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# Results of the Crater Formation Drilling Rum Jungle District, Northern Territory

*by*

*J. S. Morlock and R. N. England*

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## CONTENTS



## PLATES

## SUMMARY

The No. 1 Conglomerate of the Crater Formation was tested by two rotary percussion drill holes, both of which obtained core from the conglomerate. One hole was continued and core recovered to the base of the Crater Formation.

Fresh drill core and heavy mineral concentrates of weathered surface material from the Crater Formation were examined by R.N. England, optically with the aid of autoradiographs and by electron proble. Heavy mineral concentrates of both fresh drill core and weathered material were examined microscopically, by x-ray diffraction, electron probe, and gamma-ray spectrometry. After acid leaching their radioactivity was rechecked by gamma-ray spectrometer. The only source of significant radioactivity is an opaque or slightly translucent brown acid-soluble amorphous or metamict phosphate containing about 20-30% Th but no detectable U. It also contains an appreciable amount of Ca and some Fe, Si Al, Ti and Ce.

## PREVIOUS WORK

Radioactive anomalies were discovered in the Crater Formation soon after the finding of uranium mineralization at Whites in 1949. Surface work showed that the anomalous radioactivity was strongest and most persistent in what was called the No. 1 Conglomerate. Outcrop samples and drill cores samples tested showed that most, if not all, of the radioactivity was due to thorium. However, the drill core samples available were somewhat leached. Rhodes (1960) reported the presence of some uranium in addition to thorium.

Because of its similarities to the Blind River Uranium Province it was decided that further testing of the Crater Formation should be carried out. Accordingly, in 1969, D.J. French examined the Crater Formation throughout the Rum Jungle District and selected the Shirley Area which he mapped in detail (French, 1970). He recommended two diamond drill holes to test the No. 1 Conglomerate and the underlying "Crater Grits".

## 1970 DRILLING

Rotary-percussion drills were available in 1970 and hence French's inclined diamond drill sites were modified to vertical holes which would test the No. 1 Conglomerate at about 400 foot depth.

Hole No. 70/R53 was drilled by a truck mounted Fox rig working one shift. It was drilled by hammer and rotary to 360 feet and cutting samples collected every ten feet. At this depth the hole was cemented to seal off water and control circulation losses. On redrilling the bit was deflected slightly. Coring commenced at 328 feet and was continuous to total depth of 358 feet. No. 1 Conglomerate zone was cored from 328 feet to 344 feet.

A Mayhew drill working two shifts drilled hole 70/R54. No drilling problems were encountered. Cutting samples were collected over ten foot lengths and short cores cut every hundred feet till continuous

coring commenced at 320 feet and continued to total depth of 790 feet. The No. 1 Conglomerate zone was cored from 335 feet to 375 feet and then the "Crater Grits" to 765 feet when the Celia Dolomite was entered.

Both holes were logged by Widco Portalogger giving single point resistance, self-potential and gamma logs.

Hole 70/R54 was completed by placing 1½" water pipe to total depth as requested by ANU.

## RESULTS

The lithological logs of the two holes show the same sequence down to the No. 1 Conglomerate zone with but minor differences in thickness e.g. the siltstone immediately above the zone has a true thickness of about 71 feet in 70/R53 and of 79 feet in 70/R54.

The No. 1 Conglomerate zone is better developed in the section intersected by 70/R54 where thin beds of conglomerate occur below the main conglomerate bed, which is the base of the zone in 70/R53.

Core of 70/R54 shows that the "Crater Grits" consist of alternating fine to medium grained felspathic sandstone, arkosic grit and fine conglomerate with minor pebble conglomerate beds.

The gamma log of 70/R54 shows good correlation between radioactive highs and conglomerate. No. 1 Conglomerate zone extends from 335 feet to 375 feet and the maximum radioactivity is in the main conglomerate bed from 357 to 366 feet. Anomalous radioactivity is also associated with conglomerate zones at 410 to 455 feet and 725 to 765 feet - the base of the Crater Formation. Radioactivity is very low and uniform in the siltstone above the No. 1 Conglomerate zone and is also low but not so uniform in the upper Celia Dolomite penetrated.

The gamma log of hole 70/R53 is very similar. Very low and uniform radioactivity from the siltstone confirms the identity of the No. 1 Conglomerate zone immediately below. Again the maximum radiation is from the main conglomerate bed of the zone from 336 to 344 feet. Hole 70/R53 was drilled only a few feet deeper than the No. 1 Conglomerate zone.

The approximate uranium: thorium rations of samples from each of the radioactive conglomerate zones were determined from gamma spectrometer counts at appropriate energy levels. The ratios which are shown in Table 1 indicate the gamma radiation is essentially due to thorium. The maximum thorium content indicated is 0.12% $ThO_2$.

TABLE 1

$U_3O_8$ : $ThO_2$ and % $ThO_2$

| Sample | | $U_3O_8$ : $ThO_2$ | % $ThO_2$ |
|---|---|---|---|
| 70/R53 | 336' | 0.01 | 0.06 |
| | 338' | 0.01 | 0.04 |
| 70/R54 | 359' | 0.01 | 0.12 |
| | 366' | 0.01 | 0.05 |
| | 427' | 0.01 | 0.07 |
| | 748' | 0.15 | 0.04 |
| | 764' | 0.01 | 0.06 |

Gamma spectrogram obtained by 256 channel spectrometer.
0.07% $ThO_2$ standard used.

## SOURCE OF RADIOACTIVITY IN THE CRATER FORMATION

by

R.N. England

### FRESH CORE MATERIAL

(a) Petrography and Electron Probe Examination

Four Polished thin sections of fresh drill core material were examined. The most radioactive part of the core is a pebble conglomerate containing about 50% of large subangular to rounded fragments (up to 2 cm across) of vein quartz in various stages of recrystallization. The matrix is a fairly fine-grained aggregate of deep green moderately birefringent chlorite with some fine-grained quartz and carbonate. Euhedral and fragmentary grains of zircon are common. Small grains of opaque minerals make up about 1% of the rock. Autoradiographs show that opaque grains are the sole source of significant radioactivity and over half the opaques blacked x-ray film. Electron probe examination revealed the presence of the following elements in the radioactive mineral:

P, Th, Fe, Ca, Si, Al, Ti, Ce (in approximate order of abundance). It is not clear whether it is of clastic or concretionary origin.

(b) X-Ray Diffraction

Four unsuccessful attempts were made to obtain an x-ray diffraction pattern from the radioactive material. Only the lines of rutile, hematite ilmenite and zircon were present in power photographs of a heavy mineral concentrate for the core material. It is concluded that the radioactive phosphate is either metamict or too fine-grained to give an x-ray pattern.

(c) Gamma-ray Spectrographic Examination

After measuring the total intensity of gamma radiation from a heavy mineral concentrate, the material was boiled for 2 hours in 5M hydrochloric acid. The intensity was measured and the following results were obtained.

Total Gamma-Ray Intensity less Background.

| Unleached Concentrate | Leached Concentrate | Solution (evaporated to dryness) |
|---|---|---|
| 28.0 c/s | 0.4 c/s | 17.2 c/s |

The gamma-ray spectrum obtained from the acid soluble fraction is that of $Th^{232}$ and its daughter-products. No U peaks were detected. The solution obtained was tested for phosphate with ammonium molybdate and gave strong positive results.

HEAVY MINERAL CONCENTRATES OF WEATHERED SURFACE MATERIAL

(a) Petrography and Electron Probe Examination.

The concentrates consist mainly of angular opaque or dark brown grains (mostly iron oxides with some zircon grains which may be euhedral, fragmentary or rounded. Quartz may be present in composite grains with iron oxide.

Autoradiographs indicate that sources of radiation are rare in most samples but moderately common in others (especially 69070115 and 69070135). They are generally opaque but may be translucent reddish brown with high refractive index and patchy, moderately high birefringence. Qualitative electron microprobe analysis showed the mineral to be similar in composition to the fresh material described above. 69070110 and 69070115 contained a few grains of galena, sphalerite and chalcopyrite. Some Th was detected in veins within two zircon grains in 69070135. As the grain is traversed, the production of Th radiation is accompanied by a sharp drop in the intensity of Zr and Si radiation without increase in radiation from any other element. For this reason the Th-bearing phase is thought to be thorianite. In any case, the quantity of Th occurring in this manner is insignificant compared with that in the phosphate mineral.

(b) X-ray Diffraction

After separation of most of the magnetic material, powder photographs were made of the heavy fraction of three samples and lines of the following phases were noted.

| 69070110 | 69070115 | 69070135 |
|---|---|---|
| Quartz | Quartz | Quartz |
| Zircon | Zircon | Zircon |
| Hematite | Hematite | Magnetite |
| | Magnetite | Rutile |
| | Rutile | |

No lines attributable to the Th-bearing phosphate were found.

(c) Gamma-ray Spectrographic Examination

Total gamma-ray intensity was measured in 20g each of 4 samples before and after leaching for 2 hours in boiling 5M hydrochloric acid. The following results were obtained:-

| Sample | Total gamma-ray intensity less background | | Percentage of sample dissolved |
|---|---|---|---|
| | Initial concentrate | Leached material | |
| 69070101 | 16.7 c/s | 7.7 c/s | 13 |
| 69070129 | 15.0 c/s | 4.2 c/s | 15 |
| 69070135 | 14.4 c/s | 3.0 c/s | 24 |
| 69070136 | 18.3 c/s | 5.7 c/s | 25 |

The gamma-ray spectrographic and acid leaching Tests were carried out by A.D. Haldane.

The source of radioactivity in the Crater Formation is an opaque or, more rarely, translucent brown acid-soluble amorphous or metamict phosphate of Th, Ca and Fe containing small amounts of Si, Al, Ti and Ce. It could be related to the mineral cheralite or to the synthetic phase Ca, Th $(PO4)_2$ but its structure is unknown. The mineral occurs in small opaque grains in the matrix of the conglomerate but it is not clear whether it is of clastic or concretionary origin.

## CONCLUSIONS

The drilling of the Crater Formation has confirmed the sequence established by French (1970). It has shown that higher radioactivity is associated with zones of conglomerate which occur within a stratigraphic

interval of over 300 feet extending from the No. 1 Conglomerate zone through the "Crater Grits" to the base of the formation. The main conglomerate bed in the No. 1 Conglomerate zone is the thickest and most radioactive unit. This bed has a true thickness of about 4 feet in hole 70/R53 and 7 feet in hole 70/R54.

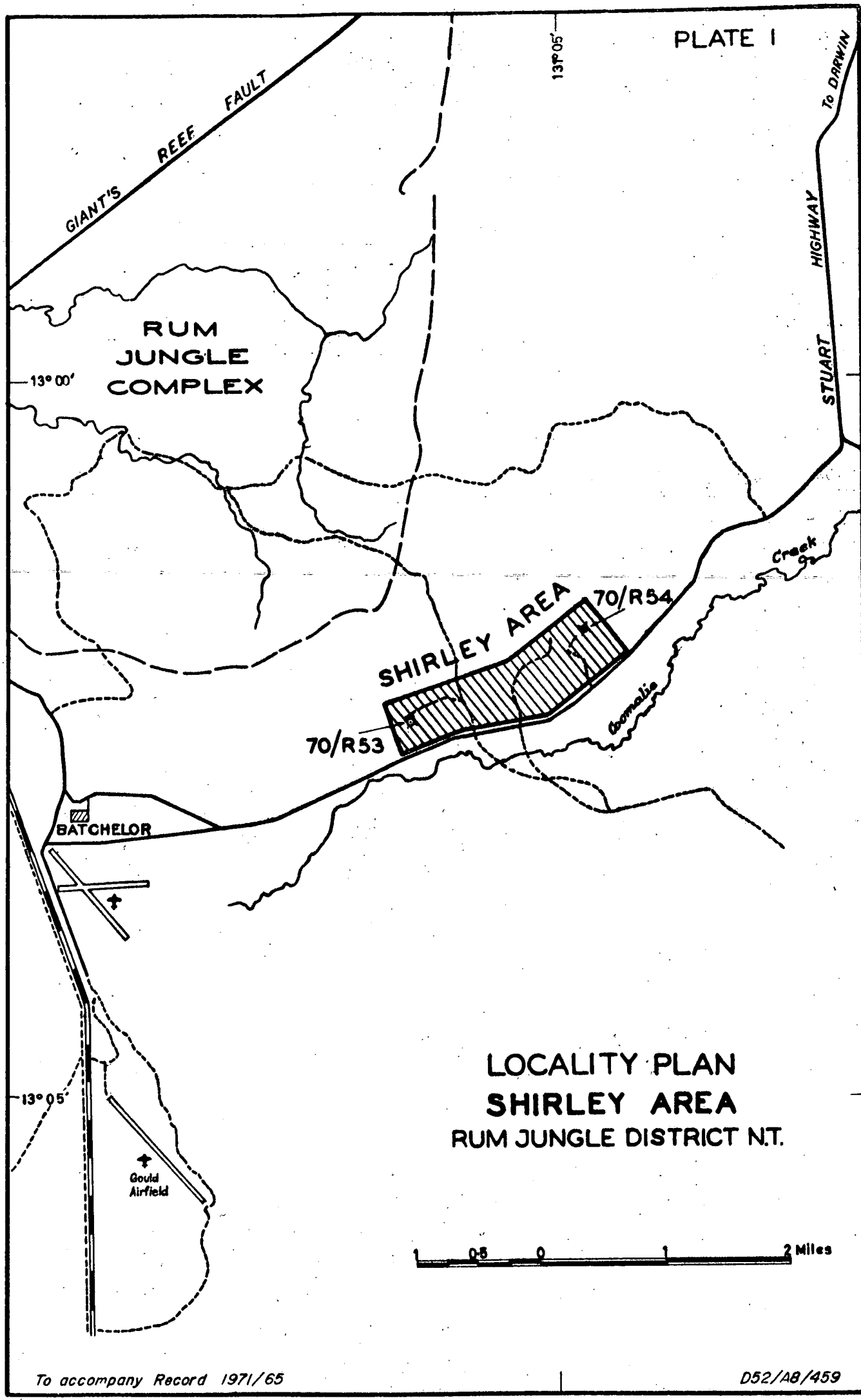
Tests carried out on unleached speciments of core confirm results of previous investigations: the anomalous radioactivity of conglomerates in the Crater Formation is essentially due to thorium and that this mineralization is well below possible ore grade.

## REFERENCES

FRENCH, D.J., 1970 - Crater Investigation, Rum Jungle District, N.T. 1969. Rec. Bur. Min. Resour. Aust. 1970/65

RHODES, J.M., 1960 - Results of Diamond Drilling by Bureau of Mineral Resources, 1959-60, at the Crater Line, near Batchelor, N.T. Rec. Bur. Min. Resour. Aust. 1960/123

PLATE 1




*To accompany Record 1971/65*

D52/A8/459

B.M.R. DARWIN FEB. 71

PLATE 2

18 000 N — 52 000 E — 54 000 E — 56 000 E — 58 000 E — 60 000 E — 18 000 N

16 000 N — 16 000 N

14 000 N — 14 000 N

12000 N — 12000 N

10000 N

52 000 E — 54 000 E — 56 000 E — 58 000 E

## REFERENCE

- TRACK
- ALLUVIUM BOUNDARY
- CONGLOMERATE
- HEMATITE BOULDER CONGLOMERATE
- VQ — VEIN QUARTZ
- SYNCLINE
- ANTICLINE
- $T_{10}$ — DIPS AND STRIKE
- SHAFT
- FAULT
- QUARTZITE OUTCROP LINES
- Q — QUARTZ
- T — TOURMALINE
- $Fe$ — HEMATITE
- Py — PYRITE
- R34 — ROTARY PERCUSSION HOLE
- A — B — SECTION LINE
- 14 000 N — MAIN GRID — T.E.P. MINE GRID (Ft)
- 8 N — LOCAL GRID — CRATER LINE GRID (100Ft)
- ROTARY PERCUSSION DRILL HOLE 1970

BASELINE 45° 30' TO "H"

70/R54

70/R53

CRATER PEBBLE BEDS

No. 1 CONGL.

No. 2 CONGL.

SHALE

BATCHELOR ROAD

TO DARWIN

TO BATCHELOR

# GEOLOGY

D. FRENCH

RUM JUNGLE DISTRICT N.T.

## SHIRLEY AREA

CRATER INVESTIGATION 1969-70

GRID SURVEYED
TIMBS & BRITTEN 1969

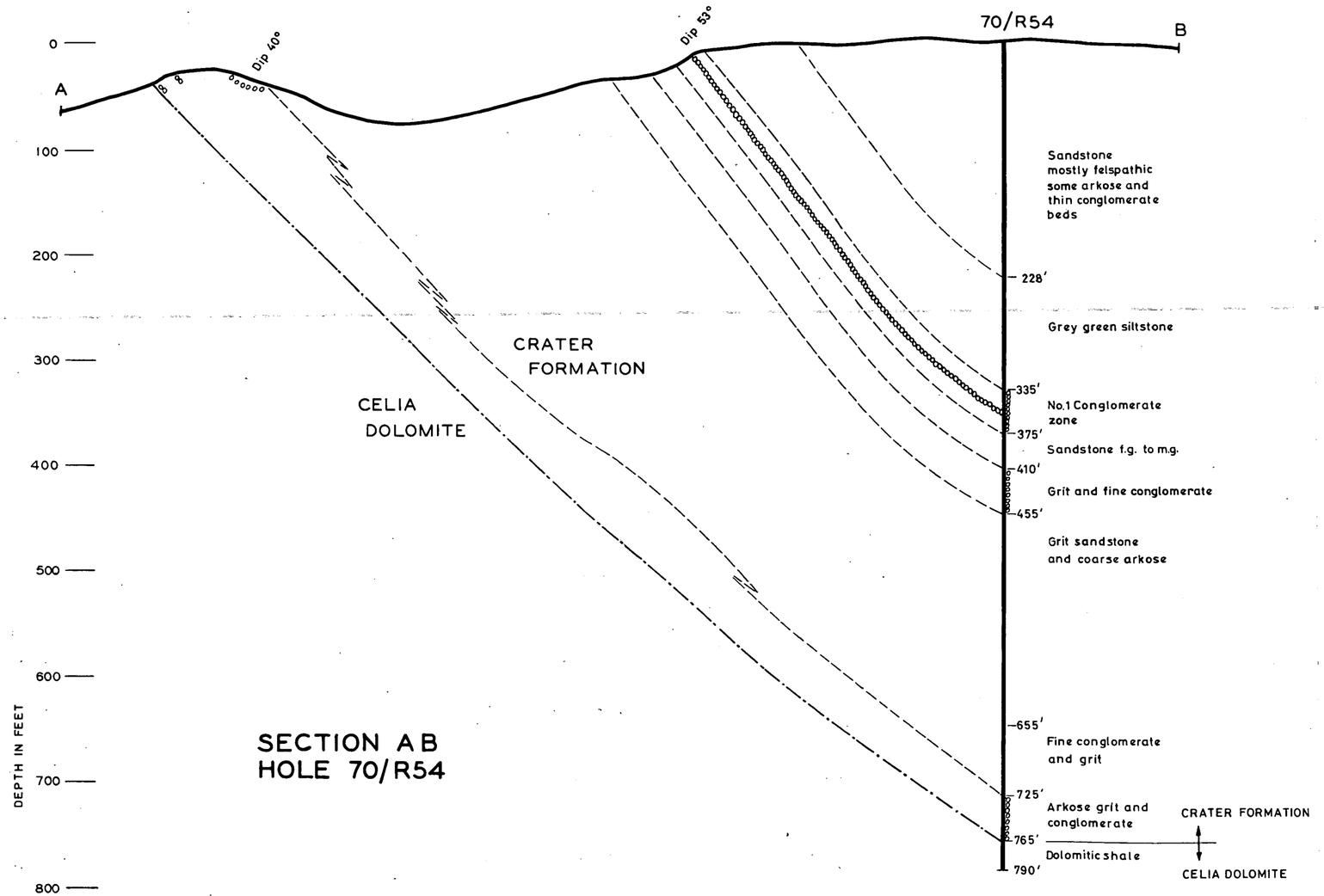
SCALE : 400 FEET TO 1 INCH

To accompany Record 1971/66

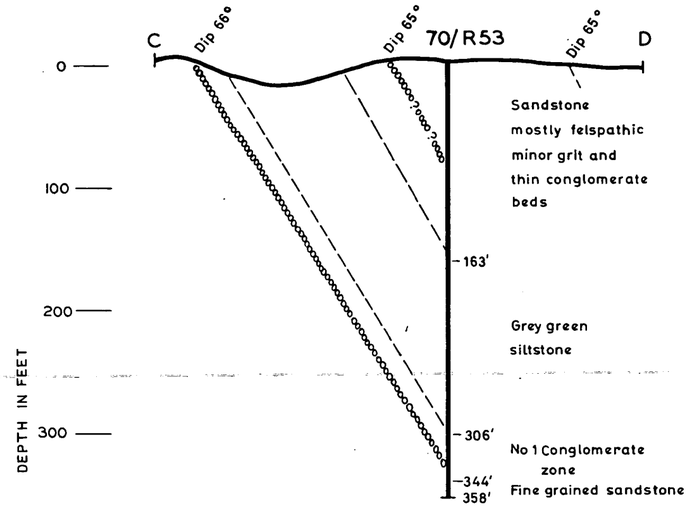
B.M.R. DARWIN N.T. OCT. 1969 R.H.F.

D52/A8/463

35/69




SECTION AB
HOLE 70/R54




SECTION CD
HOLE 70/53

# SECTIONS AB & CD
# HOLES 70/R53 & 70/R54
# SHIRLEY AREA

RUM JUNGLE DISTRICT N.T.

SCALE: 1 INCH = 100 FEET

PLATE 4

# 701 R 53 (No 2)

10 Dec 70

DEPTH ±2' | GAMMA LOG 1 2 3 4 Mr/hr approx. | SELF POTENTIAL 50. mV | LITHOLOGY | SINGLE-ELECTRODE LOGS RESISTANCE 200.Ω

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350

Core taken

Mostly weathered felspathic sandstone

Weathered medium grained felspathic siltstone dip 60°

Water level

163'

2" Sandstone above grey green siltstone

Grey green phyllitic siltstone

Mostly grey green phyllitic siltstone a few thin sandstone lenses

Grey green phyllitic siltstone

306'

Mostly coarse felspathic sandstone

Arkosic grit Pebble conglomerate

Arkosic grit dip 50°

336'

No 1 conglomerate

346'

dip 60° and 65° fine grained sandstone

T.D. 358'

Arenite | Siltstone | Grit | Conglomerate

PLATE 5

# PR/RES4

LOGGED 4 DEC 74.

GAMMA LOG

SINGLE ELECTRODE LOGS.

SELF POTENTIAL

RESISTANCE

DEPTH ft

LITHOLOGY

Metres (approx.)

50mV

200 Ω

Feldspathic sandstone

Well weathered sandstone

Coarse arkose grit slightly weathered dip 10°

Boundary from drilling company

Grey-green massive siltstone

Grey-green siltstone

Continuous dipmy

Dip 65° Dip 25° at base contact

Grit and coarse sandstone dip 35°

Fine grained sandstone

Fine grained sandstone

Fine grained to medium grained sandstone felspathic dip 30°

Coarse sandstone and grit

Conglomerate pebbles about ½"

Fine conglomerate or pebbly grit

Fine grained felspathic sandstone dip 35°

Coarse arkose (red tinted) some disseminated pyrite

Fine grained sandstone

Arkose grit

Fine grained sandstone

Grit and coarse felspathic sandstone

dip 25°

dip 20°

Fine (up to ½") conglomerate and grit

dip 25° dip 20°

dip 25°

6" conglomerate

Arkose grit

Conglomerate

Conglomerate dip 35°

dip 25° N?

Grit dip 45°

COAL SEQUENCE

T.D. Depth recorded by Wicks Peterhager

Depth from drillers log and core

Breccia

Siltstone

Grit

Conglomerate (up to ½")

Conglomerate (up to 4")