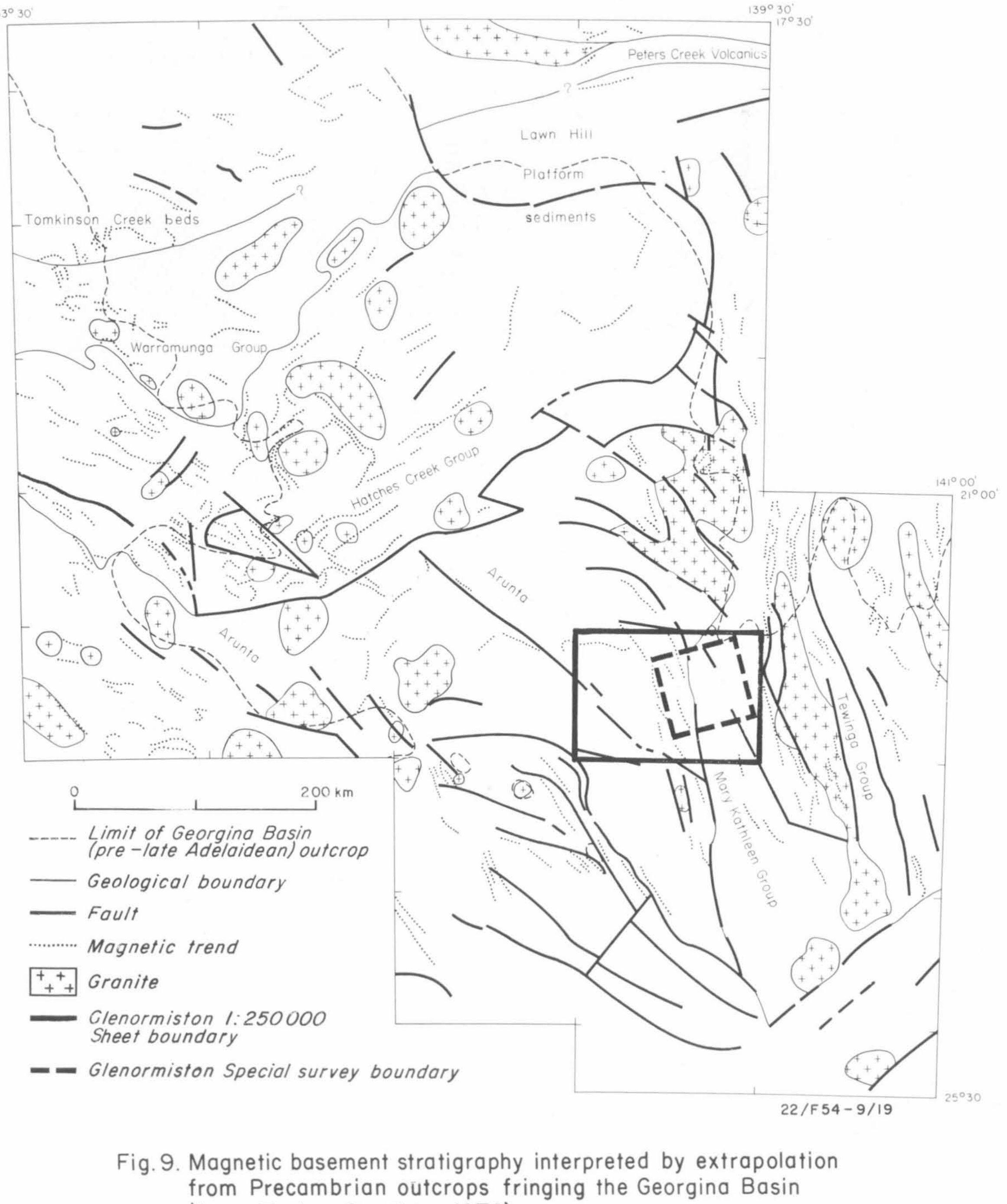


Fig. 9. Magnetic basement stratigraphy interpreted by extrapolation from Precambrian outcrops fringing the Georgina Basin (from Tucker & others, 1979).

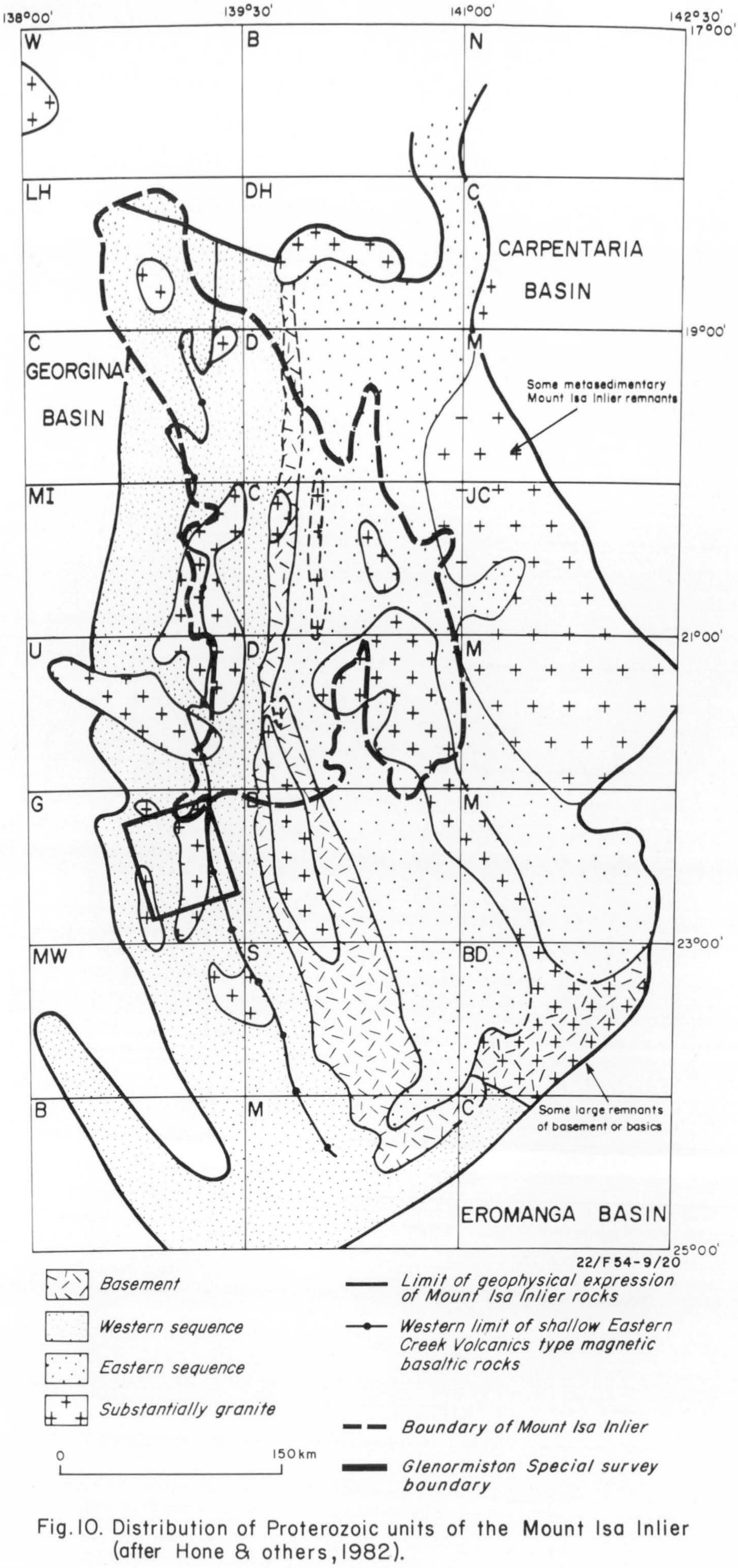


Fig. 10. Distribution of Proterozoic units of the Mount Isa Inlier (after Hone & others, 1982).

places the western boundary of the Orogen near 138°30'E, whereas Tucker & others (1979) indicated this boundary to be closer to 139°00'E in GLENORMISTON (Fig. 8). Another difference between these two interpretations is the distribution of granitic bodies.

Rees (1981) commented briefly upon the significance of the results of the detailed aeromagnetic survey which is the subject of this Report.

GEOLOGICAL INTERPRETATION DERIVED FROM ANALYSIS OF GEOPHYSICAL DATA

Basement composition

Rock units which can be recognised as comprising basement are interpreted primarily from the distribution and characteristics of associated magnetic anomalies, and to a lesser extent from Bouguer gravity anomalies. Structure is interpreted from patterns evident in the magnetic data. These patterns are in part formed by a combination of anomaly truncations and offsets, and by significant changes in anomaly amplitude along strike. In general such patterns are related to faulting. Folds are indicated by patterns involving curvature or closure of elongated anomalies.

From an analysis of the detailed magnetic and regional gravity data, basement has been divided into four principal categories - A, B, C, and D; a fifth basement type, E, is interpreted to underlie parts of B, C, and D type basements (Fig. 11).

Type A basement comprises magnetic rock units which form a belt 5 to 10 km wide along the eastern margin of the survey area. Modelling of the magnetic data indicates that rock units are commonly 2-3 km wide, and that apparent bulk susceptibilities are in the range 0.04 to 0.12 SI units. All anomalies have a marked northerly elongation. Forward modelling of these anomalies for a number of profiles indicates that type A basement has a simple internal structure involving commonly three magnetic

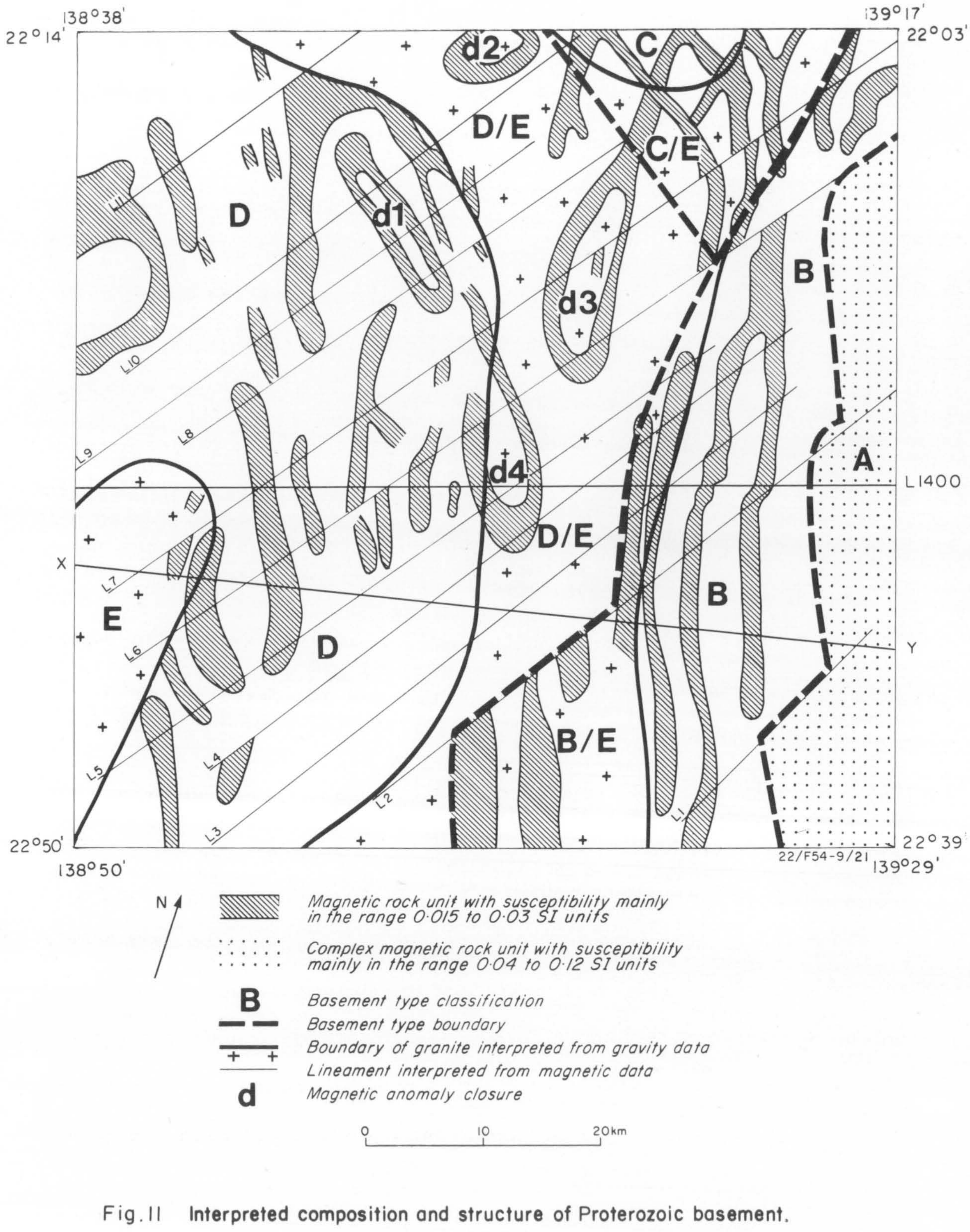


Fig. 11 **Interpreted composition and structure of Proterozoic basement.**

rock units - A1, A2, and A3 (Fig. 12).

Previously recorded magnetic anomalies over URANDANGI (BMR, 1966) leave no doubt that these basement rocks are the strike extension of the Jayah Creek Metabasalt mapped by Bultitude (1982) in the Ardmore 1:100 000 Sheet area. Relatively non-magnetic elements (A2,3 in Fig. 12) would be interpreted as sandstone similar to the Timothy Creek Sandstone Member within the Jayah Creek Metabasalt.

Type B basement magnetic units parallel those of type A basement, exhibiting the same pronounced northerly anomaly elongation, which tends to swing east of grid north in the northeast corner of the survey area. Modelling indicates that these rock units have bulk susceptibilities in the range 0.01 to 0.04 SI units; most are in the range 0.015 to 0.03 SI units. The shape and amplitude of the anomalies suggest their source to be a rock unit consisting of metabasalt and interlayered sandstone beds with a lesser overall content of metabasalt than type A basement magnetic rock units.

The strike of type B basement extends northwards into the southeastern part of Ardmore 1:100 000 Sheet area. The stratigraphy of magnetic basement in this locality (Fig. 13) has been interpreted by extrapolating from outcrop, which implies that either the Sulieman Gneiss or Jayah Creek Metabasalt is the source of type B basement. As some anomaly trends associated with the Sulieman Gneiss are oblique to those of type B basement, the preferred interpretation is that the Jayah Creek Metabasalt is the source of type B basement, which is further interpreted to contain less metabasalt than type A basement.

Type C basement contains two sets of cross-cutting magnetic units - oriented northerly and northwesterly - with anomaly amplitudes tending to increase at magnetic unit intersections. Bulk susceptibilities for both sets

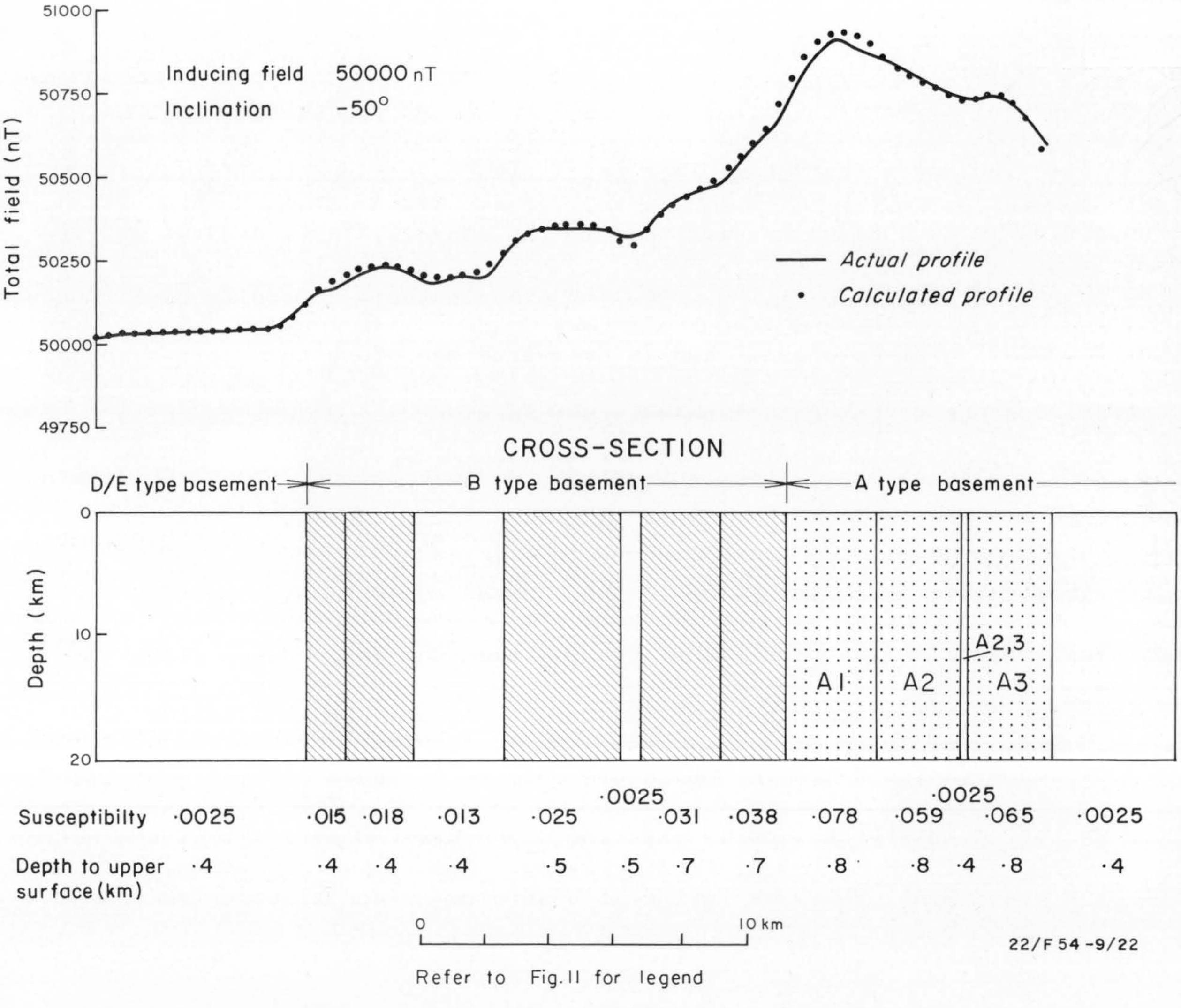


Fig. 12. Assemblage of magnetic rock units which constitute types A and B basement, as determined by computer modelling, along flight-line L1400.

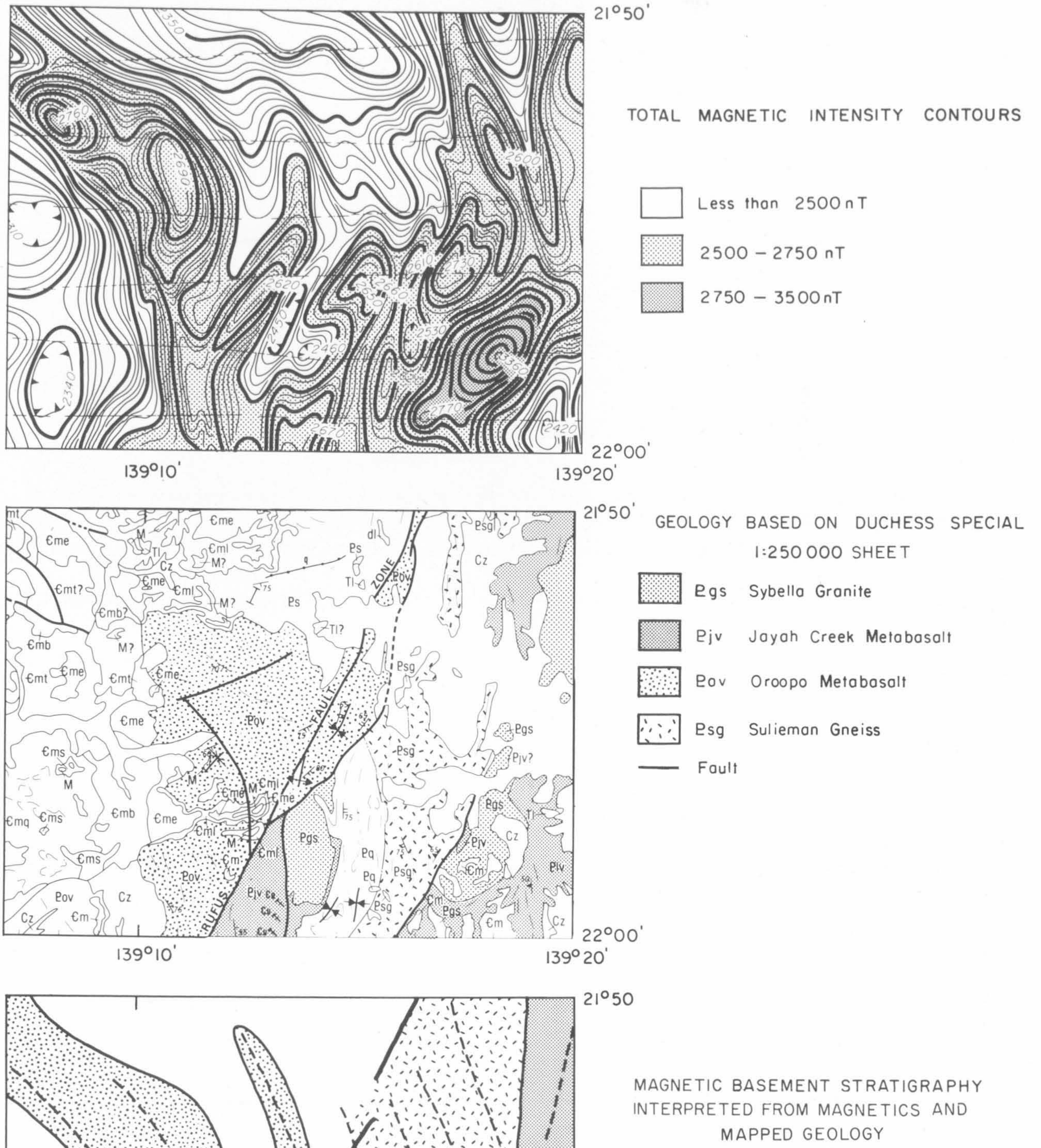


Fig. 13. Interpreted stratigraphy of magnetic basement in the southeast of the Ardmore 1:100 000 Sheet area. Location of this area relative to the Glenormiston Special survey area is shown in Figure 7.

of units lie within the range 0.01 to 0.04 SI units (most are in the range 0.015 to 0.03 SI units); the northerly set occupies the upper end of the range, and the northwesterly set has susceptibilities at the lower end of the range.

Magnetic contours and geology in the Ardmore Sheet area (Fig. 13) indicate that the northwesterly trending magnetic units correlate with either the Oroopo Metabasalt or Sulieman Gneiss. The northerly trending magnetic units are considered to indicate the presence of type B basement rock units.

Type D basement underlies much of the remainder of the survey area to the west of types B and C basement. Magnetic rock units are characterised by elongated anomalies which in many localities have such a pronounced curvature as to complete anomaly closures, indicative of basins or domes.

Figure 14 illustrates the contour pattern created by what is interpreted to be the doming of magnetic rock units by intrusion of Sybella Granite in the Ardmore Sheet area. The magnetic rock units are interpreted to be metadolerite intrusions, possibly sills, within Saint Ronans Metamorphics.

The Saint Ronans Metamorphics are interpreted as the source of type D basement with magnetic anomalies produced by amphibolite or metadolerite horizons at the basement surface. The ratio of non-magnetic to magnetic-related strata is much higher than in types B or C basement. Bulk susceptibilities of magnetic units are, however, similar to those for types B and C basement.

Type E basement, or perhaps intrabasement, is interpreted as intrusive Sybella Granite, primarily from an analysis of the Bouguer gravity data. Inspection of gravity results and geology in URANDANGI reveals the distinctive anomaly gradient associated with this granite/metabasalt contact between latitudes 139°15' and 139°25' throughout the Sheet area but best displayed in the north.

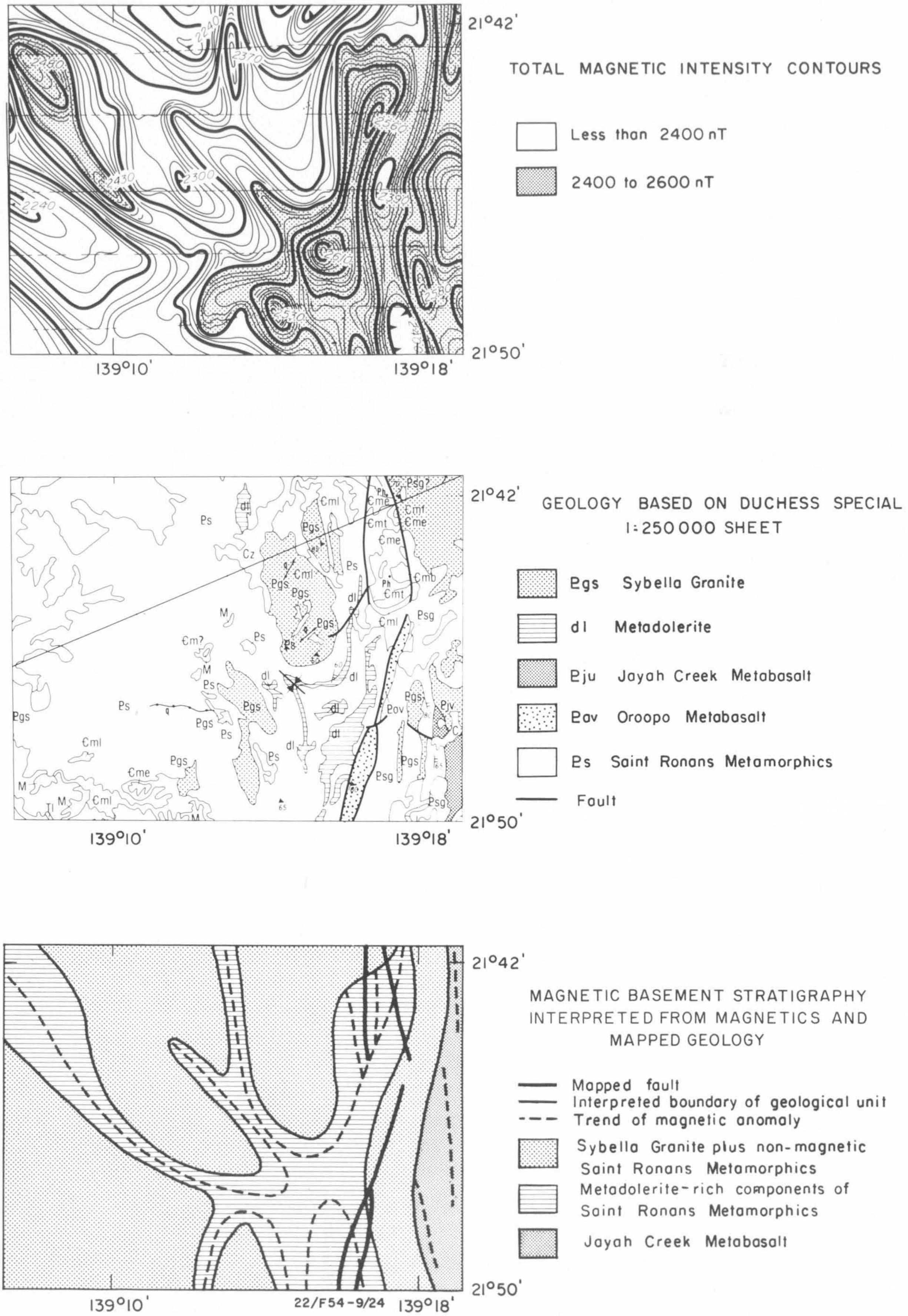


Fig.14. Interpreted stratigraphy of magnetic basment in the southeast of the Ardmore 1:100 000 Sheet area north of the area shown in Figure 13. Location of this area relative to the Glenormiston Special survey area is shown in Figure 7.

It appears that only a thin veneer of metamorphics overlies the granite, and that some magnetic anomalies may have a significant component of remanent magnetisation resulting from metamorphic aureole effects. Granite is most likely to be present at the basement surface at the centre of elliptically shaped magnetic anomalies.

Basement structure

A series of lineaments, L1 to L11, which strike northeasterly (roughly N 40°E true) is interpreted from the magnetic data (Fig. 11).

Lineaments L1, L2 and L6, spaced at intervals of 15 km, are most evident in regions of types A and B basement where magnetic rock units are offset by up to 3 km in a dextral sense.

Lineaments L5, L7, and L10, spaced at intervals of 10 km, are most obvious in the region of type D basement. These lineaments mark significant changes in anomaly amplitude along strike, including anomaly truncation, and distinctive anomaly lows. L10 is particularly notable as an alignment of anomaly lows, most apparent where it intersects the northern end of the domal type anomaly closure d1.

Anomaly closures or near-closures, d1 to d4 (Fig. 11), are interpreted as being produced by the doming of magnetic rock units in type D basement by intrusion of Sybella Granite as mentioned previously. In the western part of the survey area, flexures in anomaly trends suggest that the principle axis of folding is oriented a few degrees west of north (about N 15°W true).

Alternatively the sources of anomalies d1 to d4 could be associated with metamorphic aureoles.

Basement geometry

There is no evidence to suggest that any significant magnetic anomalies are produced by the Palaeozoic or Mesozoic cover rocks in the survey area.

These rocks are primarily of calcareous, quartzose composition. Accordingly magnetic basement in general is expected to define the unconformity between the Proterozoic metamorphic and igneous rocks, and the flat-lying lower Palaeozoic sedimentary rocks.

Analysis of depth to basement (Fig. 15) was carried out using a combination of interpretative techniques, which included:

1) computer-based interpretation of data along selected flight lines, using the Werner deconvolution method (see Appendix 1);

2) computer-based interpretation of distinct anomalies, using inversion modelling procedures; and

3) manual methods of interpretation, using analogue data records applying such methods as Peters's half-slope (Peters, 1949).

Over much of the survey area, depth contours are expected to be reliable within an accuracy of about ±15 per cent. The main exception to this is in the southeast corner where closely spaced sources produce a particularly complex anomaly. Depth estimates on this compound anomaly using any method will tend to produce values too large. Nevertheless, the shape of the anomaly does indicate a deepening of the unconformity.

Source depth analysis by the Werner deconvolution method, applying a simple susceptibility interface model, for survey lines L1010, L1400, and L1600 (Figs. 16, 17, and 18) shows that the shallowest sources resolved are weakly magnetised; these are most probably associated with laterite. The analysis for L1600 (Fig. 18) is of particular interest as it indicates two magnetic horizons: the more clearly resolved horizon is at a depth of 700 m; above this, at about 300 m, is a less distinctly resolved magnetic source. Neighbouring lines provide better evidence for the shallower source at about 400 m and less evidence for the deeper source. The shallower source is more readily resolved using manual interpretation methods.

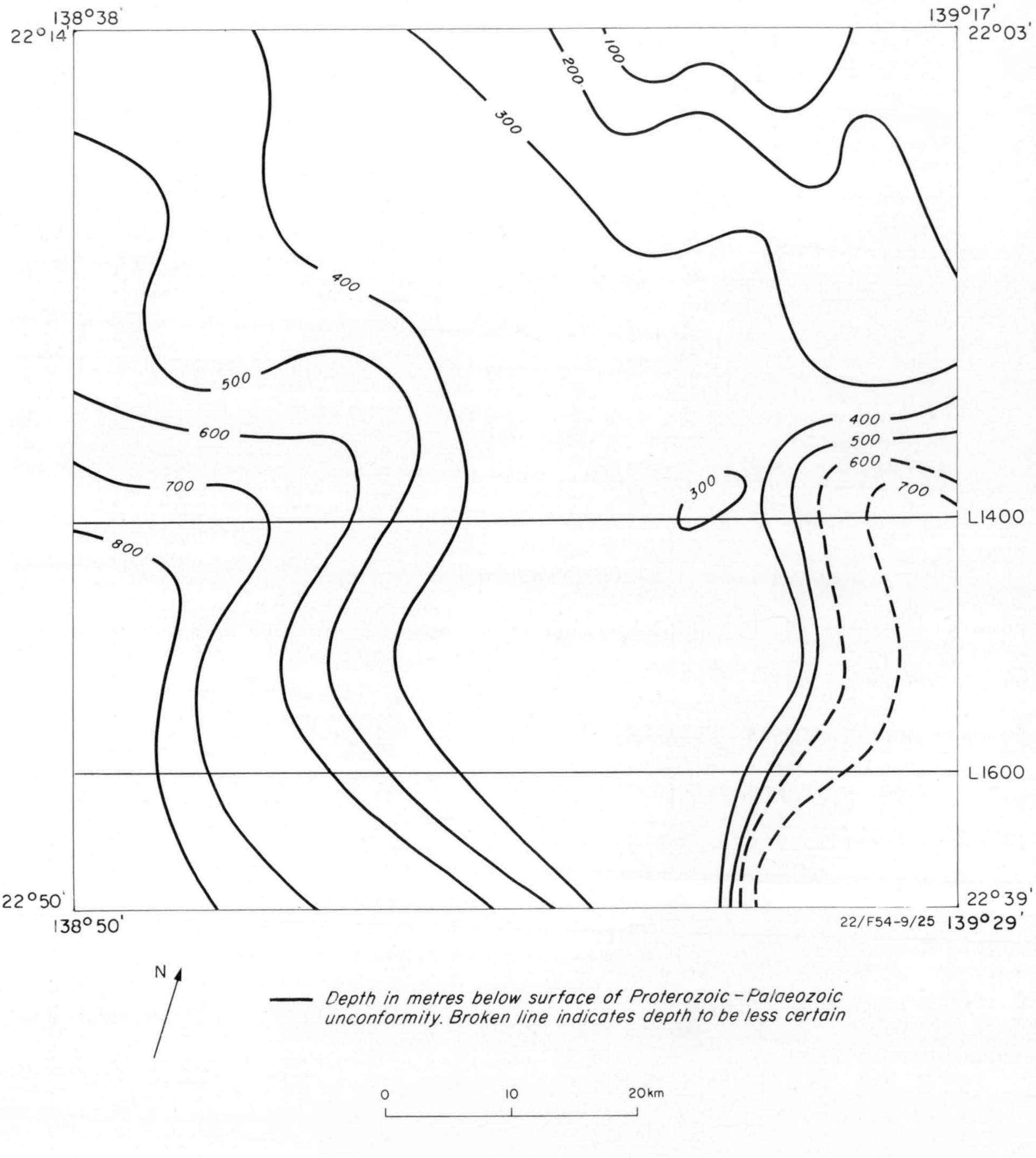
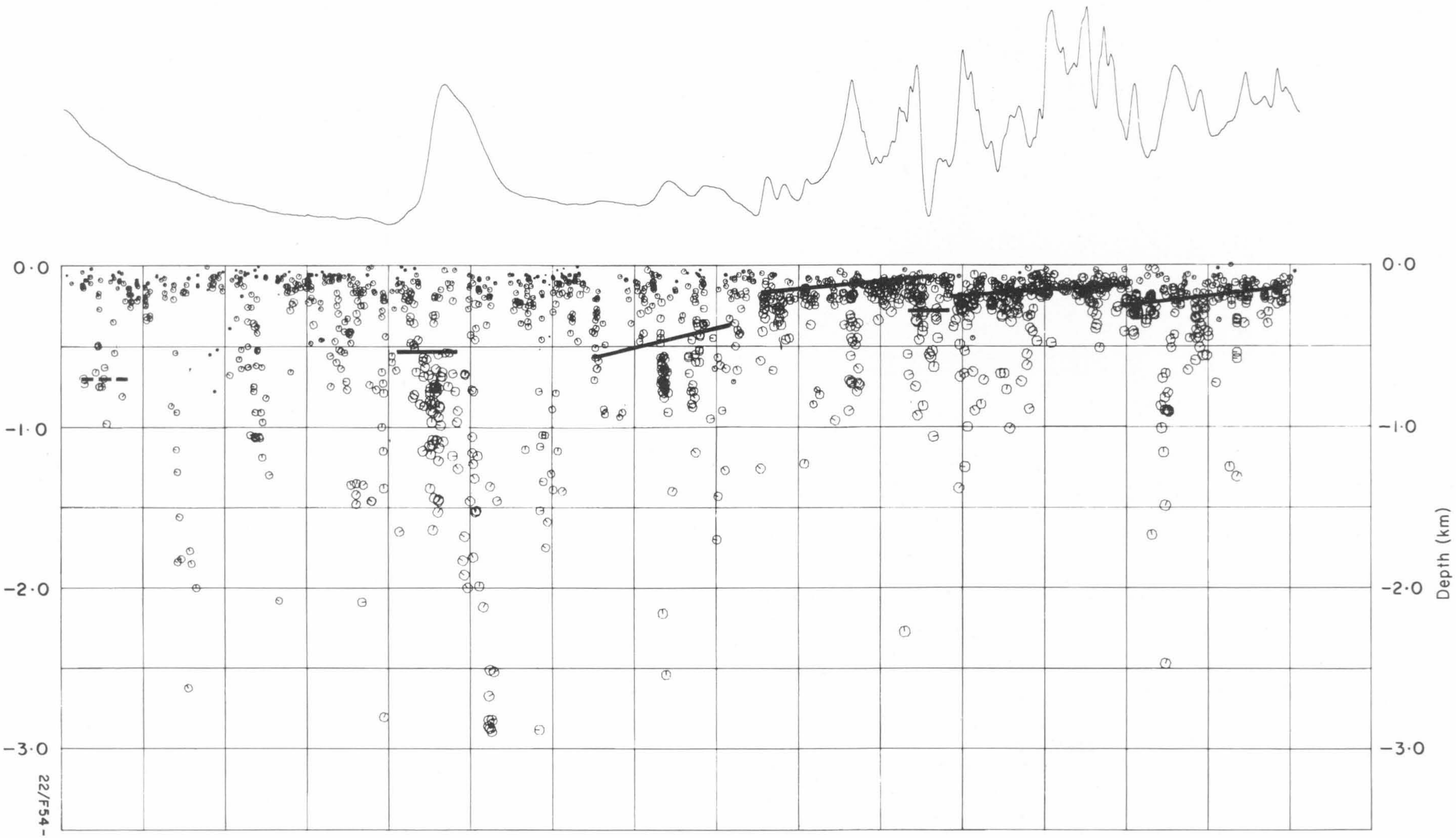


Fig. 15. Magnetic basement depth interpretation.



Magnetic basement surface derived from upper limits of causative sources

Depth estimate of causative body: symbol size reflects intensity of magnetisation; magnetisation direction indicated by straight-line segment within symbol.

Fig.16. Magnetic basment depth estimates determined from the Werner deconvolution method for flight-line L 1010.

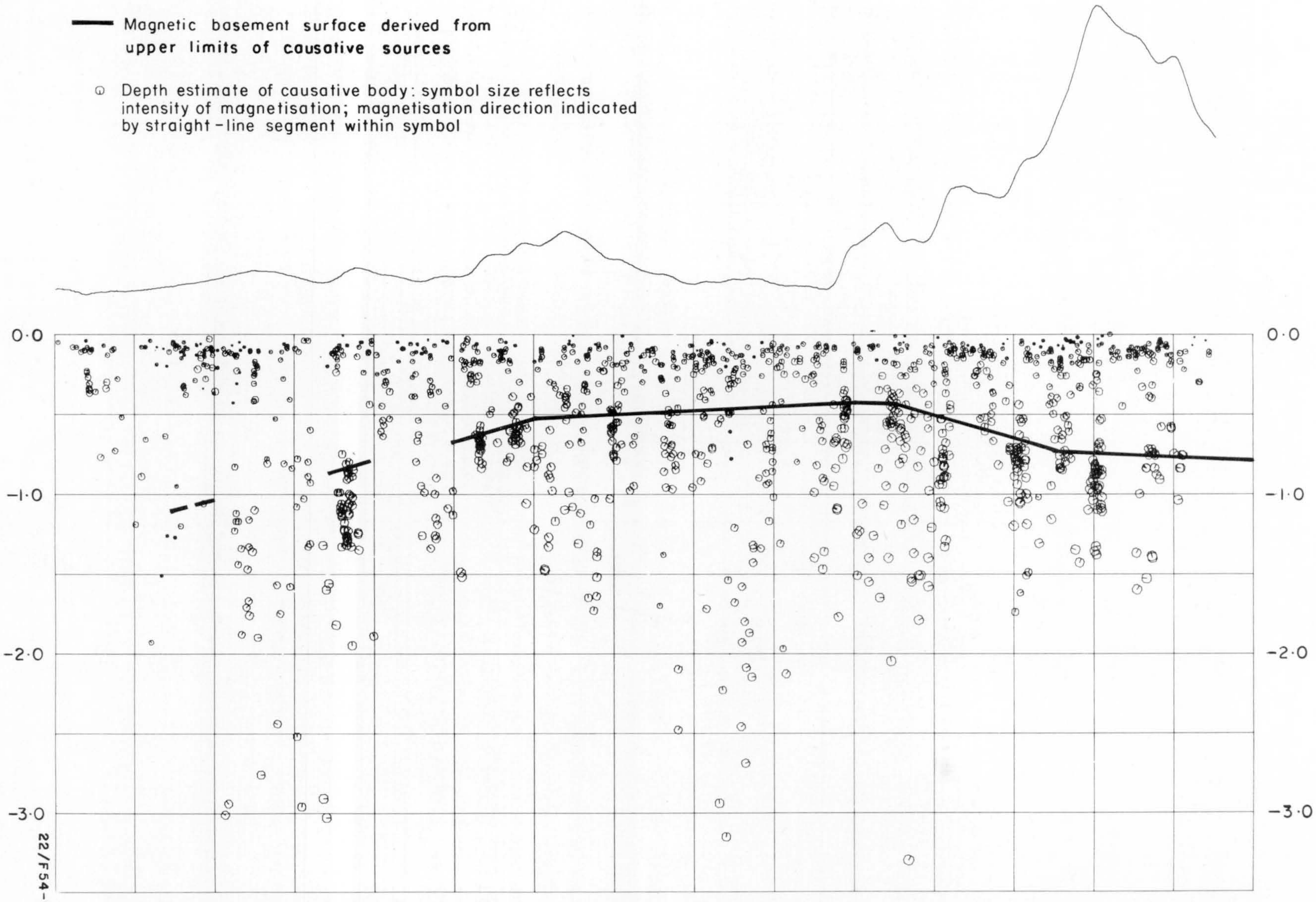


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Fig.17. Magnetic basement depth estimates determined from the Werner deconvolution method for flight-line L1400.

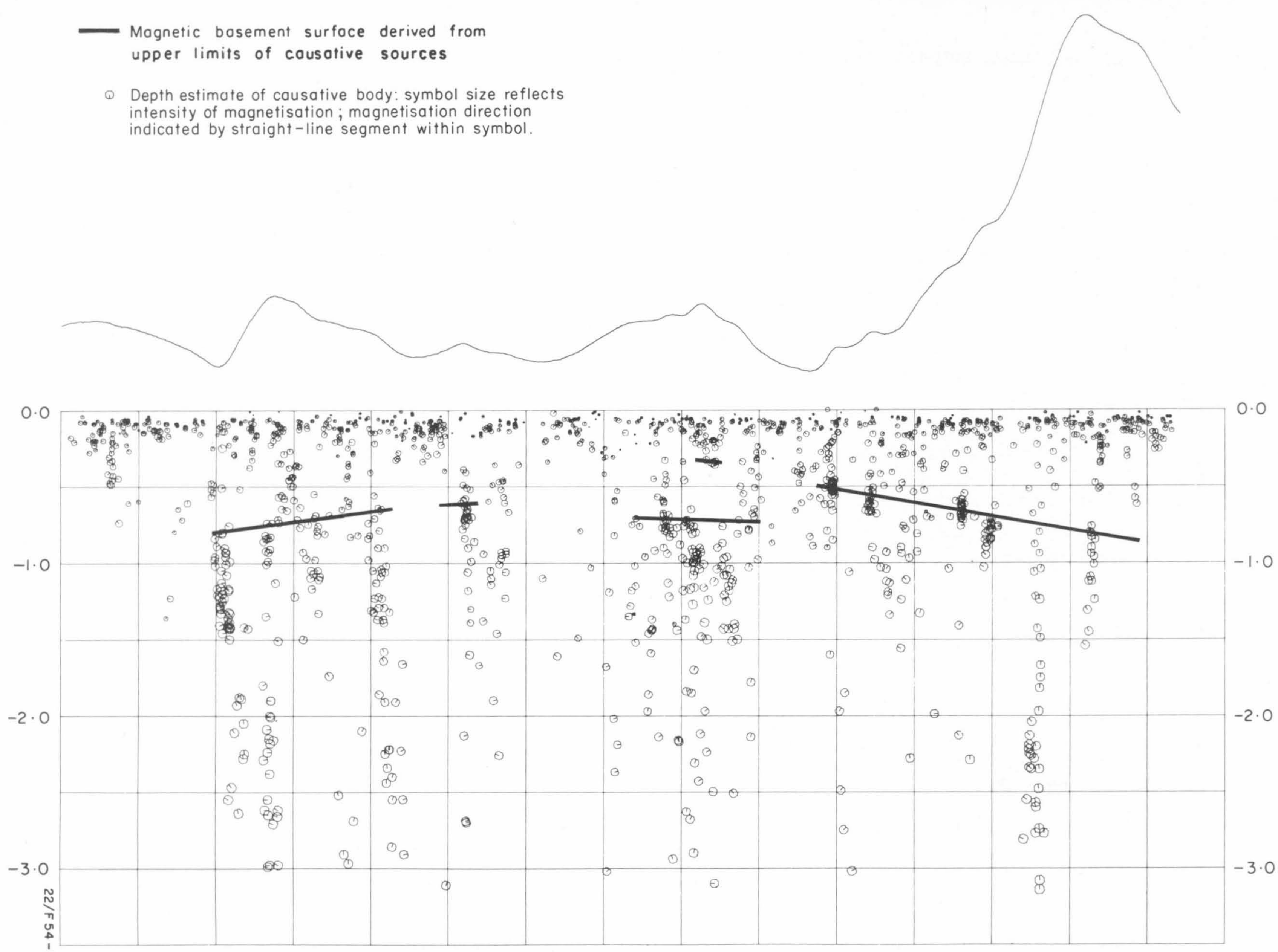

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Fig.18. Magnetic basement depth estimates determined from the Werner deconvolution method for flight-line L 1600.

The deeper magnetic horizon, if real, would have to be interpreted as an intrabasement feature, most probably associated with the Sybella Granite.

Bouguer anomaly attributable to basement composition and geometry

A calculated Bouguer gravity anomaly - modelled from the basement composition presented in Figure 11, from the basement geometry presented in Figure 15, and from density values consistent with those measured by Hone & others (1982) - correlates well with the observed Bouguer anomaly (Fig. 19), thus lending support to the analysis of basement composition. However, the following points must be noted:

1. The gravity data themselves have been used to extrapolate the extent and lateral boundaries of granitic bodies.
2. A lower-density cell (-0.03 t/m^3) has had to be introduced to develop fully the gravity low west of the most magnetic rock unit. A dome-shaped granitic body with the lower-density value would be one of many possible models to fit the data.
3. The lower surfaces of all major units have been set arbitrarily at 5 km, which therefore controls density contrasts as indicated. Should the lower surfaces be either shallowed or deepened, then density contrasts would need to be increased or decreased respectively to retain data correlation.
4. The Bouguer contour map presented in Figure 6, from which profile XY was constructed, is based on a 7 x 15 km gravity observation grid. This necessarily limits the accuracy of profile XY, particularly with respect to anomaly shape and to a lesser extent anomaly amplitude.

CONCLUSIONS

Analysis of the semi-detailed magnetic and regional gravity data has enabled an interpretation to be made of the relief, structure, and composition of

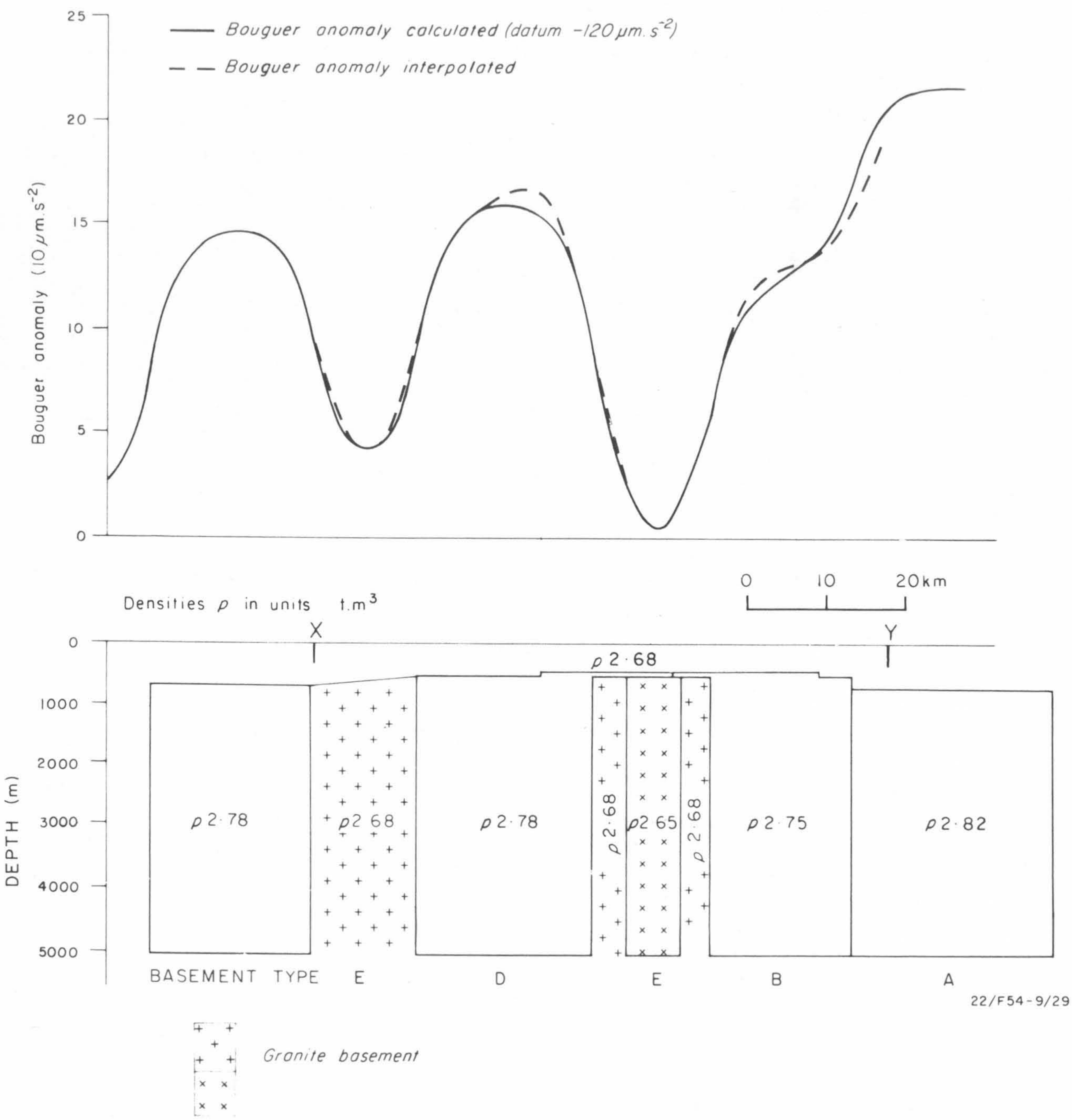

Fig. 19. Comparison of Bouguer gravity anomaly interpolated along section XY (Figure 6) with that modelled from interpreted basement composition and geometry presented in Figures 11 and 15.

Proterozoic basement which underlies the lower Palaeozoic sedimentary rocks in the Glenormiston survey area.

The Proterozoic-Palaeozoic unconformity is interpreted from the magnetic data to form a broad ridge which extends through the survey area from 22°05'S, 139°10°E to 22°43'S, 139°15'E. This ridge pitches to the south from less than 100m below the surface at the northern survey boundary to over 400 m below the surface at the southern survey boundary. The thickest Palaeozoic sections occur in the southwest and southeast corners of the survey area, where section thicknesses of 800 m and 700 m respectively are interpreted. The reliability of the latter estimate is not high owing to the complex character of large magnetic anomalies used for depth analysis.

The Proterozoic basement within the survey area has been divided into four principal rock units. These are equated with a southerly extension of the Jayah Creek Metabasalt adjacent to the eastern survey boundary; to the immediate west, a near-parallel belt which could constitute a southerly extension of the Sulieman Gneiss or alternatively, and more likely, a rock unit showing some similarity to the Jayah Creek Metabasalt unit but with a lower metabasalt content; a small zone which flanks the southern outcrop of the Sybella Granite and which has anomaly characteristics of cross-cutting metabasalt units; and finally, over the western half of the survey area, an extensive basement unit which contains arcuate magnetic anomalies of a similar character to those occurring over the Saint Ronans Metamorphics exposed to the north. The Sybella Granite is interpreted to underlie the eastern extremity of the westernmost basement unit.

The distribution of non-outcropping granite has been interpreted primarily from gravity data. Results obtained are consistent with those presented by Hone & others (1982) in their regional study of the Mount Isa Inlier. Furthermore the results of this more detailed study support Hone &

others' interpretation of the western boundary of the Mount Isa Orogen to the west of the Georgina River, and not east of it as suggested by Tucker & others (1979).

The most obvious basement structure evident in the magnetic data is a suite of lineaments oriented approximately N40°E. These lineaments are interpreted as faults, three of which show displacement of magnetic rock units by up to 3 km in a dextral sense.

Arcuate magnetic anomalies in the most westerly basement unit are interpreted as evidence for the presence of domed magnetic rock units. The contrast between this anomaly form and the prominent parallel linear anomalies over the eastern basement units may delineate a major fault which could be a continuation of the major fault mapped 9 km to the east of the Rufus Fault Zone in the southern part of the Ardmore 1:100 000 Sheet area.

The interpretation presented in this Report should enable hypotheses to be developed to outline the more favourable areas for the possible location of stratabound Pb-Zn mineral occurrences. The intersections of N40°E interpreted faults with the possible major fault marking the eastern boundary of the Sybella Granite must be attractive targets, particularly as the loci of these intersections lie along the interpreted Proterozoic basement high.

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APPENDIX 1

MAGNETIC BASEMENT DEPTH DETERMINATION USING WERNER DECONVOLUTION

The following text has been extracted from a BMR Record written by H. Hsu & L. Tilbury (1977), who developed a computer program for the quantitative interpretation of magnetic data for use within BMR. The process of interpretation involves analyses of magnetic data to provide information about the source of an anomaly. The program was written in FORTRAN IV, and applied successfully to both theoretical and observed marine magnetic data using the CYBER 76 computer at CSIRO's Division of Computing Research. Subsequently the program was extended for use with aeromagnetic data.

The initiative and idea of developing such a program was derived from a document published by Aero Service Corporation (1974) about the technique of interpretation known as Werner deconvolution (Werner, 1953). The model adopted in BMR's interpretation procedure assumes that the observed magnetic field arises from two discrete sources and a quadratic magnetic background.

Theoretical models

The magnetic anomaly produced by a simple rectangular body of 0.038 SI units susceptibility contrast 4 km wide, 2 km thick, and buried to a depth of 1 km is shown in Figure A1, together with its interpretation applying the Werner deconvolution for an interface model. It is apparent that the technique defines the top corners of the bodies extremely well, as shown by the major clusters of estimates. However, the bottom corners are transparent to this method (and to most magnetic inversion methods). Note that outliers occur, even for a simple theoretical anomaly curve. In practice, with many bodies and observed data, these outliers can disguise the true form of the magnetic basement. It is this aspect, of distinguishing between 'good' and 'bad' estimates, that is most difficult in the interpretation.

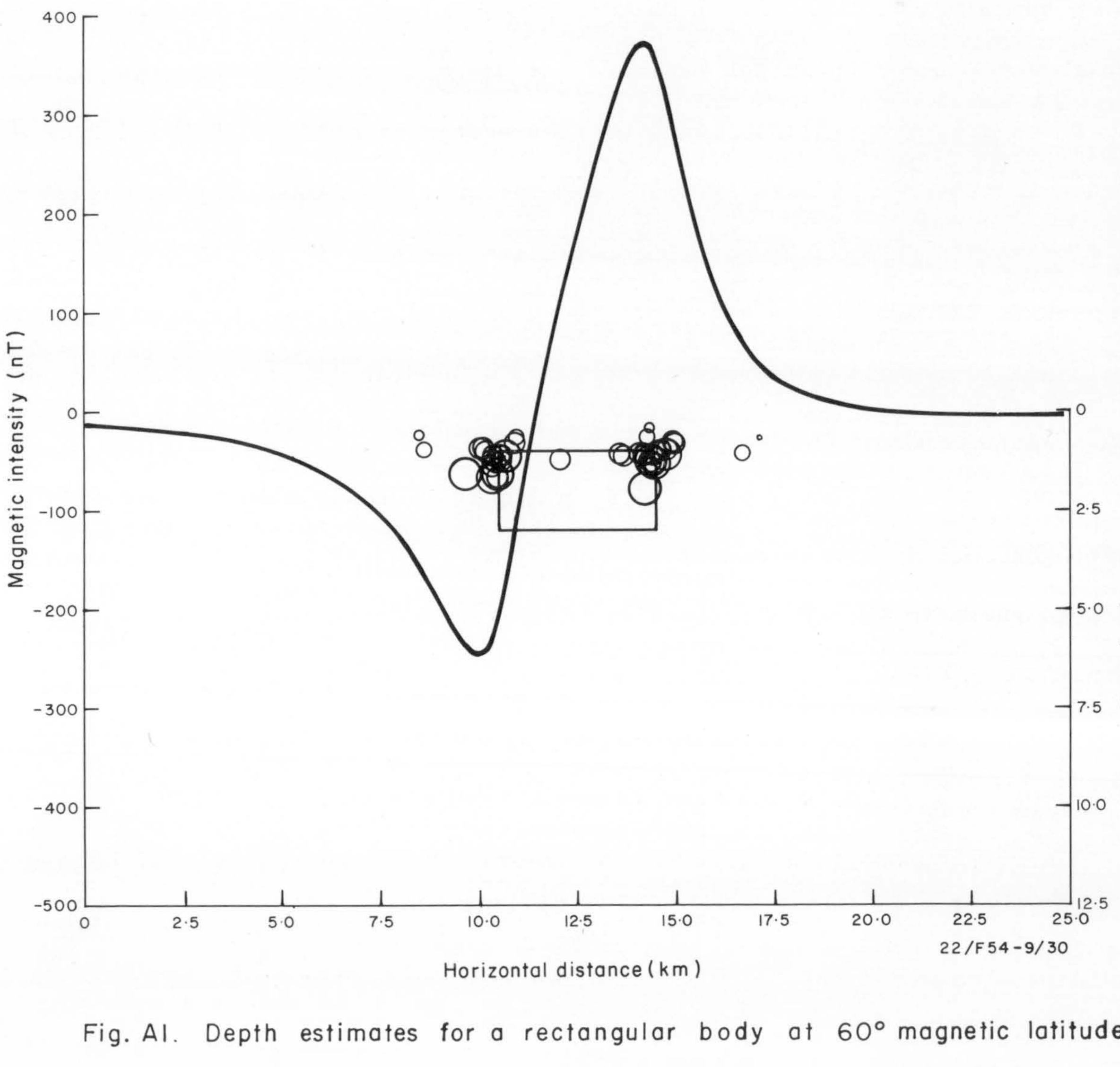

Fig. A1. Depth estimates for a rectangular body at 60° magnetic latitude.

Aero Service Corporation example

A simulated geological cross-section (Fig. A2) - similar to the example of Aero Service Corporation (1974) - was chosen by Hsu & Tilbury (1977) for comparison when testing the Werner deconvolution program. It simulates - from left to right - a reversely polarised vertical dyke, a normally polarised vertical dyke, a normally polarised dipping dyke, a suprabasement plate terminated by small normal faults, a graben with dipping faults (or contacts) on each side, and two vertical interfaces (or contacts) forming a 'well' in the basement. The theoretical anomaly was computed using a susceptibility of 0.013 SI units for the main basement block, susceptibility contrasts of 0.013 SI units for the dykes, and field parameters of 7°E declination, 60° inclination, and 60 000 nT total field.

The results using the interface model option in the Werner program are shown. The top corners of the major interfaces on the graben and 'well' are reasonably well-defined, but the depth extents of these features are poorly expressed. Estimates over the minor features on the section, namely the dykes and small faults, are under-estimated: that is, the depths to the bodies are too shallow, and the clusters are more diffuse.

In general when the interface model can be applied, the surface of the magnetic basement is fairly well represented by a line joining the near-apices of clusters.

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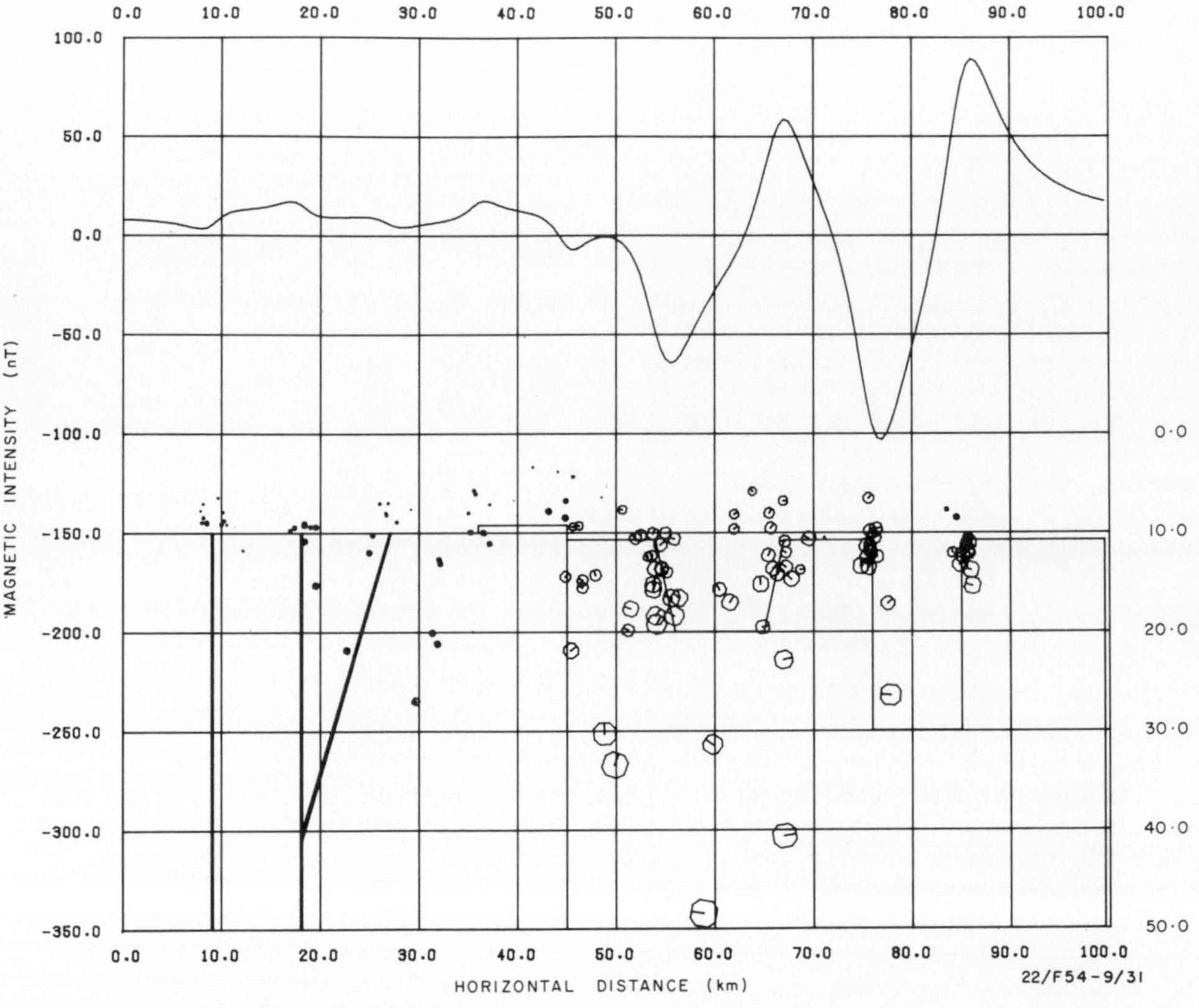

Fig. A2. Depth estimates for Aero Service Corporation example – interface model.

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