BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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GEOPHYSICAL MAPPING OF BURIED PRECAMBRIAN ROCKS IN THE CLONCURRY AREA, NORTHWEST QUEENSLAND

by

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ABSTRACT

In 1975 the Bureau of Mineral Resources carried out a program of geophysical mapping - based on the analyses of existing geophysical, geological, and drilling information, supported by ground geophysical and geological fieldwork - in the eastern part of the Cloncurry 1:250 000 Sheet area, northwest Queensland. The aim of the mapping was to determine the lithology, structure, and depth of burial of the Precambrian Cloncurry Complex beneath a thin cover of alluvium and Mesozoic Carpentaria Basin sediments.

The results of the mapping indicate that Precambrian basement extends at shallow depths - <100 m over most of the survey area, <50 m over half of it - beneath the cover sediments for about 40 km east of the eastern limit of outcrop. The contact between shallow-buried basement and sediments of the Carpentaria Basin is marked by a major fault dipping steeply eastwards. Interpretation suggests that the Cloncurry Complex does not continue beneath the Carpentaria Basin, but gives way to less dense granitic basement east of the fault.

Within the basement complex, the Naraku Granite is interpreted as intruding both the Corella Formation, in which a complex geophysical response suggests contact metamorphism, and the less magnetic rocks of the Soldiers Cap Group with no noticeable contact effect. Dense metabasalts and amphibolites of the Soldiers Cap Group form a distinct zone of Bouguer anomaly highs, which enables them to be mapped in areas of no known outcrop. Localised intense magnetic and gravity anomalies appear to indicate magnetite and hematite-rich rocks in the interpreted contact aureole in the Corella Formation. Fold patterns are complex, and several interpreted major magnetic lineaments appear to be related to granite emplacement.

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*Copies of the plates at their original scale of 1:100 000 may be purchased from the Copy Service, Government Printer (Production), Wentworth Avenue, Kingston, ACT 2604 (GPO Box 84, Canberra 2600).

1. INTRODUCTION

During 1975 the Bureau of Mineral Resources (BMR) carried out a program of geophysical mapping in an area of 1900 km^2 in the eastern part of CLONCURRY* (Fig. 1). The survey area lies to the east of outcropping Precambrian Cloncurry Complex rocks, and is bounded roughly by latitudes $20^\circ 15'$S and $20^\circ 42'$S and longitudes $140^\circ 32'$E and $140^\circ 53'$E. Regional gravity and aeromagnetic data indicate that the survey area is part of an extensive region underlain at shallow depth by Cloncurry Complex rocks. As the Cloncurry Complex contains the major mineral deposits of the Mount Isa/Cloncurry area, the region of buried Precambrian rocks is of potential economic interest.

The purpose of the survey was to investigate the potential of geophysical methods to map the lithology, structure, and depth of burial of Precambrian rocks under thin cover. Geophysical methods used in the mapping program, which was designed around the results of existing geophysical, geological, and drilling results, were magnetic, gravity, resistivity/IP, and rock property measurements. Detailed geological mapping supplemented the geophysical mapping.

Acknowledgement

The assistance of Chevron Exploration Corporation in providing information on the geology and geophysics of the survey area is gratefully acknowledged.

2. GEOLOGY

REGIONAL GEOLOGY

The mainly Middle Proterozoic Cloncurry Complex crops out over an area of about 64 000 km^2 in northwestern Queensland (Fig. 1). It was first mapped, at the scale of 1:250 000, by joint BMR and Geological Survey of Queensland (GSQ) field parties, between 1950 and 1958 (Carter, Brooks, & Walker, 1961), and is currently being remapped by BMR and GSQ geologists at the more-detailed scale of 1:25 000 for map presentation at 1:100 000 (Wilson & Derrick, 1976).

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

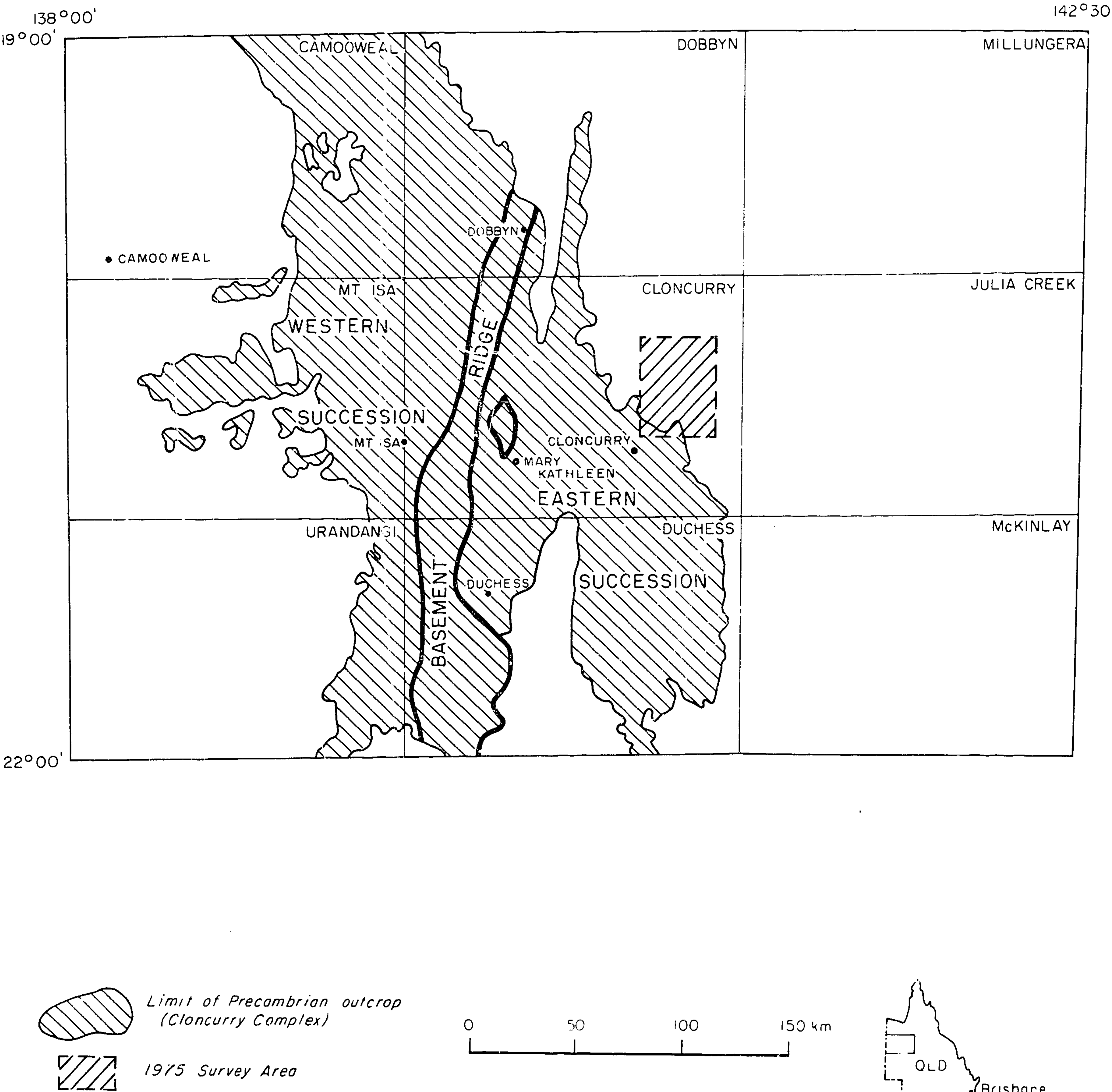

Fig.1 Location map

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The Cloncurry Complex comprises two mainly sedimentary successions which developed contemporaneously in north-trending basins east and west of an older north-northeast-trending acid volcanic and plutonic basement ridge 10-20 km wide (Fig. 1). In the eastern succession, adjacent to the survey area, metavolcanics and metasediments of the Soldiers Cap and Malbon Groups are overlain by mainly calc-silicate rocks (Corella Formation) and slate (Marimo Slate and equivalents) of the Mary Kathleen Group. These units are commonly intruded by granitic plutons and numerous basic dykes, and are complexly folded and faulted. Fold patterns are in general disrupted by faulting and granite intrusion.

Most of the rocks of the Cloncurry Complex have been metamorphosed to the upper greenschist grade. In the eastern succession, small areas of amphibolite-grade metamorphic rocks occur in zones surrounding granite intrusions, such as round the Naraku Granite 50 km northwest of Cloncurry.

The Cloncurry Complex is overlain by Palaeozoic, Mesozoic, and Cainozoic sediments, which form a thin cover around the edges of the outcropping complex. From the eastern edge of the Cloncurry Complex the Mesozoic sediments thicken eastwards and form part of the Carpentaria Basin (Doutch, Ingram, Smart, & Grimes, 1970; Grimes, 1972; Smart, Grimes, Doutch, & Pinchin, in prep.).

Important mineral discoveries have been made throughout the Cloncurry Complex. Copper is the most common mineral in the eastern succession, and many deposits containing up to 1000 tonnes of copper have been mined, much of it from the Corella Formation and Marimo Slate. The copper mineralisation appears to be localised by faults or basic igneous intrusions, or both, although some stratabound mineralisation does occur (Wilson, Derrick, & Hill, 1972).

LOCAL GEOLOGY

The outcrop geology within the survey area is presented in Plate 1. This information is based on recent detailed mapping by BMR (Glikson & Derrick, 1970; Glikson, 1972; Derrick & Hill, 1976; Hill, Wilson, Glikson, & Derrick, in prep.)

Outcrop of Precambrian rocks is restricted to the south and west of the survey area. In the south the most extensive unit is the Toole Creek Volcanics, which is the upper formation in the Soldiers Cap Group and consists of dense amphibolites and metabasalts. Conformable below this unit is a steeply dipping sequence of impure feldspathic quartzite, shale, and banded iron formation, which forms the upper part of the Mount Norna Quartzite - the middle formation of the Soldiers Cap Group. To the north of these Soldiers Cap Group rocks, and unconformably overlying them, are calc-silicate breccias of the Corella Formation.

In the west of the survey area, the Corella Formation is intruded by the polyphase Naraku Granite, a medium-grained porphyritic biotite granite. A broad northeast-trending zone of intermixed Corella Formation and Naraku Granite indicates a shallow southeast-dipping contact zone in which the calc-silicates appear to be hornfelsed. Less extensive outcrops of granitic rock occur at Mount Margaret in the east, and along the Cloncurry River north of Mount Fort Constantine.

Intrusions of dolerite into Soldiers Cap Group rocks form dykes and sills, some of which are olivine-bearing and appear to be unmetamorphosed. Large irregular intrusions of dolerite are also common in the Corella Formation.

Small isolated outcrops of banded magnetite and hematite-rich rocks occur near the southern edge of the survey area and extend in a northeasterly direction to Castle Rock, roughly following the zone of intermixed Corella Formation and Naraku Granite. Similar outcrops of magnetite occur irregularly between Castle Rock and Mount Fort Constantine, and outside the survey area at Mount Leviathan (Black Mountain), 3 km southwest of Cloncurry (Derrick, Wilson, Hill, & Mitchell, 1971; Derrick, in prep.). Many of the magnetite outcrops outside the survey area appear to contain bedded iron-rich metasediments similar to the banded iron formations within the Soldiers Cap Group; in contrast, the magnetite-hematite bodies in the survey area appear to be closely related to the zone of intermixed granite and Corella Formation.

The main rock type at Mount Fort Constantine consists of angular, possibly porphyritic clasts of fine-grained pink siliceous rock in a matrix of fibrous actinolite. These rocks may be of acid volcanic origin (possibly agglomerate), but this is still uncertain, and they cannot be correlated with other known formations in the region.

The remainder of the survey area largely consists of black-soil plains and alluvium which, farther east, cover flat-lying Mesozoic sediments (generally conglomerate, sandstone, and mudstone) of the Carpentaria Basin. In the centre of the survey area the Precambrian basement appears to be covered by only a thin veneer of young sediments.

Mineralisation in the survey area includes copper, which has been mined at Monakoff from quartzose metasediments containing borite and fluorite adjacent to a banded iron formation just below the Toole Creek Volcanics; these metasediments also have high radioactivity (field scintillometer observation). Small, rare malachite-stained gossans crop out in the Corella Formation southeast of Castle Rock. Copper and alluvial gold deposits have been worked south of the survey area (Carter & others, 1961; Glikson & Derrick, 1970), and more recently stratiform lead-zinc mineralisation has been discovered in the Soldiers Cap Group south of Cloncurry (Derrick, 1976).

Several companies have recently explored parts of the survey area for minerals. Data from an extensive program of shallow drilling by Chevron Exploration Corporation in 1974, and from local water-bores, are presented in Appendix 1, and illustrated in Plates 1 (generalised basement rock types) and 2 (depths to Precambrian basement). The Chevron holes were drilled by rotary rigs, did not core, and mostly penetrated only a few metres into the top of the Precambrian basement.

The subsurface geology interpreted from drilling indicates several areas of granitic basement, the most prominent occurrence being adjacent to the outcropping Naraku Granite in the west of the area. Granite penetrated in several boreholes in the centre and northwest of the area appears to be surrounded by metasediments, which were intersected in adjacent holes; these holes may have penetrated a zone of intermixed granite and Corella Formation. Basic (basaltic or doleritic) rock, intersected in many of the holes, appears to be common throughout the area.

3. BACKGROUND GEOPHYSICS

GRAVITY

From several reconnaissance helicopter gravity surveys between 1957 and 1966, BMR has established a regional gravity station network based on an 11-km grid over the Cloncurry region (Flavelle, 1965; Gibb, 1967; Darby & Vale, 1969; Shirley & Zadoroznyj, 1974). Data from these surveys form the basis of the regional Bouguer anomaly contour map (Fig. 2) which covers most of the Cloncurry Complex.

The main feature of the gravity data is a broad north-south-trending positive Bouguer anomaly zone outlined by the 0 mGal contour. This gravity zone coincides roughly with the outcrop of the Cloncurry Complex. The Bouguer anomaly highs within this zone may correlate with either basic intrusives or areas of metamorphic rocks of the eastern sedimentary succession; for rocks of the Corella Formation, Tucker (1975) has calculated a 'bulk density estimate' of 2.89 g/cm^3, which is higher than average for metasediments. Bouguer anomaly lows within the Cloncurry Complex coincide in general with granitic intrusions (Darby & Vale, 1969). The areal extent of Bouguer anomaly lows suggests that the Cloncurry Complex is intruded by a larger proportion of granitic rocks than indicated by outcrop.

In the east of CLONCURRY, Bouguer anomaly highs in the north-south gravity zone extend well into areas of Cainozoic cover, indicating the presence of dense rocks at shallow depths. Near the eastern edge of CLONCURRY, the eastern extent of these shallow-buried basement rocks is clearly represented by a sharp north-northwest-trending gradient in which Bouguer values decrease by about 2 mGal/km.

AEROMAGNETIC

In 1973, BMR made an airborne magnetic and radiometric survey of CLONCURRY along east-west flight lines 1.5 km apart and 150 m above ground level (Tucker, 1975). Contoured aeromagnetic data from this survey (Fig. 3) indicate strong, shallow-source anomalies over most of the Precambrian outcrop. The eastern extent of these anomalies is well into

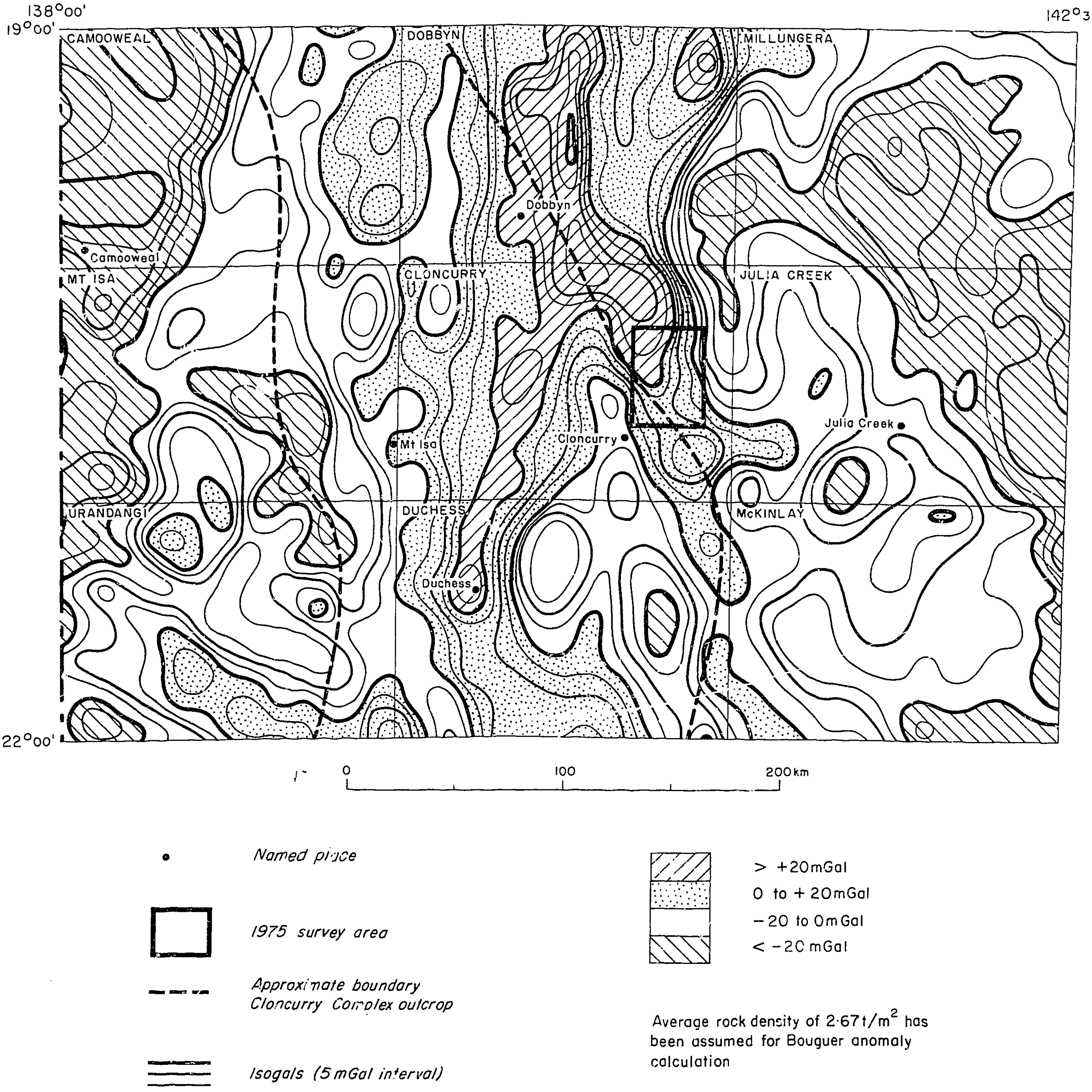

Fig.2 Regional Bouguer anomalies, Mount Isa / Cloncurry area

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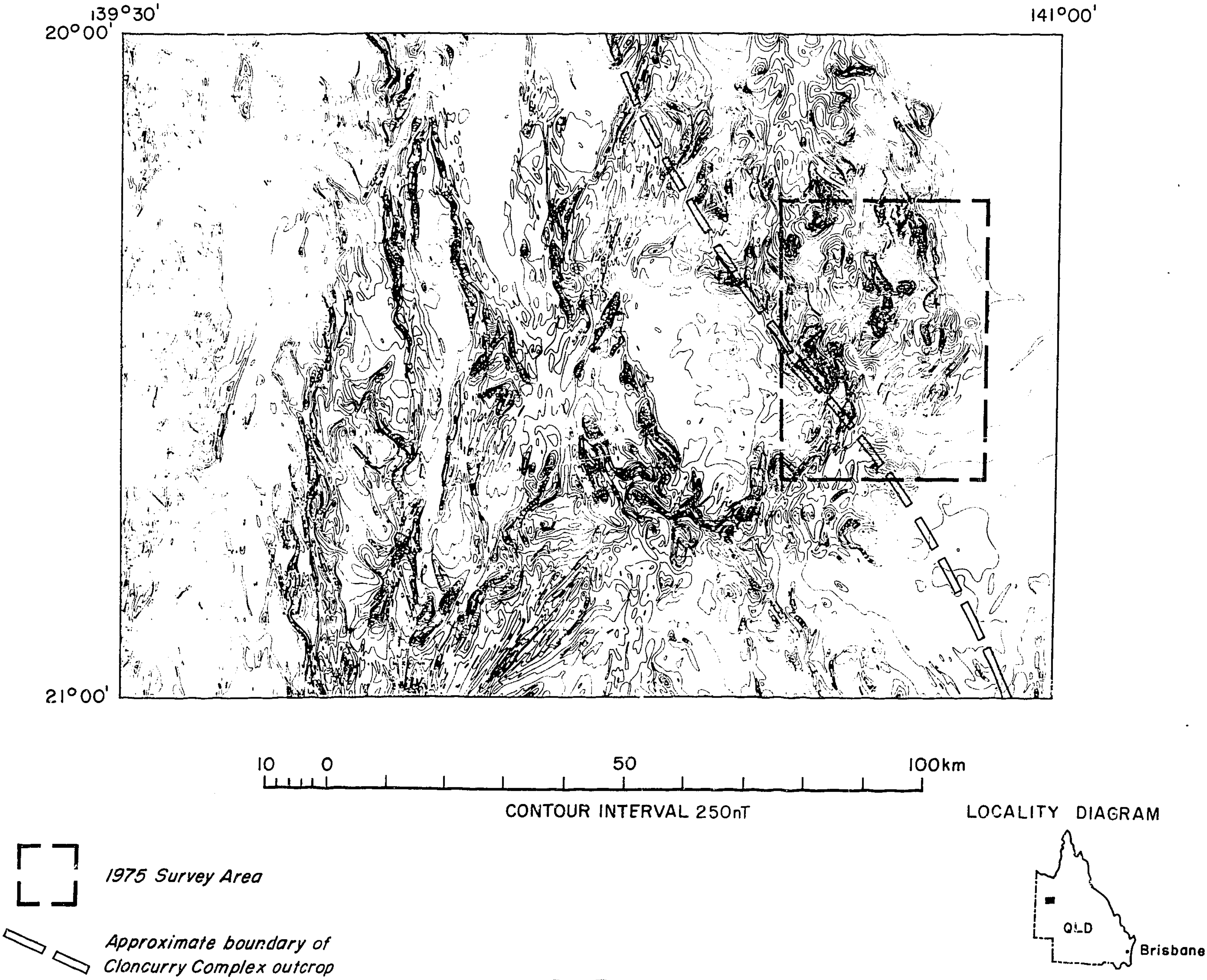

Fig.3

Aeromagnetic contours

(based on map F 54/B1-121), CLONCURRY

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the area of Cainozoic cover, and corresponds to the easterly limit of the positive Bouguer anomaly zone outlined by the regional gravity results. The magnetic anomalies tend to be linear, with north to northeast and northwest trends, and are consistently associated with areas containing Corella Formation rocks. Tucker (1975) has interpreted these anomalies as typical of steeply dipping, inductively magnetised tabular bodies, such as metamorphosed rock units parallel to the sedimentary layering, cross-cutting basic dykes, and possibly magnetic material in faults.

In general, granites have little magnetic response. Linear anomalies over known plutons may be caused by basic intrusives or metamorphic roof pendants. The contact between the Naraku Granite and Corella Formation is associated with linear magnetic features. Some anomalies up to 2000 nT in amplitude appear to be associated with faults. High-amplitude anomalies tend to be associated with rocks exhibiting high metamorphic grade. Tucker's interpretation suggests that the sources of anomalies below the Cainozoic cover are in general steeply dipping beds at depths of 100 to 500 m.

RADIOMETRIC

The 1973 BMR airborne survey of CLONCURRY also recorded four-channel gamma-ray spectrometer data (Tucker, 1975). Many radiometric anomalies are associated with outcropping Corella Formation, Marimo Slate, and granite. Only a few anomalies - generally associated with small granite outcrops - are evident in the eastern third of the Sheet area, where the widespread cover of alluvium masks the response of the buried rocks.

GROUND GEOPHYSICAL SURVEYS

In 1973, BMR (Ogilvy, 1978) made a resistivity depth-sounding and profiling survey over buried Soldiers Cap Group rocks immediately south of the 1975 BMR survey area, in order to determine whether resistivity would be a useful method to map Precambrian basement beneath 100 to 200 m of sedimentary and alluvial cover. The survey showed that reliable estimates of the depth to basement could be made from vertical electrical soundings (VES) using either the Schlumberger or equatorial dipole arrays. However, neither VES nor profiling techniques were effective in mapping lateral lithological changes in the basement.

More recently, Chevron Exploration Corporation made about 35 VES in the western part of the 1975 survey area. Using an inverse computer-modelling program developed by A.A.R. Zohdy of the US Geological Survey (Zohdy, 1975), BMR re-interpreted the results (see Appendix 2). The solutions indicated several layers at all the VES sites, and at most sites the top of the basement was apparent. At some of the sites, however, no reasonable depth to basement could be determined as the VES curve could not be interpreted in terms of a horizontally layered section. Plate 2 shows the VES locations in the survey area, and the calculated basement resistivities and depths to basement. The VES depths to basement were generally 10 to 30 m more than the depths at which the basement was intersected in the boreholes, suggesting that the top of the basement is considerably weathered.

The VES curves of both Ogilvy and Chevron suggest that basement rocks have a much higher resistivity than overlying Mesozoic sediment . However, most of the downhole single-point resistance logs made by Chevron as part of their drilling program show little contrast in resistance between the sediments and the top of the basement; this is consistent with weathering of the basement, as indicated by the VES results. A contrast in the single-point resistance log might have been evident had the holes penetrated more than 30 m into the basement.

Induced polarisation (IP) surveys by BMR 50 km west of the survey area in 1972 and 1973 (Sampath & Ogilvy, 1974) indicate that exposed Cloncurry Complex rocks have resistivities of 200 to 2000 ohm-m. Frequency effects of about 2% were recorded over Corella Formation rocks.

PHYSICAL PROPERTY MEASUREMENTS

Laboratory determinations of electrical properties and densities have been made on samples of Precambrian rocks collected from the Cloncurry area (Sampath & Ogilvy 1974). In general these measurements indicate that igneous rock, calc-silicate (Corella Formation), and coarse-grained siliceous rock (quartzite) are resistive, whereas finer-grained metasediments (shale and siltstone) are relatively conductive. Induced polarisation effects for samples of the Corella Formation and Soldiers Cap Group were generally low. The density data do not clearly define the various rock types and formations, possibly owing to inadequate sampling. The results of density and magnetic susceptibility measurements made on these rock samples are included as Appendix 3A.

Density measurements on samples of similar rock types from the Dobbyn area, about 100 km northwest of Cloncurry, provide a more useful guide to the anticipated variations. These data, which aided the interpretation of a detailed gravity survey of the Dobbyn area (Smith, 1966), indicate that density contrasts between the Naraku Granite (average density = 2.58 g/cm^3) and the main rock types of the Corella Formation (2.72), quartzite units (2.66), and Toole Creek Volcanics (2.94) are quite distinct.

4. FIELDWORK AND RESULTS

Previous geophysical surveys indicate that gravity and magnetic methods are the most useful tools for mapping the buried Precambrian basement. To support the interpretation of the existing magnetic and gravity data, BMR carried out a field program of gravity, ground magnetic, rock property, and resistivity/IP measurements, and geological mapping. Much of this work was along detailed and semi-regional traverses (Plate 3).

As the density of granite is distinct from that of most of the metamorphic rocks in the Cloncurry Complex, the program included gravity measurements, but at stations closer to one another than those in the regional network in order to map more accurately the extent of the granite. Similarly, because of the high magnetic susceptibility contrast between some metamorphic rocks, the program included ground magnetics to identify and assist in the mapping of metamorphosed units.

The results of previous electrical surveys by BMR and Chevron suggested that such work did not have widespread application as a regional mapping tool. Nevertheless electrical methods were included in the program because they do have the potential for determining depths to basement and for detailed mapping in areas of thin cover.

SURVEY CONTROL

Detailed traverses

Surveyors from the former Department of Services and Property, Canberra, worked with BMR during the 1975 survey and accurately located and pegged traverses as required. the traverses were positioned where possible along the Australian Map Grid (AMG) Zone 54 grid lines, and thus were restricted in direction to either north-south or east-west.

Traverse names (in kilometres) and station numbers (in metres) relate directly to grid position. For example, traverse 39N is an east-west traverse along grid line 39 000 m north, which was surveyed (as indicated in Pl. 3) between stations 66 700E and 71 000E. Note that station 69 500E on traverse 39N is at the same position as station 39 000N on traverse 69.5E (a north-south traverse along grid line 69 500 m east).

Traverses were pegged at 100-m intervals. Permanent steel markers were placed at each end of a traverse. Elevations were measured at each peg to an accuracy of 0.1 m. These elevations were then tied to a known spot height to give an absolute elevation for each traverse to an accuracy of about ± 1 m. The relative accuracy of the position of each peg on a traverse is ± 0.5 m, and the absolute accuracy of the position of a traverse is ± 10 m.

Semi-regional work

Semi-regional traverses (Pl. 3) - generally along tracks and fences - supplemented the detailed traverses, whose results could then be interpreted more significantly in terms of the interpreted structural setting and lithological distribution of the large area under investigation. The positions of stations were identified from landmarks (bores, trig points, fence intersections, etc.) on maps or airphotos; the distances between adjacent stations were measured on the odometer of the traverse vehicle: and traverse directions were read off a prismatic compass.

The location of a station on a semi-regional traverse is generally accurate to ± 100 m, although some stations may be misplaced by as much as 300 m. The gravity stations were barometrically levelled to an accuracy of about ± 2 m.

GRAVITY

Instruments used for this work were a Worden gravity meter (No. W140), and a Sharpe gravity meter (No. S145), which has better instrument drift characteristics. Scale values were determined at 0.102 and 0.099 mGal/scale division respectively. For all reductions, the value of 0.1 mGal/s.d. was adopted. A Bouguer density of 2.67 g/cm^3 was used throughout. All reduced readings were tied to a first-order gravity station (5099.9955) at Cloncurry airport.

On detailed traverses, gravity measurements were recorded at 50-m intervals. Elevations of stations between the accurately levelled 100-m pegs were interpolated. In areas of steep terrain (traverses 16N and 17N), only readings at levelled stations (100-m pegs) have been reduced, since elevation errors at intermediate stations may be substantial. Where gravity readings showed little variation along a traverse, station spacing was also increased to 100 m.

On semi-regional traverses, readings were taken every 500 or 1000 m. Elevations were determined by comparing barometric readings taken at each gravity station with a set of reference microbarometer readings taken every 10 minutes at a convenient base station positioned on a known spot height; elevations so determined have an accuracy of about ± 2 m.

Results

A 1:100 000 Bouguer anomaly contour map produced from the semi-regional data shows a variation of about 50 mGal from northwest to southeast (Plate 4). Some steep gradients are apparent, making it difficult to isolate residual high and low features; for example, a typical gravity profile from semi-regional traverse C (Fig. 4) indicates two residual peaks on a steep regional gradient, but the anomalies are not conspicuous on the Bouguer anomaly contour map.

The more useful profile in Figure 4 then is the residual anomaly, which was obtained by subtracting a regional gradient from the Bouguer anomaly. Residual anomaly maps were computed by calculating a polynomial surface which approximates the regional Bouguer anomaly data, and then subtracting this surface from the detailed Bouguer anomaly map; Skeels

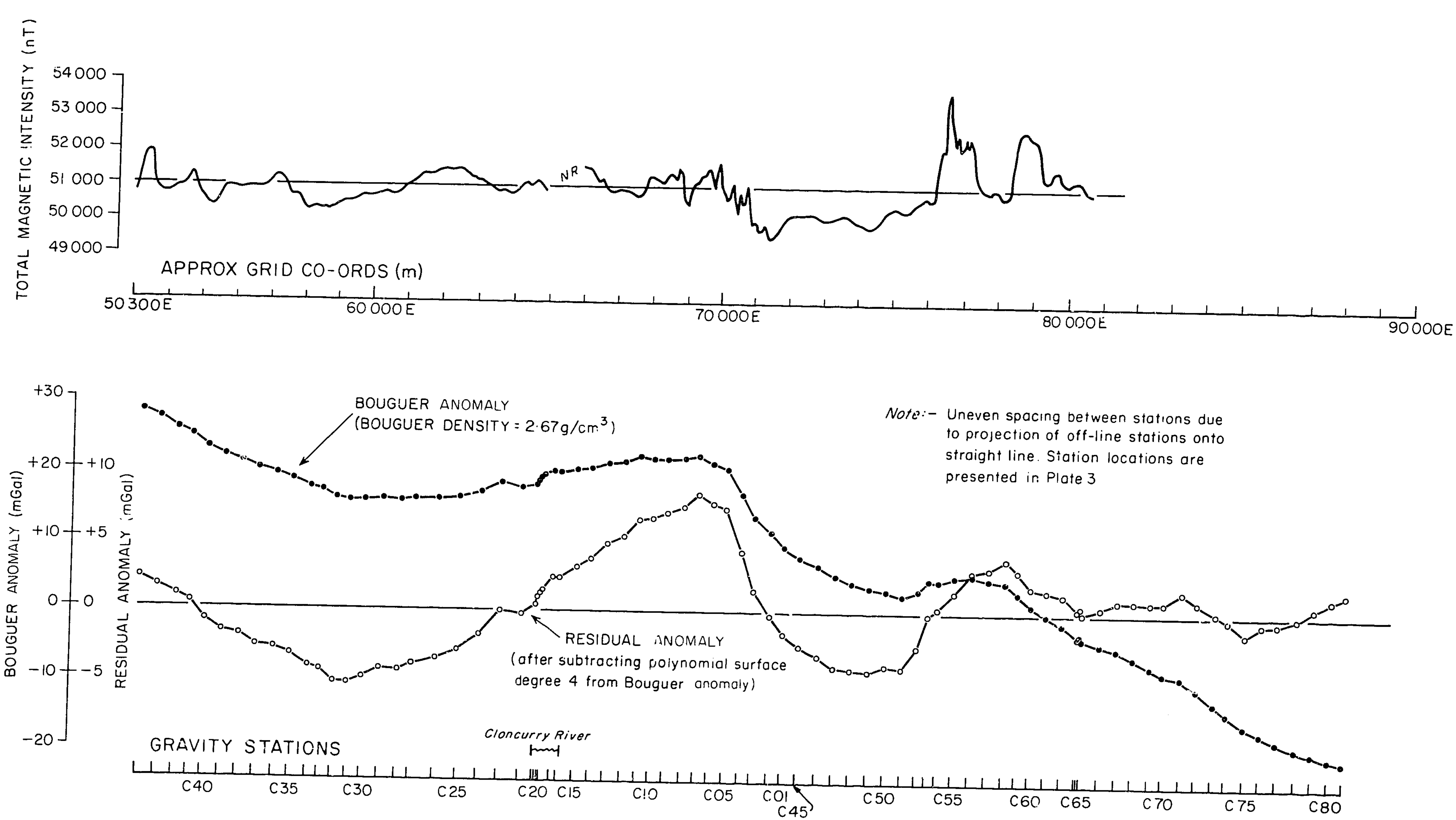

Fig. 4 Traverse C : magnetic and gravity results

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(1967) has briefly described this technique and the problems associated with its application. Polynomial surfaces for degrees 1 to 8 were computed; that of degree 4 was found to represent a good approximation to the regional gravity field for the survey area, and is shown in Figure 5. A 1:100 000 residual anomaly map (Pl. 5) derived by subtracting the polynomial surface of degree 4 from the Bouguer anomaly map retains the essential features of the Bouguer anomaly map, but also enhances many small anomalies.

A comparison of the outcrop and borehole geology with the gravity results indicates that low-density acid intrusives produce broad Bouguer and residual anomaly lows, whereas the significantly denser rocks of the Toole Creek Volcanics, parts of the Corella Formation, and dolerite intrusives account for the residual highs. The residual highs tend to be more linear than the residual lows.

A series of residual highs which tend to 'drape' around a broad low in the north of the survey area illustrates the difficulty of interpreting the gravity data. The semi-circular pattern of highs suggests a folded sequence of metamorphic rocks, but, more likely, it simply defines the boundary of a granite body producing the residual low.

Gravity data from the detailed traverses are presented in Plate 6 as Bouguer anomaly and residual anomaly profiles. The residual anomaly profiles were produced by subtracting the value of the polynomial surface of degree 4 (calculated from Fig. 5 for each station) from the Bouguer anomaly value. To enhance the variations in the residual anomaly profiles, they are plotted at a vertical scale larger than that of the Bouguer anomaly profiles.

GROUND MAGNETICS

Along most traverses, total magnetic intensity measurements were recorded on a Geometrics G-816 portable proton precession magnetometer with the sensor 2.4 m above the ground. The accuracy for this instrument is normally ±1 nT, but where the local magnetic field exceeded the gradient tolerance of the instrument (e.g., over Mount Margaret in the east, and near outcropping magnetite bodies) the readings - if taken - are less accurate. Owing to the occurrence of steep magnetic gradients and very large anomalies

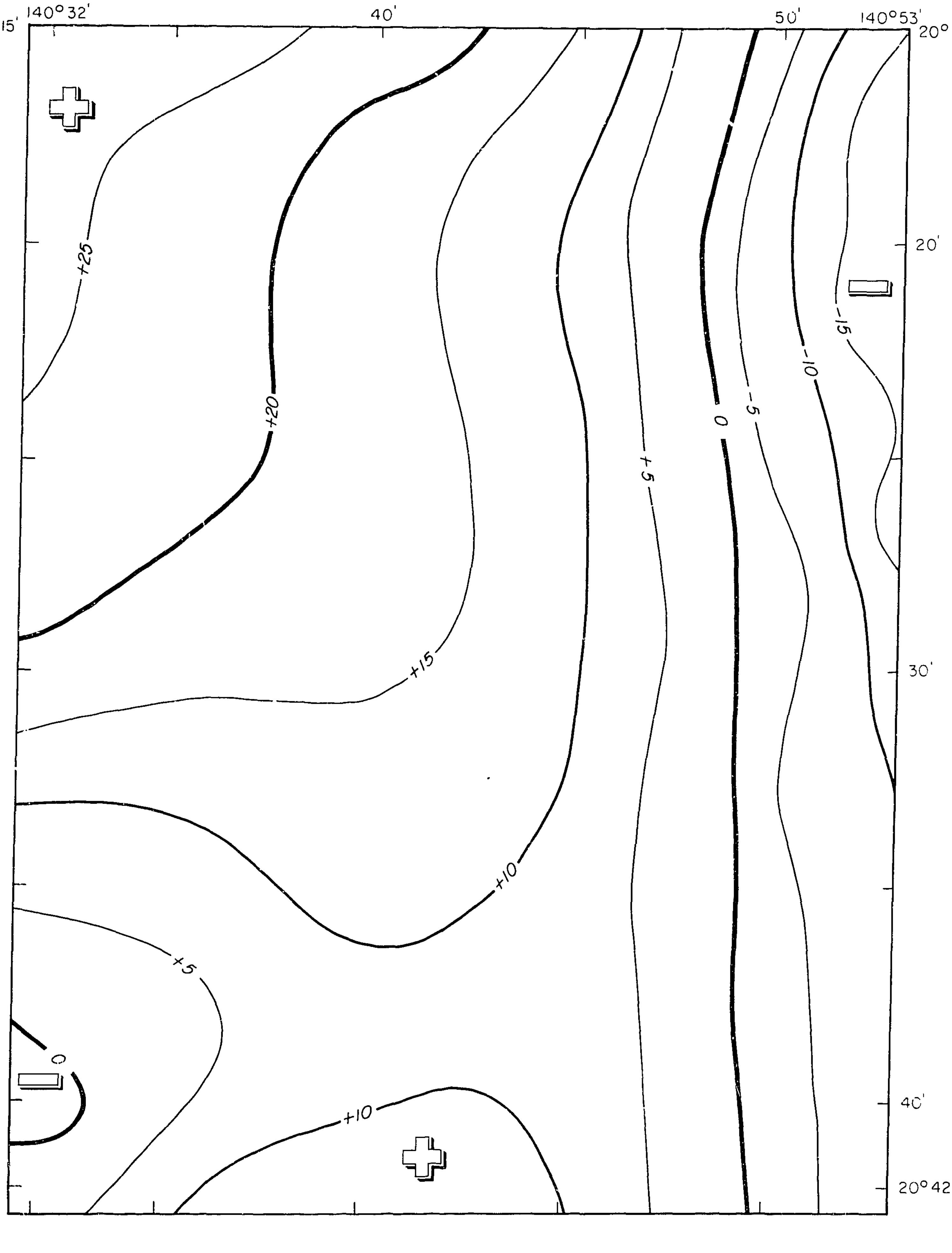

Fig. 5 Regional gravity contours derived from polynomial surface of degree 4

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(over 10 000 nT in places), the tuning of the instrument had to be checked continually. Provided that this tuning was achieved, the measurements in areas of extreme magnetic disturbance are still accurate to ± 10 nT.

Along detailed traverses, magnetometer readings were generally recorded every 25 m, or 50 m in magnetically quiet areas. On semi-regional traverses, the stations were about 50 m apart.

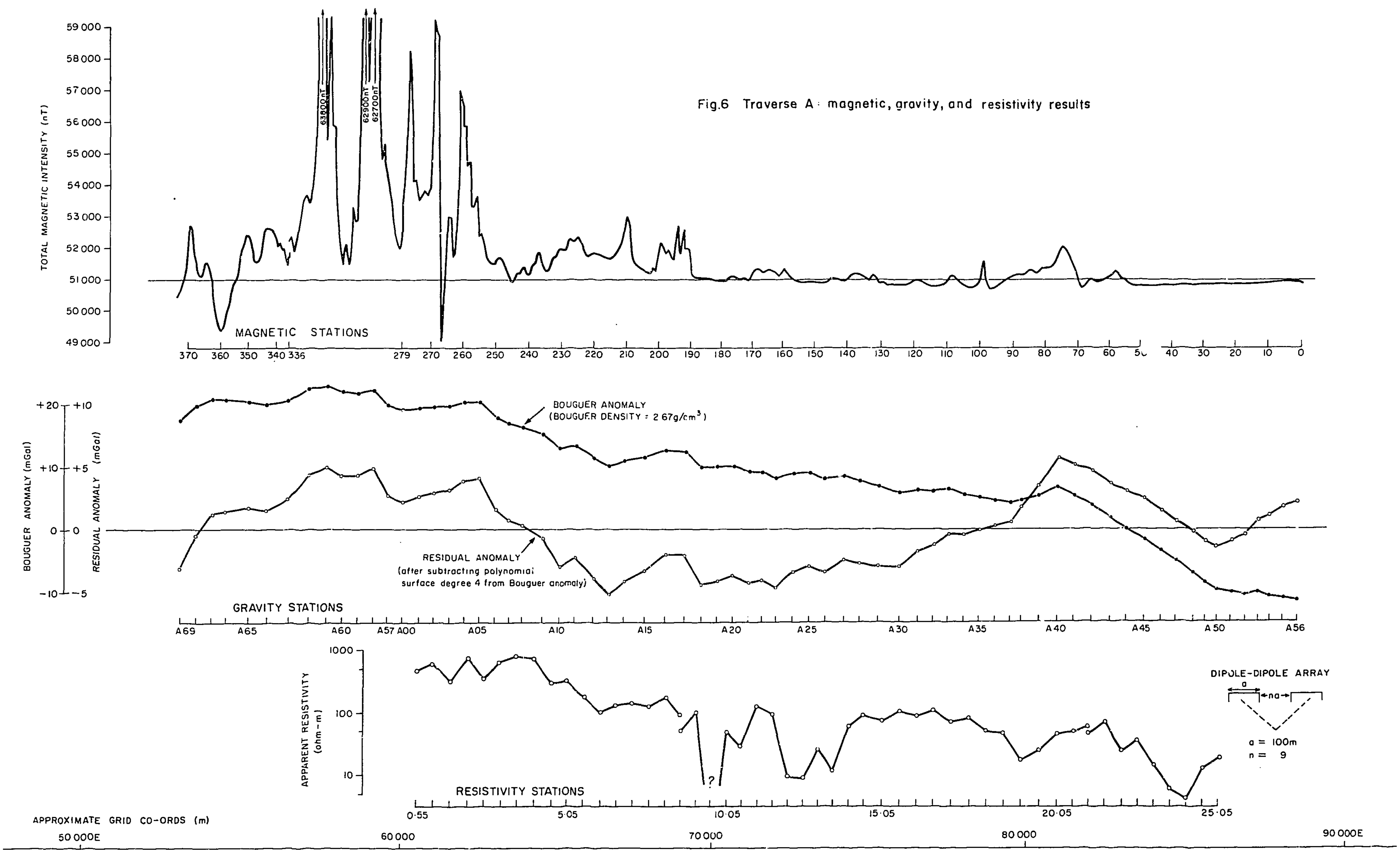
Results

Much of the ground magnetic work was designed primarily to supplement results from an analysis of the 1973 aeromagnetic data. This analysis constituted an integral part of the mapping program, and included interpretation of raw-data profiles, and of contour maps covering the survey area. Aeromagnetic contours are presented in Plate 7. Ground magnetometer results from all detailed traverses within the survey area are presented as profiles in Plate 8. Profiles for semi-regional traverses C and A are presented in Figures 4 and 6 respectively.

The highly disturbed aeromagnetic contour pattern appears to be a simplification of the more-complex magnetic patterns derived from the ground magnetic traverses. Most magnetic sources appear to be shallow and heterogeneous. Very strong magnetic sources appear to have a short strike length. The aeromagnetic data provide a good general picture of the distribution of magnetic sources, but it is not possible to use the aeromagnetic contours to define the geometry or magnetic susceptibility of individual magnetic sources. The aeromagnetic map indicates extensive areas of strong, linear anomalies surrounding zones of weaker magnetic response. This pattern in general represents magnetic rock units within a folded and faulted metamorphosed sequence which is intruded by less-magnetic granite.

The largest magnetic anomalies, recorded from both ground and airborne surveys, appear to be associated with the small isolated magnetite/hematite concentrations shown in Plate 1. Flight lines of the airborne survey (Tucker, 1975) pass over two of these concentrations - at 62 200E/30 000N and 500 m southeast of Mount Fort Constantine (Pl. 1) - which show up on the contour map as areas of exceptionally strong magnetic disturbance. However, the strength of the aeromagnetic response of these

Fig.6 Traverse A: magnetic, gravity, and resistivity results



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magnetite/hematite concentrations would depend on the composition and magnetic properties of their host rock, their position in relation to the flight lines, and their size. Aeromagnetic contours indicate that the magnetite/hematite outcrops at Castle Rock and at 64 800E/28 200N lie on a different belt of aeromagnetic anomalies in a band of moderately magnetic rocks; as the flight lines do not pass directly over these bodies, they do not show up as unusually strong anomalies, suggesting - as inferred from the geological mapping - that the magnetite/hematite bodies are discrete concentrations. The anomalies associated with the bodies at 62 200E/30 000N and near Mount Fort Constantine are similar to other large anomalies in the area, suggesting that other magnetite concentrations occur at shallow depths beneath the black-soil plains.

In the interpretation of the magnetic data, it is necessary to avoid placing too much emphasis on these highly magnetic local features, particularly as the magnetite concentrations may be unrelated to stratigraphy. The intense anomalies associated with such features would tend to conceal more subtle variations caused by lithological changes.

ELECTRICAL SURVEYS

Vertical electrical soundings

The results of Schlumberger array VES yielded no positive information on lateral variations in resistivity. Appendix 2 documents these results, and Plate 2 shows the interpreted depths to basement and basement resistivities.

Resistivity/IP profiling

Electrical profiling using dipole-dipole arrays was carried out along semi-regional traverse A and traverses 17N, 18N, and 36.25N. The results, together with the detailed gravity and magnetic results, which provide a guide to the geology, are presented in Figures 6 to 9.

Traverse A (Fig. 6). This traverse extends roughly east-west across the centre of the survey area (about 33 000N). Extensive outcrop of Naraku Granite west of 55 000E coincides with a decrease in gravity anomaly values and a moderately disturbed magnetic response. The outcrop at Mount Fort Constantine (59 000E) occurs in the centre of a zone of highly disturbed magnetic response and increased gravity anomaly values. Outcrop along the remainder of the traverse is concealed, although the gravity high at 81 000E occurs only 6 km south of the exposed granitic rocks at Mount Margaret. The rock type and depth of the buried basement changes abruptly at about 83 000E, as indicated by the sharp change in magnetic response and rapid decrease in gravity anomaly values.

Resistivity measurements, using a Geoscience IP transmitter (signal frequencey 0.1 Hz), in conjunction with a Fluke d.c. high-impedance millivoltmeter (connected to a Moseley chart recorder) as reciever, were recorded at 500-m intervals along this traverse between 60 000E and 86 000E. This instrumentation is sensitive enough to resolve small signals through a background of relatively high-amplitude noise. A dipole-dipole array was used with 100-m dipoles and a constant separation of 1000 m between the centres of the dipole pairs. This large separation was used in an attempt to obtain information about basement resistivities by minimising the effects of resistivity variations of the Mesozoic cover.

Resistivities decrease from 1000 ohm-m to about 10 ohm-m from west to east across the area. This is probably caused by a thickening of lower-resistivity overburden to the east. A significant resistivity low at about 70 000E may represent the contact between granite and low-density metamorphic rock. An abrupt change in the magnetic pattern is also observed in this vicinity. The edge of the Cloncurry Complex basement at 83 000E corresponds with a sharp decrease in resistivity.

Traverse 17N (Fig. 7). Precambrian rocks are exposed along much of this detailed traverse, therefore providing good control for interpretation. Corella Formation rocks have been mapped at the western end of the traverse, and Soldiers Cap Group rocks at the eastern end. A supposed contact between the two mapped near 64 000E (Glikson & Derrick, 1970) has proved to be the boundary between two rock types in the Mount Norna Quartzite of the Soldiers Cap Group - a quartzite unit to the west and a shale and siltstone band to the east (R.M. Hill, BMR, personal communication 1978). The contact between the quartzite and Corella Formation farther west (at about 63 500E) does not produce significant magnetic or gravity anomalies: in general, the difference in magnetic

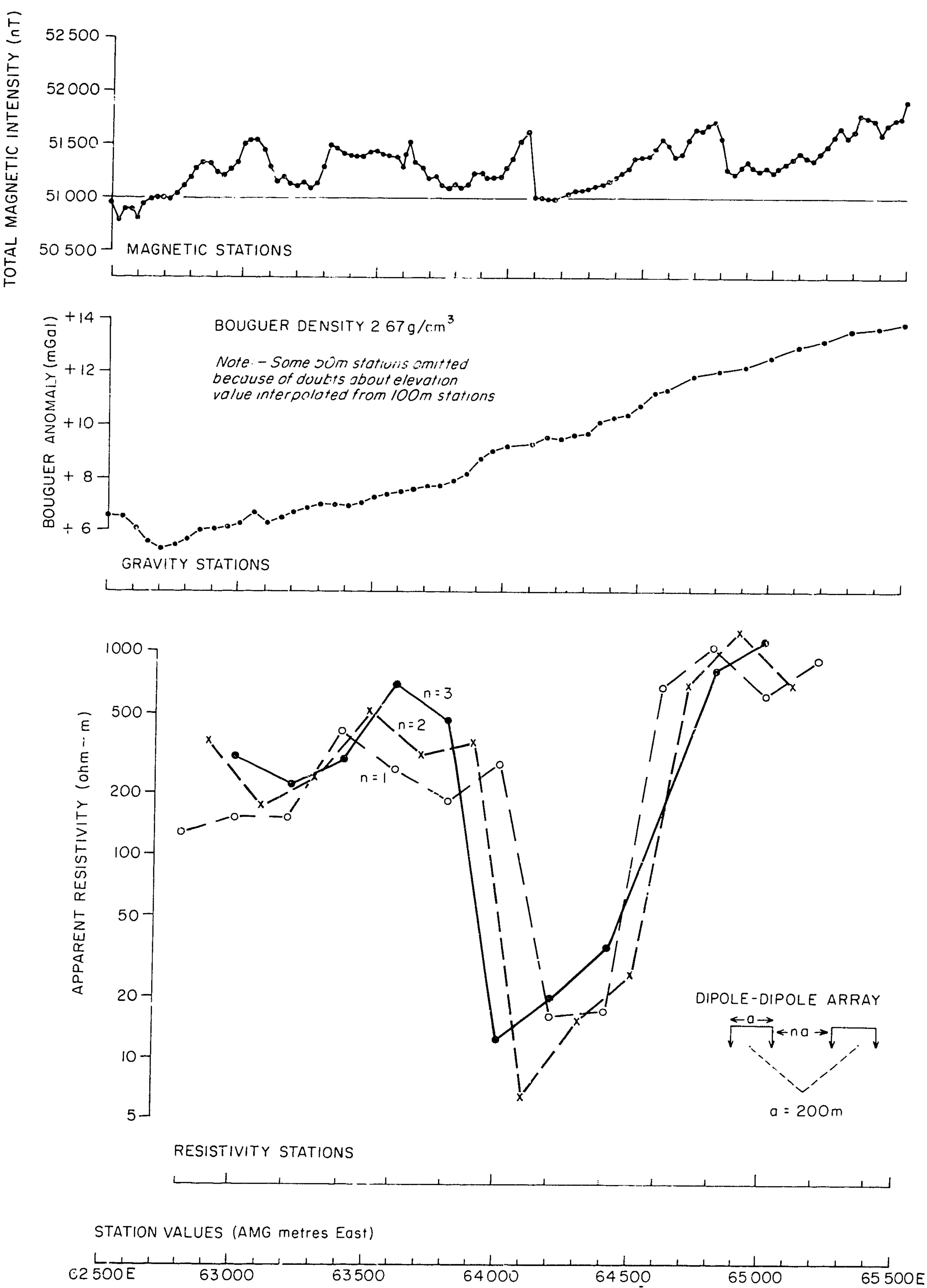


Fig. 7 Traverse 17N: magnetic, gravity, and resistivity results

F54/B7-83A

character between the Corella Formation and Soldiers Cap Group near their contact appears to be small, but the gravity anomaly values increase significantly toward the denser Toole Creek Volcanics, which crop out east of 65 500E.

Resistivity readings, taken with a Geoscience IP transmitter and McPhar IP receiver using 200-m dipoles and n = 1, 2, and 3 (Fig. 7), indicate a distinct low-resistivity zone (readings less than 20 ohm-m) between 64 000E and 64 500E, bounded to the west by moderate resistivities (100-600 ohm-m) and to the east by higher resistivities (greater than 600 ohm-m).

The low-resistivity zone, which is also characterised by high IP values (frequency effects greater than 6%), correlates well with the shale and siltstone band in the Mount Norna Quartzite. This band contains minor pyrite, which may be related to the mineralisation at the Monakoff mine - to the northeast - since both occur at roughly the same stratigraphic level. A slight decrease in resistivity at about 63 500E may represent the unconformity between the Corella Formation and Mount Norna Quartzite.

Traverse 18N (Fig. 8). The amount of Precambrian outcrop along this traverse is less than on 17N, but again Corella Formation rocks crop out at the western end. A distinct change in pattern of the magnetic profile at 65 300E is probably due to the Corella Formation/Soldiers Cap Group contact. Gravity results clearly indicate the presence of denser Toole Creek Volcanics east of 66 500E. The source of the magnetic anomaly between 66 500 and 66 700E is interpreted as dolerite intruded along a north-northwest-trending fault. The magnetic and gravity responses over the Corella Formation are variable, suggesting either complex structural or lithological changes. The source of the magnetic anomaly centred on 63 850E is not known.

Apparent resistivity measurements were recorded west of 65 800E on the Geoscience/McPhar equipment, with 100-m dipoles and n = 1, 2, and 3. Readings east of this point were measured on the Austral IP system, with 200-m dipoles and the same n values. The Austral equipment also recorded frequency effects.

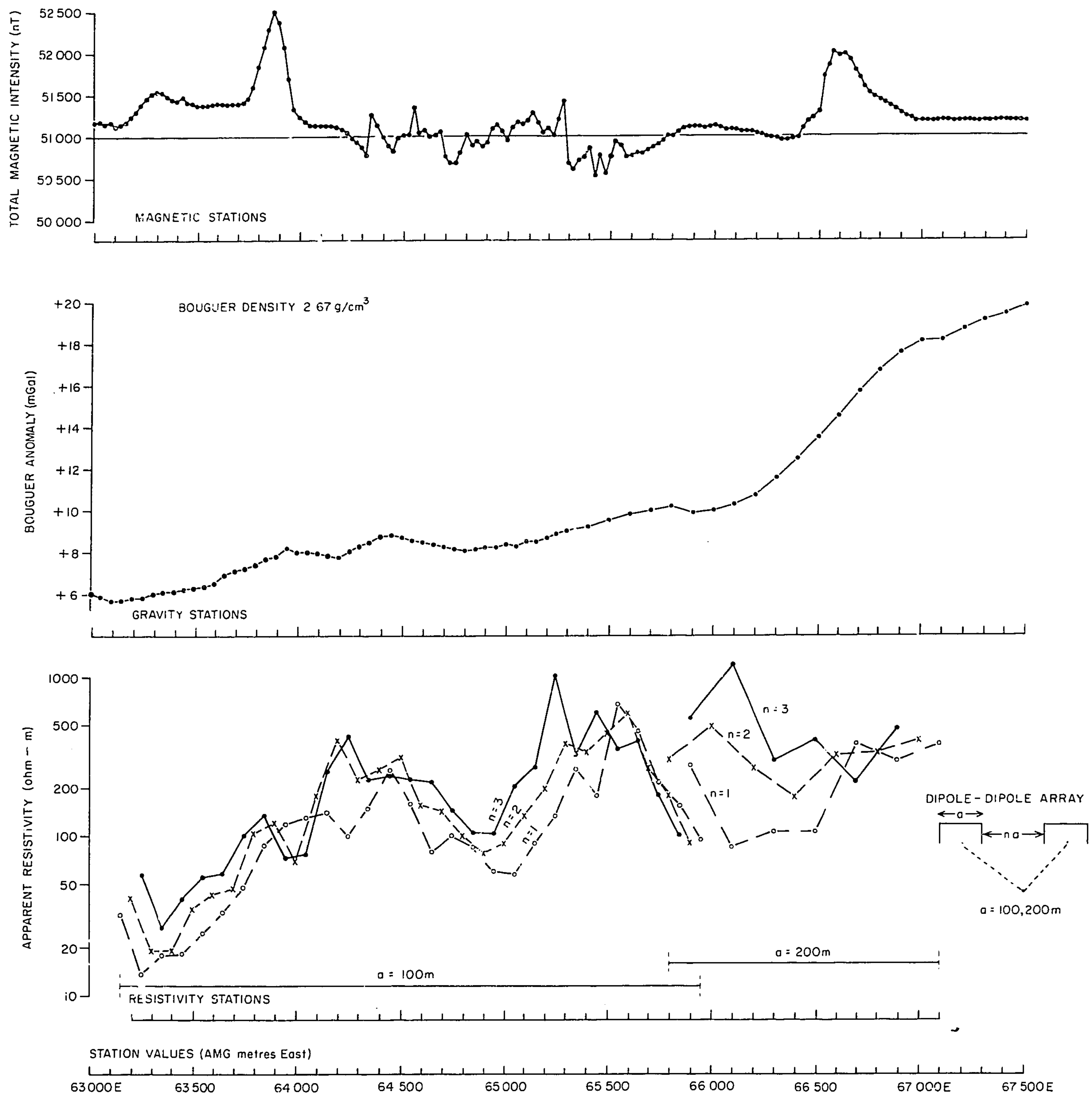


Fig. 8 Traverse 18N : magnetic, gravity, and resistivity results

F54/B7-84

The lowest resistivities occur west of 63 900E, where the magnetic results indicate deeper basement than farther east on 18N. Hence the decrease in apparent resistivity at the western end indicates a thickening of conductive overburden. The increase in resistivities east of 65 200E probably represents the change in rock type over the unconformity separating less resistive Corella Formation to the west from more resistive Mount Norna Quartzite and Toole Creek Volcanics to the east. Hence some correlation between 17N and 18N is apparent, but interpretation is more difficult on 18N owing to the effect of increasing thickness of conductive overburden, and the lack of distinct electrical contrasts between the main units of the metamorphosed sequence. For these reasons, it is doubtful whether an extension of resistivity profiling work into non-outcrop areas farther north would aid subsurface mapping of the basement.

Traverse 36.25N (Fig. 9). The basement does not crop out along this traverse, but gravity and magnetic results indicate a distinct contact - possibly between granite and Corella Formation - near 61 800E. To determine how well the resistivity method could map this contact below conductive cover, two sets of dipole-dipole resistivity readings were taken.

The first set was measured at 100-m intervals on the Geoscience IP transmitter (signal frequency 0.1 Hz) and the highly sensitive Fluke receiving system (as in traverse A), with 50-m dipoles and n=3. The second set of readings was measured on the Austral IP system, with 100-m dipoles and n = 1, 2, and 3. The Austral IP system also recorded frequency effects but as these were small (not greater than 2%) they have been omitted from the figure.

Both sets of resistivity data indicate a distinct decrease in apparent resistivity from west to east across the contact, suggesting a less resistive basement east of 61 800E. However, an analysis of the Austral resistivity results for n = 1, 2, and 3 suggests also that the conductive overburden thickens to the east, since the profiles tend to diverge in this direction. The contribution to the decrease in resistivity caused by a change in basement lithology appears to be less than that due to the thickening of conductive overburden.

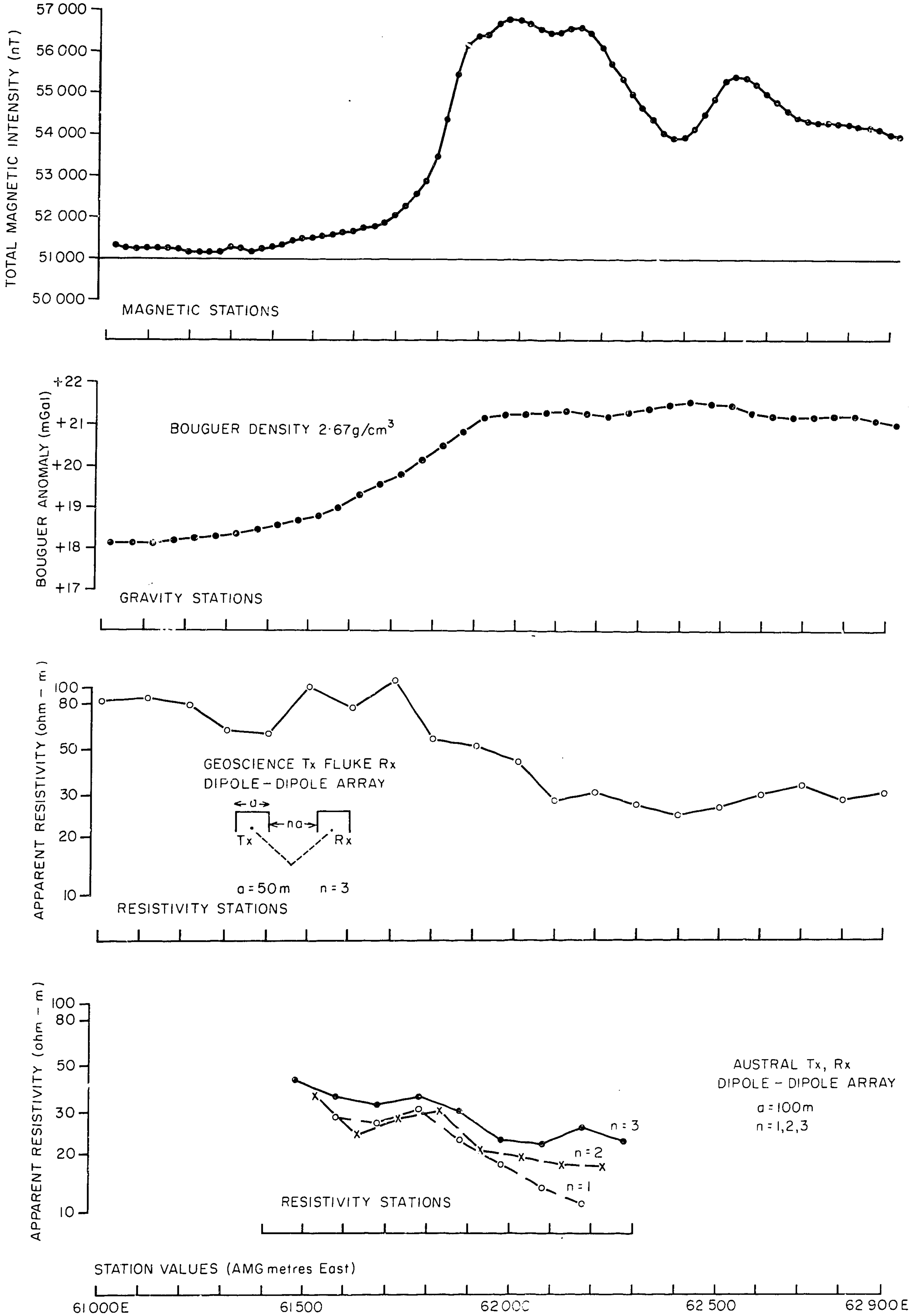


Fig.9 Traverse 36·25 N magnetic, gravity, and resistivity results F54/B7-85A

PHYSICAL PROPERTY MEASUREMENTS

Samples of rocks which crop out within the survey area were collected for subsequent laboratory measurement of density and magnetic susceptibility; R.M. Hill (BMR) examined some of these samples in thin section. The results of the physical property measurements on 58 samples are presented in Appendix 3B, and, together with those of Sampath & Ogilvy (1974), are summarised in Table 1.

An analysis of density data presented by Smith (1966) for samples from the Dobbyn area compares favourably with results in Table 1, although Smith's mean density values for samples of Naraku Granite, calc-silicate rock, and quartzite and siliceous rock are in general 0.04 to 0.06 g/cm^3 lower than values that we have determined.

5. INTERPRETATION

Three broad geophysical regions (A, B, and C) have been interpreted from an analysis of the geophysical data (Pl. 9). Two of them have been further divided into zones: region C, the most complex, into four zones; and region B into three. Each of the regions has a characteristic geophysical response, which is outlined in Table 2. This table also indicates the correlation between outcropping lithologies and the various regions and zones.

DISTRIBUTION OF LITHOLOGIES

Region A

This region coincides with the western extent of sediments of the Carpentaria Basin. The boundary between the basin sequence and the shallow buried Precambrian basement of the Cloncurry Complex is clearly defined by a sharp change in the magnetic character (from broad low-amplitude anomalies to narrow, linear high-amplitude anomalies) and a distinct Bouguer anomaly gradient of about 2 mGal/km over the boundary. Both responses suggest that the boundary is faulted and dips steeply to the east.

TABLE 1. SUMMARY OF PHYSICAL PROPERTY MEASUREMENTS PRESENTED IN APPENDIX 3

Classification	Rock types	Possible formation	No. of samples	Density range/(mean) (g/cm^3)	Susceptibility range/(mean) (SI units x 10^6)
1	Granite (excluding granitic rocks from Mt Margaret)	Pgu	8	2.60-2.68 (2.64)	200-23 000 (10 300)
2	Mount Margaret granodiorite	?Pgu, ?Pkc	5	2.62-2.75 (2.66)	20 500-75 200 (49 400)
3	Calc-silicate rock, hornfels, granofels	Pkc	22	2.56-3.01 (2.76)	10-132 100 (15 100)
4	Quartzite and siliceous metamorphic rock	Pkc, Pon	11	2.56-2.97 (2.69)	20-36 000 (4 200)
5	Acid volcanics - rhyolite, dacite	?Pon	8	2.56-2.73 (2.63)	20-47 400 (12 800)
6	Banded iron formation, magnetite/hematite rock (including ferricrete)	?	7	2.91-4.66 (3.65)	2 100-231 000 (121 600)
7	Amphibolite, basic volcanics (metabasalt)	Pot	5	2.80-3.11 (2.98)	620-5 800 (1 900)
8	Basic igneous intrusives (metadolerite)	do	6	2.71-3.05 (2.97)	780-29 000 (18 800)

Notes:

1. Analyses based on 58 samples collected during the 1975 survey, and 14 samples collected immediately south of the survey area in 1972 (Sampson & Ogilvy, 1974). See Appendix 3.
2. Average density of granitic rocks (1 + 2) = 2.65 g/cm^3; average density of all other rocks = 2.87 g/cm^3.
3. Key to formations: Pgu = Naraku Granite; Pkc = Corella Fm; Pon = Mount Norna Quartzite; Pot = Toole Creek Volcanics; do = dolerite.

TABLE 2. SUMMARY OF GEOPHYSICAL RESPONSES

		Physical properties of samples		Gravity response		Magnetic response	
Region/ zone	Outcropping rocks	Density range/ (mean) g/cm^3	Suscept. range/ (mean) SI x 10^6	Detailed	Regional	Ground	Airborne
A	No Precambrian outcrop; Mesozoic sediments of Carpentaria Basin near surface	-	-	Smooth regular decrease to E; W boundary of region marked by distinct gradient change	Regular Bouguer anomaly decrease of 2 mGal/km to E; broad residual lows of 10 mGal	Extremely smooth; no near-surface disturbance; flat gradient	Very flat; low-amplitude (300 nT) anomalies trending NE-SW; source depth 200 to 300 m
B1 B2 B3	Naraku Granite (mostly in B1); may contain vestiges of metamorphic rocks (Classification 1 in Table 1)	2.60-2.68 (2.64)	200-23 000 (10 300)	Smooth; local Bouguer lows	Broad Bouguer lows; well-defined residual lows of 10-15 mGal	Smooth to moderately disturbed; includes several broad anomalies up to 2000 nT, depths less than 100 m	Large areas of very weak disturbance (less than 100 nT); some areas of moderate disturbance with linear anomalies up to 1000 nT; varying trend directions appear to follow boundary of pluton
C1	Naraku Granite, granodiorite, Corella Fm, magnetite/hematite concentrations, minor dolerite; possible contact aureole of granite plutons (Classifications 1 to 6 in Table 1)	2.56-4.66 (2.81)	10-231 000 (27 200)	Irregular; numerous residual highs, up to 10 mGal, suggest local dense bodies	Several small isolated highs of 2 to 6 mGal exhibiting irregular pattern; distinct contrast with lows of region B	Highly disturbed; shallow-source (0-50 m) intense anomalies with amplitudes generally 500 to 5000 nT and often more than 10 000 nT	Relief mostly >3000 nT; some intense linear anomalies >5000 nT; varying trend directions, commonly N-S or NE-SW; shallow-source (0 to 100 m) anomalies become weaker away from region B
C2	Corella Fm; Mt Norna Quartzite with minor banded iron formation; minor Toole Creek Volcs and dolerite (Classifications 3, 4, 5 in Table 1)	2.56-3.01 (2.72)	10-132 100 (11 700)	Relatively smooth; gradient increases gradually toward C3; no local anomalies	No distinct gravity anomalies; zone forms general low between residual highs of C1 and C3	Generally mild disturbance only; small anomalies up to 500 nT; shallow depths (less than 50 m) to source	Weakly disturbed; few shallow-source linear anomalies up to 500 nT, with general N-S trend
C3	Toole Ck Volcs, dolerite intrusives (Classifications 7, 8 in Table 1)	2.71-3.11 (2.97)	620-29 000 (11 100)	Smooth broad Bouguer high of 10 mGal flanked by steep gradients	Very regular; broad well-defined Bouguer and residual highs of 10 mGal	Very smooth; infrequent anomalies up to 500 nT	Weak to moderate disturbance; broad anomalies up to 1000 nT; trends commonly NE-SW to E-W; shallow source (0-50 m)
C4	No Precambrian outcrop	-	-	Smooth; broad Bouguer and residual highs up to 10 mGal; steep gradient increases to NW	Broad Bouguer high of 15 mGal increasing to NW of area; distinct boundaries with residual lows due to granite bodies in S and E	Moderately disturbed; some anomalies up to 5000 nT; quieter to W away from granite; depths to source about 100 m	Weak to moderate disturbance; broad anomalies up to 4000 nT adjacent to granite bodies; trends commonly NW-SE or N-S; various depths to source (50-100 m) may indicate basement relief

The nature of the basement beneath the Carpentaria Basin sediments can be determined from modelling the Bouguer anomaly across the boundary, and from the depth-to-basement interpretation of the aeromagnetic data. The gravity modelling yields at least two quite different models (Fig. 10), each of which could produce the observed gravity anomaly. Model 1 shows high-density rocks of the Cloncurry Complex continuing at depth beneath a thick cover of Carpentaria Basin sediments. The throw of the postulated fault across the boundary is calculated to be about 5 km. However, as the interpreted depth to the sources of aeromagnetic anomalies in region A is only a few hundred metres below the surface, and the flat-lying Carpentaria Basin sediments are unlikely to include magnetic rocks, model 1 does not appear to be a realistic solution.

Model 2 provides a good fit to the observed gravity data, but also takes into account the relatively shallow depth to magnetic basement. It shows low-density granitic basement buried by only a few hundred metres of sediments east of the postulated fault. The source of the magnetic anomalies at the top of the granitic basement may be roof pendants or basic dykes. This model agrees with data from boreholes (Appendix 1) which intersected mainly granitic and quartzitic basement at depths similar to those interpreted from the magnetic data. The relation between this basement and the higher-density Cloncurry Complex to the west is not clear, but the Cloncurry Complex does appear to end rather abruptly along the western boundary of region A.

Region B

Region B comprises three separate zones with similar geophysical responses that are believed to signify mainly granitic rocks. In the southwest of the survey area, zone B1 includes most of the outcrop of the Naraku Granite. There is virtually no outcrop in either B2 or B3. Small outcrops of granitic rock between B1 and B2 and east of B2 appear to be in areas where the Precambrian surface is mainly composed of metamorphic rocks.

Pronounced Bouguer anomaly lows and a magnetic response less disturbed than that of the predominant metamorphic rocks (calc-silicates and metabasalts) characterise the areas of granitic rock. Throughout the survey area, the contrast in average density (Table 1) between these groups

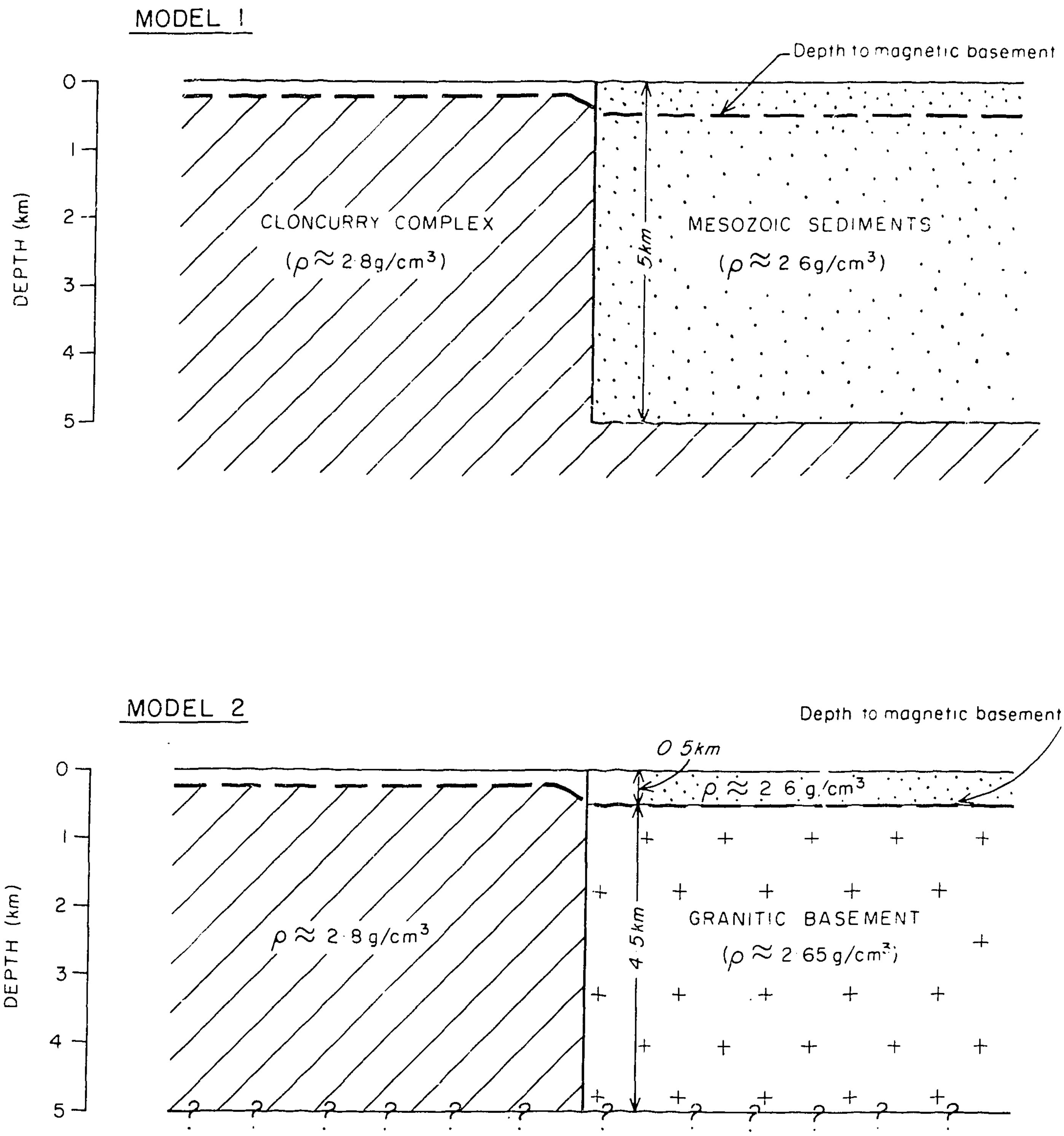


Fig. 10 Gravity modelling at the edge of the Cloncurry Complex

F54/B7-86A

of rocks is large enough (0.22 g/cm^3) to distinguish areas of granitic basement. Ground and airborne magnetic data provide additional information for defining the extent of granite intrusion, but susceptibility contrasts between granite and the metavolcanics and some metasediments (Table 1) are not sufficiently distinct to rely on the magnetic method alone for interpretation. Magnetic anomalies in region B may be due to remnants of metamorphic rock (roof pendants, etc.) in the main body of granite.

Region C

This is the most complex of the three regions, mainly because of the variety of rock types it contains, and the influence of structural and metamorphic effects on these rocks. In general the region is characterised by numerous small gravity highs, typically up to 5 mGal in amplitude, and by a moderately to highly disturbed magnetic response comprising narrow, linear anomalies which mainly trend northwest to northeast with amplitudes commonly in excess of 5000 nT. This region coincides with the outcrop of both the Corella Formation and Soldiers Cap Group rocks in the south of the survey area.

A more detailed interpretation of the gravity and magnetic data has enabled a further division of region C into four distinct zones.

Zone C1. Much of zone C1 contains total magnetic intensity contours greater than 3000 nT. A highly disturbed magnetic response characterises the zone, which probably outlines the distribution of iron-rich Corella Formation rocks within the survey area. Intense residual magnetic and gravity anomalies are distributed throughout the zone, and may reflect the aureole around the granite intrusion where iron-rich rocks have been contact-metamorphosed.

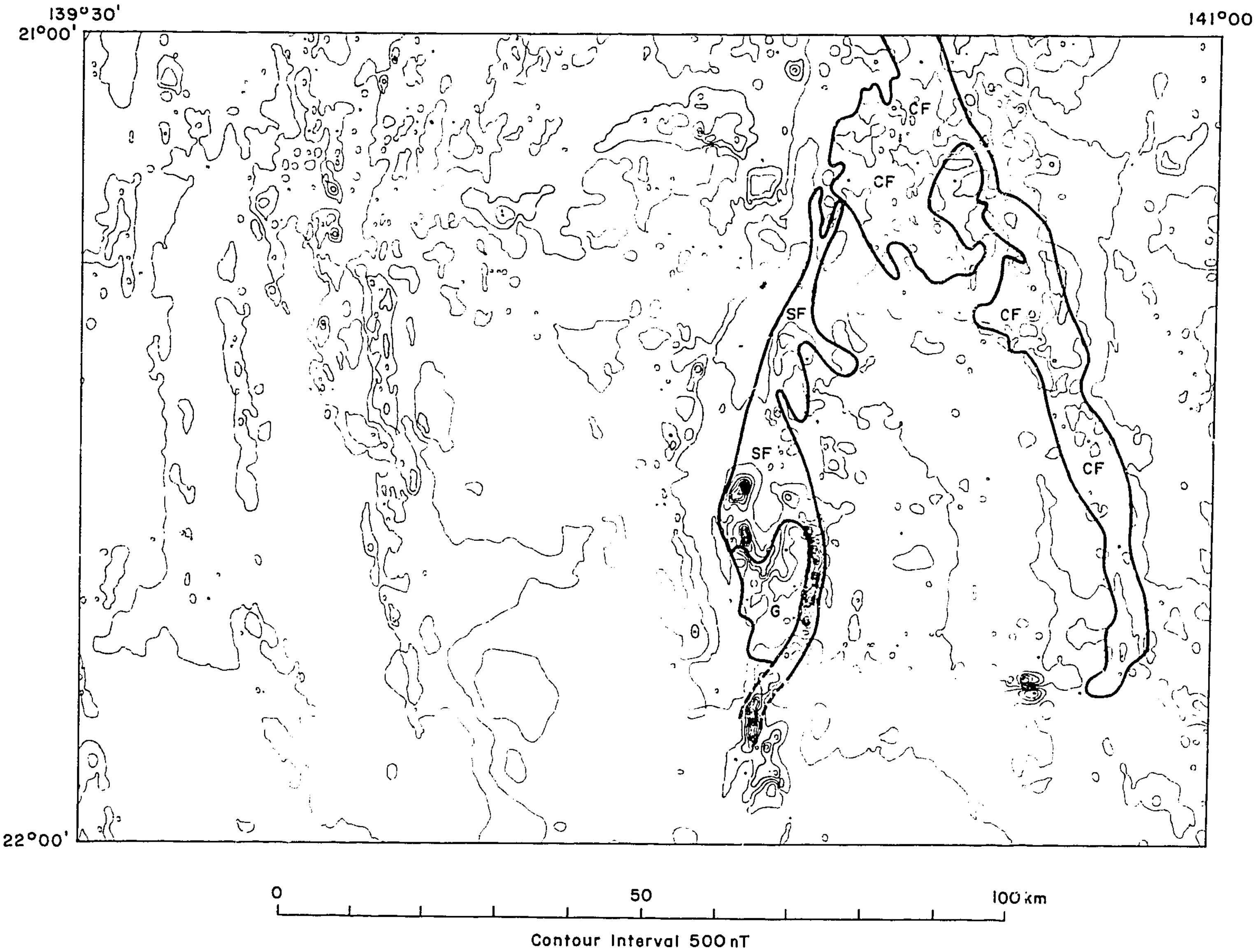
That zone C1 outlines the distribution of mainly Corella Formation rocks is supported by observations that such rocks have been mapped within this zone in the southwest of the survey area (Pl. 1) and Corella Formation rocks are consistently the most magnetic rocks in CLONCURRY (Tucker, 1975). The proposition that intense magnetic and gravity anomalies reflect the effects of contact metamorphism is supported by observations that, within zone C1, Corella Formation rocks often occur near granite outcrop, and magnetite/hematite concentrations occur close to outcropping granite at Castle Rock and several other locations. Where granite has intruded less magnetic rocks such as quartzite or the Toole Creek Volcanics, contact metamorphic effects are not evident in the geophysical data.

The Corella Formation rocks in the southwest of the survey area vary from moderately magnetic calc-silicates to weakly magnetic siliceous metamorphic rocks, and tend to correlate with a distinct aeromagnetic trend that suggests a fold structure. However, detailed ground magnetics indicate a very complex local magnetic pattern in this vicinity, suggesting that the aeromagnetic trends are an over-simplification of the complex data. Aeromagnetic anomalies similar to those in the southwest occur to the north around zone B2.

Complex magnetic and gravity patterns which characterise zone C1 rocks also occur near Mount Margaret, which lies near the eastern boundary of the interpreted granite intrusion represented by zone B2. This area, then, probably also contains iron-rich metasediments of the Corella Formation intruded by granite, but no Corella Formation rocks crop out. Samples of granitic rock from Mount Margaret have particularly high magnetic susceptibilities (up to 75 000 x 10^{-6} SI units) which are typical of magnetite/hematite rock. However, the samples have densities typical of granite (2.66 g/cm^3), even though small residual Bouguer anomaly highs occur nearby. R.M. Hill (BMR, personal communication) has described rock samples from Mount Margaret as altered granodiorites containing a high proportion of opaques - presumably magnetite or hematite.

Outcropping magnetite/hematite bodies in the south of the survey area are associated with exceptionally strong magnetic responses (often greater than 20 000 nT on the ground). The widespread occurrence within zone C1 of similar magnetic anomalies suggests that many other magnetite/hematite bodies underlie the alluvium. Aeromagnetic anomalies possibly caused by such bodies are indicated in Plate 9; note that magnetite concentrations may occur anywhere along these anomalies.

The magnetic anomaly pattern in zone C1 is similar to that in an area in DUCHESS 100 km south of Cloncurry (Fig. 11). In this area, a narrow zone of rocks of the Staveley Formation, which is stratigraphically



INDEX TO ADJOINING SHEETS

MT ISA	CLONCURRY	JULIA CREEK
URANDANGI	**DUCHESS**	McKINLAY
GLENORMISTON	BOULIA	MACKUNDA

SF	*Staveley Formation*
CF	*Corella Formation*
G	*Granite*

Fig. 11 Relation between aeromagnetic contours (based on map F54/B1-127) and the Staveley Formation, DUCHESS

F54/B7-96A

equivalent to the Corella Formation farther north (Noon, 1978, p.21), crops out adjacent to granite. The Staveley Formation rocks, which include calc-silicates and magnetite/hematite ironstones, are directly associated with a highly disturbed airborne magnetic response featuring shallow-source, extremely intense linear anomalies with amplitudes in excess of 5000 nT. These anomalies are by far the largest in DUCHESS. The anomaly intensity decreases rapidly away from the granite, suggesting that magnetite concentrations are associated with the contact zone surrounding the granite.

The similarity between zone C1 and the magnetic zone associated with the Staveley Formation intruded by granite supports the geological interpretation in the survey area. The zones of enriched magnetite content in both DUCHESS and CLONCURRY appear to be related to the intrusion by granite of iron-rich metasediments which are part of the Corella Formation.

Zone C2. This zone is in the south of the survey area and is characterised by little magnetic relief and no distinct gravity anomalies. It is interpreted as an area containing mainly rocks of the Corella Formation - apparently neither strongly magnetic nor contact-metamorphosed - and Mount Norna Quartzite. Boundaries between rock units are not distinguishable; in particular, minor banded iron formations within the Mount Norna Quartzite are not evident in the regional data. Ground surveys show that these iron-rich rocks are only moderately magnetic, suggesting that the iron is mainly in the form of hematite.

Zone C3. This zone is moderately magnetic and is clearly defined by a broad residual gravity high which forms a sharp contrast with the response of zone C2 to the northwest, and the gravity low of region A to the east. Amphibolites and metabasalts of the Toole Creek Volcanics crop out in this zone and are likely to be the main rock types within it. A distinct density contrast (0.25 g/cm^3) between these rocks and samples of the surrounding quartzites would account for the sharp change in gravity response, which is also evident in the detailed results of traverse 18N. The similar magnetic response of zones C2 and C3 is explained by the low susceptibilities of the major rock types they contain.

Zone C4. Precambrian rocks do not crop out in this zone, but drilling results suggest that both granitic and metamorphic basement underlie a shallow cover. The magnetic results show a few linear anomalies of moderate intensity; such a response is typical of either granitic or weakly magnetic metamorphic rocks. However, the gravity results show an extensive residual anomaly high in the south of the zone, which suggests the presence of dense basic rocks. The only unit containing weakly magnetic rocks with consistently high densities is the Toole Creek Volcanics. Therefore, zone C4 is thought to consist mainly of Soldiers Cap Group rocks, of which the Toole Creek Volcanics occupy a large area in the south. Drillhole information supports this interpretation: although several holes in the north of the zone have intersected granite, other holes to the south have intersected dolerite or basalt, and a few have intersected quartzite (possibly Mount Norna Quartzite). Even though part of the basement in this zone is apparently composed of granitic rocks, the effects of contact metamorphism are not evident.

FOLDING AND FAULTING OF THE BASEMENT ROCKS

The influence of the intrusive granite on the regional geophysics masks the response of any folds that may be present in the metamorphic sequence. Where the aeromagnetic contours give an impression of relatively simple folding, such as in zone C1 in the southwest of the area, the fold patterns and structure - as already noted - are generally much more complex.

Geophysically interpreted lineaments (Pl. 9), defined by sharp changes in magnetic character, are probably due to steeply dipping faults or granite intrusion into the metamorphic sequence. Some faulting may be associated with the intrusive contacts, but there is no evidence of lateral movement along the lineaments, which trend mainly northwesterly and northeasterly.

DEPTH TO BASEMENT

The depth to the Precambrian basement beneath the sediment cover has been determined by drilling, interpretation of VES, and analysis of aeromagnetic profiles.

The bulk of the depth determinations, which are presented in Plate 2, are based on aeromagnetic profile interpretations. These data yield the least accurate results for shallow-depth analysis for two reasons: (1) the sampling interval - about 100 m - of the aeromagnetic survey from which they were interpreted is too wide; and (2) the magnetic sources are complex. Therefore the results have a limited accuracy - about ±25 m - irrespective of the interpretation technique used. An elementary analytical method (Peters, 1949) was used to calculate the depths of about 300 anomalies in the survey area. These calculated depths have been grouped, as shown in Plate 2, to take account of their limited accuracy.

A simple two-dimensional dyke model with an average width-to-depth ratio of two was assumed in the calculation of depths by Peters's method. The depths were calculated for narrow magnetic anomalies representing shallow sources, of which none are likely to be younger than the Precambrian basement: only in areas apparently lacking shallow sources were depths calculated for broader anomalies representing deeper sources. Thus the majority of calculated depths are at or close to the unweathered Precambrian surface. Forward modelling on several of the interpreted bodies was carried out to check the validity of the results. It appears that, for most anomalies, Peters's method gives acceptable results within the ±25 m accuracy range.

A comparison of the depths determined from drilling, VES, and magnetic interpretation indicates that these depths are not always compatible; this is because each method delineates a different part of the subsurface: drilling indicates depth to weathered basement, VES indicates depth to unweathered basement, and aeromagnetic estimates refer to depths to magnetic basement. Thus, the depth to basement recorded in a drillhole is likely to be shallower than that interpreted from VES and magnetic data.

Contours on the buried Precambrian surface (Pl. 2) - drawn from drilling depths and the results of the aeromagnetic interpretation - show the undulating topography and the sharp increase in depth along the eastern margin of the survey area. They also show that the Cloncurry Complex is less than 100 m below the surface for most of the survey area; that about 50% of this area is covered by less than 50 m of sediment; and that basement depressions - possibly representing ancient drainage channels - occur west and southwest of Mount Margaret, and in the northwest corner of the survey area.

To study the basement relief in some detail, the ground magnetic data along traverse 38N was interpreted with a computer program based on the Werner deconvolution (Hsu & Tilbury, 1977). This program prints out, in a vertical cross-section, points representing the estimated depths to magnetic sources. The shallowest depth points along the vertical section through traverse 38N probably represent the Precambrian surface; the profile drawn through them (Pl. 2) shows the variation in Precambrian topography from west to east across the area, and correlates with drilling data to within ± 10 m.

6. CONCLUSIONS

The results of geophysical mapping of buried Precambrian rocks northeast of Cloncurry suggest that gravity and magnetic methods can be used to determine the lithology, broad structure, and depth of burial of rocks of the Cloncurry Complex which are covered by a thin veneer of younger sediments. Regional magnetic and gravity surveys indicate that up to 30% of the whole Cloncurry Complex is thinly covered by Mesozoic and Cainozoic sediments, and the geology of these buried Cloncurry Complex rocks can probably be investigated by additional surveys of the type described in this Report.

In the area studied, the shallow-buried Precambrian basement extends roughly 40 km east of the limit of its outcrop, where the magnetic character suddenly changes and the Bouguer anomaly values decrease. The edge of the shallow basement, which appears to coincide with its contact with sediments of the Carpentaria Basin, is probably faulted and dips steeply to the east. The depth to weathered basement ranges from less than 100 m west of the contact to more than 200 m beneath the sediments to the east. The basement beneath the Carpentaria Basin does not appear to be a continuation of the Cloncurry Complex, but is more likely to comprise less dense granitic rock.

Distinct gravity lows combined with a less disturbed magnetic response define the granitic basement in the Cloncurry Complex. In the southwest of the survey area, such a response corresponds to outcrop of the Naraku Granite batholith. Small magnetic anomalies within the granite may represent roof pendants of metamorphic rock.

Irregular patterns of magnetic and gravity anomalies characterise the Precambrian metamorphic rocks. A zone of high magnetic relief and residual gravity anomaly highs appears to outline the iron-rich Corella Formation rocks. The most intense magnetic anomalies appear to coincide with Corella Formation rocks in the metamorphic aureole surrounding intrusive granite. Where granite intrudes less magnetic units, such as the Soldiers Cap Group and the apparently less iron-rich parts of the Corella Formation, a strong magnetic aureole is lacking. A Bouguer anomaly high in the south of the survey area clearly defines the extent of metabasalts and amphibolites of the Toole Creek Volcanics (Soldiers Cap Group). Similar dense rocks may underlie the alluvium in the northwest of the survey area, where a large increase in Bouguer anomaly values occurs.

Outcropping concentrations of magnetite and hematite appear to lie in the contact aureole around intrusive granite. The aeromagnetic data indicate that further concentrations of magnetite and hematite may underlie the thin cover of sediments. Similar magnetic patterns are evident 100 km south of Cloncurry where granite intrudes iron-rich units equivalent to the Corella Formation.

The survey area is structurally complex. Detailed geology and geophysics show that fold patterns are more complex than the regional geophysical patterns suggest. Several magnetic lineaments interpreted within the basement rocks appear to coincide with the edges of granitic intrusions, whereas lineaments along the eastern margin of the survey area represent the faulted contact between the shallow-buried Cloncurry Complex and the sediments of the Carpentaria Basin.

The results of drilling and the interpretation of magnetic and electrical sounding results show that the depth to the Precambrian basement is less than 100 m below the surface over most of the survey area, and for half of the area is less than 50 m.

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APPENDIX 1. BOREHOLE DATA

Reference no.	Location(km)* E	N	Hole no. **	Basement depth (m)	Basement lithology
1	452	7770	CLDH20	129	quartzite
2	457	7769	CLDH21	94	quartzite
3	490	7769	R11276	323	black slate
4	449	7761	CLDH15	72	basaltic rock
5	455	7763	CLDH36	105	granite or ?gneiss
6	456	7763	CLDH3	106	?schist
7	456	7762	CLDH18	113	diorite or gabbro
8	457	7762	CLDH35	109	?metabasalt or diorite
9	463	7761	CLDH22	76	granite
10	449	7759	CLDH40	91	granite
11	455	7760	CLDH29	72	granite
12	459	7760	CLDH23	103	granite, granodiorite
13	469	7759	R2718	N.A.	
14	491	7758	R1815	N.A.	
15	500	7759	R2327	>309	(?basement not intersected)
16	498	7765	R30654	320	granite
17	485	7766	R2699	315	quartzite
18	448	7756	CLDH26	64	?granite
19	449	7757	CLDH31	97	?metadolerite
20	451	7759	CLDH30A	113	dolerite
21	452	7758	CLDH25	106	granite, granodiorite
22	452	7759	CLDH30	>42	(basement not intersected)
23	452	7758	CLDH32	101	dolerite
24	452	7759	CLDH24	114	granite

Reference no.	Location(km)* E	N	Hole no. **	Basement depth (m)	Basement lithology
25	455	7759	CLDH4A	90	?dioritic rock
26	455	7758	CLDH4	>75	(basement not intersected)
27	459	7758	CLDH27	64	quartzite, basaltic rock
28	470	7757	R12688	>30	(?basement not intersected)
29	480	7755	R2697	N.A.	
30	483	7756	R2701	N.A.	
31	452	7756	CLDH33	94	granite
32	457	7755	CLDH34	76	?granite
33	473	7753	R2711	N.A.	
34	449	7752	CLDH6	57	?metabasalt
35	454	7753	CLDH5	61	?basic or ultrabasic rock, kaolinite
36	465	7751	R15723	>20	(?basement not intersected)
37	471	7750	R13834	>45	(?basement not intersected)
38	485	7749	R2715	>53	(?basement not intersected)
39	495	7748	R2703	N.A.	
40	448	7748	CLDH50	70	dolerite
41	453	7748	CLDH7	64	?metabasalt
42	456	7750	CLDH37	61	?chlorite schist
43	457	7746	CLDH38	68	?dolerite
44	461	7746	CLDH53	63	granitic rock
45	463	7747	CLDH39	34	granitic rock
46	473	7743	R2713	>69	(?basement not intersected)

Reference no.	Location(km)* E	N	Hole no. **	Basement depth (m)	Basement lithology
47	481	7742	R2714	79	granite
48	498	7744	R2707	214	quartzite
49	449	7744	CLDH52	41	amphibolite
50	454	7744	CLDH51	74	?dolerite
51	458	7744	CLDH8	61	?chlorite schist
52	448	7742	CLDH208	32	quartzite
53	451	7742	CLDH92	71	chlorite schist
54	452	7742	CLDH82A	76	basalt, dolerite
55	452	7742	CLDH82	>12	(basement not intersected)
56	451	7740	CLDH86	61	gneissic granite
57	452	7741	CLDH90	68	?metabasalt
58	448	7738	CLDH211	27	quartz diorite
59	451	7738	CLDH88	52	granitic rock
60	454	7739	R2811	N.A.	
61	457	7738	CLDH81	66	diorite, gabbro
62	459	7738	CLDH213	59	granite
63	490	7737	R2705	180	granite, limestone
64	493	7736	R2706	205	black shale, quartzite
65	448	7737	CLDH225	26	?metabasalt
66	449	7738	CLDH84	33	granite
67	450	7737	CLDH96	39	granite
68	451	7738	CLDH98	44	granite
69	451	7738	CLDH100	45	granite
70	451	7737	CLDH94	44	granite
71	452	7736	CLDH83	28	granite
72	455	7736	CLDH87	44	dolerite
73	456	7737	CLDH89	54	quartzose sandstone

Reference no.	Location(km)* E	N	Hole no. **	Basement depth (m)	Basement lithology
74	456	7736	R2721	N.A.	
75	460	7736	CLDH223	18	metasediment
76	463	7736	CLDH221	43	metabasalt
77	465	7737	CLDH231	24	metabasalt
78	465	7738	CLDH232	44	metabasalt
79	465	7736	CLDH230	27	metabasalt
80	453	7735	CLDH214	>27	(basement not intersected)
81	453	7735	CLDH214B	35	granite, metasediment
82	453	7734	CLDH216	36	basaltic and granitic rocks
83	456	7734	CLDH85	47	metabasalt, andesite
84	457	7734	CLDH215A	42	metasediment
85	460	7734	CLDH219	10	metabasalt
86	464	7734	CLDH222A	21	metasediment
87	465	7735	CLDH228	34	metasediment
88	465	7734	CLDH226	30	metabasalt
89	467	7734	CLDH224	41	metasediment
90	469	7736	R14526	>45	(?basement not intersected)
91	469	7736	CLDH75	47	metasediment
92	469	7734	CLDH76	36	dolerite, carbonate sediment
93	458	7733	R15724	>23	(?basement not intersected)
94	456	7732	CLDH217	21	granite
95	466	7732	CLDH218	31	metabasalt
96	467	7732	CLDH220	31	metabasalt

Reference no.	Location(km)* E	N	Hole no. **	Basement depth (m)	Basement lithology
97	469	7732	CLDH69	30	basaltic rock
98	472	7731	CLDH67	56	quartzose sandstone
99	473	7731	CLDH70	32	?metabasalt
100	473	7732	CLDH68	43	?dolerite
101	474	7733	CLDH59	51	granitic and schistose rocks
102	474	7731	CLDH66	54	quartzite
103	480	7733	CLDH10	71	granitic rock
104	480	7732	R2717	62	black slate
105	496	7731	R2698	N.A.	
106	466	7731	CLDH9	13	metabasalt
107	469	7730	CLDH71	28	carbonate-rich metasediments, ?metabasalt
108	478	7728	CLDH58	42	mica schist
109	482	7728	R12217	>65	(?basement not intersected)
110	486	7729	R2709	273	quartzite
111	488	7730	R2691	182	granite/metasediment
112	465	7722	R6096	N.A.	
113	472	7726	R12722	N.A.	
114	476	7727	R12830	>36	(?basement not intersected)
115	475	7725	CLDH11	3	metabasalt
116	475	7724	CLDH56	9	mica schist
117	477	7724	CLDH57	24	?metabasalt
118	481	7724	CLDH13	57	chlorite-mica schist
119	497	7724	R13533	>37	(?basement not intersected)

Reference no.	Location(km)* E	N	Hole no. **	Basement depth (m)	Basement lithology
120	468	7723	CLDH54	2	black slate, schist
121	472	7723	CLDH55	12	?granite, ?metasediment
122	475	7723	R12573	N.A.	
123	488	7722	R13522	N.A.	
124	489	7721	R2754	228	dolerite/granite
125	498	7721	R2707	>245	(?basement not intersected)
126	470	7722	R13484	23	limestone/black shale
127	475	7721	R13457	4	metabasalt
128	475	7720	CLDH63	14	schistose and gneissic rocks
129	477	7721	CLDH12	34	schist
130	477	7720	CLDH65	49	?amphibolite
131	480	7719	CLDH64	58	limestone
132	484	7799	CLDH14	81	schist, quartzite
133	473	7715	CLDH60	2	?metabasalt
134	476	7716	CLDH62	29	black slate, hornfels
135	478	7716	CLDH61	45	schist
136	492	7715	R5481	N.A.	
137	470	7713	R2757	N.A.	
138	476	7711	R2747	>41	(?basement not intersected)
139	483	7712	R2745	114	dolerite
140	495	7713	R2755	211	quartzite
141	463	7718	R6097	N.A.	
142	471	7713	R5651	N.A.	

Reference no.	Location(km)* E	N	Hole no. **	Basement depth (m)	Basement lithology
143	458	7767	R11654	>66	(?basement not intersected)
144	467	7766	R6343	>150	(?basement not intersected)
145	474	7767	R6345	>18	(?basement not intersected)
146	450	7763	R6281	>65	(?basement not intersected)

* Location reference is AMG co-ordinates (in kilometres) for Map Zone 54.

** CLDH = Chevron Exploration Corporation drillholes;
R = Government water-bores;

N.A. = Data not available

APPENDIX 2. VERTICAL ELECTRICAL SOUNDING RESULTS

VES reference no.* and location**	AB/2(m)	Observed resistivity (ohm-m)	Reduced thickness (m)	Reduced depth (m)	Reduced resistivity (ohm-m)
	10.0	7.8	8.1	8.1	6.8
	14.7	8.8	54.7	62.8	19.7
	21.5	10.2	23.0	85.8	5.3
C1	31.6	12.5	73.1	158.9	1.6
	46.4	13.7	>1000	>1000	371.6
451.0E	68.1	15.3			
7758.0N	100.0	14.6			
	146.8	10.3			
	215.4	7.0			
	316.2	7.8			
	10.0	11.9	5.0	5.0	9.0
	14.7	15.0	11.8	16.8	23.1
	21.5	16.0	20.8	37.6	11.6
C2	31.6	15.9	48.0	85.5	24.3
	46.4	16.0	70.7	156.2	3.4
452.0E	68.1	16.2	>1000	>1000	63.4
7758.5N	100.0	16.2			
	146.8	14.1			
	215.4	11.8			
	316.2	14.2			
	10.0	19.2	3.8	3.8	14.5
	14.7	22.1	19.9	23.7	28.1
	21.5	24.1	96.4	120.1	17.5
C3	31.6	23.3	69.0	189.1	11.0
	46.4	20.5	>1000	>1000	17.4
453.0E	68.1	23.0			
7758.5N	100.0	21.8			
	146.8	18.4			
	215.4	14.8			
	316.2	15.1			
	10.0	12.6	4.6	4.6	10.9
	14.7	14.0	6.7	11.3	16.4
	21.5	14.5	14.7	26.0	12.9
C4	31.6	14.7	32.4	58.3	23.5
	46.4	14.3	0.3	58.7	5.3
454.0E	68.1	15.6	108.0	166.7	3.9
7758.3N	100.0	14.7	>1000	>1000	465.0
	146.8	10.7			
	215.4	9.4			
	316.2	11.8			
	10.0	47.0	8.1	8.1	53.6
	14.7	39.0	55.6	63.8	26.1
	21.5	34.0	127.3	191.1	7.1
C5	31.6	32.0	>1000	>1000	173.6
	46.4	26.1			
455.3E	68.1	24.8			
7758.2N	100.0	19.2			
	146.8	14.8			
	215.4	12.9			
	316.2	15.4			

VES reference no.* and location**	AB/2(m)	Observed resistivity (ohm-m)	Reduced thickness (m)	Reduced depth (m)	Reduced resistivity (ohm-m)
	10.0	7.4	8.6	8.6	7.4
	14.7	9.0	30.7	39.3	21.9
C6	21.5	11.7	28.0	67.3	75.0
	31.6	14.2	>1000	>1000	311.8
457.8E	46.4	13.4			
7738.0N	68.1	22.3			
	100.0	36.5			
	146.8	55.0			
	10.0	19.2	3.4	3.4	43.5
	14.7	11.7	2.5	5.9	14.5
	21.5	12.5	3.4	9.2	5.2
C7	31.6	14.4	49.7	58.9	17.1
	46.4	13.9	42.8	101.7	13.0
456.9E	68.1	15.5	93.9	195.6	52.5
7737.7N	100.0	18.0	>1000	>1000	127.9
	146.8	18.6			
	215.4	24.0			
	316.2	34.5			
	464.2	45.0			
	10.0	12.2	12.4	12.4	12.1
	14.7	13.1	2.0	14.4	149.6
C8	21.5	14.9	33.3	47.7	4.3
	31.6	15.0	>1000	>1000	87.1
456.0E	46.4	13.9			
7737.5N	68.1	12.2			
	100.0	12.5			
	146.8	14.9			
	10.0	12.7	3.9	3.9	9.2
	14.7	14.2	13.0	16.9	19.4
C9	21.5	14.8	37.5	54.4	7.4
	31.6	14.0	>1000	>1000	34.0
455.3E	46.4	10.6			
7738.3N	68.1	11.5			
	100.0	14.0			
	146.8	16.6			
	10.0	9.3	2.0	2.0	8.1
	14.7	10.9	18.0	20.0	12.3
C10	21.5	12.2	26.8	46.8	8.2
	31.6	12.1	33.4	80.2	11.5
454.6E	46.4	11.4	>1000	>1000	262.1
7738.9N	68.1	12.3			
	100.0	14.1			
	146.8	19.1			
	10.0	14.0	13.1	13.1	13.2
	14.7	14.2	>1000	>1000	31.8
C11	21.5	17.8			
	31.6	19.1			
454.0E	46.4	20.2			
7739.7N	68.1	24.7			
	100.0	28.3			
	146.8	29.8			

VES reference no.* and location**	AB/2(m)	Observed resistivity (ohm-m)	Reduced thickness (m)	Reduced depth (m)	Reduced resistivity (ohm-m)
	10.0	6.7	7.1	7.1	5.5
	14.7	8.9	14.1	21.2	22.4
C12	21.5	11.3	64.7	85.9	34.2
	31.6	14.1	>1000	>1000	26.3
453.3E	46.4	16.8			
7740.3N	68.1	21.5			
	100.0	25.6			
	146.8	25.6			
	10.0	17.7	21.0	21.0	17.4
	14.7	17.2	62.6	83.7	6.2
C13	21.5	16.2	>1000	>1000	58.5
	31.6	14.7			
452.7E	46.4	11.8			
7741.0N	68.1	9.3			
	100.0	9.3			
	146.8	11.9			
	10.0	11.9	7.4	7.4	12.0
	14.7	15.2	30.9	38.3	29.6
	21.5	20.0	71.4	109.7	23.6
C14	31.6	24.0	>1000	>1000	68.7
	46.4	24.2			
465.8E	68.1	18.0			
7732.6N	100.0	29.5			
	146.8	26.6			
	215.4	36.0			
	316.2	41.5			
	10.0	61.0	5.4	5.4	68.3
	14.7	64.0	4.5	9.9	90.3
C15	21.5	47.0	4.2	14.1	37.4
	31.6	26.2	1.8	15.9	3.5
465.2E	46.4	19.0	2.2	18.1	1.4
7733.4N	68.1	25.2	6.6	24.7	70.3
	100.0	32.0	8.0	32.7	453.1
	146.8	39.0	>1000	>1000	46.2
	10.0	25.5	4.5	4.5	17.6
	14.7	32.0	19.8	24.3	55.7
C16	21.5	38.5	66.1	90.4	29.0
	31.6	42.0	>1000	>1000	51.9
464.5E	46.4	37.5			
7734.1N	68.1	38.0			
	100.0	38.0			
	146.8	37.5			
	10.0	9.6	7.4	7.4	7.5
	14.7	11.4	71.1	78.4	26.4
C17	21.5	14.2	>1000	>1000	368.4
	31.6	17.9			
463.8E	46.4	18.2			
7735.0N	68.1	22.0			
	100.0	28.5			
	146.8	38.0			

VES reference no.* and location**	AB/2(m)	Observed resistivity (ohm-m)	Reduced thickness (m)	Reduced depth (m)	Reduced resistivity (ohm-m)
	10.0	18.5	4.1	4.1	15.3
	14.7	24.0	18.7	22.8	31.5
C18	21.5	29.0	41.4	64.3	24.9
	31.6	29.0	>1000	>1000	37.7
463.2E	46.4	23.5			
7735.7N	68.1	29.0			
	100.0	30.0			
	146.8	31.0			
	10.0	19.3	4.5	4.5	14.7
	14.7	22.8	7.7	12.2	34.6
C19	21.5	23.3	>1000	>1000	21.0
	31.6	24.5			
462.6E	46.4	21.6			
7736.5N	68.1	21.8			
	100.0	23.5			
	146.8	23.2			
	14.6	20.9	13.5	13.5	18.2
	21.5	26.6	29.7	43.2	101.6
C20	31.5	33.8	>1000	>1000	316.8
	46.2	44.6			
460.1E	67.8	58.0			
7734.5N	99.5	79.0			
	146.0	105.0			
	14.6	21.1	15.2	15.2	19.3
	21.4	25.5	35.5	50.7	76.1
C21	31.5	32.0	23.7	74.4	174.3
	46.2	38.2	>1000	>1000	334.5
461.0E	67.8	49.6			
7734.1N	99.5	65.0			
	146.0	87.0			
	14.6	18.9	1.1	1.1	16.6
	21.4	22.2	37.6	38.7	21.3
C22	31.5	25.0	>1000	>1000	266.7
	46.2	27.6			
461.9E	67.8	36.5			
7733.8N	99.5	48.9			
	146.0	66.0			
	14.6	13.8	14.4	14.4	13.0
	21.4	14.8	5.3	19.7	25.3
C23	31.5	16.7	26.3	45.9	14.5
	46.2	19.0	6.1	52.0	172.8
462.8E	67.8	23.6	>1000	>1000	>1000
7733.5N	99.5	33.0			
	146.0	51.0			
	14.6	13.2	9.2	9.2	11.1
	21.4	16.1	44.2	53.4	22.7
C24	31.5	18.8	8.1	61.5	181.2
	46.2	22.1	>1000	>1000	839.6
463.7E	67.8	26.4			
7733.0N	99.5	36.6			
	146.0	54.0			

VES reference no.* and location**	AB/2(m)	Observed resistivity (ohm-m)	Reduced thickness (m)	Reduced depth (m)	Reduced resistivity (ohm-m)
	14.6	34.0	10.5	10.5	37.4
	21.4	29.9	40.0	50.5	20.5
C25	31.5	27.6	>1000	>1000	104.8
	46.2	24.1			
464.7E	67.8	30.0			
7732.6N	99.5	35.0			
	146.0	44.0			
	14.6	31.7	27.1	27.1	31.7
	21.4	31.0	68.0	95.1	18.7
C26	31.5	38.5	>1000	>1000	46.7
	46.2	23.5			
465.5E	67.8	21.1			
7732.2N	99.5	21.4			
	146.0	25.0			
	14.7	36.0	6.6	6.6	21.1
	21.5	56.0	14.3	21.0	122.5
C27	31.6	63.0	159.9	180.8	55.3
	46.4	65.0	>1000	>1000	>1000
466.4E	68.1	63.0			
7731.7N	100.0	66.0			
	146.8	67.0			
	215.5	75.0			
	316.3	100.0			
	14.7	34.5	9.9	9.9	30.0
	21.5	43.0	38.0	47.9	64.2
C28	31.6	46.5	>1000	>1000	181.3
	46.4	54.0			
467.3E	68.1	62.0			
7731.2N	100.0	75.0			
	146.8	93.0			
	14.7	41.5	8.8	8.8	42.6
	21.5	38.5	3.7	12.5	76.3
C29	31.6	31.5	4.0	16.4	23.3
	46.4	25.3	18.9	35.4	9.4
468.3E	68.1	27.3	>1000	>1000	238.0
7731.4N	100.0	38.0			
	146.8	52.0			
	14.7	69.0	14.7	14.7	68.7
	21.5	66.0	5.6	20.3	27.9
C30	31.6	76.0	26.8	47.1	199.1
	46.4	89.0	>1000	>1000	390.4
454.1E	68.1	112.0			
7732.3N	100.0	146.0			
	146.8	185.0			
	14.7	31.5	11.6	11.6	32.0
	21.5	30.0	15.3	26.9	21.4
C31	31.6	31.5	48.5	75.4	84.4
	46.4	38.5	>1000	>1000	>1000
453.6E	68.1	48.0			
7733.2N	100.0	64.0			
	146.8	99.0			

VES reference no.* and location**	AB/2(m)	Observed resistivity (ohm-m)	Reduced thickness (m)	Reduced depth (m)	Reduced resistivity (ohm-m)
	14.7	15.0	17.0	17.0	13.9
	21.5	17.2	57.4	74.5	64.5
C32	31.6	21.4	>1000	>1000	200.9
	46.4	26.5			
453.1E	68.1	34.0			
7734.0N	100.0	43.0			
	146.8	57.0			
	14.7	18.0	16.1	16.1	16.8
	21.5	20.2	86.7	102.8	50.9
C33	31.6	24.0	>1000	>1000	11.8
	46.4	26.0			
452.6E	68.1	31.0			
7734.9N	100.0	36.0			
	146.8	33.5			
	14.7	15.1	9.1	9.1	10.6
	21.5	18.5	28.0	37.1	51.7
C34	31.6	25.0	52.7	89.8	21.3
	46.4	30.5	>1000	>1000	396.7
452.0E	68.1	32.0			
7735.8N	100.0	32.0			
	146.8	43.0			
	14.7	13.1	15.4	15.4	12.4
	21.5	15.1	46.8	62.2	28.0
C35	31.6	17.4	>1000	>1000	92.0
	46.4	19.2			
451.2E	68.1	23.0			
7736.4N	100.0	29.2			
	146.8	37.0			
	10.0	10.5	11.3	11.3	9.9
	14.7	11.2	7.0	18.3	23.5
	21.5	12.6	94.8	113.1	14.9
	31.6	14.1	79.4	192.4	66.5
B1	46.4	15.3	>1000	>1000	>1000
	68.1	16.1			
469.5E	100.0	17.2			
7738.1N	146.8	20.1			
	215.4	26.3			
	316.2	37.1			
	464.2	53.7			
	10.0	5.3	10.9	10.9	4.6
	14.7	6.4	85.8	96.7	21.2
	21.5	8.1	75.5	172.2	198.0
	31.6	9.5	>1000	>1000	>1000
B2	46.4	10.8			
	68.1	13.0			
469.5E	100.0	17.1			
7740.0N	146.8	23.5			
	215.4	33.8			
	316.2	47.5			
	464.2	70.0			

VES reference no.* and location**	AB/2(m)	Observed resistivity (ohm-m)	Reduced thickness (m)	Reduced depth (m)	Reduced resistivity (ohm-m)
	10.0	12.4	14.3	14.3	11.8
	14.7	13.5	70.8	85.1	31.0
	21.5	14.9	106.9	192.0	159.3
	31.6	16.9	116.2	308.1	688.0
	46.4	19.2	>1000	>1000	>1000
B3	68.1	23.1			
	100.0	29.5			
461.1E	146.8	40.0			
7736.3N	215.4	50.9			
	316.2	77.0			
	464.2	111.0			
	681.3	164.0			
	1000.0	240.0			
	10.0	7.5	5.9	5.9	6.0
	14.7	9.0	33.0	38.9	18.5
	21.5	11.3	55.5	94.4	9.3
B4	31.6	14.2	27.4	121.8	181.8
	46.4	15.2	>1000	>1000	>1000
462.6E	68.1	14.6			
7736.3N	100.0	15.8			
	146.8	18.7			
	215.4	25.8			
	316.2	41.0			

* Reference no. prefix: C = Chevron Exploration Corporation VES site;
B = BMR 1975 VES site.

** Location reference is Australian Map Grid co-ordinates (in kilometres) for Map Zone 54.

APPENDIX 3. PHYSICAL PROPERTY MEASUREMENTS AND DESCRIPTIONS OF ROCK SAMPLES

A. SAMPLES COLLECTED SOUTH OF THE SURVEY AREA IN 1972 (SAMPATH & OGILVY, 1974)

Sample no. (laboratory)	Sample no. (field)	Location (km)* E	N	Rock unit	Rock type (classification in Table 1)	Weathering (**)	Density (g/cm^3)	Susceptibility (SI units x 10^6)	Remarks
76/146	G10	446	7711	Naraku Granite	Fine to medium-grained granite (1)	SW	2.63	6 900	Grey pink, quartz-rich
76/147	G12	467	7707	Soldiers Gap Gp	Fine to medium-grained dolerite (7)	F	3.02	1 300	Toole Creek Volcs
76/148, 9	G13	465	7707	Corella Fm	Coarse-grained bedded limestone (3)	F	2.73	280	Unconformable on Soldiers Cap Gp. Pyrrhotite flakes
76/150	G14	474	7700	Soldiers Cap Gp or Malbon Gp equivalent	Fine-grained grey-green rock (4)	SW	2.67	60	?Impure quartzite or metabasalt
75/151	G15	474	7700	Soldiers Cap Gp or Malbon Gp equivalent	Fine-grained grey-green rock (4)	MW	2.97	430	?Impure quartzite or metabasalt
76/152,3	G16	469	7691	Soldiers Cap Gp or Malbon Gp equivalent	Medium to fine-grained quartzite (4)	SW	2.66	85	?Mitakoodi Quartzite
76/154,5	G17	469	7687	Soldiers Cap Gp or Malbon Gp equivalent	Grey cleaved siltstone (4)	MW	2.70	130	
76/156	G18	451	7705	Soldiers Cap Gp or Malbon Gp equivalent	Coarse-grained quartzose and micaceous greywacke (4)	MW	2.67	20	?Mitakoodi Quartzite
76/157	G19	451	7709	Soldiers Cap Gp or Malbon Gp equivalent	Massive basalt or amphibolite (7)	SW	3.11	900	Toole Creek Volcs
76/158	G20	448	7709	Metadolerite	Fine to medium-grained dolerite (8)	SW	2.99	29 000	Intrudes Corella Fm and ?Soldiers Cap Gp
76/159,160	G21	450	7705	Corella Fm	Calc-silicate rock (3)	SW	2.84	3 500	Quartz-feldspar-epidote-actinolite granofels
76/161	G22	450	7698	Corella Fm	Brecciated calcareous shale, veinlets of limestone (3)	F	2.68	10	Some calc-silicate minerals
76/162	G23	450	7698	Corella Fm	Impure limestone (3)	F	2.70	10	Veins of brecciated calcareous shale
76/163,4	G25	448	7693	Corella Fm	Calc-silicate rock (3)	SW-MW	2.70	9 200	Calcite, actinolite, quartz, feldspar

B. SAMPLES COLLECTED IN 1975 SURVEY AREA

Sample no. (laboratory)	Location (km)* E	Location (km)* N	Rock unit	Rock type (classification in Table 1)	Weathering (**)	Density (g/cm^3)	Susceptibility (SI units x 10^6)	Remarks
(i) Granitic rocks								
75/585	458.7	7719.0	Naraku Granite	Medium-grained granite (1)	MW	2.65	2 000	Pink colour due to hematite precipitated along cleavage planes in feldspars
75/593	481.0	7738.0	?Naraku Granite	Altered granodiorite (2)	MW	2.66	54 100	) Large irregular opaque aggregates present (Mt Margaret granodiorite)
75/594	481.0	7738.0	?Naraku Granite	Altered granodiorite (2)	MW	2.63	59 200	)
75/595	481.0	7738.0	?Naraku Granite	Altered granodiorite (2)	MW	2.65	37 800	)
75/596	481.0	7738.0	?Naraku Granite	Altered granodiorite (2)	MW	2.62	20 500	)
75/597	481.0	7738.0	?Naraku Granite	Altered granodiorite (2)	MW	2.75	75 200	)
75/604	451.6	7723.7	Naraku Granite	Biotite granite (1)	SW	2.64	19 800	
75/605	450.7	7722.2	Naraku Granite	Granite with xenolith (1)	SW	2.68	12 200	Contains vestiges of Corella Fm rocks
75/606	450.2	7719.0	Naraku Granite	Granite (1)	SW	2.61	5 300	
75/613	456.2	7718.1	Naraku Granite	Porphyritic biotite granite (1)	F	2.68	23 000	
75/625	452.9	7721.7	Naraku Granite	Biotite granite (1)	SW	2.60	13 000	
75/636	466.0	7726.7	?Naraku Granite	?Sheared biotite granite (1)	SW-MW	2.63	200	
(ii) Metamorphic rocks								
75/577	464.4	7718.0	Corella Fm	Micaceous calcareous quartzite (3)	MW	2.69	220	Chlorite-muscovite-calcite-quartz rock; ?contact-metamorphosed
75/578	464.4	7748.0	Corella Fm	Quartz-hornblende-calcite granofels (3)	F	2.98	132 100	Sulphides present (<1%)
75/587	459.9	7719.0	Corella Fm	Banded hornblende-plagioclase-quartz granofels (3)	MW	2.82	2 200	Metasediment
75/588	464.1	7723.9	Corella Fm	Banded hornblende-plagioclase-quartz granofels (3)	MW	2.72	28 300	Metasediment; ?contact-metamorphosed
75/589	464.1	7723.9	Corella Fm	Banded hornblende-plagioclase-quartz granofels (3)	W	2.76	43 300	Metasediment; ?contact-metamorphosed

B. SAMPLES COLLECTED IN 1975 SURVEY AREA (continued)

Sample no. (laboratory)	Location (km)* E	N	Rock unit	Rock type (classification in Table 1)	Weathering (**)	Density (g/cm^3)	Susceptibility (SI units x 10^6)	Remarks
75/590	464.1	7723.9	Corella Fm	Calc-silicate (3)	SW	2.80	25 900	Epidote-hornblende-plagioclase-quartz rock; ?contact-metamorphosed
75/591	464.8	7726.0	Corella Fm	Hornblende-plagioclase-quartz granofels (3)	F	2.90	38 700	
75/607	472.9	7721.0	Corella Fm	Brecciated calcareous quartzite (3)	SW	2.63	520	Quartzite clasts in calcareous matrix
75/612	453.6	7717.8	Corella Fm	Scapolitic amphibolite (7)	SW	2.86	620	
75/616	461.2	7708.5	Corella Fm	Brecciated calc-silicate (3)	SW	2.66	80	Hornblende-feldspar-quartz rock
75/621	460.0	7726.0	?Corella Fm	Fine-grained quartzite breccia (4)	SW	2.61	280	Origin uncertain
75/626	454.2	7718.4	Corella Fm	Quartz-hornblende-feldspar granofels (3)	SW	2.71	1 200	Granitised sediment
75/628	454.6	7718.5	Corella Fm	Quartz-plagioclase-hornblende rock (3)	SW	2.85	900	Metasediment
75/630	464.9	7718.0	Corella Fm	Hornblende-quartz-feldspar granofels (3)	SW	2.64	330	Metasediment
75/631	464.3	7718.0	Corella Fm	?Diopside limestone (3)	SW	3.01	430	
75/635	459.9	7719.0	Corella Fm	Quartz-hornblende-plagioclase rock (3)	SW	2.89	38 000	Metasediment
75/617	463.7	7715.0	Toole Creek Volcs	Epidote quartzite (7)	MW	3.02	5 800	Generally crenulated or folded
75/619	469.7	7716.7	Toole Creek Volcs	Metabasalt (7)	SW	3.11	1 300	Vesicular
75/623	466.8	7718.8	Toole Creek Volcs	Garnet amphibolite (7)	SW-MW	2.80	940	
75/579	464.4	7718.0	Mt Norna Quartzite	Banded quartz-magnetite rock (6)	W	3.56	220 000	Magnetite pseudomorphosed by hematite; probably a metasediment. Veined by quartz
75/580	465.4	7718.0	Mt Norna Quartzite	Banded hematite rock (6)	W	3.73	2 100	Possibly of sedimentary origin
75/582	465.5	7718.0	Mt Norna Quartzite	Porphyritic rhyolite (5)	SW	2.57	60	
75/584	464.7	7716.9	Mt Norna Quartzite	Labile quartz (4)	MW	2.65	4 400	

B. SAMPLES COLLECTED IN 1975 SURVEY AREA (continued)

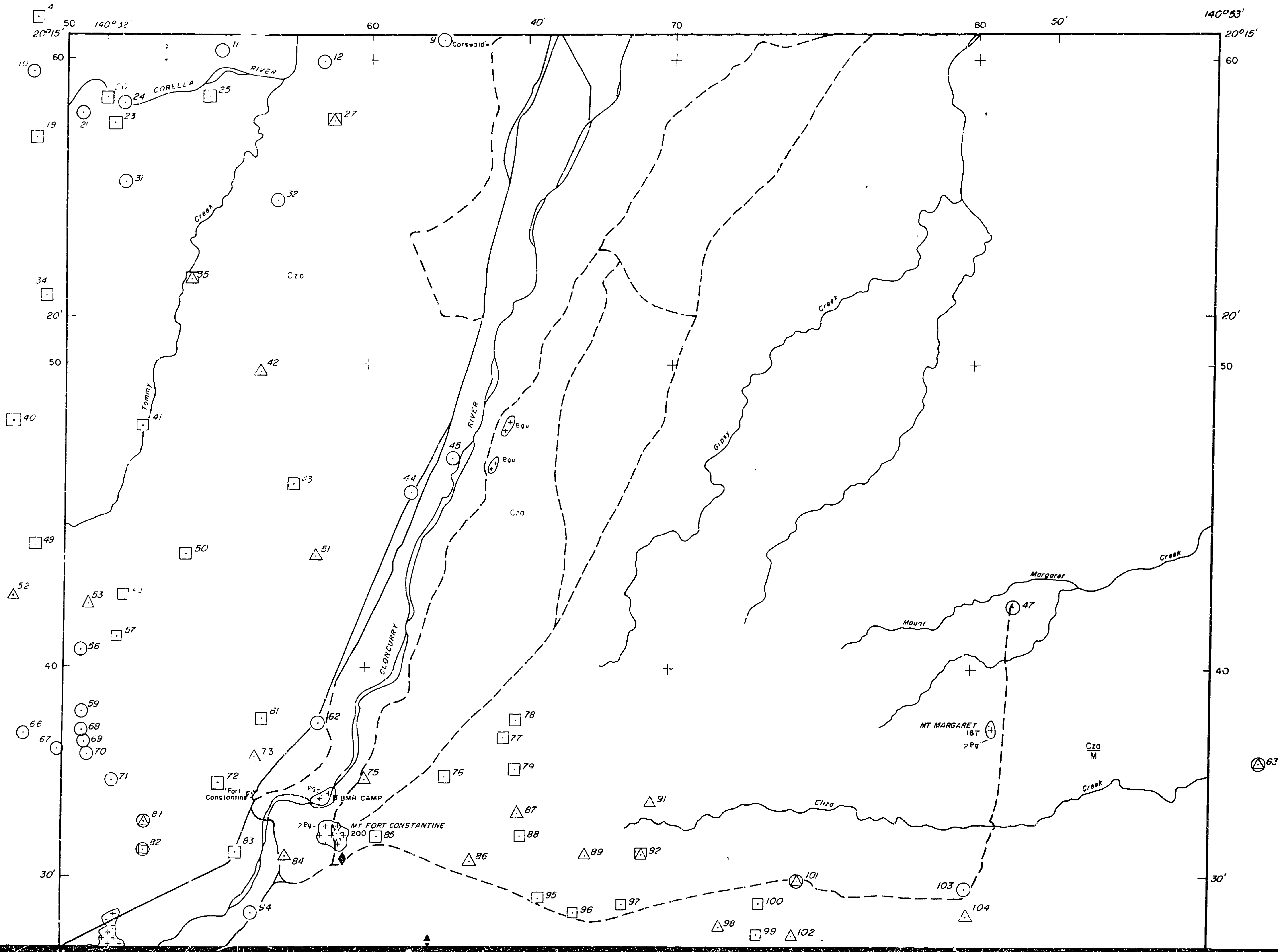
Sample no. (laboratory)	Location (km)* E	N	Rock unit	Rock type (classification in Table 1)	Weathering (**)	Density (g/cm^3)	Susceptibility (SI units x 10^6)	Remarks
75/614	456.6	7713.6	Mt Norna Quartzite	Fine-grained calcareous quartzite (4)	MW	2.63	5 100	Folded veined meta-sediment
75/615	456.9	7713.2	Mt Norna Quartzite	Feldspathic quartzite (4)	SW	2.64	3 400	Actinolite up to 8%
75/622	465.7	7718.1	Mt Norna Quartzite	Feldspathic quartzite (4)	SW	2.64	120	
75/624	466.8	7718.8	Mt Norna Quartzite	Laminated shale (4)	MW	2.78	36 000	
75/629	467.2	7718.8	Mt Norna Quartzite	Banded iron formation (6)	MW	3.14	150 000	
75/632	465.6	7718.0	Mt Norna Quartzite	Scapolitic calcareous siltstone (3)	SW	2.74	1 000	
75/633	465.7	7718.0	Mt Norna Quartzite	Rhyolite (5)	SW	2.60	20	
75/634	464.7	7716.9	Mt Norna Quartzite	Labile quartzite (4)	MW	2.70	1 400	cf. 75/584
(iii) Other rocks (unclassified)								
75/576	463.0	7718.1		Limonitic vein quartz (4)	W	2.56	95	Weathered ?mineralised vein in Corella Fm. Sulphides broken down to limonite
75/581	465.4	7718.0		Quartz-hematite rock (6)	W	2.91	8 700	?Ferricrete
75/592	464.8	7728.3		Calcrete with hematite rock fragments (6)	W	2.93	23 600	?Tertiary surficial rock
75/598	458.9	7734.5		Rhyodacite (5)	MW	2.70	47 400	?Porphyritic granodiorite
75/599	458.9	7734.5		Rhyolitic agglomerate (5)	SW-MW	2.68	17 100	?Brecciated acid volcanics
75/600	459.1	7734.5		?Rhyolitic agglomerate (5)	MW	2.73	36 800	Large amount of actinolite present
75/601	459.2	7734.8		Rhyolite (5)	SW-MW	2.56	60	
75/602	459.7	7734.2		Banded hematite-magnetite (6)	MW	4.66	216 000	) Origin uncertain-meta-) sedimentary or contact) metasomatic
75/603	459.7	7734.2		Banded hematite-magnetite (6)	W	4.62	231 000	)
75/608	473.2	7721.0		Calcareous shale (3)	MW	2.56	45	Veined by calcite; ?metamorphosed; may have been pyritic. ?Soldiers Gap Gp

B. SAMPLES COLLECTED IN 1975 SURVEY AREA (continued)

Sample no. (laboratory)	Location (km)* E	N	Rock unit	Rock type (classification in Table 1)	Weathering (**)	Density (g/cm^3)	Susceptibility (SI units x 10^6)	Remarks
75/620	461.6	7726.0		Rhyolite (5)	SW	2.60	1 200	
75/583	464.7	7717.0		Metadolerite (8)	F	3.05	780	Texture retained but no pyroxene: amphibole and altered plagioclase form bulk of rock
75/586	459.0	7719.0		Dolerite (8)	F	3.01	25 800	Young unaltered dolerite
75/618	470.9	7716.5		Dolerite (8)	F	2.71	29 000	Pyroxene-bearing
75/627	454.4	7718.4		Metadolerite (8)	SW	3.01	27 000	Plagioclase amphibolite

* Location reference is Australian Map Grid co-ordinates (in kilometres) for Map Zone 54. Note: Positional accuracy for 1975 samples (Appendix 3B) is ± 50 m, and for 1972 samples (Appendix 3A) ± 500 m.

** W = weathered; M = moderately; S = slightly; F = fresh.



140°32'
140°53'
20°15'
20'
30'
40'
50'
CORELLA RIVER
Tommy Creek
CLONCURRY RIVER
Gipsy Creek
Mount Margaret Creek
Eliza Creek
Cotswold's
Czo
Pgu
BMR CAMP
'Fort Constantine'
MT FORT CONSTANTINE
200
MT MARGARET
167
?Pg
Czo/M

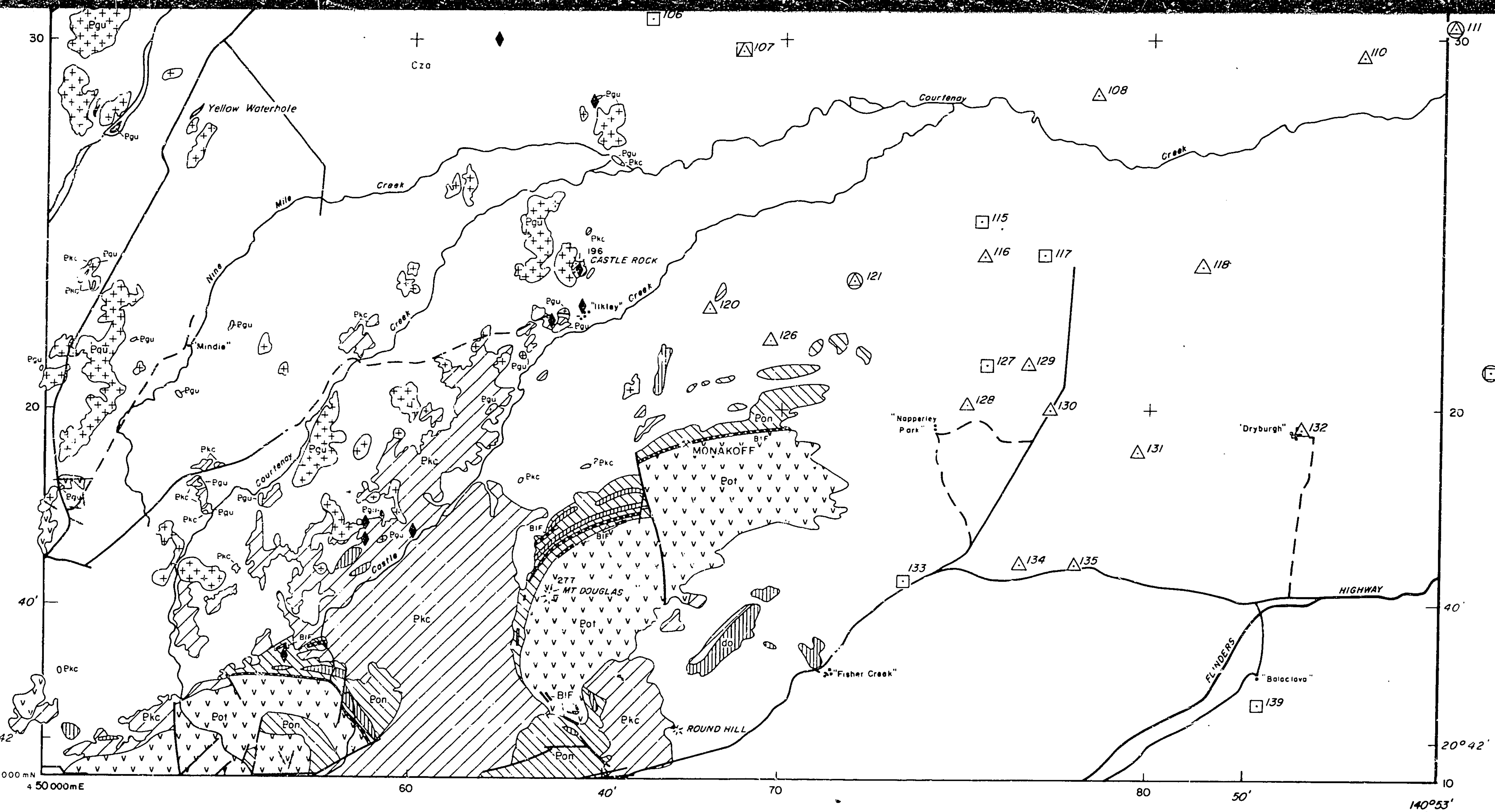
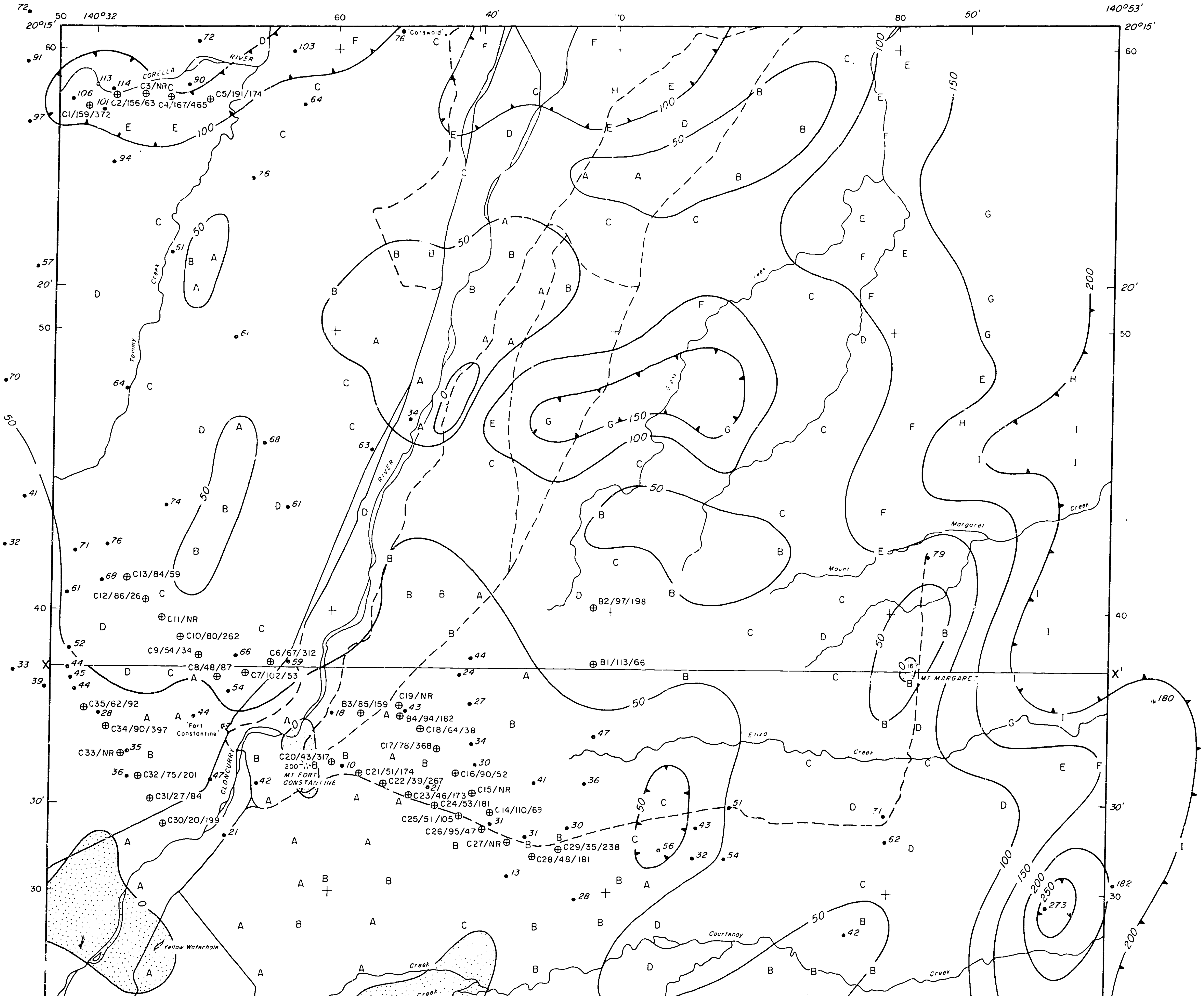


Plate I Outcrop and borehole geology



20°15'
140°32
140°53'
40'
50'
20'
30'
60
50
40
30
80
70
'Corswold'
CORELLA
RIVER
Tommy
Creek
'Fort Constantine'
MT FORT CONSTANTINE
CLONCURRY
RIVER
Yellow Waterhole
Margaret
Creek
Mount
MT MARGARET
Eliza
Creek
Courtenay
Creek
X
X'
C1/159/372
C2/156/63
C3/NR
C4/167/465
C5/191/174
C6/67/312
C7/102/53
C8/48/87
C9/54/34
C10/80/262
C11/NR
C12/86/26
C13/84/59
C14/110/69
C15/NR
C16/90/52
C17/78/368
C18/64/38
C19/NR
C20/43/317
C21/51/174
C22/39/267
C23/46/173
C24/53/181
C25/51/105
C26/95/47
C27/NR
C28/48/181
C29/35/238
C30/20/199
C31/27/84
C32/75/201
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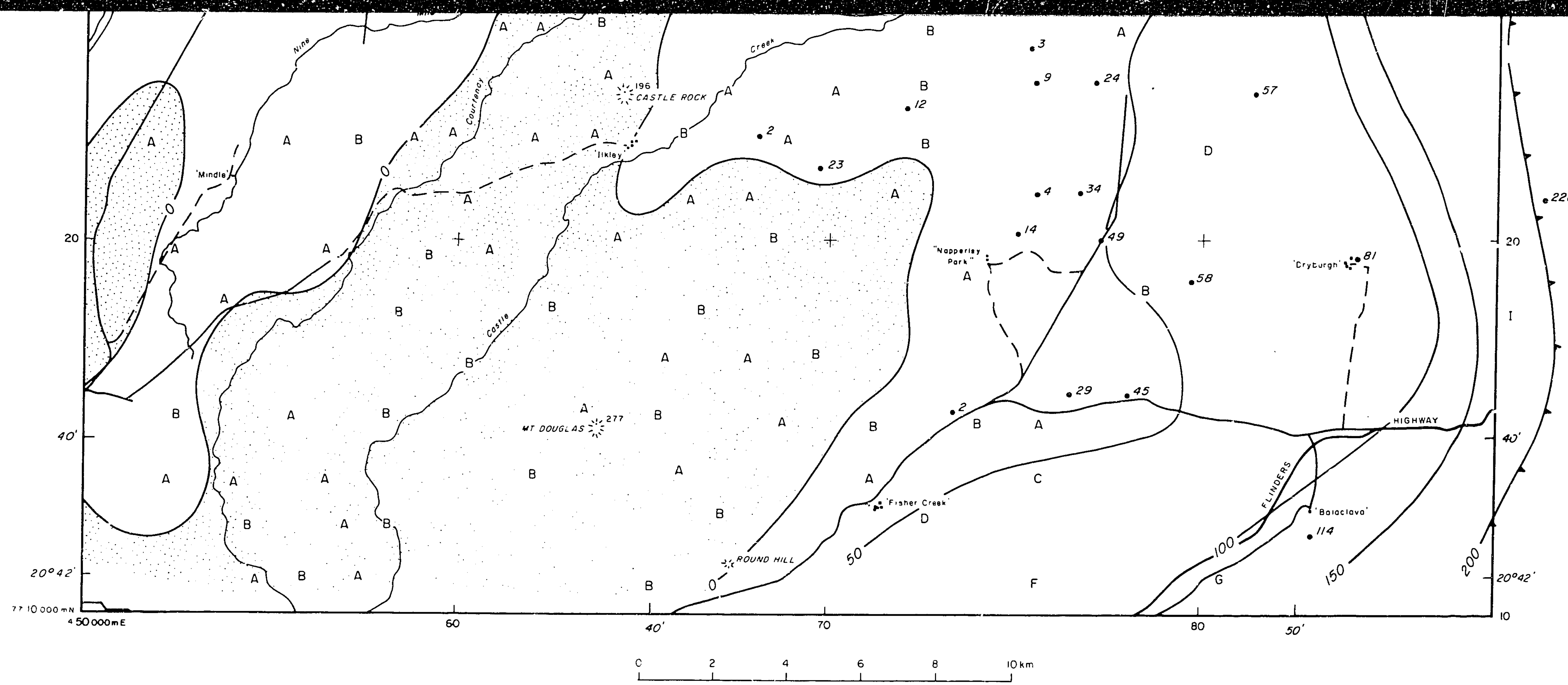
B2/97/198
B3/85/159
B4/94/182
273



DEPTH TO PRECAMBRIAN SURFACE

Contour interval 50 metres

BOREHOLE DATA

•61 Depth to weathered basement (metres)

VERTICAL ELECTRICAL SOUNDINGS (VES)

⊕ VES site

C35/62/92 VES Reference No (refer Appendix 2)/ depth to top of unweathered basement (metres)/ basement resistivity (ohm-metres)

NR Basement depth and resistivity not resolved

AEROMAGNETIC INTERPRETATION

A	0 - 25	metres below ground level
B	25 - 50	
C	50 - 75	
D	75 - 100	
E	100 - 125	
F	125 - 150	
G	150 - 175	
H	175 - 200	
I	> 200	

TOPOGRAPHY

River or creek

Hill feature

·277 Elevation (metres)

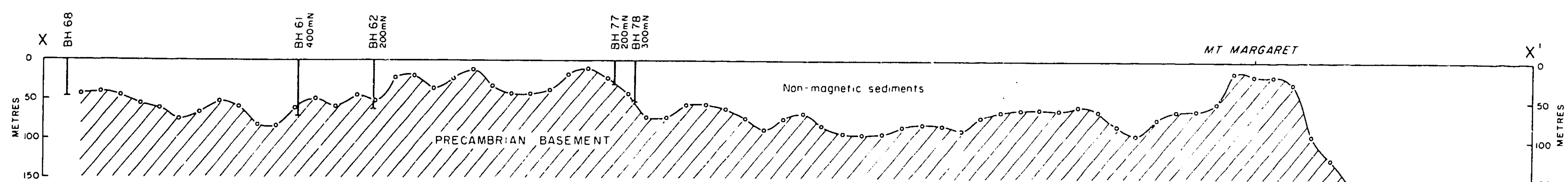
Road / track

•'Ilkley' Homestead

Area containing Precambrian outcrop

Interpreted basement depression

SECTION X-X' INTERPRETED FROM DETAILED GROUND MAGNETIC TRAVERSE 38N

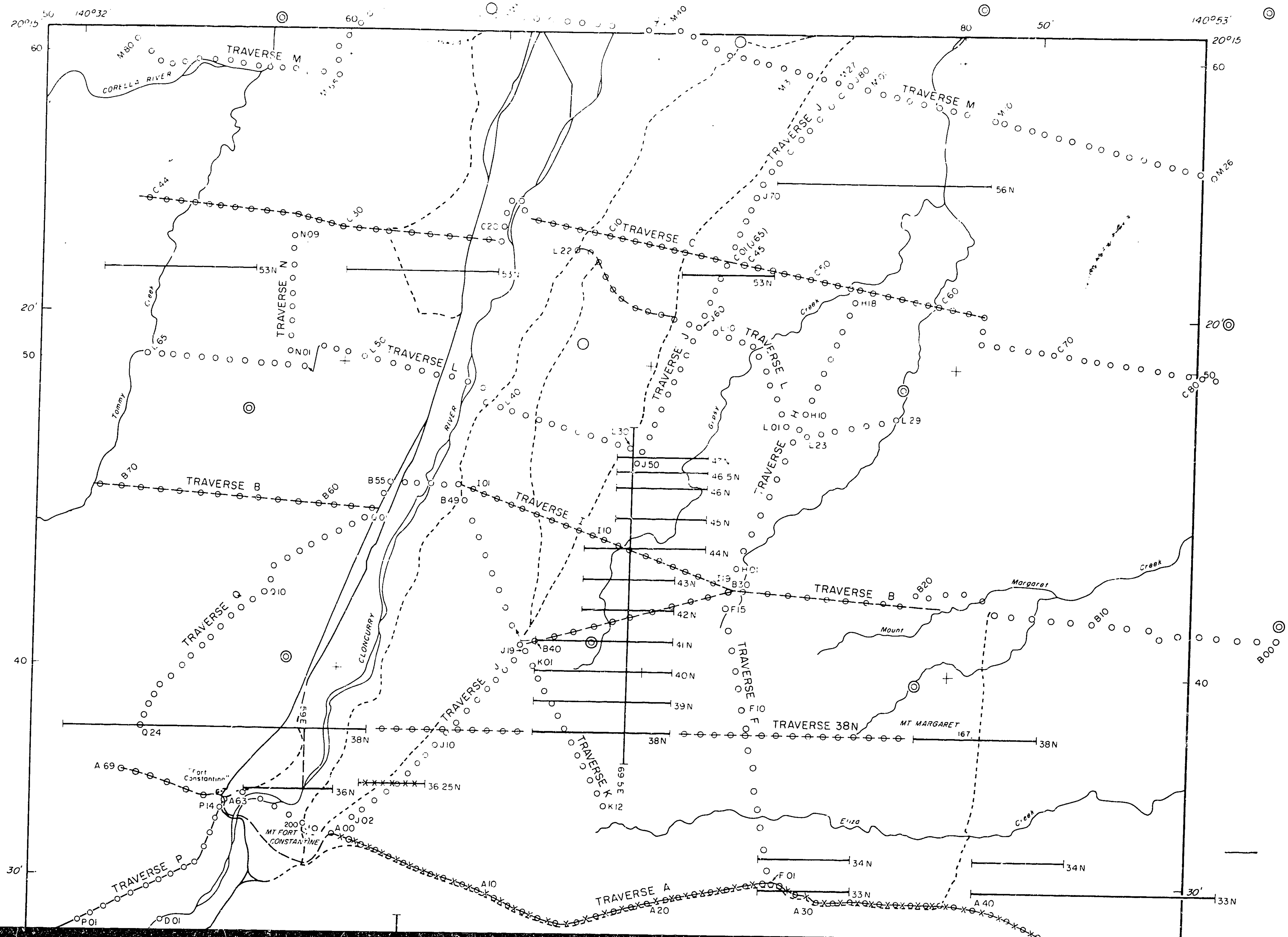


BH 61 } Borehole Reference No and
400mN } offset from Traverse 38N

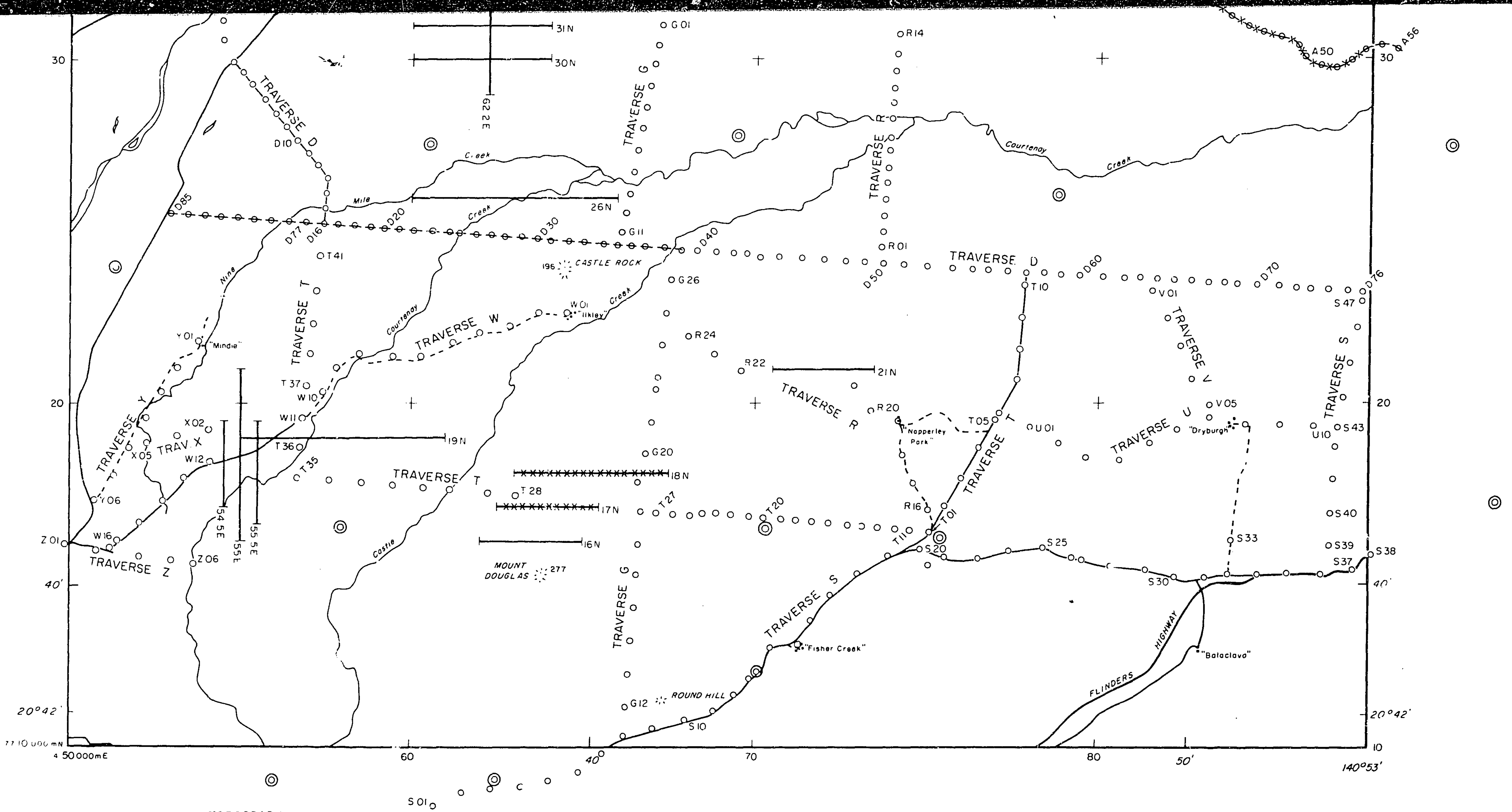
$\frac{V}{H} = 20$

Plate 2 Basement depth interpretation

F54/B7-88



TRAVERSE M
CORELLA RIVER
TRAVERSE C
TRAVERSE N
TRAVERSE L
TRAVERSE J
TRAVERSE H
TRAVERSE B
TRAVERSE I
TRAVERSE Q
TRAVERSE K
TRAVERSE F
TRAVERSE 38N
TRAVERSE P
TRAVERSE A
CLONCURRY RIVER
Tommy Creek
Gipsy
Margaret Creek
Mount
Eliza Creek
MT MARGARET
MT FORT CONSTANTINE
"Fort Constantine"
56N
53N
47N
46.5N
46N
45N
44N
43N
42N
41N
40N
39N
38N
36N
36.25N
34N
33N
59E
69.5E
140°32'
140°53'
50'
20°15'
20'
30'



TOPOGRAPHY

River or creek

Hill feature

.196 Elevation (metres)

Road/track

"Ilkley" Homestead

0 2 4 6 8 10 km

Plate 3 Detailed and semi-regional traverse locations

TRAVERSE KEY

19N — Detailed magnetic and gravity traverse (25 or 50m magnetic stations, 50 or 100m gravity stations)

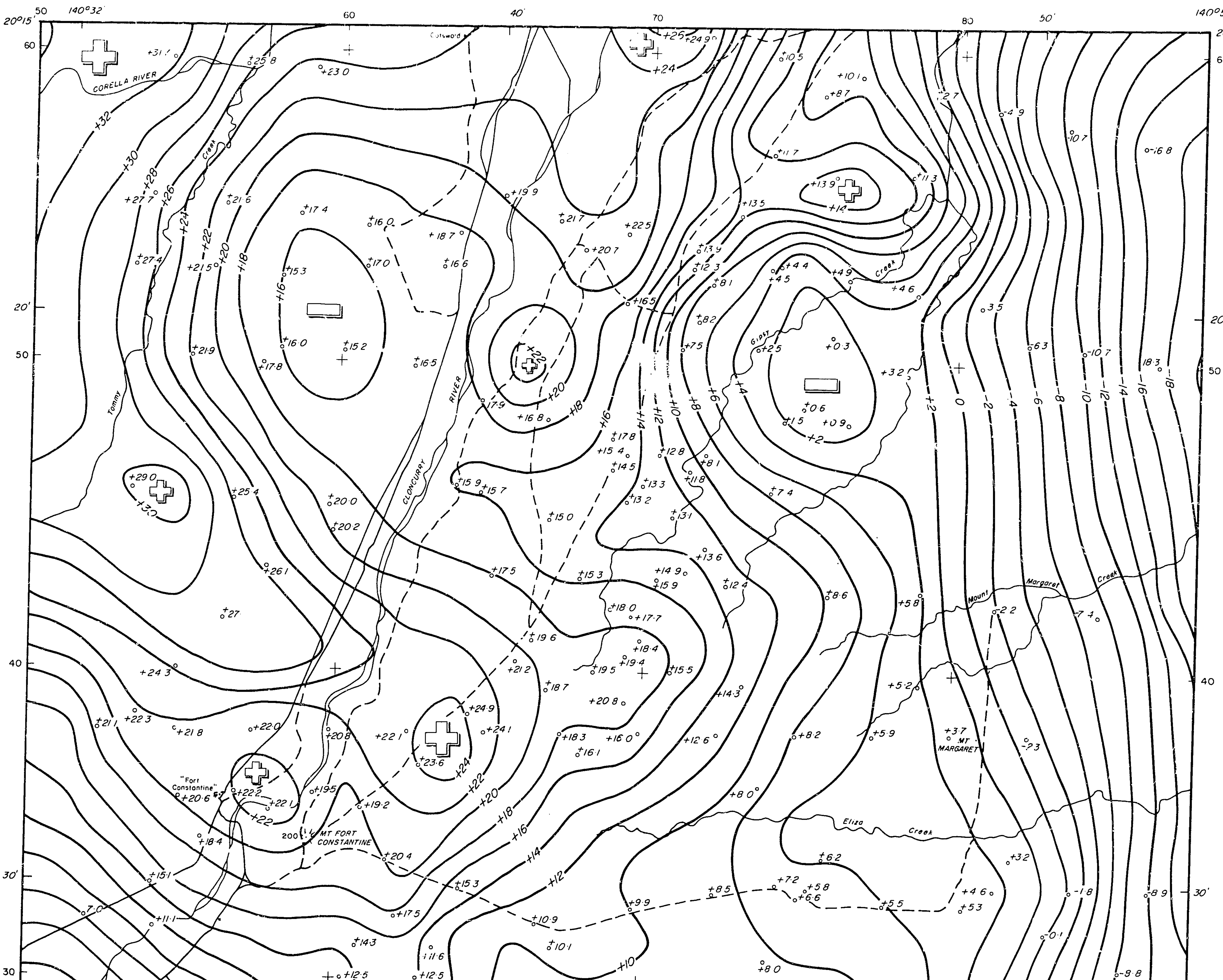
TRAV A — Semi-regional gravity traverse (0.5 or 1.0km stations - circles represent station locations)

TRAV. D — Semi-regional magnetic traverse (approx 50m stations)

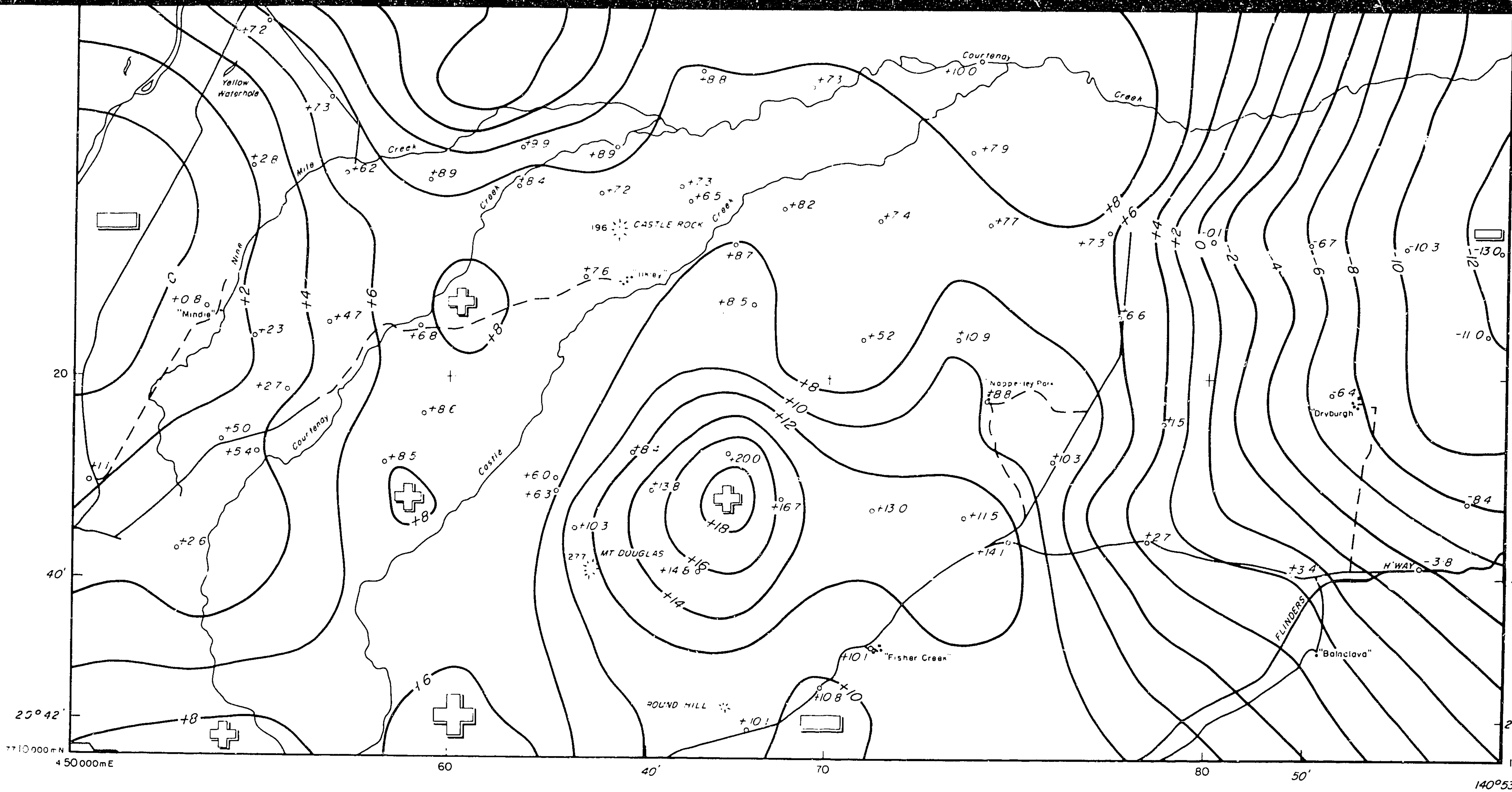
XXXX XXX — Resistivity profiling along detailed or semi-regional traverse

Regional gravity station (1966 helicopter survey)

F54/B7-89



20°15'
140°32'
140°53'
20'
30'
CORELLA RIVER
Creek
Tommy
CLONCURRY
RIVER
Gipsy
Creek
Mount Margaret Creek
MT MARGARET
Eliza Creek
"Fort Constantine"
MT FORT CONSTANTINE
Cotswold



F 54/B7-90

TOPOGRAPHY

River or Creek

Hill feature

.196 Elevation (metres)

Road/track

."Ilkley" Homestead

0 2 4 6 8 10 km

CONTOUR INTERVAL 2 mGal

Plate 4 Bouguer anomaly contours

GRAVITY

-12.3 Bouguer anomaly (milligals)

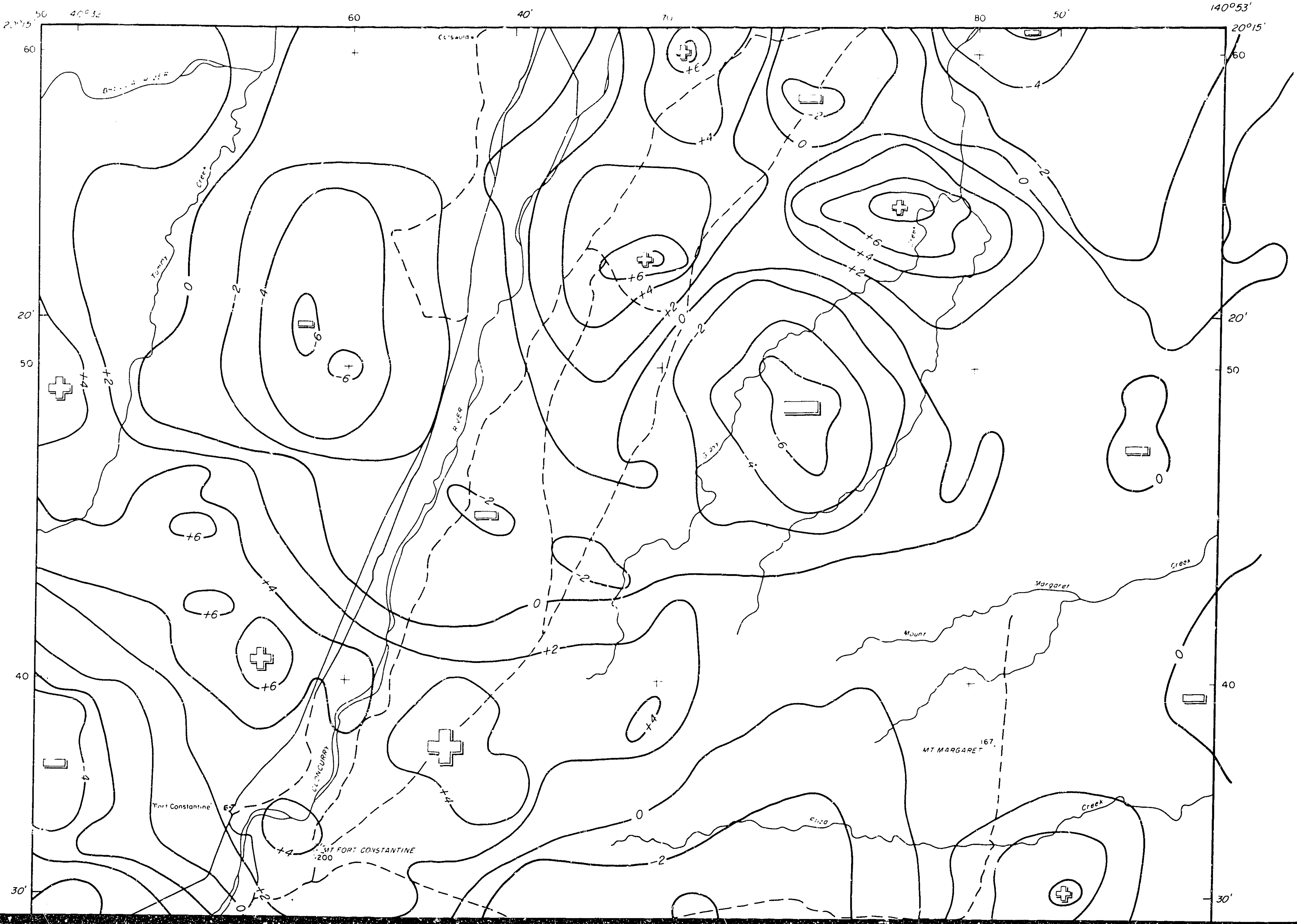
--5-- Isogal

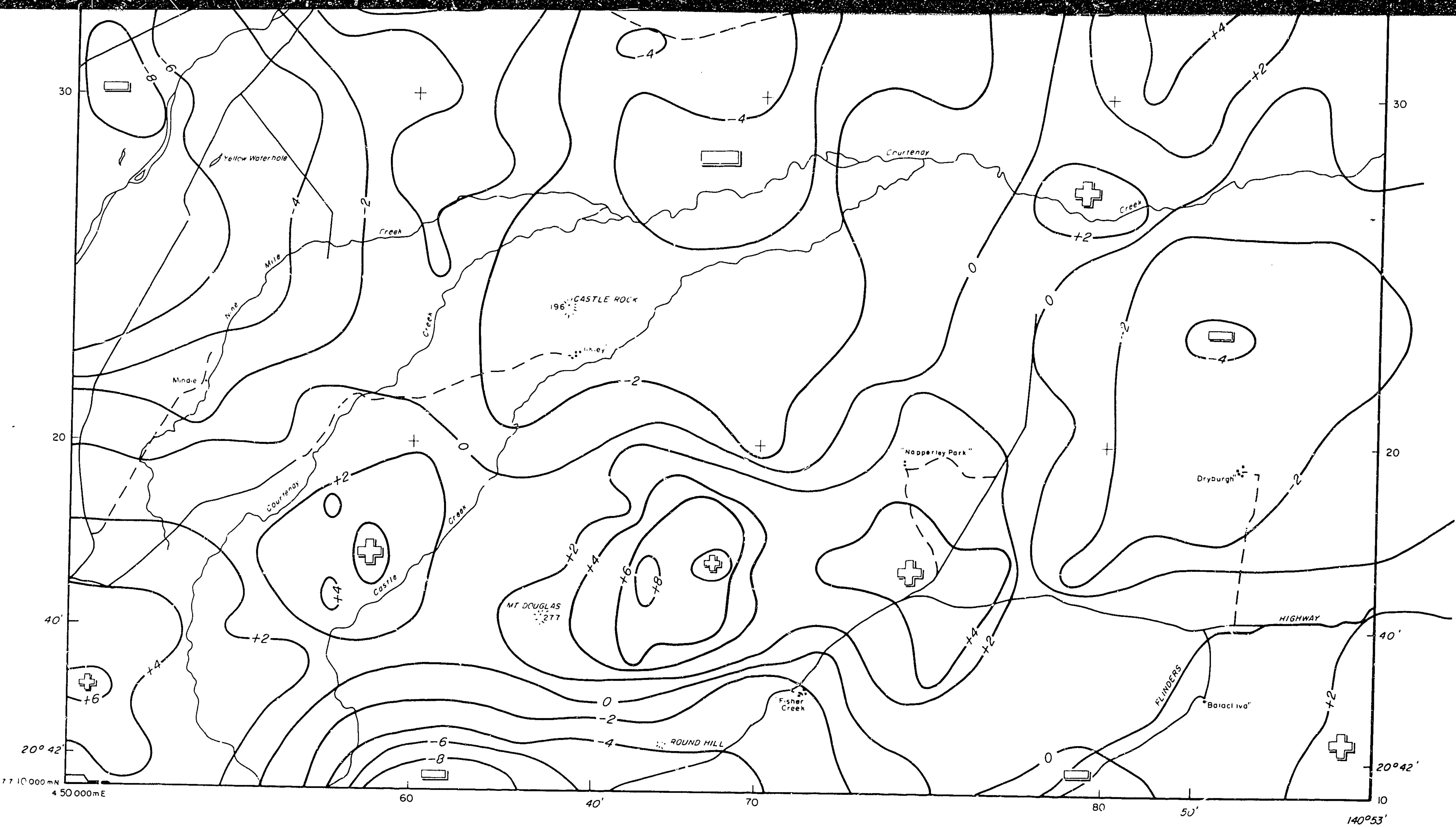
'High' feature

'Low' feature

o Gravity station

For the calculation of Bouguer anomalies 2.67g/cm^3 has been adopted as an average rock density


140°53'
20°15'
60
40'
70
80
50'
20'
50
40
30'
Tommy
Creek
RIVER
Cloncurry
Fort Constantine
MT FORT CONSTANTINE
200
Mount
Margaret
Creek
MT MARGARET
167
Eliza
Creek
+6
+4
+2
0
-2
-4
-6



F54/B7-91

TOPOGRAPHY

River or creek

Hill feature

·196 Elevation (metres)

Road/track

Homestead

0 2 4 6 8 10 km

CONTOUR INTERVAL 2 mGal

Regional gravity field (Fig 5) has been subtracted from Bouguer anomaly (Pl. 4) to produce this map.

GRAVITY

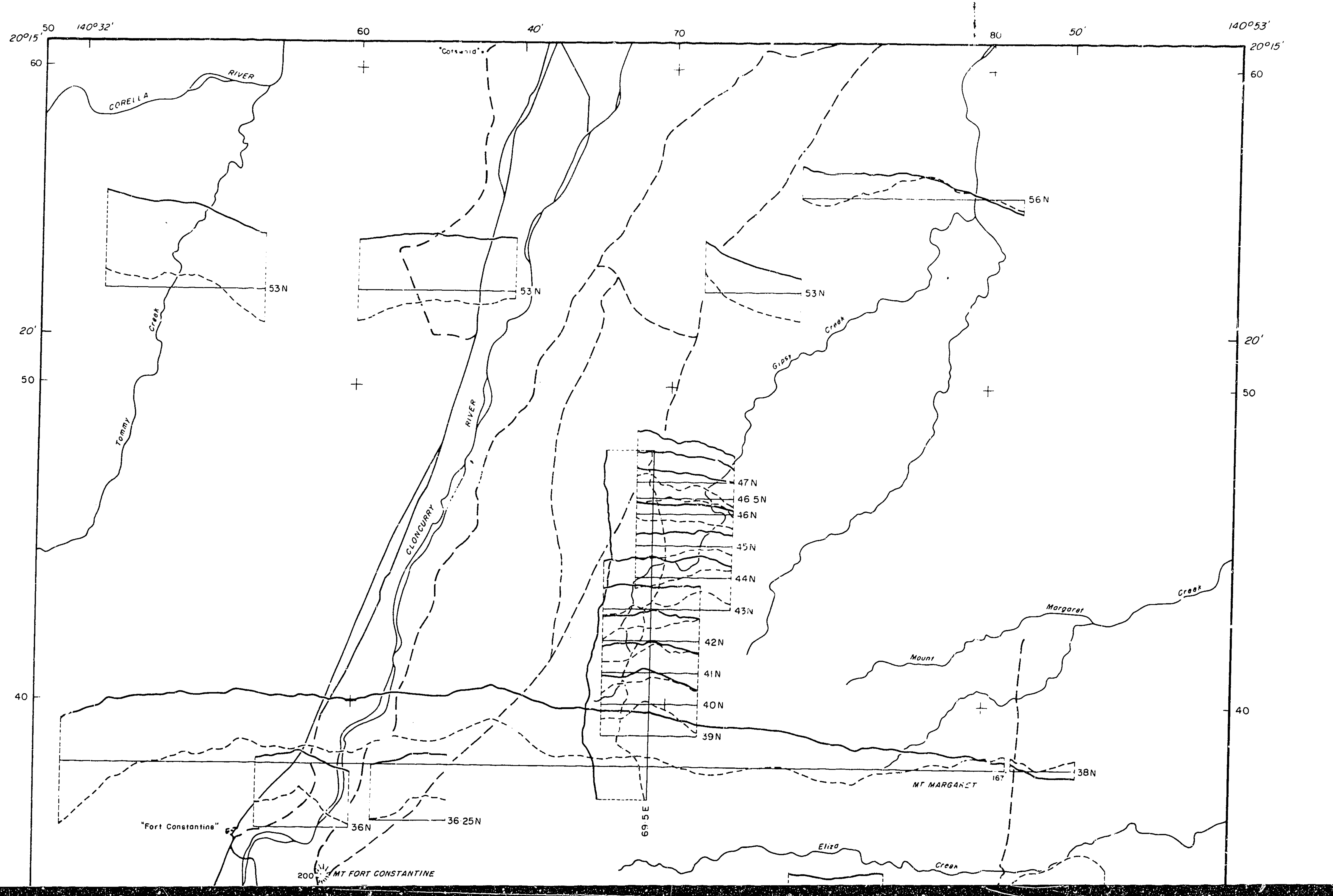
+2 Isogal

'High' feature

'Low' feature

For the calculation of Bouguer anomalies 2.67g/cm³ has been adopted as an average rock density

Plate 5 Residual anomaly contours



20°15'
50
140°32'
60
40'
70
80
50'
140°53'
20°15'
60
60
"Cotswold"
CORELLA
RIVER
53N
53N
53N
56N
20'
20'
50
50
Tommy
Creek
CLONCURRY
RIVER
Gipsy
Creek
47N
46 5N
46N
45N
44N
43N
42N
41N
40N
39N
38N
40
40
Margaret
Creek
Mount
MT MARGARET
167
36N
36·25N
69·5E
"Fort Constantine"
200
MT FORT CONSTANTINE
Eliza
Creek

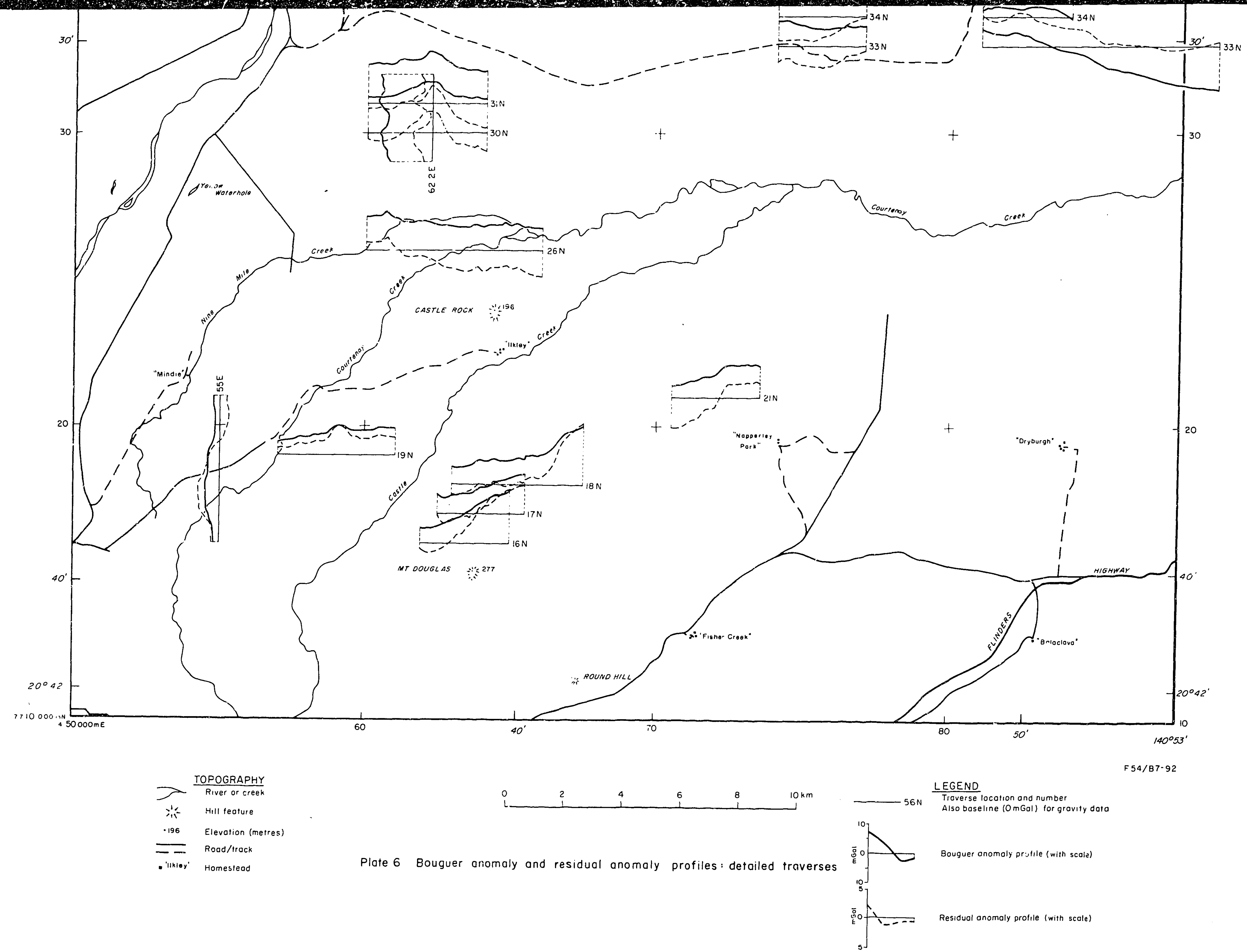
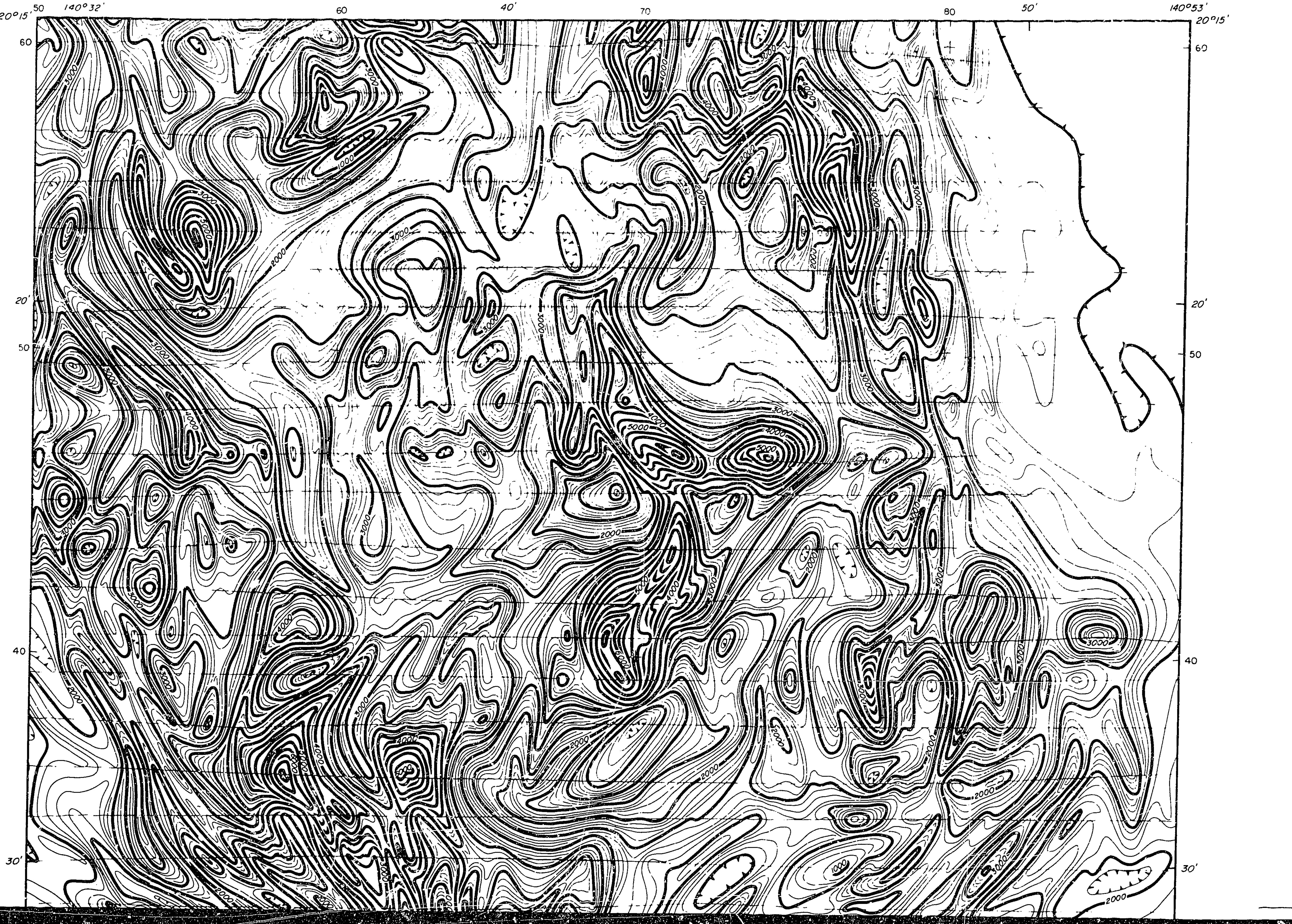


Plate 6 Bouguer anomaly and residual anomaly profiles: detailed traverses



20°15'
140°32'
40'
50'
140°53'
20°15'
20'
30'
50
60
70
80
40
1000
2000
3000
4000
5000
6000

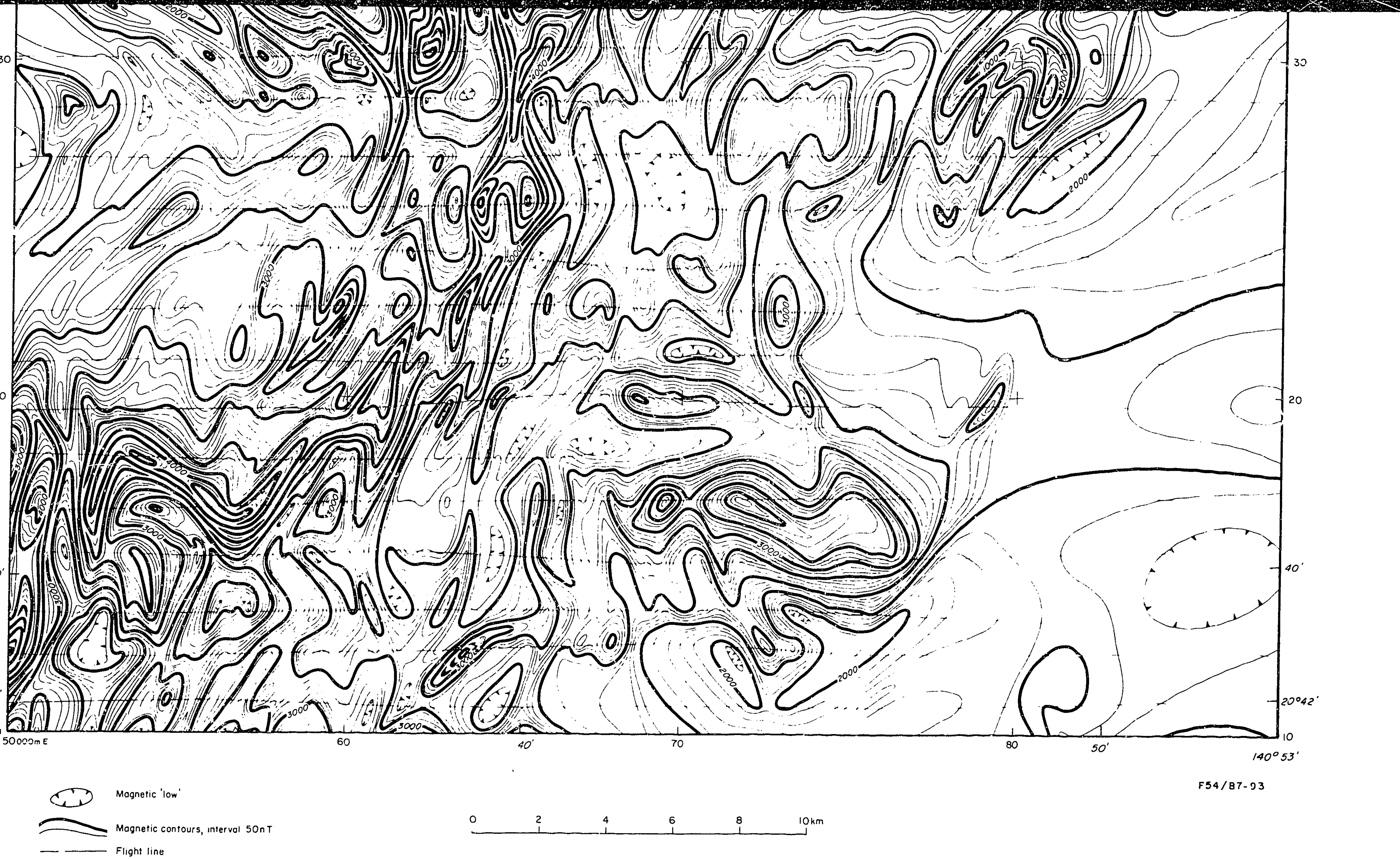
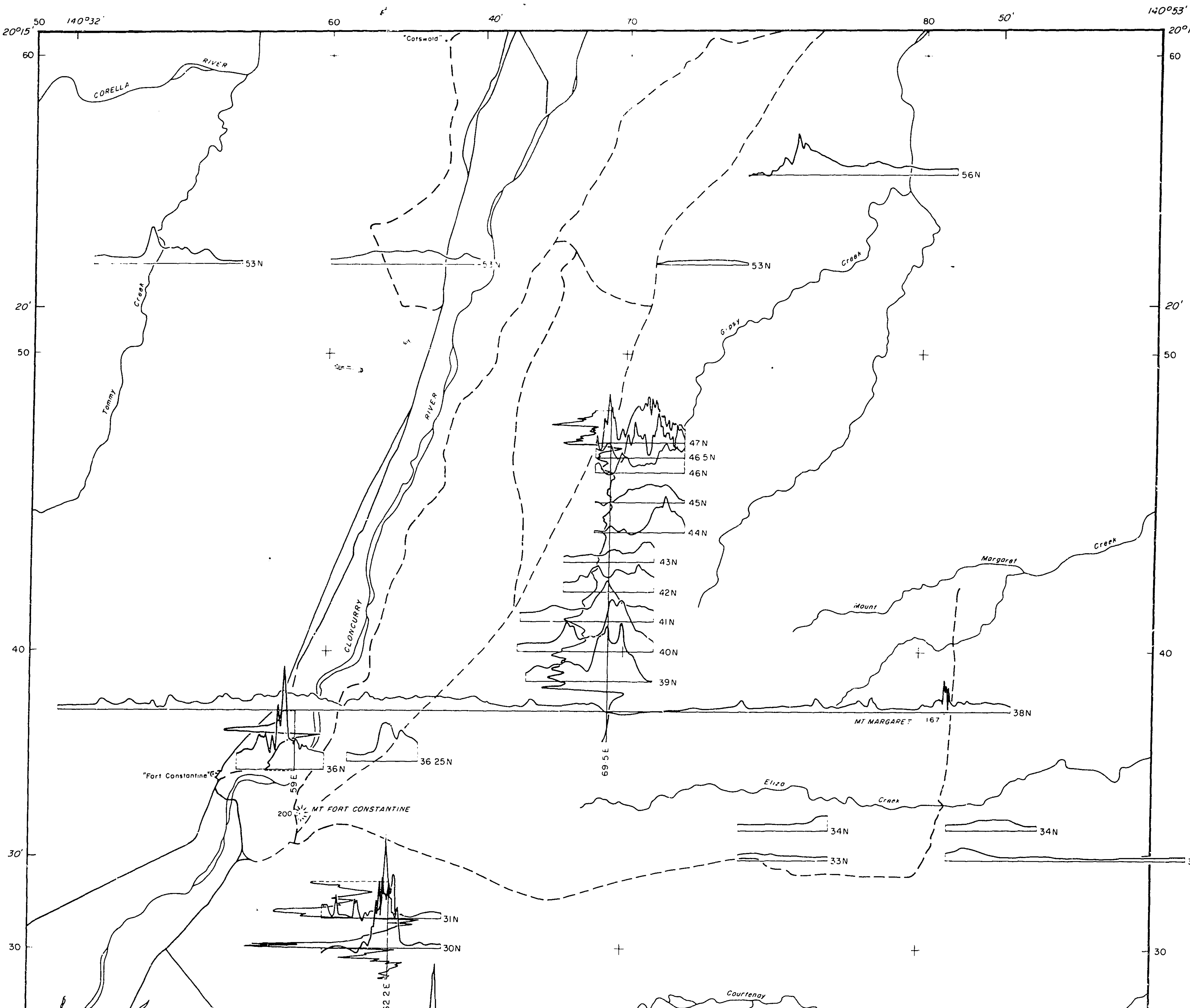
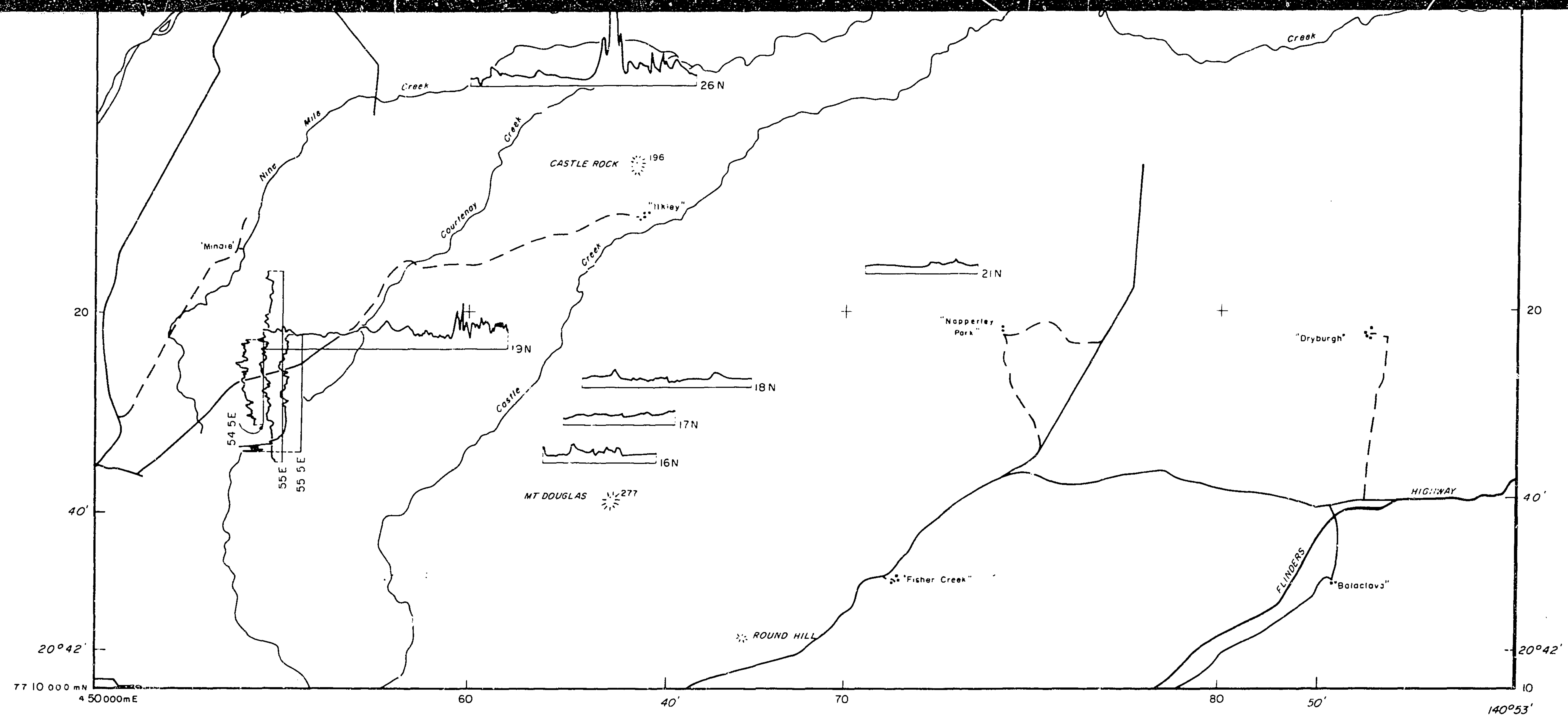


Plate 7 Aeromagnetic contours



50
140°32'
60
40'
70
80
50'
140°53'
20°15'
20°15'
60
60
"Cotswold"
RIVER
CORELLA
53N
53N
53N
Creek
Tommy
Creek
Gipsy
Creek
20'
20'
50
50
56N
RIVER
47N
46 5N
46N
45N
44N
43N
42N
41N
40N
39N
CLONCURRY
Margaret
Creek
Mount
40
40
38N
MT MARGARET
167
69 5E
36N
36 25N
59E
"Fort Constantine"
200
MT FORT CONSTANTINE
Eliza
Creek
34N
34N
33N
33N
30'
31N
30N
30
30
62 2E
Courtenay



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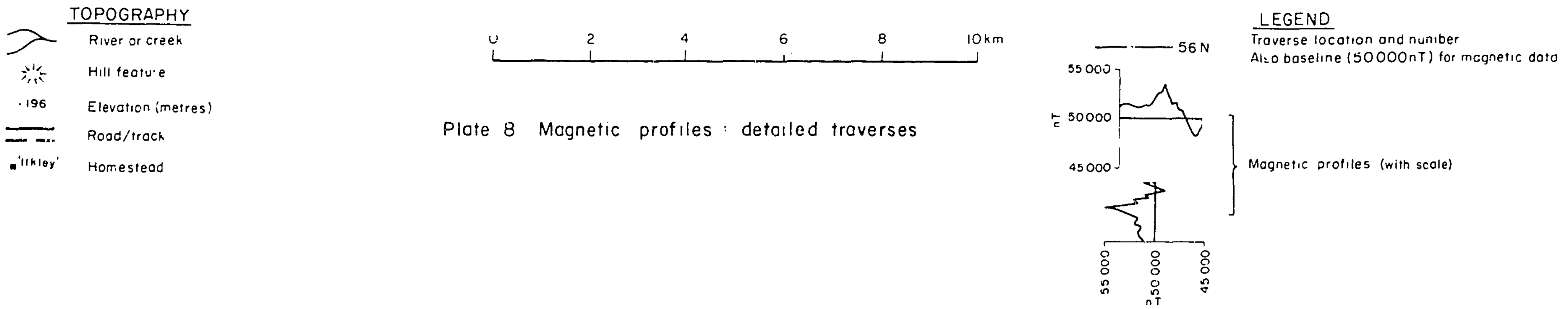
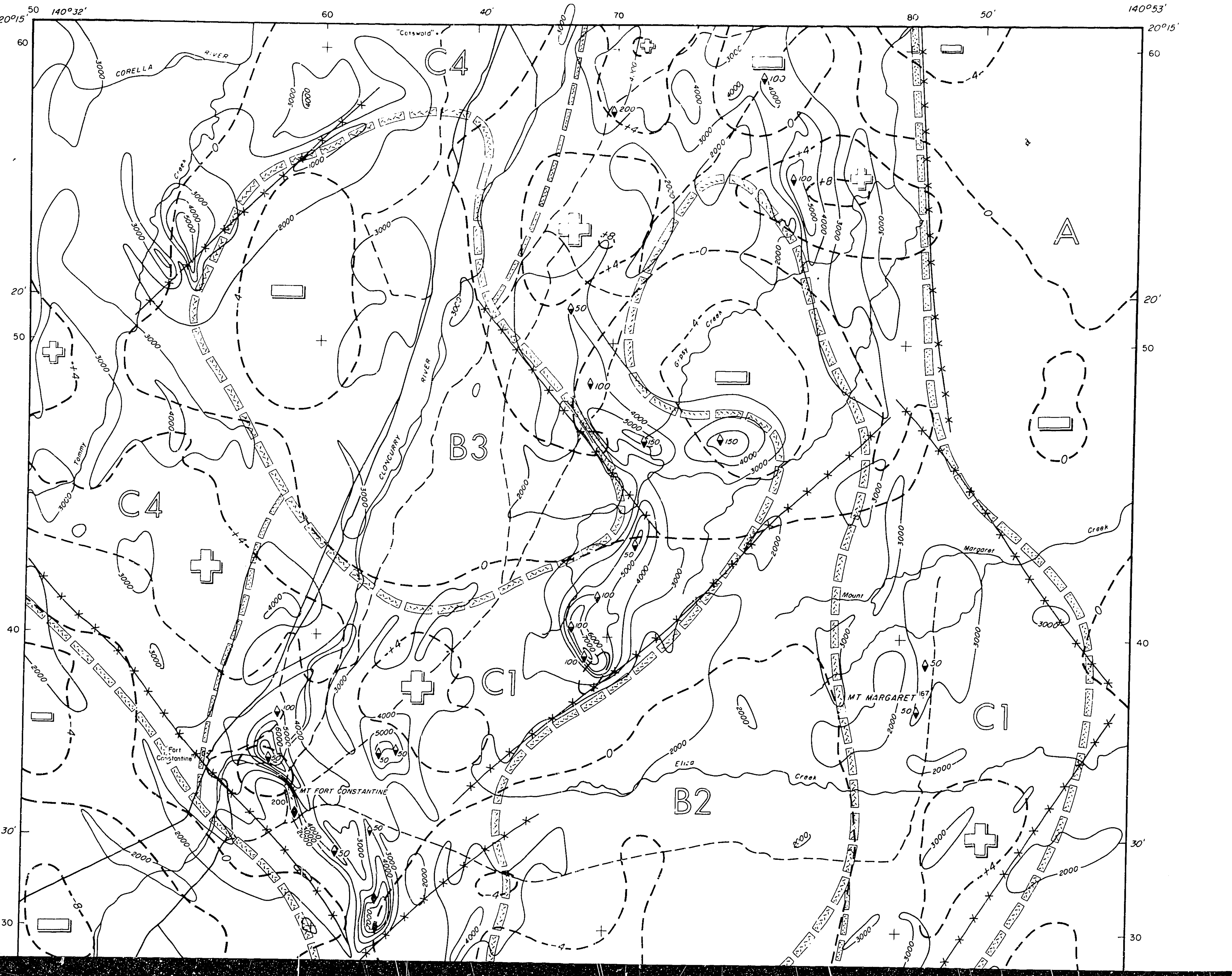
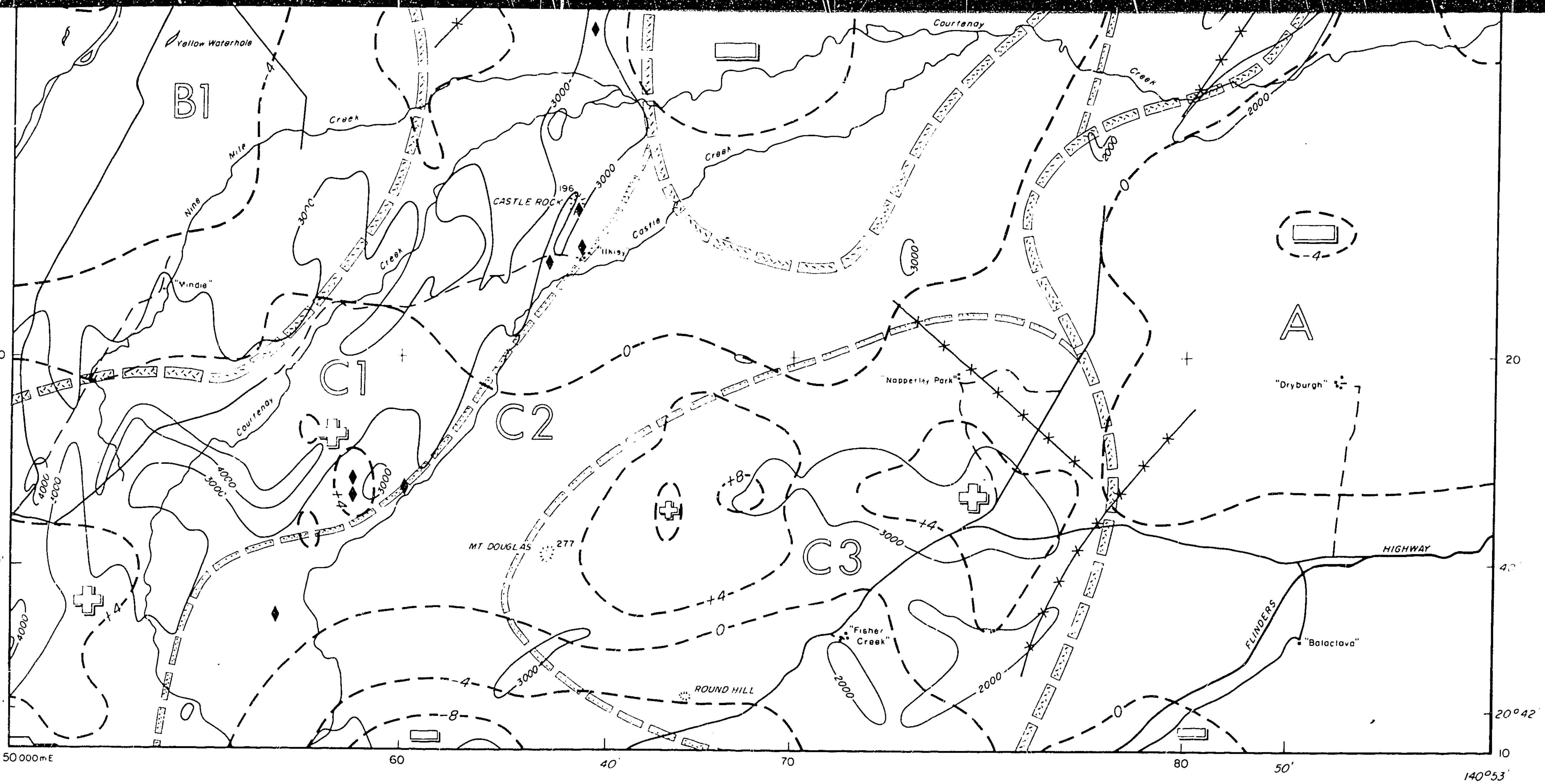


Plate 8 Magnetic profiles : detailed traverses



20°15'
140°32'
60
40'
70
80
50'
140°53'
"Cotswold"
CORELLA RIVER
Creek
C4
A
B3
C1
B2
CLONCURRY RIVER
Gipsy Creek
Tommy
Margaret Creek
Mount
MT MARGARET
Eliza Creek
Fort Constantine
MT FORT CONSTANTINE
20'
50
40
30'
30



LEGEND

- River or creek
- Hill feature
- ·196 Elevation (metres)
- Road/track
- "Ilkley" Homestead
- —3000— Total magnetic intensity contours at 1000nT interval
- —+4— Residual (gravity) anomaly isogals at 4mGal interval
- 'High' gravity feature
- 'Low' gravity feature
- A Geophysical region
- C1 Geophysical zone
- Geophysical lineament
- Magnetite/hematite outcrop
- 100 Area containing possible magnetite body and interpreted depth to it

0 2 4 6 8 10 km

Plate 9 Geophysical interpretation

F54/B7-95