COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS

RECORDS:

1964/127

COMPLETION REPORT

B.M.R. NO. 13 WELL, SANDOVER, NORTHERN TERRITORY

by

A.R. Lloyd and M. Bell

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SUMMARY

The Bureau of Mineral Resources stratigraphic well B.M.R. No. 13 (Sandover) was drilled in the Elkedra 1:250,000 Sheet area of the Georgina Basin, Northern Territory. The well site is 190 miles north-east of Alice Springs and 4 miles east of the turn-off to Ooratippra Homestead on the Alice Springs-Lake Nash-Queensland Road. The objectives of the well were to assist petroleum search in the Georgina Basin by determining the depth to economic basement, reservoir characteristics, and lithologies and thicknesses of sedimentary units of the Palaeozoic sequence which have been mapped elsewhere in the Basin; and to provide seismic velocity data.

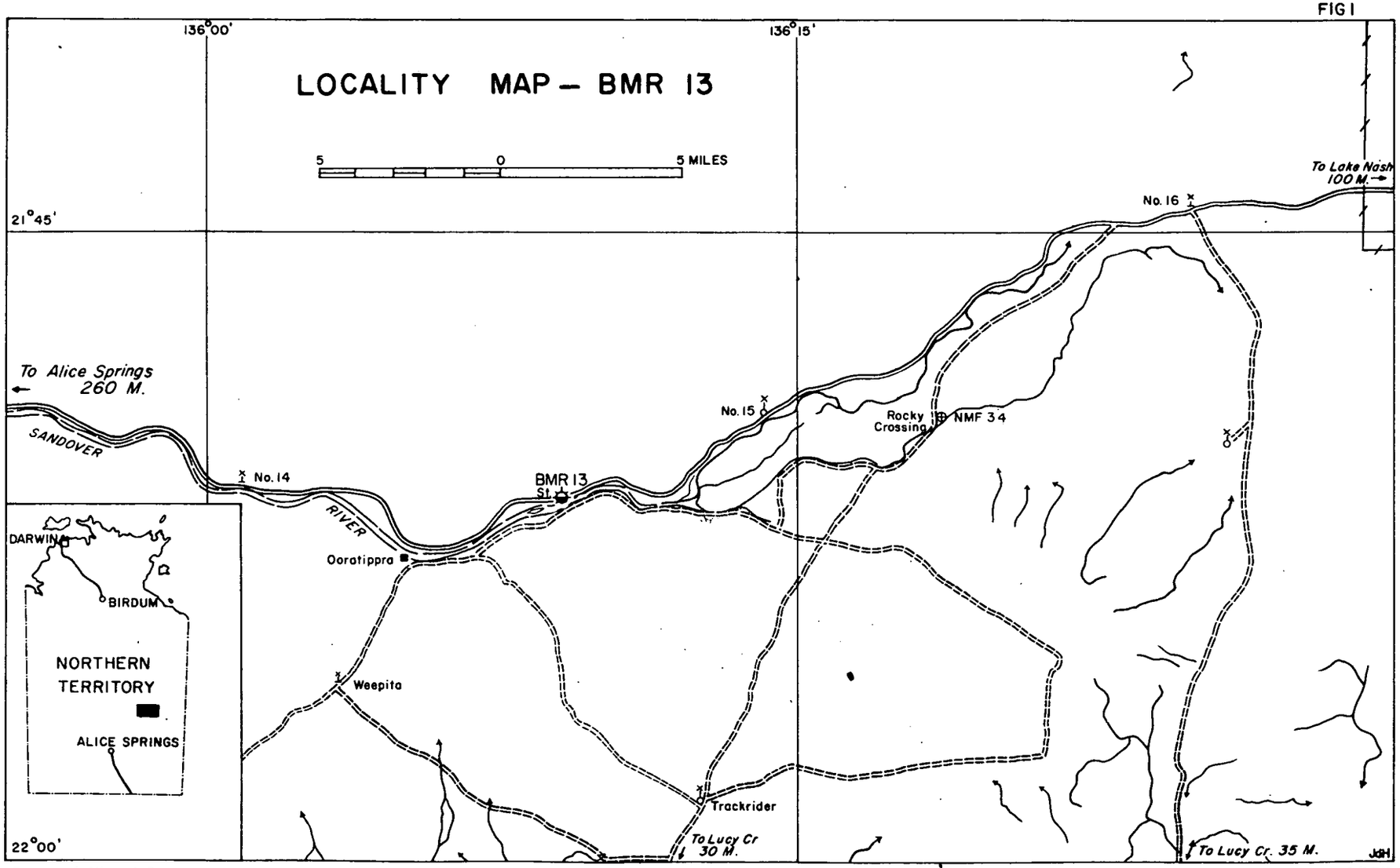
The well spudded on 15th January, 1964, and reached a total depth of 3330 feet on 6th July, 1964. A Failing 2500 Holemaster rig, equipped to drill with both air and mud, was used. The hole was drilled with air from surface to 352 feet, and from 352 feet to total depth using bentonite-fresh water mud.

The following sequence was penetrated in the well:

Depth (R.T.) (feet)	Age	Formation	Lithology
0 - 40	Quaternary		quartz sand
40 -2235	Upper Cambrian	Arrinthrunga	dolomite, shale, quartz sandstone and siltstone
2235-3097	Middle Cambrian	Arthur Creek ~~Equivalent~~	limestone, dolomite and siltstone; sponge spicules, phosphatic brachiopods and the trilobites Pagetia significans and Xystridura sp.
3097-3304	?Lower Cambrian	?Mount Baldwin	dolomite, quartz sandstone, phosphatic brachiopods
3304-3328	?Archaean	?Arunta Complex	gneiss
3328-3331	?		granite

A fragmentary, phosphatic brachiopod was found at 2574-2579 feet; Core 11 (2579-2582½ feet) contained sponge spicules and fragmentary brachiopods; Core 12 (2817-2827 feet) contained the trilobites Pagetia significans and Xystridura sp; fragmentary brachiopods and fragments of Pagetia sp. were found in cuttings between 2660 and 2820 feet and brachiopod fragments at 3320-3230 feet.

FIG 1



Bureau of Mineral Resources Geology and Geophysics. June 1964 To accompany Record 1964/127

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A show of oil and gas was obtained from a calcareous, argillaceous and bituminous dolomite between 2952 and 2975 feet. A drill stem test carried out over this interval recovered 22 cu. ft. of gas cut mud at 61 lbs/cu.ft; salinity 800 p.p.m. NaCl. (see Appendix 10 to this report). Tests were also carried out on unwashed cuttings, core and mud samples from this interval (see Appendices 8,9, and 11 to this report). From the unwashed cuttings, an extraction with toluene produced 0.31% by weight of oil. A sample of mud taken during the drilling of the interval 2952-2960 feet yielded about 1.5% by weight of a black, highly mobile fraction with a strong naphthenic odour.

During air-drilling operations from surface to 352 feet, the supplies from the various aquifers were measured by air-lifting the water. Fresh water was first encountered at 85 feet but the supply was too small to be measured. A supply of 900 gallons per hour was obtained from dolomite at 242 feet. The main aquifer is in a quartz sandstone between 325 and 340 feet, which provided an additional 1600 gallons per hour.

INTRODUCTION

B.M.R. No.13 is situated 190 miles north-east of Alice Springs, Northern Territory and 4 miles east of the turnoff to Ooratippra Homestead on the Alice Springs-Lake Nash-Queensland road, in the south-east of the Elkedra 1:250,000 Sheet area. It is the second of three stratigraphic wells drilled by the Bureau of Mineral Resources in the Georgina Basin.

The objectives of B.M.R. No.13 were -

1. to determine the stratigraphic sequence beneath sand cover;
2. to determine the depth to and nature of economic basement;
3. to gain information on the permeability and porosity of the rocks penetrated in the well;
4. to gain information on the underground water and oil potential of the area, and
5. to provide basic information for aeromagnetic and seismic surveys.

A water bore was drilled to supply water for drilling and domestic purposes. A supply of 1900 gallons per hour of fresh water was obtained from a quartz sandstone between 310 and 333 feet and 200 gallons per hour from dolomite at 253 feet.

The contractor's Failing 2500 rig was used throughout the operation.

Well-Site Geologists were:
A.R. Lloyd 8/1/64 to 25/3/64
R.D. Shaw 18/3/64 to 27/5/64
R.A.H. Nichols 27/5/64 to 10/7/64.

Petroleum Technologists at the well-site were:

B.A. McKay 8/1/64 to 10/2/64
M. Bell 15/2/64 to 1/4/64
P. Duff 13/6/64 to 16/6/64 and 3/7/64 to 17/7/64.

In the lithological descriptions of the cuttings (Appendix 1) minor is taken as being $< 1\%$; and where no percentage is shown it is understood to be 100%. The dolomite is mostly calcareous to some degree but this was omitted to save repetition.

WELL HISTORY

GENERAL

Well Name and Number	B.M.R. No.13 (Sandover)
Location	Long. 136°09' 06" East Lat. 21°51' 25" South
Tenement Holder: (at time of drilling)	Smith Australian Oil Company Pty Ltd., Suite 605, 80 Richmond Street West, Toronto. Ontario. Canada.
Petroleum Tenement:	Oil Permit No.41, N.T. 7211 sq. miles. Expired 29.5.64.
Area:	Georgina Basin, N.T.
Total Depth:	Driller 3330' Schlumberger 3331'.
Date Drilling Commenced:	15th January, 1964
Date Drilling Completed:	6th July, 1964.
Date Well Abandoned:	21st July, 1964.
Date Rig Released:	21st July, 1964.
Drilling Time to T.D.:	173 days.
Elevations:	Rotary table 1063 feet a.s.l. Ground level 1055 feet a.s.l.
Status	Plugged and abandoned.
Total Cost:	Drilling £54,000 Consumables £10,665 Logging £ 4,795 £69,460

DRILLING DATA:

Drilling Contractor:	W.L. Sides & Son Pty Ltd, 9th Floor, Temple Court, 422 Collins Street, Melbourne. C.1. Victoria.		
Drilling Plant	Make and Type: Failing 2500' Holemaster		
	Rated Capacity: 4000' with 3½" drill tubing		
	Motors: 2x4/71 G.M. 110 H.P.		
Rig Mast:	Make and type: Failing 75' tubular (including 17' extension)		
	Rated capacity: 45,000 lbs. with extension to mast.		
Pumps:	Make:	Gardner-Denver	Wheatley
	Type:	FOFXO	WBD
	Size:	7¼" x 10"	5" x 10"
	Motors:	6/71 G.M.	Rig.
Compressors:	Make:	Consolidated-Pneumatic	Holman-Howden
	Type:	Reciprocating	Rotary
	Model:	C.P. 500	'Rotair 600'
	Motors:	Lincoln-Ruston	Rolls-Royce
B.O.P.:	Make: Baash-Ross		
	Size and model: 6¼ 'Autolock'		
	Working pressure: 3000 p.s.i.		
Hole Sizes:	12¼" sfc. to 42'		
	8½" 42' to 1620'		
	6¼" 1620' to 3330' (T.D.)		
Casing Strings:	Size:	9⅝"	7"
	Grade:	J-55	J-55
	Weight:	36 lbs.	20 lbs.
	Set at:	42 ft	1615 ft.
Casing Cement:	Size:	9⅝"	7"
	Sks.cmt.	14	65
	Cmt.rise: to sfc. to 1315 ft (calc)		
	Method: single stage, plug, in both cases.		
Drilling Fluid:	Sfc. to 352' : air		
	352' to T.D. : fresh water/ bentonite mud.		

Interval Drilled ft (R.T.)	Average Mud Properties					
	Weight lbs/ft³	Viscosity secs/1000c.c.	W.L. c.c.	F.C. 1/32"	pH	Sand %
352- 750	69	39	21	3	11	¾
750-1250	70	40	15	2½	10	½
1250-1750	70	36	13	2½	10	¼
1750-2250	66	37½	12	2	9	¼
2250-2750	65	37½	14	2½	9½	1
2750-3330	67½	38	13	2	8½	¾

Water Supply: From water bore drilled to supply the domestic and drilling requirements at the site.

Perforation and Shooting Record: Nil

Side-Tracked Hole: Nil

Plug Back Jobs:

1) Bottom Plug: to give seat for anchor to test interval 2950'-2990'

1st Job: with open ended drill pipe at 3330' equalized 52 sacks of construction cement mixed to 105.5 lbs/cu.ft. Located top of cement at 3216' and drilled out to hard cement at 3221'.

2nd Job: with open ended drill pipe at 3210' equalized 42 sacks of constrcution cement mixed to 105.5 lbs/cu.ft. Located top of cement at 3004' and drilled out to hard cement at 3013'.

2) Plug Above Test Zone 2950'-2990'

With open ended drill pipe at 2900' equalized 8 sacks of construction cement mixed to 105.5 lbs/cu.ft. Located top of cement at 2845'. Tested satisfactorily with full weight of string.

3) Plug at 7" casing shoe (1615')

With open ended drill pipe at 1600' mixed and equalized 8 sacks of construction cement mixed to 105.5 lbs/cu.ft. Located top of hard cement at 1569' and tested with full weight of string.

4) Top Plug 4 sacks cement placed in top of 7" casing at surface.

Squeeze Cement Jobs: Nil

Fishing Operations:

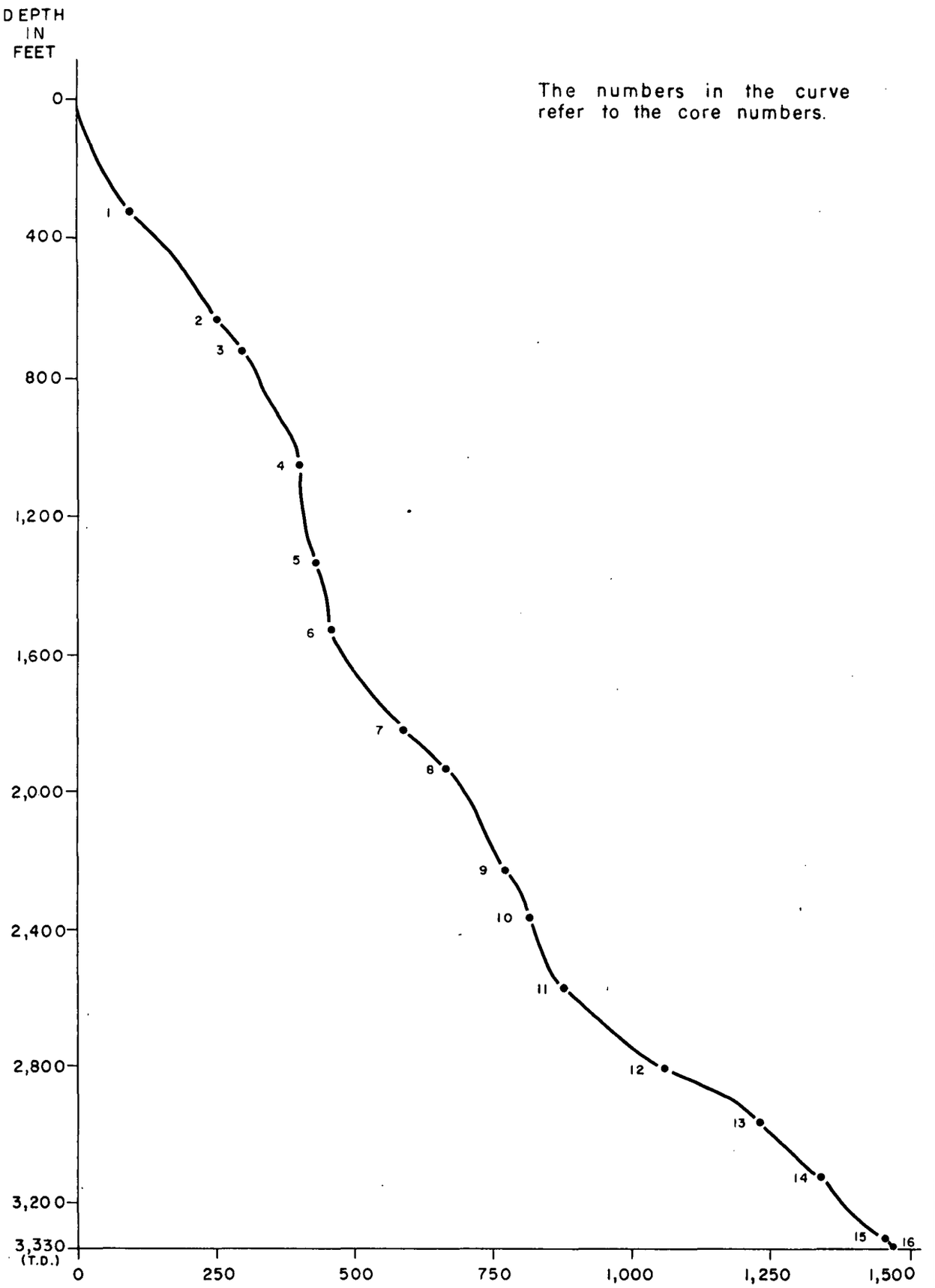
Date	Depth	Hrs.Lost	Fishing Job	Method Recovered
21.3.64	1887'	12¾	Pin failure caused 98' D.C. to be left in hole.	Fished out with tapered tap.
15.4.64	2607'	181¾	Tool jt. failure caused 188' D.C. to be left in hole.	Collars and bit recovered in stages using over-shot, diesel spot & working free. Cones recovered singly with magnet & junk-basket.
16.5.64	2639'	8¼	D.P. twist-off due to tool jt. failure.	String fished out with Baash-Ross over-shot.

Fig. 2

B.M.R. No.13 (Sandover)

DEPTH V TIME ROTATING ON BOTTOM FROM SPUDDING

after
M. Bell



TO ACCOMPANY RECORD 1964/127

Bureau of Mineral Resources, Geology and Geophysics. August 1964.

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Date	Depth	Hrs.Lost	Fishing Job	Method Recovered
20.5.64	2732'	18	Twist-off at tool jt. leaving 322' D.C. in hole.	String fished out with Baash-Ross over-shot. Cones with magnet & junk-basket.
26.5.64	2830'	8¾	D.P. twist-off at pin end of tool jt. above D.C.'s.	Fished out with Bowen over-shot.
30.5.64	2896'	30¼	D.P. twist-off at tool jt. above D.C.'s.	Fished out with Bowen over-shot; cones & bearings out with magnet.
17.6.64	3091'	17 pin.	90' of D.P. twisted off at	Recovered with over-shot.
2.7.64	3326'	72¼	Bit cones left in hole after trip out due to worn bearings & pin.	Recovered with junk-basket & core-catcher.
16.7.64	3330' (T.D.)	42¾	55½ tail pipe sheared off leaving pressure recorder & carrier in hole during D.S.T.	Fishing job unsuccessful and called off after expiry of time limit.

Time Distribution

The following is a time analysis of the drilling operations at the well. The period covers the 27 weeks from 12.01 am. 15th January to 11.59pm 21st July, 1964.

Drilling Operation	Total Hours	% of Time
Rigging Up & Down	44½	0.98
Drilling Actual	1457	32.12
Reaming	45¾	1.01
Circulate & Condition Mud	135¾	3.00
Trips & connections	324½	7.15
Lubricate Rig (service)	33½	0.74
Deviation Surveys	17½	0.39
Test B.O.P.	2	0.04
Cut & Slip Drilling Line	23½	0.52
Repair Rig	400	8.82
Coring	72½	1.59
Wire Line Logging	26	0.57
Running Casing & Cementing	31	0.68
Waiting on Cement	187½	4.13
Drill Stem Testing	15¾	0.35
Other	753	16.60
Fishing	398¼	8.78
Rig Shut Down	568¼	12.53
Totals	4536	100.00

LOGGING AND TESTING

Ditch Cuttings. Samples were collected from the shale shaker at ten foot intervals. Cuts were distributed to the Geological Branch, B.M.R., Canberra the Resident Geologist, B.M.R., Alice Springs, and a cut was collected for the tenement holder.

Coring The original programme called for routine cores to be cut at convenient bit changes to give a coring interval of about 300 feet between successive cores. This was maintained except where other cores were required by the well-site geologist for additional information.
The table below lists the 16 cores taken at the well. They were all cut with a 6" Reed K-500 barrel using HF coreheads, and all have a diameter of 2⅜".

Core No.	Depth Interval From	to	Footage	Recovery Feet	%
1	325'	345'	20	4'6"	22½
2	630'	640'	10	2'7"	26
3	717'	723½'	6½	2'5"	37
4	1050'	1060'	10	4'6"	45
5	1340'	1350'	10	7'0"	70
6	1530'	1540'	10	1'10"	18
7	1820'	1824'	4	2'8"	67
8	1932'	1938'	6	1'5"	24
9	2228'	2238'	10	9'6"	95
10	2368'	2380'	12	1'5"	12
11	2579'	2582½'	3½	2'2"	62
12	2817'	2827'	10	8'2½"	82
13	2960'	2980'	20	7½"	3
14	3117½'	3127½'	10	9½"	8
15	3305'	3310½'	5½	5'1"	92
16	3328'	3330'	2	1'1"	54

The total footage cored was 149½ and of this 55'9½", or 37% was recovered.

Side-Wall Sampling

It was the intention to take Schlumberger side-wall cores over the potentially productive interval but the caliper log showed the hole to have too large a diameter for the tool to be effective.

Well Logging

The well was logged by Schlumberger on two occasions: prior to running the 7" surface casing and after reaching total depth. All the logs are on scales of both 2" and 5" to 100', and they are summarized below.

Log Type:	Run No.	Depth Interval	Curves
Electric	1	1676' - 42'	S.P. & Resistivity
	2	3330' -1615'	S.P. & Resistivity
Microlog	1	1630' - 42'	Microcaliper
	2	3331' -1615'	Microcaliper
Sonic	1	1665' - 42'	S.P. & Sonic
	2	3326' -1614'	Gamma & Sonic
Radioactivity	1	1670' - 30'	Gamma
	2	3326' -1614'	Gamma

The sonic log was integrated on the 2nd run. No micro-resistivity curves were obtained on either run due to malfunctions in the tool.

Drilling Time and Gas Log

There was no automatic device on site to detect the presence of gas, but the minutes taken to drill every five feet were recorded by the drillers. These formed the basis of the penetration rate log on the Composite Well Log attached to this Record.

Deviation Surveys

All deviation surveys were taken with a Totco Double Recorder tool and they are listed below. The readings have been plotted on the Composite Well Log.

Depth	Drift	Depth	Drift	Depth	Drift
45'	½°	1100	¾°	1850'	1½°
95'	¾°	1200'	½°	1950	1¼°
195'	1°	1295'	1°	2050'	¾°
300'	¾°	1400'	1°	2250'	1°
395'	½°	1490'	1¼°	2400'	1°
500'	½°	1600'	1°	2550'	1¼°
590'	¾°	1635	1°	2700'	1½°
710'	1°	1670'	1½°	2850'	1¾°
790'	1°	1700'	¾°	2930'	1½°
900'	½°	1750'	¾°	3020'	1¼°
1000'	¾°	1800'	2°	3300'	¾°
				3320'	¾°

Other Well Surveys: Nil

Formation Testing:

D.S.T. No.1 Date: 15th July, 1964

Test Interval: 2950' - 2990' (R.T.)

Test by: P.G. Duff, Bureau of Mineral Resources

Witnessed by: G. Birkensleigh, W.L. Sides & Son, Pty Ltd.

The testing tools were run into the hole, the mud pressure was balanced, the packer was set, the equalizing valve was closed and the retaining valve opened. After waiting one hour for the pressure to build up, the go-devil was dropped and the disc broken; a blow to surface resulted.

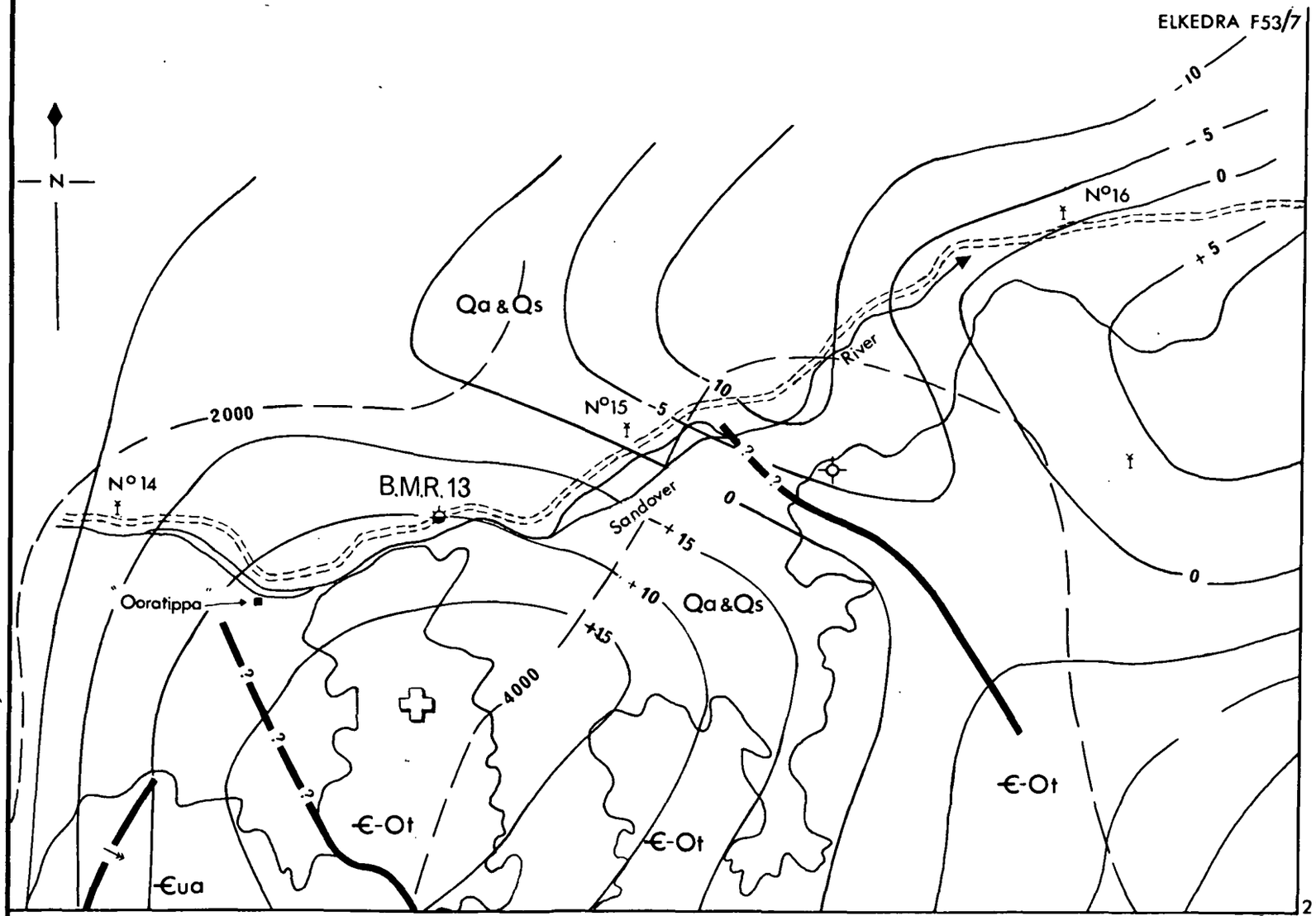
The mud level began to drop in the annulus after 8 minutes but remained steady after setting the packer with an additional 5,000 lbs weight. Six minutes later the pipe dropped 4 to 5 feet bending and fracturing the tail-pipe. This forced the end of it into the test zone cavity allowing the packer to reset. The test resumed with the level of mud in the annulus steady.

The surface blow commenced at a rate of 120 cu. ft./ /hr. and decreased to zero flow after a period of 31 minutes. Prior to pulling the packer the well was allowed to sit for an additional 30 minutes, and on pulling out it was discovered that the 1¼" Humble subsurface pressure gauge and 56 ft of 3½" line-pipe used as tail-pipe had been left in the hole.

Further details of the test may be found in Appendix 10 to this Record.

FIG 3

GRAVITY CONTOURS AND DEPTH CONTOURS ON MAGNETIC BASEMENT



REFERENCE

QUATERNARY	Qa & Qs	*Sand & soil*
UPPER CAMBRIAN / LOWER ORDDVICIAN Tomahawk Beds	€-Ot	*Dolomite sandstone siltstone*
UPPER CAMBRIAN Arrinthrunga Formation	€ua	*Dolomite Limestone siltstone and sandstone*

— 0 — Gravity contours

Geological boundary

Fault

Water Bore

Dud Bore

Location of Stratigraphic well B.M.R. 13

Positive Gravity Anomaly

—2000— Preliminary depth contours on magnetic basement
Depth in feet below sea level

Aero Magnetic Data from Wells & Milsom 1964

Gravity Data from Gravity Map G69-75-3

Scale 1:250,000

Bureau of Mineral Resources, Geology and Geophysics

To accompany Record N° 1964/127

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GEOLOGY

Summary of previous work

Geological The Elkedra and all surrounding 1:250,000 Sheet areas have been mapped by field parties from the Geological Branch of the Bureau of Mineral Resources. Most of this work was done during a programme of regional mapping in the Georgina Basin, but some of the work in areas of Precambrian outcrop, formed part of the Bureau's metalliferous surveys. The principal authors on the geology of the Elkedra Sheet area are Öpik (1956), Smith, Stewart & Smith (1961), and Smith & Milligan (1963); others are listed in the References.

In 1962 the Bureau augmented its knowledge of the Georgina Basin by coring 19 shallow wells, of which four were situated in the Elkedra Sheet area and four inthe Huckitta Sheet area (Milligan 1963). Additional subsurface information was obtained in Farmout-Place Ammaroo Nos. 1 and 2 wells, both in the Elkedra Sheet area.

Geophysical The Geophysical Branch of the Bureau conducted a gravity survey of the Elkedra Sheet area in 1960 (Map G69-75-3) and an aeromagnetic survey in 1963 (Wells & Milsom, 1964). The gravity contours and preliminary depth contours on magnetic basement in the vicinity of B.M.R. 13 are shown on Figure 3.

Summary of regional geology

The regional geology of the south-west part of the Georgina Basin is shown on the Geological Map of this area enclosed with this Report. Precambrian basement rocks crop out on the north-western and southern margins of this part of the Basin, and a thick sequence of Upper Proterozoic, Cambrian, Ordovician and Devonian sediments in the south is separated by a cover of Quaternary sand from a thin Cambrian sequence in the north. The following tables (summarised from Smith, Stewart & Smith (1961), Smith & Milligan (1963); and Smith (1964a) show the Precambrian and Palaeozoic stratigraphy in each of the Huckitta and Elkedra 1:250,000 Sheet areas.

(a) Huckitta Sheet area

Age	Map Symbol	Rock Unit	Max. Thickness (feet)	Lithology	Stratigraphic Relationship
Upper-Devonian	Dud	Dulcie Sandstone	2300	Quartz sandstone with pebble bands.	Disconformable on Nora Formation and Tomahawk Beds
Middle Ordovician	Omn	Nora Formation	400	Siltstone, Dolomite	
Lower Ordovician - Upper Cambrian	€-Ot	Tomahawk Beds	650	Dolomite, siltstone, limestone, quartz sandstone.	Disconformable on Arrinthrunga Formation.
Upper Cambrian	€ua	Arrinthrunga Formation	3500	Dolomite, limestone, oolite limestone, siltstone, quartz sandstone	Conformable on Arthur Creek Beds
Upper Cambrian	€ua(e)	Eurowie Sandstone Member	50	Quartz sandstone	Member in Arrinthrunga Formation
Middle Cambrian	€ma	Arthur Creek Beds	1000?	Limestone, siltstone, shale, sandstone, dolomite	Disconformable on Mount Baldwin Formation
Lower Cambrian	€lb	Mount Baldwin Formation	1300?	Quartz, sandstone, siltstone, greywacke, dolomite	Conformable on Grant Bluff Formation
Upper Proterozoic	Bug	Grant Bluff Formation	525	Quartz, sandstone, siltstone, dolomite	Conformable on Elyuah Formation
Upper Proterozoic	Bue	Elyuah Formation	300-3500	Siltstone, arkose	Disconformable on Mount Cornish Formation
Upper Proterozoic	Buc	Mount Cornish Formation	40-	Siltstone, boulder beds	Unconformable on Lower Proterozoic and on ?Archaean metamorphic rocks
Lower Proterozoic				Granite	Intrudes Arunta Complex
?Archaean	Aa	Arunta Complex	?	Gneiss, schist metaquartzite amphibolite	Crystalline basement

(b) Elkedra Sheet area (excluding Devonian, Cambro-Ordovician and Upper Cambrian units which are mappable continuations of formations exposed in the northern part of the Huckitta Sheet area).

Upper Cua Cambrian	Arrinthrunga Formation	300	Dolomite, siltstone, quartz sandstone	Contact with Sandover Beds not exposed.
Middle Cms Cambrian	Sandover Beds	800?	Limestone, shale, siltstone, quartz sandstone, pebble conglomerate	Unconformable on Hatches Creek Group
Lower P Proterozoic			granite	Intrudes Hatches Creek Group
Lower P Proterozoic	Hatches Creek Group	20,000	Quartz sandstone, greywacke, shale, siltstone, acid lavas	Underlying rocks not exposed

The Arrinthrunga Formation was divided into four broad units in the eastern and north-eastern part of the Huckitta Sheet area (Smith, 1964a). These are, in descending order:

Unit 4 Hard, brown dolomite; thin quartz sandstone; brown dolomite grading laterally to quartz sandstone; green siltstone; soft, buff, fine-grained dolomite.

Unit 3 Quartz sandstone with ripple-marks and halite pseudomorphs - the Eurowie Sandstone Member.

Unit 2 Blue oolitic limestone; blue algal limestone; thin quartz sandstone; numerous concealed beds (blue-grey siltstone has been obtained from water bores in this unit).

Unit 1 Hard brown and yellow dolomite with chert nodules; thin quartz sandstone.

Two core holes, B.M.R. Grg 7 and 8 were drilled in the Arrinthrunga Formation by the Bureau of Mineral Resources (Milligan 1963, p.10).

Grg 7 penetrated the following sequence:

6 - 465 feet	limestone and siltstone
465 - 520 feet	aphanitic dolomite
520 - 755 feet	aphanitic dolomite with dolarenite and pebbly dolomite.

Grg 8 penetrated the following sequence :

12 - 88 feet	limestone and calcilutite and siltstone
88 - 295 feet	limestone and siltstone with calcarenite, sandy, oolitic, pink and grey.

Milligan considered that Grg 7 spudded in Unit (2) and penetrated Unit (1) of the Arrinthrunga Formation at 465 feet; and that Grg 8 penetrated a part of Unit (2) stratigraphically above that in Grg 7.

Three shallow wells were cored to the north of B.M.R. No.13 in the Elkedra Sheet area, of which Grg 4 penetrated

the following sequence (Milligan 1963, p.21).

0 - 420 feet	pellet dolarenite and dololutite
420 - 590 feet	pellet calcarenite and dolarenite
590 - 620 feet	chiefly aphanitic limestone
620 - 739 feet	chiefly aphanitic dolomite.

Milligan (1963) states "The top 600 feet of section penetrated in Grg 4 reveals a number of lithologic similarities to unit (2) of the Arrinthrunga Formation".

The Farmout-Place Ammaroo No.1 and 2 Wells penetrated sequences in the Sandover Beds consisting of grey argillaceous limestone with chert and fossil fragments; black bituminous limestone and shale with fossil fragments; grey dolomitic shale, white sandstone or quartz siltstone and quartzite. Ammaroo No.1 penetrated chloritic mica schist and Ammaroo No.2 penetrated granite basement (Farmout Drillers N.L. 1963) Farmout Drillers N.L. considered the basement rocks belong to the Hatches Creek Group. Garnets were recorded in the schist from Ammaroo No.1, which indicate a higher degree of metamorphism than has been found in the Hatches Creek Group. It is possible that the schist does not belong to the Hatches Creek Group but to the ?Archaean Arunta Complex which crops out to the south in the Harts Range area. The granite in Ammaroo No2 may be Lower Proterozoic in age.

Casey and Gilbert-Tomlinson (1956, p.66) recorded three fossil horizons in the Arthur Creek Beds - (a) Dinesus - Xystridura; (b) Ptychagnostus atavus and (c) Leiopyge laevigata which are lower, middle and upper Middle Cambrian respectively.

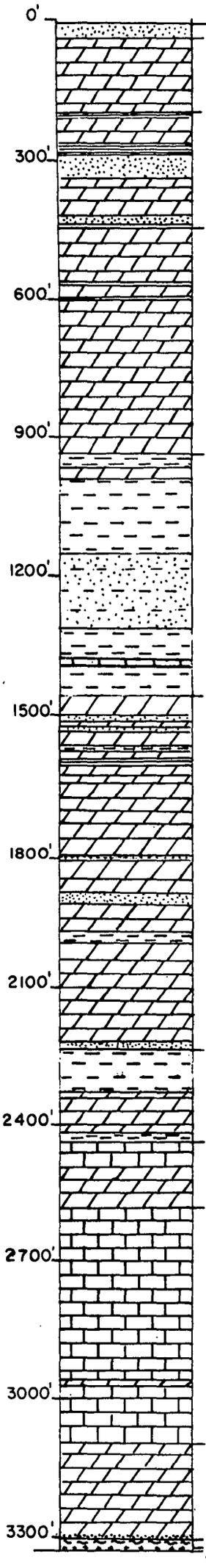
Opik (1956, p.43) recorded a list of trilobites from the Sandover Beds. It included species of Xystridura and numerous agnostids which indicate a lower Middle Cambrian age.

Gilbert-Tomlinson (1963) records a number of fossils collected from outcrops in the vicinity of Ammaroo Wells Nos. 1 and 2. They include Pagetia sp. and Xystridura sp. She concludes that this fauna is characteristic of the Sandover Beds and the lower part of the Arthur Creek Beds and that the age is early (but not earliest) Middle Cambrian (Xystridura time).

Tectonics Smith (1964) recorded that the strongest Palaeozoic orogeny in the south-western part of the Georgina Basin occurred in post Upper Devonian time. It was severe in the southern part of the Huckitta Sheet area but its effects were much milder to the north and north-west where the Sandover Beds are not folded and are only very weakly faulted.

STRATIGRAPHIC COLUMN for BMR Nº 13 (Sandover)

FIG 4



UNIT 1
UNIT 2
UNIT 3
UNIT 4
UNIT 5
UNIT 6
UNIT 7
UNIT 8
UNIT 9
UNIT 10 ? MT. BALDWIN FORMATION
UNIT 11 ? ARUNTA COMPLEX
UNIT 12

ARRINTHRUNGA FORMATION

ARTHUR CREEK BEDS EQUIVALENT

QUATERNARY

UPPER CAMBRIAN

MIDDLE CAMBRIAN

? LOWER CAMBRIAN

? ARCHAEAN

Bureau of Mineral Resources Geology and Geophysics — To accompany Record Nº 1964/127 — F53/A7/3

Stratigraphy

Section Penetrated (R.T. 1063')

Unit No.	Lithology	Depth (feet) (R.T.)	Depth (feet) M.S.L.	Thickness (feet)	Age	Formation
1	Quartz sand	8	+1055	32	Quaternary	
2	Dolomite	40	+1023	163+	UPPER CAMBRIAN	ARRINTHRUNGA
3	Dolomite, Shale and Quartz Sandstone	203	+ 860	248		
4	Dolomite and Shale	451	+ 612	489		
5	Siltstone, Quartz, Sandstone, Dolomite, and Limestone	940	+ 123	524		
6	Dolomite, Quartz Sandstone Shale and Siltstone	1464	- 401	771		
7	Siltstone and Dolomite	2235	-1172	203	MIDDLE CAMBRIAN	ARTHUR CREEK
8	Dolomite and Limestone	2438	-1375	144		
9	Limestone	2582	-1519	515		
10	Dolomite and Quartz Sandstone	3097	-2034	207	?Lower Cambrian	?Mt. Baldwin
11	Gneiss	3304	-2241	24	?Archaean	?Arunta Complex
12	Granite	3328	-2265	2+	?	
T.D.		3330	-2267			

Quaternary

Unit 1 Surface to 40 feet (32 feet)

Lithology: Quartz sand; 100%, red and brown, fine to medium-grained, rare coarse-grained, rounded to sub-rounded; rare chert.

Arrinthrunga Formation

Unit 2 40 to 203 feet (163+ feet)

Lithology: Dolomite; 98%, light brown with rare green-brown, red-brown, grey-brown, yellow and medium grey, microcrystalline, hard.

Claystone; 1%, yellow-green, soft.

Chert: 1% green, aphanitic.

Unit 3 203 to 451 feet (248 feet)

Lithology: Dolomite: 40%, light grey, medium grey, white, green-grey and light brown, microcrystalline, hard; quartz sand in parts; rare vughs, rare pyrite.

Shale: 30%, light to medium-grey, green grey, dark green, purple and red-brown, moderately hard, slightly calcareous, grading into a Siltstone in parts; interbedded with dolomite above.

Quartz Sandstone: 28%, white, rare pink and yellow, fine-grained, medium to coarse-grained in parts, well-sorted, rounded to subrounded, porous, friable, some calcareous cement.

Claystone: 1% yellow-green, soft.

Chert: 1%, green aphanitic.

Unit 4 451 to 940 feet (489 feet)

Lithology: Dolomite: 90%, white, light, medium and dark grey, light green, green-grey, light brown, creamy and brown-grey, microcrystalline, medium and coarsely-crystalline in parts; sandy, silty and argillaceous in parts; rare dolomite and calcite euhedra.

Shale: 10%, medium to dark grey, black, green-grey, red-brown, moderately hard, soft in parts; slightly calcareous; rare mica and quartz, grading into a siltstone in parts; present as thin interbeds in the dolomite.

Unit 5 940 to 1464 feet (524 feet)

Lithology: Siltstone: 50%, light brown, light to medium grey, red, brown, white, pink and green-grey, calcareous, quartz abundant to rare in parts; rare parts sandy; soft, becoming hard in parts; rare vughs; mica, pyrite and ?glauconitic in parts; some red limonite staining.

Quartz Sandstone: 25%, white, light grey, minor pink, green, fine-grained, coarse-grained in parts, rounded to subrounded, well-sorted, some calcareous and dolomitic cement, porous, friable; rare pyrite, mica and glauconite; grading into a sandy dolomite in parts.

Dolomite: 15%, medium and light grey, white, light green, green-grey and pink, microcrystalline, rarely medium to coarsely-crystalline, saccharoidal, hard, rarely soft; some quartz sand, pyrite and ?glauconite; rare euhedral rhombs.

Shale: 5%, medium to dark grey, black and green-grey, moderately soft to hard; slightly calcareous; rare pyrite.

Limestone: 5%, pale pink to white, light grey and light green, microcrystalline, hard, rarely soft; rare pyrite and quartz sand.

Unit 6 1464 to 2235 feet (771 feet)

Lithology: Dolomite: 85%, light brown, pink, white, light grey, dark grey to black, grey-brown and green, finely-crystalline, rarely microcrystalline, and medium to coarsely-crystalline, saccharoidal, hard; rare quartz silt and sand; rare pyrite and ?bitumen; small vughs in parts; rare calcite euhedra.

Quartz Sandstone: 13%, light grey, white and brown, fine-grained, rarely medium and coarse-grained, rounded, well-sorted, some dolomitic cement; rare pyrite and mica; rare chert pebbles.

Shale: 1%, black, dark grey, medium grey and dark green, soft; rare mica and quartz silt.

Siltstone: 1%, green-grey, white, pink, green and black, soft, rarely hard; rare pyrite and mica; some quartz in parts.

Chert: <1%, light brown, pink, green and white, aphanitic.

Arthur Creek Beds [redacted]

Unit 7 2235-2438 feet (203 feet)

Lithology: Siltstone: 50%, medium and light grey, brown, dolomitic, grading into a silty dolomite in parts; mica, quartz and ?magnetite in parts, grading into a fine-grained sandstone; massive with thin laminations of clayey material; rare vughs with euhedral rhombs; hard.

Dolomite: 50%, light grey, light brown and grey-brown, rare white, finely-crystalline to microcrystalline, hard, silty in parts, grading into a dolomitic siltstone; rare stylolites; saccharoidal in parts; rare ?bitumen.

Unit 8 2438-2582 feet (144 feet)

Lithology: Dolomite: 65%, white, light brown, light grey and grey-brown microcrystalline, rarely finely-crystalline and saccharoidal, hard; rare quartz silt and pyrite; rare vughs with euhedral rhombs; rare ?bitumen.

Limestone: 34%, white, pale brown, grey-brown, medium to finely-crystalline, rarely microcrystalline, soft to moderately hard, speckled with coarse blacks flecks; rare fossils - brachiopods sponge spicules.

Siltstone: 1%, black, grey, fine laminae.

Unit 9 2582-3097 feet (515 feet)

Lithology: Limestone: 95%, grey-brown, medium and dark grey, pale grey, microcrystalline, rarely finely-crystalline, hard, relatively soft in parts; quartz silt, argillaceous and carbonaceous in parts, sometimes grading into a calcareous siltstone;

speckled with black flecks, laminated friable and platey in parts; rare white chalcedony; rare calcite euhedra and veins; fossiliferous with trilobites and brachiopods.

Siltstone: 2%, dark grey, grey-brown, rare light grey and black, calcareous, carbonaceous, argillaceous and quartzose, hard; finely disseminated pyrite in parts; sometimes fissile; grading into a fine-grained quartz sandstone in parts; rare calcite euhedra and veins; present as fine laminae in the limestone.

Shale: 2%, dark grey-black, argillaceous, carbonaceous (?bituminous), calcareous, hard; forms thin laminae (0.5 mm) between limestone bands (1.00 mm).

Dolomite: 1%, brown and dark grey, microcrystalline, soft; bituminous, porous, calcareous and argillaceous; laminated, fissile; pale green fluorescence, amber-yellow globules of oil.

Unit 10 3097-3304 feet (207 feet)

Lithology: Dolomite: 90%, white, light grey, light brown, dark grey to black, blue grey, microcrystalline to medium-crystalline, hard, mainly tight, 5% porosity in parts; slightly calcareous; rare glauconite, pyrite and carbonaceous flakes; quartz silt in parts, grains angular to subangular; rare vughs with rhombic euhedra; rare fossils; rare chert.

Quartz Sandstone: 5%, light to medium brown, white, rare red and grey, mottled white and red-brown, fine to medium-grained, angular to subangular; some scattered medium to coarse-grained, subrounded; average to well-sorted, hard; no porosity; rare mica and pink-orange ?feldspar; slightly calcareous, ferruginous, ?clay matrix.

Shale: 5%, interpreted from E-log.

Arunta Complex

Unit 11 3304-3328 feet (24+ feet)

Lithology: Gneiss: pink well-rounded, fine bands of light and dark material; quartz, microcline, biotite, altered sericitic and chloritic material, carbonate, ?plagioclase, muscovite and scapolite; veins of carbonate and scapolite medium-crystalline, rarely coarsely-crystalline.

Unit 12 3328-3330 feet (2+ feet)

Granite: orange and white mottled, coarsely-crystalline, quartz and feldspar with rare muscovite, biotite, ?phlogopite and ?haematite; green talc or chlorite along oblique fractures.

REASONS FOR DISTINGUISHING THE UNITS 1-12

The twelve units into which the succession has been divided are purely lithological. The fossil evidence is meagre but does give some control, indicating definite lower Middle Cambrian strata between 2710 and 2927 feet.

CORRELATION

The well entered Unit (2) of the Arrinthrunga Formation of Smith, Vine & Milligan (1961b) at 40 feet and penetrated Unit (1) of this formation at about 1480 feet. There is no palaeontological control over the lower boundary and it is placed tentatively at 2235 feet, based on lithological similarities with the basal unit of the Arrinthrunga Formation.

The sequence from 40 to 451 feet in the well is lithologically similar to the carbonate sequence which crops out in a ridge running north-east to Annitowa Homestead from a point 12 miles north of B.M.R. 13. This outcrop sequence, mapped as ?Arrinthrunga Formation by Smith and Milligan (1963, p.9) can now be placed confidently in Unit (2) of the Arrinthrunga Formation.

The sequence between 2235 and 2097 feet is regarded as the lateral equivalent of the Arthur Creek Beds. The boundaries are defined purely on lithology, as there is no palaeontological control, however, early Middle Cambrian fossils were found within the interval.

Gatehouse (Appendix 5 to this report) recorded a fragmentary brachiopod at 2574-2579 feet which Dr Öpik believes is almost certainly Middle Cambrian in age. He recorded the trilobite Pagetia sp. from 2750 to 2800 feet; Pagetia significans alone at 2800-2810 feet and in association with Xystridura sp. in Core 12 (2817-2827 feet). This permits a correlation with the basal unit of the Arthur Creek Beds and the Sandover Beds which are lower Middle Cambrian in age.

Gatehouse concluded that the stratigraphic position of the interval 2750-2830 feet is not conclusive because the specific identity of the Xystridura is not determinable. However, in a personal communication from Dr Öpik, he states that "in the Sandover Beds, Xystridura sp. and Pagetia significans are associated with agnostid trilobites which indicate an age about Ptychagnostus gibbus Zone of the Middle Cambrian for these beds. The fossiliferous horizons between 2710-2827 feet are considered to be high in the lower Middle Cambrian."

Unit 10 (3097-3304 feet) is defined purely on lithology. The fragmentary brachiopods at 3220-3230 feet indicate a Lower or Middle Cambrian age (A.A. Öpik pers.comm.). The age of Unit 10 is therefore possible Middle or possible Lower Cambrian. It may be lowermost Middle Cambrian because the fossiliferous horizon at 2827 feet is thought to be high in the Lower Middle Cambrian, leaving considerable time for more Middle Cambrian, below this depth. K.G. Smith (pers.comm.). considers the lithologies of Unit 10 to be similar to the lithologies of the Mount Baldwin Formation which is mapped as Lower Cambrian on the Huckitta Sheet area. In this deeper part of the basin, Lower Cambrian sediments could quite conceivably be present but on the other hand there could be thickening of the Middle Cambrian sequence and Unit 10 could belong to the lowermost Middle Cambrian. On Figure 4 and the Composite Well Log this unit is shown as ?Lower Cambrian.

The basement gneiss (3304-3328 feet) is similar to the gneiss of the Arunta Complex to the south of B.M.R. 13 (Joklik 1955; Smith 1964a) and is of a much higher degree of metamorphism than that found in the Lower Proterozoic Hatches Creek Group. It is therefore considered to be ?Archaean in age.

If the granite (3328-3330 feet) intrudes the gneiss, the relationship may be the same as that in the southern part of the Huckitta Sheet area where Lower Proterozoic granite intrudes the Arunta Complex. However, the exact relationship of the granite and gneiss could not be ascertained in the well and the age is in doubt.

Structure

B.M.R. No.13 was not sited on a surface structural feature, although it is sited close to a positive gravity anomaly. Dip measurements from the cores showed the bedding was horizontal or sub-horizontal throughout the Cambrian sequence. There was no evidence of faulting in the well.

Porosity and permeability of sediments penetrated

The porosity of the carbonate is variable; the porous horizons are vughy, fractured or cavernous and in some instances, intergranular porosity was noted. The sandstones are mainly porous and near the top of the well, they constitute the main aquifer. The strongly cemented dolomitic and calcareous sandstones are impermeable.

Hydrology

Information on the hydrology of the region gathered from the numerous water bores is set out in the various reports by K.G. Smith and co-workers.

In B.M.R. No.13, the first water was struck at 85 feet but the supply was too small to measure. A supply of 900 gallons per hour was measured at 242 feet from dolomite. The main aquifer is in quartz sandstone at 325-340 feet which provided an additional 1600 gallons per hour. The well was making considerable water around 1680 feet but the supply was not measured. The standing water level was measured at 85 feet.

In the water bore drilled to supply the drilling needs for B.M.R. No.13 a supply of 200 gallons per hour was obtained at 253 feet in dolomite and 1900 gallons per hour from quartz sandstone at 310-330 feet. An analysis of a water sample from this bore showed it to be good fresh water suitable for domestic purposes (see Appendix 7 to this Report).

Hydrocarbons

Small quanities of a bituminous material were observed in the cuttings from various depths between 1210 feet and 2570 feet. An analysis of some of this material may be found in Appendix 9 to this Report.

A show of gas and oil was obtained from a soft calcareous, argillaceous and bituminous dolomite between 2952 and 2975 feet. The penetration rate increased considerably in this interval. The dolomite effervesced and contained amber-yellow globules of oil which gave a strong pale green fluorescence. The mud contained small globules of oil and gave off minute bubbles of gas.

A drill stem test was carried out by P.G. Duff and laboratory tests were carried out in the Petroleum Technology Laboratory of the Bureau of Mineral Resources on mud samples and core and cuttings from this interval (see Appendices 8,9, 10 and 11 to this Report).

Previous reports of hydrocarbons in the Middle Cambrian strata of this region were made by Mackay and Jones (1956); Milligan (1963, p.11) and Farmout Drillers N.L. (1963).

Significant Results from B.M.R. No.13

(a) The presence of a crystalline basement rock of ?Archaean age was established. It is about 800 feet shallower than the interpretation of 3000 feet below sea level of magnetic basement by Wells & Milsom (1964 p.9) and also shows that the

south-east trending Hatches Creek Group does not extend from the Davenport Range to B.M.R. No.13.

(b) Upper Proterozoic sediments are not present beneath the Middle Cambrian strata.

(c) Lower Cambrian sediments may be present.

(d) The presence of Middle Cambrian sediments is proven beneath the Arrinthrunga Formation which lies beneath the sand covered areas.

(e) On lithological grounds, a good correlation is possible between the Upper Cambrian Arrinthrunga Formation in the well and the carbonate sequence which crops out 12 miles north of the well at the south-west extremity of a ridge trending north-east to Annitowa Homestead (Smith and Milligan 1963 p.9). This outcropping sequence, previously mapped as ?Arrinthrunga Formation, can now be placed confidently in the Arrinthrunga Formation.

(f) The Tomahawk beds which crop out to the south of the well site and the top two units of the Arrinthrunga Formation are not present in the well. They may have been removed by erosion. K.G. Smith (pers.comm.) has suggested that the Tomahawk Beds transgressed over an eroded surface of the Arrinthrunga Formation in the vicinity of B.M.R. No.13. This would confirm a similar stratigraphic relationship suspected in Lucy Creek Homestead area (Smith, Vine & Milligan, 1961).

(g) The presence of gas and oil in the Middle Cambrian strata.

(h) The presence of good supplies of fresh water in quartz sandstone and dolomite aquifers in the Arrinthrunga Formation in this area.

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APPENDIX 1

Sample Descriptions - B.M.R. 13

Feet	
0-10	Quartz Sand, red, fine and medium grained, rounded to sub-rounded; minor red and yellow, coarse grained, rounded to subangular, frosted.
10-20	As above, grading to brown at base, rare Chert pebbles, yellow.
20-30	As above with rare chert chips; grading to brown at base.
30-40	Quartz Sand, brown, medium grained, minor coarse grained, rounded to subrounded; rare mica.
40-50	Dolomite, light brown, green-brown, microcrystalline, hard; rare dendritic manganese.
50-60	Dolomite, as above.
60-70	Dolomite, light brown, red-brown, blue-grey, microcrystalline, hard.
70-80	Dolomite, light brown, red-brown, grey-brown, microcrystalline, hard.
80-90	Dolomite, light brown, microcrystalline, hard.
90-100	Dolomite, as above. Minor Chert, green. Minor Claystone, green, soft.
100-110	Dolomite, as above. Minor Chert, light green.
110-120	Dolomite as above. Minor Chert, light green.
120-130	Dolomite, light brown, yellow-brown, microcrystalline, hard; rare dendritic manganese. Minor Chert, light green.
130-140	Dolomite light brown, yellow-brown, microcrystalline, saccharoidal texture in parts, hard, vughy. Minor Shale, green, slightly calcareous, hard. Minor Chert, green.
140-150	Dolomite, brown to yellow-brown, microcrystalline, hard. Minor Chert, green.
150-160	Dolomite, light brown, microcrystalline, hard.
160-170	Dolomite as above. [illegible] Minor Claystone, yellow-green, soft. Minor Chert, green.
170-180	Dolomite, light brown, medium grey, microcrystalline, hard; rare dendritic manganese.
180-190	Dolomite as above. Minor Claystone, medium grey, calcareous, soft.
190-200	95% Dolomite, medium grey, light brown, microcrystalline, oolitic and argillaceous in parts, hard. 5% Shale, medium grey, slightly calcareous, hard. Minor Chert, light green, dendritic manganese.

200-210 — 80% Dolomite, medium grey to green-grey, light brown, microcrystalline, hard; argillaceous impurities in parts; rare quartz grains, rounded.
20% Shale, medium grey to green-grey, slightly calcareous, moderately hard.

210-220 — Dolomite, light to medium grey, light brown, microcrystalline, hard.

220-230 — Dolomite, light brown, medium grey, microcrystalline, hard, vughy.
Minor Shale, medium grey, calcareous, moderately hard.

230-240 — Dolomite as between 220-230 feet.
Minor Claystone, yellow, soft.

240-250 — 80% Dolomite, light brown to dark brown, green and white, microcrystalline, hard, vughy.
20% Shale, dark grey, green, calcareous, moderately hard.

250-260 — 50% Shale, dark grey to green-grey, calcareous, hard.
50% Sandy Dolomite, light brown and light grey, microcrystalline, sugary texture in parts, hard; 25% quartz grains, rounded, scattered.

260-270 — 80% Shale, red-brown, light grey, calcareous, ferruginous, rare manganese, hard.
20% Dolomite grey-brown and light grey, microcrystalline, hard.

270-280 — 50% Dolomite, white, microcrystalline, hard.
50% Shale, dark grey, red-brown and green-grey, calcareous, ferruginous, hard.

280-290 — 90% Shale as between 270-280 feet.
10% Dolomite as between 270-280 feet with minor light brown .

290-300 — 70% Quartz Sandstone, white, fine grained, rounded, well sorted, friable, porous, some dolomitic cement.
25% Dolomite, white to pinkish-grey, light brown, microcrystalline, hard.
5% Shale dark grey and green-grey, slightly calcareous, moderatly hard.

60% Quartz Sandstone as between 290-300 feet.
40% Shale green and red-brown, ferruginous, moderately hard.
Minor Dolomite, light brown, microcrystalline, hard.

310-320 — Shale, green, to green-grey and red-brown as above.
Minor Quartz Sandstone as between 290-300 feet.
Minor Dolomite as above.

320-330 — 90% Quartz Sandstone, white, fine to medium-grained, rounded to subrounded, well sorted, porous, friable, some dolomite cement.
10% Shale, green-grey, light grey and red-brown as between 300-310 feet.

330-335 — Quartz Sandstone, white, yellow and pink, as above, moderately hard.
Minor Shale as between 320-330 feet.

Feet	
335-340	80% Quartz Sandstone as above. 10% Chert, white. 10% Dolomite, medium grey and green-grey, microcrystalline, hard. Minor Shale, medium grey, green-grey and red-brown, ferruginous, moderately hard.
340-345	90% Shale, red-brown, medium grey, green-grey as between 335-340 feet. 10% Dolomite white, light grey and light brown, microcrystalline, hard.
345-350	60% Shale light grey, green-grey and purple, slightly calcareous, ferruginous, moderately hard. 40% Dolomite, white and light grey, microcrystalline, hard.
350-360	80% Dolomite, white as above. 10% Quartz Sandstone, white and medium grey, fine-grained, rounded to subrounded, well sorted, friable, porous, some dolomite cement. 10% Shale, purple and medium to light grey, slightly calcareous and moderately hard.
360-370	70% Dolomite as above. 30% Quartz Sandstone as above.
370-380	90% Dolomite, white, light grey, microcrystalline, hard. 10% Shale, red-brown, slightly calcareous, ferruginous, moderately hard. Minor Quartz Sandstone as between 350-360 feet.
380-390	40% Quartz Sandstone, white and light grey, fine grained, rounded, well sorted, friable, porous, some dolomite cement. 60% Shale, grey, slightly calcareous, moderately hard; rare mica. Minor Dolomite as between 370-380 feet.
390-400	100% Dolomite, white and green-grey, microcrystalline, hard. Minor Quartz Sandstone as between 380-390 feet.
400-410	95% Dolomite, white to light grey, microcrystalline, hard, with 5% quartz grains, sand size, rounded, scattered. 5% Quartz Sandstone as between 380-390 feet. Minor Shale, grey, moderately hard. Minor Calcite, white.
410-420	50% Dolomite, white to light grey, microcrystalline, hard. 50% Shale, medium grey to green-grey, calcareous, moderately hard. Minor Quartz Sandstone white, otherwise as between 380-390 feet.
420-430	50% Quartz Sandstone as between 410-420 feet 25% Dolomite, brown-grey and light grey, microcrystalline, hard. 25% Shale, brown-grey and medium grey, otherwise as between 410-420 feet.
430-440	80% Quartz Sandstone as between 410-420 feet 15% Dolomite as between 420-430 feet 5% Shale, brown-grey and blue grey, otherwise as between 420-430 feet.

440-450	20% Quartz Sandstone as between 410-420 feet. 40% Dolomite, light brown and light to medium grey, microcrystalline, hard. 40% Shale, medium grey, strongly calcareous, moderately hard. Trace Calcite, white and pyrited.
450-460	90% Dolomite, white, light grey and medium grey, microcrystalline, pelletal, oolitic, hard. 10% Shale, green-grey to dark grey, otherwise as between 440-450 feet.
460-470	95% Dolomite dark grey and white to light grey, microcrystalline, oolitic, pelletal, hard. 5% Shale, dark grey, otherwise as between 440-450 feet.
470-480	80% Dolomite, white to light grey, medium and dark grey, microcrystalline, oolitic, hard. 20% Shale,dark grey, calcareous, moderately hard; rare mica.
480-490	Dolomite, white to light grey, medium grey, microcrystalline, hard, oolitic; rare glauconite, rare quartz grains, sand size. Minor Shale, black, slightly calcareous, hard.
490-500	Dolomite, medium grey, microcrystalline, hard; rare oolites, rare glauconite. Minor Shale, dark grey to black, otherwise as between 480-490 feet.
500-510	Dolomite, light and medium grey, otherwise as between 480-490 feet.
510-520	Dolomite, creamy, light and medium grey, green-grey, microcrystalline, hard; rare glauconite, oolitic and pelletal. Minor Shale as between 480-490 feet.
520-530	80% Dolomite, medium to dark grey,green-grey, cream and light grey, microcrystalline, hard;rare glauconite and quartz grains, rounded, scattered. 20% Shale, dark grey, calcareous, moderately hard.
530-540	95% Dolomite, medium and light grey, green-grey, microcrystalline, hard; rare glauconite. 5% Shale as between 520-530 feet.
540-550	95% Dolomite as above. 5% Shale as between 520-530 feet.
550-560	Dolomite, white to light grey, medium and dark grey,green-grey, microcrystalline, hard, rare glauconite and quartz grains, rounded. Minor Shale as between 520-530 feet.
560-570	80% Dolomite as between 550-560 feet. 20% Shale as between 520-530 feet, with rare mica.
570-580	60% Shale, dark grey to black, otherwise as between 520-530 feet. 20% Siltstone, medium to green-grey, rare quartz and glauconite, moderately soft to soft. 20% Dolomite, light and medium grey, green-grey, white, microcrystalline, hard, rare glauconite.

580-590 Dolomite, light to medium grey, green-grey, microcrystalline to finely-crystalline, hard to moderately hard; (Rare glauconite).

Minor Shale as between 570-580 feet
Minor Siltstone as between 570-580 feet.
Minor Calcite, white.

590-600 80% Dolomite, white, microcrystalline to finely crystalline, hard to moderately hard; rare oolites, rare glauconite.
20% Siltstone as between 570-580 feet, harder in parts.
Minor Calcite, white,

600-610 80% Dolomite as between 570-580 feet, rare oolites.
20% Shale as between 570-580 feet.
Minor Siltstone as between 570-580 feet.

610-620 Limestone, dolomitic, white to light grey, green-grey, medium to coarsely-crystalline, rare microcrystalline, moderately soft with rare parts moderately hard; rare oolites, rare glauconite and quartz grains, sand size.
Minor Shale, dark grey to black, calcareous, moderately hard.
Minor Siltstone as between 570-580 feet (? caving).
Minor Calcite, pink.

620-630 80% Limestone, dolomitic, light to medium grey, microcrystalline, hard; rare glauconite.
20% Shale as between 610-620 feet.
Minor Calcite, white.

630-635 Dolomite, white, light and medium grey, green-grey, microcrystalline, hard; rare glauconite.

635-640 90% Dolomite as above.
10% Shale as between 610-620 feet.

640-650 95% Dolomite white, light grey, green-grey, medium to dark grey, microcrystalline and medium-crystalline, hard; rare glauconite, oolitic.
5% Shale as between 610-620 feet, minor red-brown, rare mica.
Minor Siltstone, white and green-grey, rare quartz and glauconite, moderately hard.

650-660 Dolomite as between 640-650 feet, rare grey-brown.
Minor Shale as between 640-650 feet.

660-670 Dolomite as between 640-650 feet, light brown and moderately soft in parts.
Minor Shale as between 640-650 feet.

670-680 Dolomite, light grey, green-grey, mottled dark grey and pink, white, microcrystalline with 5% coarsely crystalline, moderately hard; rare glauconite and quartz grains and pyrite.
Minor Shale, green and blue-grey, calcareous, moderately soft.
Minor Calcite, white, soft.

680-690 90% Dolomite medium and light grey, microcrystalline to medium-crystalline, hard; rare glauconite, rare stylolites.
10% Shale, medium to dark grey, calcareous, rare mica, moderately hard.

690-700 95% Dolomite light grey, medium grey, pale green and green-grey, medium to coarsely-crystalline, minor microcrystalline, hard, glauconitic; rare white calcite veins.
5% Shale as between 680-690 feet.

Feet	
700-710	Dolomite, light to medium grey, pink, green-grey and light green, mottled pink and grey in parts, 60% microcrystalline, 40% coarsely-crystalline, moderately hard, glauconitic, pyritic. Minor Shale, green, blue-grey, calcareous, moderately soft.
710-717	Dolomite, white to light grey, pink, green-grey, mottled in parts, 50% microcrystalline, 50% coarsely-crystalline, moderately hard to very hard, oolitic, glauconitic; rare pyrite. Minor Shale, green-grey, slightly calcareous, moderately soft.
717-722	Dolomite as between 710-717 feet. Minor Shale as between 710-717 feet. Minor Calcite, white, pink.
722-730	Dolomite, white, light grey, green-grey and light pink, microcrystalline, minor medium-crystalline, hard; oolitic, glauconitic; rare pyrite, rare quartz grains, rounded. Minor Shale, dark green, clacareous, moderately soft. Minor Calcite, white and pink.
730-740	95% Dolomite, light grey, green-grey, light green and dark grey, microcrystalline, hard; glauconitic and oolitic. 5% Shale, black, slightly calcareous, moderately hard. Minor Calcite, white and pink.
740-750	95% Dolomite light green-grey, light grey pink to pinkish brown, microcrystalline, hard; rare glauconite, oolites and pyrite. 5% Shale, black to dark grey, slightly calcareous, moderately hard.
750-760	95% Sandy Dolomite, white, light green-grey, light and medium grey, pink, microcrystalline, hard; oolitic, rare glauconite, rare pyrite; 40% quartz grains, rounded; vughy with clear euhedral Calcite crystals. 5% Shale, medium grey and green-grey, calcareous, moderately soft.
760-770	Dolomite, dark grey, white, light green-grey, light and medium grey, pink, microcrystalline, hard; 10% quartz grains, rounded, scattered; rare glauconite, rare oolites; vughy with clear euhedral Calcite crystals; rare black micaceous layers. Minor Shale as between 750-760 feet with rare mica.
770-780	Dolomite, green-grey, pink and light green, microcrystalline, minor coarsely-crystalline and sugary texture, hard; rare glauconite; oolitic; vughy with rare clear euhedral calcite crystals; rare black micaceous laminae.
780-790	Dolomite, dark grey, medium grey and dark green-grey, microcrystalline with minor coarsely-crystalline and saccharoidal, moderately hard; rare glauconite, rare pyrite; vughy with white calcite crystals and veins. Minor Shale, black, moderately hard.
790-800	Dolomite, cream, light and dark green, light grey, mottled in parts, microcrystalline, moderately hard; rare oolites and glauconite. Minor Shale, dark grey, hard and green, moderately soft.
800-810	Dolomite, white to light grey, green-grey, microcrystalline, hard; rare glauconite; rare calcite, white and pink. Minor Shale as between 790-800 feet.

Feet	
810-820	Dolomite, medium to dark grey, greenish and light grey in parts, microcrystalline, hard; rare glauconite. Minor Shale, dark grey to black, moderately hard, slightly calcareous.
820-830	Dolomite, medium and dark grey, brown-grey, microcrystalline, hard; rare glauconite. Minor Shale as between 810-820 feet.
830-840	Dolomite, light to medium grey, microcrystalline, hard; rare glauconite. Minor Shale as between 810-820 feet.
840-850	95% Dolomite, light brown, light and dark grey, light green, microcrystalline, hard; rare glauconite. 5% Shale as between 810-820 feet.
850-860	Dolomite light and dark brown, green, white, microcrystalline, hard; rare glauconite. Minor Shale, dark brown, slightly calcareous, hard; rare mica.
860-870	90% Dolomite, light brown, medium grey, green-grey, microcrystalline, hard; rare glauconite. 10% Shale dark brown, slightly calcareous, moderately hard; and green, moderately soft.
870-880	Dolomite, dark grey, light grey, light brown, microcrystalline, hard; rare glauconite, vughy with calcite crystals. Minor Shale, dark green-grey, slightly calcareous, moderately hard.
880-890	Dolomite, white to light grey, medium grey, light brown and light green, microcrystalline, hard; rare glauconite, vughy; rare white calcite veins. Minor Shale, black, otherwise as between 870-880 feet.
890-900	90% Dolomite, white to light grey, light green, dark grey and light brown, microcrystalline, saccharoidal in parts, hard, rare glauconite, rare pyrite, vughy with calcite crystals, rare reddish-yellow iron staining. 10% Shale as between 790-800 feet.
900-910	95% Dolomite, white and dark grey, otherwise as between 890-900 feet. 5% Shale as between 810-820 feet
910-920	95% Dolomite as between 890-900 feet. 5% Shale black, slightly calcareous, moderately hard and green, moderately soft.
920-930	95% Dolomite medium and light grey, white and green-grey, microcrystalline, hard, rare glauconite. 5% Shale as between 910-920 feet.
930-940	95% Dolomite light and medium grey, white, microcrystalline, hard, rare glauconite. 5% Shale medium grey, slightly calcareous, moderately hard.
940-950	60% Quartz Siltstone, light brown, strongly calcareous, soft. 40% Dolomite medium grey to brown grey, microcrystalline, hard. Minor Shale, dark grey and green-grey, calcareous, moderately hard.

Feet	
950-960	70% Dolomite, light to medium grey, light brown, then as between 940-950 feet. 30% Siltstone as between 940-950 feet.
960-970	60% Dolomite, white, light brown, light to medium grey and green-grey, microcrystalline, trace medium-crystalline, hard, vughy. 30% Shale, medium grey, green-grey and brownish-grey, slightly calcareous, moderately hard. 10% Siltstone, as between 940-950 feet, medium grey in parts.
970-980	75% Dolomite, white, light grey, green-grey, light brown, microcrystalline, rare medium-crystalline, hard; rare glauconite, rare pyrite. 25% Shale, medium grey and green-grey slightly calcareous, moderately hard. Minor Siltstone as between 940-950 feet. Minor Calcite crystals, white.
980-990	40% Siltstone as between 940-950 feet, medium grey in parts, rare glauconite, rare pyrite. 40% Shale green-grey, medium grey, slightly calcareous, rare pyrite, moderately soft. 20% Dolomite, white, light brown, medium grey, green-grey and pinkish, microcrystalline, hard; rare glauconite, rare pyrite. Minor Calcite as between 970-980 feet.
990-1000	45% Siltstone as between 980-990 feet, moderately hard. 45% Dolomite light brown, white and green-grey, then as between 980-990 feet. 10% Shale as between 980-990 feet.
1000-1010	90% Dolomite, white, light brown, light green and light grey, microcrystalline, coarsely crystalline and sugary textured in parts, moderately hard; rare glauconite, rare pyrite, vughy with calcite crystals. 10% Siltstone as between 940-950 feet but moderately hard in parts. Minor Shale, dark green-grey, slightly calcareous, soft.
1010-1020	70% Siltstone as between 1000-1010 feet, rare pyrite. 30% Dolomite, light to medium grey, green-grey, microcrystalline, coarsely-crystalline and sugary textured in parts, hard; rare pyrite, vughy with calcite crystals. Minor Shale as between 1000-1010 feet.
1020-1030	60% Siltstone as above. 40% Dolomite, light brown, then as between 1010-1020 feet.
1030-1040	90% Siltstone as above. 10% Dolomite as between 1010-1020 feet. Minor Shale as between 1010-1020 feet.
1040-1050	80% Siltstone as above. 20% Dolomite, light brown, light grey and green, then as between 1010-1020 feet. Minor Shale as between 1010-1020 feet.
1050-1055	90% Quartz Siltstone, light brown and light grey, calcareous, moderately hard; iron stained in parts. 10% Shale, dark green-grey, slightly calcareous, moderately hard; abundant finely-disseminated pyrite.

Feet	
1055-1060	70% Quartz Siltstone as above. 20% Shale as above. 10% Dolomite, light grey, coarsely-crystalline, hard; rare glauconite, rare calcite crystals.
1060-1070	90% Siltstone as between 1050-1055 feet; ? oolites in parts. 10% Shale, light grey and green, calcareous, moderately soft. Minor Calcite crystals, white and pink.
1070-1080	80% Quartz Siltstone, light grey, light brown, white and green-grey, then as between 1050-1055 feet; rare pyrite. 20% Dolomite, white, medium to coarsely-crystalline, saccharoidal, moderately hard; rare pyrite; vughy with white calcite crystals.
1080-1090	Quartz Siltstone, light brown, light grey, white and green-grey, then as between 1050-1055 feet; rare pyrite.
1090-1100	Siltstone, light brown, light to medium grey and green, slightly calcareous, moderately hard; minor quartz grains, some of sand size; rare glauconite; limonite staining in parts.
1100-1110	Siltstone as above.
1110-1120	Siltstone as above.
1120-1130	Siltstone as between 1090-1100 feet. Minor Dolomite, light grey and light green, microcrystalline, hard.
1130-1140	Siltstone, white and light green-grey, otherwise as above. Cavity between 1136-1137 feet 6 inches.
1140-1150	70% Siltstone, light grey to green grey, strongly calcareous, moderately hard; rare pyrite, rare glauconite and quartz. 30% Quartz Sandstone, white to light grey, fine grained, well sorted, rounded, friable, dolomite cement; rare glauconite, pyrite and mica; rare ?bitumen. Minor Dolomite, light grey to white, microcrystalline, hard; rare glauconite and pyrite; rare white calcite veins.
1150-1160	70% Quartz Sandstone as above. 30% Siltstone as above. Minor Dolomite as above.
1160-1170	60% Quartz Sandstone, white to light grey, fine-grained, minor coarse-grained, fairly well sorted, rounded, dolomite cement, argillaceous in parts, moderately hard; rare red-yellow limonite staining. 40% Siltstone as between 1140-1150 feet. Minor Dolomite, light grey, microcrystalline, hard.
1170-1180	50% Quartz Sandstone as above. 50% Siltstone as between 1140-1150 feet, moderately hard in parts. Minor Dolomite, light grey to white, microcrystalline, hard; vughy; rare pink and white calcite veins.
1180-1190	Dolomite, white, light grey and green-grey, microcrystalline and coarsely-crystalline, saccharoidal, hard; vughy; rare calcite crystals, white to creamy. Minor Quartz Sandstone as between 1160-1170 feet. Minor Shale, green-grey, calcareous, pyritic, moderately hard to moderately soft.

Feet	
1190-1200	45% Siltstone, red-brown, green-grey, slightly calcareous, moderately soft to moderately hard. 45% Quartz Sandstone as between 1160-1170 feet. 10% Dolomite as between 1180-1190 feet.
1200-1210	60% Siltstone as above. 30% Quartz Sandstone as between 1160-1170 feet. 10% Dolomite as above.
1210-1220	95% Quartz Sandstone as between 1160-1170 feet, rare bitumen. 5% Siltstone, green-grey and red-brown, otherwise as between 1190-1200 feet.
1220-1230	70% Quartz Sandstone as between 1160-1170 feet, rare bitumen. 20% Siltstone, as between 1190-1200 feet. 10% Dolomite, light green-grey, microcrystalline, hard.
1230-1240	90% Quartz Sandstone, white, fine-grained, minor coarse-grained, fairly well-sorted, rounded, moderately soft. 10% Siltstone as between 1190-1200 feet.
1240-1250	90% Quartz Sandstone as between 1230-1240 feet. 10% Siltstone as between 1190-1200 feet. Minor Chert, pale green.
1250-1260	60% Quartz Sandstone as between 1230-1240 feet. 40% Siltstone, white, light red-brown and green-grey, calcareous, moderately soft. Minor Chert, pale green.
1260-1270	Quartz Sandstone, light grey, white and dark brown, fine grained, well-sorted, rounded, dolomitic cement, friable, rare mica. Minor Shale, green, slightly calcareous, soft, rare quartz.
1270-1280	Quartz Sandstone as above, rare calcite crystals. Minor Siltstone, green and red, otherwise as between 1250-1260 feet.
1280-1290	70% Quartz Sandstone, white, rare pink, fine-grained, well-sorted, rounded, dolomitic cement, moderately hard. 20% Siltstone, red and green, moderately soft. 10% Dolomite, light grey and green, microcrystalline, hard. Minor Shale, green, soft.
1290-1300	60% Quartz Sandstone as above, rare pyrite. 40% Siltstone, red, as between 1280-1290 feet, micaceous.
1300-1310	80% Siltstone, red and green, micaceous, pyritic, moderately hard. 20% Quartz Sandstone, white, pink, and light green, fine grained, well-sorted, rounded, micaceous, friable, dolomitic cement; rare pyrite. Minor Shale, green and light grey, soft.
1310-1320	60% Quartz Sandstone as above. 25% Siltstone as above. 10% Dolomite, light green, green-grey and white, microcrystalline, hard; finely disseminated pyrite in parts; rare quartz grains; rare glauconite. 5% Shale as between 1300-1310 feet.

Feet	
1320-1330	Siltstone, light grey, green-grey, white, pale pink and red, soft, rare pyrite. Minor Quartz Siltstone, light grey and white, then as between 1300-1310 feet. Minor Dolomite as between 1310-1320 feet.
1330-1340	Siltstone, red and green, rare pale pink and white, micaceous, soft, rare pyrite. Minor Quartz Sandstone as between 1300-1310 feet. Minor Dolomite, light grey, microcrystalline, hard. Minor Chert, yellow.
1340-1345	Siltstone, red, pink, light grey and green-grey, micaceous, moderately hard. Minor Dolomite medium grey and light green, microcrystalline, hard. Minor Quartz Sandstone, white, then as between 1300-1310 feet.
1345-1350	60% Quartz Sandstone, light green, fine grained, well-sorted, rounded to sub-rounded, dolomite cement, hard; grading into a Sandy Dolomite, light green, microcrystalline, hard, 40% quartz grains, rounded, scattered. 20% Dolomite, white to light green, microcrystalline, hard. 20% Siltstone, green, calcareous, hard; rare quartz sand, mica. Minor Shale, black moderately hard.
1350-1360	50% Limestone, light grey, white and light green, microcrystalline, hard; rare quartz grains. 40% Siltstone, red and green, slightly calcareous, micaceous, moderately hard. 10% Quartz Sandstone as between 1345-1350 feet.
1360-1370	60% Limestone, pale pink, white, light grey and light green, microcrystalline, hard; rare ?bitumen. 40% Siltstone as between 1350-1360 feet.
1370-1380	90% Siltstone red, pink and green, then as between 1350-1360 feet; pyritic. 10% Limestone as between 1360-1370 feet, finely disseminated pyrite.
1380-1390	80% Siltstone white, pale pink and green, then as between 1370-1380 feet. 10% Limestone as between 1360-1370 feet, quartz grains in parts, grading into a calcareous quartz sandstone. 10% Quartz Sandstone, white and pale pink, fine to medium grained, rounded, fairly well-sorted, calcareous cement, moderately hard in parts; grading into a sandy limestone in parts; rare mica; friable and porous in parts.
1390-1400	50% Siltstone as between 1380-1390 feet. 50% Limestone, pink, microcrystalline, hard; silty in parts.
1400-1410	95% Quartz Siltstone, light grey and green, strongly calcareous, moderately soft, rare mica, grading into a fine grained Quartz Sandstone in parts. 5% Limestone, pale green, microcrystalline, hard, Minor Quartz Sandstone, light grey to white, medium-grained, well-sorted, rounded, strongly calcareous cement, hard; rare white calcite veins.

Feet	
1410-1420	95% Siltstone, red to chocolate, white, light grey, green and dark grey, calcareous, moderately hard; rare mica. 5% Limestone, light to medium grey, light green, microcrystalline, hard.
1420-1430	90% Siltstone, as between 1410-1420 feet. 10% Limestone, light to medium grey, light green, microcrystalline, hard.
1430-1450	Quartz Sandstone, white, fine grained, well-sorted, rounded, friable, porous, slight calcareous cement. Minor Siltstone, red, green and grey as between 1430-1440 feet. Minor Limestone as between 1430-1440 feet.
1450-1460	Siltstone, red to brown, white and blue-green, calcareous, moderately soft; micaceous, rare pyrite. Minor Quartz Sandstone as between 1440-1450 feet. Minor Limestone as between 1430-1440 feet.
1460-1470	60% Dolomite, light brown, dark grey and black, microcrystalline, hard; rare bitumen; fine white calcite veins. 40% Siltstone, red, dark grey, black, white and light grey, calcareous, moderately hard.
1470-1480	Dolomite, medium grey, light brown and dark grey, microcrystalline, hard; rare bitumen; rare quartz grains, rounded. [illegible]. Minor Siltstone, light grey, calcareous, soft.
1480-1490	Dolomite, light to medium grey and light green, microcrystalline, hard; rare pyrite; rare silty layers; vughy with rare calcite crystals. Minor Siltstone, pink, light grey and green, calcareous, soft; rare mica.
1490-1500	Dolomite, light brown, medium grey and light green, microcrystalline, hard; rare pyrite; rare quartz grains, rounded, scattered; vughy with rare calcite crystals. Minor Shale, dark grey, rare pyrite.
1500-1510	40% Dolomite as above. 50% Quartz Sandstone, white, fine grained with minor medium to coarse-grained, fairly well-sorted, rounded, dolomite cement, moderately hard. 10% Shale, green, calcareous, moderately soft. Minor Siltstone, black, slightly calcareous, moderately soft.
1510-1520	95% Dolomite as above except quartz absent. 5% Siltstone brown and green, calcareous, moderately soft; rare mica.
1520-1530	90% Quartz Sandstone, white and light brown, fine-grained, medium-grained in parts, fairly well-sorted, rounded, dolomite cement, moderately hard. 10% Dolomite, light brown, light green, microcrystalline, hard; rare quartz grains; rare pyrite. Minor Siltstone, white and green, then as between 1510-1520 feet.

Feet	
1530-1535	90% Dolomite, light brown to pink, finely-crystalline, rarely medium-crystalline, saccharoidal, moderately soft; rare calcite crystals. 10% Siltstone, medium to dark grey, red and green, calcareous, moderately soft; rare mica. Minor Chert, grey-brown.
1535-1540	95% Dolomite as above. 5% Quartz Sandstone, medium and dark grey, fine-grained, well-sorted, rounded, dolomite cement, moderately hard; rare mica and ? magnetite. Minor Siltstone, light to medium grey, micaceous, soft. Minor Chert, light brown to pink.
1540-1550	90% Dolomite as between 1530-1535 feet. 10% Siltstone green-grey, micaceous, moderately hard. Minor Chert, light brown.
1550-1560	90% Dolomite as between 1530-1535 feet. 5% Chert as between 1540-1550 feet. 5% Siltstone, green-grey, white, pink and light brown, soft; rare pyrite.
1560-1570	Dolomite as between 1530-1535 feet. Minor Chert as between 1540-1550 feet. Minor Siltstone as between 1550-1560 feet.
1570-1580	70% Siltstone light and dark grey, moderately hard; rare mica, pyrite and quartz. 30% Dolomite white, medium to dark grey, light green and brown red, microcrystalline with rare coarsely-crystalline, sugary texture, hard.
1580-1590	40% Dolomite, light brown, finely-crystalline, sugary texture, hard. 60% Siltstone, white, light brown, light and dark grey, soft; micaceous, rare pyrite, rare quartz. Minor Chert, light brown.
1590-1600	95% Limestone, dolomitic, light brown, pink, microcrystalline and finely-crystalline, saccharoidal, hard; rare soft pink calcite veins and calcite crystals. 5% Shale, black, dark green, soft.
1600-1610	90% Dolomite, light brown to pink, dark brown, medium grey, finely-crystalline, coarsely-crystalline in the dark brown fraction, saccharoidal, moderately hard. 10% Shale, medium grey, rare mica and quartz grains, slightly calcareous, moderately hard.
1610-1620	70% Shale, black, dark grey, slightly calcareous, moderately hard. 30% Dolomite, light brown, pink, red-brown and grey, finely crystalline, saccharoidal; moderately hard.
1620-1630	Dolomite, 50% pink, finely-crystalline, sugary texture, hard; 50% dark brown, coarsely-crystalline, hard, vughy with calcite crystals.
1630-1640	Dolomite, pink as between 1620-1630 feet. Minor Shale, black, hard.

Feet	
1640-1650	Dolomite, pink and light grey as between 1630-1640 feet. Minor Chert, light brown. Minor Shale, black, moderately hard.
1650-1660	Dolomite 50% pink, 50% dark brown, as between 1620-1630 feet.
1660-1670	Dolomite 95% pink, 5% dark brown, as between 1620-1630 feet. Minor Shale, green, soft. Minor Chert, brown.
1670-1680	Dolomite, pink with rare dark brown, as between 1620-1630 feet. Minor Shale, dark grey, moderately soft. Minor Chert, brown.
1680-1690	Dolomite as above.
1690-1700	Dolomite as between 1620-1630 feet.
1700-1710	Dolomite as between 1670-1680 feet.
1710-1720	Dolomite pink, rarely dark brown, vughy, yellow iron staining in parts; rare quartz grains, sand size, rounded, scattered. Minor Chert, dark green.
1720-1730	Dolomite as above except quartz grains absent; rare ?manganese. Minor Chert, brown, light green, with lenses of bitumen.
1730-1740	Dolomite, pink to white, rare brown, fine to medium-crystalline, saccharoidal, rare pyrite, rare bitumen, rare stylolites, hard, small vughs.
1740-1750	Dolomite, white to pink, light grey, finely-crystalline, sugary hard, rare bitumen, small vughs.
1750-1760	Dolomite as between 1730-1740 feet. Minor Quartz Sandstone, light grey, fine grained, well-sorted, rounded, with rare mica, rare bitumen; dolomite cement, moderately hard.
1760-1770	Dolomite as above, rare quartz sand. Minor Chert, light grey.
1770-1780	Dolomite, pink, finely-crystalline, sugary texture, hard, vughy.
1780-1790	90% Dolomite pink to light brown, light grey, finely-crystalline, sugary texture, hard; rare quartz grains, sand size; rare small vughs. 10% Quartz Sandstone, light grey, fine-grained, minor coarse-grained, well-sorted, rounded, micaceous, dolomite cement; hard; small light brown chert pebbles in coarse grained section. Minor Chert, white. Minor Calcite, white.
1790-1800	Dolomite, white, pink and grey-brown, finely-crystalline, saccharoidal, hard, rare bitumen; rare small vughs; red and yellow-red iron staining in parts; rare white calcite crystals. Minor Quartz Sandstone, light grey, fine grained, well-sorted, rounded, rare mica, dolomite cement, hard; with black micaceous laminae.

Feet

1800-1810 50% Dolomite as above.
50% Quartz Sandstone as between 1790-1800 feet with rare bitumen.

1810-1824 75% Dolomite, pink to light brown, finely crystalline, sugary texture, hard; rare small vughs.
25% Quartz Sandstone, light grey, fine grained, well-sorted, rounded, micaceous, rare bitumen, dolomite cement, hard.

1824-1830 70% Dolomite, white to light grey, finely-crystalline, minor coarsely-crystalline, saccharoidal, hard; rare small vughs.
30% Quartz Sandstone, light grey, fine-grained, well-sorted, rounded, rare mica, rare pyrite and ?bitumen; dolomitic cement, hard, rare laminae of black, micaceous silt.

1830-1840 80% Dolomite, white to pink, grey-brown, finely-crystalline, rare medium-crystalline, saccharoidal, hard; rare pyrite; rare vughs.
20% Quartz Sandstone as between 1824-1830 feet.
Minor Chert, white,

1840-1850 85% Dolomite white, grey, sometimes mottled, microcrystalline, hard; rare vughs.
15% Quartz Sandstone as between 1824-1830 feet, rare bitumen.

1850-1860 95% Dolomite, white, grey-brown, microcrystalline with minor fine to medium-crystalline and saccharoidal, hard.
5% Quartz Sandstone as between 1834-1830 feet.

1860-1870 Dolomite, light grey, white, grey-brown, finely-crystalline, rare medium to coarsely-crystalline, saccharoidal, hard; rare pyrite, rare mica.
Minor Quartz Sandstone as between 1824-1830 feet.
Minor Shale, black.

1870-1880 Dolomite, light grey, white, green-grey and grey-brown, finely-crystalline,rare medium crystalline, saccharoidal, hard; rare clay impurities, rare bitumen; rare black laminae with pyrite.

1880-1890 Dolomite, light grey, white and grey-brown, 60% finely-crystalline, 40% medium to coarsely crystalline, moderately hard; numerous vughs; rare black layers or films.

1890-1900 80% Quartz Sandstone as between 1824-1830 feet, except pyrite and silty layers absent.
20% Dolomite, white and grey-brown, finely-crystalline with rare medium to coarsely-crystalline, hard; rare white calcite.
Minor Siltstone, black, micaceous, soft.

1900-1910 Dolomite, white to pale grey, grey-brown and pink, microcrystalline, rare medium-crystalline, hard; rare bitumen; vughy; intergrangular porosity in medium-crystalline part.
Minor Quartz Sandstone as between 1890-1900 feet.
Minor Siltstone as between 1890-1900 feet.

1910-1920 50% Quartz Sandstone, pale grey, fine-grained, well-sorted, 40% dolomite cement, hard; very rare bitumen; highly micaceous grey laminae in parts.
50% Dolomite,grey-brown and white, medium crystalline, rare finely-crystalline, saccharoidal, hard with moderately soft parts; rare quartz grains of sand size; rare vughs, intergranular porosity.

Feet	
1920-1930	85% Quartz Sandstone as between 1910-1920 feet. 15% Dolomite as between 1910-1920 feet. Minor Siltstone, black.
1930-1932	85% Quartz Sandstone as between 1910-1920 feet. 15% Dolomite as between 1910-1920 feet.
1932-1937	90% Dolomite, white, microcrystalline, hard; 5% quartz sand, scattered. 10% Quartz Sandstone, pale brown, fine-grained, well-sorted, rounded, dolomite cement, hard; rare ?bitumen.
1937-1940	95% Dolomite as between 1932-1937 feet with minor light grey with rare ?bitumen.
1940-1950	Dolomite, white, pale brown and light grey, then as between 1932-1937 feet; rare clear dolomite crystals.
1950-1960	75% Dolomite white to pale brown then as between 1932-1937 feet; rare clear dolomite crystals. 25% Quartz Sandstone, light grey, as between 1932-1937 feet, except ?bitumen absent, grading into a grey Sandy Dolomite.
1960-1970	Dolomite as between 1950-1960 feet.
1970-1980	80% Siltstone, pale grey, moderately hard; minor quartz sand, with micaceous layers and rare ?bitumen. 20% Dolomite, white and pale brown, microcrystalline, hard; rare dolomite crystals.
1980-1990	Dolomite, white, rare pale brown and light grey, 90% microcrystalline, 10% medium-crystalline, saccharoidal, hard; rare quartz sand, rare vughs; intergranular porosity in medium-crystalline part. Minor Quartz Sandstone, blue grey, fine-grained, well sorted, rounded, dolomite cement, hard; micaceous.
1990-2000	75% Dolomite, white, as between 1980-1900 feet. 25% Siltstone, pale grey, dolomitic matrix, grading into a silty dolomite, moderately hard; with thin black micaceous layers.
2000-2010	Dolomite, white to pale grey, finely-crystalline, rare medium-crystalline and saccharoidal, rare quartz sand, grading into a dolomitic quartz sandstone in parts; rare bitumen, moderately hard; intergranular porosity and vughy in medium crystalline part; rare thin black micaceous layers.
2010-2020	Dolomite as between 2000-2010 feet.
2020-2030	Dolomite as between 2000-2010 feet, pelletal in parts.
2030-2040	Dolomite, white, pale grey, as between 200-2010 feet, rare ?bitumen.
2040-2050	Dolomite, white, brown and pale grey, mottled in parts, otherwise as between 2000-2010 feet.
2050-2060	Dolomite, white as between 2000-2010 feet, rare stylolites. Minor Shale, black, soft.

Feet	
2060-2070	Dolomite as between 2000-2010 feet.
2070-2080	Dolomite as between 2000-2010 feet. Minor Shale black, soft.
2080-2090	Dolomite, as between 2040-2050 feet. Minor Quartz Sandstone, pale grey, as between 1980-1990 feet.
2090-2100	Dolomite, white and pale grey, as between 2000-2010 feet. Minor Quartz Sandstone as between 2080-2090 feet.
2100-2107	Dolomite as between 2000-2010 feet; rare bitumen.
2107-2108	Cavity.
2108-2115	No returns.
2115-2120	Dolomite, white, rare grey, finely-crystalline, saccharoidal, moderately hard; grey parts argillaceous; rare galena; rare vughs.
2120-2130	Dolomite, white, rare pale grey and pale brown, finely-crystalline, rare medium and coarsely-crystalline, saccharoidal, moderately hard; rare small vughs. Cavity between 2125-2126 feet.
2130-2140	Dolomite as between 2120-2130 feet, rare bitumen.
2140-2150	Dolomite white, rare pale grey and pale brown, microcrystalline, rare medium-crystalline, saccharoidal, moderately hard; argillaceous in grey parts, rare mica, rare bitumen; rare vughs; intergranular porosity in medium-crystalline part. Minor Chert, yellow. Minor Quartz Siltstone, grey.
2150-2160	Dolomite as between 2140-2150 feet.
2160-2170	Dolomite as between 2140-2150 feet, rare white calcite veins.
2170-2180	Dolomite as between 2140-2150 feet, rare calcite veins. Minor Shale, black.
2180-2190	Dolomite as between 2140-2150 feet, rare pyrite. Minor Quartz Sandstone, pale grey, fine grained, well sorted, rounded, dolomitic cement, moderately hard, laminated.
2190-2200	Dolomite, light brown, grey brown and white, microcrystalline, moderately hard; 30% quartz grains of silt size and argillaceous impurities; grading into a quartz siltstone in parts; rare ?bitumen very finely disseminated.
2200-2210	Dolomite, light brown, pale grey and white, microcrystalline, moderately hard; rare quartz grains of silt size; rare ?bitumen finely disseminated.
2210-2220	60% Dolomite, white and pale grey, microcrystalline, rare fine to medium to coarsely-crystalline, moderately hard; rare vughs. 40% Quartz Siltstone, grey, moderately hard, grading into a silty dolomite; argillaceous in parts; rare ?bitumen finely disseminated.

Feet	
2220-2228	60% Dolomite, white, microcrystalline, moderately hard. 40% Quartz Sandstone, grey, fine grained, well sorted, rounded, dolomite cement, moderately hard; argillaceous in parts.
2228-2230	Quartz Sandstone as between 2220-2228 feet; rare mica; rare limonite staining; rare ? bitumen finely disseminated. Minor Dolomite as between 2220-2228 feet.
2230-2235	95% Quartz Sandstone as between 2228-2230 feet. 5% Dolomite as between 2220-2228 feet; rare pale brown.
2235-2238	80% Siltstone, medium grey, moderately hard; rare dark grey films. 20% Dolomite as between 2220-2228 feet; rare vughs.
2238-2240	95% Siltstone as between 2235-2238 feet. 5% Dolomite as between 2220-2238 feet, rarely medium-crystalline.
2240-2250	75% Siltstone as between 2235-2238 feet, rare mica. 25% Dolomite as between 2220-2228 feet, rare pale brown, medium-crystalline.
2250-2258	70% Siltstone as between 2235-2238 feet, rare mica. 30% Dolomite as between 2240-2250 feet.
2258-2260	98% Siltstone as between 2235-2238 feet. 2% Dolomite as between 2240-2250 feet.
2260-2270	95% Siltstone as between 2235-2238 feet. 5% Dolomite as between 2240-2250 feet.
2270-2280	Siltstone as between 2235-2238 feet, minor Dolomite as between 2240-2250 feet.
2280-2285	Siltstone as between 2235-2238 feet, rare mica. Minor Dolomite as between 2240-2250 feet
2285-2295	Very few returns, Dolomite and Siltstone as above. 50% of each.
2295-2300	60% Dolomite as between 2240-2250 feet. 40% Siltstone as between 2235-2238 feet, rare black, argillaceous.
2300-2310	Dolomite, light grey, light brown, white, 15% microcrystalline, 20% medium to coarsely-crystalline, 65% finely-crystalline, saccharoidal [illegible], moderately hard with minor moderately soft; 30% quartz grains of silt size and argillaceous impurities in a finely-crystalline matrix, grading into a dolomitic siltstone; rare ?bitumen finely disseminated, rare mica; rare vughs.
2310-2320	30% Dolomite, pale grey, pale brown, grey-brown, white and rare dark grey; 60% microcrystalline, 40% medium to coarsely-crystalline, hard; quartz grains of silt size and argillaceous impurities in grey parts grading into a dolomitic siltstone. 70% Siltstone medium grey, dolomitic, moderately soft to moderately hard; rare finely-disseminated ?bitumen, rare mica.
2320-2330	95% Dolomite, white, rare brown to grey-brown and pale green, microcrystalline, rare medium to coarsely crystalline, saccharoidal, moderately hard; rare clear dolomite crystals. 5% Siltstone as between 2310-2320 feet. Minor Chert, orange.

Feet	
2330-2340	Dolomite, white, pale grey, pale brown, mottled in parts, 70% finely-crystalline, 30% medium to coarsely-crystalline, moderately soft; 10% quartz grains of silt size in the grey parts, grading into a dolomitic siltstone; rare ?bitumen.
2340-2350	Dolomite, white, and pale brown, microcrystalline and finely-crystalline, moderately hard; rare small vughs; rare ?bitumen.
2350-2360	Dolomite as between 2340-2350 feet
2360-2368	Dolomite as between 2340-2350 feet, rare light grey, argillaceous.
2368-2370	Dolomite, pale grey, pale brown and white, fine to medium-crystalline, rare coarsely-crystalline, saccharoidal, moderately hard; rare ?bitumen finely disseminated; rare vughs.
2370-2375	Dolomite as between 2368-2370 feet.
2375-2380	Dolomite as between 2368-2370 feet.
2380-2390	Dolomite, pale brown, rare grey-brown and white, medium to coarsely-crystalline, rare finely-crystalline, moderately soft; rare argillaceous impurities. Minor Shale, black.
2390-2400	Dolomite as between 2380-2390 feet; rare ?bitumen. Minor Shale, black, rare mica.
2400-2410	Dolomite, pale brown, grey brown and white, fine to medium crystalline, soft; rare argillaceous impurities. Minor Chert, white; Minor Shale, black.
2410-2420	Dolomite as between 2400-2410 feet; rare ?bitumen.
2420-2430	Siltstone, medium grey, rare black, soft, micaceous; grading into a silty dolomite. Minor Dolomite as between 2400-2410 feet.
2430-2440	Siltstone, as between 2420-2430 feet, grading into a Silty Dolomite, finely-crystalline, pale brown. Minor Dolomite, white and pale brown, medium to finely-crystalline. Minor Limestone, light brown, medium crystalline, dolomitic, moderately hard; rare finely disseminated ?bitumen.
2440-2450	65% Limestone, white and pale brown, medium to finely-crystalline, soft; finely disseminated ?bitumen. 25% Dolomite, white and pale brown, translucent, medium to finely-crystalline, moderately soft. 10% Quartz Siltstone, grey-brown, pale brown, calcareous, soft; finely-disseminated ?bitumen.
2450-2460	75% Limestone as between 2440-2450 feet. 20% Dolomite as between 2440-2450 feet. 5% Siltstone as between 2440-2450 feet. Minor Shale, black.
2460-2470	65% Limestone, grey-brown, pale brown, white, microcrystalline, moderately hard to hard, argillaceous in parts, rare black ?bitumen flecks. 25% Siltstone as between 2440-2450 feet but grading into a silty dolomite. 10% Dolomite as between 2440-2450 feet.

Feet	
2470-2480	30% Limestone grey-brown, pale brown and white, microcrystalline in brown parts, medium to finely-crystalline, moderately hard; argillaceous in parts, black ?bitumen flecks in parts. 30% Siltstone as between 2460-2470 feet. 40% Dolomite, white, pale grey, then as between 2440-2450 feet. Minor Shale, black.
2480-2490	80% Siltstone as between 2460-2470 feet. 10% Limestone, grey-brown, white and pale brown, medium to finely-crystalline, moderately hard, black ?bitumen flecks in parts. 10% Dolomite, white to pale brown, microcrystalline, moderately hard, white and clear crystals of dolomite.
2490-2500	5% Limestone as between 2480-2490 feet. 30% Siltstone as between 2460-2470 feet. 65% Dolomite as between 2460-2470 feet, and 30% pale brown, moderately hard, silty, finely disseminated ?bitumen.
2500-2510	Dolomite, white to pale brown and pale grey, finely-crystalline, rare medium-crystalline, moderately hard; argillaceous in parts; rare finely-disseminated ?bitumen. Minor Shale, black, grey. Minor Limestone as between 2480-2490 feet.
2510-2520	Dolomite as between 2500-2510 feet, rare pyrite. Minor Shale, black, grey, rare mica. Minor Limestone as between 2480-2490 feet.
2520-2530	70% Dolomite as between 2500-2510 feet with 25% microcrystalline, rare translucent. 15% Quartz Siltstone, grey, grey-brown and black, moderately hard; micaceous, rare ?bitumen. 15% Limestone, white, then as between 2480-2490 feet.
2530-2540	85% Dolomite, pale brown, white, rare translucent, finely-crystalline, rare medium-crystalline and microcrystalline, rare sugary texture, hard. 15% Limestone, white, dark grey, mottled, medium to finely-crystalline, moderately soft. Minor Quartz Siltstone, medium grey, micaceous, moderately hard.
2540-2550	90% Dolomite as between 2530-2540 feet, rare pyrite, rare ?bitumen. 10% Limestone as between 2530-2340 feet. Minor Siltstone as between 2530-2540 feet.
2550-2560	95% Dolomite as between 2530-2540 feet with 5% dark grey-brown, argillaceous. 5% Limestone as between 2530-2540 feet, rare bitumen. Minor Shale, black, grey, rare mica. Minor Siltstone, blue-grey, soft.
2560-2570	95% Dolomite as above with rare ?bitumen flakes. 5% Limestone as between 2530-2540 feet. Minor Chert, pale brown. Minor Shale, dark grey.
2570-2574	Dolomite as above. Minor Shale, dark grey, micaceous.
2574-2579	80% Dolomite as above. 20% Siltstone as between 2550-2560 feet but hard with euhedra of dolomite.

Feet	
2579-2590	90% Limestone, medium grey to brown grey, rare dark grey and pale grey, microcrystalline to cryptocrystalline, hard; rare black flecks sparsely disseminated; argillaceous and carbonaceous in parts; rare quartz grains of silt size; rare chalcedony, white; and chert. 10% Siltstone as between 2574-2579 feet.
2590-2600	95% Limestone as above. 5% Siltstone as between 2574-2579 feet; rare pyrite; grading into a silty limestone.
2600-2607	75% Limestone as above. 25% Siltstone as between 2590-2600 feet.
2607-2612	85% Limestone, brown, pale to medium grey, sometimes grey-brown, microcrystalline to cryptocrystalline, hard; silty, minor sparsely disseminated fine black flecks; minor chalcedony, white. 15% Siltstone, dark grey-brown grading into Limestone above. Minor Dolomite, white, medium to finely-crystalline.
2612-2620	Limestone, medium grey-brown, dark grey and pale grey, finely-crystalline to microcrystalline, hard; silty and argillaceous in dark grey parts, grading into a siltstone with rare mica and calcite crystals; rare black flecks; rare chalcedony.
2620-2630	Limestone as between 2612-2620 feet.
2630-2640	Limestone as between 2612-2620 feet.
2640-2650	90% Limestone as between 2612-2620 feet. 10% Dolomite (?cavings)
2650-2660	90% Limestone as between 2612-2620 feet. 10% Dolomite (? cavings)
2660-2670	Limestone as between 2612-2620 feet. Minor Shale, black.
2670-2680	75% Limestone as between 2612-2620 feet 25% Dolomite (cavings)
2680-2690	80% Limestone as between 2612-2620 feet. 20% Dolomite (cavings)
2690-2700	70% Limestone as above. 30% Dolomite (cavings)
2700-2710	As above.
2710-2720	As above. Rare fossil fragments
2720-2730	As above.
2730-2740	As above. Rare fossils fragments.
2740-2750	As above. Rare fossil fragments.
2750-2760	As above. Rare fossil fragments.
2760-2770	As above.
2770-2780	As above.

Feet	
2780–2790	As above. Rare brachiopod fragments.
2790–2800	As above. Rare fossil fragments.
2800–2810	Limestone, medium grey-brown, pale grey, dark grey, cryptocrystalline to finely-crystalline, hard to moderately soft; slightly argillaceous; rare calcite, white; rare chalcedony, white; brachiopod and ?trilobite fragments.
2810–2817	95% Limestone as between 2800–2810 feet; with silt in dark grey part, sometimes laminated with pale grey limestone, sometimes fissile, rare mica; brachiopod and trilobite fragments. 5% Siltstone, pale brown, rare grains of quartz and white chalcedony.
2817–2820	Limestone as between 2810–2817 feet, 3% grading into a dark grey Siltstone; rare shell fragments.
2820–2827	Limestone, medium to pale grey-brown, pale grey, dark grey, microcrystalline to finely crystalline, hard; silty in grey parts, grading into dark grey Siltstone, sometimes fissile, with euhedra of calcite; rare fossil fragments.
2827–2830	Limestone as between 2820–2827 feet; rare black flecks; rare calcite and chalcedony; rare fossil fragments. Minor Siltstone.
2830–2840	80% Limestone, medium grey-brown, rare pale grey, microcrystalline, hard; rare quartz silt and sand; argillaceous in parts; rare calcite veining; tight. 10% Siltstone, dark grey, calcareous, carbonaceous, rare quartz, friable. 10% Dolomite (?caving).
2840–2850	As above.
2850–2860	80% Limestone as above; slightly carbonaceous. 15% Siltstone as above; pyritic. 5% Dolomite (?caving).
2860–2870	80% Limestone as above. 10% Siltstone as above. 10% Dolomite (?caving)
2870–2880	70% Limestone, medium grey-brown, microcrystalline, hard, tight; silty, argillaceous. 20% Siltstone dark grey-black as between 2830–2840 feet. 10% Dolomite, light grey, microcrystalline, hard, tight (?caving).
2880–2890	70% Limestone as between 2870–2880 feet. 20% Siltstone as between 2870–2880 feet. 10% Dolomite as between 2870–2880 feet (?caving).
2890–2900	65% Limestone, 50% light grey, microcrystalline, silty and sandy, containing 5–10% scattered quartz and carbonaceous grains, slightly friable; some intergranular porosity. 50% medium grey-brown microcrystalline, hard, tight; with clay minerals, slightly carbonaceous. 25% Siltstone as above. 10% Dolomite, white, light grey, microcrystalline, hard, tight (?caving).
2900–2910	70% Limestone, 70% medium grey-brown as above; 30% light grey as above. 25% Siltstone as above. 5% Dolomite as above (?caving).

Feet	
2910-2920	75% Limestone, 30% light grey as above; 70% medium grey-brown as above. 25% Siltstone as above. Minor Dolomite as above (?caving).
2920-2930	70% Limestone, 80% medium brown-grey as above; 20% light grey as above with some clay minerals. 20% Siltstone as above. 10% Dolomite as above.
2930-2940	80% Limestone as between 2920-2930 feet. 10% Siltstone as above. 10% Dolomite as above; rare ?bitumen (?caving).
2940-2950	70% Limestone, 90% medium brown-grey, 10% light grey as above; some calcite veins. 15% Siltstone as above. 15% Dolomite as above; some quartz silt.
2950-2960	75% Dolomite, 90% brown and dark grey, microcrystalline, soft; bituminous; porous; calcareous and argillaceous; laminated, fissile; contained amber-yellow globules of greasy oil; foamed in HCl and gave strong, pale green fluorescence under U/V light. Commenced at 2952'6". 10% white, as above (?caving). 25% Limestone as between 2940-2950 feet.
2960-2970	Dolomite, brown, grey, soft porous, bituminous, as above.
2970-2975	Dolomite, bituminous, as between 2960-2970 feet.
2975-2980	95% Limestone, medium to dark grey-brown, microcrystalline, hard; argillaceous in parts; possibly some intergranular porosity. 5% Dolomite, white, and brown, microcrystalline, soft and hard; slight patchy pale green fluorescence, considered contamination (?caving).
2980-2990	60% Limestone, 90% medium grey-brown, microcrystalline, hard, tight; slightly argillaceous. 10% light grey, microcrystalline, rare quartz, silt, slightly friable. 30% Shale, dark grey-black, argillaceous, carbonaceous (?bituminous), calcareous, hard. Forms thin laminae (0.5 mm.) between limestone bands (1.0 mm.). 10% Dolomite, white and brown as above (?caving).
2990-3000	70% Limestone, 80% medium grey, microcrystalline, hard; slightly argillaceous; some intergranular porosity; rare calcite veins. 20% light grey, microcrystalline, rare quartz silt, slightly friable; possibly intergranular porosity. 20% Shale as between 2980-2990 feet. 10% Dolomite, white and brown as above (?caving).
3000-3010	60% Limestone, 90% medium to dark grey, microcrystalline, hard, tight; argillaceous, possibly carbonaceous. 10% light grey, microcrystalline; some quartz silt, slightly friable. Some intergranular porosity. 40% Shale as between 2980-2990 feet. minor Dolomite as above (?caving) Some fluorescence; possibly contamination.
3010-3020	80% Limestone as between 3000-3010 feet. 10% Shale as above. 10% Dolomite as above (?caving).
3020-3030	70% Limestone as above. 20% Shale as above. 10% Dolomite as above (?caving).

Feet	
3030-3040	50% Limestone as above. 50% Shale as above. minor Dolomite as above (?caving)
3040-3050	70% Limestone as above; porous; some calcite veining. 30% Shale as above. minor Dolomite as above (?caving)
3050-3060	75% Limestone, 90% medium grey as above. 10% light grey, microcrystalline, silty (mica, carbonaceous and rare quartz grains), slightly friable. Porous. Some calcite veins. 25% Shale as above. minor Dolomite as above (?caving)
3060-3070	70% Limestone as between 3050-3060 feet. 30% Shale as above.
3070-3080	80% Limestone, 60% medium grey, 40% light grey as between 3050-3060 feet. 20% Shale as above.
3080-3090	75% Limestone, 40% medium grey, microcrystalline, hard, tight, argillaceous; rare specks blue opaline? silica in 20% of chips. 60% light grey-white, microcrystalline, silty to fine sandy, with distinct rounded carbonaceous grains. Opaline silica in 5% of chips, blue to purple in patches. (Possibly spicules). 25% Shale as above. minor Dolomite as above (?caving).
3090-3100	55% Shale, dark grey, argillaceous, carbonaceous, slightly calcareous, hard, tight; rare pyrite. 33% Dolomite, white, microcrystalline to medium - crystalline, hard, tight, slightly calcareous; rare quartz silt and scattered ?glauconite (pale green, granular, in small grains and patches), 5%. 12% Limestone, 50% medium grey, microcrystalline hard; argillaceous. 50% light grey, microcrystalline, silty (with carbonaceous grains). Minor blue silica specks. Sharp junction at 3097 feet.
3100-3110	90% Dolomite, white to light brown, microcrystalline to medium - crystalline, hard, tight, slightly calcareous; 5% with minute patches of ?glauconite; some dark grey-black carbonaceous material; 2% intergranular porosity. 5% Shale as above (?caving). 5% Limestone, medium-grey as between 3090-3100 feet. (?caving).
3110-3117'5"	99% Dolomite as above; some vughs with euhedral rhombs. 1% Shale as above (?caving).
3117'5"-3122	Dolomite, white, light brown-grey, microcrystalline to medium crystalline, hard, tight, slightly calcareous. Some rhombic euhedra with black carbonaceous material along rhomb boundaries; minor pyrite; 20% porosity. minor Shale as above (?caving).
3122-3127'5"	Dolomite as above. minor Shale as above (?caving).
3127'5"-3130	Dolomite as above; 10% porosity. minor Shale and Limestone as above (?caving).
3130-3140	Dolomite as above; 30% porosity.

Feet	
3140-3150	Dolomite as above; 30% porosity; very rare pyrite and specks of carbonaceous material.
3150-3160	Dolomite as between 3140-3150 feet.
3160-3170	Dolomite as between 3140-3150 feet; 20% porosity.
3170-3180	Dolomite, white, light grey and brown, microcrystalline to medium-crystalline, hard; partly tight, some parts with 20% porosity, vughs with rhombic euhedra; rare pyrite. Minor Limestone, light grey, silty (?caving). Minor Shale as above (?caving).
3180-3190	Dolomite as between 3170-3180 feet. Minor Limestone as above (?caving)
3190-3200	Dolomite as between 3170-3180 feet; 10% porosity; rare unidentified light blue mineral. Minor Limestone, light grey-brown, microcrystalline, carbonaceous silt (?caving).
3200-3210	98% Dolomite, light to medium brown and grey, white, microcrystalline to medium-crystalline, hard, tight; slightly argillaceous; rare rhombic euhedra and pyrite. 2% Limestone, light grey, microcrystalline, carbonaceous silt (?caving). Minor Shale, black, argillaceous, carbonaceous, calcareous (?caving).
3210-3220	98% Dolomite, light to medium grey-brown, 40% dark grey, rare white, microcrystalline to medium-crystalline, hard, tight; argillaceous, carbonaceous in dark grey part; some black carbonaceous flakes or grains; rare pyrite and yellow crystals; some dolomite veining. 1% Limestone as above (?caving). 1% Shale as above (?caving).
3220-3230	Dolomite as above; rare fossils.
3230-3240	98% Dolomite as above. 1% Limestone as above (?caving). 1% Shale as above (?caving).
3240-3250	Dolomite, light to medium brown-grey and white with approximately 20% blue-grey to green-grey admixture, microcrystalline to medium-crystalline, hard, tight; brown-grey, partly argillaceous and carbonaceous; blue-green-grey, partly ?glauconitic, also microcrystalline with pyrite specks (up to 5%) and rare quartz silt. Minor Shale and Limestone as above (?caving).
3250-3260	Dolomite, white, brown, blue-grey and dark grey, microcrystalline, rare medium-crystalline; argillaceous; pyrite (5%) in white and blue-grey dolomite; rare quartz silt; possibly carbonaceous in dark grey dolomite; rare rhombic euhedra in vughy parts; 5% porosity.
3260-3270	Dolomite, brown, dark grey, blue-grey and white, microcrystalline; argillaceous, possibly carbonaceous; rare quartz silt; rare pyrite as above; 5-10% porosity.

Feet	
3270–3280	Dolomite, 85% white, light brown, dark grey and blue-grey, microcrystalline and medium-crystalline; argillaceous, possibly carbonaceous. 15% silty and fine sandy, white and blue-grey, microcrystalline; angular quartz silt and sand, poorly sorted; some white pellets and round quartz, some calcareous cement; rare rhombic euhedra; rare chert and pyrite; 10% porosity.
3280–3290	Dolomite, brown, white, dark grey, blue-grey, mottled brown and white (possibly algal pellets or recrystallised), microcrystalline, hard; 15% with quartz silt; calcareous in white parts; very rare glauconite; pyrite and quartz silt in some white and blue-grey dolomite. Some carbonaceous bands and white patches. Some parts appear fissile; 10% porosity.
3290–3300	40% Dolomite, white, brown, dark grey, blue-grey, mottled white, microcrystalline to medium-crystalline, hard; rare rhombic euhedra; 10% silty with scattered angular quartz grains; no porosity. 60% Quartz Sandstone, light to medium brown, white and rare grey; some mottled white and red-brown, fine-grained, angular to subangular some scattered medium to coarse-grained, subrounded, average to well-sorted, hard; no porosity; rare pink-orange ?feldspar in one or two grey chips; matrix slightly calcareous, possibly dolomitic in white part, ferruginous and with white clay material (possibly from decomposed feldspar); rare mica. Boundary at 3294 feet.
3300–3305	70% Quartz Sandstone, medium brown, dark red, fine to medium grained, angular to subangular, average sorting; possibly feldspathic, slightly calcareous ferruginous, clay? matrix. 30% Gneiss, orange and black, medium-crystalline, quartz, biotite, feldspar, subhedral, hard; no porosity. Considerable Dolomite caving.
3305–3310'6"	No Returns - see core 15 description.
3310'6"–3320	Gneiss as above, some green chloritoid? mineral. Considerable Dolomite caving.
3320–3328	Gneiss as above. Considerable Dolomite caving.
3328–3330	Granite orange, white, medium crystalline, quartz and feldspar, rare biotite and muscovite, rare green ?chlorite. (Small amount of Dolomite and Sandstone caving).

APPENDIX 2

Core Descriptions - B.M.R. 13

Core No. 1 — 325 - 345 feet. Recovered 4 feet 5 inches.

Quartz Sandstone, white, medium to coarse grained, well sorted, rounded to subrounded, some calcareous cement, some porosity, friable; with 2 inch band Chert, green-grey, near base.

Core No. 2 — 630 - 640 feet. Recovered 2 feet 7 inches.

1 ft. 5 ins. — Dolomite, dark grey, green-grey, medium to coarsely crystalline, very hard; rare glauconite; argillaceous in parts; rare quartz grains, sand size, rounded, scattered; rare thin veins white calcite; with very thin Shale interbeds, grading and lenticular, black to dark grey, micaceous, calcareous, moderately hard; bedding horizontal; rock very tight, porosity nil.

1 ft. 2 ins. — Dolomite, medium to light grey, green-grey, finely crystalline to microcrystalline, very hard; rare glauconite; rare stylolites; rare small vughs lined with white and pink calcite crystals; rare thin veins white calcite; rare Shale as above; thin lenticular band of Siltstone at top, white to light green-grey, calcareous, moderately hard at top; bedding horizontal; rock very tight, porosity nil except for vughs and stylolites.

Core No. 3 — 717 - 723 feet 6 inches. Recovered 2 feet 5 inches.

2 ft. 1½ ins. — Dolomite, pale green-grey, microcrystalline, hard; rare glauconite and quartz grains of sand size; rare stylolites, rare white and pink calcite veins; laminae of Silt, blue-green, micaceous, pyritic; bedding horizontal in top 2 inches, remainder contorted, slumped.

3½ ins. — Dolomite, medium grey, microcrystalline, very hard; oolitic, stylolitic; rare small vughs lined with euhedral calcite crystals.

Core No. 4 — 1050 - 1060 feet. Recovered 4 feet 6 inches.

9 ins. — Quartz Siltstone, light grey with thin light green and pink bands, dolomitic, hard; red limonite staining along fractures and in patches; rare vughs.

7 ins. — Shale, dark green-grey, calcareous, moderately hard but soft in parts; abundant finely disseminated pyrite.

3 ft. 2 ins. — Quartz Siltstone as at top of core; rare pyrite; vughy and fractured; infilled with dolomite crystals; argillaceous at top, with small lenses green clay in parts; thin band intraformational breccia 4 inches from from top with cream angular dolomite pebbles up to ½ inch; thin bed black Shale 18 inches from top of siltstone.

Core No. 5	1340 - 1350 feet. Recovered 7.0 feet.
2 ft. 8 ins.	Siltstone, interbeds of red and light grey to green-grey up to 1¼ inches thick, dolomitic, moderately hard; bedding horizontal with some convolute; ½ inch band Dolomite, medium grey, microcrystalline hard, ½ inch above base.
1 ft. 2 ins.	Dolomite as above interbedded with and lensing into Siltstone, dark grey to black, rare mica, finely disseminated pyrite; bedding convolute, slumped in parts, boudinage and pull-apart structures.
1 ft. 7 ins.	Siltstone, pale green strongly calcareous, hard; with thin interbeds of a lighter green Siltstone, micaceous, strongly calcareous. Thin beds, 1½ inches from top and a ½ inch bed 3 inches above base, of Quartz Sandstone, white, rare green, fine grained, well sorted, rounded, hard, rare mica, rare ?magnetite; thin band black Shale at base.
5 ins.	Dolomite, light grey to light green-grey, microcrystalline, hard; interbedded with a similar Sandy Dolomite with about 40% quartz grains of sand size, rounded.
4 ins.	Quartz Sandstone, light green, fine grained, rounded, well sorted, dolomite cement, hard, grading into a Sandy Dolomite, light green, microcrystalline, hard, with 40% quartz grains of sand size; laminae of black micaceous Silt towards top.
2 ins.	Dolomite, pale green, microcrystalline, hard; massive, 5% pelletal; fractured and stylolitic in last 1½ inches.
Core No. 6	1530 - 1540 feet. Recovered 1 foot 10 inches.
8 ins.	Quartz Sandstone, medium grey, fine grained at top, becoming medium grained throughout, rounded, well sorted, dolomite cement, hard; small lenses and grains of pink Chert and numerous laminae of dark grey, micaceous Silt.
4 ins.	Dolomite, light brown to pink, finely crystalline with rare medium crystalline, sugary texture, moderatly hard; small lenses and bands of Chert, pink.
10 ins.	Quartz Sandstone as at top of core; small vugh near base.
Core No. 7	1820 - 1824 feet. Recovered 2 feet 8 inches.
1 ft. 10 ins.	Dolomite, pink to light brown, finely crystalline, aroidal sacch/ texture, hard; numerous small vughs; massive with semblance of horizontal bedding in parts; rare laminae of black micaceous silt.
10 ins.	Quartz Sandstone, light grey, fine grained, well sorted, rounded, dolomite cement, very hard; rare mica, rare pyrite and rare ?bitumen; rare vughs lined with clear dolomite crystals; rare Chert lenses, light brown.
Core No. 8	1932 - 1938 feet. Recovered 1 foot 5 inches.
6 ins.	Dolomite, pale grey, finely crystalline, hard; 40% quartz grains of sand size; rare pyrite and ?magnetite; massive; poorly developed stylolites; vughs lined with ?bitumen.
7 ins.	Dolomite, white, microcrystalline, hard; rare quartz grains of sand size; vughy in parts, sometimes vughs lined with ?bitumen, sometimes with dolomite crystals; rare limonite staining; rare black ?bitumen layers; rare small Chert lenses; rare Calcite.

Core No. 8 continued.

4 ins. Quartz Sandstone, pale brown, medium to fine-grained, well sorted, dolomite cement, hard, massive.

Core No. 9 2228 - 2238 feet. Recovered 9 feet 6 inches.

Quartz Siltstone grading into Quartz Sandstone, very fine-grained in upper half, medium grey, well sorted, rounded, dolomitic cement, moderately hard; rare ?magnetite, ?micaceous, massive; with discontinuous, wavy, dark grey argillaceous laminations, bifurcating and paper thin, sometimes concentrated in domains; ? laminations suggest near horizontal bedding; bottom 8½ inches somewhat "flaggy"; small vughs in lower half, especially in bottom 2 feet, sometimes filled with dolomite crystals.

Core No. 10 2368 - 2380 feet. Recovered 1 foot 5 inches.

3½ ins. Dolomite, pale grey, minor pale brown, mottled in parts, microcrystalline, coarsely crystalline in brown parts, moderately hard; intergranular porosity, vughy with ?bitumen lining the vughs; massive to flaggy; rare partings possibly reflecting bedding, near horizontal; rare white Chert lenses.

1 ft. 1½ ins. Dolomite, pale grey, rare grey-brown, mottled in parts, microcrystalline to cryptocrystalline, rarely medium-crystalline, moderately soft; numerous vughs in parts, sometimes lined with dolomite crystals; rare irregular partings and stylolites lined with dark grey clay, sometimes micaceous.

Core No. 11 2574 - 2582½ feet. Recovered 2 feet 2½ inches.

Limestone, medium grey to brown-grey, rare dark grey and pale grey, microcrystalline to cryptocrystalline, hard to very hard in parts; rare black flecks sparsely disseminated; very fine dark grey carbonaceous and argillaceous laminae alternating with pale grey cryptocrystalline limestone with rare quartz grains of silt size; the laminae often irregular and wavy, ?slumped; rare irregular patches and fracture veins of white, rarely transparent chalcedony throughout core; rare white translucent dolomite; rare Chert; rarely flaggy; bedding near horizontal.

Core No. 12 2817-2827 feet. Recovered 8 feet 2 inches

Limestone, medium grey-brown, cryptocrystalline to microcrystalline, hard, slightly argillaceous; laminated with minor limestone, very pale grey, cryptocrystalline, slightly silty, more abundant in lower two thirds.

Minor Silty Limestone, dark grey to black, cryptocrystalline, hard, grading into Siltstone. Limestone is laminated, rarely flaggy, with wavy laminae; rare load casts, near-horizontal dip; rare lineation on parting surfaces. Rare irregular veins, patches and thin irregular bands of calcite, white; rare veins and patches of chalcedony, bluish-white, occasionally transparent; both throughout core.

Core No. 13 2960-2980 feet. Recovered 7½ inches.

2960-2975' Nil. See Cuttings descriptions.

2975-2980' Limestone: medium to dark grey, microcrystalline, slightly argillaceous, possibly some quartz silt, hard, tight, but may be intergranular porosity. Uniform texture. No bedding discernable. Unfossiliferous. Patchy fluorescence, pale green under U/V; may be contamination from bituminous dolomite in section above.

Core No. 14 3117'5"-3127'5". Recovered 9½ inches

Dolomite light brown, grey, microcrystalline, often uniform texture, some medium crystalline patches; occasional white patches slightly calcareous. Generally hard and tight, but with 30% vughs lined with medium to coarse euhedral rhombs, translucent. Black, carbonaceous material along rhomb boundaries (asphaltic ?). Unfossiliferous. Rare pyrite granules. Fractured in parts; some carbonaceous material along slickensides. Appears horizontally bedded.

Core No. 15 3305-3310 feet 6 inches. Recovered 5 feet 1 inch

Feldspathic Gneiss, pink, well-banded, consisting of fine alternating bands of light and dark material, which grade laterally and vertically into each other. The rock is cut by thin veinlets and patches of carbonate and scapolite.

Minerals present: Quartz, microcline, biotite, altered sericitic and chloritic material, ?plagioclase, carbonate, muscovite and scapolite.

The quartz is evenly distributed, fine globular crystals. The microcline occurs mostly in bands together with quartz and minor biotite. The biotite is present as sub-parallel flakes, often in clusters and bands.

Core No. 16 3328-3330 feet. Recovered 1 foot 1 inch

Granite, orange and white mottled, coarsely crystalline, quartz and feldspar with rare muscovite, biotite, ?phlogopite (light grey mica) and ?haematite. Green talc or chlorite along fractures and veins of ?chlorite. Fractures run oblique to vertical axis.

APPENDIX 3

Petrographic description of Cuttings from B.M.R. No.13, interval 2952-2975 feet.

by

L.V. Bastian

Cuttings from the interval 2952-2975 feet of B.M.R. No.13 were examined by means of thin section and chemical tests.

In the hand specimen, the material is a rather dark brown rock in which fine laminae can be faintly discerned.

Thin Section:

The lithology is made up for the most part of an aggregate of dolomite rhombs, which range in size from under 0.01mm., to about 0.08 mm. They appear to be rather loosely arranged at random but bedding is apparent is some of the fragments and is marked by variation in the abundance and size of dolomite crystals. One piece has many lobate, dark brown, opaque filaments, which appear to be coagulated bituminous matter. The dolomite crystals lie in a matrix of brown translucent matter with many spots and irregular patches of dark brown opaque matter. In reflected light the whole matrix appears simply a non-reflecting dark brown. The translucent part is isotropic, with a moderate relief (R.I. Canada Balsam), and may include collophane. It lacks cellular structures, nor does it have any distinctive patterns. The dark opaque matter is likewise featureless. In some chips there are minor amounts of quartz silt, with grains ranging up to about 0.06 mm. in size, but at most this is much subordinate to the brown matter.

A phosphate test was made on powdered material, and gave a positive result.

A calcimeter test was also run on material that had been ground and passed through a 30 mesh screen according to the same general procedure as used on other Georgina Basin holes, using 10% HCl. It gave the following results for carbonate percentage -

after 1 minute reaction - 14%
after 10 minuets reaction - 60%

The 10 minute figure accords reasonable well with the impression obtained of the proportion of dolomite to other material in the thin section. The 1-minute figure probably is due to reaction on dolomite, rather than calcite, because the

the reaction began rather slowly, unlike the way it would begin if calcite were present in significant amounts. Hence I consider that all the carbonate mineral in the rock is dolomite. After reaction with the HCl the sample gave off a strong tarry smell. This suggests that the darker material in the matrix may be bituminous.

The appearance of the lithology does not resemble normal dolomite, but dolomite mineral is certainly the major constituent, and it must be named a "dolomite" accordingly.

The approximate composition may be taken as follows:

dolomite	70%
isotropic matter (?collophane and bituminous matter)	20%
?bituminous matter, opaque	5%
quartz	5%

NAME: ?Phosphatic, bituminous DOLOMITE

An assay for P_2O_5 gave the following results:

1. Before extraction 2.1%.
2. After extraction 1.8%.

APPENDIX 4

PETROGRAPHIC DESCRIPTION OF SAMPLE FROM CORE 15, 3308 feet, B.M.R. No. 13

by

J.M. Rhodes

Pink well-banded FELDSPATHIC GNEISS consisting of fine alternating irregular bands of light and dark material, which grade laterally and vertically into each other. The rock is cut by thin veinlets and patches of carbonate.

Minerals present are:-

Quartz, microcline, biotite, altered sericitic and chloritic material, ?plagioclase, carbonate, muscovite and scapolite.

Quartz

Fairly even distributed, fine globular crystals.

K-Feldspar

Microcline, mostly occurring in bands together with quartz and minor biotite. The typical "grid iron" twinning is fairly well developed.

Biotite

Sub-parallel flakes, often in elongate clusters and bands. Pleochroic from greyish yellow to moderate brown. Contains broad well developed pleochroic haloes around small inclusions. Small amounts of muscovite are frequently associated with biotite.

Altered Material

Irregular masses of iron-stained chloritic and sericitic material which texturally resembles pinnite, an alternation product of cordierite. However, there are possible vague remnants of plagioclase which are also strongly sericitised. Distinction between the two is not easy and much of the altered material could be due to plagioclase as well as cordierite. Neither mineral could be identified positively. The rock is cut by veins of carbonate, which also contain tabular crystals of strongly birefringed scapolite (identified by x-ray diffraction). The R.I. is about 1.54 suggesting that the scapolite is closer to the marialite ($3\ NaAlSi_3O_8$ - NaCl) end of the solid solution series. The carbonate and scapolite are of presumably metasomatic origin. Scapolitized rocks have been described by Edwards from the Mt. Isa region.

APPENDIX 5

REPORT ON PALAEONTOLOGICAL WORK CARRIED OUT ON B.M.R. NO.13 STRATIGRAPHIC WELL

by

C.G. Gatehouse

SUMMARY

Core 11 (2579-2582½ feet), Core 12 (2817-2827 feet) and cuttings from several intervals between 2660 and 3230 feet were examined for macrofossils. Samples from both cores were also treated with 10% formic acid and the residues examined for microfossils.

OBSERVATIONS

Cuttings	2574-2579 feet	Inarticulate brachiopod (identified by A.A. Öpik)
Core 11	2579-2582½ "	lithistid desmas, phosphatic brachiopods, lyssakid sponge spicules.
Cuttings	2660-2670 "	Inarticulate brachiopod (identified by A.A. Öpik)
"	2710-2720 "	No fossils observed.
"	2730-2740 "	Inarticulate brachiopods, sponge spicules.
"	2750-2760 "	Pagetia sp., indeterminate phosphatic brachiopods, sponge spicules.
"	2760-2770 "	indeterminate phosphatic brachiopods.
"	2780-2790 "	Pagetia sp., indeterminate phosphatic brachiopods, lyssakid sponge spicules.
"	2790-2800 "	Pagetia sp.
"	2800-2810 "	Pagetia significans, Lingulella, obolids.
"	2820-2817 "	Pagetia significans, Xystridura sp., lithistid desmas, lyssakid spicules, indeterminate phosphatic brachiopod fragments
"	2817-2820 "	Pagetia significans, phosphatic brachiopods, lyssakid sponge spicules.
"	2820-2830 "	Pagetia significans, indeterminate phosphatic brachiopods, fluorite crystals.
"	3220-3230 "	indeterminate phosphatic brachiopods

DISCUSSION & CONCLUSIONS

A fragment of a phosphatic brachiopod in cuttings taken from the interval 3220-3230 feet with a circular hole suggesting the base of a hollow spine. The limestone in which it occurs is dark grey and bituminous; on lithological grounds it may be Middle Cambrian, there are no reasons for assuming a Lower Cambrian age.

Core and cuttings from the interval 2750 feet to 2830 feet contain Pagetia significans (Etheridge Jr) (specific identity by A.A. Öpik) and Xystridura sp. indeterminate. Spicules belonging to two orders of sponges, the Lithistida and Lyssakida are common.

The specific identity of the Xystridura fragment is not determinable, therefore the precise position of the interval 2750-2830 feet is stratigraphically inconclusive within early Middle Cambrian time. However, in the Sandover beds Xystridura spp. and Pagetia significans are associated with agnostid trilobites which indicate an age about Ptychagnostus gibbus zone of the Middle Cambrian for these beds. The fossiliferous horizons between 2710-2827 feet are considered to be high in the lower Middle Cambrian (A.A. Öpik, pers. comm.).

Core 11 and cuttings from the interval 2590 feet to 2740 feet contain phosphatic brachiopods and lithistid sponge spicules. It is above and somewhat younger than the interval 2750 to 2830 feet.

A fragmentary phosphatic brachiopod found at 2574-2579 feet is thought to be almost certain Middle Cambrian in age (A.A. Öpik pers. comm.).

APPENDIX 6

SPECTROGRAPHIC ANALYSIS OF SAMPLES FROM B.M.R. No.13 (SANDOVER)

by

A.D. Haldane

This report gives the results of analysis of dark grey and black shale from the stratigraphic hole B.M.R. No. 13 being drilled near Ooratippra. The samples were submitted by D. Woolley from the Resident Geologist's Office, Alice Springs.

All results are expressed in parts per million.

B.M.R. No.13	Ni	Co	Cu	V	Pb	Remarks
250' - 260'	10	20	25	150	a	
270' - 280'	12	20	5-	500	a	
280' - 290'	12	20	10	300	a	
440' - 450'	5	12	10	100	a	
470' - 480'	15	30	25	300	10	
520' - 530'	15	20	20	300	5	
560' - 570'	15	20	15	50	10	(Mo, 50)
570' - 580'	5	12	15	50	a	
600' - 610'	5	12	15	50	10	
620' - 630'	10	20	100	200	a	
1010' - 1020'	10	30	50	300	5	
1030' - 1040'	20	60	50	300	5	
1055' - 1060'	15	15	10	300	a	
1140' - 1150'	20	30	10	50	5	
1610' - 1620'	5	20	20	200	10	
1620' - 1630'	5	12	15	50	50	(Mo, 50)

Sn, Zn and P were sought but not detected in any sample

Plate No. 789

APPENDIX 7

ANALYSIS OF SAMPLE FROM WATER BORE FOR B.M.R. No.13

by

L.R. Murray*
Animal Industry Branch, N.T.A., Alice Springs

ANALYSIS	(RESULTS IN p.p.m.)
Hardness Total	254
Hardness Temporary	248
Hardness Permanent	6
Free Alkali	NIL
Chloride	22
Sulphate	7
Fluoride	0.2
Calcium	30
Bicarbonate	291
Carbonate	6
Sodium	10
Potassium	10
Magnesium	43
Nitrate	1
pH 8.4	
Total Salts	420

* With permission of the Director of Animal Industry, N.T.A., Darwin.

APPENDIX 8

Petroleum Technology Laboratory
Bureau of Mineral Resources, Geology and Geophysics

MUD TESTS - B.M.R. NO.13 (SANDOVER)

Oil was extracted chemically from a 630 gm. sample of mud taken during the drilling of the interval 2952'-60'. The sample yielded about 1.5% by weight of a black, highly mobile fraction with a strong naphthenic odour. In addition, it yielded about 0.3% by weight of a light brown, soft, odourless solid. There was an insufficient amount of the lighter fraction to determine its viscosity.

The following results were obtained by qualitative fractionation and are only approximate.

Density : 0.93-0.98 gm./ml. i.e. 20.5°A.P.I. - 12.7°A.P.I.

Distillation :	below 170°C	40% by weight
	170° -250°C	35% by weight
	above 250°C	25% by weight

A sample of mud in circulation two days after penetrating the potentially productive interval was also tested. The extracted oil occupied 0.09% of the mud volume, it fluoresced an orange-yellow colour and proved to be similar to the extracts from the cuttings.

A sample of slightly gas cut mud was obtained during D.S.T. No.1 from the drill collars immediately above the retaining valve. It yielded an oil which was sluggish to flow at room temperature, deep orange-brown in colour and with a bright greenish yellow fluorescence. The mud contained 0.104% by volume of oil.

APPENDIX 9

Petroleum Technology Laboratory, Bureau of Mineral Resources

TEST OF BITUMINOUS MATERIAL 1140'-50' and 1365'-70' AND SEALED UNWASHED CUTTINGS 2955'-60' FROM B.M.R. No.13 (SANDOVER)

1. TEST 'BITUMINOUS' MATERIAL 1140'-59' & 1365'-70'

Test	Cuttings 1140'-1150'	Cuttings 1365'-1370'
Weight of sample as received	0.3 gms.	0.2 gms.
Fluorescence as received	Not discernable	Nil
Carbonaceous material present	Yes	Yes
Acetone solubility	Inappreciable	Inappreciable
Acetone colour	Nil	Nil
Acetone fluorescence	Trace	Trace
Acetone precipitate	Nil	Nil
Toluene solvent colour	Yellow	Trace
Toluene solvent fluorescence	Fair	Fair
Chromatographic strip under ultra violet light	Bright orange	Bright orange

The chromatographic strips obtained compare well with a chromatographic strip obtained from Core No.61 at 63[illegible] feet in the GRG. No.14 hole drilled by the Bureau of Mineral Resources.

Because of the lack of reaction with acetone it may be said that no free oil exists in the samples as received and that acetone would not dissolve any fractions from the black material. Positive acetone tests were obtained with GRG. No.14, core 61, however.

Because of the solubility at 110°C in toluene and because of the insoluble black material remaining, it may be said that the cuttings contained an asphaltic hydrocarbon. The GRG. No.14, core 61, retained an insoluble black material in the vugs of the core.

2. TEST OF SEALED UNWASHED CUTTINGS 2955'-60'

The sample consisted of mud and cuttings sealed at the rig site; and an 'oily' smell was noted on breaking the seal in the laboratory. The sample fluoresced; mainly a bright whitish yellow colour; a strong fluorescence of the

acetone solution and a precipitate described as trace to fair.

Extraction with toluene for 8 hours produced 0.31% by weight of oil which was not readily soluble in cold acetone. The oil was a dark orange-brown colour with a bright whitish yellow fluorescence; it was just mobile at 50°F and was sluggish at 60°F.

Gravity determination on a very small sample was 0.99 at 80°C (or about 11°A.P.I.) but an accurate temperature was hard to obtain. However the S.G. of the oil is certainly below 0.93 (about 20.5°A.P.I.).

The residue after 24 hours extraction with toluene was also a dark-orange brown and had an orange fluorescence. But the sample was too small to determine flow characteristics or gravity.

APPENDIX 10

FORMATION TEST - D.S.T. No.1 B.M.R. No.13 (SANDOVER)

by

P.G. Duff

General Data:

Date: 15th July, 1964	Total Depth: 3330'
Interval tested: 2950'-2990'	Main hole size: 6¼"
Plugged back to: 3013'	Rat hole size: none
Casing size: 7"	Liner size: none

Mud Details:

Type: bentonite	Fluid loss: 18 c.c.
Weight: 64 lbs/cu.ft	Filter cake: 2/32"
Viscosity: 39 secs./946 c.c.	Salinity: 600 p.p.m. NaCl

Test and Tool Data:

Tester size and type:	3½" Johnson Formation Tester
Packer size and type:	5¼" Straight Hole Packer without shear pin
Packer set at: 2930'	Reset at: 2935'
Packer set initially with 20,000 lbs; subsequently with 25,000 lbs.	
Air Chamber: length 120'	I.D. 2.25"
Sump volume: 22 cu.ft	Vol.air chamber Volume 3.25 cu. ft sump: 14.8%
Cushion: Nil	B.H. Choke size: ½" packer
Pressure Recorder 1¼" Humble; Type 96; subsurface; range 5,000 p.s.i.g.	
Clock range: 10 hrs.	Recorder depth: 3010'
Anchor Perforations: 60 x ½" dia. over 21.4 ft (Approx.3/ft)	

Diary of Events

	Time	Pressure	Sfc.choke
Recorders started (installed) at:	0740		
Opened Tool at:	1312		
Recorder in carrier in tail pipe at:	0743		Open flow
Finished running collars at:	0900		
Inserted trip valve: running pipe at:	1020		
Sitting for mud pressure at:	1140		
Packer set at:	1210		
Dropped Go-Devil at:	1312		
Packer re-set as annulus started to drop at:	1320		
Pipe dropped, tail pipe in cave, packer set at:	1326		
Pulled packer free at:	1426		
Out of hole at:	1750		

Time Data:

First flow period:	68 mins	Second flow period:	mins.
First shut-in:	62 mins	Second (Final) shut in:	Nil

Temperature and Pressure:

Well temperature and pressures not obtained as recorder left in hole as unrecovered fish. Test inconclusive.

APPENDIX 11

Petroleum Technology Laboratory, Bureau of Mineral Resources, Geology and Geophysics

RESULTS OF CORE AND CAVINGS ANALYSIS B.M.R. No.13 (SANDOVER)

Notes:- (i) Unless otherwise stated, the porosities and permeabilities were determined on two small plugs (V & H) cut at right angles from the core or sample. Ruska porosimeter and permeameter were used, with air at 30 p.s.i.g. and dry nitrogen, respectively, as the saturating and flowing media. (ii) Residual oil and water saturations were determined using Soxhlet type apparatus. (iii) Acetone test precipitates and fluorescence of solvent after extraction are recorded as, nil, trace, fair, strong or very strong. N.D. means not determined.

Date 22nd July, 1964

Well or Area	Core or Sample No.	Depth From:- To:-	Lithology	Effective Porosity in % by Vol.		Absolute Permeability in Millidarcys		Avg. density in gms./cc.		Fluid Saturation in % Pore Space		Acetone Test		Solvent after Extraction		Remarks
				V	H	V	H	Dry Bulk	Apparent Grain	Water	Oil	Colour	Pre-cipitate	Colour	Fluor.	Fluorescence of freshly broken rock.
B.M.R. 13	13	2975'-80'	Limestone	2		Nil		2.63	2.69	84	16	Trace	Fair	Yellow	Fair	Nil
"	13	2975'-80'	Limestone	2		Nil		2.64	2.70	91	9	Pale Yellow	Trace	Bright Yellow	Fair	Nil

Note: Porosities were confirmed using the gas expansion method.

Date 3rd August, 1964

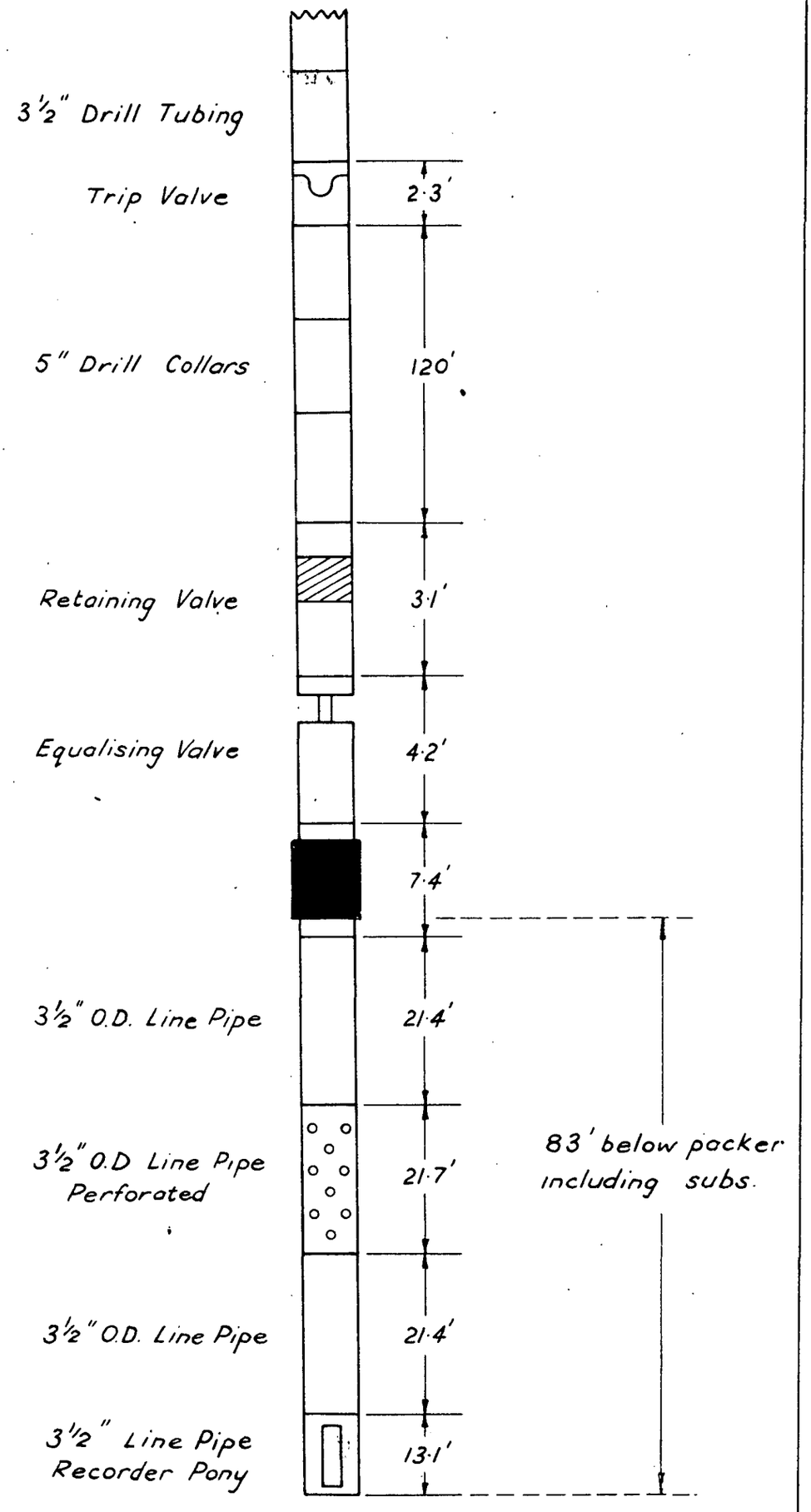
B.M.R. 13	Cavings 1	Circa. 2950'-80'	Dolomite	37		N.D.	6	1.78	2.83	Nil	1	N.D.	N.D.	Golden	Strong	Extracted oil Colour: light orange brown. Fluorescence: bright greenish yellow.
B.M.R.	Cavings	Circa.	Dolomite	33		N.D.	8	1.87	2.80	72	2	N.D.	N.D.	Golden	Strong	As above.

Note: Acid solubility on above sample, 79%. Only the very central pieces of core were used for test.

Surface Information:

Well flowed : no formation fluid to surface
Reversed out: nil
Fluids recovered: 22 cu.ft gas cut mud at 61 lbs/cu.ft
salinity
800 p.p.m. NaCl.
Max.sfc. pressure: Not recorded

FIG.5 SKETCH OF TESTER ASSEMBLY (D.S.T. No.1)



To accompany Record No 1964/127.

APPENDIX 12

Geophysical Branch, Bureau of Mineral Resources

Magnetic Susceptibility and Specific Gravity of Samples of ?Archaean Gneiss, Core 15, 3305 feet, B.M.R. No.13

The magnetic susceptibility and specific gravity of a sample of the basement ?Archaean gneiss from Core 15, 3304 feet, B.M.R. No.13 (Sandover) stratigraphic well, Georgina Basin, Northern Territory, were measured in the laboratory of the Geophysical Branch, Bureau of Mineral Resources.

The results of the measurements were as follows:-

Magnetic Susceptibility: 0.079×10^{-3} C.G.S. units.
Specific Gravity : 2.69.

APPENDIX 13

WIRELINE LOG INTERPRETATION, B.M.R. No. 13

by
M. Gahan
Schlumberger Seaco, Inc.

From the logs run, a number of interesting points are indicated in this well, which appears to be water saturated throughout except for the zone from 1950 to 2980 where gas was recovered. This zone cannot be interpreted as it is extremely caved and none of the logging tools read accurately with such enlarged hole size.

A plot was made of the Sonic log readings compared to the readings from the 64" normal corrected for bore hole effect. The plot was made on an inverse squared resistivity scale compared to the linear Sonic reading (see attached chart) and it was found that the readings fall on two parallel lines, one being for Dolomite and one for Limestone. There was some scatter due perhaps to shaliness or Dolomite/ Limestone mixtures.

From the close agreement of the results over all depths of the well with the results from the Cutting log, it would seem that the connate water resistivity is constant over all the formations traversed. The few differences between the Cutting log and the interpretation results could be due to a variation in the depths recorded by the driller and Schlumberger.

Porosities on the chart attached were obtained from the value of the resistivity and not from the Sonic, as the variation in Matrix velocities which occur greatly affect the Sonic porosity values obtained.

Note that the technique of Lithological identification shown is generally carried out by comparing two porosity tools rather than one porosity and one resistivity device.

Interesting Point: At 3092 a very radioactive zone occurs with a Gamma Ray count considerably more than double that normally found in shale. In fact, we are unable to say what the radioactivity was as our recording device has gone completely off scale.

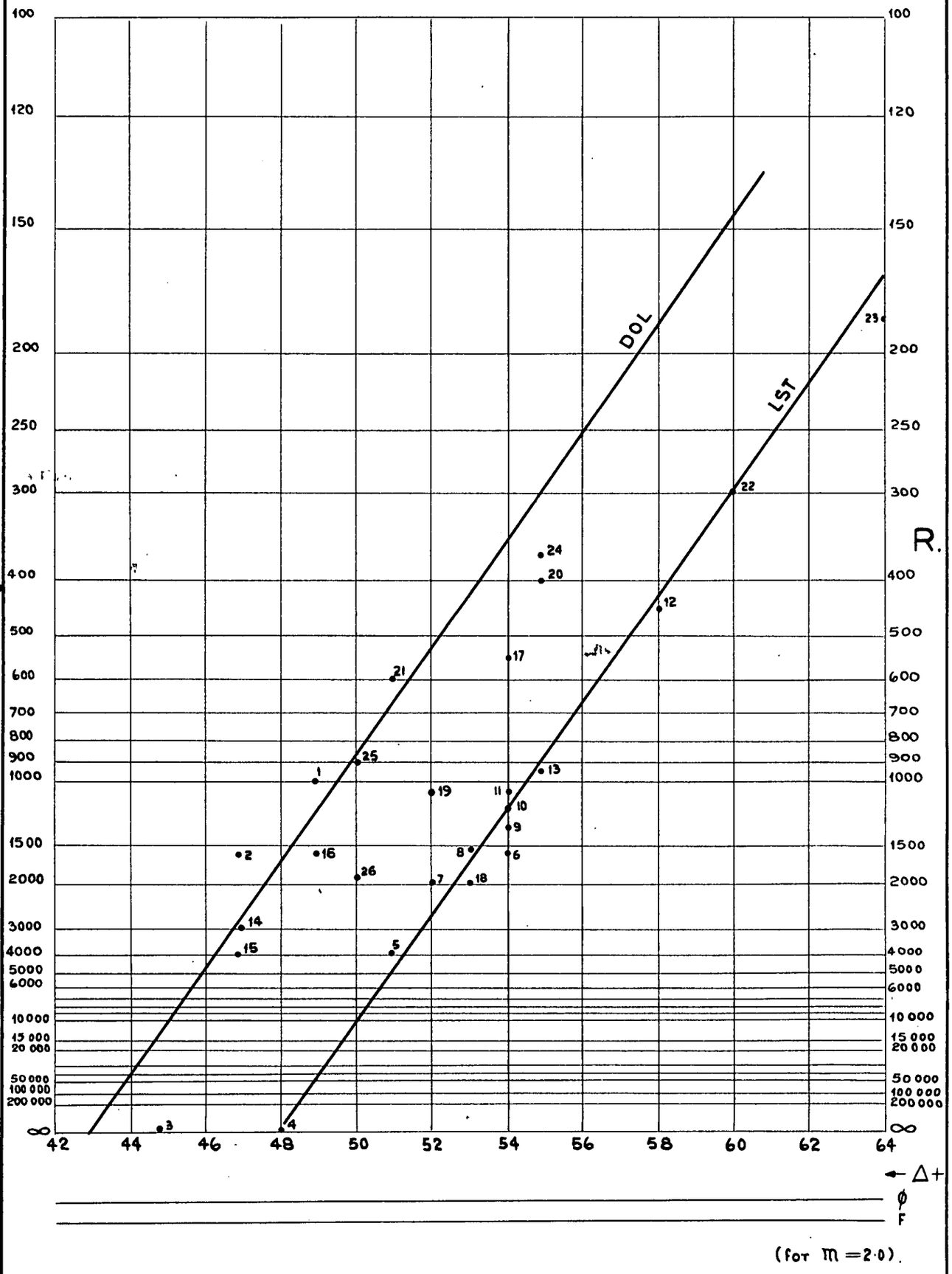
INTERPRETATION OF: B.M.R. No.13

	Depth	Sl	R64	Ø	R64 Corr.	Cuttings Identifi-	Log Identifi-
1.	3260	49	1500	4	1000	Dol	Dol
2.	3235	47	2500	3	1600	Dol	Dol
3.	3190	45		0		Dol	Dol
4.	3150	48		0		Dol	Dol
5.	3100	51	4000	2	4000	Lst/Dol	Lst
6.	2990	54	2500	3	1600	Lst	Lst
7.	2948	52	2500	3	2600	Lst	lst
8.	2820	53	2500	3	1600	Lst	Lst
9.	2800	54	1500	3	1300	Lst	Lst
10.	2735	54	1400	4	1200	Lst	Lst
11.	2520	54	1300	4	1100	Dol	Lst
12.	2440	58	700	6	450	Lst	Lst
13.	2380	55	1000	4	950	Dol	Lst
14.	2180	47	2500	2	3000	Dol	Dol
15.	2150	47	3300	2	4000	Dol	Dol
16.	2120	49	2000	3	1600	Dol	Dol
17.	2102	54	800	6	550	Dol	Dol/Lst
18.	2050	53	2500	3	2000	Dol	Lst
19.	1990	52	1300	4	1100	Dol	Dol/Lst
20.	1960	55	700	7	400	Dol	Dol
21.	1935	51	1000	5	600	Sand	Dol
22.	1835	62	500	8	360	Dol	Lst
23.	1720	64	300	10	180	Dol	Lst
24.	1600	55	600	7	390	Dol	Dol
25.	1496	50	1300	4	900	Dol	Dol
26.	100	50	2000	3	1900	Dol	Dol/Lst

FIG. 6.

BMR. Nº 13. (SANDOVER).

SONIC vs RESISTIVITY.



Bureau of Mineral Resources, Geology and Geophysics. December 1964 F 53/A7/5

To accompany Record No 1964/127

AUSTRALIA 1:250,000

GEOLOGICAL MAP OF SOUTH-WEST GEORGINA BASIN

NORTHERN TERRITORY SF 53 7-12

Reference
QUATERNARY
Q Alluvium
TERTIARY
Ta Arltunga Beds
Unconformity
DEVONIAN
Dud Dulcie Sandstone
Unconformity
MIDDLE ORDOVICIAN
Omn Nora Formation
LOWER ORDOVICIAN TO UPPER CAMBRIAN
€-Ot Tomahawk Beds
CAMBRIAN
UPPER
€ua Arrinthrunga Formation
€u(e) Eurowie Sandstone Member
€u Undifferentiated (Ammaroo Area)
MIDDLE
€ms Sandover Beds
lst. Limestone
sh. Shale
ss. Sandstone
€ma Arthur Creek Beds
LOWER
Mt Baldwin Formation
MOPUNGA GROUP
UPPER PROTEROZOIC
Pug Grant Bluff Formation
Elyuah Formation
Unconformity
Puc Mt Cornish Formation
Unconformity
LOWER PROTEROZOIC
Pld Dneipier Granite
Ple Jervois Granite
Plj Jinka Granite
Plm Marshall Granite
Pls Mt Swan Granite
Plh Hatches Creek Group
ARCHAEAN
Arunta Complex
Aa Undifferentiated
Geological boundary
Anticline showing plunge
Syncline
Fault
Where location of boundaries, folds and faults is approximate, line is broken where inferred queried, where concealed, boundaries and folds are dotted, faults are shown by short deshes.
Strike and dip of strata
Dip < 15°
Trend of bedding
Photo interpretation
Quartz vein
Stratigraphic well
Water-bore
Abandoned well with show of oil and gas
"Lucy Creek" Homestead
Landing ground
Windpump
Road
Vehicle track
NORTHERN TERRITORY
DARWIN
BIRDUM
ALICE SPRINGS
INDEX TO ADJOINING SHEETS
BARROW CREEK
ELKEDRA
SANDOVER RIVER
ALCOOTA
HUCKITTA
TOBERMORY
ALICE SPRINGS
ILLOGWA CREEK
HAY RIVER
DULCIE RANGE
JINKA PLAIN
MT. SANDY
AMMAROO WELL No.1
AMMAROO WELL No.2
BMR No F53/7 A8

Bureau of Mineral Resources, Geology and Geophysics. August 1964.

To accompany Record 1964/127

Scale 1:250,000

Adapted from Huckitta & Elkedra 1:250,000 Preliminary edition 1962.

Geology by: K.G. Smith, J.W. Smith, D.R. Woolley, J.M. Pulley, R.R. Vine, K. Gough, E.N. Milligan, G.F. Joklik, J.R. Stewart.

COMPOSITE WELL LOG

OPERATOR: BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

PETROLEUM TENEMENT: OIL PERMIT 41. WELL NAME AND No: B.M.R. No.13 (SANDOVER)

NORTHERN TERRITORY 1:250,000 SHEET: ELKEDRA BASIN: GEORGINA WELL STATUS: PLUGGED AND ABANDONED

LOCATION - Lat. 21°51'25"S. Long. 136°09'06"E.
ELEVATION - Reference Datum (R.T.) 1063·3' A.S.L.
Ground Level 1055·1' A.S.L.
Date Spudded 15. 1. 64.
Date Drilling Completed 6. 7. 64.
Date Rig Released 21. 7. 64.
Total Depth Driller 3330'
GRN Log 3331'

Hole Size

in.	from	to
12¼	Sfc.	42'
8½	42'	1620'
6¼	1620'	T.D.

Casing

In.	Wt.	Gr.	Depth	Cmt.	Cmt'd To
9⅝	36	J-55	42'	14 sx	sfc.
7	20	J-55	1615'	65 sx	1315' (calc)

Cement Plugs:

From	To	Sacks
3320'	3221'	52
3221'	3012'	42
2900'	2845'	8
1620'	1569'	8
Top 7' Casing		4

Drilling Contractor: W.L. Sides & Son Pty. Ltd.
Well Head Fittings: 3' Riser Pipe with Valve
Logged by: Schlumberger
Drilling Method: Air Hammer & Rotary
Mud logging by: Nil
Lithology by: A.R. LLOYD, R.D. SHAW, R.A.H. NICHOLS, other by: M.D. BELL.

ELECTRIC LOG DATA

SERVICE	SCHLUMBERGER	
LOG TYPE	Electric	S.P. & 16"N
RUN No & SCALE	1 2" & 5"	2 2" & 5"
DATE RUN	10. 3. 1964.	7. 7. 1964.
FIRST READING	1676'	3330'
LAST READING	42'	1615'
INTERVAL MEASURED	1631'	1715'
CASING: E-LOG	42'	1615'
: DRILLER	42'	1615'
DEPTH REACHED	1678'	3331'
BOTTOM DRILLER	1680'	3330'
MUD NATURE	BENTONITE	BENTONITE
DENSITY	1·13	1·10
RESISTIVITY	3·71 92°F.	2·86 72°F.
RESIST. B.H.T.	3·2 109°F.	1·70 115°F.
STANDING WATER LEVEL	85'	85'
BIT SIZE: 1	8½" to 1620'	8½" to 1620'
: 2	6¼" to T.D.	6¼" to T.D.
SPACING AM_1	16"	16"
AM_2	64"	64"
AO	18'8"	18'8"
WEIGHT USED	Nil	Nil
RECORDED BY	P. HUSTEN	D. BAIRD

RADIOMETRIC LOG DATA

SERVICE	SCHLUMBERGER	
LOG TYPE	Gamma	Gamma
RUN No & SCALE	1 2" & 5"	2 2" & 5"
DATE RUN	10. 3. 1964.	7. 7. 1964.
FIRST READING	1670'	3326'
LAST READING	30'	1614'
INTERVAL MEASURED	1640'	1712'
CASING: GRN-LOG	—	1614'
: DRILLER	42'	1615'
MUD NATURE	BENTONITE	BENTONITE
STANDING WATER LEVEL	85'	85'
TIME CONSTANT SECS.	2	2
LOGGING SPEED ft./min.	30	30
STAT. VARIATION ins.		
RECORDED BY	P. HUSTEN	D. BAIRD

SONIC LOG DATA

SERVICE	SCHLUMBERGER	
LOG TYPE	SONIC	SONIC
RUN & SCALE	1 2" & 5"	2 2" & 5"
DATE RUN	10. 3. 1964.	7. 7. 1964.
FIRST READING	1665'	3326'
LAST READING	42'	1614'
INTERVAL MEASURED	1623'	1712'
CASING S. LOG	42'	1614'
CASING DRILLER	42'	1615'
MUD NATURE	BENTONITE	BENTONITE
STANDING WATER LEVEL	85'	85'
RECORDING SPEED ft/hr	4000	1800
BIAS	90	85-90V
RECORDED BY	P. HUSTEN	D. BAIRD

OTHER BORE-HOLE LOG

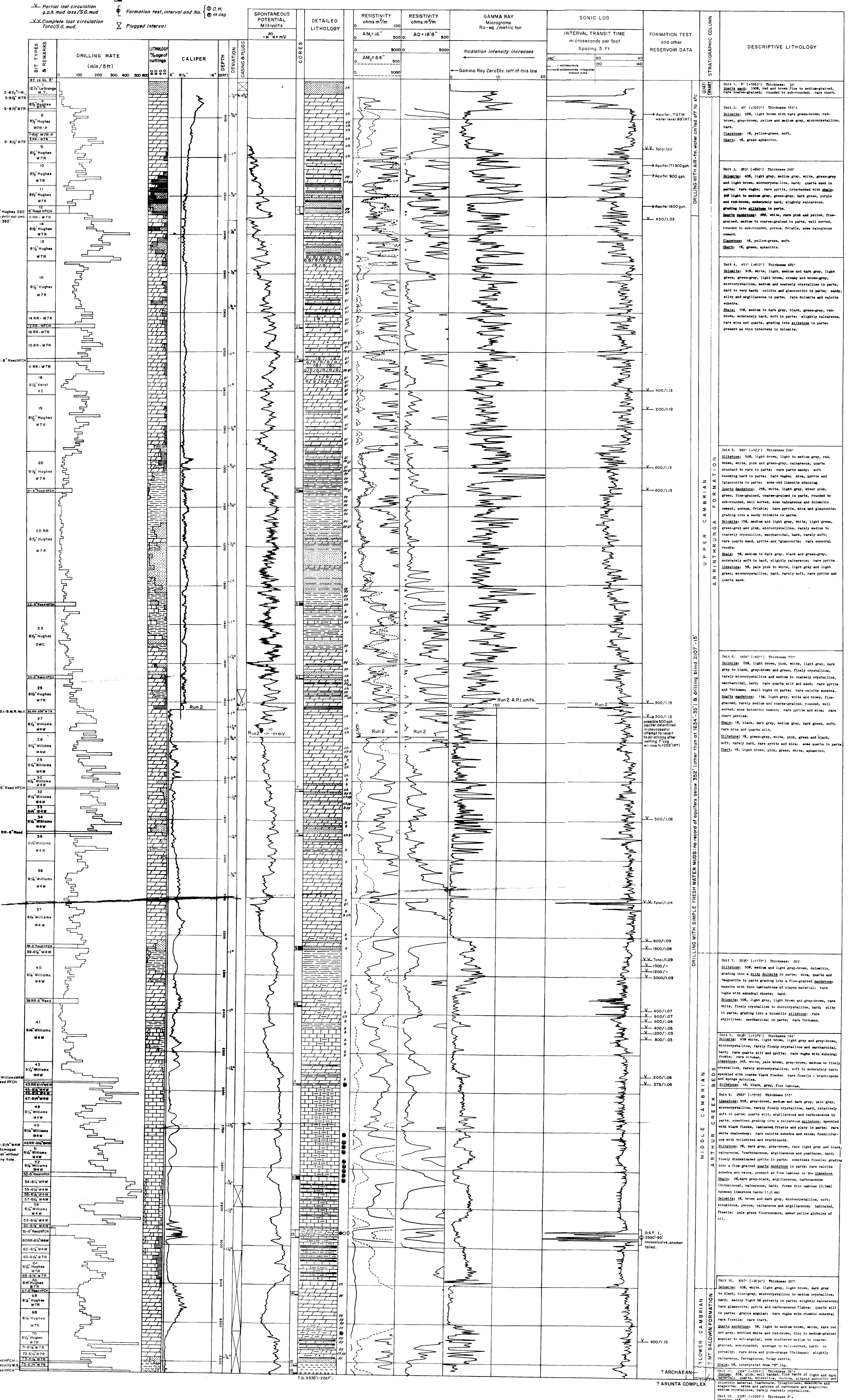
Microcaliper - Schlumberger
Run 1 2" & 5" 1630'-42'
Run 2 2" & 5" 3331'-1615'
Microlog - Schlumberger
Run 1 & 2 - Nil, not recorded
Other logs - Nil

LITHOLOGICAL REFERENCE

Quartz Sandstone — Shale — Siltstone — Dolomite — Oolitic Dolomite — Limestone — Macrofossils
Gneiss — Granite — *py* – Pyrite — *ch* – Chert — *b* – Bitumen — *gl* – Glauconite

WELL SYMBOLS

Small oil and gas show
Flourescence
Partial lost circulation g.p.h. mud loss/S.G. mud
Complete lost circulation Total/S.G. mud.
→ *Formation water*
Core, interval, number and recovery
Formation test, interval and No. { *O.H.* / *in csg.* }
Plugged interval



Bureau of Mineral Resources, Geology and Geophysics. December 1964.

To accompany Records No. 1964/127.

F 53/A7/4

EJ