BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD

Record 1981/20

McARTHUR BASIN RESEARCH

JULY-DECEMBER, 1980

K.A. Plumb (Co-ordinator)

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PREAMBLE

With the reduction in fieldwork, and emphasis on interpretation and report writing in the present phase of the McArthur Basin Project, the production of significant new results do not warrant regular quarterly reports at this stage. This report, therefore, covers the six-month period, July-December 1980. The next report will cover January-May 1981 (before fieldwork in June). Future reports will depend on the nature of the program being undertaken.

PRINCIPAL RESULTS

1) Extensive pseudomorphs after evaporite minerals have been identified from the Wollogorang Formation. A saline lake or lagoonal palaeoenvironment is indicated.

2) Three distinct types of sulphide mineralisation have been identified from the Wollogorang Formation.

3) Interpretation of seismic refraction data suggests the presence of westward-thickening wedge of Roper Group sediments up to 4 km thick, between OT Downs and Daly Waters. This thins out suddenly west of Daly Waters.

4) At Borroloola, 370 m of Roper Group can be distinguished from an underlying sequence of mostly Tawallah Group. At Robinson River only the Tawallah Group is present. Basement lies at 3.3-3.5 km.

5) The 1978-79 gravity survey was completed, with measurements along the Carpentaria Highway, Beetaloo Road and Stuart Highway.

6) All profile and contour maps from the 1977-78 airborne magnetic and radiometric surveys of the McArthur Basin have been completed.

PUBLICATIONS

The following papers were published during the period:

MUIR, M.D., ARMSTRONG, K.J., & JACKSON, M.J., 1980. Precambrian hydrocarbons in the McArthur Basin, N.T. BMR Journal of Australian Geology & Geophysics, 5(4), 301-304.

MUIR, Marjorie, LOCK, David, & VON DER BORCH, Chris, 1980. The Coorong model for penecontemporaneous dolomite formation in the Middle Proterozoic McArthur Group, Northern Territory, Australia. SEPM Special Publication 28, 51-67.

The following Records are with editors.

CULL, J.P., SPENCE, A.G., MAJOR, J.A., KERR, D.W., & PLUMB, K.A., in press. The 1978 McArthur Basin magnetotelluric survey. Bureau Mineral Resources, Australia, Record 1981/1.

COLLINS, C.D.N., in press. Crustal seismic investigations in northern Australia, 1979: operational report. Bureau Mineral Resources, Australia, Record 1981/2.

GEOLOGY

M.J. Jackson (Task Leader), K.J. Armstrong

SEDIMENTOLOGICAL STUDIES

Wollogorang Formation

Detailed studies of thin sections from BMR Mount Young 2 has indicated the probable former occurrence of evaporite minerals throughout the formation there. Equant aggregates of radially-extinguishing length-slow chalcedony, in bands parallel to bedding, are common in the upper 30 m

of the drillhole; comparison with published information suggests they are probably after anhydrite nodules. Similar chalcedony grains are also present within a grey laminated siltstone sequence between 40 and 60 m. Red-brown siltstones near the base of the formation contain evaporite pseudomorphs, preserved either as discontinuous wavy laminae (0.1 mm thick) of fibrous dolomite along bedding, or as nodular veins (up to 1 mm thick), parallel or slightly oblique to bedding. Poorly preserved chevron-like structures and distinct cubic crystal outlines indicate the former presence of halite. The oblique nature of some of the veins and the disruption of bedding laminations above and below cubic casts indicate displacive growth of evaporites within the sediments. These features, together with the oxidised nature of the sediments and stratigraphic setting indicate a saline lake or lagoon origin for this part of the formation.

Three distinct types of sulphide minerals have been recognised:

1) disseminated small (2-20 micrometres) euhedral crystals of pyrite and sphalerite. These are stratabound, spatially related to the organic matter in the black siltstones, and most likely of synsedimentary or early diagenetic origin; 2) large crystal aggregates (few mm in size) of pyrite, chalcopyrite, sphalerite, and galena associated with ovoid nodules between 60-84 m, and indicating a later diagenetic origin; and 3) crystals of chalcopyrite, replacing quartz after evaporite minerals, near the top of the formation.

General

A poster display dealing with the BMR's sedimentological studies in the basin was presented at the Geological Society's Specialist Group in Sedimentology meeting held in Canberra on 1-2 December.

Facies variations within the Wollogorang Formation, Masterton Sandstone and Emmerugga Dolomite were described in a lecture to James Cook University on 12 July. The use

of comparative sedimentology, using sequences of distinctive lithologies and sedimentary structures to elucidate the depositional setting of the formations, was emphasised.

GEOPHYSICS

SEISMIC REFRACTION SURVEY (C.D.N. Collins)

Deep seismic refraction data were recorded during 1979 between Daly Waters and H.Y.C., and between Borroloola and Westmoreland, to investigate the crustal structure of the McArthur Basin. A detailed investigation of these data has been made to delineate the shallow structures, where the data are adequate for this purpose. The recording scheme and other operational details are described in BMR Record 1981/2. A report of the interpretation and results is being prepared.

A low-velocity surface layer occurs along both traverses, with a velocity of about 1.7 km/s. Between Daly Waters and OT Downs it is 180-210 m thick; at H.Y.C it is 70 m thick; between Borroloola and Westmoreland it is about 50 m thick. This shallow layer has been interpreted mainly from the small weathering spreads used to correct the vertical seismic reflection data at each shot-point, and it is assumed to be continuous along the traverses. It represents both the surface alluvium and the weathered layer.

Below this at Daly Waters, a layer 4.1 thick, with a velocity of 4.62 km/s, probably represents the combined Cretaceous cover plus the underlying Cambrian and Proterozoic sediments; The data are not sufficiently detailed to distinguish between them. The Proterozoic sediments may be Roper Group. The Cambrian carbonates probably have a higher velocity, but are relatively thin, about 300 m; the Cretaceous sediments may be less than 100 m thick.

The basement to this layer at Daly Waters, at a depth of about 4.3 km, has an apparent velocity of 5.90 km/s.

Farther east at OT Downs and H.Y.C., strong arrivals with a trace velocity of about 5.80 km/s are recorded. Assuming that the basement at Daly Waters has a similar velocity, the higher apparent velocity there shows that the boundary dips westwards; i.e. the 4.62 km/s layer thins towards the east. This is confirmed by much smaller delays in the basement travel-times at OT Downs, and by no delays at all at H.Y.C.

Assuming that the major part of the 4.62 km/s layer comprises Roper Group sediments, the layer must wedge out near the Mallapunyah Fault, about 25 km east of OT Downs. No direct arrivals are recorded from this layer at OT Downs, but from the delays in basement arrivals and from the thickness of the surface layer there, its maximum thickness is interpreted to be 1.4 km. The delays to basement increase about 60 km west of OT Downs, indicationg that the 4.62 km/s layer increases rapidly in thickness to about 3 km, 100 km west of OT Downs.

This model is consistent with the regional gravity along the traverse. A profile was obtained from the regional Bouguer anomaly contour map and compared with the gravity field calculated from the seismic model, using two-dimensional modelling techniques. The traverse is roughly normal to the major structural trends, but the assumption of two-dimensionality is only approximate. Densities were derived from the average valocities, and no account was taken of the effects of deeper bodies. In spite of these limitations, the interpretation shows that the major anomalies in the observed gravity can be explained by the changes in thickness of the 4.6 km/s layer. A major north-south-trending gravity low to the east of Daly Waters probably indicates that this layer continues to the south of Daly Waters, and increases in thickness. West of Daly Waters, the gravity indicates that it thins rapidly. A more detailed interpretation cannot be justified from the seismic data.

The basement velocity of about 5.80 km/s at Daly

Waters is the same as the velocity measured in the McArthur Group carbonates between OT Downs and H.Y.C. However, the nature of the basement is unknown.

Below the surface alluvium and weathering at Borroloola, on the eastern traverse, a layer with a velocity of 3.58 km/s and 370 m thick is interpreted. At Robinson River the equivalent layer has a velocity of 4.81 km/s and a thickness of 650 m. From the surface geology and the observed gravity, it appears these layers are not continuous with each other along the traverse. Below these layers the velocity increases to 5.55 km/s at Borroloola, and to 5.44 km/s at Robinson River. The thickness of this layer is about 2.88 km, and does not vary significantly. Basement lies at a depth of 3.3 - 3.5 km, and has a velocity of 6.04 km/s.

The basement arrivals indicate a slight shallowing, 20-50 km northwest of the Robinson River shot point. This is consistent with the regional gravity data, from which a basement ridge may be inferred to extend northwards from a dome, recognised geologically, at Robinson River homestead. The regional gravity was modelled in a similar manner to the western traverse, and the gross features of the measured gravity profile are in reasonable agreement with the gravity field calculated from the seismic model.

The 3.58 km/s layer at Borroloola probably represents the Roper Group, which wedges out eastwards. The 4.81 km/s layer at Robinson River represents Tawallah Group, and perhaps thin McArthur Group, sediments; these continue southeast from Robinson River with much the same thickness. The 5.44-5.55 km/s layer represents Tawallah Group sediments and volcanics.

GRAVITY (W. Anfiloff, Task Leader; R. Tracey)

During August, 1980, the gravity coverage established by BMR in 1978 and 1979 was extended westwards along the Carpentaria Highway, the Beetaloo Road, and a large section

of the Stuart Highway. The survey produced 866 new observations, mainly at 0.5 km intervals (Plate 1).

Anomalies with amplitudes up to 25 mGal were delineated (Plate 2-4). In some areas the anomalies are exceptionally broad and smooth, suggesting a thick cover of undeformed sediments. Elsewhere fault anomalies and structural boundaries are evident. Overall the gravity data give a good indication of deep structure and basement topography, over a large area where geological exposure is very poor.

AIRBORNE MAGNETIC AND RADIOMETRIC (I. Zadoroznyj)

1978 Airborne Survey Data

The production of maps from data collected during the 1978 airborne survey of the northern part of the McArthur Basin was completed in October 1980. These maps supplement the earlier coverage of the southern part of the basin, in 1977. The main sheet areas covered during 1978 were Milingimbi, Arnhem Bay, Gove, Mount Marumba, Blue Mud Bay, Port Langdon, and offshore Roper River. A brief assessment of these data is given below.

Magnetic data The total magnetic intensity contour maps of the area show a range in magnetic anomalies from short wavelength (about 2 km) high amplitude (100 nT) features, to broad flat features varying by only a few tens of nanoteslas over 50 km or more, as well as several relatively broad but high amplitude magnetic anomalies.

The anomalous areas occupy nearly all of the MOUNT MARUMBA sheet area and the southwestern part of MILINGIMBI. There is an overall northeasterly trend in the anomalies, more pronounced in MOUNT MARUMBA and paralleling the regional structure. Most of these anomalies can be attributed simply to the ubiquitous Proterozoic dolerite sills found in this part of the McArthur Basin, and to basalts in the western part of these sheets.

Other anomalous zones are separated by areas of

less magnetic relief. A belt of north-northwest-trending anomalies extends from the north of the BLUE MUD BAY sheet area across the middle of the ARNHEM BAY, while other anomalous areas occur in the northwest and southwest corners of the GOVE area, with extensions into adjoining sheets, and over much of Groote Eylandt.

The belt of magnetic anomalies extending across ARNHEM BAY correlates with a major structural zone in which Lower Proterozoic sediments and acid volcanics of the Ritarango Beds and Fagan Volcanics are exposed in a fault block. These anomalies are probably caused by associated proterozoic dolerites. Deepening basic intrusives are interpreted as the source of the broader anomalies in the northern extension of this belt.

The plutonic rocks of the Mirarrmina Complex exhibit very little magnetic effect. In contrast, Proterozoic plutonic rocks appear to be the cause of the magnetic anomalies in the northwest and southwest parts of the GOVE sheet area.

The higher level of magnetic activity over Groote Eylandt suggests a high concentration of magnetite within the sediments of the Groote Eylandt Beds.

Radiometric data The total count contour maps generally show low count rates over most of the region, particularly where the younger sediments form the cover. Slightly higher counts are recorded over older sediments.

Higher count rates are observed in a few areas, and relate to particular rock formations; these are the granites in northwest and southwest GOVE, the Spencer Creek Volcanics in ARNHEM BAY and Fagan Volcanics in BLUE MUD BAY, and the Nungbalgarri Volcanic Member in MILINGIMBI.

Interpretation

Work has commenced on the determination of magnetic basement-depths over the whole of the McArthur Basin. Thus

far, the work has been confined to the BAUHINIA DOWNS 1:250 000 area. A number of recently developed methods, all computer based, have been tried.

A spectral analysis approach was thought to be the best way to determine basement depths below magnetic rocks (e.g. dolerite sills) within the sedimentary section. This was abandoned when it appeared that more development of the method would be needed to determine depths.

Two methods involving inversion of the magnetic profile are being tested. The method known as "Werner deconvaluation" is giving depth values too scattered to be used usefully. The other method is the inversion of particular anomalies on the profiles, to produce a simple dyke-like source. The latter method appears to be giving the most reliable results and will probably be used in the overall interpretation.

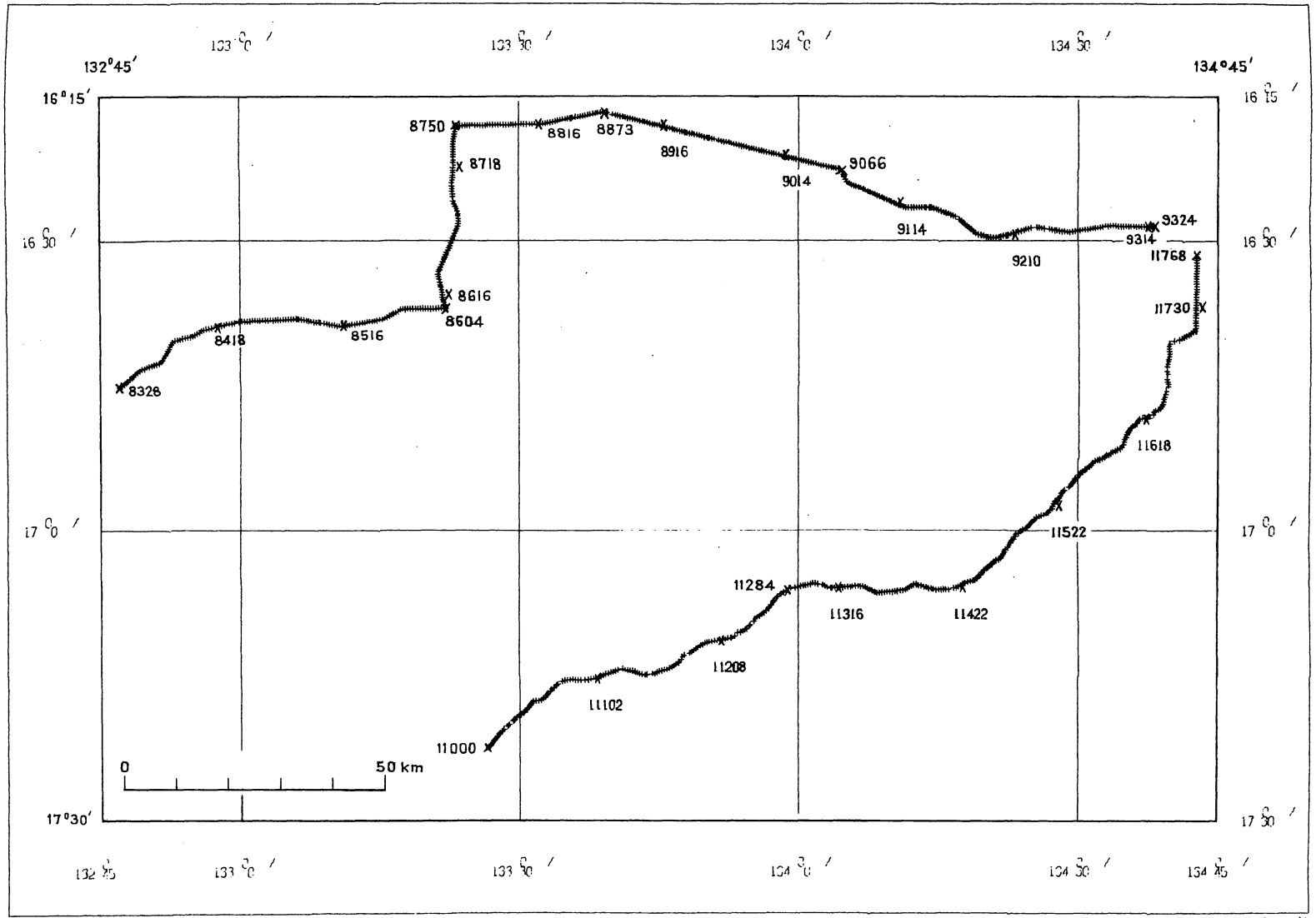

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PLATE 1 MACARTHUR BASIN GRAVITY SURVEY 1980

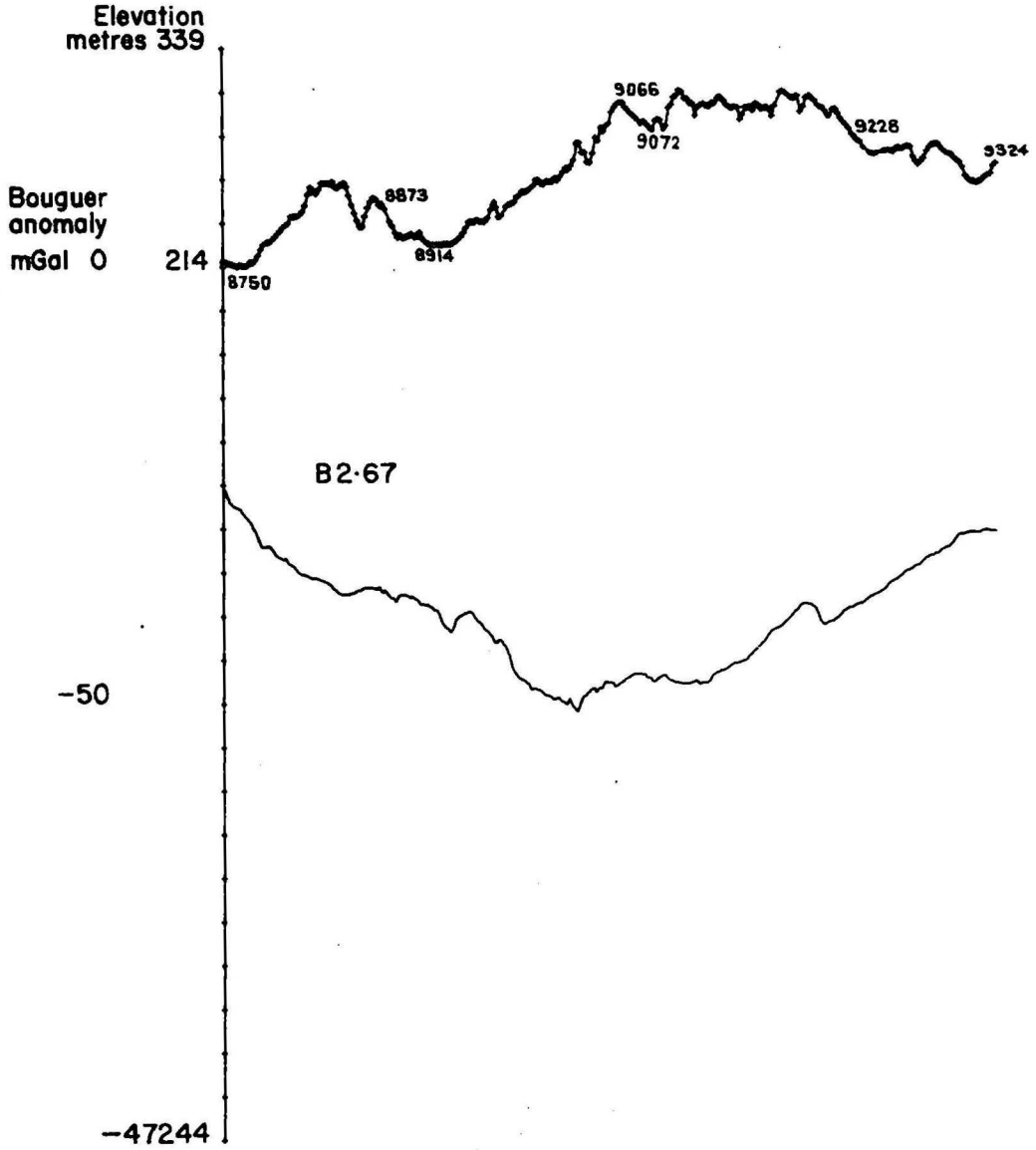

PLATE 2 Carpentaria Highway, Carpentaria Hyw Gravity Traverse, 1980
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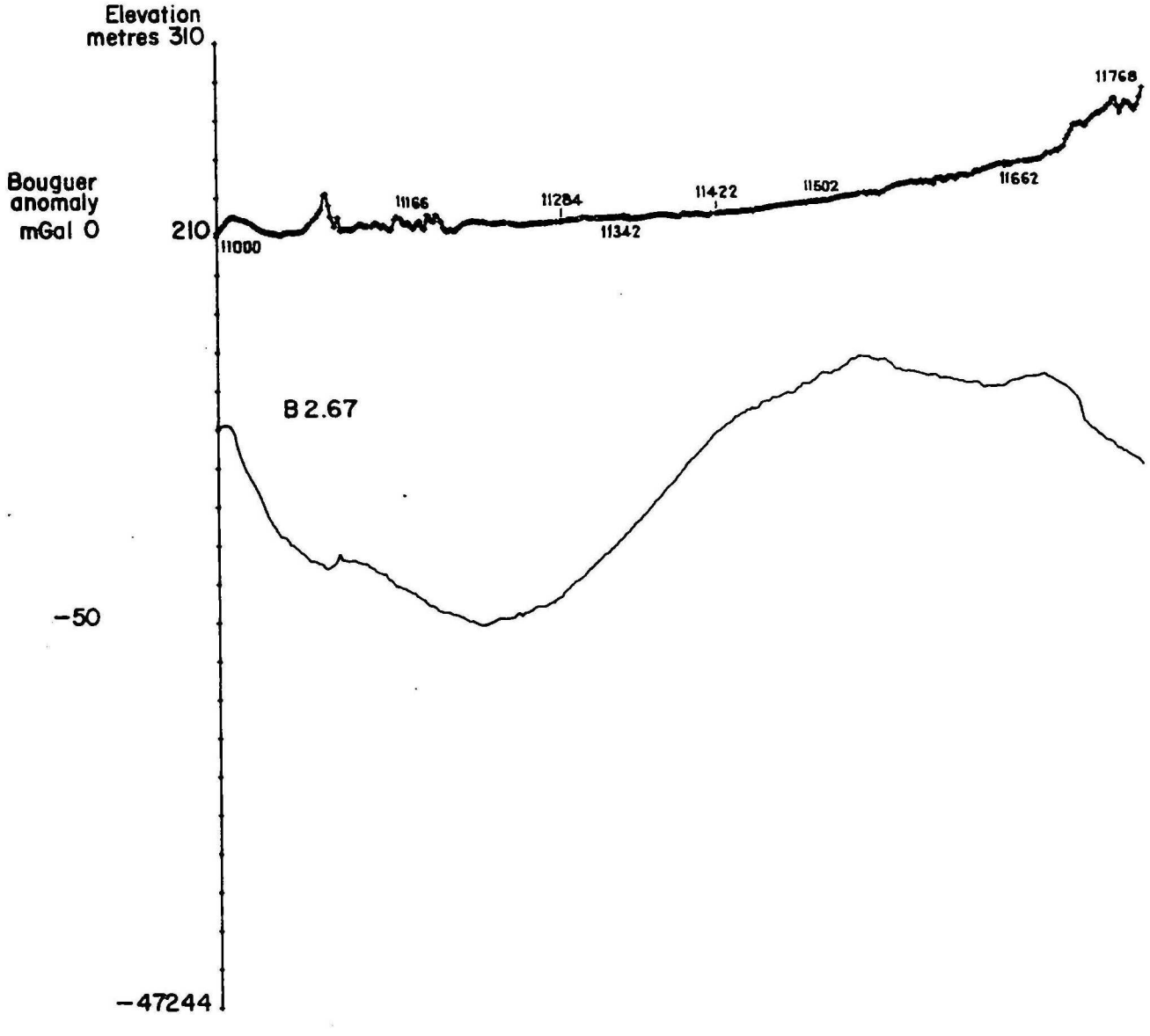

PLATE 3 Beetaloo Road, Beetaloo Gravity Traverse, 1980

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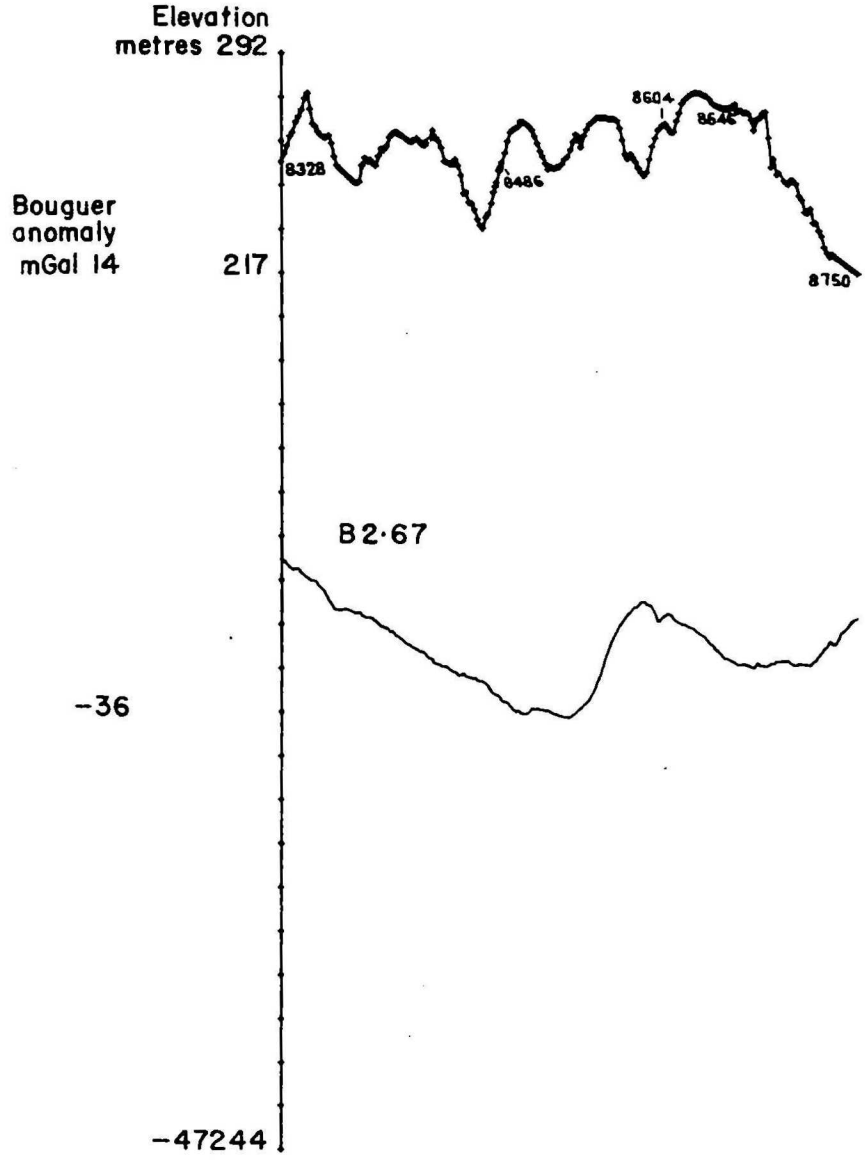

PLATE 4 Stuart and Buchannan Highways, Stuart and Buchannan Gravity Traverse, 1980

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