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DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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ARLTUNGA NAPPE DETAILED GRAVITY SURVEY, N.T., 1973.

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SUMMARY

The Arltunga Nappe detailed gravity survey was carried out in September 1973 across the northern edge of the Amadeus Basin, the Arltunga Nappe, and part of the adjacent Arunta Complex, 120 km east of Alice Springs, N.T. Gravity was measured mainly at 1 km intervals along 180 km of north-south traverse, and special readings were made over the Harts Range to determine its bulk density. Over half the readings, including the special ones, were obtained using helicopter transport, and these had noticeably less drift than the readings made using vehicular transport.

The gravity results indicate that there is no deformation of the basement beneath the Arltunga Nappe. The nappe may therefore have moved from the north along a major low-angle thrust. Another thrust is identified within the Arunta Complex, and linked with the uplifting of the Harts Range.

The special gravity data across the Harts Range were reduced to multiple density Bouguer profiles. These gave a density estimate of 2.85± 0.05 g cm^{-3} for the 300 m high range, a value that appears to hold for the bulk density of the Arunta Complex metamorphics over several kilometres of the survey traverse.

The Arunta Complex north of the Arltunga Nappe is known to be a zone of Proterozoic crustal uplift, because granulites are exposed at the surface. However, the regional gravity level there is similar to areas with no granulites. This indicates that although a large block of crust moved upwards, there is no excess mass at depth in the uplift zone.

Three anomalous bodies are identified within the Arunta Complex. The largest appears to be a near-surface 10 km wide zone of dense, weathered, slightly magnetic rocks, with possible economic potential.

INTRODUCTION

The Arltunga Nappe detailed gravity survey was carried out in September, 1973, 120 km east of Alice Springs, N.T. Two traverses were made, AA' and BB', and together they totalled 180 km, extending from the northern edge of the Amadeus Basin, across the Arltunga Nappe Complex, and part of the Arunta Complex (Plate 1). The object of the survey was to delineate structures in the two complexes, to complement geological mapping carried out by the Bureau of Mineral Resources (BMR).

Station spacing was generally 1 km, except in the Harts Range area, where a closer spacing was used to obtain a detailed gravity profile over the range. This profile was used to determine the bulk density of the range. All stations were optically levelled. The observations along traverse AA' were made using helicopter transport, and those along traverse BB' were made using a four wheel drive vehicle.

Previous geophysical surveys of the area include:

1. a reconnaissance helicopter gravity survey, on an 11 km grid, made by BMR in 1961 (Langron, 1962);

2. airborne magnetic and radiometric surveys, of the Amadeus Basin in 1965 (Young and Shelley, 1966). Also, in 1972, two similar surveys were made over the Arltunga Nappe Complex (Taylor, in prep.), and the ALCOOTA sheet (Wyatt, 1974).

GEOLOGY

The Arltunga Nappe Complex is one of several nappe complexes situated along the boundary between the Amadeus Basin and the Arunta Complex, all apparently caused by southwards overthrusting during the Carboniferous Alice Springs Orogeny. The geology of the survey area has been mapped in considerable detail, and has been described by, amongst others; Shaw et al (in prep.), Wells (1969), Shaw, et al (1971), Shaw & Stewart (in press).

A geological section based on Wells (1969) and Shaw (pers. comm.) is shown in Plate 2. The main features of this section from south to north are:

The Amadeus Basin sequence, consisting of up to 8 km of Proterozoic to Devonian sediments, flat-lying in the south, becoming deformed northwards, with large isoclinal folds, thrust faults, and decollement surfaces, and grading into a zone of maximum deformation at the Arltunga Nappe Complex.

The Arltunga Nappe Complex, comprising the White Range and Winnecke nappes. The nappes consist of a core of granites, enveloped by sediments of Heavitree Quartzite and Bitter Springs Formation, the lowermost units of the Amadeus Basin sequence. They were formed when the Arunta Complex was thrust over the northern edge of the Amadeus Basin during the Carboniferous. The nappe complex is underlain by granites, probably several kilometres thick (Shaw, pers. comm.).

A major thrust, separating the Arltunga Nappe Complex from the Arunta Complex. The exact location of this thrust is not known, but low-angle thrusting appears to have been responsible for the deformation of the Arltunga Nappe Complex, and its southward movement of at least 10 km. Other thrusts have been mapped, and extrapolated to the locations marked on the geological section.

The Arunta Complex metamorphic basement. The Complex crops out between the Arltunga Nappe Complex and the Georgina Basin, and consists mainly of amphibolite-grade metasediments, with some pockets of granulites, granites, and gneisses. The granulites, which occur east and west of traverse BB' (Plate 1), indicate that crustal uplifting has occurred, probably in conjunction with the major uplifting in the Southern Arunta Deformed Zone, further to the west. (Anfiloff and Shaw, 1973). Geological mapping of the complex is uncertain because of complex changes in rock composition and metamorphic grade and a lack of good marker beds. Only one major stratigraphic unit - a metasedimentary layer - and a series of faults, indicating decreasing uplift northwards, are shown in the section in Plate 2. In the northern part of the Arunta Complex, granites crop out and apparently extend under the Georgina Basin.

The Harts Range is an important feature in the area of Arunta Complex outcrop. It has a steep northern escarpment, which separates very rugged terrain to the south from a flat plain to the north (Plate 5). This implies that the northern face of the Range is a major fault scarp, and that the Arunta Complex south of this fault was elevated relative to the rest of the Complex to the north.

RESULTS

The locations of the gravity stations are shown in plan in Plate 4, and profiles of the elevation, observed gravity, and multiple density Bouguer gravity profiles are shown in Plate 5. The data across Harts Range are shown in Plate 7. The elevation profile (Plate 5) shows the Harts Range, with a relief of 300 m, rugged topography to the south, and very flat topography to the north. A slight dip immediately north of the range coincides with a 30 mGal gravity high. The observed gravity profile across Harts Range shows a combined elevation and terrain effect of about 60 mGal.

The multiple density Bouguer gravity profiles, calculated using the slab formula for densities 2.0 g cm^{-3} to 3.5 g cm^{-3}, show variations in form along traverse AA', where the terrain varies considerably, whereas along BB', where the terrain is flat, the profiles all have the same form. The main features of the Bouguer gravity are:

- fairly flat gravity with minor local anomalies of up to 5 mGal in amplitude in the Arltunga Nappe area,
- a steady rise in gravity over the Arunta Complex as the Harts Range is approached from the south,
- two positive anomalies and a negative anomaly over the Arunta Complex north of the Harts Range.

An extended gravity profile derived from reconnaissance gravity contours is shown in Plate 6. This is a north-south profile between latitudes 20 and 26°S and passing through the survey area. It shows the gravity of the surveyed area in a regional context, and also compares the detailed and reconnaissance gravity data along traverses AA' and BB'. A 10 mGal discrepancy occurs between them in two places: over the Arltunga Nappe, and just north of Harts Range.

ANALYSIS

Qualitative comparison of elevation and Bouguer gravity profiles - A dip in the elevation profile at point Z on traverse BB' (Plate 5) correlates with a 30 mGal gravity high. This and the steepness of the flanks of the anomaly suggests, firstly, that the material causing the gravity high is very close to the surface, and secondly, that the material is possibly an ultrabasic body, because it is more susceptible to weathering and erosion than the surrounding rocks.

Multiple density profiling - This was carried out across the Harts Range; (Plate 1), traverse AA' cuts the range perpendicularly. The reduction of the observed gravity across the Harts Range to a set of multiple density profiles (Plate 7), and the analysis of these to obtain a bulk density estimate for the range is described by Anfiloff (in press). By comparing the elevation and multiple density Bouguer profiles visually, a bulk density estimate of 2.85 ± 0.05 g cm^{-3} was obtained. Since the 2.85 g cm^{-3} Bouguer profile is fairly smooth across the three main inflexions of the elevation profile in the Harts Range area, the determination holds over a distance of three kilometres.

INTERPRETATION

Gravity traverses AA' and BB' have a horizontal separation of about 12 km (Plate 4). For the gravity interpretation, they were combined into a single traverse AC, as they effectively overlap along the strike of the 30 mGal anomaly north of Harts Range. A structural interpretation along traverse AC is shown in Plate 8.

The main features of the interpretation are:

1. There are no large gravity anomalies across the Arltunga Nappe, and the gravity does not indicate the structure of the nappe complex. However, the lack of large anomalies implies that there can be little or no basement deformation under the nappe. This suggests that the nappes were transported from the north along a major low angle thrust, but the gravity does not indicate the location of the thrust at the surface.

2. A 6 km thick section of Amadeus Basin sediments plus underlying granites is interpreted. This thickness depends on the density assumed for the Arunta Complex at depth, but is in general agreement with geological mapping.

3. A density of 2.85 g cm^{-3} is assumed for the Arunta Complex. Since the Harts Range density determination is valid over several kilometres of the surface, and the range appears to have been uplifted, the determination can apply to the Arunta Complex at depth in that vicinity. The density immediately north of the range must therefore be at least 2.95 g cm^{-3}. This body is interpreted to be about 10 km across and over 10 km thick. It partly coincides with a disturbed magnetic zone (Wyatt, 1974, Zone I), and also with a dip in the elevation profile (Plate 5), which suggests that it is more easily weathered than the surrounding rocks, and is close to the surface. These factors suggest that the gravity anomaly is caused by basic or ultrabasic rocks, which could contain mineralisations. Alternatively, it could be caused by granulites, since these occur both east and west of the traverse (Plate 1), approximately in line with the strike of the anomaly.

Two other anomalous bodies are interpreted north of the Harts Range; a small pocket of granite and another dense body, both close to the surface. There are no anomalies south of Harts Range which could correlate with the metasedimentary layer shown in Plate 2.

4. The interpretation depicts a flat Conrad Discontinuity, nominally at 20 km, and does not involve any density variations in the lower crust. There have been major uplifts within the Arunta Complex, which possibly should have produced deformations of the lower crust. The zone between thrust A and thrust B appears to have been thrust upwards, during the Alice Springs Orogeny (300 m.y.) and, subsequently, when the Harts Range escarpment was formed, with a total vertical displacement of at least 5 km. The emplacement of granulites into the upper crust during the Proterozoic should also have deformed the lower crust. However, mass excesses, resulting from uplift in the lower crust, would have produced a higher level of gravity over the complex than the observed level, which is similar to that in areas much further north (Plate 6). One explanation is that uplift was confined to the upper crust above the Conrad Discontinuity. Another, proposed by Anfiloff and Shaw (1973), is that density variations below the Conrad Discontinuity are gradually annulled after tectonism ceases. In either case, the resulting Conrad Discontinuity would be fairly flat.

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APPENDIX

OPERATIONS REPORT AND STATISTICS

The gravity stations of the Arltunga Nappe detailed gravity survey were optically levelled by the Department of Services and Property, Special Surveys Branch, Canberra. 236 stations were levelled and pegged, including 18 stations along tracks adjacent to traverse AA', and 35 special stations across the Harts Range (Plate 4). Most of the stations were pegged at 1 km intervals along traverses AA' and BB', and traverse AA' was plotted on aerial photographs so that it could be easily located when the gravity stations were occupied using helicopter transport. Helicopter transport was essential along most of traverse AA' since it was completely inaccessible by vehicle (the optical levelling had been done using horse transport).

The gravity survey took place between 10/9/73 and 19/9/73. Dumps (88 gallons) of aviation fuel were set up at stations 250, 500, 860, and 1110 along traverse AA' for the helicopter operation. Traverse BB' was surveyed over two days using vehicular transport and the 73 stations along it were tied to station 68-31 at the Mt Riddock H.S. Because of the bumpy nature of the tracks used, meter drift over this section of the survey was of the order of 0.1 mGal/hour. Traverse AA' was surveyed over a period of 4 days using helicopter transport, and the 163 stations occupied were also tied to station 68-31. The total flying time for traverse AA' was 25 hours. The average cost of about $15 per station, was offset by the convenience and speed of the helicopter operation, and the extreme difficulty of occupying the top of the Harts Range and other difficult areas by any other means. In addition, the drift rate of the gravity meter was only about 0.01 mGal/hour, a tenfold improvement over that for the roadwork along traverse BB'. This is attributable to the much reduced jolting that a gravity meter is subjected to when carried by helicopter.

Personnel

Party Leader	W. Anfiloff
Meter Observer	W. Anfiloff
Helicopter Pilot	R. Newman (Jayrow Helicopters)

Equipment

Gravity Meter	M.W. 548 (temperature compensated)
Land Rover 4 x 4	
Helicopter	Bell 47J Alpine

Log of Activities

11.9.73 - 13.9.73	Fuel dumps established for the helicopter
14.9.73 - 15.9.73	Gravity observed along traverse BB'
16.9.73 - 19.9.73	Gravity observed along traverse AA'

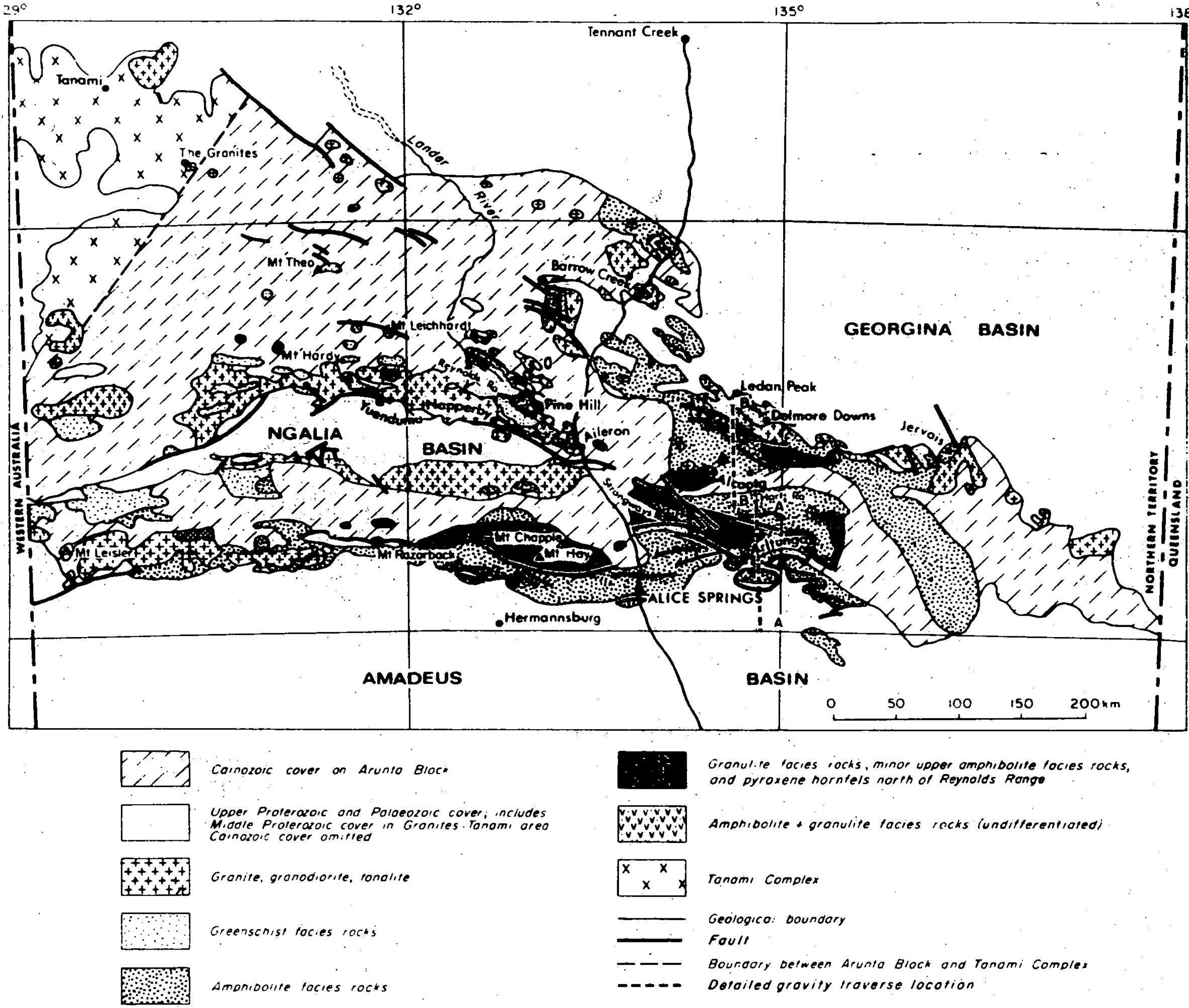
BMR survey number - 7308

Survey tied to 68-31 at "Mt Riddock" H.S.
(observed gravity = 978688.61 Gal)

Pre survey calibration at Alice Springs, using road transport
C.F. = 0.10968 mGal/div.

Post survey calibration at Alice Springs, using helicopter transport.
C.F. = 0.10959 mGal/div.

Calibration factor used in reductions = 0.10959

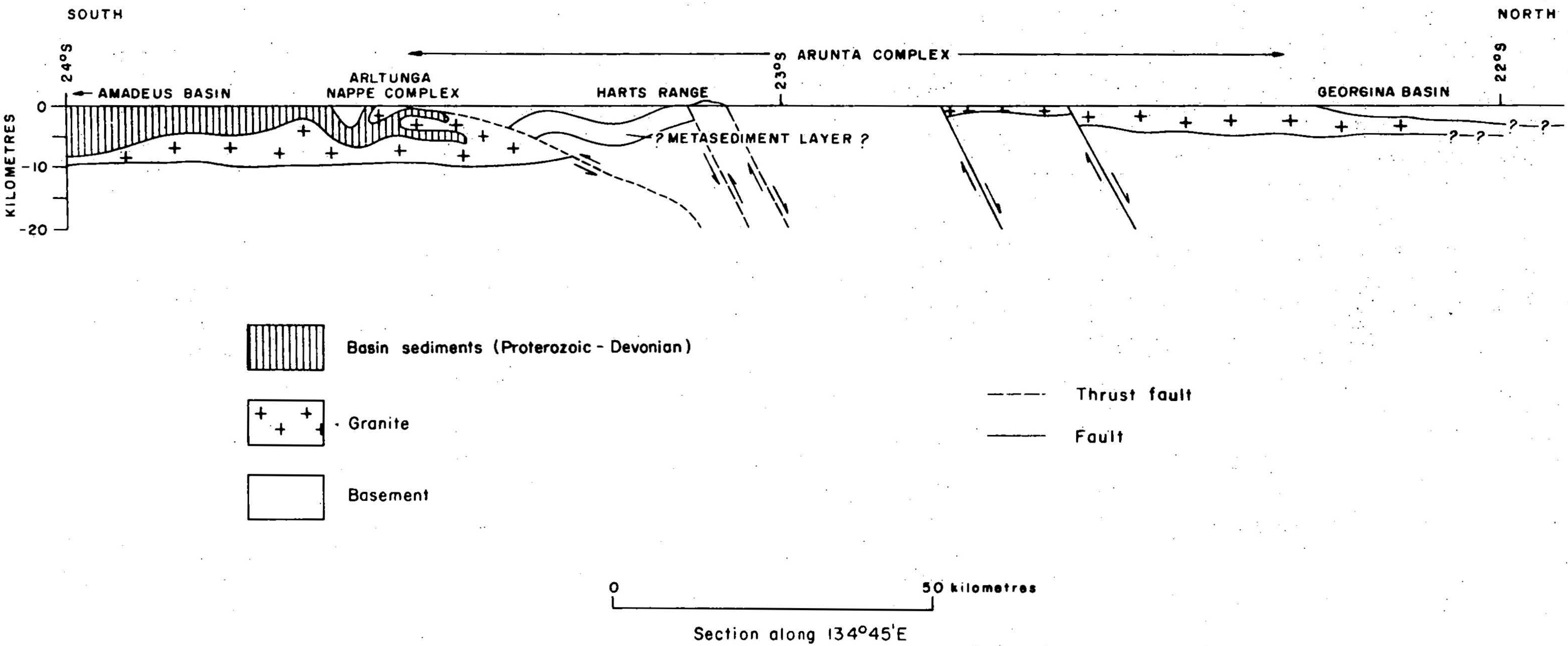


REGIONAL GEOLOGY AND TRAVERSE LOCATIONS

(Distribution of metamorphic rocks modified after Forman and Shaw, 1973)

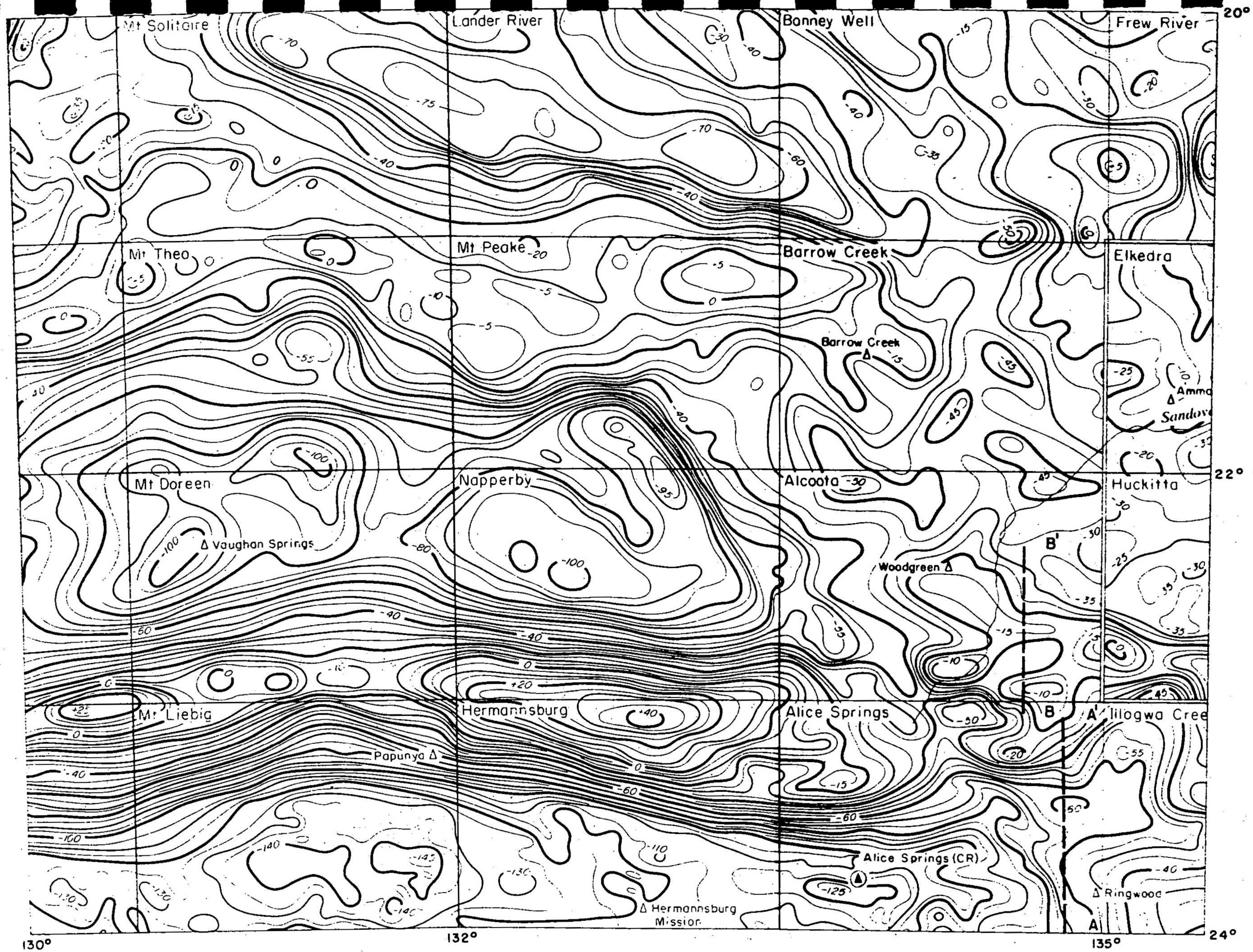
F53/B2-67A

PLATE 1



GEOLOGICAL SECTION

BASED ON WELLS (1969) AND SHAW (PERS COMM)

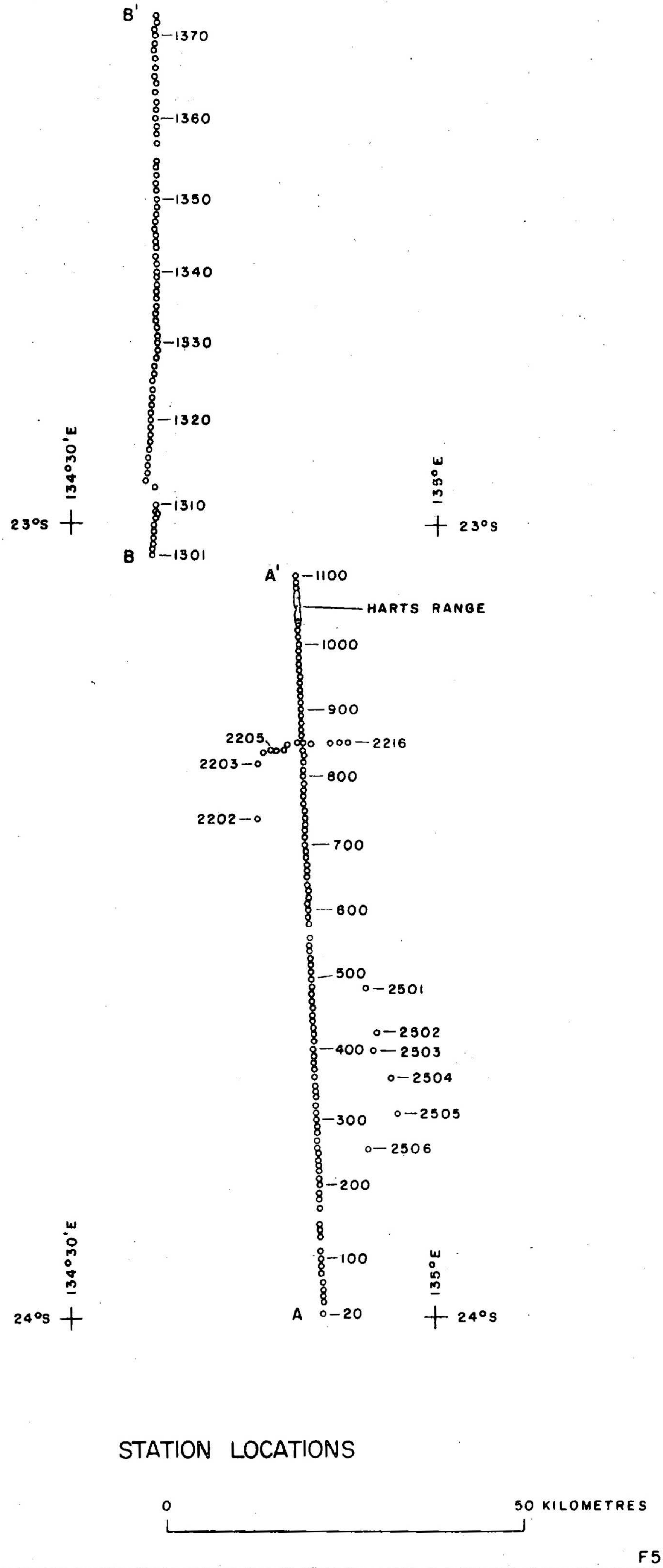


50 0 50 100 kilometres

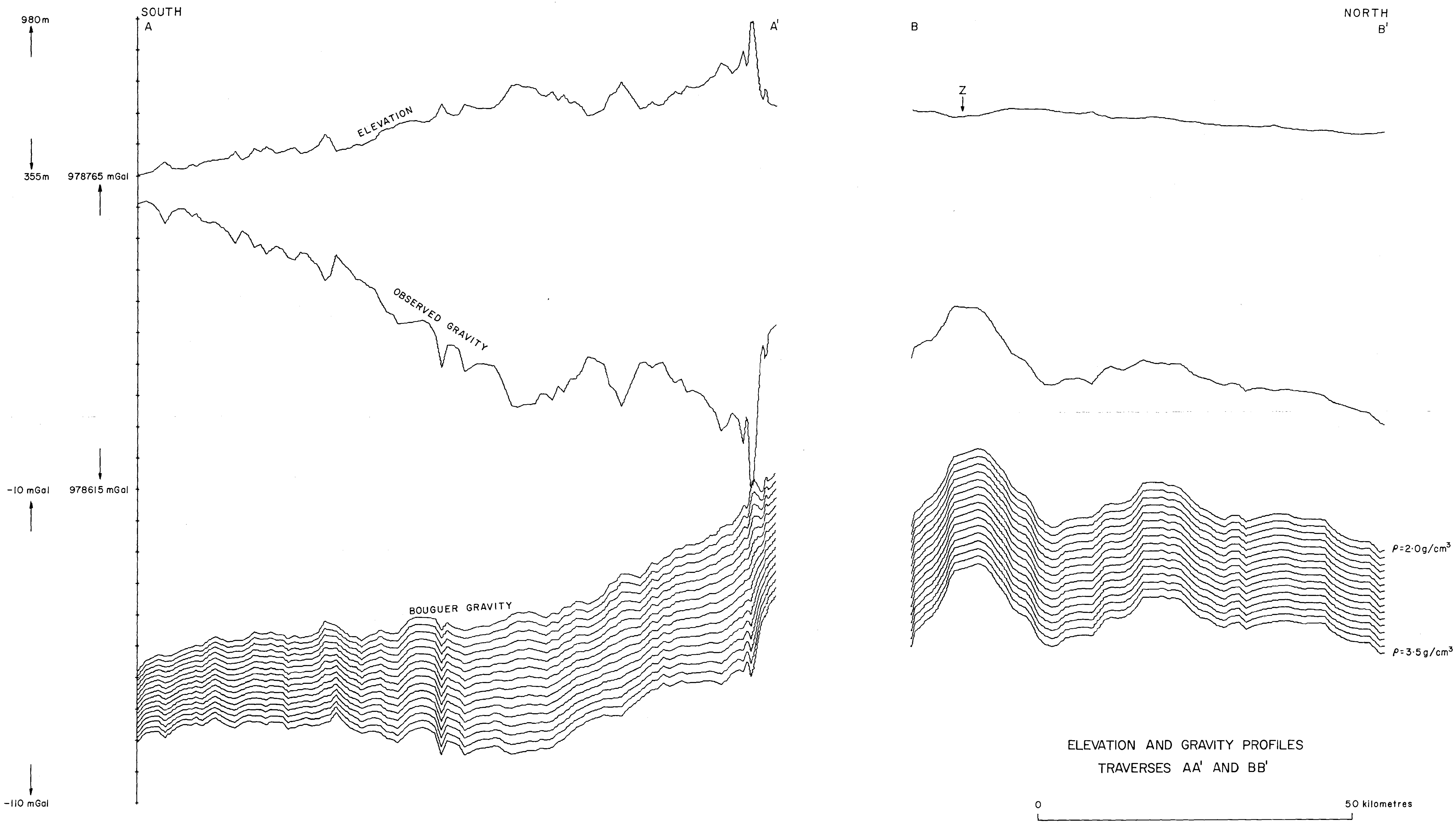
BOUGUER ANOMALIES

— — Traverse location

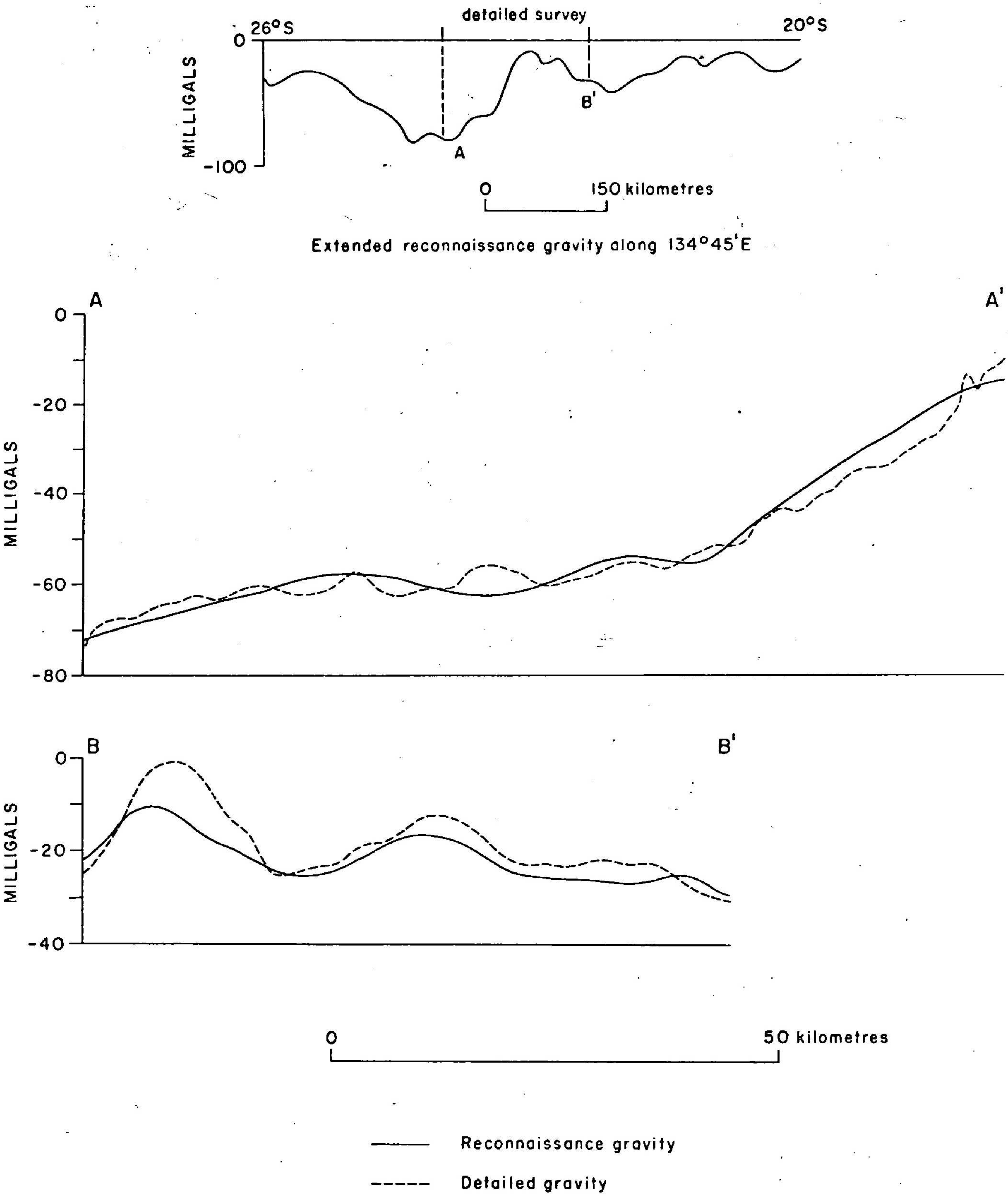
PLATE 4



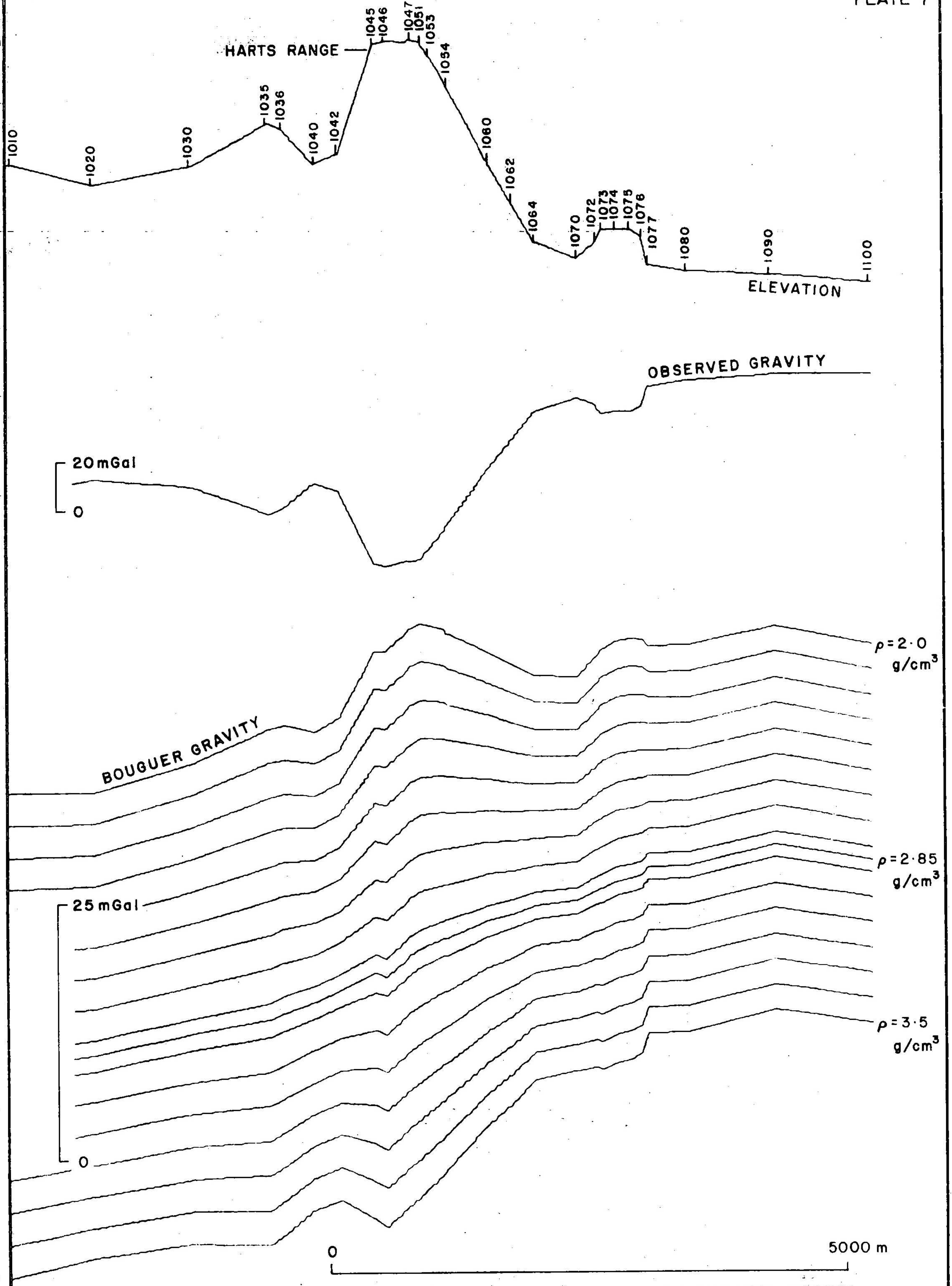
STATION LOCATIONS



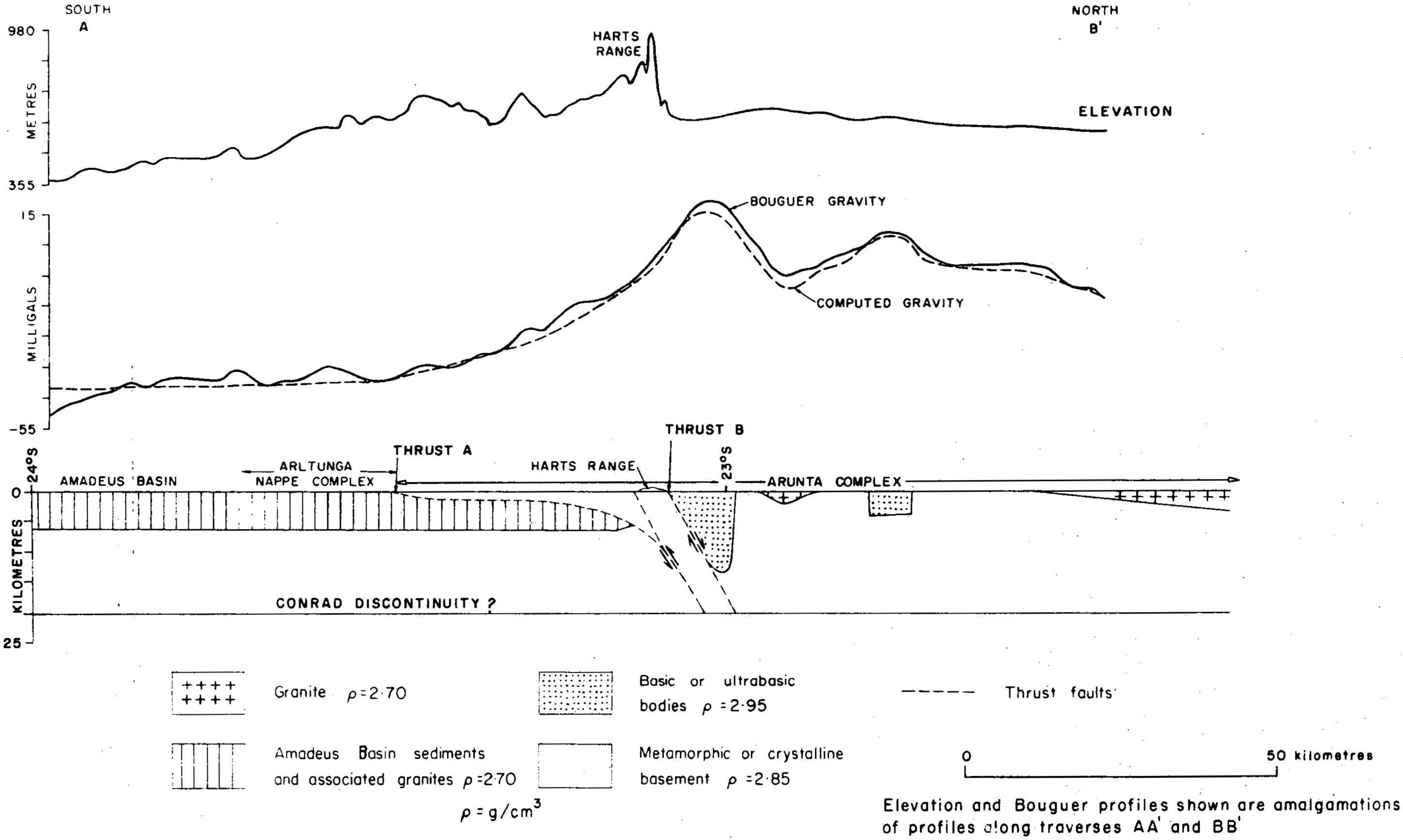
ELEVATION AND GRAVITY PROFILES
TRAVERSES AA' AND BB'



COMPARISON OF RECONNAISSANCE AND DETAILED GRAVITY PROFILES



MULTIPLE DENSITY BOUGUER PROFILES ACROSS HEARTS RANGE



INTERPRETATION

F53/B2-74A

PLATE 8