COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS.

RECORDS.

1960/127

COMPLETION REPORT ON BORE B.M.R. 10A, BEAGLE RIDGE, WESTERN AUSTRALIA.

by

R.A. McTavish

COMPLETION REPORT ON BORE B.M.R. 10A, BEAGLE RIDGE WESTERN AUSTRALIA.

by

R.A. McTavish

RECORDS 1960/127

CONTENTS

APPENDICES

TEXT-FIGURES

PLATES

SUMMARY

B.M.R.10A was drilled to a total depth of 4862 feet to complete the stratigraphic drilling project on Beagle Ridge. Basement dominantly of metamorphic rocks similar to some from the Greenough Block was first encountered at 4794 feet; it is possibly a faulted southern extension of the Greenough Block.

A sequence of Pleistocene, Jurassic, Triassic, and Permian sediments similar to that in B.M.R. 10 was encountered to 3900 feet. Below 3900 feet a sequence of about 900 feet of Permian (Artinskian) sediments comparable to the Artinskian sequence of the Irwin River area lies unconformably on basement. The sequence comprises interbedded siltstone and sandstone gradually passing downwards into a sequence of rapidly alternating sandstones, siltstones, shale, and thin beds of coal. The basal unit consists of an interbedded sequence of siltstone, sandstone, and mudstone, all calcareous in part, and a thin limestone bed.

Definite correlation of the upper and lower limits of the Permian succession are impossible at present, but their Artinskian age is certain.

Beagle Ridge was apparently a positive feature during most of the Palaeozoic, at least, and was not submerged until the Lower Permian (Artinskian-Upper Sakmarian).

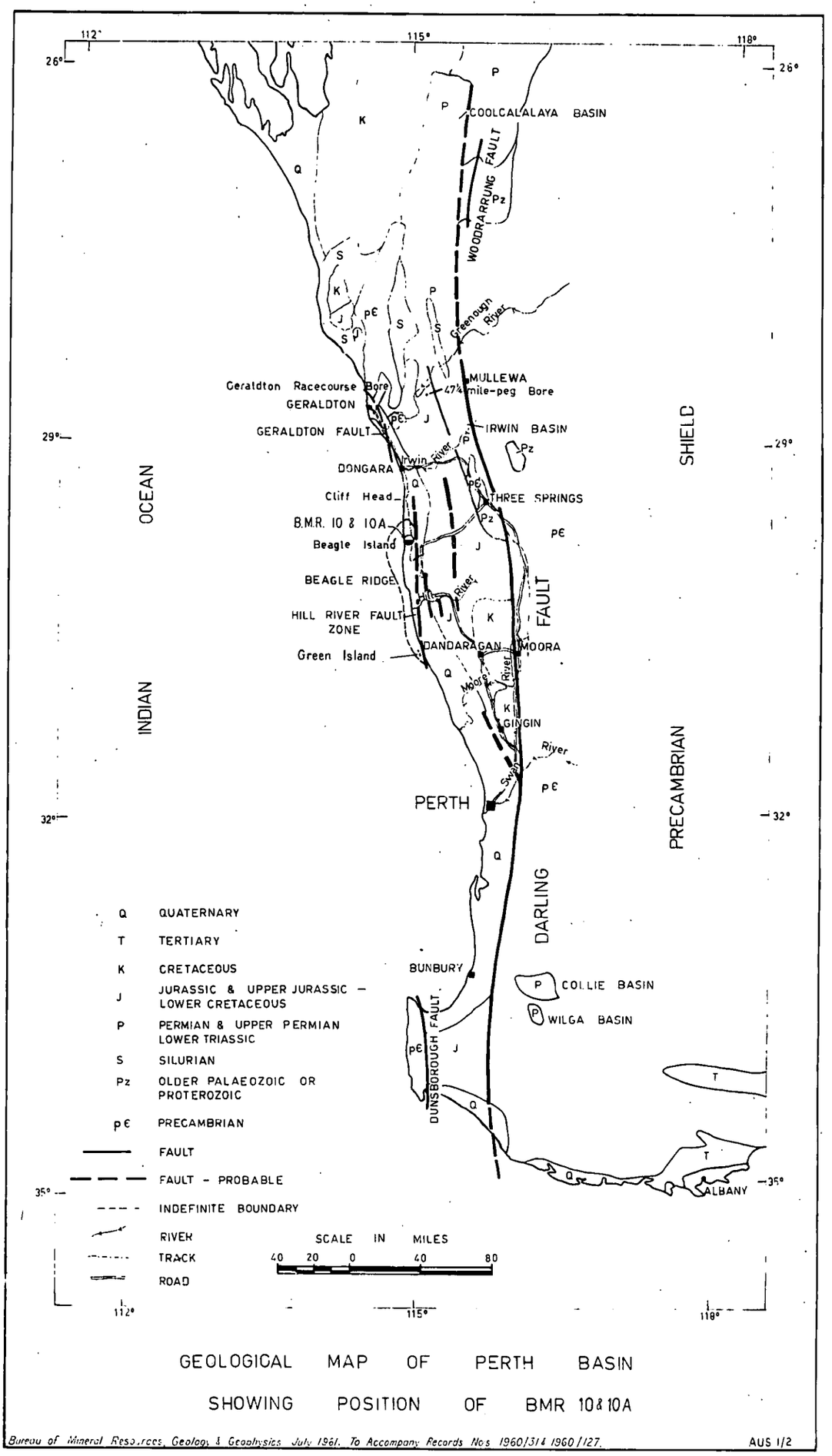
INTRODUCTION

B.M.R. 10 was abandoned before reaching basement because of mechanical difficulties. Therefore, B.M.R. 10A was drilled as a replacement to complete the project of drilling to basement.

In order to introduce as little change in geological conditions as possible and to simplify the rig move, B.M.R. 10A was sited 150 feet north of B.M.R. 10, and about 40 miles south of Dongara at latitude 29°49'36½" South, longitude 114°58'30"East.

The access road used to reach B.M.R. 10A was through Dongara on the Geraldton Highway. The turnoff to the wellsite is about four miles east of Dongara township, at Pell's Bridge; from the turnoff about 43 miles of fair graded earth roads and tracks lead south to the Beagle Ridge. Also there is now an airstrip suitable for light aircraft at Green Head, about 15 miles south of the well-site.

Publication of the results of the water analysis and the proximate coal analysis is by the permission of the Director of the Western Australian Government Chemical Laboratories, Perth.



GEOLOGICAL MAP OF PERTH BASIN

SHOWING POSITION OF BMR 10 & 10A

Bureau of Mineral Resources, Geology & Geophysics. July 1961. To Accompany Records Nos. 1960/314 1960/127. AUS 1/2

A C B

Reduce AB (11") to AC (5½")

WELL HISTORY

Table I.

General Data:

Well Name and Number: Beagle Ridge B.M.R. 10A.

Location: Lat.29°49'36½"S., Long.114°58'30"E.
Co-ordinates - 3,305,600 yards N., 291,660 yards E.

Tenement Holder: West Australian Petroleum Pty.Ltd.,
251 Adelaide Terrace, Perth, Western Australia.

Tenement: Permit to Explore 27H, area 52,000 square miles;
expiry date 22/10/1960.

District: Beagle-Logue, Western Australia.

Total Depth: 4,862 feet.

Drilling commenced: 2nd May, 1960.

Drilling completed: 24th June,1960.

Well Abandoned: 10th July,1960.

Date Rig Released: Midnight 10th July, 1960.

Drilling Time to Total Depth: 53 days.

Elevation: Rotary table 26 feet above mean sea level (datum
for depths)
Surface 15 feet " " "

Status: Abandoned: cement plugs at 3,692 feet, 3,640 feet,
3,241 feet, 2,386 feet, 264 feet, and
surface.

Drilling Data:

Contractor: Oil Drilling and Exploration (W.A.) Pty.Ltd.,
Adelaide Terrace, Perth, Western Australia.

Drilling Plant: National Supply Co., T-20 trailer mounted.

Rating: 4½" drill pipe to 4,000 feet.
3½" drill pipe to 6,000 feet.

Motors: General Motors, Series 6-71, B.H.P. 200.

Mast: Lee C. Moore, cantilever 94 feet, rating 290,000 lbs.

Pumps: (I) National-Ideal C-150-B; size 7¼" x 12";
motor GM series 6-71, 200 B.H.P.

(II) National-Ideal D-50; size 5" x 10";
motor Caterpillar D311.

Blow-Out Preventer: Cameron SS 10", series (A.P.I.) 900.

Hole Size: 17½" to 276 feet.
12¼" from 276 feet to 1620 feet.
8¾" from 1620 feet to 4852 feet.
7⅞" from 4852 feet to 4862 feet.

Casing: 13⅜" x 48 lbs./ft. Range 2 A.P.I. Grade H 40,
set at 276 feet.
9⅝" x 40 lbs./ft. Range 2 A.P.I. Grade J 55,
set at 1616 feet, cut and recovered from 264 feet
during abandonment.

Casing and Cementing Details:

Size:	13⅜"	9⅝"
Setting depth	276'	1616' (see below)
Cemented with: (Number of sacks).	180 @ 115 lbs/cu.ft.	269 @ 115 lbs/cu.ft.
Cemented to: (rise behind Csg.)	Surface	700' (calculated)
Method used:	Plug	Plug

Drilling Fluid: The drilling fluid used in B.M.R. 10A was a bentonite-water mud without weighting material. Treatment consisted of addition of caustic soda and Myrtan (Quebracho equivalent) for viscosity control, and starch and bentonite for water loss control.

Average properties were:

Weight	- 76 lbs./ft.
Viscosity	- 60 secs. (Marsh)
Water Loss	- 11 ccs.
Filter Cake	- 2/32 ins.
pH	- 9
Sand content	- 2%

Details of changes in drilling fluid properties are shown on Composite Log part I (Plate 1).

Water supply: Adequate water supplies were drawn from a shallow water well drilled at the well site.

Perforation and shooting record: There was no perforation or shooting undertaken in B.M.R. 10A.

Plugging Back and Squeeze Cementation Jobs:

Plugs:

3640' - 3680' 25 sacks (Drilled out firm cement from 3627' to 3640').
3240' - 3280' 25 sacks (Drilled out firm cement from 3232' to 3240').
2386' - 2450' 25 sacks
264' 25 sacks (At top of the $9\frac{5}{8}$" casing).
Surface - 11' 10 sacks (In $13\frac{3}{8}$" casing).

Squeeze Cementation:

No squeeze jobs were carried out in B.M.R. 10A.

Fishing Operations:

Two fishing operations were carried out in the drilling of B.M.R. 10A.

The first at 3870 feet was caused by stuck pipe while pulling out of the hole. Diesel oil was spotted around the bit and after $8\frac{1}{4}$ hours the drill pipe worked free and was pulled.

The second fishing job occurred at 4700 feet where the bit stuck while replacing the wash pipe in the swivel. A circulating head was used while repairs were made but on completion of repairs the bit was found to be stuck.

Diesel oil was spotted around the bit and the drill collars. The drill pipe was backed off and washed over. Ten days were spent in washing over and backing off the drill pipe with the string shot method before the complete fish was recovered.

Drilling Data

B.M.R. 10A was drilled for the Bureau of Mineral Resources, Geology and Geophysics by Oil Drilling and Exploration (W.A.) Pty. Ltd. of Perth. The equipment used was a National T-20 rig and a 94 feet high Lee C. Moore mast owned and operated by O.D. & E. Pty. Ltd. The details of the equipment, mud pumps, motors, hole size, etc. are given in the preceding section.

Twelve and one-quarter inch (12¼") hole was drilled to 276 feet, then opened to 17½" to this depth. Thirteen and three-eights inch (13⅜") casing was run and cemented at 276 feet with 180 sacks of cement mixed to a slurry of 115 lbs./cu. ft., and a topplug.

Drilling continued using 12¼" bits to 1150 feet where the bit size was reduced to 8¾" and the drill collars were changed from 7¾" to 6½" O.D., and 8¾" hole was drilled to 2300 feet. The hole size was reduced at 1150 feet to see whether the upper sands from the shoe of the 13⅜" casing to 950 feet would stand up to drilling without being cased off, and to check whether lost circulation zones existed at greater depths. The smaller hole size reduced the volume of cuttings to be lifted as well as allowing for reaming out if difficulties arose.

At 2300 feet it was considered that the danger of bad hole conditions developing was too great and it was decided to run a string of 9⅝" casing.

The 8¾" hole was opened to 12¼" from 1150 feet to 1620 feet. A caliper survey was run but the results were inconclusive.

Casing (9⅝" x 40 lbs./ft., J-55) was run and cemented at 1616 feet with 269 sacks of construction cement mixed to a slurry of 115 lbs./cu.ft. Full returns were received during cementing and displacing.

A temperature survey run 12 hours after cementing indicated that the cement rose to about 1170 feet with some channelling above that point. The calculated rise of the cement was to 700 feet.

Drilling continued with an 8¾" bit to 4852 feet. Between 2400 feet and 3430 feet there was a tendency for the hole to run off, and the drift built up to 3½°. Corrective measures were applied and the drift was satisfactorily controlled. During the drilling of the interval 3800 feet to 4852 feet, two fishing jobs occurred, and are described in detail under 'Fishing Operations' in the preceding section. It is interesting to note that the fishing job at 3870 feet occurred at almost the same depth as that in B.M.R. 10 where the bit became stuck at 3850 feet. This is opposite a water-sand zone of high salinity. In addition, there was a sharp rise in the mud water loss characteristics opposite this zone as well as a rise from 2% to 4% in the sand content. It is possible that the salt water flocculated the water-base bentonite mud to cause the increase in water loss.

The hole was cored with 7⅞" Hughes core head from 4852 feet to the final depth of 4862 feet.

On the completion of drilling, electric, gamma-ray, and caliper logs were run. A velocity survey was conducted, and sidewall cores were taken. Descriptions of these operations appear later in this report.

Before rigging down, the 9⅝" casing was cut and pulled from 264 feet and the hole was bridged and plugged as described in the preceding section of the report.

The well was abandoned on the 10th July by welding a cover plate on the 13⅜" casing. This plate showed the well number, total depth, and the date, 'B.M.R. 10A
T.D. 4862 ft.
10:7:60'.

Ditch Cuttings:

Ditch cuttings were collected at five feet intervals from 600 feet to 2,200 feet and from 3,910 feet to 4,862 feet, during both drilling and coring. Alternate ten feet samples were examined and splits of these samples were sent to West Australian Petroleum Pty.Ltd. and the Geological Survey of Western Australia.

Coring

The coring programme for B.M.R. 10A was ten feet of core to be cut in every consecutive 100 feet of hole drilled below 3,900 feet, with additional cores when required by the wellsite geologist. Fourteen cores were cut using a Hughes Type 'J' core barrel with Hughes $7\frac{7}{8}$" hard formation cutting heads. A total footage of 150 feet was cored for 101 feet recovery.

Two cores above 3,900 feet were cut, at 209-219 feet (Core 1) and 1,565 - 1,585 feet (Core 2), to provide drilling information.

Core 12 (4,691 - 4,701 feet) was cut immediately below core 11 (4,681 - 4,691 feet) which had yielded no core. The core recovery in core 12 may, however, be part of core 11 picked up on the rerun into the hole.

Details of the coring in B.M.R. 10A are presented in Appendix D.

Sidewall Coring

Sidewall cores were taken at 3,210 feet, 3,220 feet, 3,245 feet, 3,273 feet, 3,626 feet, 3,633 feet, 3,640 feet, 3,723 feet, 4,074 feet (two), 4,750 feet, and 4,790 feet with a HOMCO sidewall coring tool. There was no recovery from the core at 3,245 feet.

Description of the sidewall cores are included in Appendix D.

Logging

The logs were recorded by the Bureau of Mineral Resources, Geophysical Branch, on their Failing Logmaster unit as shown below.

Electric Logs

Run I (2,300' to 10') Mud resistivity, 0.925 ohms at 28°C - S.P., Single Point Resistivity, 16" Normal, 63" Normal.

Run II (3,900' to 1,600') Mud resistivity, 1.467 ohms at 16.6°C - S.P., Single Point Resistivity, 16" Normal, 63" Normal.

Run III (4,525' to 3,800') Mud resistivity, 1.02 ohms at 34°C - S.P., Single Point Resistivity.

Run IV (4,862' to 1,600') Mud resistivity, 1.65 ohms at 21°C - S.P., Single Point Resistivity, 16" Normal, 63" Normal.

Gamma Ray Logs

Run I (3,900 to 50'). Run II (4,862' to 20').

Caliper Logs

Run I - misrun. Run II - misrun. Run III - misrun.

Run IV (4,862' to surface) In 9⅝" casing from 1616 feet. Log unsatisfactory because of unreliable recordings.

Drilling Time Records

No detailed drilling time records were kept for B.M.R. 10A, but drilling rates below 3,900 feet were usually between 7 ft./hr and 20 ft./hr.

Formation tests

Formation tests were attempted of the zones between 3200 to 3230 feet and 3610 to 3640 feet using a Johnston Tester. Details of the mechanically successful test are reported in Appendix C.

All attempts to test the zone 3610-3640 feet and the first attempt to testthe 3200-3230 feet zone were mechanically unsuccessful because of the inability to seat the packer in the absence of reliable caliper logs.

Deviation Surveys

Deviation surveys were made at 22 levels using a TOTCO drift indicator. The maximum deviation was 4½° at 3760 feet and 4185 feet.

Appendix E gives the record of the deviation surveys in B.M.R. 10A.

Temperature Logs

Temperature logs were run from 1550 feet to 25 feet and from 4525 feet to 25 feet (see Plates 4 and 5).

The log 1550-25 feet was run 12 hours after cementing, and its temperature gradient was 1°F in 90 feet in 1550 feet.

The log 4525-25 feet was run immediately after pulling out of the hole (about 2 hours after circulation ceased), and its temperature gradient was approximately 1°F in 110 feet. The temperature at 4525 feet was 115°F.

Velocity Survey

A velocity survey of B.M.R. 10A was conducted by Geophysical Services International S.A., William Street, Perth, but the results of this survey are not available yet.

Personnel

Bureau of Mineral Resources staff assigned to B.M.R. 10A were: R. McTavish, geologist (Geological Branch); E. Beever, boring supervisor (Petroleum Technology Section); N. Jackson, logging operator (Geophysical Branch).

S.P. Willmott was the WAPET observer-geologist, and G. Wallace was toolpusher for the contractor, Oil Drilling and Exploration (W.A.) Pty. Ltd.

TABLE II

AGE	FORMATION	Depth	FORMATION TOP Reduced Level	Thickness
Pleistocene	Coastal Limestone	11'	+ 15'	95'
Jurassic	Cockleshell Gully Sandstone	106'	- 80'	1017'
Triassic	Unit 'A'	1123'	-1097'	363'
	Unit 'B'	1486'	-1460'	517'
	Kockatea Shale	2003'	-1977'	1231'
Permian	Unit 'A'	3234'	-3208'	377'
	Carynginia Formation	3611'	-3585'	383'
	Irwin River Coal Measures	3994'	-3968'	671'
	Unit 'D'	4665'	-4639'	129'
Precambrian	Basement	4794'	-4768'	68'
Total	Depth	4862'	-4836'	

GEOLOGY

B.M.R. 10A was drilled to complete the project outlined for B.M.R. 10 - to drill to basement on Beagle Ridge. Therefore no notes on the General Geology pertaining to B.M.R. 10A will be included as these have already been presented in the completion report of B.M.R. 10 (McTavish, 1960), which must be read to supplement the information in this report. Hence, for complete information on the stratigraphic drilling at Beagle Ridge, the reports on B.M.R. 10 and B.M.R. 10A should be read together.

Formations Penetrated in B.M.R. 10A (General)

The section penetrated in B.M.R. 10A to 3900 feet was strikingly similar to that encountered to total depth (3910 feet) in B.M.R. 10 (see McTavish, 1960). The sequence in B.M.R. 10A contains Pleistocene calcarenite unconformable on coarse-grained Jurassic sandstone which passes into a Triassic sequence which grades from fine-grained sandstone, through interbedded siltstone and sandstone, to shale which is calcareous near its base. Disconformable below the Triassic is a thick unit of Permian siltstone which passes into interbedded sandstone and siltstone to 3900 feet. Below 3900 feet the Permian section comprises rapidly alternating sandstone, siltstone, shale and coal beds, overlying a thin unit of dark coloured siltstones, sandstones, and a thin limestone bed, all of which are fossiliferous. At 4794 feet gneiss, which is taken as basement, is found immediately below the limestone bed. Total depth is 4862 feet where the lithology is garnet gneiss.

The succession in B.M.R. 10A (Beagle Ridge) is shown in Table II.

The evidence for the section above 3900 feet in B.M.R. 10A is based mainly on the comparison of the S.P. logs of B.M.R. 10 and B.M.R. 10A to 3000 feet (the maximum depth logged in B.M.R. 10) and the relating of the ditch cuttings below 3000 feet in B.M.R. 10 with the S.P. log between 3000 feet and 3900 feet of B.M.R. 10A.

As already stated, the sections in B.M.R. 10A and B.M.R. 10 are readily comparable, but the formation tops in B.M.R. 10A are generally 25-30 feet deeper below sea level than those in B.M.R. 10. The exceptions to this generalization will be discussed in the explanatory notes concerning the epi-Permian sediments of B.M.R. 10A.

The base of the Coastal Limestone has been placed at 106 feet in B.M.R. 10A on evidence from the gamma ray log.

For two reasons, the top of the Kockatea Shale does not conform with the above generalization. First the Kockatea Shale has been expanded to include Triassic Unit 'C' of B.M.R.10 which comprises interbedded siltstone and sandstone, and contains Lingulids and Kockatea Shale microflora. Also, although the Triassic Unit 'C' has been included in the Kockatea Shale, the top of the Kockatea Shale in B.M.R. 10A is not coincident with the top of Triassic Unit 'C'. Rather, the top of the Kockatea Shale has been raised 27 feet to coincide with the top of a prominent siltstone bed which registers a distinct but small rise in resistivity and marks the top of a series of increased radioactivity recorded on the gamma ray log, and overall decrease in S.P.

Permian

From the description above of the section penetrated in B.M.R. 10A it appears that the Permian sediments of this well can be related readily to the Artinskian sediments of the Irwin River area. However, correlation at formation level is not as simple as it might seem at first. Because some modifications have to be made to the interpretation of Permian Unit 'A' and Permian Unit 'B' the entire Permian section will be considered in this report, although its uppermost 620 feet have been described already, in the report on B.M.R. 10 (Mc Tavish, 1960).

The Permian section in B.M.R. 10A is about 1560 feet thick. It can be divided into four units, but the definition of the boundaries of the units is not always easy. The uppermost unit is dominantly a siltstone with marine fossils in its upper half. Below this unit is a section of interbedded carbonaceous siltstone and sandstone that passes gradually into the third unit, which is a sequence of rapidly alternating sandstone, siltstone, and shale with occasional thin beds of coal. The basal unit consists of a sequence of interbedded dark coloured siltstone and sandstone, both of which are slightly calcareous and fossiliferous, some claystone and a thin limestone bed.

In the following discussion, all cores below 3900 feet are from B.M.R. 10A but above this depth there are cores from both B.M.R. 10 and B.M.R. 10A; hence all cores from above 3900 feet are prefixed by the well number when mentioned.

Permian Unit 'A' (3234'-3611'): This unit consists of black, carbonaceous, slightly micaceous, argillaceous siltstone, pyritic in parts, and poorly bedded, with thin lenticles of light grey, silty, fine-grained sandstone. Slumping is common and fossils are present.

Dickins (Dickins, McTavish and Balme 1961) and Appendix B reports "Chonetes" sp., Strophalosia sp., Permorthotetes? sp., and Neospirifer sp. as well as a conulariid from the upper part of this unit. Worm tubes are also present, and wood fragments have been seen near the base. Microplankton, spores and pollen grains are also present.

The top of this formation can be recognized easily by the marked change in lithology from the Triassic calcareous shale and siltstone to dominantly carbonaceous siltstone containing Permian fossils. In B.M.R. 10A, the top of the Permian Unit 'A' is taken as the top of the bed showing the first rise in S.P. below the thick section of Triassic shale which registers a strikingly uniform S.P. This bed is immediately below the Triassic calcareous bed, which has a high resistivity in contrast to the resistivity of Permian Unit 'A'. There is also a sharp change from the carbonaceous siltstone of this formation to the thick sandstone bed which marks the top of the Carynginia Formation in B.M.R. 10A and shows a high S.P. and resistivity, but very low radioactivity on the gamma-ray log.

Lithologically, this formation is most like the Indarra Beds, but the palaeontological evidence, which suggests an Artinskian age for Permian Unit 'A' does not support correlation with the Indarra Beds; nor does the disconformity between Permian Unit 'A' and the Triassic, for the Indarra Beds-Kockatea Shale Section is apparently conformable. Rather, correlation with the Mingenew Formation or Carynginia Formation is more probable. Both Formations have yielded marine fossils, but to date, with the exception of one indeterminate pelecypod, only microfossils - foraminifera (Crespin, 1958) and microplankton

(Balme in McWhae et al., 1958) have been found in the Carynginia Formation. However, a fauna of megafossils has been found in the Mingenew Formation; brachiopods and pelecypods were identified by Dickins (1956).

The fauna of B.M.R. 10 is sparse and correlation based on it, in the light of our present knowledge of brachiopod distribution in the Perth Basin, would be unsound. Nevertheless, the presence of the megafauna and its composition suggest that, of the Permian formations known from the Perth Basin, the Mingenew Formation has most affinities with Permian Unit 'A'; but the problem of the position of Permian Unit 'A' in the Permian succession of the Perth Basin remains unsolved.

Permian Unit 'A' is 377 feet thick; its distribution is unknown at present in the absence of a definite correlation.

The paucity of its benthonic fauna, the presence of worm-burrows which destroy the bedding, wood fragments, the uniform silty lithology, the high carbonaceous content, and the presence of small-scale slump structures together indicate that the formation was deposited in a shallow water marine environment of restricted circulation perhaps as the bottom set beds of a delta.

The age of this unit has been considered in some detail in Dickins et al. (1960) and Dickins (Appendix B). An age similar to that for part, most likely the lower part, of the Byro Group of Artinskian age has been suggested.

Carynginia Formation (3611' - 3994'): The Carynginia Formation is described by P.E. Playford and S.P. Willmott in McWhae et al. (1958), where it is stated (p.78): "It is characterized by micaceous grey siltstone, with interbedded yellow and white fine-grained sandstone and rare beds of fine conglomerate."

This formation is identified in the bore from 3611 to 3994 feet where it consists of moderately sorted, very fine-to medium-grained, light grey kaolinitic sandstone and quartz greywacke, which is interbedded with black, carbonaceous shale and fissile siltstone. Rare very thin beds of moderately sorted, coarse-grained to very coarse-grained sandstone occur near the base.

Slump structures, contorted laminae, and worm burrows have obscured or obliterated much of the bedding. However, the sandstone appears to be thin-bedded and to show cross-bedding in parts and rare graded-bedding. The graded bed in core 41 of B.M.R. 10 (3810'-3820') is six inches thick and grades upwards from fine-grained silty sandstone to shaly carbonaceous siltstone. Large ditch cuttings have shown grading between the same lithologies, but the magnitude and end products of the grading cannot be determined. A bed of intraformational breccia between 3720' and 3722' in core 40 of B.M.R. 10 contained pebbles (max. 7.5 cms.) of dark shaly siltstone in sandstone. Slickensides are present throughout the formation, but maximum vertical displacement is only about 2.5 cms. Dip is 10° - 15°.

Other than worm burrows and occasional pyritized plant fragments, no megafossils have been found in this formation at Beagle Ridge. However, a single specimen of foraminifera, Hyperammina, has been found in core 40 of B.M.R. 10 (Belford, pers. comm.), and spores are present (Balme, in Willmott, 1959).

The top of this formation corresponds with the top of the uppermost thick sandstone bed (30') encountered in the Permian section of B.M.R. 10 and B.M.R. 10A. This sandstone registers high S.P. and resistivity, and shows a marked decrease in radioactivity. Although the formation is distinct from those above and below it, its base is difficult to distinguish, because of its transitional contact with the Irwin River Coal Measures. Therefore the base has been defined arbitrarily to coincide with the base of the bed immediately overlying the first siltstone above the highest coal seam of the Irwin River Coal Measures.

Because it conformably succeeds the Irwin River Coal Measures; because of its overall lithological aspects; and, finally, because of the quality and quantity of its organic content, this formation is identified with the Carynginia Formation.

For reasons similar to those presented for the interpretations of the environments in which Triassic Units 'A' and 'B' accumulated (McTavish, 1960), it is considered that the Carynginia Formation was deposited in a deltaic environment. In addition, slump structures, contorted laminae, and intraformational breccia, which may be a result of sub-aqueous gliding, indicate that this environment was on the pro-delta slope, and that this formation represents the foreset beds of a delta.

At Beagle Ridge, the Carynginia Formation is 383 feet thick. The formation crops out in the Irwin River area, and near Woolaga Creek it is 846 feet thick.

Because of its position in sequence this unit is Artinskien in age.

Irwin River Coal Measures (3994'-4665'): According to P.E. Playford and S.P. Willmott (in McWhae et al., 1958, p.77), "The Irwin River Coal Measures is a sequence of rapidly alternating siltstone and fine- to medium-grained sandstone, with lenticular coal beds and carbonaceous clay."

At Beagle Ridge, the formation comprises a sequence of rapidly alternating sandstone, siltstone, shale and thin coal beds.

The sandstone is light grey, greyish white, salmon-pink, and buff; kaolinitic, slightly micaceous, slightly carbonaceous, and rarely pyritic (pyrite clots); it is poorly to moderately sorted; fine- to very coarse-grained, and gritty in rare thin beds and laminae; grains are sub-angular to sub-rounded, but some coarse grains show secondary regrowth of quartz. Commonly the sandstone is well-bedded, interlaminated with siltstone, and frequently cross-bedded.

The siltstone and shale are usually dark grey or black, carbonaceous, slightly pyritic, fissile or thin-bedded, and plant bearing.

Black coal first appears at 4010 feet in the ditch cuttings, It is hard, brittle, and sub-bituminous. A sample from core 5 (4115-4125 feet) has been analyzed by the Western Australian Government Chemical Laboratories, Adelaide Terrace, Perth, whose results are presented in Appendix A. During the analysis there were indications that this is a coking coal.

Small scale slump structures (occasional 'snowball whirls' and contorted laminae), worm burrows, rare cut and fill

structures, and graded bedding are also present. The graded bedding is from light grey, very fine-grained sandstone upwards through interlaminated silty shale and sandstone to black carbonaceous shale. As in the Carynginia Formation high-angle slickensides are common, but the maximum displacement appears to be only about 1.5 cms. Dip is 15^{o}-20^{o}.

The top of the Irwin River Coal Measures at Beagle Ridge has been taken as the top of the siltstone immediately overlying uppermost coal seam rather than the top of the sandstone as suggested by Clarke, Prendergast, Teichert, and Fairbridge (1951). As pointed out by Playford G. (1959, p.20), the decision by Johnson, Gleeson, and de la Hunty (1954, p.49) to include the Carynginia Formation with the Irwin River Coal Measures is untenable despite their transitional contact. The selections of the boundary between the Irwin River Coal Measures and the overlying Carynginia Formation both in this report and by Clarke et al. (1951) are arbitrary because of the transitional and apparently conformable contact between these formations. However, the formation top in this report was chosen to coincide with the top of a unit, recognizable on the S.P. log, which includes the youngest coal seam.

This coal-bearing sequence in B.M.R. 10A can be identified readily with the Irwin River Coal Measures because of its age (Artinskian), its rapid changes in lithology, its coal content, and the obvious similarity of its environment of deposition to that proposed for the Irwin River Coal Measures in the Woolaga Creek area (Playford G., 1959).

The environment of deposition of the Irwin River Coal Measures has been considered in some detail by Playford G.(1959) who enumerated several criteria by which he determined the environment. A few of the criteria (rapid alternation of rock types, presence of well preserved plant fossils, absence of marine fossils; evidence of worm activity, assumed presence of primary pyrite, and small-scale cross-bedding) are present in the coal measures of Beagle Ridge. Additional supporting evidence from Beagle Ridge is the presence of small-scale cut and fill structures. Playford concluded that, "The Irwin River Coal Measures are considered to represent a composite fluviatile and paludal deposit, which possibly accumulated as the topset component of a delta."

The only megafossils observed in the Irwin River Coal Measures were leaf impressions, and some worm-tubes near the top of the formation (Core 4, 4010-4020 feet).

In B.M.R. 10A, the Irwin River Coal Measures are 671 feet thick. This formation is also known from the Irwin River area, 60-80 miles north-east of Beagle Ridge, where the type section on the Irwin River near High Cliff is 217 feet thick. At Woolaga Creek, the formation is about 400 feet thick (Playford G., 1959; Playford P.E. and Willmott S.P., in McWhae et al., 1958, p. 77) have stated, "The unit is also believed to be present in the Eradu area, where Permian coal seams with associated sandstones are known from bores. Exposures tentatively referred to the Irwin River Coal Measures are also known from the Greenough River in this area. Further palynological work is necessary to confirm this correlation".

Permian Unit 'D' (4665'-4794'): This unit comprises interbedded dark-coloured siltstone, sandstone, some claystone andrare thin beds of limestone.

The siltstone is dark grey to black, carbonaceous, slightly calcareous, poorly bedded with occasional lighter grey, fossiliferous bands.

The sandstone is dominantly quartz-greywacke; it is grey or grey-white, slightly calcareous, and in parts carbonaceous, generally poorly sorted, fine- (0.1 mm.) to very coarse-grained (1.5 mm.), grains usually sub-angular, but some coarse grains rounded and frosted.

Claystone is present in sidewall core SWC 11 (4750 feet), where it is greenish-grey, calcareous, massive, and soft.

Limestone is prominent only near the base of the formation. It is buff, massive, and fossiliferous, but its fossils are indeterminate. Other thin limestone or calcareous beds can be interpreted in this formation from the resistivity logs, but they are not apparent in the ditch cuttings.

The top of this formation is taken as the top of the first calcareous bed recognizable on the resistivity logs, and its base coincides with the base of the limestone which rests unconformably on the metamorphic basement complex.

Fossils are present throughout the formation and include Spiriferids, and Strophalosia. Worm burrows are present in core 12 (4691'-4701').

The fossil evidence implies a marine environment of deposition for this formation. However, the dark, highly carbonaceous siltstones suggest that restricted circulation may have dominated conditions in at least part of the sedimentation of this formation.

Although this formation conforms well with the definition of the Fossil Cliff Formation in that it contains interbedded siltstone and sandstone, with some limestone, and is fossiliferous, it cannot be identified with the Fossil Cliff Formation. Rather, its fauna appears to be more akin to that of the High Cliff Formation at Woolaga Creek (Dickins, 1957; and Appendix B). However, it must be emphasized that the fossiliferous material available from this unit in B.M.R. 10A is inadequate for definite conclusions concerning its correlation.

The fauna indicates an Artinskian age for this formation.

Basement (4794'-4862')

In B.M.R. 10A a gneissic rock taken as basement was first recognized in core 13 (4803'-4813'). The gamma-ray and S.P. logs indicate that basement was first encountered at 4794 feet.

The basement complex penetrated to total depth (4862') contained granitic augen-gneiss, quartz-feldspar-biotite-garnet schist, and pink and white pegmatite?.

The Precambrian rocks of the southern part of the Greenough Block were discussed by P.E. Playford (1959, p.104), who reported garnetiferous granite gneisses and granulites. Comparison of the metamorphics of B.M.R. 10A with this suite indicates that the quartz-feldspar-biotite-garnet schist may be similar in composition to the garnet gneiss of the Greenough Block, which is approximately 1.1×10^9 years old (Jeffrey, pers.

comm.), but their textures and grain sizes are, of course, different. Also, the augen-gneiss may be similar to the acidic gneisses which grade into granulite in some localities.

Samples of the basement rocks from B.M.R.10A have been sent to Dr. Jeffrey of the Physics Department, University of Western Australia, for radioactive age determination.

With the available evidence, correlation of the basement complex of B.M.R. 10A with part of the Precambrian suite from the Greenough Block is suggested. Also, as basement in B.M.R. 10A is probably composed of part of the 'younger' Precambrian metamorphic complex (1.1×10^9 years) of Western Australia similar to that known from the Greenough Block, it may represent an en-échelon faulted southern extension of the Greenough Block.

Contributions to Geological Knowledge

1. The contributions presented here are based on the evidence from both B.M.R. 10 and 10A. Basement at Beagle Ridge is about 4,800 feet below sea level, is composed of a rock suite dominantly of high-grade metamorphics comparable to those from parts of the Greenough Block, about 60 to 100 miles north of B.M.R. 10A, and is possibly a faulted southern extension of the Greenough Block.

2. The oldest sediments at Beagle Ridge are of Lower Permian (Artinskian) age. Hence it is probable that Beagle Ridge was above sea level during at least the Palaeozoic up to and including the Sakmarian. The submergence of the ridge in the early Artinskian times may have been affected by the eustatic change of sea level accompanying the melting of the continental ice-caps.

3. Sediments of Pleistocene, Lower Jurassic, Triassic, and Permian age were encountered in B.M.R. 10 and B.M.R. 10A. Several interesting points arose concerning the succession encountered in these bores.

(a) From the age determined by palynological studies, the Cockleshell Gully Sandstone at Beagle Ridge appears to be slightly older than any previously known.

(b) A thick Triassic sequence of marine and deltaic sediments previously unknown from the Perth Basin, has been recognized. Although it is unlikely that the entire Triassic is represented in this succession, the strata range in age from Lower Triassic (Scythian) to Upper Triassic.

Two new Triassic units and the Kockatea Shale have been distinguished.

Evidence from the rich marine fauna, which includes the first definite Triassic ammonites found in Australia, enables a Scythian age determination to be made for the Kockatea Shale.

This Triassic sequence will probably be found underlying the Jurassic almost everywhere in the Perth Basin.

(c) Upper Permian sediments appear to be absent from the succession in B.M.R. 10 and B.M.R. 10A. Hence there has been a probable Artinskian- Lower Triassic hiatus which may have been associated with mild tectonic activity.

Apart from this hiatus there is no marked break in sedimentation apparent until the Lower Jurassic - Pleistocene lacuna.

(d) Although the Permian succession encountered in B.M.R.10 and B.M.R. 10A could be associated readily with the Permian of the Irwin River area, precise correlation of the upper and lower limits of the sequence on the basis of the fossil material available is conjectural. The Irwin River Coal Measures at Beagle Ridge are much thicker than those of the Irwin River area and the coal is of a higher rank.

4. Unfortunately the cores were not oriented so it is impossible to determine the direction, true magnitude, and subsequently the full significance of their dips.

Dips of 5^{o} - 10^{o} in B.M.R. 10 have been discussed elsewhere (McTavish, 1960). These dips were considered to be primary structures whose attitudes were determined by the slope of the sedimentary environment with slight modification by tectonism.

Below 3,900 feet in B.M.R.10A dips range from 10^{o}- 20^{o}, and increase with depth. Although the two agencies mentioned above may have been effective in the Permian of B.M.R. 10A, it is likely that tectonism played a greater role than in the younger sediments. Alternatively the uniform decrease in dip upwards may be simply a result of lateral thickening of the units away from the crest of Beagle Ridge.

5. High-angle slickensides with small vertical displacement in many cores from the Kockatea Shale and Permian sediments of B.M.R. 10 and B.M.R. 10A are more likely a result of compaction of the sediments than tectonic activity.

6. During deposition of the Permian and Mesozoic sediments on Beagle Ridge conditions were stable, except for some possible minor tectonism between Artinskian and Lower Triassic times.

REFERENCES

CLARKE, E.de C., PRENDERGAST, K.L., TEICHERT, C., and FAIRBRIDGE, R.W., 1951 - Permian Succession and Structure in the Northern Part of the Irwin Basin, Western Australia. J.Roy.Soc.W.Aust. 35.

CRESPIN, Irene, 1958 - Permian Foraminifera of Australia. Bur.Min.Resour.Aust.Bull. 48.

DICKINS, J.M., 1956 - Fossils from Eradu and Mingenew, Western Australia. Bur.Min.Resour. Aust.Rec. 1956/19. (Unpubl.)

DICKINS, J.M., 1957 - Permian Fossils from Woolaga Creek, Irwin Valley, Western Australia. Bur.Min.Resour.Aust. Rec.1957/110 (Unpubl.)

DICKINS, J.M., McTAVISH, R.A., BALME, B.E., 1961 - The Beagle Ridge Bore. Aust.Oil Gas J. 7, (4).

JOHNSON, W., DE LA HUNTY, L.E., and GLEESON, J.S., 1954 - The Geology of the Irwin River and Eradu Districts and surrounding country. Geol.Surv.W.Aust. Bull.108.

McTAVISH, R.A., 1960 - Completion Report on Bore B.M.R.10, Beagle Ridge, Western Australia. Bur.Min.Resour.Aust.Rec. 1960/31. (Unpubl.)

McWHAE, J.R.H., PLAYFORD, P.E., LINDNER, A.W., GLENISTER, B.F., and BALME, B.E., 1958 - The Stratigraphy of Western Australia. J.geol.Soc.Aust., 4, (2).

PLAYFORD, G., 1959 - Permian Stratigraphy of the Woolaga Creek area, Mingenew District, Western Australia. J.Roy.Soc.W.Aust., 42.

PLAYFORD, P.E., 1959 - Jurassic Stratigraphy of the Geraldton District, Western Australia. J.Roy.Soc.W.Aust. 42.

WILLMOTT, S.P., 1959 - Bureau of Mineral Resources Stratigraphic Bore No.10, Beagle Ridge. Geological Completion Report. Unpubl.rept. for WAPET.

APPENDIX A

A water sample from 25 feet in the Coastal Limestone in a water well approximately 50 yards East of B.M.R. 10A was analysed by the Government Chemical Laboratories of the Western Australian Government. Also, approximate analysis of a coal sample from a 2 inch band between 4115 and 4125 feet in B.M.R. 10A was made by the same organization.

The results of the above analyses are presented below.

(a) Water analysis:

Reaction,	Neutral
pH	7.6

Mineral Matter	Parts per million
Calcium, Ca	162
Magnesium, Mg	188
Sodium, Na	1510
Potassium, K	26
Bicarbonate, HCO_3	394
Carbonate, CO_3	nil
Sulphate, SO_4	296
Chloride, Cl	2740
Nitrate, NO_3	3
Silica, SiO_2	13
Iron oxide, Fe_2O_3 / Aluminium oxide, Al_2O_3	1
Total:	5333

Assumed combination on evaporation at N.T.P.

Calcium carbonate, $CaCO_3$	323
Magnesium carbonate, $MgCO_3$	nil
Sodium carbonate, Na_2CO_3	nil
Calcium sulphate, $CaSO_4$	111
Magnesium sulphate, $MgSO_4$	273
Sodium sulphate, Na_2SO_4	nil
Magnesium chloride, $MgCl_2$	515
Potassium chloride, KCl	50
Sodium chloride, NaCl	3840
Sodium nitrate, $NaNO_3$	4

Hardness calculated as Calcium carbonate

Total hardness	1177
Bicarbonate (temporary) hardness	323
Non-carbonate (permanent) hardness	854
Calcium hardness	404
Magnesium hardness	773

Sample position: from 25 feet in Coastal Limestone in a water well approximately 50 yds. East of B.M.R. 10A.

(b) Coal proximate analysis

Proximate analysis	As received	Dry, ash free
	per cent	
Moisture	6.4	
Ash	9.5	
Volatile matter	31.8	37.8
Fixed carbon	52.3	
	100.0	

	B.t.u. per lb.	
Calorific value	12460	14820

	per cent, dry basis
Ash	10.1

	Colour
	Off white

Indications during the analysis are that this is a coking coal.

Sample position: from 2 inch band between 4115 and 4125 feet in B.M.R. 10A.

APPENDIX B

PERMIAN FOSSILS FROM THE BEAGLE RIDGE BORES B.M.R. 10 and 10A

by

J.M. Dickins

B.M.R. 10

The fossils, consisting of brachiopods and a conulariid can be identified as follows:-

Core 36 (3,300 to 3,310 feet)

Permorthotetes? sp.

Strophalosia sp.A

Neospirifer sp.

Core 37 (3,400 to 3,410 feet)

"*Chonetes*" sp.

Conulariid.

On the basis of further study made since these fossils were reported on in Dickins, McTavish and Balme (1961), it can now be stated that this small fauna is similar to that found in the Mingenew Formation, and the Madeline Formation of the Byro Group, although such a fauna is not necessarily confined to these formations. It is certainly younger than that of the Fossil Cliff Formation on one hand and older than the Upper Liveringa beds (Hardman Member) of the Fitzroy Basin on the other hand. "*Chonetes*" sp. is probably the same species as that occurring in the Mingenew Formation, but at present "*Chonetes*" is not of much value for detailed correlation as the species are long ranging and the ranges are not known accurately. The most interesting species for correlation is *Neospirifer* sp. It is similar to a species which is known only from the Mingenew Formation, the lower part of the Madeline Formation and beds of a similar age on the Lyndon River in the northern part of the Carnarvon Basin. Unfortunately, in the bore, *Neospirifer* sp. is represented only by a single incomplete specimen which is not sufficient for a reliable comparison. Taking the fauna as a whole it has only the less specialized forms characteristic of the lower part of the Byro Group and lacks any of the forms characteristic of the upper part of the group. It seems likely, according to the marine macrofossils, that these beds are correlable with the lower part of the Byro Group.

B.M.R. 10A

Identifiable fossils were obtained only from Core 12 (4,691-4701 feet). These consisted of brachiopods and can be identified as:-

Strophalosia sp. B
Spiriferidae sp. nov.

Strophalosia sp. B is rather sparsely spinose and is similar to an undescribed species which occurs in the Callytharra Formation and in the basal part of the One Gum Formation.

Spiriferidae sp.nov. appears to be the same species as that which is abundant in the basal part of the High Cliff Formation at Woolaga Creek (see Playford: 1959, p.19). Whether

this species occurs lower down in the Fossil Cliff Formation is doubtful.

The occurrence of this species here suggests these beds are to be correlated with the High Cliff Sandstone rather than the Fossil Cliff Formation.

APPENDIX C

Formation Test Report

Well: B.M.R. 10A Test No.: 5 Date: 9th July, 1960.

Object: To test interval 3200' to 3230'

Type of Tester: Johnston Type & Size of Packer: Open-hole $8\frac{3}{4}$" Choke-NIL

Well depth: 4862' Pack off at 3175' Sump at 3234'

Hole diameter: $8\frac{3}{4}$" S.G. of Drilling Fluid: 1.15

Operation

Started run in at 0500 hrs. Completed Run in at 0700 hrs.

Packer set at	3175'
Trip valve opened	0700 hrs.
Retaining valve closed	0708 hrs.
Flow period	0008 hrs.
Shut in period	NIL
Unseated packer at	0708 hrs.
Fluid level in drill stem at	3' above tester
Nature of fluid	drilling mud
Recorder chart	No. 5 satisfactory
Bottom hole temperature	101°F
Bottom hole pressure	1400 p.s.i.

Comments

After tripping valve very slight bubbling observed at surface for half minute. After half minute no flow. Packer unseated after eight (8) minutes. Recorder chart showed that formation had been opened to atmospheric pressure.

APPENDIX D

Core Records

Core No.	Section cored	Recovery	% Recovery	Prog. % Recovery
1	209' - 219'	8'	80	80
2	1565' - 1585'	12'	60	66.6
3	3900' - 3910'	10'	100	75
4	4010' - 4020'	8'	80	76
5	4115' - 4125'	9'	90'	78.3
6	4205' - 4215'	7'	70'	77.1
7	4315' - 4325'	10'	100	80
8	4415' - 4425'	6½'	65	78.3
9	4515' - 4525'	9½'	95	80
10	4610' - 4620'	10'	100	81.8
11	4681' - 4691'	-	-	75
12	4691' - 4701'	4'	40	72.3
13	4803' - 4813'	3'	30	69.3
14	4852' - 4862'	4'	40	67.3
TOTAL	150'	101'	67.3	

Core Specific Gravities

Core No.	S.G.	Lithology
1	2.16	Sandstone
2	2.39	Siltstone
3	2.46	Siltstone/Sandstone
4	(a) 2.49	Carbonaceous Shale
	(b) 2.54	Siltstone/Sandstone
5	(a) 1.29	Coal
	(b) 2.39	Sandstone
6	2.38	Sandstone
7	2.47	Sandstone
8	2.44	Sandstone
9	2.46	Siltstone/Sandstone
10	2.31	Siltstone/Sandstone
12	2.53	Calcareous, carbonaceous Siltstone
13	2.62	Gneiss
14	2.82	Gneiss

Core 1 (209'-219') Recovered 8'

5' - Banded red-brown, brown, and light green-grey Siltstone, arenaceous, slightly micaceous, massive, soft, with occasional thin (2.5 cms.) beds of grey-white, coarse grained, slightly argillaceous Sandstone.

1' - Siltstone grey, micaceous, argillaceous, massive.

2' - Interlaminated, cross-bedded Siltstone/Sandstone. Siltstone dark grey-black, micaceous: Sandstone grey-white, fine-grained (0.2 mm.), argillaceous, friable.

Core 2 (1565'-1585') Recovered 12'

4' - Interlaminated, cross-bedded Siltstone/Sandstone with some graded bedding. Siltstone dark green-grey, micaceous, carbonaceous: Sandstone (quartz greywacke) grey-white, fine- to medium-grained (up to 0.5 mm.), fair sorting, argillaceous, friable.

3' - Shale dark green-grey, and mottled brown and green in parts, massive, carbonaceous, with carbonized plant remains.

5' - Siltstone dominantly green-black, carbonaceous, micaceous, laminated, with very contorted laminae of Sandstone as above, with carbonized plant remains.

Core 3 (3900'-3910') Recovered 10'

4' - Siltstone, black or dark grey, carbonaceous, micaceous, fissile, containing occasional pyritized plant remains, with very thin interbeds of Siltstone grey-white, quartzose, argillaceous. Dissected by talc? slickensides.

2' - Siltstone as above, in contorted laminae, and containing occasional worm-tubes, with Quartz-greywacke grey-white, very fine-grained (0.1 mm.), as infilling in worm-tubes and intercalated between siltstone.

4' - Siltstone grading to fine-grained Quartz-greywacke grey-white, quartzose, interlaminated with Siltstone grey-black, carbonaceous, micaceous. Dissected by small faults (vertical displacement ca. 2.5 cms.). Dip 10° - 15°.

Core 4 (4010' - 4020') Recovered 8'

1' - Shale black, carbonaceous, laminated, with occasional lens dark grey, arenaceous Siltstone and silty Sandstone.

5½' - Interlaminated Siltstone (60) and Sandstone (40), laminae contorted and lenticular. Siltstone black, carbonaceous, slightly micaceous: Sandstone light grey, fine-to very fine-grained (up to 0.1 mm.), as infillings of worm tubes and interlaminae. At 2½' is a six inch bed of grey, medium- to very coarse-grained and gritty (ca. 5.0 mms. maximum) Sandstone.

1½' - Interlaminated Sandstone (90) and Siltstone (10) - Siltstone laminae as discontinuous streaks. Sandstone grey-white, arenaceous, fine- to medium-grained (0.3 mm. maximum): Siltstone grey-black, micaceous, carbonaceous. Dissected by high-angle slickensides. Dip 10°-15°.

Core 5 (4115'-4125') Recovered 9'

4½' - Interlaminated Shale and Siltstone. Shale grey-black, carbonaceous, massive, fissile: Siltstone grey-white, arenaceous, cross-bedded, hard, laminae very thin in top 3' then

thin-bedded in lower 1½', with contorted Shale laminae.

3' - Sandstone with thin interlaminated carbonaceous, silty Shale in three inch beds at 1' and 1½'. Sandstone (top 1') salmon-pink to buff, quartzose, well-sorted, fine-grained, with occasional blebs of carbonaceous shale. (Bottom 2') grey-white, fair sorting, fine- to medium-grained (0.5 mm.), grains sub-angular to sub-rounded, cross-bedded.

½' - Shale as at top of core, with Coal black, vitreous, sub-bituminous, brittle.

1' - Sandstone grey-white, as above, medium-grained, with interlaminated Siltstone black-grey, carbonaceous, with clots of pyrite (ca. 1cm. x 0.5 cm.). Dip 15°-20°.

Core 6 (4205'-4215') Recovered 7'

7' - Sandstone grey-white, arenaceous, well-sorted, fine-grained (0.2 mm.), low porosity, laminated with thin (1-2 mm.) laminae of carbonaceous, micaceous, grey-black Siltstone, cross-bedded. Dip 15°-20°.

Core 7 (4315' - 4325') Recovered 10'

10' - Sandstone grey-white (speckled), kaolinitic, moderately sorted, medium- to coarse-grained (0.4 - 1.0 mm.), sub-angular grains, poorly bedded with occasional discontinuous laminae and angular grit (7.5 mms.) of black carbonaceous Siltstone. Fossiliferous -leaf impressions. Slickensides. Dip 15°-20°.

Core 8 (4415'-4425') Recovered 6½'

6½' - Sandstone grey-white, arenaceous, slightly micaceous, moderately sorted, medium-grained (0.5 - 0.75 mm.), sub-angular to sub-rounded grains, well-bedded with thin beds of interlaminated black, carbonaceous Siltstone and Sandstone as above, cross-bedded, rare pyrite nodules (1.5 cm.) in parts. Fossilferous - leaf impressions. Dip 15°-20°.

Core 9 (4515'-4525') Recovered 9½'

9½' - Interlaminated Sandstone and Siltstone with occasional thin interbeds of Shale and some graded bedding from Sandstone to Shale. Sandstone grey-white, arenaceous, moderately sorted, fine-grained, sub-angular to sub-rounded, well-bedded, with thin laminae of Siltstone and occasional Shale, cross-bedded: Siltstone grey-black, carbonaceous, micaceous, in laminae (occasionally undulose): Shale black, carbonaceous, in laminae and thin beds, with occasional carbonaceous plant remains. High-angle slickensides (Vertical Displacement 1.0 cm.). Dip 15°-20°.

Core 10 (4610'-4620') Recovered 10'

10' - Sandstone grey-white, arenaceous, micaceous in parts, moderately sorted, fine-grained, sub-angular to sub-rounded, well-bedded with thin laminae of Siltstone grey-black, carbonaceous, micaceous, fissile, cross-bedded in part, pyritic - pyrite in frequent clots (0.5-2.0 cms.) and lens (1-7 cms.). Slickensides 45°.

Core 11 (4681' - 4691') No recovery.

Core 12 (4691'-4701')*Recovery 4'.

4' - Siltstone grey-black, carbonaceous, and grey fine-grained, calcareous Sandstone (greywacke), poorly-bedded, with

worm-tubes, and fossils in the calcareous bands.

*Core 11 from 4681'-4691' yielded no recovery, but core 12 may represent part of Core 11 picked up on the rerun into the hole to cut core 12.

Core 13 (4803'-4813') Recovery 3'.

3' - Gneiss granulated, coarse grained augen-gneiss with pink microperthite orthoclase augen up to 4 cms. across, augen sheathed by quartz-feldspar (probably plagioclase and orthoclase) and quartz-feldspar-biotite layers of 2 mm. grain size; rock extensively shattered and sheared, especially along biotite layers, the feldspars are partly kaolinized and the biotites are chloritized.

Core 14 (4852' - 4862') Recovery 4'

2½' - Schist finely laminated, fine-grained garnetiferous quartz-feldspar-biotite schist, grain size ca. 1 mm., some biotite segregated into layers, mafic layers contain some red garnets and a few small patches of copper pyrites.

1' - Quartz-feldspar rock (Pegmatite?) a granular aggregate of very coarse-grained pink feldspar and white quartz, with traces of biotite or chlorite, massive.

½' - Schist as above.

Sidewall Core Descriptions

SWC1 - 3210' - Siltstone, white, quartzose, calcareous, carbonaceous, sugary texture, in part sandy (fine-grained 0.1 mm.) with thin laminae (1.0 mm.) of Shale, light grey-green, arenaceous, massive, soft.

SWC2 - 3220' - Siltstone, as at 3210 feet.

SWC4 - 3273' - Sandstone (Quartz Greywacke), very light green, quartzose, poorly sorted, fine-grained to medium-grained - dominantly about 0.1 mm., grains angular to sub-rounded, matrix approximately 5 0%, argillaceous, with thin bands of Quartz-greywacke, grey-white, otherwise as above, matrix 25%.

SWC5 - 3626' - Sandstone, grey-white, quartzose, well-sorted, fine-grained to medium-grained (0.2 - 0.5 mms.), grains angular to sub-rounded, poorly cemented, soft, moderately porous.

SWC6 - 3633' - Sandstone, as at 3626 feet.

SWC7 - 3640' - Sandstone, as at 3626 feet.

SWC8 - 3723' - Sandstone, light green-grey, very fine-grained, silty, (grains dominantly 0.05 mm. but ranging from 0.1 mm. to less than 0.025 mm.), angular grains quartzose, non-calcareous.

SWC9 - 4074' - Sandstone, grey-white, quartzose, moderately-sorted, fine-grained (0.2 mm.), grains angular, reticulated with veins of carbonaceous Siltstone, interbedded with Sandstone, mottled black and white, carbonaceous, medium-grained to coarse-grained (0.5 - 1.0 mm.), grains angular, carbonaceous grains 60% (include woody fragments and coal), quartz grains 40%.

SWC 10 - 4074' - Sandstone, as in SWC 9.

SWC 11 - 4750' - Claystone, greenish-grey, calcareous, shaly, massive, soft.

SWC 12 - 4790' - Claystone as at 4750' interbedded with Sandstone white, slightly calcareous, moderately sorted, fine-grained, occasional quartz grains to 0.4 mm. Fe-stained in part, sub-angular, and rare green mineral, low porosity.

A sidewall core at 3245 (SWC 3) feet did not yield any core.

A core-analysis of a sidewall core from 4074 feet (SWC 9) by M.C. Konecki of the Petroleum Technology Section, showed a porosity of 33% and a permeability of 432.94 millidarcies at 22°C.

APPENDIX E

DEVIATION RECORDS

"TOTCO"

Depth	Deviation Degrees	Variation
100'	$\frac{3}{4}^{o}$	
200'	$\frac{1}{2}^{o}$	- $\frac{1}{4}^{o}$
550'	$\frac{1}{4}^{o}$	- $\frac{1}{4}^{o}$
777'	$\frac{1}{4}^{o}$	
1009'	$\frac{1}{4}^{o}$	
1150'	-	
1565'	$\frac{3}{4}^{o}$	+ $\frac{1}{2}^{o}$
2161'	$2\frac{1}{2}^{o}$	+ $1\frac{3}{4}^{o}$
2280'	$2\frac{1}{2}^{o}$	
2550'	3^{o}	+ $\frac{1}{2}^{o}$
2700'	$3\frac{1}{2}^{o}$	+ $\frac{1}{2}^{o}$
2843'	4^{o}	+ $\frac{1}{2}^{o}$
2887'	$3\frac{1}{4}^{o}$	- $\frac{3}{4}^{o}$
3095'	3^{o}	- $\frac{1}{4}^{o}$
3430'	$3\frac{1}{2}^{o}$	+ $\frac{1}{2}^{o}$
3760'	$4\frac{1}{2}^{o}$	+ 1^{o}
4000'	$3\frac{3}{4}^{o}$	- $\frac{3}{4}^{o}$
4185'	$4\frac{1}{2}^{o}$	+ $\frac{3}{4}^{o}$
4310'	4^{o}	- $\frac{1}{2}^{o}$
4490'	4^{o}	
4660'	4^{o}	
4800'	4^{o}	

BMR 10a BEAGLE RIDGE
Composite Well Log (Pt.1)

State	Western Australia	Basin	Perth	Area	Beagle I. – L. Logue
Location	Lat. 29°49'36"S. Long. 114°8'30" E	Hole Profile	17-1/2" 11 – 276ft 12-1/4" 276–1620ft 8-3/4" 1620–4862 ft. 7-7/8" 4862–4862 ft.		
Elevation (above S.L.)	Surface 15 ft. Rotary table (depth datum) 26ft.				
Date spudded	2nd May 1960				
Date T.D. reached	24th June 1960	Casing	13-3/8" 12–276ft. 9-5/8" 12–1616ft		
Date completed	10th July 1960				
Total depth	4862 ft.				
Status	ABANDONED	SYMBOL			
Lithology by	R.A. McTavish	Casing	C		

SYMBOLS:
- Limestone
- Sandstone
- Siltstone
- Shale
- Coal
- Basement (Metamorphics)
- Depth of deviation reading ^
- Plug

MUD PROPERTIES

Weight (lbs/c.f.) 6,5 | 7,0 | 7,5 | 8,0 | 8,5 — W
Viscosity (ccs/sec) 3,0 | 4,0 | 5,0 | 6,0 | 7,0 — V
WL (ccs/sec) 5 | 1,0 | 1,5 | 2,0 | 2,5 — WL
Sand (% vol) 5 | 1,0 | 1,5 | 2,0 | 2,5 — S
pH 4 | 6 | 8 | 10 | 12 — pH

BIT RECORD

1. REED T-2 12¼"
2. HTC HPCH 7⅞"
3. Reamed 17½" to 276'
4. REED T-2 12¼"
5. REED T-2 12¼"
6. REED T-2 12¼"
7. REED YT3 8¾"
8. HTC HPCH 7⅞"
9. Reamed 12¼" to 1620'
10. HTC OSG2 8¾"
11. SEC S 6 8¾"
12. REED YT 3 8¾"
13. REED YT 3 8¾"
14. SEC S 4 8¾"
15. REED YT 3 8¾"
16. REED YT3 8¾"
17. SEC S 4 8¾"
18. HTC HPCH 7⅞"
19. SEC S 4 8¾"
20. HTC HPCH 7⅞"
21. REED YT 3 8¾"
22. HTC HPCH 7⅞"
23. REED YT3 8¾"
24. HTC HPCH 7⅞"
25. HTC HPCH 7⅞"
26. HTC HPCH 7⅞"
27. REED YT3 8¾"
28. HTC HPCH 7⅞"
29. REED YT3 8¾"
30. HTC HPCH 7⅞"
31. HTC OSG 2
32. HTC HPCH 7⅞"
33. REED YT3 8¾"
34. HTC HPCH 7⅞"
35. HTC OWV 8¾"
36. HTC OWV 8¾"
37. HTC HPCH 7⅞"
38. HTC OWV 8¾"
39. SEC S 6 8¾"
40. HTC HPCH 7⅞"
41. SEC M4L 8¾"
42. HTC HPCH 7⅞"

DEPTH: 0 Sea Level; 500; 1000; 1500; 20; 2500; 3000; 3500; 4000; 4500

DEVIATION: 3/4° ^ 1/2° ^ 1/4° ^ 1/4° ^ 3/4° ^ 2 – 1/2° ^ 2 – 1/2° ^ 3° ^ 3 – 1/2° ^ 4° ^ 3 – 1/2° ^ 3° ^ 3 – 1/2° ^ 4 – 1/2° ^ 3 – 3/4° ^ 4 – 1/2° ^ 4° ^ 4° ^ 4° ^ 4° ^

Casing & Cementation: 266 13⅜" C 275 180; 9⅝" C 1615 269; 2385; 3241; 3640 below 3662

Percentage LITHOLOGIC LOG

AGE: PERMIAN; P€

T.D. 4862

S WL pH V W

Bureau of Mineral Resources, Geology & Geophysics June 1961 To Accompany Record No. 1960/127

M(B)/3a

BORE BMR 10A BEAGLE RIDGE

COMPOSITE WELL LOG (Pt. 2 A)

STATE: WESTERN AUSTRALIA BASIN: PERTH AREA: BEAGLE I. - L. LOGUE

LOCATION: Latitude 29° 49' 36½"S Longitude 114° 58' 30"E

ELEVATION (above S.L.): Surface 15 ft; Rotary table (depth datum) 26 ft

DATE SPUDDED: May 2nd 1960

DATE COMPLETED: July 10th 1960

DATE T.D. REACHED: June 24 th 1960

TOTAL DEPTH: 4862 ft.

STATUS: Abandoned

LITHOLOGY BY: R.A. M^{C} Tavish

HOLE PROFILE

17-1/2"	11 - 276 feet
12-1/4"	276 - 1620 feet
8 - 3/4"	1620 - 4852 feet
7 - 7/8"	4852 - 4862 feet

CASING

13 - 3/8"	12 - 276 feet
9 - 5/8"	12 - 1616 feet

SYMBOLS

LITHOLOGICAL

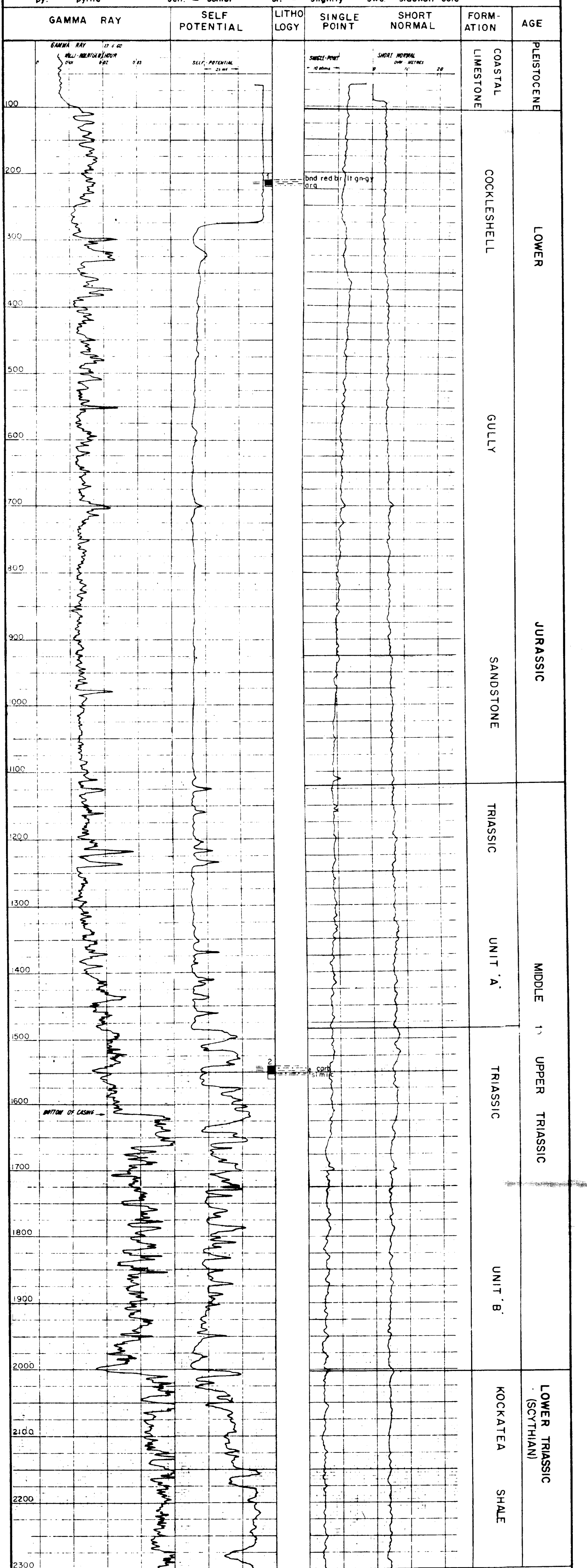
- Limestone
- Calcilutite
- Sandstone
- Quartz Greywacke
- Siltstone
- Shale
- Coal
- Basement Complex

MISCELLANEOUS

- Bedded
- Laminated
- Cross bedded
- Contorted laminae
- Slumped
- Megafossils: Plant; Animal
- Zone of mechanically successful drill stem test
- Core interval core recovery in black
- Dip in unoriented core
- Side core by mechanical methods 10-15°
- with recovery
- without recovery

ABBREVIATIONS

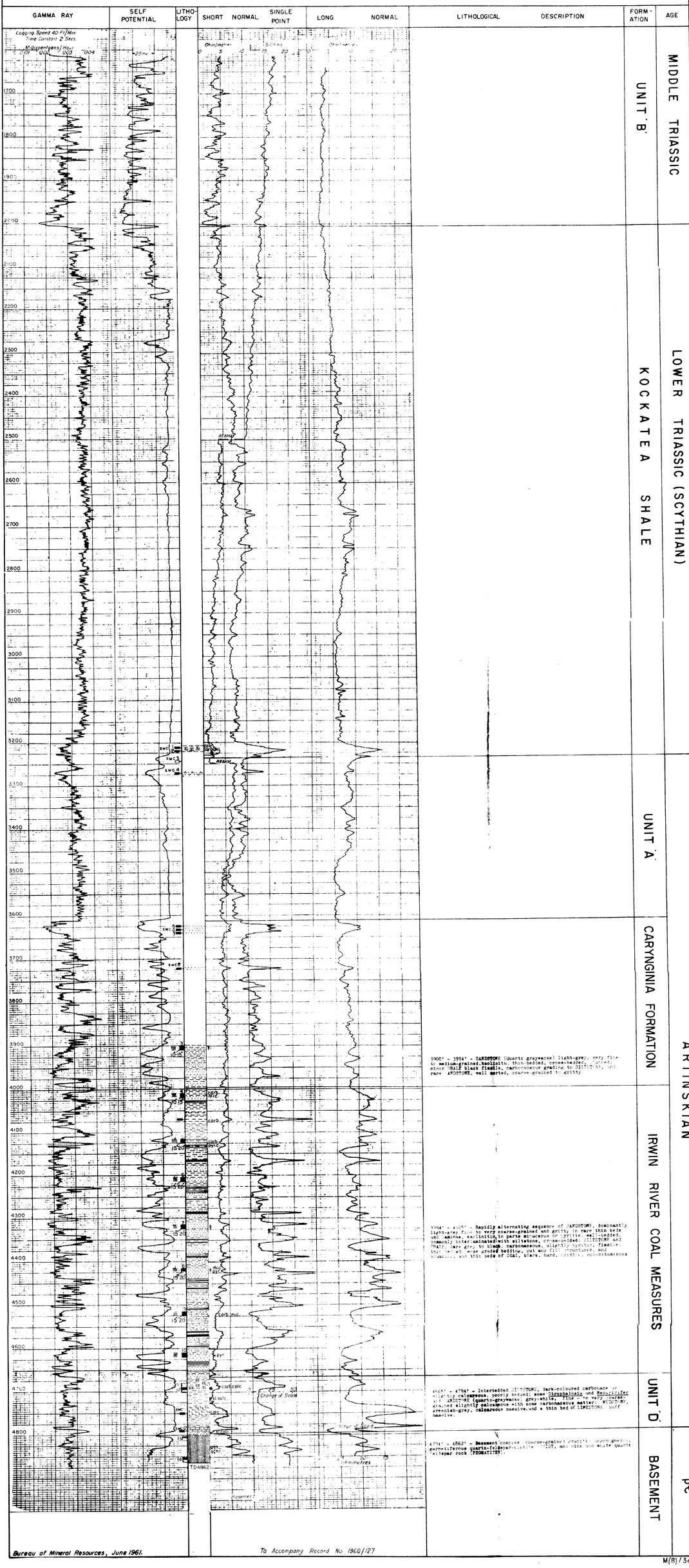
arg. – argillaceous; bnd. – banded; calc. – calcareous; carb. – carbonaceous; c – coal; grn. – green; gry – grey; gns. – gneiss; lt. – light; mic. – micaceous; py. – pyrite; sch. – schist; sl. – slightly; swc – sidewall core



To Accompany Record No. 1960/127

BORE BMR 10A BEAGLE RIDGE

COMPOSITE WELL LOG (PT 2B)



Bureau of Mineral Resources, June 1961.

To Accompany Record No. 1960/127

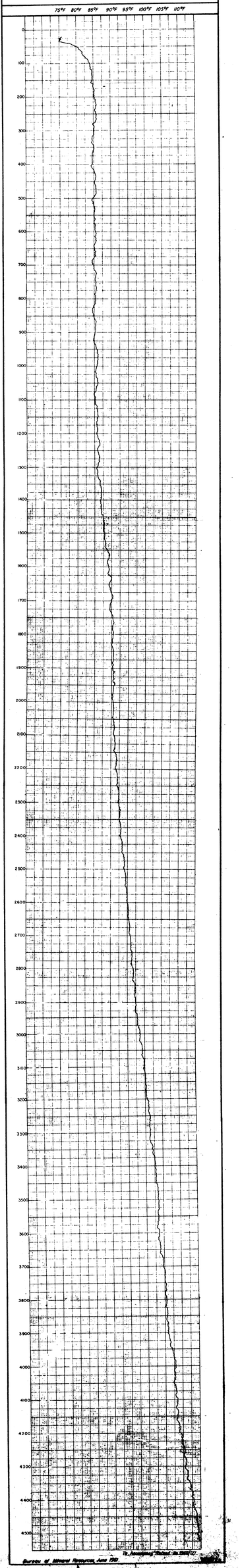
M(B)/3c

B.M.R. 10A BEAGLE RIDGE

TEMPERATURE LOG 1

STATE: Western Australia BASIN: Perth

AREA: Beagle I-L Logue



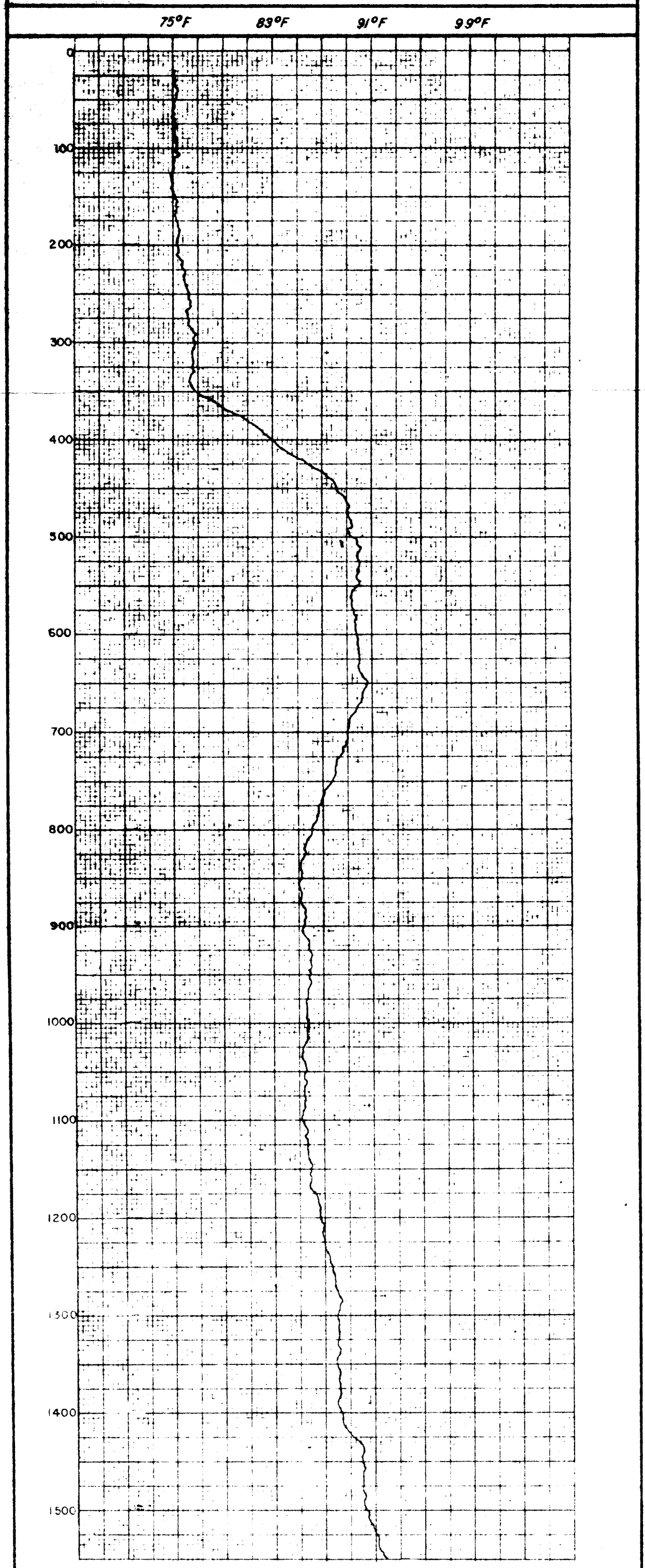
Bureau of Mineral Resources, June 1961.

B.M.R. 10A BEAGLE RIDGE

TEMPERATURE LOG 11

STATE: Western Australia **BASIN: Perth**

AREA: Beagle I - L. Logue



To Accompany Record No 1960/127

Bureau of Mineral Resources, June 1961 M(B) 2b