Report:GS/69/428
OE/3020

AUSTRALIAN AQUITAINE PETROLEUM PTY. LTD.

KEEP RIVER NO. 1

OP.162 Northern Territory

WELL COMPLETION REPORT

OPEN FILE

Compiled by J. P. Caye
Well History by J. Branger, M. Richeux and R. Camp

Australian Aquitaine Petroleum Pty. Ltd.
Perry House,
131 - 145 Elizabeth Street,
BRISBANE QLD.

18th June, 1969

[redacted]

PR69/9H

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I. SUMMARY

Aquitaine Keep River No. 1 was drilled to 15623' in Proterozoic or Devonian sediments in an area about 65 miles North of Kununurra, Western Australia. The well was located on an anticlinal structure probably faulted to the South.

The sedimentary sequence has been divided into formations on electrical log, lithological and paleontological data collected.

Lower Permian fluvioglacial deposits form the initial 1575' of the column, and include a topmost 140' of weathered fine grained sandstones, The sequence is mainly sandstone with minor silty and microconglomeratic variations and thin seams of vitreous friable coal.

Weakly calcareous sandstones of the Upper Visean Tanmurra Formation constitute the following 905' of the sediments unconformably underlying the Lower Permian. There are traces of pure limestone in the sandstone.

There is a substantial thickness of Milligan Formation which is divided into members 1-4, correlating with those of Bonaparte 1 and Kulshill 1.

The member 4 of the Milligan Formation marks the first appearance of substantial methane gas shows.

The Lower Carboniferous Septimus Formation includes calcareous oolitic sandstones and non-calcareous shales rich in crinoid and algae remains. This overlies Tournaisian Enga Burt Range sediments correlating with those found in the Southern Burt Range syncline.

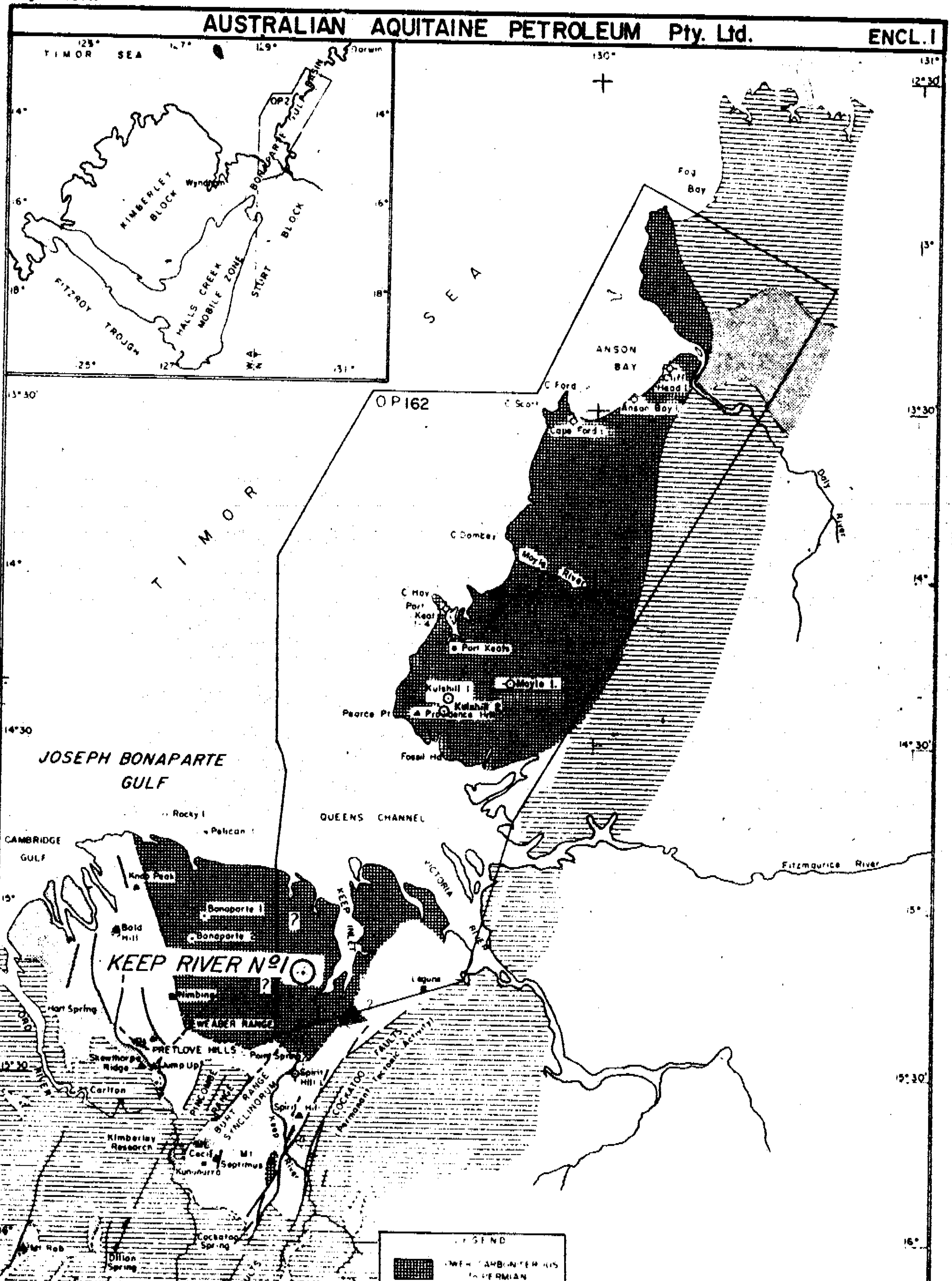
An overall increase in calcaro-dolomitic content from 11620'-12180' marks the Burt Range Formation (Upper Devonian). Famennian reefal facies of the Ningbing Limestone lie directly on Cockatoo Formation or Proterozoic quartzitic basement and constitute the final 3360' of sediment encountered.

Gas shows occured throughout the Lower Carboniferous and to a lesser extent in fracture zones of the Upper Devonian.

Drill stem tests produced a substantial flow of methane.

A total of 25 cores were collected at an average spacing of 600 feet, except where the sequence was monotonous.

Drg. Nº 4671.


AUSTRALIAN AQUITAINE PETROLEUM Pty. Ltd.
ENCL. I
TIMOR SEA
Darwin
KIMBERLEY BLOCK
Wyndham
BONAPARTE GULF BASIN
OP2
STURT BLOCK
HALLS CREEK MOBILE ZONE
FITZROY TROUGH
SEA
Fog Bay
ANSON BAY
C Ford
C Scott
Cape Ford 1
Anson Bay 1
Cliff Head 1
O P 162
TIMOR
C Dombey
Moyle River
C Hay
Port Keats
Kulshill 1
Moyle 1
Kulshill 2
Pearce Pt
Providence Hill
Fossil Hd
Daly River
JOSEPH BONAPARTE GULF
Rocky I
Pelican I
QUEENS CHANNEL
CAMBRIDGE GULF
Knob Peak
Bonaparte 1
Bonaparte 2
Bold Hill
KEEP RIVER Nº 1
KEEP INLET
VICTORIA RIVER
Fitzmaurice River
Laguna
Hart Spring
Nimbing
WEABER RANGE
PRETLOVE HILLS
Point Spring
Spirit Hill
Skewthorpe Ridge
Carlton
BURT RANGE SYNCLINORIUM
COCKATOO FAULTS
Kimberley Research
Cecil
Kununurra
Mt Septimus
Keep River
Cockatoo Spring
Dillon Spring
Mt Rob
LEGEND
LOWER CARBONIFEROUS To PERMIAN
UPPER DEVONIAN To LOWER CARBONIFEROUS
CAMBRIAN To ORDOVICIAN
PROTEROZOIC
0 10 20 40 60 Mls.
Scale in miles

The significant information gained from the drilling of Keep River No. 1 includes the following:

- Discovery of a much thicker Paleozoic sequence than anticipated; due mainly to increase in the Lower Carboniferous sediments, by the presence of the Septimus Burt Range Formations not encountered in Bonaparte well No. 1.
- Confirmation of Keep River being a high zone by the discovery of a Famennian reef, similar to that of the Ningbing sub-basin.
- Methane all along the Member 4 of the Milligan Formation and in the Septimus - Burt Range Formations.

II. INTRODUCTION

Aquitaine Keep River No. 1 was drilled during the period 3rd September 1968 - 23rd February, 1969 with further logging and testing completed by 22nd March. Drilling was intended to begin early in June but unseasonable heavy rain in May and July delayed the spudding in to 3rd September and obliged drilling through the wet season. Special arrangements had to be undertaken such as the construction of a large airstrip, a fuel storage of significant size, etc. etc.

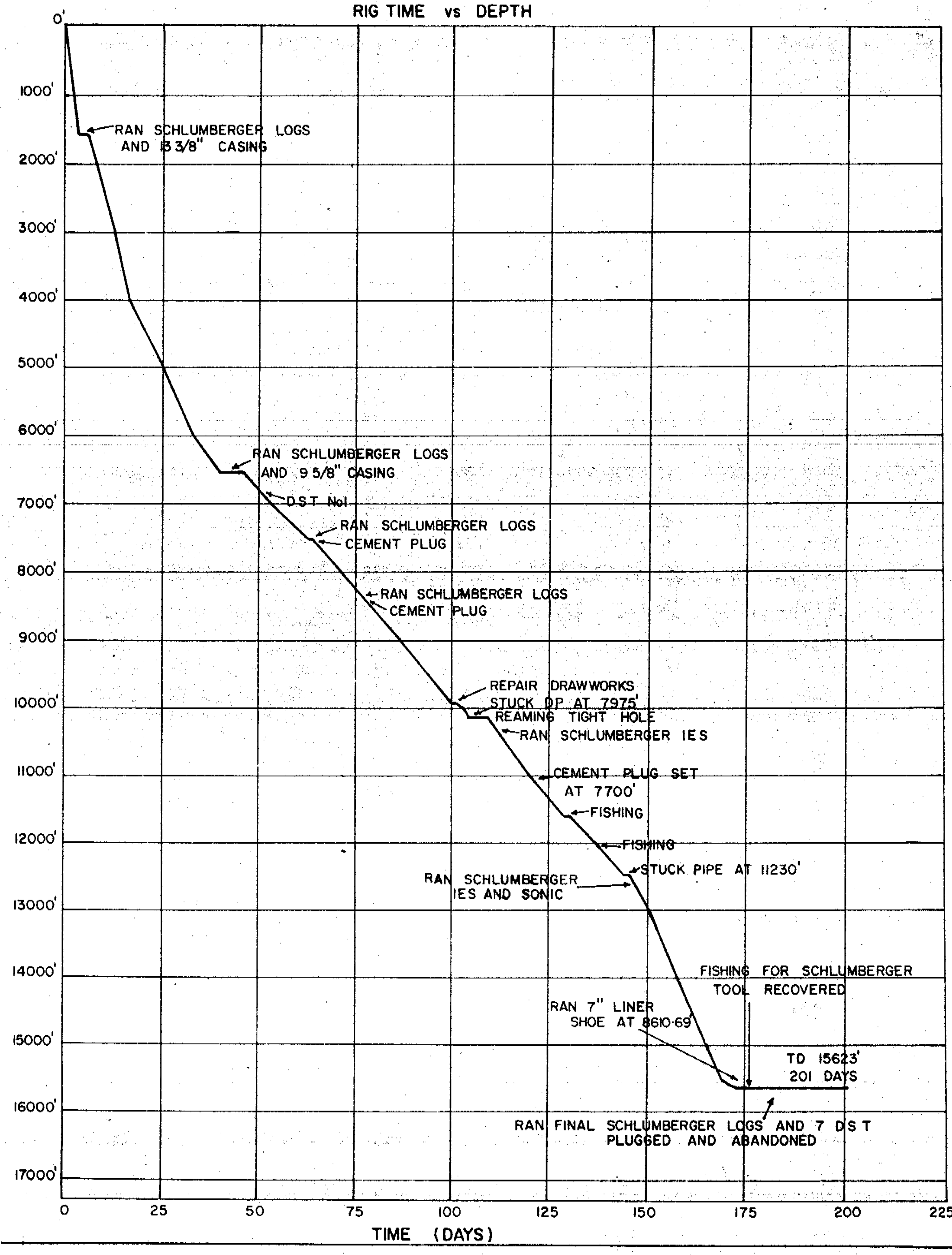
The purpose of this well was to investigate Lower Carboniferous and Upper Devonian sequences known in the Bonaparte Gulf Basin and to test the hydrocarbon potential of these sediments.

The Keep River structure has been defined by Geophysical evidence as an anticline faulted to the South.

The Paleozoic sediments directly overlying the Cockatoo Formation or Proterozoic basement were thought to be at least 12000' in thickness, based on seismic reflection (1900 milliseconds two way time) and refraction (marker 20000' per second velocity). However an additional 3360' of tight limestone was encountered giving a total depth of 15623'.These limestones having a ligh velocity of 22000' ft/sec. had originally been misinterpreted as the basement.

Enclosure 2.

AUSTRALIAN AQUITAINE PETROLEUM PTY LTD
KEEP RIVER No1
RIG TIME vs DEPTH



III. WELL HISTORY.

(1) General data.

(a) Well name and number:	KEEP RIVER No.1.
(b) Name and address of operator:	Australian Aquitaine Petroleum Pty.Ltd., Perry House, 131-145 Elizabeth Street, BRISBANE, Qld. 4000.
(c) Name and address of tenement holder:	Australian Aquitaine Petroleum Pty.Ltd., Perry House, 131-145 Elizabeth Street, BRISBANE, Qld. 4000.
(d) Details of Petroleum tenement:	Oil Permit 162 -(Onshore part) issued on 21st December 1967.
(e) District:	Port Keats.
(f) Location (co-ordinates):	Latitude: 15° 10' 05" S Longitude: 129° 05' 22" E
(g) Elevation - ground:	75'
- rotary table:	91'
(h) Total depth:	15,623'.
(i) Date drilling commenced:	3.9.1968.
(j) Date total depth reached:	23.2.1969.
(k) Date well completed:	22.3.1969.
(l) Date rig released:	22.3.1969.
(m) Drilling time in days to total depth:	173 days.
(n) Status:	Plugged and abandoned, with 9.5/8" spool left.
(o) Total cost according to cost control:	$A.1,505,000.00

(2) Drilling Data.

(a) Name and address of drilling contractor:	Oil Drilling & Exploration (W.A.)Pty.Ltd., 196 Adelaide Terrace, PERTH, W.A. 6000.

(b) Drilling plant.

Make:	Ideco.
Type:	Super 7 - 11.
Rated capacity with 5" drill pipe:	17,000' with 5" drill pipe.
Motors:	3
Make:	Caterpillar.
Type:	D398 A - TAC.

(c) Mast.

Make:	Ideco.
Type:	Full view.
Rated capacity:	1,015,000 lbs. (580,000 lbs 6 lines (650,000 lbs 8 lines (710,000 lbs 10 lines.

(d) Pumps: (Two)

- Make:	Ideco.
- Type:	MM 1000 F
- Size:	$7\frac{1}{2}$ x 16

Pump Motor.

- Make:	Caterpillar.
- Type:	750 HP

(e) Blowout preventer equipment.

(1) Make:	Hydril GK
Size:	13.5/8"
Series (A.P.I.)	5000
(2) Make:	Shaffer.
Size:	Type E 13.5/8" double gate.
Series (A.P.I.)	5000.

(f) Hole sizes and depths:

$17\frac{1}{2}$" to 1576 ft.

$12\frac{1}{4}$" to 6534 ft.

$8\frac{3}{4}$" & $8\frac{1}{2}$" to 15,623 ft.

(g) Casing details.

Size:	13.3/8"	9.5/8"	7" Liner.
Weight:	54.5 lbs/ft.	(40 lbs/ft. (36 lbs/ft.	29 lbs/ft.
Grade:	J.55	(N.80 (J.55	N.80
Range:	2	2	2
Setting depths:	1557 ft.	6519 ft.	8610 ft.

Casing cementing details.

Size:	13.3/8"	9.5/8"	7" Liner
Setting depth:	1557 ft	6519 ft.	8610 ft.
Quantity cement:	60 tons	58 tons	31 tons.
Cemented:	to Surface	to 5400'	to 8250' and from 7740' to 6770'
Method used:	Plug	Plug	Plug and cement retainer.

(h) Drilling Fluid.

Type:	Lignosulfonate.
Average S.G.	1.20
Treatment:	Weight controlled by Barytes Water Loss controlled by CMC Viscosity controlled by XP20. Spersene and CC16, Q.Broxin.

Properties - Average Weekly Analysis:-

Week.	Weight. (S.G.)	Viscosity. (V/M)	Filtrate.	Ph.	Cake. ins.
1.	1.13	43	16	NO READINGS.	
2.	1.15	43	7.8	11.9	2/32
3.	1.23	60	6.1	9.4	2/32
4.	1.25	74	7.0	9.0	2/32
5.	1.24	75	7.3	8.8	2/32
6.	1.24	81	7.5	9.0	2/32
7.	1.14	51	11.9	10.5	2/32
8.	1.13	55	8.7	10.9	2/32
9.	1.13	67	8.8	11.0	2/32

Properties - Average Weekly Analysis (Continued):-

Week.	Weight. (S.G.)	Viscosity. (V/M)	Filtrate.	Ph.	Cake. ins.
10.	1.07	95	5.2	10.1	2/32
11.	1.07	71	6.5	9.5	2/32
12.	1.09	68	7.5	10.0	2/32
13.	1.07	71	7.9	9.6	2/32
14.	1.10	100	6.9	9	2/32
15.	1.11	120	5.1	8.5	2/32
16.	1.11	149	4.2	8.7	2/32
17.	1.14	158	4.3	8.7	2/32
18.	1.18	135	5.3	9.8	2/32
19.	1.20	125	5.2	9.6	2/32
20.	1.20	127	4.1	9.5	2/32
21.	1.20	117	3.8	9.5	2/32
22.	1.20	120	4.8	9.4	2/32
23.	1.21	123	5.1	9.7	2/32
24.	1.22	128	5.3	9.6	2/32
25.	1.21	115	5.1	9.2	2/32
26.	1.21	104	4.6	9.5	-
27.	1.21	90	6.9	10.0	-
28.	1.20	80	NO READINGS.		-
29.	1.20	55	NO READINGS.		-

(i) Water Supply: Two water wells were drilled on well site.

(j) Perforation and shooting record:

Run No.1	4 shots at 7740' for cementing job.
Run No.2	180 shots from 7510' to 7600' for testing job. (90 ft.)
Run No.3	48 shots from 7177' to 7235' for testing job. (58 ft.)
Run No.4	72 shots from 6443' to 6479' for testing job. (36 ft.)
Run No.5	40 shots from 6174' to 6200' for testing job. (26 ft.)

(k) Plugging:

Plugging, to control losses.

(1) Length and type of plug:	217 ft. (from 7360' to 7577')
Quantity of cement:	150 sacks construction cement.
Method:	Conventional displacement, then drilled out.
(2) Length and type of plug:	282 ft. (from 8012' to 8294')
Quantity of cement:	210 sacks construction cement.
Method:	Conventional displacement, then drilled out.
(3) Length and type of plug:	485 ft. (from 7500' to 7985')
Quantity of cement:	210 sacks construction cement.
Method:	Conventional displacement, then drilled out.

Plugging at completion.

(1) Type:	Cement plug.
Length:	315 ft (from 13720' to 13405')
Quantity of cement:	120 sacks Class E.
Method:	Conventional displacement. Tested at 65000 lbs.
(2) Type:	Cement plug.
Length:	200 ft. (from 11200' to 11000')
Quantity of cement:	80 sacks cement Class E.
Method:	Conventional displacement.
(3) Type:	Cement plug below cement retainer Halliburton SDC.
Method:	Combined with liner 7" cementing job through perforation. Depth of perforation 7740 ft. Depth of cement retainer 7655 ft.
Length:	85 ft.
Quantity of cement:	450 sacks construction cement.
(4) Type:	9.5/8 Baker Mercury Bridge Plug Model K.
Depth:	6500 ft.
Method:	Wire Line.

Plugging at completion. (Continued).

(5) Type: Cement Plug.
Length: 230 ft. (from 6500' to 6270')
Quantity of cement: 100 sacks Class E.
Method: Conventional displacement.

(6) Type: 9.5/8" Baker Mercury Bridge Plug Model N.
Depth: 6250'.
Method: Wire Line.

(7) Type: Cement Plug.
Length: 300 ft. (from 6200' to 5900')
Quantity of cement: 150 sacks Class E.
Method: Conventional displacement.

(8) Type: Cement Plug.
Length: 300 ft. (from 1000' to 700')
Quantity of cement: 150 sacks Class E.
Method: Conventional displacement.

(1) Fishing Operations:

(1) 15th, 16th and 17th December,1968. Stuck at 7975' during reaming.
Spot fuel oil, first 30 bbls., then 55 bbls.; string free but stuck again at 8330'.
Spot another 45 bbls. fuel oil: string free.

(2) 8th January,1969. While drilling at 11607' 2 cones were lost.
5 fishing runs were required to clean the hole:

Run No.1	Ran with bit plus Junk Sub.
Run No.2	Ran with Magnet plus Junk Sub.
Run No.3	Ran with bit plus Junk Sub.
Run No.4	Ran with mill plus Junk Sub.
Run No.5	Ran with bit plus Junk Sub.

(3) 19th January 1969. While drilling at the depth of 12066 ft.
1 leg of bit was broken off.
Two fishing runs were required to clean the hole.

Run No.1	Ran with bit plus Junk Sub.
Run No.2	Ran with Junk Basket plus Junk Sub.

(4) 23rd January,1969. Pipe stuck at 11230 ft.
Pump 30 bbl. fuel oil - no success - then 12 bbl. acid - string released.

(5) 24th January,1969. After instrumentation on the 23rd January, 4 runs were required to clean the hole:-

Run No.1	Ran with Junk Basket and Junk Sub.
Run No.2	Ran with bit plus Junk Sub.
Run No.3	Ran with Junk Mill plus Junk Sub.
Run No.4	Ran with Magnet plus Junk Sub.

(6) 27th February,1969. During Schlumberger operations lost tool Gamma Gamma at 8450 ft. Two fishing runs were required to pull out the gamma gamma.

(7) 8th March,1969. Whilst running in 9.5/8" Baker Plug with Schlumberger wire line stuck at 8370 ft. two runs were required, one to cut wire line and a second one to push down the plug.

(m) Side Tracked Hole: None.

(3) Logging and Testing:

(a) Ditch cuttings:

Method of sampling: Samples collected from shaker, washed, dried and stored in labelled polythene bags.

Interval: Every 10 feet.

Repositories:

(1) B.M.R. Core and Cuttings Laboratories,
Fyshwick,
Canberra, A.C.T.

(2) Director of Mines,
N.T.Administration,
Darwin, N.T.

(3) Arco Limited,
Associated National House,
8-12 Bridge Street,
Sydney, N.S.W.

(4) S.N.P.A.Centre de Recherche,
Chemin Micouleau,
PAU 64,
France.

(5) Australian Aquitaine Petroleum Pty.Ltd.,
Perry House,
131 Elizabeth Street,
Brisbane, Qld.

(b) Coring:

(i) Total number of cores cut:-

- before setting 13.3/8" (17½" hole) 1 core.
- from 1603' to 6387' (12¼" hole) 6 cores.
- from 6387' to total depth (8½" hole) 18 cores.

Total 25

Footage cored: 240.75 ft.

Recovered: 225.70 ft. Average recovery 93%

Equipment used: 1 Christensen Core Barrel 6¾"x4"x60' (1) C.9 8.7/16" Core Bit.
(1) C.8 8.7/16" " "
1 Christensen Core Barrel 5¾"x3½"x60' (1) C.8 8.15/32" " "
(1) C.8 8.7/16" " "
(1) C.9 8.7/16" " "
1 Christensen Core Barrel 4¾"x2.5/8"x60' (1) C.20 5.15/16" " "
(2) C.9 5.15/16" " "
(2) C.8 5.15/16" " "

Core No.	Interval Cored.	Feet Cut.	Recovery (feet)	Recovery %.
1	1603' - 1623'	20	14.8	74
2	2221' - 2241'	20	12.6	63
3	3038' - 3052'	14	13.6	96
4	4037' - 4047'	10	10	100
5	5018' - 5028'	10	10	100
6	6052' - 6055'	3	3	100
7	6387' - 6400'	13	13	100
8	6708'6"- 6712'	3'6"	3'6"	100
9	7477' - 7486'	9	9	100
10	8171' - 8176'6"	5'6"	5	90
11	8924' - 8934'	10	10	100
12	9907' - 9917'	10	10	100
13	10451' - 10462.8'	11.8	11.8	100
14	10200' - 10206'	6	6	100
15	11462' - 11476'	14	14	100
16	12066' - 12068'	2	2	100

(b) Coring (Continued).

Core No.	Interval Cored.	Feet Cut.	Recovery (feet).	Recovery %.
17	12251' - 12254'	3	3	100
18	12875' - 12888'	13	13	100
19	13469'6" - 13472'	11.5	11.5	100
20	13995' - 14006'	11	11	100
21	14572' - 14584.1	12.1	12.1	100
22	15139' - 15154'	15	14.6	97
23	15574' - 15578'	4	3	75
24	15614' - 15617'3"	3'3"	3'3"	100
25	15617'3" - 15623'	5'9"	5'9"	100

(ii) Repositories of core material.

(1) B.M.R. Core and Cuttings Laboratories, address as aforementioned.

(2) Director of Mines, N.T. Administration, Darwin, N.T.

(3) S.N.P.A. Centre de Recherche, address as aforementioned.

(c) Sidewall Sampling: None.

(4) Logging and surveys:

(a) Electrical and other logging (Schlumberger).

Induction Electrical Log:	Run No.1	1578' - 30'
	Run No.2	6527' - 1557'
	Run No.3	7039' - 6522'
	Run No.4	8366' - 6523'
	Run No.5	10445' - 8150'
	Run No.6	12613' - 10240'
Sonic Log:	Run No.1	1568' - 30'
	Run No.2	6025' - 1557'
	Run No.3	8358' - 6523'
	Run No.4	12605' - 8140'
	Run No.5	15610' - 12500'
Gamma Ray and Formation Density:	Run No.1	1576' - 50'
	Run No.2	6034' - 1557'

(a) Electrical & other logging - Schlumberger. (Cont'd.)

Gamma Ray and Formation Density:	Run No.3	8366' - 6523'
	Run No.4	13362' - 8394'
Neutron Side Wall Porosity:	Run No.1	13360' - 6520'
Laterolog:	Run No.1	8364' - 6526'
	Run No.2	15618' - 8150'
Microlaterolog:	Run No.1	6031' - 3900'
	Run No.2	7038' - 6522'
	Run No.3	8364' - 6523'
	Run No.4	13400' - 8500'
Continuous Dipmeter:	Run No.1	1576' - 30'
	Run No.2	5600' - 3450'
	Run No.3	15280' - 6528'
Proximity Log:	Run No.1	8364' - 6523'
	Run No.2	11000' - 8160'

(b) Penetration rate and gas logs:

Drilling time log: This was taken from the Geolograph plotted as minute per foot.

Gas log: Geoservices equipment was used to log.

(c) Deviation Surveys:-

Equipment: Sureshot recorder.

Results:-

No.	Depth.	Degrees.	No.	Depth.	Degrees.	No.	Depth.	Degrees.
1	500'	$\frac{3}{4}$	9	3700'	$\frac{3}{4}$	17	5400'	2
2	900'	1	10	4125'	$\frac{3}{4}$	18	5535'	$\frac{1}{2}$
3	1390'	1	11	4320'	$\frac{1}{2}$	19	5700'	2
4	1570'	$1\frac{3}{4}$	12	4600'	1	20	5925'	$2\frac{1}{2}$
5	2030'	1	13	4835'	1	21	6040'	3
6	2455'	$\frac{1}{2}$	14	4990'	$1\frac{1}{2}$	22	6155'	$2\frac{1}{4}$
7	2740'	$\frac{3}{4}$	15	5160'	2	23	6300'	$\frac{1}{2}$
8	3030'	$\frac{1}{2}$	16	5290'	$2\frac{1}{2}$	24	6520'	$1\frac{1}{4}$

(c) Deviation Surveys: (Cont'd.)

No.	Depth.	Degrees.	No.	Depth.	Degrees.	No.	Depth.	Degrees.
25	6700'	1½	34	8734'	6¼	43	10180'	4.30
26	6875'	2	35	8924'	7	44	10690'	2.45
27	7105'	2.15	36	9070'	7	45	11330'	5.30
28	7415'	1	37	9293'	10	46	11755'	6
29	7671'	1	38	9334'	9	47	12480'	3
30	7910'	2.45	39	9457'	6.30	48	13105'	2½
31	8072'	2½	40	9552'	7.30	49	13720'	1.45
32	8378'	4	41	9690'	5.30	50	14430'	1.30
33	8548'	5	42	9885'	2.30	51	15130'	4

(d) Temperature Surveys: None, but the following were obtained during these operations:-

	Depth ft.	Temperature °F	°C
Schlumberger	15600	370	188
D.S.T. No.2	13310	290	143.
Schlumberger	13270	290	143
D.S.T. No.3	12760	290	143
Schlumberger	12600	266	130
D.S.T. No.4	11000	200	93
Schlumberger (from run 5 of I.E.S.)	10445	NO BOTTOM HOLE	TEMPERATURE
Schlumberger	8400'	182	83
D.S.T. No.5	7600	200	93
D.S.T. No.6	7235	200	93
Schlumberger (from run 3 of I.E.S.)	7039	175	79
Schlumberger	6500	162	72
D.S.T. No.7	6479	170	77
D.S.T. No.8	6200	170	77
Schlumberger	1580	128	54

(e) Other well surveys:-

Velocity Survey: One run at total depth.

(5) Testing.

(a) Formation testing: (Appendix No.1)

Drill Stem Test No.1.

Interval:	6893.20' to 6963'
Method:	Open hole.
Result:	Recovered 5920 ft. Salt Water From 15.8 to 28.00 gr./l.

The two Recorders did not work but final closed in pressure was 2600 p.s.i. Data calculated from the height of fluid in the drill pipe as the flow was stabilized.

Reasons: Increase in drilling rate and mud losses.

Drill Stem Test No.2.

Interval:	13252' to 13310'	
Method:	Open hole.	
Result:	Recovered 366 ft. of mud and salt water. 23 gr./l.	
I.H.P.	6884	
I.C.I.P.	5350	
I.F.P.	3514	B.H.T. = 290°
F.F.P.	3530	
F.C.I.P.	-	
F.H.P.	6743	

Reasons: Porous zone determined from S.P.E.Logging.

Drill Stem Test No.3.

Interval:	12702' to 12760'	
Method:	Open hole straddle test.	
Result:	Recovered 150 ft. of mud & salt water, 35 gr./l.	
I.H.P.	6652	
I.C.I.P.	4795	
I.F.P.	3535	B.H.T. = 290°
F.F.P.	3550	
F.C.I.P.	4643	
F.H.P.	6384	

Reasons: Gas show associated with increasing drilling rate.

(a) Formation Testing (Continued).

Drill Stem Test No.4.

Interval:	8475' to 11000'	
Method:	Casing test packer set in shoe of the 7" liner.	
Result:	6725 ft of gas cut mud. Gas to flare during 8 hrs. decreasing from 3,000,000 cub.ft. to 200,000 cub.ft./day.	
I.H.P.	5543	
I.C.I.P.	5233	
I.F.P.	3176	B.H.T. = 200°
F.F.P.	3021	
F.C.I.P.	3201	
F.H.P.	5506	

Reasons: Gas shows.

Drill Stem Test No.5.

Interval:	7510' to 7600'	
Method:	Casing test (through perforation)	
Result:	Recovered 187 ft Mud.	
I.H.P.	3869	
I.C.I.P.	3120	
I.F.P.	1146	B.H.T. = 200°
F.F.P.	1217	
F.C.I.P.	3096	
F.H.P.	3869	

Reasons: Fissured reservoir (important mud losses). Knowledge of the transmissibility.

Drill Stem Test No.6.

Interval:	7177' to 7235'	
Method:	Casing test (through perforation).	
Result:	350 ft Gas cut mud. 4450 ft.salt water 22.5 gr./l. Gas flow during 2 hours.	
I.H.P.	3700	
I.C.I.P.	2994	
I.F.P.	725	B.H.T. = 200°

Drill Stem Test No.6 (Continued).

F.F.P.	2157
F.C.I.P.	2974
F.H.P.	3700

Reasons: 1. Porous zone determined by Schlumberger logging and increase in the drilling rate.
2. 60% to 70% of water saturation in the upper part of the layer.

Drill Stem Test No.7

Interval:	6443' to 6479'	
Method:	Casing test.	
Result:	Recovered 4500 ft. Salt water 20.7 gr./l.	
I.H.P.	3351	
I.C.I.P.	2719	
I.F.P.	759	B.H.T.170°
F.F.P.	2693	
F.C.I.P.	2719	
F.H.P.	3321	

Reasons: Porous zone, but not logged,and showing 14.5% of Methane on G.D.

Drill Stem Test No.8

Interval:	6174' to 6200'	
Method:	Casing test.	
Result:	Recovered 450 ft. Salt water 14.5 gr./l.	
I.H.P.	3229	
I.C.I.P.	2592	
I.F.P.	458	B.H.T. 170°
F.F.P.	885	
F.C.I.P.	2575	
F.H.P.	3210	

Reasons: Reservoir zone from I.E.S. not controlled by porosity logs.

Details of these tests are given in Appendix.No.1.

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IV GEOLOGY.

4.1 Summary of Previous Work.

41.1 Geological.

Prior to 1948 numerous surface geological surveys were carried out in the Bonaparte Gulf Basin, including one by the Standard Vacuum Oil Company; subject of a confidential report by F. Reeves.

It was only from 1944 to 1955 however, that the first comprehensive study of this area was realised by D.M. Traves on behalf of the Bureau of Mineral Resources and C.S.I.R.O. This work, which was published in 1955, recorded at least 15,000' of Paleozoic sediments ranging from Lower Cambrian to Permian in age.

In 1956 a complementary field geological survey of the Keep River area was carried out by R.J. Allen for Associated Australian Oilfields N.L., tenement holder of the permit OP.2 located in the north eastern portion of the basin. In 1963 J.R. Drummond, B.M.R. geologist, compiled the geology of the Bonaparte Gulf Basin. At the same time geologists of the French Petroleum Institute working for the B.M.R. made photogeological studies on the Cambridge Gulf, Auvergne, Port Keats and Cape Scott 4-mile sheets.

Two large independent field parties to the area in 1963 were led by J. Veevers of the B.M.R. and M. Zimmermann of A.A.P., both parties working in close contact and co-operation. Stratigraphy and tectonics were revised and completed.

From all of these investigations a general picture emerged of Cambrian, Ordovician, Devonian and Carboniferous sediments outcropping along the south western and south eastern margins of the basin, and dipping toward the north east where they are unconformably overlain by Permian and Mesozoic units.

In the Port Keats region only Permian outcrops. Because of the lack of pre-Permian outcrops in this area it was impossible to forecast an exact succession before drilling. Thickness of Permian in the area was estimated to be at least 2,000', under which it was hoped to find again Carboniferous and Devonian.

41.2 Geophysical

The major part of gravity reconnaissance work in the Bonaparte Gulf Basin was carried out between 1955 and 1958.

- The first gravity survey was done in 1955 by Mines Administration Pty. Ltd., and covered the Southern part of OP. 2 (Keep River).

- In 1956 A.A.O. conducted a gravity survey in the Port Keats area while the Keep River reconnaissance was completed by the B.M.R.

- Gravity work intensified in the North East part of the basin in 1957. The B.M.R. completed the Port Keats area and extended lines to Daly River. A.A.O. undertook a new survey from Daly River Inlet along the beach to Keep Inlet. At this point all gravity results available were synthesized by Minad who published the results "Regional Gravity Survey on the Bonaparte Gulf Basin" early in 1958. In this year complementary gravity reconnaissance work was conducted by the B.M.R.

The first seismic studies were commenced during 1960 in OP.2. Austral Geoprospectors carried out a reflection survey for A.A.O, profile length 100km.

In 1961 a marine seismic survey of 297.7km was done by Seismic Surveys Ltd. for A.A.O.

A reflection and refraction seismic survey in the Port Keats area was carried out in 1962 by Geophysical Services Incorporated for A.A.O. (70km, reflection and 77 km. refraction).

In 1963 a seismic reflexion and refraction and gravity survey was carried out in the Port Keats area. In 1964 detailed seismic work was done on the Port Keats area by C.G.G. The same year Petty Geophysical Compagny carried out a reconnaissance seismic survey in the Legune area, and Western Geophysical conducted a marine seismic survey in the Queen's Channel. In 1965 new information on the offshore part of OP. 2 was obtained through the Sparker-Gravity Survey carried out by the Bureau of Mineral Resources. In 1966, C.G.G. carried out a detail survey in the Port Keats area and Moyle River area and an extensive marine survey on the offshore part of the permit. In 1967, C.G.G. conducted a detailed seismic reflection, refraction and gravity survey in the Keep River area which achieved the delineation of the "Keep River structure". The same year, complementary lines were shot by Western Geophysical Compagny in the offshore part of the permit.

41.3 Drilling

At the beginning of the century several coal bores had been drilled along the coast from Port Keats to Cliff Head. The deepest - Port Keats No. 4 and Anson Bay No 2 - reached expproximately 1500' in Permian (Fossil Head formation), while Cliff Head No. 1 reached granitic basement at 728'.

Prior to 1963, the only oil well put down in the Bonaparte Gulf Basin was Spirit Hill No. 1, located 40 miles North East of Kununurra in the North Eastern portion of the Burt Range Syncline. Having drilled through the Lower Carboniferous series it passed into U pper Devonian at 3003'.

In 1963 the oil well Bonaparte No. 1, was drilled to 10530' by Alliance Oil Development N.L. on Permit 127 H, Western Australia. Lower Carboniferous formations encountered in this well were much thicker than was anticipated from the field work and with extensive facies changes. (See Summary of the regional geology).

Drilling was stopped in the Upper Devonian series, consisting of silicified sandstone, much less porous and permeable than anticipated from the Cockatoo Group outcrops.

In 1964 Alliance Oil Development N.L. drilled another well, Bonaparte No. 2, located 6 miles South West of Bonaparte No. 1. Again variations in thickness and facies were observed, A strong gas flow of 1,540,000 cubic feet/ day was tested in a Lower Carboniferous sandstone level interbedded in the Milligan Beds. The flow was not commercial but offered encouragement to further exploration.

In 1965 Australian Aquitaine Petroleum drilled Kulshill Well No. 1. It penetrated 6000' of Permian section, with glacial facies comparable to those found in the Canning Basin, attesting the presence of considerable Permian thickness in the Bonaparte Gulf Basin. The Lower Carboniferous and Devonian section was similar to that found in Bonaparte No. 1.

In 1966 Australian Aquitaine Petroleum drilled Kulshill No. 2 im the same area. Only variations in facies and thickness were observed and little was added to the stratigraphic knowledge. Moyle No. 1 (TD 1767) was drilled by the company the same year. The well struck gabbroic basement at 1698' after penetrating Permian glacials. In this case the Eastern boundary of the Devono-Carboniferous Basin was delineated and found to be considerably overlapped by Permian transgression.

4.2 Summary of Regional Geology

From Lower Permian times it is apparent that the Bonaparte Gulf Basin has reacted as a huge single downwarping basin. Prior to this, mainly during the Devonian and Lower Carboniferous, the area was divided into numerous sub-basins.

The Port Keats sub-basin was separated from the Ningbing sub-basin by the Keep River high. Ningbing and Burt Range sub-basins were separated by the Pincombe high and Burt Range separated from Port Keats sub-basin by the Queen's Channel high zone. The various high zones must not however be considered as impervious barriers; so that exchange of material always occurred between the 3 main sub-basins. In the Southern area, the outcropping Paleozoic ranges from Lower Cambrian to Lower Permian.

In the Northern area, only the Permian was found on the surface as scattered outcrops and in coal bores together with a veneer of Jurassic to Lower Cretaceous outcrop. The monotonous nature of these rocks and the lack of lithological or continuous fossil markers prevented the establishment of good structural and stratigraphic relationships between the Northern and Southern zones of the basin.

Geophysical results indicate a seaward extension of the basin with a gradual, but important increase of sedimentary section.

42.1 Stratigraphy

A brief discussion of the outcropping series above the Proterozoic Basement follows:

421.1 Southern Part of the Basin

The Antrim Plateau Volcanics, Lower Cambrian in age, were the first deposits, laying unconformably on the Proterozoic palaeo relief. The volcanics consist of basaltic levels accompanied by a varying sequence of interbedded tuffs and conglomerate. Maximum thickness of this unit is at least 1000', but the unit may be completely eroded in parts.

Unconformably overlying these Lower Cambrian volcanics is a sequence of pink to red fine feldspathic sandstone, conglomeratic at base; calcareous or dolomitic sandstone, oolitic limestone, white sandstone and phosphatic glauconitic sandstone. The sequence is Middle and Upper Cambrian to Lower Ordovician in age and approximately 4200' thick.

These Cambrian and Ordovician outcrops appear as a fringe of sediment interbedded between the Lower Cambrian Volcanics and the Upper Devonian along the South West boundary of the basin.

At the present stage it is impossible to tell if these outcrops correspond to an isolated small Cambrian and Ordovician basin or if the area was the only one preserved after Upper Ordovician or Lower Devonian erosion. No drills have as yet penetrated to a sufficient depth to encounter this sequence.

In the following Upper Devonian units which unconformably overlie the Cambro-Ordovician, it is necessary to distinguish two areas of sedimentation separated by the Pincombe Range, which has a North East trend.

In the South East area known as the Burt Range Syncline (D.M. Traves) or Decantation Sub-basin (A.A.P.), we have a sequence of soft friable sandstone with lenses or interfingering of conglomerate. A fossiliferous shaly silt dolomite complex is interbedded in the middle of the detritic section. The complete sequence is of Frasnian age and totals approximately 3600' in thickness.

The South East area was apparently a basin of piedmont sedimentation during the Frasnian while the North West area was open to the sea. This hypothesis seems to be confirmed by the shaly and silt-sand nature of possible equivalent sediments drilled in Bonaparte No. 1. It should be added that although Bonaparte No. 1 passed fairly certainly into Devonian sediments, fossil evidence is insufficient to date them accurately as Frasnian. The nature of Frasnian sedimentation in the central axis of the Bonaparte Gulf Basin is unknown.

Sedimentation in both the Carlton Embayment and Burt Range Syncline continued during the Upper Devonian with the Ningbing Reef Limestone complex, conformably overlying the Frasnian units and approximately 2000' in thickness. Reef, back reef and fore reef facies are well exposed along the South West margin of the basin in the Carlton Embayment, but only a few scattered outcrops of the back reef facies have been recorded in the Burt Range Syncline. This calcareous formation, previously correlated with the Burt Range Formation (Tournaisian) has been dated Famennian from conodont studies by P.J. Jones and E.C. Druce. It has been recognised as a reef complex very similar to those of the Northern Canning Basin by P.E. Playford, J.J. Veevers and J. Roberts. Any extension to the North of these reefs along the Eastern margin of the Bonaparte Gulf Basin is unknown. A possible equivalent of these Famennian reefs in Bonaparte No. 1 could be variegated and red shaly siltstones found between 9250' and 9550'.

Unconformably overlying these Upper Devonian units, several Lower Carboniferous formations are well exposed in the Burt Range Syncline. The alternating successions of zoogenous limestone, marl, shale and fine sandstone total 4100' in thickness and are of Tournaisian age. Very few outcrops of Tournaisian limestone and sandstone have been found along the South West margin of the basin in the Carlton Embayment.

In the Burt Range Syncline a sequence of sandstone and black shale Visean in age lies above the Lower Carboniferous series. Outcrop is very poor and the black shales of the Milligan Fm. are known mainly from seismic shot holes and from the Bonaparte and Kulshill wells where nearly 6000' were drilled. Along the South West margin of the basin only one outcrop of calcarenite was attributed to the Visean by B.M.R. geologists.

Due to the numerous unconformities affecting the Lower Carboniferous, thicknesses vary greatly from one sub-basin to the other. For example Bonaparte 1 penetrated 5800' of black silty shale attributed to the mainly Visean Milligan Formation, similar to Kulshill 1, but with very little or no Tournaisian. In the Southern Burt Range syncline more than 4000' of Tournaisian sediments exist.

The succession which follows the Carboniferous in the Southern part of the Bonaparte Gulf Basin consists of sandstone, more or less calcareous towards base, with conglomerate and tillite. Ranging in age from Lower Carboniferous to Lower Permian its thickness was unknown from field ~~evidence~~ at the time of drilling Kulshill No. 1.

Enclosure 3

STRATIGRAPHIC NOMENCLATURE OF THE BONAPARTE GULF BASIN

Established by D. M. TRAVES and later modified by J. VEEVERS et al. (B.M.R.) and by Australian Aquitaine Petroleum.

AGE	FORMATION
MESOZOIC	No stratigrahic name applied
---------- UNCONFORMITY ----------	
LOWER PERMIAN	PORT KEATS GROUP
---------- UNCONFORMITY ----------	
LOWER CARBONIFEROUS	BORDER CREEK FORMATION POINT SPRING SANDSTONE TANMURRA FORMATION MILLIGAN FORMATIONS ------ UNCONFORMITY ? ------ ZIMMERMAN FORMATION ------ LOCAL UNCONFORMITY ------ SEPTIMUS FORMATION ENGA FORMATION ------ LOCAL UNCONFORMITY ------ BURT RANGE FORMATION
---------- UNCONFORMITY ----------	
UPPER DEVONIAN	NINGBING LIMESTONE COCKATOO FORMATION
---------- UNCONFORMITY ----------	
LOWER ORDOVICIAN	PANDER GREENSAND
MIDDLE TO UPPER CAMBRIAN	CLARK SANDSTONE PRETLOVE SANDSTONE SKEWTHORNE FORMATION HARTSPRING SANDSTONE TARRARA FORMATION BLATCHFORD FORMATION
---------- UNCONFORMITY ----------	
LOWER CAMBRIAN	ANTRIM PLATEAU VOLCANICS
---------- UNCONFORMITY ----------	
P R O T E R O Z O I C	

421.2 Northern Part of the Basin

In the Port Keats area, only Permian and Mesozoic sediments were exposed at surface. The poor quality of these outcrops prevented the compilation of a complete stratigraphic column. According to D.M. Traves, Permian outcrops in the North should overlie the tillitic formation, it being the most recent Paleozoic found in the South near Keep Inlet.

Permian sediments of the Port Keats area include micaceous sandstone, siltstone and black shale. Coal bores give the best section and total thickness of sediment is at least 2000'.

Analysis of macrofossils from outcrop in the Port Keats area by G.A. Thomas gave ages ranging from Lower Permian to Triassic. In 1969 A.A.P. undertook a geological survey, which has lead to the stratigraphy proposed in the enclosure.3.

42.2 Tectonics

In broad terms, folds are virtually unknown in the Bonaparte Gulf Basin and the main movements have been those associated with step and block faulting, tilting and epirogeny.

Numerous faulting trends have been recognised and classified under three main successions.

- first and most important is reflected in faults of the Halls Creek Mobile Belt, which has a North and Northeastern strike.
- second forms the faults trending Northwest, clearly visible in the Cambro-Ordovician sediments of the Pretlove Hills.
- third, is a Pre-Devonian reactivation of the Halls Creek Mobile Belt continuing through Lower Carboniferous to define the main sub-basins previously mentioned.
- the fourth and possibly final movement is a reactivation of the Northwest trend visible in the South of Weaber Range and the shore line lineation.

4.3. Stratigraphic Sequence of Keep River No. 1

Depth	Thickness	Formation	Age
0'			
1575'	1575'	Kulshill	Lower Permian
2481'	906'	Tanmurra	Lower Carboniferous (U.Visean)
2900'	419'	Milligan Fm. Member 1	Visean
3780'	880'	Milligan Fm. Member 2	Visean
5936'	2156'	Milligan Fm. Member 3	Visean
8193'	2257'	Milligan Fm. Member 4,U.part	Visean
9510'	1317'	Milligan Fm. Membe[illegible] ,L.part	Visean
10570'	1060'	Septimus	Tournaisian
11305'	735'	Enga	Tournaisian
11715'	410'	Burt Range	Tournaisian
12180'	465'	Unnamed Fm.	Upper Devonian to Tournaisian
15540'	3360'	Ningbing Limestone	Upper Devonian
15623'	83'	Cockatoo/Unnamed	Upper Devonian or Proterozoic
TD15623'			

4.4. Stratigraphy of Keep River No. 1

The stratigraphic succession of Keep River No. 1 ranges from Lower Permian to Proterozoic (?) sediments. It has been divided into formations on the basis of lithological, electrical log and paleontological criteria.

Stratigraphic nomenclature is the same as that used for the Kulshill and Bonaparte wells in adjacent areas of the Basin.

Where necessary, boundaries have been modified following microfacies and age studies by the C.R.P. division of S.N.P.A., Pau. (Refer Appendix 111)

(0 - 1575') PORT KEATS GROUP (Lower Permian)

Kulshill Formation

The group consists of a sandstone sequence with minor silty and microconglomeratic variations. There is insufficient data to aid further stratigraphic divisions; the sediments probably all fall in the fluvio-glacial deposits of the Kulshill Formation.

(0' - 140') Weathered Zone

Fine grained sandstones are weathered throughout and of greyish yellow colour. Individual quartz grains are subangular and vary in size from 50 μ - 200 μ. Cementation is poor and the rocks are friable; becoming more silty with organic and biotite traces evident from 100'.

(140'-720') Silty Shale

Siltstones are argillaceous, grey, with poor to medium sorting; grading in parts to very fine grained sandstone. Interbedded dark shale is characterised by Coal seams at the 170', 200' and 395' levels. The coal is black, vitreous, containing plant remnants. Seams are no more than 5-10' thick.

Several coarse sandstone bands are interbedded in the silty shale sequence, and contain sub-rounded pebbles 0.5 - 1.0 cm diameter of quartz and lithic material; together with pyrite, mica and rare glauconite.

(720'-1575') Sandstone

Generally well cemented, the clear quartz grains are subrounded, fine-medium grained (250μ average diameter) and are associated with minor plagioclase feldspar, green mineral, pyrite and traces of vitreous coal. From 1000' the sandstones increase in grain size and poor sorting to contain characteristic pebbles.

Dark grey shale areas rich in pyrite and with coal traces becomes microconglomeratic between 1310'-1440'.

From 1440' the sandstones revert to fine grained, clear and well sorted without the accompanying feldspar, dark mineral or argillaceous cement. They are well consolidated and there is a gradual grain size increase to 600μ towards the base of the Port Keats Group.

(1575'-2480') TANMURRA FORMATION (Upper Visean)

The Tanmurra Formation is clearly defined at the top by the sudden appearance of calcareous sandstone and at the base by a clear shale increase. It is a 900' alternation of fine and medium grained sandstones, weakly calcareous with traces of pure limestone.

(1575'-1940') Sandstone

Greyish white, very fine to medium grained, subangular poorly sorted quartz in a translucent sparite matrix. The sandstone becomes pure, quartzitic at 1750', non-calcareous with little to no cement. Accessories include pyritic aggregates, green-black well-rounded grains, and weakly calcareous grey shale with organic flakes.

(1940'-2480') Sandstone

Becoming coarser grained with max. diameter 350m. There is also the introduction of whitish cream, opaque, microcrystalline limestone and between 2036'-2100' finer grained, brownish sandstone with microdolomitic cement. Oolites and crinoid fragments are common.

Millimetric seams of micaceous pyritic shale with plant fragments appear and greyish brown calcarodolomitic siltstone beds increase in the final 300' of Tanmurra Formation.

(2480'-9510') MILLIGAN FORMATION (Lower Carboniferous)

The Milligan Formation was originally divided into 4 members in the Bonaparte holes and were traced in the following wells Kulshill 1 and 2 drilled by Australain Aquitaine Petroleum. These members are litho-stratigraphic divisions which are also reflected in the electrical logs, and include the following:

Member 1 - sandstone - shale
Member 2 - pure shale
Member 3 - sandstone - shale - limestone
Member 4 - quartzitic sandstone - shale units (Upper Part)
Member 4 - shale and rare sandy limestone (Lower Part)

(2480'-2900') Member 1

Silty Shale and Sandstone

The silty shale is grey, non-calcareous and poorly sorted. Fine grained sandstone (60μ - 150μ) becomes siltsize at 2730' and is interbedded with occasional thin beds of brown dolomitic siltstone.

(2900'-3790') Member 2

Silty Shale and Shale

Tight, grey micaceous silty shale often has a speckled texture due to pseudo-oolites. It is non-calcareous, poorly sorted and includes plant remnants and pyrite. The silty content becomes coarser from 3640'.

The non-calcareous shale occurring throughout is black and chunky, friable, with a concoidal fracture. Plant fragments are common.

Appearing at 3260', spasmodic clean white quartzose siltstone is well sorted with average grains size 50µ and subrounded. The cement is either calcareous or siliceous. Accessories are mainly pyrite or greenish grains.

(3790'-5936') Member 3

Silty Shale and Siltstone

Silty shale is light grey, sometimes speckled and variegated brown. It can be non-calcareous or weakly calcareous and dolomitic containing microangular pyrite and mica. Well-rounded oolites (250µ diameter) and quartz often make the silty shale poorly sorted.

Siltstone occupying up to 60% of the cuttings appears in 2 varieties; one as argillaceous non-calcareous and poorly sorted, the other as a white quartzose calcareous siltstone. Both grade into calcareous oolitic , fine grained sandstone (4140'-4180') and sandy limestone. The oolites are brownish green and well rounded with a maximum diameter of 300µ.

The siltstones are sometimes rich in fossils including: Endothyrids , Echinoderms, Ostracods, Algae (Anatolipora?), Paleotextularia and Crinoid stems. Crinoids are also well preserved in the shale and silty shale fractions.

The remainder of Member 2 consists of interbeds of shale, poorly sorted silty shale (with scour and fill microstructures), siltstone and minor sandstone occasionally becoming microconglomeratic. All facies contain crinoid fragments.

(5936'-8193') Member 4 (Upper Part)

Both the upper and lower limits are obvious on cutting analysis and electrical log results. It is predominently a sandy division with bands of intercalated sandstone and shale.

A brief appearance of non-calcareous sandstone 5936'-5960' forms 65% of the cuttings. It is very poorly sorted and contains medium grained angular quartz embedded in a recrystallised siliceous cement. There are traces of pyrite and calcareous siltstone.

(6495'-7610') Sandstone

Generally white, fine to medium grained and with patches of calcare - dolomitic cement. There are several hard quartzitic layers (6708' - 6730' and 7520' -7610') where the grains are angular and fissured with vugs of quartz. A fine to medium grained porous zone 6903'-6918' was tested and produced 15.5 m^3 of salty slightly fluorescent water.

A 30' bed of sandy biosparite was encountered at 6990' which showed a greasy lustre and contained fragments of Algae, Brachiopods and Echinoderms.

Non-calcareous shale, and brownish grey silty shale with crypto-crystalline, calcaro-dolomitic cement occur interbedded in the first 400' of section.

(7610'-8193') Sandstone Shale Siltstone

The nature of the sandstones does not change and calcite filled veinlets are common. Minor sandy limestone beds are rich in Brachiopod, Crinoid and Plectogyra remains.

The shale is dark to light grey, fissile, non calcareous and grades to micaceous silty shale. Archaediscus specimen was found at 8040', in calcareous dark grey siltstone.

(8193'-9510') Member 4 (Lower part)

The lower part of member 4 is essentially argillaceous and differs in character from the preceding upper part of member 4 of the Milligan beds. It has been divided into 2 portions, the lowermost completely shale. The lower part of this member also marks the first appearenace of substantial methane gas flows.

(8193'-8920') Shale, minor Sandstone

The shale is non-calcareous, dark to medium grey and rarely micaceous. Coarse quartz together with crinoid fragments often make the shale microconglomeratic.

Sandstone interbeds sometimes form 40% of the cuttings. They are white, fine-medium grained, with abundant calcareous cement. Fossil remains include Echinoderms, Brachiopod spines and unidentified Foraminifera. At 8680' - 8700' a minor increase in medium grained calcareous sandstone with calcithite gravels and biosparite is associated with gas (90% methane on the GDI). Calcite filled fissures are not uncommon.

(8920'-9090') Shale

as above with few interbeds of brown poorly sorted silty shale, calcarodolomitic cement with mica. Milimetric beds of weakly calcareous quartzose siltstone contain possible Quasiendothyra or Plectogyra.

(9090'-9500')- the topmost beds are distinguished from the overlying sequence by the appearance of medium to corase grained calcareous sandstone, containing Algae, brown-green intraclasts and pyrite set in sparite cement. Another variety of sandstone appears at 9220' and is weakly calcareous, medium - coarse, light grey, with subangular grains.

Shale forms the greater part of Member 4, it is non-calcareous and shows traces of subrounded coarse quartz grains.

The sudden appearence of coarse grained clear sandstone interbeds marks the end of this member.

(9510'-10570') SEPTIMUS FORMATION (Tournaisian)

This has a higher clastic content and is also characterised by several methane shows in the region 9680' - 9950'. Interbeds of shale and strongly calcareous sandstone (subangular quartz 100 μ - 200 μ) with Crinoids, Algae, and feldspars showing secondary growth, pass into calcareous oolithic sandstone at 9600'.

Shale increases between 9840' - 9950' with sub-rounded, medium grained poorly sorted quartz.

Decimetric interbeds of calcareous sandstone and siltstone contain debris of Ostracods, Conodonts, Molluscs, Brachiopods, and Algae. There are traces of plagioclase feldspar and pyrite.

In the remaining shale and sparitic sandstone sequence, oolites persist and trace quantities of plagioclase grains exhibiting secondary growth appear to be a characteristic. The Septimus Formation closes with an abrupt decrease in sandstone percentage.

(10570'-11305') ENGA FORMATION (Tournaisian)

This zone may be divided into an upper argillaceous fraction and a lower silty-sandy part.

(10570'-11030') Silt Shale and Siltstone

Crinoid and subrounded, coarser quartz inclusions are common throughout. There is also an increase in the argillaceous sandy limestone content with fine fragments of shell, spicules and quartz, associated with 10 - 30% weakly calcareous, very fine quartzose sandstone.

(11030'-11305') Sandy Limestone and Quartzitic Sandstone

From 11030' the sandy limestone is rich in Ostracods, Brachipod spicules, pyrite, and interbedded with fine, white, calcareous, oolitic sandstone and shaly limestone with pellets. Minor beds of shale are greyish brown, calcarodolomitic.

Fine to medium quartzitic sandstone occupies 60% of the cuttings from 11250'. It has sparitic cement and includes black patches of calcite. The grains are medium to well sorted and include minor feldspars.

This quartzitic sandstone changes abruptly to black calcareous siltstone at 11305' and defines the upper limit of Burt Range Formation sediments.

(11305'-11715') BURT RANGE FORMATION (Tournaisian)

The formation shows an overall increase in calarodolomitic content. Black to dark grey calcareous oolithic siltstone is the common lithology type. There are variations from silty limestone (argillaceous dolomicrite) to light grey sandy biosparite containing abundant Brachiopods, Bryozoan Stylioline and Crinoid fragments. Calcite filled fissures are characteristic

There is a zone 11650'-11715' of quartzitic sandstone which is grey, fine to medium grained, showing good sorting and traces of patchy carbonate. The cement is siliceous and feldspars occur as accessories.

(11715'-12180') <u>UNNAMED FORMATION</u> (Tournaisian to Upper Devonian)

Argillaceous dolomicrite, slightly micaceous, continues until the appearance of a reefal facies, the Ningbing Limestone, at 12180'. This facies represents a lagoonal environment, indicating an important change in the sedimentation, which has abruptly stopped the underlying reefal development.

(12180'-15540') <u>NINGBING LIMESTONE</u> (Upper Devonian, Fammenian) This 3360' of limestone formation exhibits the facies of a shallow marine environment, but deep enough to be out of reach of wave action. From the top till 13100', a turbulent water environment can be assumed, which has allowed builder organism to develop (Stromatactis and encrusting Algae). However from this depth to the bottom, the environment reflects calm water sedimentation confirmed by the absence of bioherms and the continuous presence of authigenic quartz which additionally allows the assumption that sedimentation has been of lagoonal type. The upper part (12180'-13100') is rich in fossils, especially encrusting Algae and Crinoids, while other parts in the lower column are completely sterile and show only dolostones indicative of a back reef lagoonal environment. The formation has in general been rendered impervious by calcaro-dolomitic recrystallisation ; porosity exists only in fissured zones. Calcite veinlets and brown dolomitic styliolites continue throughout much of the sequence.

(12180'-13100') of the varied facies biodolomicrosparite is the most common. It is generally light grey, friable and contains fragments of Brachiopods, Bryozoans, Crinoids and Gasteropods. Encrusting Algae, Solenopora, Girvanella are also found together with Quasiendothyra. Pellets 60-70μ average diameter, dark green or brown, often lend a mottled colouring to the limestone.
Intraclasts, Calcispheres and Irregularina are less abundant, but characteristic.

(13100'-15240') Facies encountered in the sequence are more micritic and azoic. Among Them:

- a light green to cream homogeneous and featureless micrite containing very rarely Ostracods, Calcispheres and Mollusc fragments.

Drg. Nº 4670.

ENCL. 4

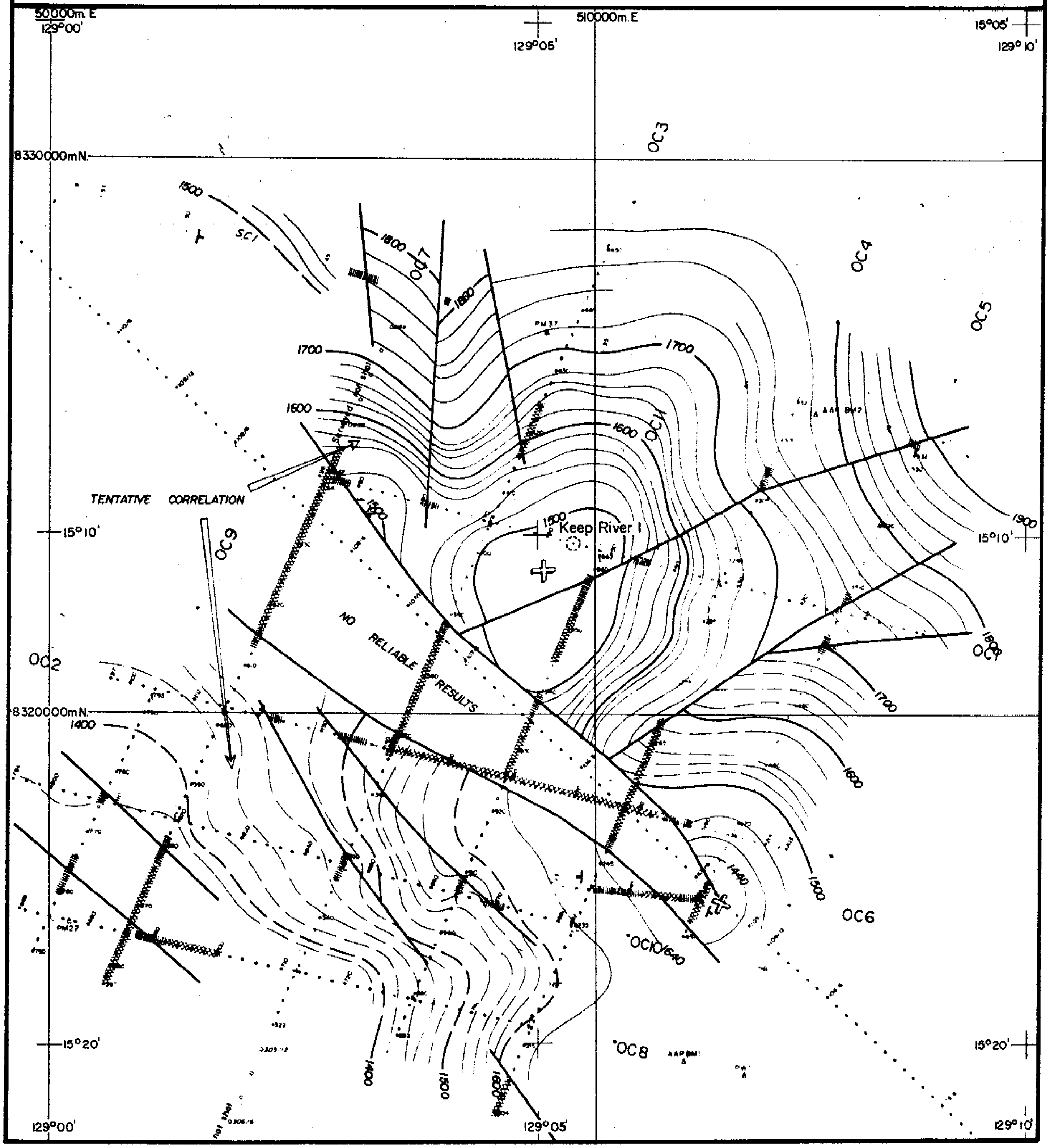
AUSTRALIAN AQUITAINE PETROLEUM Pty. Ltd.
OP 162

KEEP RIVER Nº 1
ISOCHRON MAP OF HORIZON "D" (Septimus Formation.)

SCALE 1:100,000

Each interval is equivalent to 20 milliseconds two way time.

JUNE 1969



- Dolomicrosparite with individual subhedral crystals of average diameter 16-20μ form several zones of light coloured sugar textured limestone (13250'-13400' and 13860'-14060')

-Authigenic quartz occurs in most of the facies in accessory quantity.

- Intradismicrite and peldismicrite are very frequent along the sequence, but are replaced from 15000' by a sparitic facies.

The first appearance of medium grained dolostone, rich in authigenic quartz is made at 14260' and increases to 35% of the cuttings between 15090'-15240'. They consist of tightly packed subhedral dolomite rhombs and show no porosity.

(15240'-15540') zone consists entirely of hypidiotopic dolostone, opaque to semi-transluscent, grain size 100-125μ with sugary texture and scattered euhedral fine grained pyrite throughout. Calcite and authigenic quartz form accessories.

(15540'-15623) QUARTZITIC SEQUENCE

The topmost 30-40' might be a reworked (and weathered) zone and much younger therefore than the underlying basement. It is calcarodolomitic and transitional from Famennian dolostone to (Proterozoic?) quartzite.

The true quartzite is white - grey variegated with grain size 40μ - 100 μ, subangular. There are traces of feldspar and pyrite. Some medium grained quartz is sub-rounded and gives a microconglomerate texture with the silt size angular groundmass. Subrounded coloured grains occur as accessories.

4.5 Structure

The structure on which Keep River No. 1 was located is an anticline. All flanks dip sharply except to the South where the origins of a dip cannot be traced due to seismic marker deterioration. However a possible faulted zone in this Southern area could add to the closure of the structure. (Enclosure 4)

The Dipmeter has been run from 100' to 15280' except between 5600' and 6520' due to a tight hole and from 1575' to 3450' due to break down of equipment (2 arms broken).

The dips are fairly constant from the surface to the bottom where they increase from 2° to 9°.

Kulshill Formation (Lower Permian)

Interval 0' to 1550'

The general dip is 2° NNW. The contact with the underlying Tanmurra formation is faulted.

Milligan Formation Member 3 (Lower Carboniferous)

Interval 3450' to 5400'.

Except for a few hundred feet (at 4000') where the dip is 2° to 4° SW, the general dip varies from 2° to 4° NW. Interval 5400' to 5600' also a low dip value of 3°, but with a W to SW direction.

No obvious faults have been noticed in these intervals.

Milligan Formation Member 4 - Upper Part

Interval 6530'-7265'.

The general dip is 3° NW except for the first layers (6530' to 6850') where it is SE, after a fault at 6850' lowering the North compartment, the dip returns to the NW. This interval is characterised by a sequence of silt, shale and clean sands deposited in an EW shallow trough, presumably filled by material supplied from a Northern area. The sands represent a stage of rapid deposition in a high level energy environment and appear to be thinning down dip.

Strong depositional break at 7265'.

Interval 7265' - 8200'.

This is a consistant zone showing a high energy of deposition environment and random dip orientation.

Important channel cuts filled with sand, and lying along a NW-SE axis are obvious (7510'-7600', 7670'-7700', 7750'-7800')

The general dip is flat to 2° NW.

It is a shallow water deposit in a neritic marine environment with a possible Southerly supply.

Milligan Formation Member 4 (Lower Part)

Interval 8200' - 9500'

The deposition environment is of shallow water low energy, with a Northerly current bedding. The bed pattern produced by wedge shaped sand thickening down dip towards the North results in an increase of structural dip towards the North with depth.

Though no fault limits this interval from the overlying one, the dip is 2° SW, then after a fault at 8680' with a NS axis it returns to 2° NW.

Septimus Formation

Interval 9500' to 10,000'

The environment is very shallow, active water. The general dip is 1 to 2° NW or flat, bounded at the lower part by a fault.

Interval 10.000' to 10.570'

Current bedding from a Southern source and with a 2° NW dip is very consistant. Another fault is noticed at 10,280'; and at 10,500' with a NS axis. A strong depositional break occurs at 10,570'.

Enga Formation

Interval 10,570' to 11,005'

After the preceding fault at 10.500' the dip is 4° SSW, but with a fault at 10940' it becomes again 2° NW.

This interval is characterised by rapid deposition in shallow water with supply from the NE but with a very erratic dip.

Very important depositional breaks limit this interval.

Burt Range Formation

Interval 11305' - 11620'

It seems the source of material for this interval came from the East. The dip is 4°NW, till a fault at 11380' along a NNE-SSW axis changes the orientation to 7 to 8° West. (dips of 10° were noted on cores) this dip remaining until a fault at 11620' (axis NS)

11715

Unnamed Formation

Interval 12080' - 12180'

The pattern found in this formation overlying the algal reef indicates a tallus over the steeply dipping flank of the reef (30° E) which has very likely marked a topographic relief in the area.

Ningbing Limestone

Interval 12180' - 12300'

Top of the algal reef, which seems to thin down dip towards the NE.

Interval 12300' to 15250.

The general dip is 5° NW, till a fault with a SW block upthrust is noted at 12900' and 12960' , then the dip changes to 9° NW until 13940' where an important fault with upthrust of the North compartment causes the dip to change to 8 to 6° NNW where it remains until the bottom.

Another fault is notedat 15000' with an axis NE - SW.

All information gathered appears to confirm the seismic results in that Keep River No. 1 was located on the NW flank close to the apex of the extremely faulted Keep River structure (see enclosure 4).

Three different reflexion horizons were recorded by seismic studies. After completion of the well velocity survey (Appendix 4) these horizons were identified.

The first,horizon A,corresponds to the disconformity of the Lower Permian on the Lower Carboniferous.

The second, horizon B,corresponds to the top of the Milligan Formation Member 4.

The third, horizonD,corresponds to the top of the Septimus Formation.

The refraction marker M1 (20000ft/sec) corresponds to the top of the Ningbing Formation.


A.A.P.
A.A.P. Drg No 4669.
WELL KEEP RIVER No. 1.
RIG. O.D.E IDECO Super 7-11
PERMIT OP 162
STATE N.T.
Coordinates X 129° 05' 22" Y 15° 10' 05" Zsurf 75.8' 23.12m Zkb 92.4'
Dates Spud 3/9/68 Temporary stop Recommence T.D. 23/2/69.
CASING
Ø 18 5/8 at
Ø 13 3/8 at 1557'
Ø 9 5/8 at 6519'
Ø 7" at 8600'
DIAGRAPHIES
I.E.S. Runs 1,2,3,4,5 30' – 12,614'
F.D.C. Runs 1,2,3 60' – 8,365'
B.S.L.C. Runs 1,2,3,4 30' – 12,614'
M.L.L,M.L. Runs 1,2 3900' – 8,365'
C.D.M. Runs 1, 2 30' – 5,600'
L.L.7 Run 1 6520' – 8365'
ENCL. 5.
PETROPHYSICAL LOG
SCALE 1: 5000
Strati-graphy
DEPTH in 100's m. ft.
SECTION
CORES
GAS SHOW
SALINITY G/L
POROSITY FROM SCHLUMB. LOGS and CORES
PERMEABILITY IN MILLIDARCY FROM CORES ONLY.
WATER SATURATION
S.W.
KULSHILL FORMATION L. PERMIAN
TANMURRA FORMATION L. CARBONIFEROUS (VISEAN)
MILLIGAN FM. Member I
MILLIGAN FORMATION L. CARBONIFEROUS (Visean)
Member II
Member III
Member IV (Upper Part.)
MILLIGAN FMN. Member IV
MILLIGAN MEMBER IV (lower part.) L. CARBONIFEROUS (Visean)
SEPTIMUS FMN. (TOURNAISIAN)
ENGA FMN. LOWER CARBONIFEROUS
BURT RANGE
UNNAMED FMN.
UPPER DEVONIAN
NINGBING LIMESTONE
PROTEROZOIC ? or DEVONIAN
No.1 74%
No.2 63.3%
No.3 36.4%
No 4 100%
No 5 100%
No 6 100%
No 7 100%
No 8 100%
No 9 100%
No 10 90%
No 11 100%
No 12 100%
No 13 100%
No 14 100%
No 15 100%
No 16 100%
No 17 100%
No 18 100%
No 19 100%
No 20 100%
No 21 100%
No 22 97%
No 23 75%
0°
1.06% to 54%
9% to 14%
100%
100%?
6174' 6200' to 95' tc 60'/50' 1200 ⊕ 2594/2581
6443' 6479' to 65 tc 60'/180' 14m³⊕ 2726/2728
6898' 6963' to 88' 15.5m³ ⊕ 28.00 g/l
7177' 7255' to 304' tc 60'/180' 11.3m³⊕ 2995/2989
T8
T7
T1
T6
T5
T4
T3
T2
7510' 7600' to 65' tc 60/90' 180 Mud. 3104/3079
8475' 11.000 to 1677 tc 496/430' 3,000,000 to 120 000 cfd. of Methane 4065 / 2268
Gas trap inoperative
From Schlumberger Log.
Fracture Zone
10°
13°
12760 13.402 to 38' tc 62/120' 550⊕ 345 + Methane 4795/4651
13236' 13274' to 25' tc 90' 780⊕ 5350 P.S.I.
Very weak.

4.6. Porosity Permeability

The best reservoirs occur in the Kulshill and Tanmurra Formations of Keep River Well No. 1. As they are however located at the top of the drilled section they are of little interest. (Enclosure 5)

46.1 Milligan Formation Member 4

This member underlying the thick cap rock formed by the members 1 to 3 contains the first interesting reservoirs.

461.1 Member 4 Upper Part

3 good reservoirs can be cited, 6443' - 6479', 6900' - 6915', 7218' - 7238'. Due to their limited vertical extension no cores have been cut. From the Schlumberger logs, assesments have been made of their porosity (6900' - 6915' average porosity of 7% and 7218' - 7238' average porosity 14%).

These 3 reservoirs have been tested and their output hasb been respectively;

6443' - 6479': 13,85m^3 of salt water at 20.700 ppm of NaCl in 2 h. 30 min.
6900' - 6915': 15.5m^3 of salt water of 28.000 pmm of NaCl in 1 h. 30 min.
7218' - 7238': 14m^3 of salt water at 22.500 pmm of NaCl in 5 h. plus a fair amount of gas (cf Annex 3), whose quantity has not been assessed.

As suggested by the dipmeter study there is an important change of depositional environment and the sands found below, though often thick, are much more cemented and compacted.

Severe fracturing has fissured these various levels, and during drilling considerable mud losses were recorded, particularly from 7510' to 7600', DST 5 was run in front of these levels. No flow was recorded, which means that in spite of the fissuration, no gain in permeability has occured; unless cementation during drilling has plugged the fractures.

461.2 The Member 4 - Lower Part

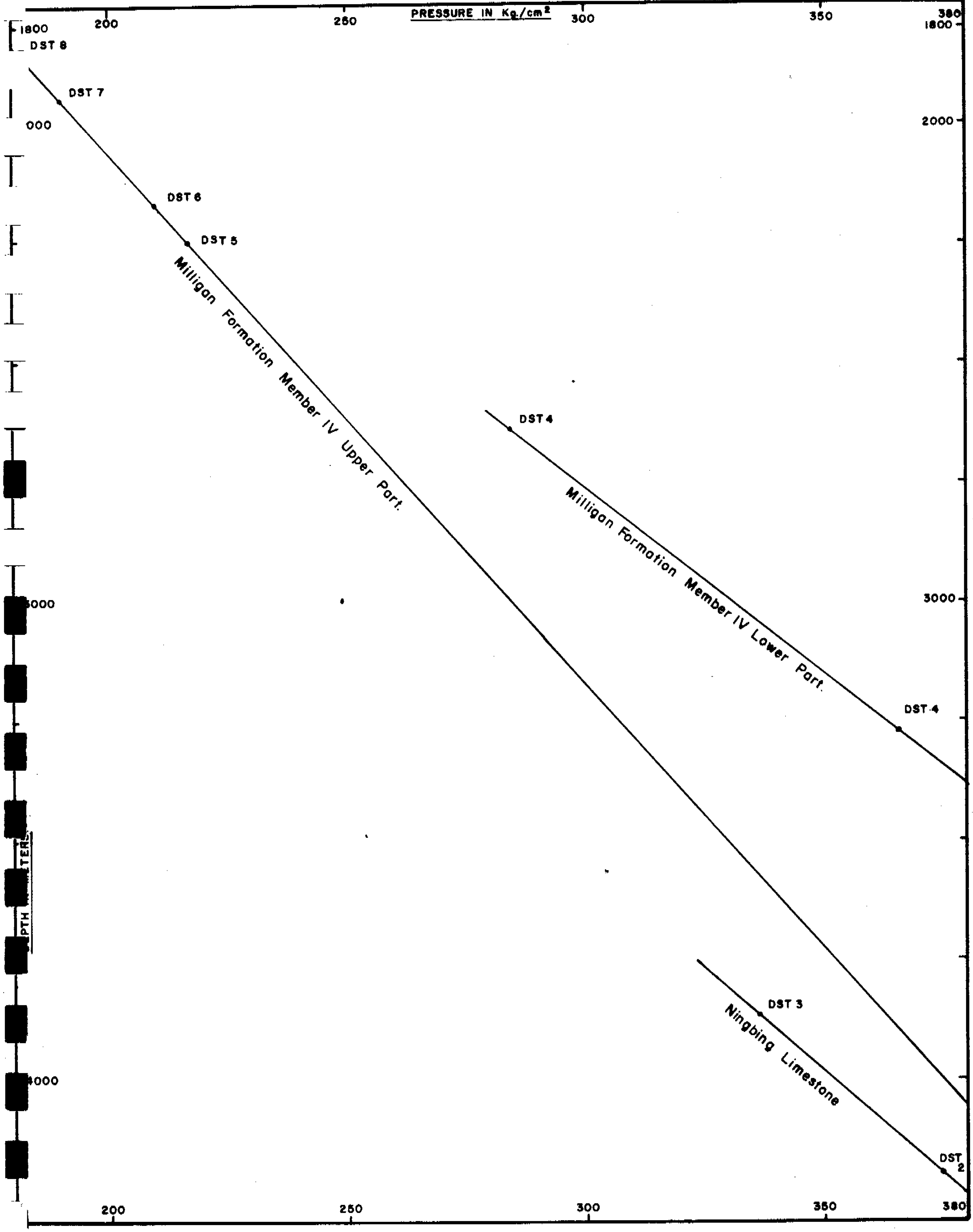
It consists mainly of shales and calcareous siltstone with very thin levels (4' average thickness) of calcareous sandstone. Again the only porosity and permeability found were in fissured zones.

As has been suggested by the dipmeter study, beds thin up dip from this level, increasing this structures possibilities, however data from DST 4 has proved the beds were of limited areal extent.

.N° 4738.

ENCL. 6

PRESSURE DATA IN RELATION WITH DEPTH.



46.2 Septimus and Enga Formation

Numerous gas peaks have been recorded during the drilling of these formations but no real reservoirs have been found, except for some very thin levels of fissured calcareous sandstone.

46.3 The Ningbing Limestone

The Ningbing Limestone reefal facies is tight. Two thin levels of 6' and 15' thickness were tested and revealed a very low permeability. It is a characteristic of algal reefs to be devoid of primary porosity. Effective secondary porosity is usually effected by fractures becoming channels for dolomitisation.

46.4 Hydrodynamism

Pressure data from the different test, have been listed in Enclosure 6.

It is now clear that at least 3 pressure trends affect the Lower Carboniferous and the Upper Devonian.

The results obtained indicate :
Homogeneity in pressure gradient of the different reservoirs of the Milligan Formation Member 4 Upper Part, showing that they are subject to the same hydrodynamic regime. There is however little likelyhood of extensive connection as salinities are different in the various levels. Faulting must be assumed to be responsible for the pressure equalisation. A barrier exists between the upper and the lower part of this member 4, as the lower part is under higher pressure. Thus the hydrodynamic closure will be negative and unless there is no possibility of leak through the cap rock, conditions for the entrapment of hydrocarbons are not good.

On the other hand the Ningbing Limestone shows a lower pressure regime than that of the overlying reservoirs (the Milligan 4 lower part and the Septimus, Burt Range Formations) and thus, hydrodynamism will aid a possible structural stratigraphic trap, this result is confirmed by the difference in the water salinity data between the Lower Carboniferous and the Upper Devonian.

46.5 Potentiometric Surface

This has only once been calculated, for test No. 6 in the upper part of Member 4. It is more or less equivalent to the static pressure, while for the lower part, even using the non-extrapolated static pressure, the potentiometric surface is at least at + 862'.

No data has been given for the Ningbing Limestone, but from the test and results it seems fairly reasonable to expect a negative potentiometric surface for this formation.

4.7. Relevance to the Occurrence of Petroleum

47.1 Salinity

Enclosure 5 shows salinity increasing from the top, where the water is fresh, to the bottom of the Tanmurra Formation and it can be assumed some barrier partly isolated these sandstones from those of the Kulshill Formation.

In the Milligan 4 Member the tests have shown an increase of salinity. This might indicate a better hydrodynamic closure with depth.

The water recovered from the Ningbing Limestone has a high NaCl content of 34500 pmm, which could correspond to the water salinity in which this formation was deposited.

47.2 Hydrocarbon Saturation

- No oil shows were detected in Keep River No. 1.
- Mud gas detection was carried out throughout the drilling. The total gas being registered on a Geoservices GDI and its constituents analysed with a Chromatograph Gal I (see Composite log).

No hydrocarbon gas was detected either in the Lower Permian sediments, or in the Milligan Formation Members 1 and 2.

The first appearance of gas was in the Member 3 of the Milligan Formation.

Milligan Formation Member 3 contained gas shows of Methane, Ethane and Propane (C_3). The shows were important because it was in Milligan 3 of Bonaparte No. 2 that a gas flow of 1,540,000 cft/day was encountered (and included C_2 and C_3 homologues).

This member has obvious hydrocarbon potential, which although not developed in Keep River No. 1, due to absence of reservoirs could increase to the South where sediments could become coarser.

Milligan Formation - Member 4 - Upper Part

Streng gas shows were encountered in this sequence, most of them eccurring in nen-poreus levels and must be considered as lenses of small extent.

Five levels have been tested; three have revealed themselves as fairly goed reserveir.

Reasons fer Testing

DST 7 and 8: IES has shown 2 sandstene levels, and the GD1, Methane shews. A tight and caving hele prevented the running of peresity teels, therefore tests of these levels were the only means of knowing their hydrecarben saturation.

DST 1 was run after mud lesses occurred fellowing an increase in the drilling rate. Due te an incorrectly set clock no pressure data was recorded

DST 6 = increase in the drilling rate and Schlumberger leg interpretations (cf Annex 4 7218' - 7226' Water saturation is 65 %) and the failure of DST 1.

DST 5 = Mud lesses and a change in the sandstene facies.

Results

DST 8 preduced saltwater with gas emulsion, but the reserveir of peer DST 1 quality and DST 7 alse recerded salt water with a faint record of gas, and a high emulsion of methane.

DST 6 preduced saltwater with large quantity of gas having the fellewing analysis:

N_2	0.7 %
H_2	0.1 %
CO_2	0.3 %
C_1	97.4 %
C_2	1.3 %
C_3	0.2 %

Ne measures through the critical flew prover have been carried out as pressures were net stabilised, but the fellewing operations were cenducted during the test.

Gas came te the surface 1.15 h after epening, then was switched te the flare through a 3/8" choke. Pressure at the well head increased from 5 to 25 PSI, then decreased, in 30' to 0, and the gas flow became faint.

The well head was closed for 2 h. 30 min. and the pressure increased from 0 to 340 PSI. The opening of the well head gave a total decompression in 10'. It can be concluded that after the beginning of gas flow, water has cut it due to an insufficient hydrocarbon saturation in the tested level but nevertheless, the test has shown the possibility of gas producing elsewhere. From the gas analysis it can be noticed as the C_1/C_2 ration reaches 65 with traces of C_3. There is the possibility of "higher range" hydrocarbon which in Keep River have been cracked by dynamometamorphism resulting from the extensive faulting.

DST 5 = Nothing was recovered, but mud.

Milligan Formation Member 4 - Lower Part - Septimus to Burt Range Formation

The strongest gas show encountered in Keep River well No. 1, came from 8680' to 10800' (cf Master Log and Enclosure 5) but as reservoirs were very thin and permeability due to fissuration, a test of the whole zone was attempted, which also needed the setting of a 7" liner.

A consistant gas flow was obtained 1 h. 20 min. after the testing opening. The first measure on the CFP with a 3/8" choke, 5 h. 30 min. after the opening gave a flow of 3000000 cft, the flow then decreased and 1 h. 30 min, later it was only 150.000 cft. After another hour it appears stabilised at 120.000 cft. Many closures of the well head were attempted to give a build up, but failed to obtain a permanent recompression of the levels.

From all the data available it seems that the feeble permeability of various levels and small radius of investigation has not allowed a good recompression and the weight ot the mud column in the string has progressively killed the flow ($15m^3$ of gas cut mud was recovered).

As it can be seen from the laboratory analysis (cf Annex 3c), the gas is dry, and the composition is essentialy methane. No water was recovered.

Drg. Nº 4662.

ENCL. 7.

AUSTRALIAN AQUITAINE PETROLEUM PTY. LTD.

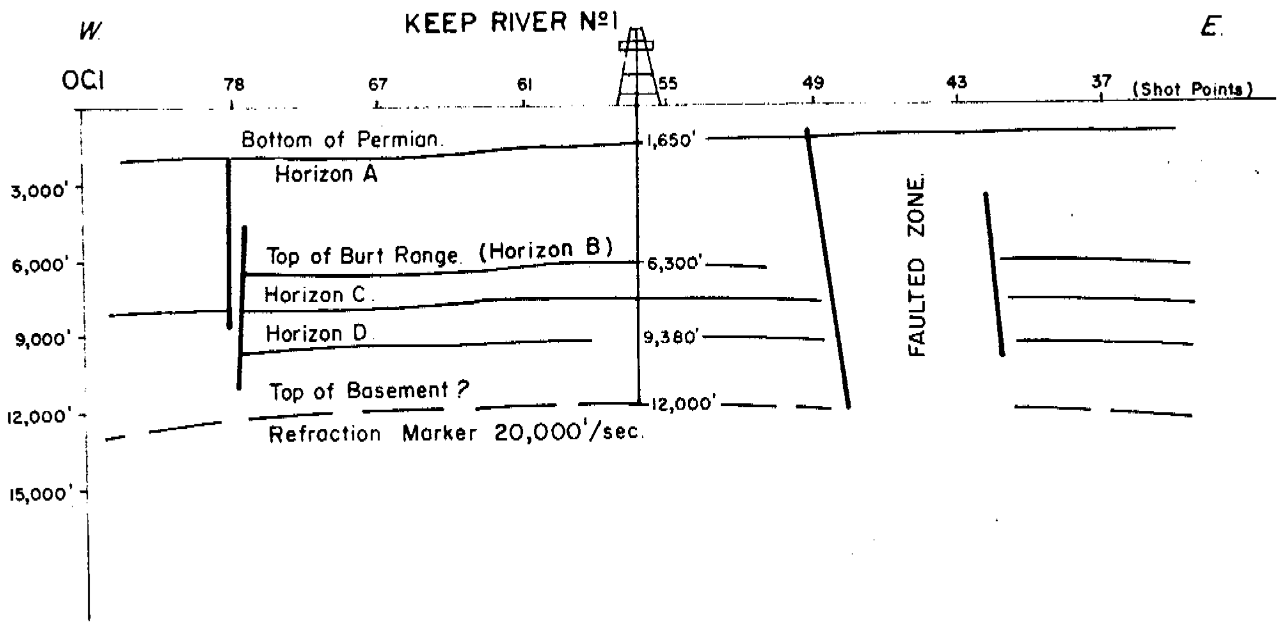
SECTIONS BEFORE AND AFTER DRILLING

KEEP RIVER Nº1.

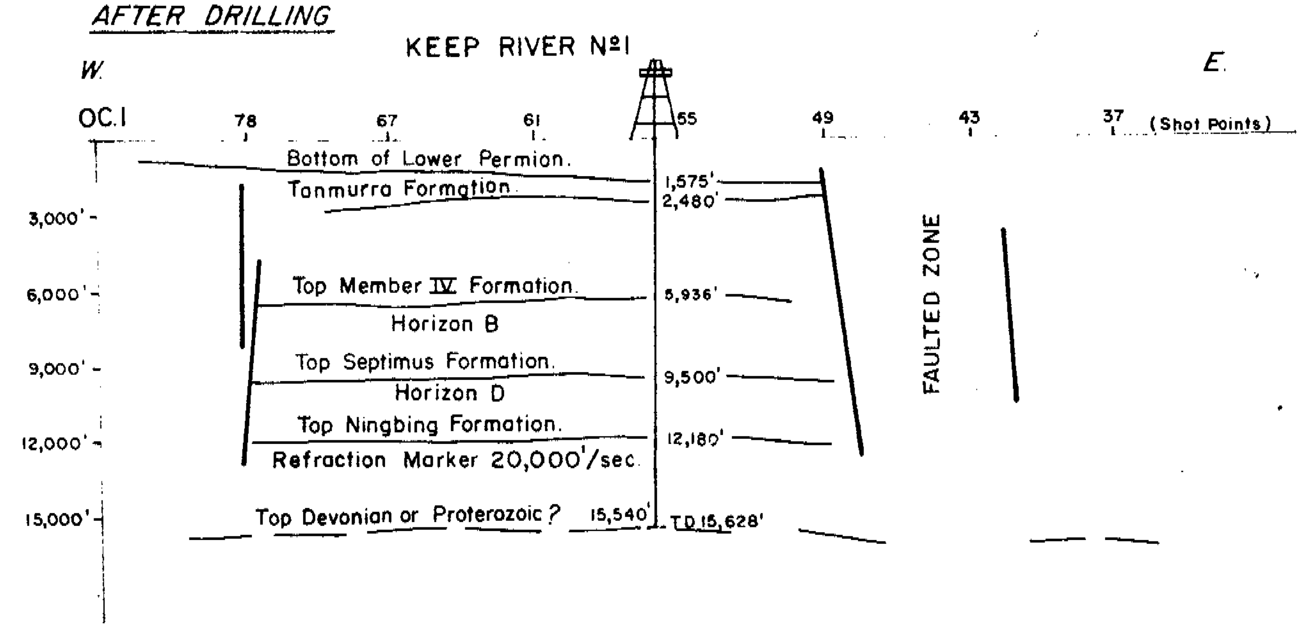
0 1000 2000 Metres.

(LOCATION KEEP RIVER Nº1. S.P. 56, OC 1.)

BEFORE DRILLING



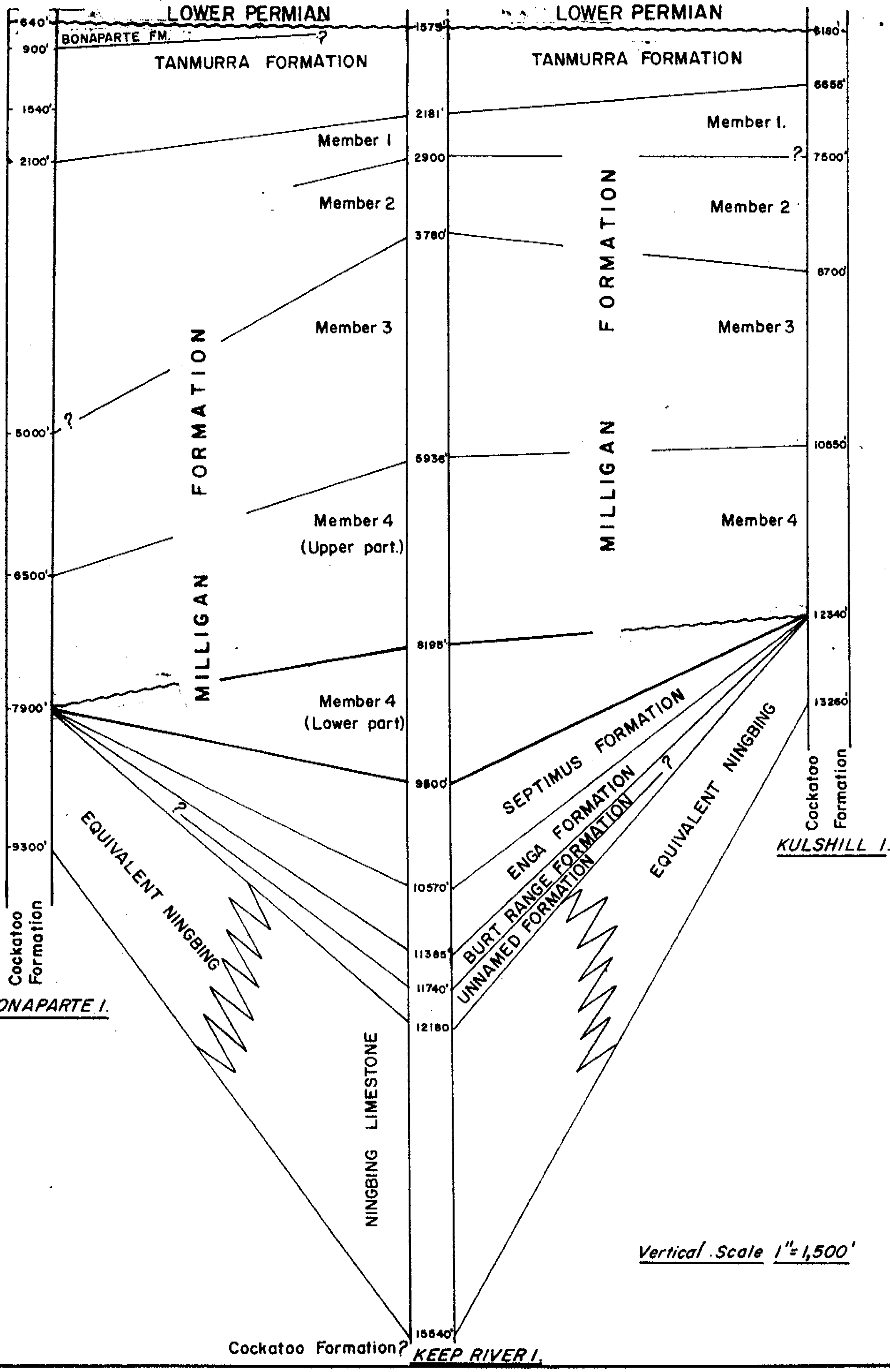
AFTER DRILLING



Drg.Nº 4737.

ENCL. 8.

LITHOSTRATIGRAPHIC CORRELATIONS



Ningbing Limestone

Two DST have been run.

DST 2, on a zone of very fast drilling and which, from the Schlumberger log interpretation had shown a fair porosity though a little shaly. Only water was recovered from the test.

The second test DST,3, on a strong gas show while drilling, gave only salt water with methane emulsion. A complete absence of permeability explains this poor result, with the probability that gas was trapped in fissures of small extent.

4.8. Contribution to Geological and Petroleum Knowledge

48.1 Geological

The thickness of Paleozoic sediments ismuch greater than expected due to an enlarged section of Lower Carboniferous rocks. Unlike Bonaparte No. 1 and Kulshill No. 1, the whole Tournaisian sequence of the Burt Range sub-basin was encountered in Keep River No. 1, cf. Enclosures 7 and 8.

The hypothesis of Keep River being a high zone was confirmed by the presence of a Famennian reefal sequence, with facies similar to those of the Ningbing area.

Consequently the geological history of the Bonaparte Gulf Basin cam be more accurately outlined as follows:

(i) after the Pre-Upper Devonian reactivation of the Halls Creek Mobile belt, a Devonian sea transgressed, resulting in the growth of algal limestone along the Ningbing, Pincombe and Keep River high zones. Between the shore and reefal barrier, a considerable thickness of sandstones was depositied whilst in the open sea argillaceous and fine sediments occurred.

(ii) Regression marks the end of the Devonian, followed by limited Tournaisian sedimentation in the Burt Range sub-basin and Keep River.

(iii) Transgression of the Visean Sea which extended over the whole area began by terrigenous deposits such as channel cut sandstone and sandstone bars , then becoming finer.

(iv) During the Upper Visean Namurian time, structural movement recommenced giving the high sandstone masses of the Tanmurra Formation and the beginning of the Lower Carboniferous regression.

48.2 Petreleum

Keep River has shewn the real pessibility ef the area as a gas preducer. It has confirmed shows at levels equivalent te those ef Benaparte Ne. 2 and has shewn the pessibility ef gaseeus hydrecarbens existing in the Lewer Member ef the Milligan Fermatiens.

The discevery ef the Ningbing Limestene deeper in the basin has added te the hydrecarben petential ef the area but it seems that enly an extensive fracture weuld permit their preductien.

V. REFERENCES

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