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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD No. 1963/112

SOUTH ALLIGATOR RIVER GEOPHYSICAL SURVEY, NORTHERN TERRITORY 1962

by

J. ASHLEY

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ILLUSTRATIONS

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SUMMARY

Self-potential surveys of 12 areas were made in the South Alligator River Uranium Field, NT, during April and September-October 1962 at the request of United Uranium N.L. Uranium deposits in this region are frequently associated with beds of carbonaceous shale, and the self-potential method is particularly successful in locating these shale beds. Evidence is given in this Record to show that self-potential anomalies occur where carbonaceous shale projects above the water table.

Negative self-potential anomalies of amplitudes ranging from -200 to -700 mV were found in seven of the 12 areas surveyed. A broad anomaly was outlined extending about three miles from Stag Creek West to Scinto 5 and a narrow anomaly found at the Koolpin Creek Prospect in 1960 was traced for a further 3000 ft. Anomalies were also located in the neighbourhood of Coronation Hill.

Recommendations are made for wagon-drilling of five of the survey areas.

1. INTRODUCTION

The position of the South Alligator Uranium Field is shown in the inset map of Plate 1. United Uranium N.L. (UUNL) is engaged in mining and exploration in a range of low, steep-sided hills that extend along the foot of the South Alligator River valley from El Sherana to Coronation Hill. Uranium ore in this region is frequently associated with Lower Proterozoic carbonaceous shale and Rowston (1961) demonstrated that carbonaceous shale beds could be detected by the self-potential (S-P) method of geophysical surveying. In 1961, 21 areas selected by UUNL were surveyed by the Darwin Uranium Group of the Bureau of Mineral Resources with the S-P and radiometric methods (Ashley, 1962). Several large S-P anomalies were detected; the anomalies were drilled by UUNL and a valuable ore deposit, associated with carbonaceous shale, was found at El Sherana North-west.

In 1962 UUNL requested further S-P surveys; these surveys were made during April and September-October 1962 by geophysicist J. Ashley and personnel of the Darwin Uranium Group.

The areas surveyed were:

Stag Creek West

El Sherana North

High Road

High Road to Scinto 5

Koolpin Creek Prospect Extension

Coronation Hill North

Coronation Hill South-east

Coronation Hill South

Coronation B.I.F.

Single reconnaissance traverses were surveyed at Scinto 6, Coronation Breccia, and Saddle Ridge East.

The 1961-62 survey areas are shown on the geological map in Plate 1. Radiometric surveying of the 1962 areas was commenced but had to be abandoned owing to faulty operation of the equipment.

2. GEOLOGY

The geology of part of the South Alligator River valley between El Sherana and Coronation Hill is shown in Plate 1. A range of hills and ridges (rising 300 to 600 ft above the valley) extends over most of the area between El Sherana and Coronation Hill.

Lower and Upper Proterozoic rocks crop out; the former strike north-west and dip at 50 to 90 degrees; the latter have variable strike and dips generally less than 50 degrees. Rock types are principally volcanics and altered sediments. There is major faulting in a north-westerly direction with minor faulting in northerly and westerly directions. The Upper Proterozoic rocks rest unconformably on the Lower Proterozoic rocks.

Ore deposits have been mined at El Sherana, Palette, Saddle Ridge, Coronation Hill, Scinto 5 North, Koolpin Creek, Scinto 6, and Cliff Face. El Sherana West is being currently mined.

The basic characteristics of the uranium ore environments are as follows:

(a) deposits occur both in Upper and Lower Proterozoic rocks,

(b) the Lower Proterozoic rocks are of the carbonaceous member of the Koolpin Formation except at Scinto 6 where the uranium is in microgranite. In many cases the Upper Proterozoic is the Kombolgie Formation,

(c) most deposits are close to the unconformable contact of Upper and Lower Proterozoic,

(d) in all cases faulting of the host rock is evident or suspected,

(e) in some cases deposits are along, or near to, shear zones; the shear zones are often coincident with near-vertical beds of carbonaceous shale.

3. SURVEY PROCEDURE AND PRESENTATION OF RESULTS

Electrical self-potentials are generated by several minerals, principally sulphides. The Lower Proterozoic carbonaceous shale of the South Alligator River area contains various amounts of disseminated sulphides and under certain conditions these generate self-potentials.

Prospecting by the S-P method entails measurement of the surface distribution of the potential field. Potential differences between a fixed point (base station) and field stations are determined; values of potential at the field stations are then referred relative to an arbitrary value of potential assigned to the base station.

The potential differences were measured by a meter connected to two electrodes, one at the base station and one at the field station. Non-polarising electrodes and a Bureau-type S-P meter were used. To ensure good electrical contact with the ground the electrodes were placed in shallow, watered holes. To gain a reliable reading it was necessary to make three measurements at each field station; this was done by placing the electrode in each of three watered holes grouped closely about the station.

Field stations were surveyed at 25-ft intervals (slope distance) along traverses spaced 150 to 1000 ft apart. Ground slopes were measured so that distances could be reduced to the horizontal plane. UUNL surveyors linked each geophysical survey area to the company grid-reference system.

The results are presented as S-P contour maps and profiles. Results of the 1961 surveys are incorporated in some of the maps. In Plate 1, the widths of the broad S-P anomalies and the axes of narrow S-P anomalies are shown. The width of an anomaly is defined as the distance over which the potential is greater than half the maximum value of the anomaly.

Several geological cross-sections have been supplied by UUNL geologists and these are presented, with the corresponding S-P profiles, in Plate 6.

4. GEOPHYSICAL RESULTS

Stag Creek West to Scinto 5 South

An S-P contour map of the whole area is given in Plate 2. Larger-scale contour maps of parts of the area are given in Plates 3, 4, and 5.

All the S-P anomalies are negative; generally they are either broad (400 to 1000 ft) and irregular, or narrow (100 to 200 ft) and well-defined. Amplitudes are in the range 300 to 700 mV. All anomalies are over the upper beds of the Lower Proterozoic Koolpin Formation and their axes are parallel to the strike of the Formation.

There are four principal anomalies, one broad, irregular anomaly extending from Scinto 5 South to within 1200 ft of the north-western limit of the Stag Creek West area, and three narrow anomalies:

(a) in the north-western part of Stag Creek West area,

(b) in El Sherana North-west area, and

(c) extending through the Monolith-Koolpin Creek, Koolpin Creek Prospect, and Koolpin Creek Prospect Extension areas.

The axis of the broad anomaly coincides closely with the axis of a ridge composed of rocks of the Koolpin Formation and the width of the anomaly coincides with the outcrop of the Formation. The Koolpin Formation here is a carbonaceous, pyritic, dolomitic marl with lenses of chert and carbonaceous siltstone. The outcrop is a ferruginous gossan, the result of oxidation with bleaching of the carbonaceous content and impregnation of the rock with iron oxides derived from pyrite (Walpole, 1958).

The narrow anomalies at El Sherana North-west and the Koolpin Creek Prospect Extension are over the same type of rock.

Coronation Hill South-east

The S-P results are shown as profiles in Plate 7 and as contours in Plate 8.

This survey was over Upper Proterozoic rocks and it is the only survey that shows S-P anomalies in the vicinity of Coronation Hill. The ore deposit at Coronation Hill was in Upper Proterozoic volcanic breccia which contains carbonaceous remnants of the Koolpin Formation. The S-P anomalies could be due to small masses of carbonaceous rocks and thus indicate an ore environment similar to that of the Coronation Hill deposit.

Coronation B.I.F. Area

The S-P profiles are shown in Plate 9.

This area includes a ridge of the Koolpin Formation and a large S-P anomaly was outlined. There is evidence of faulting south-west of the area; the survey area should have included the fault zone but was misplaced.

Saddle Ridge East, Scinto 6, and Coronation Breccia

The S-P profiles are shown in Plate 10.

The S-P variation is no greater than that anticipated for varying ground surface conditions. None of these profiles are over the Koolpin Formation; further S-P surveys in any of these areas are unlikely to be of interest.

Coronation Hill North and South

These areas are not over the Koolpin Formation; no anomalies are indicated by the profiles of Plates 11 and 12. Further S-P surveys in the vicinity of these areas would probably be worthless.

5. DISCUSSION OF RESULTS

A considerable amount of wagon drilling has been done by UUNL in order to test S-P anomalies. Plate 6 shows geological cross-sections along several traverses, based on the results of this drilling, together with the corresponding S-P profiles. The positions of the various cross-sections are shown in Plates 2 and 3.

The cross-sections show that the anomalies are correlated in a general way with bands of carbonaceous shale, but that the correlation is by no means uniform. Thus, on some cross-sections, wide bands of carbonaceous shale are not associated with any anomalies. On other cross-sections, the anomalies are associated with relatively small portions of wide bands of shale. On Cross-sections 5 and 6, part of the anomalous area is underlain by quartz breccia. On Cross-section 7, the four narrow bands of shale shown do not appear wide enough to cause the wide anomaly.

The geological information shown on the cross-sections is derived mainly from inspection of wagon-drill cuttings and is by no means as complete as would be obtained from core-drilling. Therefore it is possible that the bands of quartz breccia shown on Cross-sections 5 and 6 contain important inclusions of carbonaceous shale, which have contributed to the anomalies and that the bands of shale in Cross-section 7 are more numerous than shown. However, some further explanation must be sought for the fact that some wide bands of carbonaceous shale do not produce S-P anomalies.

According to the theory of the generation of self-potential anomalies proposed by Sato and Mooney (1960), the position of the groundwater level plays an essential part. It is suggested that, in the surveys under discussion, anomalies are produced only where the carbonaceous shale is present both above and below groundwater level. Based on this possibility, a postulated groundwater level has been drawn on the cross-sections of Plate 6 (except for Cross-section 7). If this groundwater level is approximately correct, the main features of the anomalies are consistent with the theory. The suggested position of the groundwater level is not unreasonable, but confirmation is not available. On Cross-section 5, a modified cross-section is shown that is not inconsistent with the drilling information and that fits the anomalies better than the original one in terms of the theory given above.

Experience shows that the carbonaceous slate horizons are favourable for the occurrence of uranium mineralisation. However, the orebodies of the South Alligator River region are typically small, and it would be uneconomical to attempt to prospect for them by deep drilling. If the theory suggested above is well-based, the S-P anomalies indicate particularly favourable areas for prospecting, as the carbonaceous shale will occur above groundwater level, and may be associated with orebodies at shallow depth.

The S-P anomalies are so extensive that detailed investigation of all of them would be very expensive. It is considered that the choice of sites should be restricted by the use of the controls on ore deposition suggested under Geology (Page 2). In particular, it appears that testing should be confined in the first instance to anomalous areas in which there is some evidence of faulting. The sites for testing recommended below have been selected on this basis.

6. RECOMMENDATIONS

It is recommended that the following areas be tested by systematic wagon drilling:

Stag Creek West to Scinto 5

(a) High Road to Scinto 5 (Plate 2)

Traverse 8300E, from 550S to 100N

Traverse 8700E, from 600S to 100N

The area between Traverses 7600E and 6600E, from 200S to 400N

Traverse 4200E, from 300S to 700S

The area between Traverses 1800E and 1000E, from 400S to 400N

(b) Stag Creek West (Plate 3)

The area between Traverses 305W and 1000W, from 0 to 200S

Traverse 1760W, from 300S to 500S

Traverse 3266W, from 200N to 400N

The anomalies in these areas may be extensions of the narrow anomaly at El Sherana North-west

(c) Koolpin Creek Prospect Extension (Plate 5)

Traverse K26, from 350 to 550

Traverse K28, from 400 to 500

Traverse K32, from 400 to 550

Traverse K34, from 400 to 600

Traverse K42, from 250 to 500

Traverse K48, from 200 to 350

Coronation Hill South-east (Plate 8)

Traverse 100N, from 400W to 100W

Traverse 100S, from 300W to 0

If carbonaceous rocks are intersected, drilling should be extended.

Coronation B.I.F. (Plate 9)

Traverse 700S, from 750W to 500W

Traverse 400S, from 800W to 500W

7. ACKNOWLEDGEMENTS

The co-operation of the staff of UUNL and of the field assistants provided by UUNL is gratefully acknowledged.

8. REFERENCES

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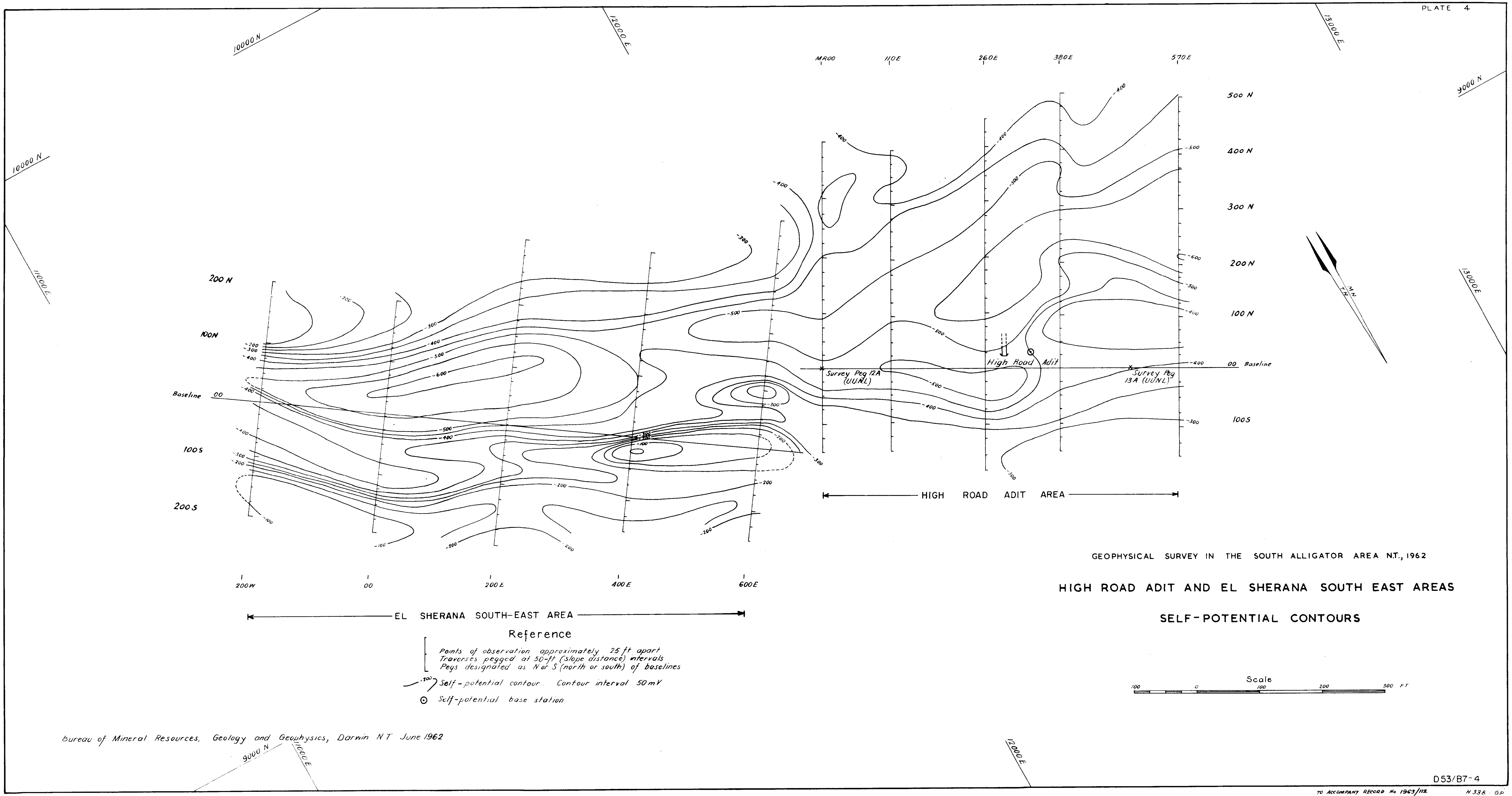
SATO, M. and MOONEY, H.M.	1960	The electrochemical mechanism of sulfide self-potentials. Geophysics, 25(1), 226-249
WALPOLE, B.P.	1958	Stratigraphy of the Darwin/Katherine region. Extract from Ph.D. Thesis Aust. Nat. Univ. (unpubl.)


PLATE I
GEOPHYSICAL SURVEY IN THE SOUTH ALLIGATOR RIVER AREA, NT 1962
GEOLOGICAL SKETCH MAP
AND SURVEY LOCALITY PLAN
Scale (approx)
0 2000 4000 6000 8000 FT.
REFERENCE
UPPER PROTEROZOIC
Katherine River Group
Kombolgie Formation
Plum Tree Volcanics Member
Andesite, andesite tuff, conglomerate, tuffaceous and micaceous sandstone
Kurrundie Member
Brown quartz greywacke, siltstone, quartz conglomerate lenses.
Edith River Volcanics
Undifferentiated. Mainly rhyolite with dacite and lenses of sedimentary breccia, tuff, greywacke, conglomerate.
Scinto Breccia Member
Silicified, sedimentary etc.
Coronation Member
Conglomerate, greywacke conglomerate, sedimentary breccia intercalated with acid and intermediate volcanics, quartz sandstone.
Quartz-filled fracture
25°
Dip and strike
Uranium deposit
LOWER PROTEROZOIC
South Alligator Group
Koolpin Formation
Basic igneous intrusives, epidiorite, etc.
Micaceous greywacke and siltstone
Carbonaceous, pyritic, and dolomite marl with chert lenses and nodules, carbonaceous siltstone
Algal bioherm reef dolomite and silicified dolomite reef breccia, minor siltstone
Masson Formation
Quartz greywacke, siltstone
Coirwong Greywacke Member
Quartz greywacke, minor conglomerate.
Archaean
Stag Creek Volcanics
Altered basalt and basalt conglomerate (greenstone)
Geology by B M R, 1955
REFERENCE
18 Geophysical survey areas
14 Geophysical traverses
1. Stag Creek West • El Sherana North •
El Sherana N-W Ridge, El Sherana N W
2 El Sherana South-east, High Road •
3. Alligator Fault
4 Chavats Line
5 Orchid Gully
6 Boundary Prospect
7 Flying Fox
8 High Road - Scinto 5 •
9 Monolith-Koolpin Creek, Koolpin Creek
Prospect, Koolpin Creek Prospect Extension •
10 Scinto 5 North
11 Scinto 6 •
12 Scinto 5 South
13 Cliff Face - Palette 5
14 Palette East
15 Palm-Scinto Camp - Clear Springs
16 Christmas Creek
17 Skull I, Skull II
18 Clear Springs
19 Saddle Ridge Open-cut
20 Saddle Ridge North
21 Saddle Ridge East •
22 Saddle Ridge South
23 Coronation Breccia •
24 Coronation Hill North •
25 Coronation Hill South-west
26 Coronation Hill South-east •
27 Coronation Hill South •
28 Coronation B.I.F. •
• Surveyed during 1962
Width of broad self-potential anomaly
Axes of narrow self-potential anomaly
MN
TN
DARWIN
Batchelor
Adelaide River
Stuart Highway
McKinley River
Mary River
South Alligator River
El Sherana
South Alligator Uranium Field
Coronation Hill
Pine Creek
All weather road
Moline
True North
Scale in Miles
0 50
132°00'
133°30'
13°00'
14°00'
MOUNT EVELYN
REFERENCE TO AUSTRALIA STANDARD MAP SERIES
South Alligator River
Middle Creek
Bamboo Creek
Koolpin Ck
Stag Ck
Christmas Ck
El Sherana
El Sherana Mine Camp
N U D Airstrip
To Moline and Pine Creek
Koolpin Ck Prospect
Scinto 6
Palette
Cross-section
Skull
Cliff Face
Saddle Ridge
Yard
Coronation Hill
To Sleisbeck
Bureau of Mineral Resources, Geology and Geophysics, Darwin N T December 1962
D53/B7-1
TO ACCOMPANY RECORD No 1963/112
GP H 355


PLATE 2
MONOLITH - KOOLPIN CREEK
KOOLPIN CREEK PROSPECT
KOOLPIN CREEK PROSPECT EXTENSION
EL SHERANA NORTH
EL SHERANA NORTH-WEST RIDGE
EL SHERANA SOUTH-EAST
HIGH ROAD
HIGH ROAD - SCINTO 5
STAG CREEK WEST
EL SHERANA NORTH-WEST
SCINTO 5 NORTH
SCINTO 5 SOUTH
South Alligator River
Mine Camp
To Main Camp
Reference
Approx. outline of El Sherana Open cut
Approx. outline of ore bearing zone, El Sherana North-west
Approx. outline of Scinto 5 North Open-cut
Approx. position of Koolpin Creek Prospect Open-cut.
Approx. position of road
Approx. position of creek
MN
TN
STAG CREEK WEST - SCINTO 5 SOUTH
SELF-POTENTIAL CONTOURS
(REFERRED TO EL SHERANA NORTH-WEST BASE STATION VALUE OF 0 mV)
CONTOUR INTERVAL 100 mV
Scale
400 0 400 800 1200 FT
Bureau of Mineral Resources, Geology and Geophysics, Darwin December 1962
D53/B7-2
TO ACCOMPANY RECORD No 1963/112
GP H354

PLATE 3
STAG CREEK WEST
EL SHERANA NORTH
EL SHERANA NORTH WEST RIDGE
EL SHERANA NORTH-WEST
Stag Creek
Reference
Traverses. Pegged at 50-ft intervals (slope distance). Distances reduced to horizontal. Station positions marked only on these traverses measured in 1962.
Approximate position of roads.
Approximate position of creek.
High Road to Koolpin Creek
El Sherana Open-cut
To Mine Camp
STAG CREEK WEST, EL SHERANA (NORTH-WEST RIDGE, NORTH, AND NORTH-WEST) AREAS
SELF-POTENTIAL CONTOURS
CONTOUR INTERVAL 100mV
Scale
200 0 200 400 600 FT
Bureau of Mineral Resources, Geology and Geophysics, Darwin. December 1962
D53/B7-3
TO ACCOMPANY RECORD No 1963/112
H353 GP

physical Survey in the South Alligator River Area NT 1962



TO ACCOMPANY RECORD No 1963/112

H338 GP

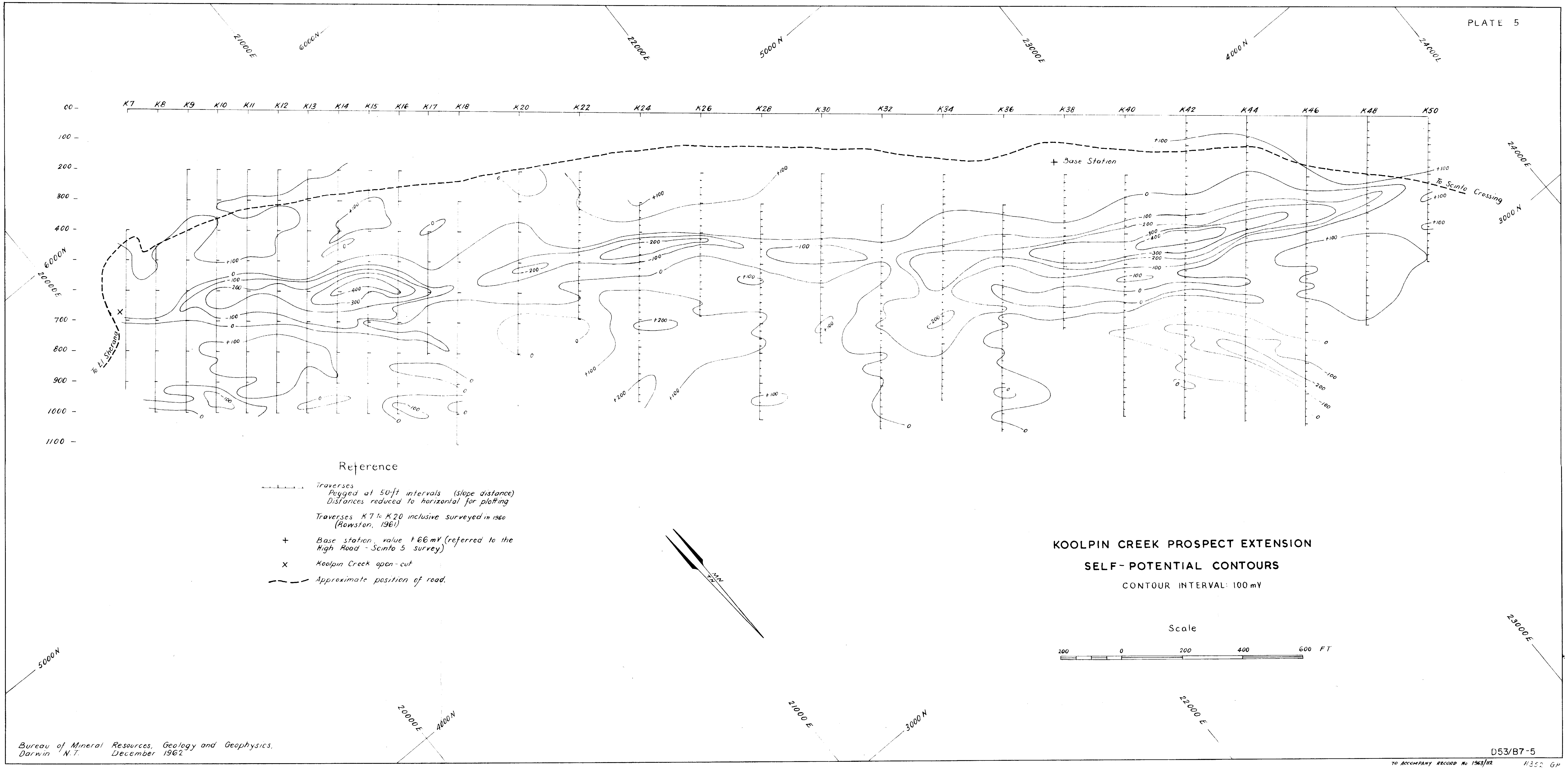
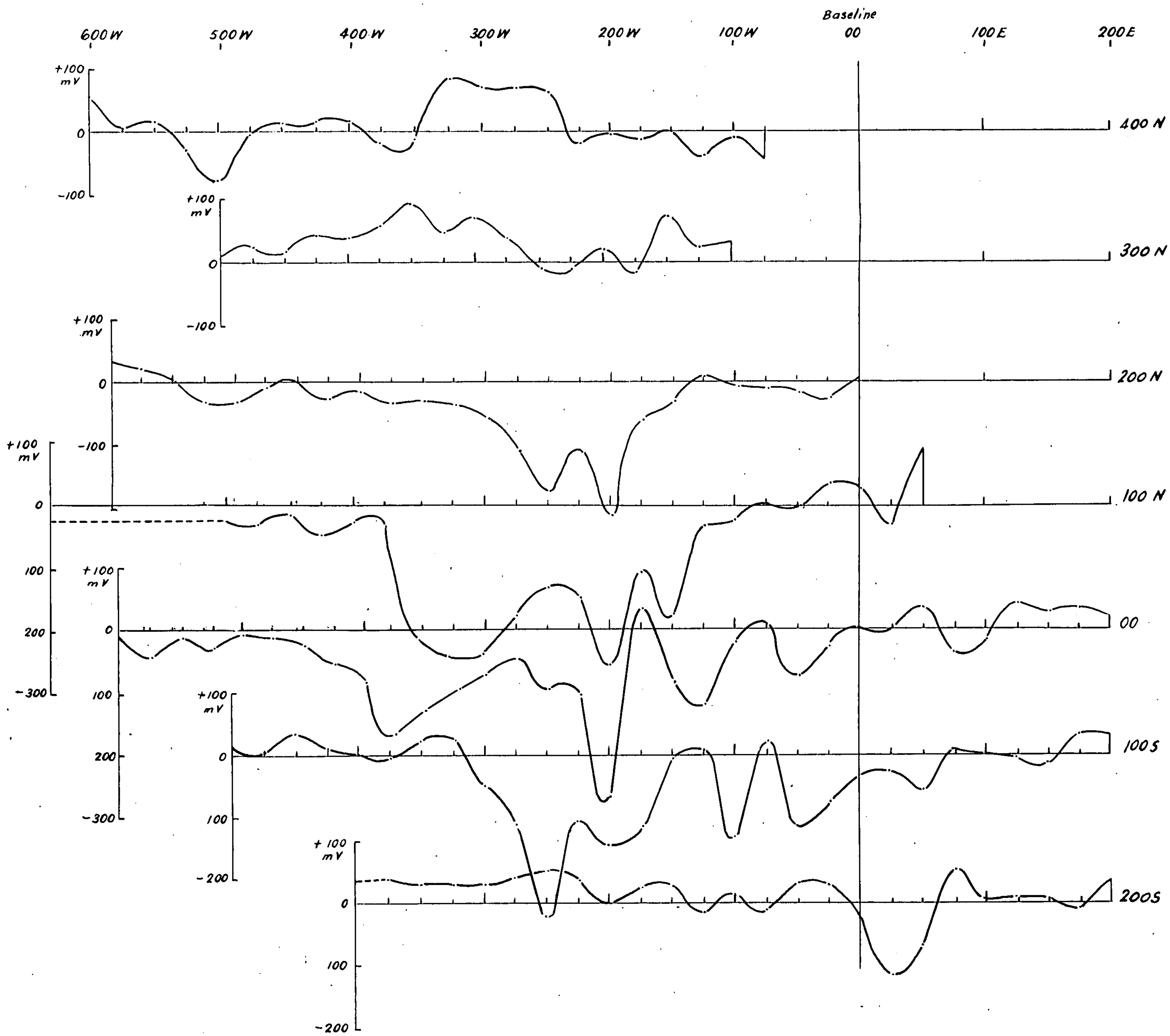
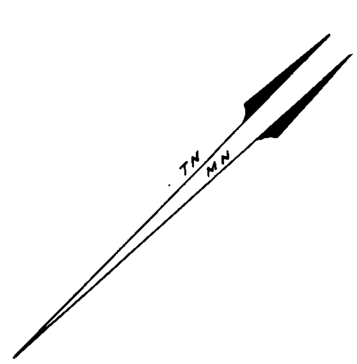


PLATE 5
KOOLPIN CREEK PROSPECT EXTENSION
SELF-POTENTIAL CONTOURS
CONTOUR INTERVAL: 100 mV
Reference
Traverses
Pegged at 50-ft intervals (slope distance)
Distances reduced to horizontal for plotting
Traverses K7 to K20 inclusive surveyed in 1960 (Rowston, 1961)
+ Base station, value +66 mV (referred to the High Road - Scinto 5 survey)
× Koolpin Creek open-cut
Approximate position of road.
Scale
200 0 200 400 600 FT
MN
TN
+ Base Station
To Scinto Crossing
To Lt Sherana
K7 K8 K9 K10 K11 K12 K13 K14 K15 K16 K17 K18 K20 K22 K24 K26 K28 K30 K32 K34 K36 K38 K40 K42 K44 K46 K48 K50
00 100 200 300 400 500 600 700 800 900 1000 1100
21000E 6000N 22000E 5000N 23000E 4000N 24000E 3000N 20000E 6000N 5000N 20000E 4000N 21000E 3000N 22000E 23000E
Bureau of Mineral Resources, Geology and Geophysics,
Darwin N.T. December 1962
D53/B7-5
TO ACCOMPANY RECORD No 1963/112
H350 GP


PLATE 6
EL SHERANA NORTH-WEST
EL SHERANA NORTH-WEST RIDGE
Bearing 14° Mag.
CROSS-SECTION 1
EL SHERANA SOUTH-EAST
Bearing 30° Mag.
CROSS-SECTION 3
Unconformity
CROSS-SECTION 5
SCINTO 5 NORTH
CROSS-SECTION 5 MODIFIED
Bearing 37° Mag.
SCINTO 5 NORTH
CROSS-SECTION 6
Bearing 37° Mag
EL SHERANA NORTH-WEST
EL SHERANA NORTH WEST RIDGE
Bearing 30° Mag.
CROSS-SECTION 2
KOOLPIN CREEK PROSPECT
TRAVERSE K13 (ROWSTON, 1961)
CROSS-SECTION 4
Bearing 40° Mag.
Peg 700
Peg 600
SKULL TRAVERSE "E
CROSS-SECTION 7
Bearing 45° Mag
Baseline
UUNL Ref Line
Feet
Reference
Diorite
UPPER PROTEROZOIC
Edith River volcanics
Sandstone
LOWER PROTEROZOIC
Carbonaceous shale
Bleached shale
"Banded iron formation"
Quartz breccia
Calcareous shale
Cherty bed
Ferruginous shale
Green chloritic schist ?
Yellow shale
Uranium ore
Self-potential profile
Groundwater table (Postulated)
GEOLOGY
AND SELF-POTENTIAL PROFILES
Scales: Vertical + Horizontal
100 0 100 200 300 FT
Geology by UUNL
Bureau of Mineral Resources, Geology and Geophysics, Darwin N.T. March 1963.
D53/B7-6
TO ACCOMPANY RECORD No. 1963/112

PLATE 7





CORONATION HILL SOUTH-EAST
SELF-POTENTIAL PROFILES

Scales

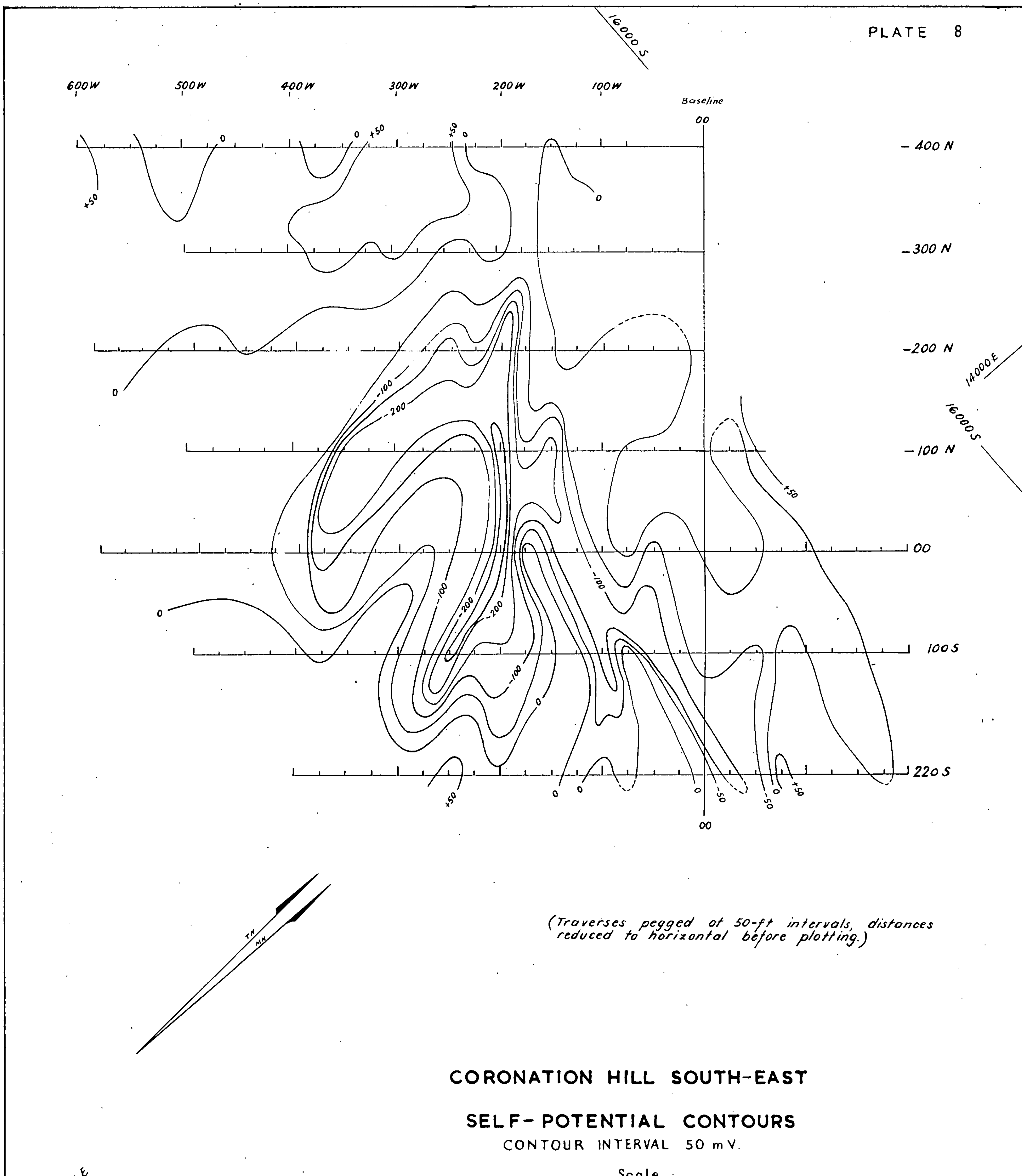
Bureau of Mineral Resources, Geology and Geophysics,
Darwin, N T November 1962.

D53/B7-7

TO ACCOMPANY RECORD No 1963/112 H346 · GP

Geophysical Survey in the South Alligator River Area NT 1962

PLATE 8



(Traverses pegged at 50-ft intervals, distances reduced to horizontal before plotting.)

CORONATION HILL SOUTH-EAST

SELF-POTENTIAL CONTOURS

CONTOUR INTERVAL 50 mV.

Scale

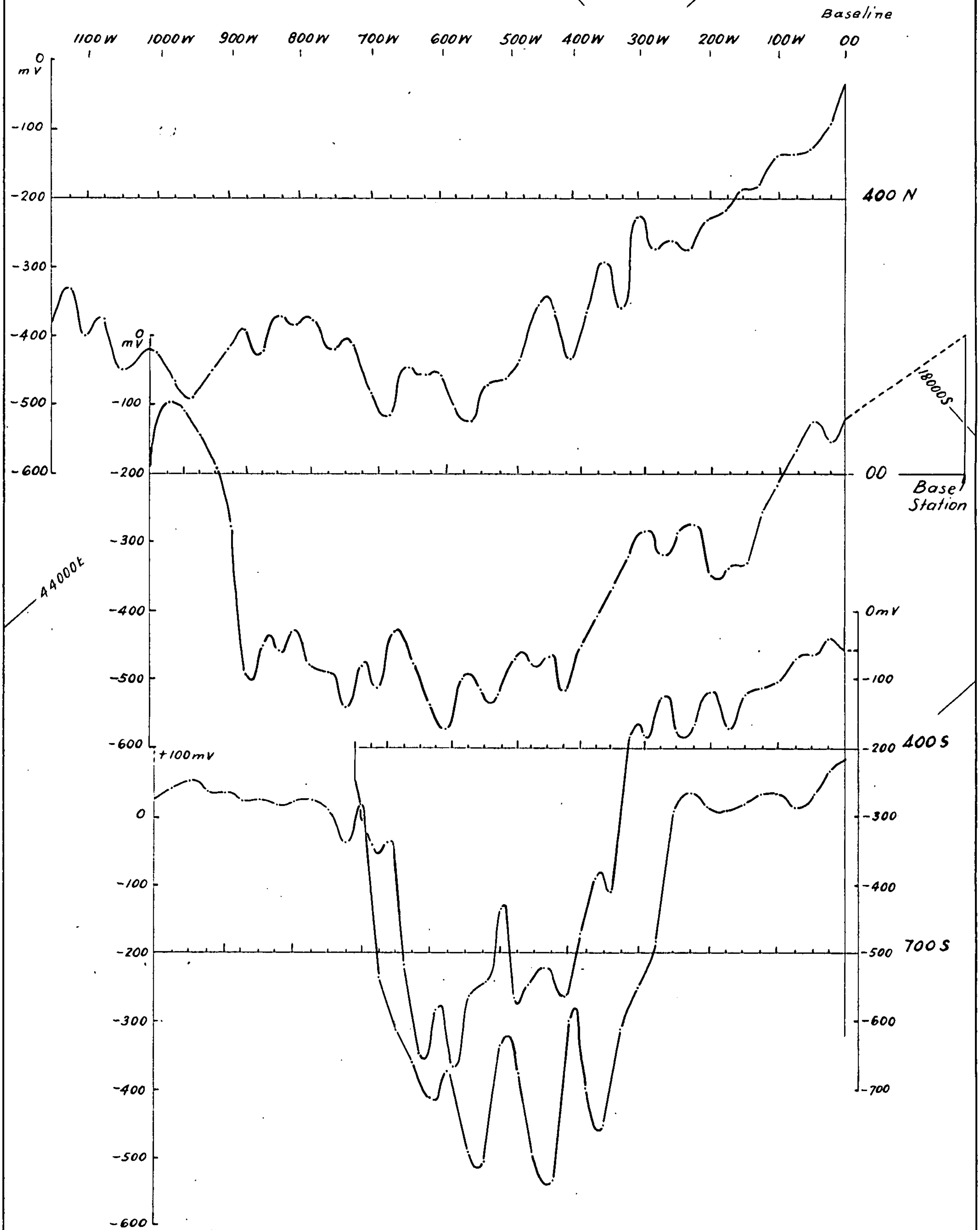
100 0 100 200 300 FEET

Bureau of Mineral Resources, Geology and Geophysics.
Darwin, N T November 1962.

D53/B7-8

TO ACCOMPANY RECORD NO. 1963/112 H345 · GP

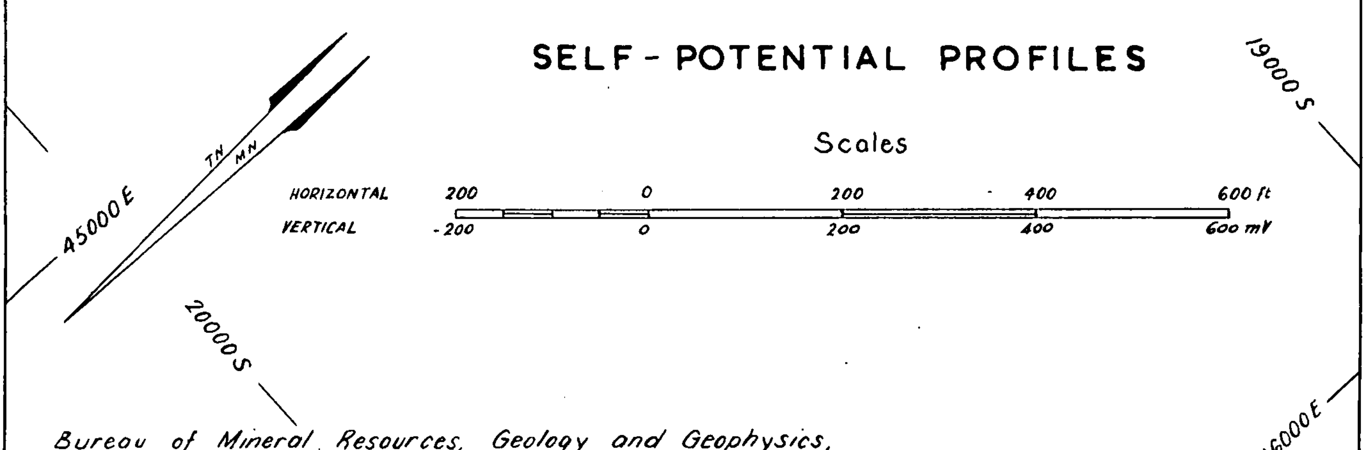
PLATE 9



CORONATION B.I.F. AREA

SELF-POTENTIAL PROFILES

Scales



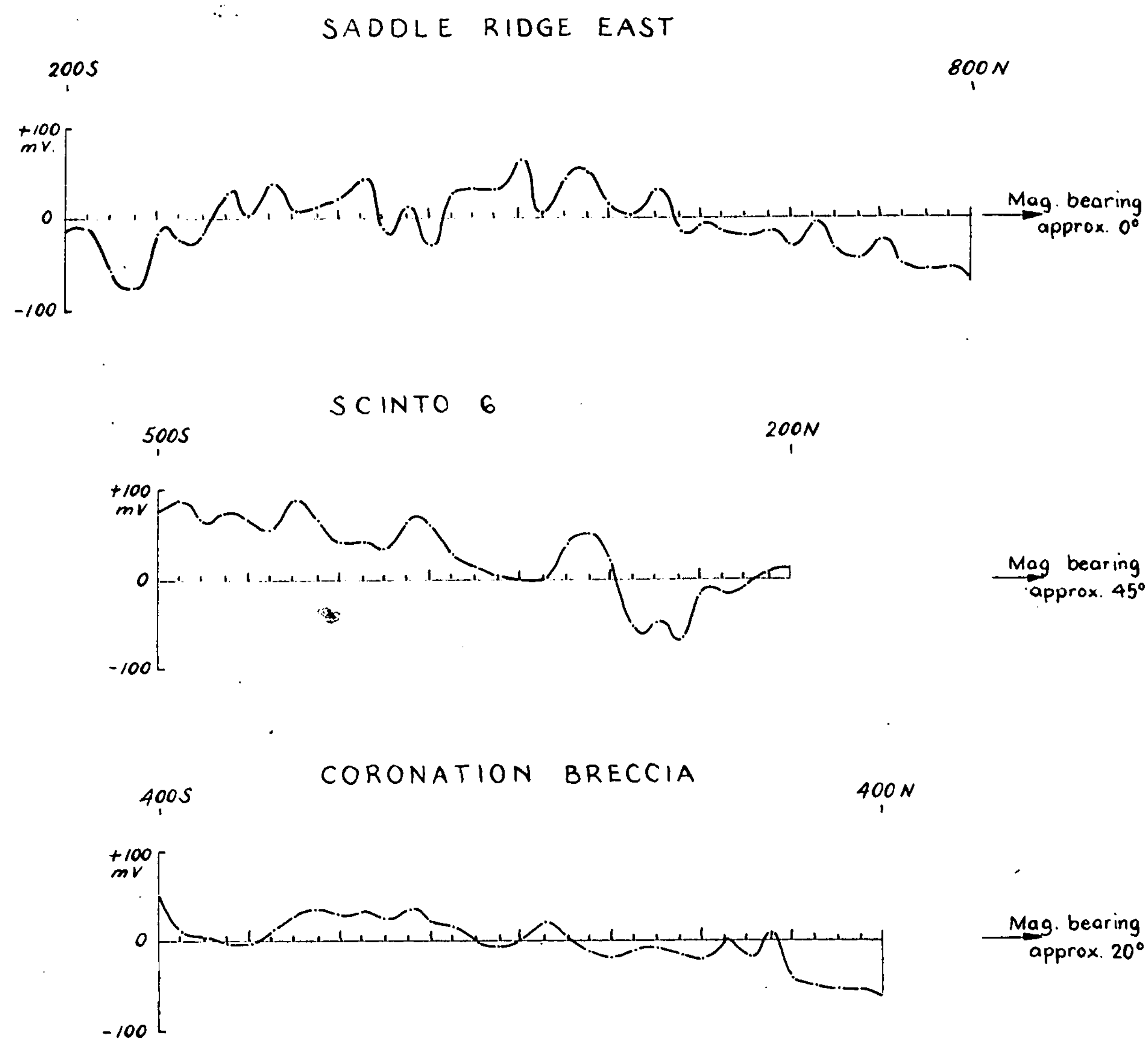
Bureau of Mineral Resources, Geology and Geophysics,
Darwin NT November 1962

D53/B7-9

TO ACCOMPANY RECORD No 1963/112

H350-GP

PLATE 10



SADDLE RIDGE EAST, SCINTO 6 AND CORONATION BRECCIA AREAS

SELF-POTENTIAL PROFILES

Scales

HORIZONTAL 200 0 200 400 600ft

VERTICAL -200 0 200 400 600 mV

Bureau of Mineral Resources, Geology and Geophysics, Darwin N T November 1962

D53/B7-10

TO ACCOMPANY RECORD No 1963/112

H351 · GP

...ophysical Survey in the South Alligator River Area NT 1962

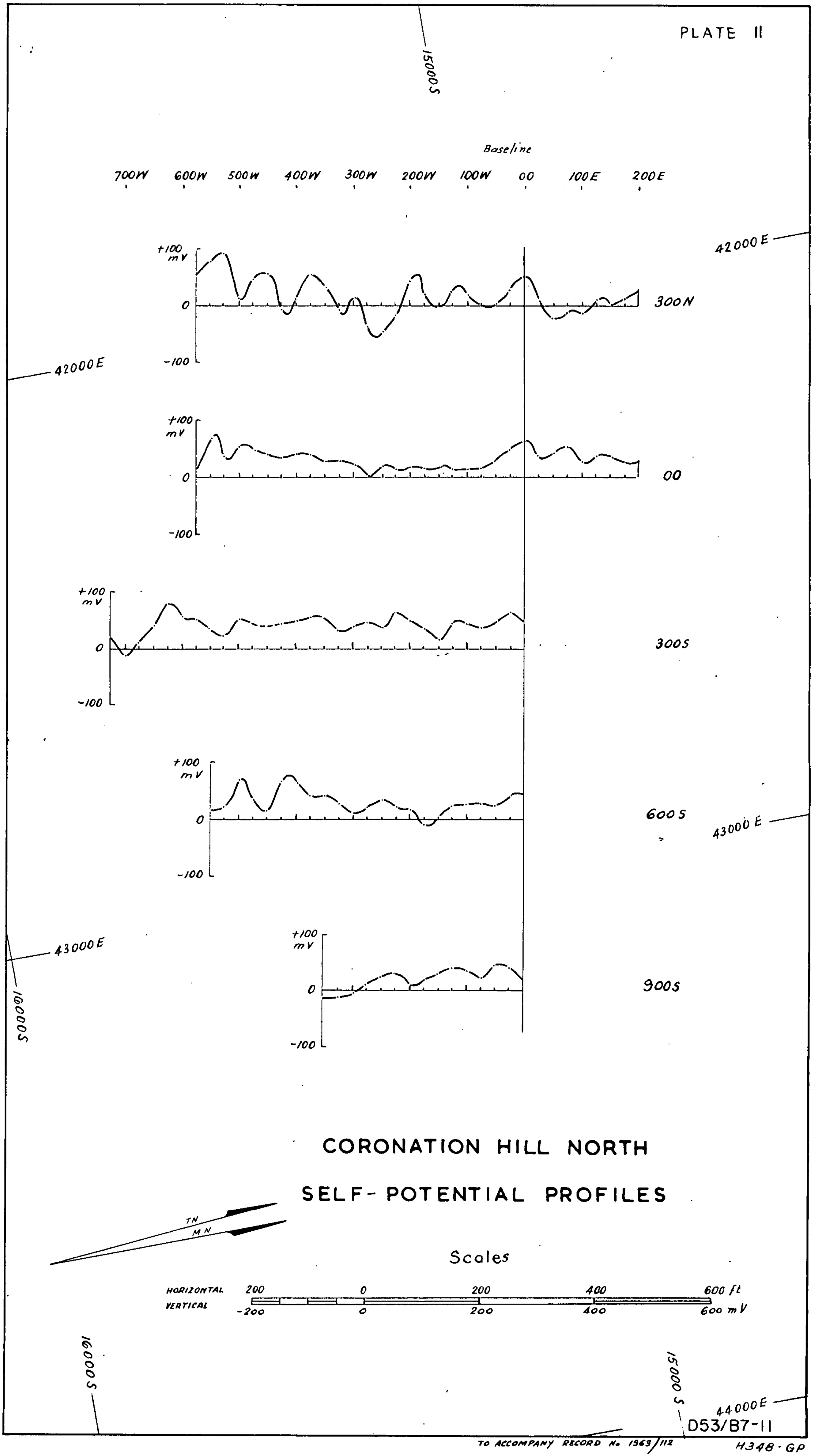


PLATE II
15000S
Baseline
700W 600W 500W 400W 300W 200W 100W 00 100E 200E
42000E
+100 mV
0
-100
300N
00
300S
600S
43000E
900S
16000S
CORONATION HILL NORTH
SELF-POTENTIAL PROFILES
TN
MN
Scales
HORIZONTAL 200 0 200 400 600 ft
VERTICAL -200 0 200 400 600 mV
44000E
15000S
D53/B7-11
TO ACCOMPANY RECORD No 1969/112
H348-GP

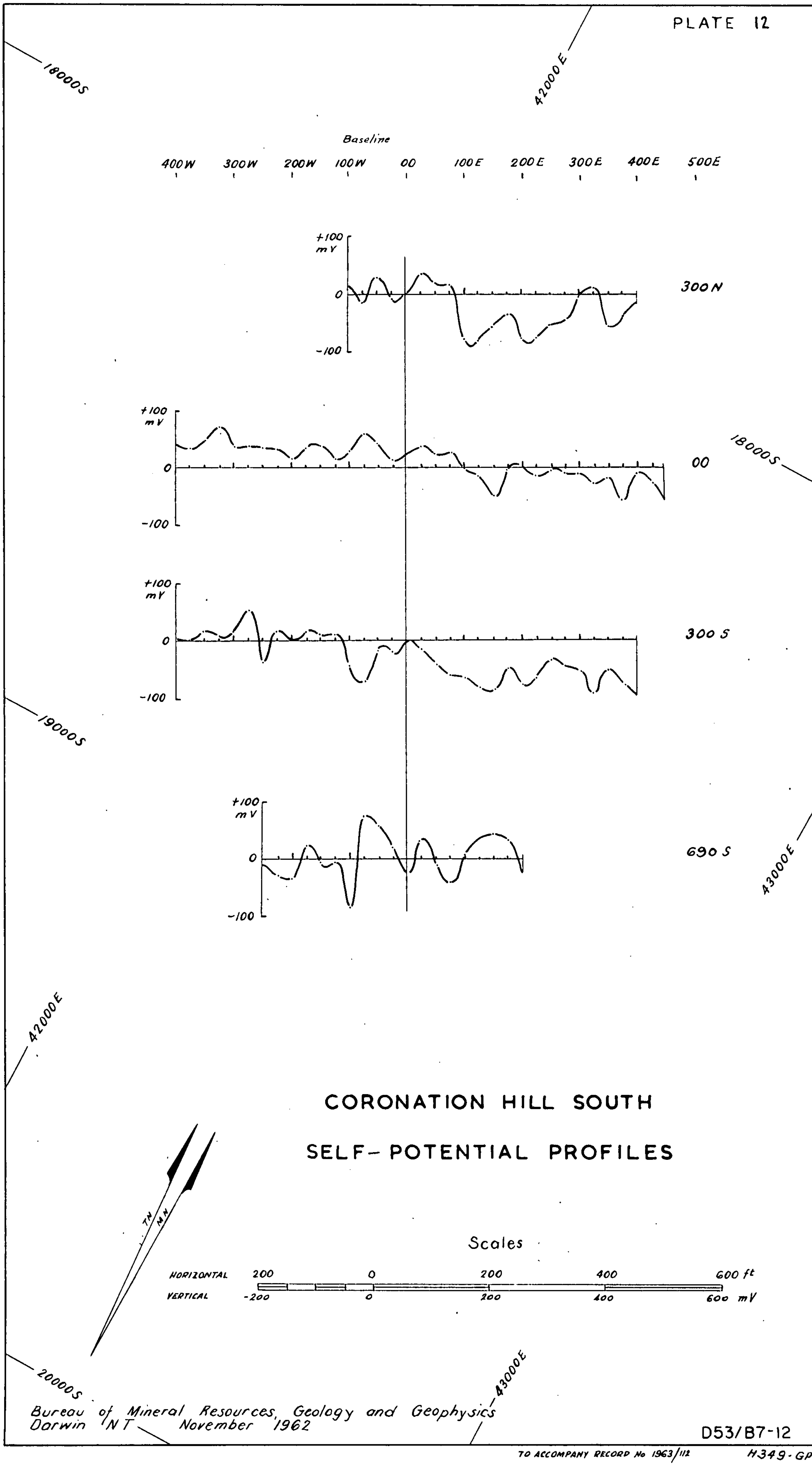


PLATE 12
18000S
42000E
Baseline
400W
300W
200W
100W
00
100E
200E
300E
400E
500E
+100
mV
0
-100
300N
00
300 S
690 S
18000S
19000S
43000E
42000E
CORONATION HILL SOUTH
SELF-POTENTIAL PROFILES
TN
MN
Scales
HORIZONTAL
200
0
200
400
600 ft
VERTICAL
-200
0
200
400
600 mV
20000S
43000E
Bureau of Mineral Resources, Geology and Geophysics
Darwin NT November 1962
D53/B7-12
TO ACCOMPANY RECORD No 1963/112
H349-GP