HAWKESDALE 1

SHELL DEVELOPMENT

(AUSTRALIA)

PTY. LTD.

WCR
HAWKESDALE-1
(W570)

SHELL

Interstate's oil shows

By GARRY OLIVER

The Shell-Frome Broken Hill group has struck hydrocarbons in its Hawkesdale No. 1 well, about 30 miles south-east of Hamilton in Victoria.

The partners cut the core from the interval 3568-3596 feet and recovered about seven feet of porous sandstone with a showing of hydrocarbons.

Hydrocarbons can mean oil, gas or both, but it is believed the find in the Hawkesdale well is oil.

The partners said in yesterday's report that further coring was in progress, and this would be followed by a drill stem test.

Hawkesdale No. 1 is geologically located in the Otway Basin area which embraces part of Victoria and spills over into South Australia.

It is the second well in the current two-well programme in the area for Shell-Frome Broken Hill. The first well — Moyne Falls No. 1 — was abandoned without encountering any shows of hydrocarbons.

Frome-Broken Hill is owned jointly by the BP group, Mobil Oil Australia and Interstate Oil, which is the petroleum off-shoot of the powerful CRA mining house.

The Shell-Frome Broken Hill group has been searching for oil in the Otway Basin since April, 1967, and wells have been put down both onshore and offshc — to date without finding anything of commercial significance.

The first well, Pecten 1A, offshore from Warrnambool, was abandoned after encountering a minor gas show of 113,000 cubic feet a day.

SIR MAURICE MAWBY, chairman of Interstate

The other two wells in the initial offshore series—Nerita and Voluta — were also dry holes.

This programme was followed by a second three-well series onshore in the Otway Basin. All three holes — Woolsthorpe, Garvoc and Purrumbete — were unsuccessful.

Bream 3 at 9767 ft.

The Esso-BHP Bream 3 well, which has already encountered oil and gas below 6200 feet, is now at a depth of 9767 feet.

Because of a labor dispute drilling operations on the partnership's Glomar III rig at the Snapper 3 location and on the Halibut platform have been suspended for the past week.

REF ID: 19537

SHELL/FROME-BROKEN HILL

HAWKESDALE NO. 1

OTWAY BASIN - VICTORIA

WELL COMPLETION REPORT

by

Shell Development (Australia) Pty. Ltd.

(Dr. J.J.K. Poll)

S.D.A. Report No. 110

Melbourne.
March, 1970

PE907924

This is an enclosure indicator page.
The enclosure PE907924 is enclosed within the container PE905809 at this location in this document.

The enclosure PE907924 has the following characteristics:

ITEM_BARCODE = PE907924
CONTAINER_BARCODE = PE905809
NAME = Rig Photograph
BASIN = OTWAY
PERMIT = PEP 5
TYPE = WELL
SUBTYPE = PHOTOGRAPH
DESCRIPTION = Photograph of the Brewster N-4 Rig on Hawkesdale-1 Locaton, in the foreground is the bore drilled for the water supply, (Figure 1of WCR) for Hawkesdale-1
REMARKS =
DATE_CREATED = 31/03/70
DATE_RECEIVED =
W_NO = W570
WELL_NAME = HAWKESDALE-1
CONTRACTOR = Shell Development (Australia) Pty Ltd
CLIENT_OP_CO = Shell/Frome-Broken Hill

(Inserted by DNRE - Vic Govt Mines Dept)

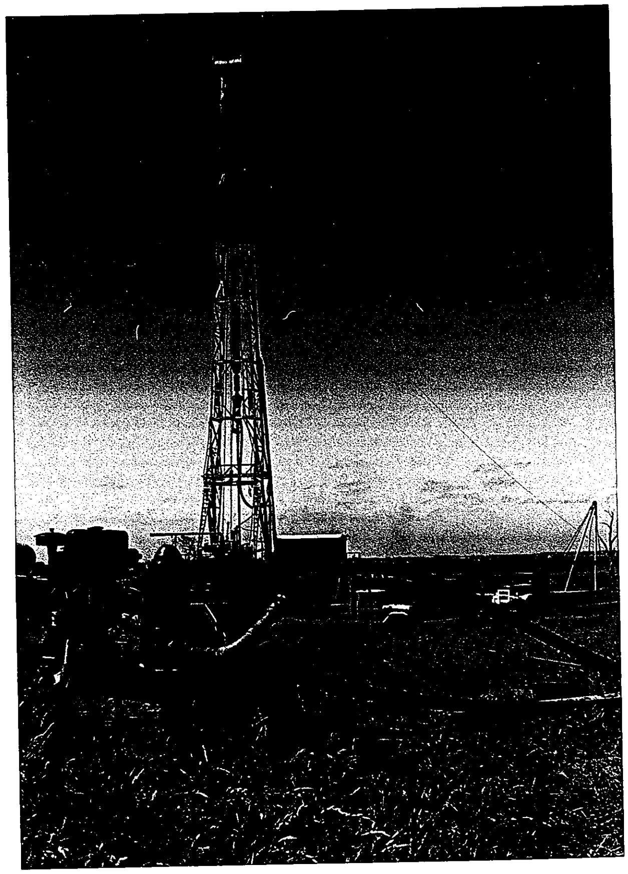


Fig. 1 The Brewster N-4 rig on the Hawkesdale No. 1 Location. In foreground the bore drilled for the water supply.

CONTENTS

TEXT FIGURES

ENCLOSURES

1a N-S Seismic Sections over Moyne Falls No. 1 and east of Hawkesdale No. 1. Drawing No. 3443.

1b Seismic contour map Horizon P (base Eumeralla Fm - Lower Cretaceous). Scale 1:100,000. Drawing No. 3430.

1c Seismic contour map Horizon D (top Palaeozoic Basement) Scale 1:100,000. Drawing No. 3432.

1d Well velocity data Hawkesdale No. 1. Drawing No. 4096.

1e Velocity function, Hawkesdale No. 1. Drawing No. 4119.

2a Structural section Pretty Hill - 1, Moyne Falls - 1, Hawkesdale - 1 and Woolsthorpe - 1.
Horizontal Scale 1:100,000.
Vertical Scale Time Scale. Drawing No. 4051.

2b Geological section before and after drilling. Drawing No. 4121.

2c Otway group Log correlation Pretty Hill - 1. Moyne Falls - 1, Hawkesdale - 1 and Woolsthorpe - 1.
Horizontal Scale 1:100,000.
Vertical Scale 1" = 500'. Drawing No. 4122.

3a, b Composite well log - Hawkesdale No. 1 (2 sheets). Drawing No. 4120A, B.

4a-g Copies of Induction - Electrical logs, Gamma-Ray Sonic logs, Formation Density logs (all on scales 1" and 5" per 100 feet) and a copy of the Continuous Dipmeter log (on scales 2" and 5" per 100 feet).

5a, b Copies of Formation Testing Service Reports DST No. 1 and 2.

APPENDICES

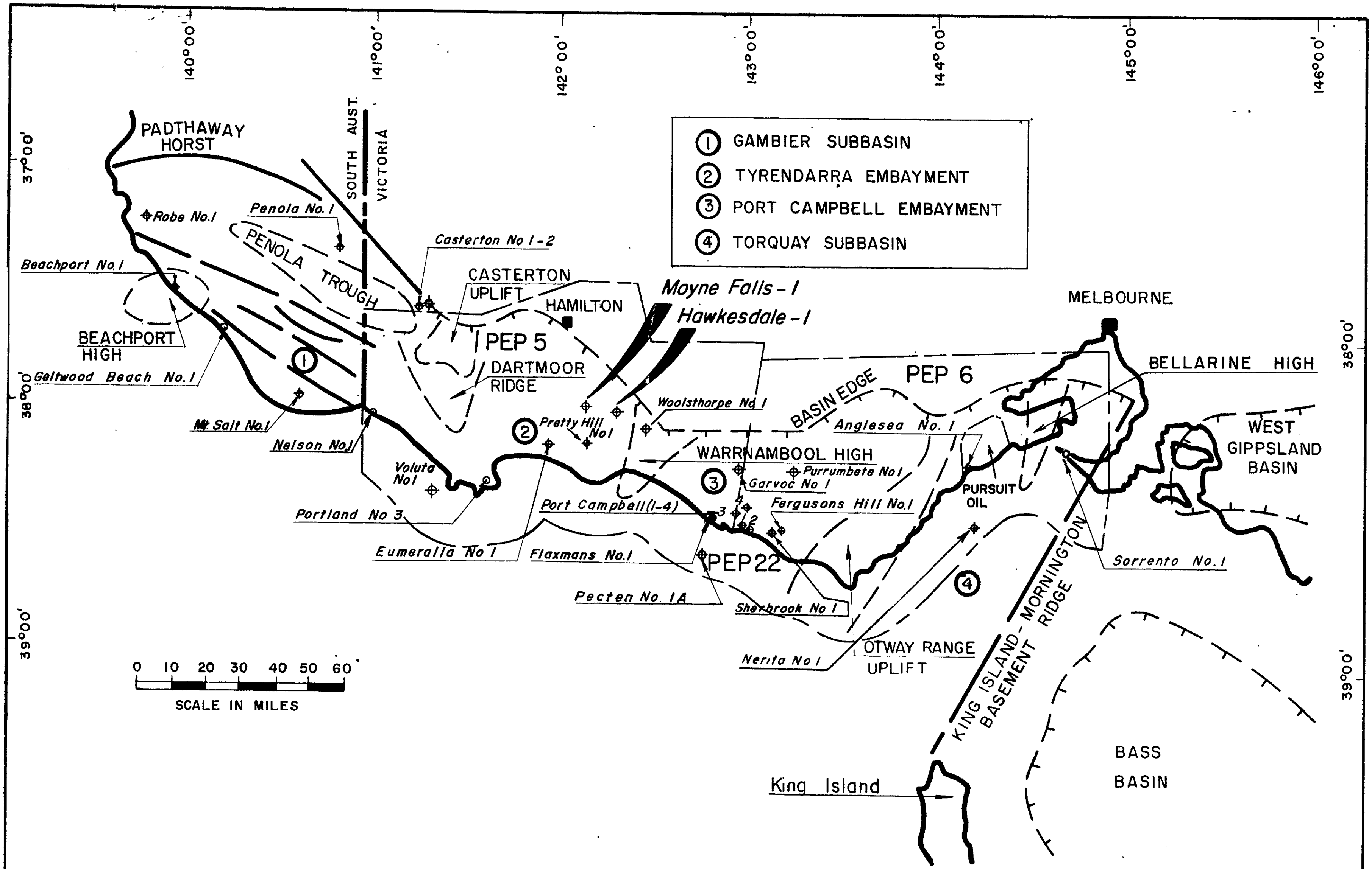


Fig 2

KEY MAP OF THE OTWAY BASIN

Drg.No. 4036

1. SUMMARY

1.1 Drilling

The Shell/Frome Hawkesdale No. 1 well, located approximately 22 miles Northwest of Warrnambool in the Otway Basin of South-western Victoria, was drilled to a total depth of 5,820 feet with a Brewster N-4 rig by Richter Bawden Drilling Pty. Ltd. on behalf of the operator Shell Development (Australia) Pty. Ltd.

The well site is located along a metalled road approximately 1 km from a sealed main road.

Drilling commenced on 2nd December, 1969 and was completed on 30th December, 1969. The well was deepened beyond 5,350 feet (programmed depth) to ensure that Palaeozoic basement (one of the objectives of the well) was reached.

Four cores were cut using a Christensen diamond core barrel. No recovery was obtained from the second coring attempt. Seventy-seven sidewall cores were attempted of which seventy-five were accepted. The wire line logging programme consisted of Induction - Electrical, Gamma Ray - Sonic, Formation Density and Continuous Dipmeter logs. Two drill stem tests were carried out but both attempts failed due to inadequate packer seats. The tests were designed to obtain a sample of formation fluids from the interval 3,501-3,603 feet, where minor oil shows were encountered in a porous and permeable Pretty Hill Sandstone reservoir.

The well was plugged back and abandoned as a dry hole on 30th December, 1969.

1.2 Geological

Hawkesdale No. 1 is located on the eastern flank of a structurally high basement block defined by gravity and seismic in the northern part of the Tyrendarra Embayment in the proximity of the northern margin of the Otway Basin.

The well was designed to test the hydrocarbon prospects of a small (3 square miles closure on top reservoir) wedge - out/fault trap at Pretty Hill Sandstone level.

The sequence penetrated consisted from top to bottom of 73 feet of recent to Pleistocene volcanics, 985 feet of carbonates of the Middle Miocene to Oligocene Heytesbury group, 2,058 feet of claystones, siltstones and sublithic sandstones of the Lower Cretaceous Eumeralla formation, 823 feet of porous quartz sandstones and minor siltstone/claystone interbeds of the Lower Cretaceous Pretty Hill Sandstone, 1,757 feet of tuffs, grits, basalts, carbonaceous clastics and chloritic siltstones of the ? Lower Cretaceous - ? Upper Jurassic Basal unit and 112 feet of phyllite and quartzite of the Palaeozoic basement.

Very good reservoir rocks were encountered in the Pretty Hill Sandstone, with porosities ranging from 15 to 32% and permeabilities up to 5 Darcy in places.

Minor hydrocarbon shows were encountered in a core cut from the interval 3,568 - 3,596 feet but the logs indicate a 100% water saturation in this interval.

The well penetrated the stratigraphic sequence as prognosticated. The Basal unit is thicker than anticipated and consists almost entirely of volcanics.

The well achieved its objectives by drilling through the Otway group into Palaeozoic basement. The well data established thereby that although excellent reservoir sands are present in the Pretty Hill Sandstone no significant hydrocarbons have accumulated in this trap.

2. INTRODUCTION

Hawkesdale No. 1 was the second of two wells drilled by the Shell/Frome partnership in the northern part of the Tyrendarra Embayment, close to the northern margin of the Otway Basin.

Significant but non-commercial shows of oil and wet gas have been encountered elsewhere within the Eumeralla formation of the Otway group. Most of these shows occurred in wells drilled in the onshore Port Campbell Embayment. The Eumeralla formation, however, generally lacks reservoir properties.

The drilling of Woolsthorpe No. 1 and Garvoc No. 1 in 1968 proved an extension of the Pretty Hill Sandstone of the Otway group to the east. The porous and permeable quartz sands of the Pretty Hill Sandstone constitute an excellent reservoir and since this formation is underlain by the Basal unit which has source rock potential in shale samples in the Casterton No. 1 well, the Pretty Hill Sandstone was considered to be a valid exploration target in the Tyrendarra Embayment. A geophysical programme was initiated in 1968 with the objective of outlining drillable prospects in the Otway group.

The geophysical programme in the Hawkesdale area started with a detailed gravity survey in order to select gravity anomalies for subsequent seismic surveying. Three pronounced positive anomalies were surveyed by seismic, followed by a geochemical survey in selected areas covering the block faulted basement highs and lower Otway group pinchouts.

Seismic interpretation indicates the Pretty Hill Sandstone to be absent on these three highs, thus discounting earlier hopes of drape structures at Pretty Hill Sandstone level on the highs. A small potential trap of Pretty Hill Sandstone occurs on the east flank of the Hawkesdale high. Although of a complex nature (fault bounded to the north and north east and wedging out on basement towards the west) and of limited size it was proposed to drill Hawkesdale No. 1 to a depth of not more than 6000 feet.

3. WELL HISTORY

3.1 General Data

(i)	Well name and number	: Hawkesdale No. 1.
(ii)	Name and address of Operator	: Shell Development (Australia) Pty. Ltd., 155 William Street, Melbourne, Vic. 3000.
(iii)	Name and address of joint tenement holders	: Frome-Broken Hill Company, Mobil Centre, 2 City Road, South Melbourne, Vic. 3205, and Shell Development (Australia) Pty. Ltd., 155 William Street, Melbourne, Vic. 3000.
(iv)	Petroleum tenement	: Petroleum Exploration Permit No. 5.
(v)	District	: Portland (1:250,000; sheet SJ 54-11)
(vi)	Location	: Latitude : 38° 04' 53" South Longitude : 142° 17' 54" East 303.840 yds N) ATM 1858, zone 6 524.580 yds E)
(vii)	Elevation	: Ground : 444' ASL RT : 456' ASL (Datum for depth measurements).
(viii)	Total Depth	: 5820' Driller 5811' Schlumberger.
(ix)	Date drilling commenced	: 2.12.1969.
(x)	Date total depth reached	: 28.12.1969.
(xi)	Date well abandoned	: 30.12.1969.
(xii)	Date rig released	: 30.12.1969.
(xiii)	Drilling time in days	: 26. Excluded 24 hours time off on Christmas.
(xiv)	Status	: Plugged and abandoned. Plugs : 2950'-2710' 120 sacks 1300'- 900' 120 sacks 200'-surface 100 sacks All plugs set by conventional displacement.

3.1 General Data (Cont'd)

(xv)	Total cost	: Approximately $A110,000.

3.2 Drilling Data

(i) Name and address of Drilling Contractor : Richter Bawden Drilling Pty. Ltd.,
Perry House,
Elizabeth Street,
Brisbane, Qld. 4000.

(ii) Drilling plant :

Make	:	Brewster
Type	:	N. 4
BHP	:	6000 ft with 4½" dp.
		7500 ft with 3½" dp.
Motors	:	
Make	:	General Motors
Type	:	Twin 6-71, Model 12103
BHP	:	356

(iii) Mast :

Make	:	Lee C. Moore
Type	:	126' Cantilever
Capacity	:	360.000 lbs.

(iv) Pumps :

Make	:	Oilwell
Type	:	214 P
Size	:	7¼" x 14"
Motors	:	
Make	:	General Motors
Type	:	Twin 6-71, Model 12103
BHP	:	356

(v) Blow out preventer equipment :

Make	:	(1) Regan	(1) Cameron
Size	:	10"	12"
Type	:	K	SS
Series	:	900	900

Operating Unit:
Payne accumulator
Model NSSUA - 80 - 3

(vi) Hole sizes : 17½" to 406 feet
12¼" to 1235 feet
8¾" from 1235 feet - Total Depth

(vii) Casing and cementing details :

Size	:	13-3/8"	9-5/8"
Weight	:	48 lbs/ft	36 lbs/ft

3.2 Drilling Data (Cont'd)

Grade	:	H40	J55
Range	:		2
Set at	:	390'	1221'

A Baker float shoe was run on the bottom of the first joint of casing, with a Larkin Baffle Collar between the first and second joint of casing. No scratchers or centralizers were used. All top and bottom plugs were Howco plugs.

Quantities of cement used:

13-3/8" casing	9-5/8" casing
150 sacks and 2% $CaCL_2$ Cemented to: 180' estimate Method : Plug	500 sacks and 2% $CaCL_2$ Surface Plug

(viii) Drilling fluid : Type : Fresh water bentonite
Average weight : 9.9 lbs/gal.

Treatment:
From surface to 1235 feet (9-5/8" csg. setting depth), the hole was drilled with a water-bentonite suspension only, thereafter chemicals were added. The mudweight was kept at about the above figure by adding water and dumping mud. Fluidloss was controlled by Cellex and Q'broxin. Viscosity was maintained in the right order of magnitude by water, Cellex, bentonite and Q'broxin. PH was controlled by caustic soda.

Average weekly analysis :

Week Ending	Weight ppg	Viscosity MF	Fluid loss cc	Filtercake (1/32 in.)	Sand %	PH
6-12	9.5	50	-	-	-	-
14-12	10.1	46	10.5	2	3.7	9.3
21-12	9.9	47	9.5	1	2.7	9.6
20-12	10.1	53	7.3	1	3.3	9.9

3.2 Drilling Data (Cont'd)

Total mud materials consumed:

Aquagel	:	215 x 100 lbs
Q'broxin	:	85 x 50 lbs
Cellex	:	38 x 50 lbs
Caustic soda	:	8 x 140 lbs
Diesel	:	1600 gall.
Sawdust	:	20 x 100 lbs

(ix) Water Supply : For this purpose, a water well was drilled appr. 100 yards from the location. The capacity of this bore was 2000 gallons/hour.

(x) Perforation and shooting record : No perforation was carried out

(xi) Plugging back and squeeze cementation jobs :

Plug No.	Length of Plug (ft)	Sacks of cement	Tested
1	2950 - 2710 (240)	120	Yes
2	1350 - 900 (450)	120	Yes
3	200 - 0 (200)	100	No

(xii) Fishing operations and hole troubles:

Although no fishing operations were needed, some troubles were experienced drilling the hole. At 165 feet circulations was lost. It was decided to drill ahead to the top of the Gellibrand Marl without circulation. Thereafter the hole was reamed out to 17½", and 13-3/8" casing was set.

While drilling beyond 3500 ft. caving shales became a problem. At one stage, the string became stuck at 2700 feet while running in with a new bit. Cavings probably stacked up on a new stabilizer, which was run in the string for the first time. The drill string was freed after it had been worked, up to maximum pull, for approx. 2 hours.

As excessive reaming became necessary, while making roundtrips beyond 5000 feet, 6% Diesel oil was added to the mud. Thereafter no further problems were experienced.

(xiii) Side tracked hole : Nil.

3.3 Formation sampling

(i) Ditch cuttings : Cuttings were collected from the shaleshaker, washed through a coarse sieve and retained and washed in a bucket. Samples were collected at 30 feet intervals from surface to 990 feet and thereafter at 10 feet intervals. The samples were treated as follows:

1 sample washed and dried for the Bureau of Mineral Resources.

1 sample washed and dried for the Victoria Department of Mines.

1 sample washed and dried for Shell Development (Australia) Pty. Ltd.

1 sample unwashed and dried for Shell Development (Australia) Pty. Ltd.

1 sample washed and dried for well reference for the well site geologist.

The samples were placed in labelled polythene bags and stored at the following locations:

(A) Bureau of Mineral Resources,
Core and cuttings Laboratory,
Collie Street,
Fyshwick, Canberra. A.C.T.

(B) Victorian Mines Department,
Core Laboratories,
Cook Street,
Port Melbourne, Vic.

(C) Shell Development (Australia) Pty. Ltd.
155 William Street,
Melbourne, Vic. 3000.

3.3 Formation sampling (Cont'd)

(ii) Coring :

Core No.	Interval Cored in feet	Feet cored	Recovery in feet	Recovery %
1	3568 - 3596	26	7, 3	26
2	3597 - 3603	6	0	0
3	4459 - 4469	10	9	90
4	5749 - 5765	16	16	100

A Christensen diamond core barrel was used for all cores. Four inches of every 2 feet of core were sent to (A) and (B). The remainder of the core is stored at (C).

(iii) Sidewall sampling : After reaching total depth Schlumberger shot 77 sidewall cores of which 75 were accepted by the well site geologist. Listed below are the depths at which these sidewall cores were taken and the recoveries:

Depth (ft.)	Recovery (ins.)	Depth (ft.)	Recovery (ins.)	Depth (ft.)	Recovery (ins.)
1245	2	2838	1¼	3698	¾
1322	2¼	2850	1½	3774	2
1442	2	2878	1½	3810	1½
1519	2	2913	1½	3840	½
1570	2	2944	1½	3884	1¼
1657	1¾	2972	1¾	3895	2
1714	2	3004	1	3925	2
1771	2	3036	1	3948	1¾
1844	2¼	3095	1½	3977	2
1918	2	3121	1½	4090	1¼
2018	2	3159	1½	4148	2
2072	2	3220	1	4205	1½
2140	1½	3278	1½	4270	2
2204	2¼	3299	1½	4318	1¾
2271	2	3309	1¾	4618	2
2325	2	3340	2	4676	1¼
2380	1¾	3396	1½	4864	0
2456	1½	3463	1	4930	1½
2467	2	3475	1½	5015	1½
2520	2	3486	1¼	5160	1¼
2576	1¾	3494	2	5240	1½
2632	1¾	3506	2	5481	1
2684	2	3506	1	5627	1
2751	1¾	3604	2	5634	½
2800	1½	3611	2	5690	¾
2819	1½	3626	2		

3.3 Formation sampling (Cont'd)

: Following lithological description part of the sidewall samples were used for petrographic and palynological determinations.

3.4 Logging and surveys

(i) Wire line logging : Performed by Schlumberger.

Logs run:

Induction Electrical + SP	: 3838 - 1222 ft
	5810 - 3600 ft
Formation Density Log	: 3838 - 2400 ft
Gamma-ray Sonic Log	: 5800 - 1222 ft
Continuous Dipmeter	: 5806 - 1222 ft

(ii) Penetration rate and gas logs : Penetration rate:

Drilling time was taken from the geolograph, and plotted in minutes per 10 feet on the composite log.

Gas log:

From 9-5/8" casing depth to total depth a continuous record of mud gas was kept using a Hot Wire Detector and Gas Chromatograph (equipment supplied by Data Analysis Pty, Ltd.).

(iii) Deviation surveys : A Totco 8° double recorder was used. Results are tabulated below. For further details, see dipmeter.

Depth ft.	Deviation Deg.	Depth ft.	Deviation Deg.
95	½	2855	1½
215	1	3528	1¼
515	1½	3987	1¼
637	¾	4344	3
737	1	4459	3¼
860	1	4625	3
1001	¾	4602	3
1120	½	5150	4¾
1843	¾	5360	2¾
2343	1½	5565	2¾

3.4 Logging and surveys (Cont'd)

(iv) Temperature surveys : None.

(v) Other surveys : Well velocity survey, see Appendix V.

3.5 Testing

(i) Formation testing : Two attempts were made to carry out a drill stem test, both covering approximately the same interval.

Both tests failed because no adequate packer seat was obtained.

More information on these tests see Appendix VI.

Attempt No.	Interval	Type of	Results
1	3528-3603 ft	Single packer, bottom hole.	No seat
2	3501-3603 ft	Same	No seat

(ii) Production testing : None.

IV GEOLOGY

4.1 History of Exploration

The search for petroleum has been carried out in the Otway Basin for many years and several companies hold exploration permits granted by the Victorian and South Australian Governments both onshore and offshore.

Following a Farm-in Agreement in 1965 with Frome-Broken Hill Company Pty. Ltd., Shell Development (Australia) Pty. Ltd. became the operator in Petroleum Exploration Permits 5, 6 and 22 and earned a 50% interest for a total expenditure of $A4,000,000 including seismic and drilling obligations. During 1966 land seismic surveys were completed in the Yambuk, Portland and Nelson areas and two marine seismic surveys were carried out. In 1967 a short geological survey was carried out in the Torquay and Port Campbell areas and a short experimental refraction survey offshore Cape Bridgewater. In that year three offshore wells were drilled. During 1968 a geological survey was carried out in the Otway Ranges and in the Casterton - Merino area, three wells were drilled onshore, a gravity survey was made of the Hawkesdale - Hamilton area and a land seismic survey started in the Hawkesdale area. Following the 1969 seismic survey in the Hawkesdale area, a geochemical survey was carried out and two wells (Moyne Falls - 1 and Hawkesdale -1) were drilled in this area.

Up to January, 1970 a total of 37 petroleum exploration wells have been drilled in the Otway Basin. A number of hydrocarbon indications have been reported but as yet no commercial accumulation has been found.

4.2 Geology

4.2.1 Summary of the geology of the Hawkesdale area.

The Hawkesdale area forms part of the northern margin of the Tyrendarra Embayment in the Otway Basin (Fig. 1). The area is bounded to the east and west by palaeoridges (the Warrnambool High and the Dartmoor Ridge respectively) which emerged at the end of the Lower Cretaceous after the Otway group deposition.

During the Lower Cretaceous, several phases of movement occurred which resulted in the uplift of basement blocks within the embayments: the Woolsthorpe high, the Hawkesdale high complex and the Branxholme high. Subsequent deep erosion removed most or all of the Basal unit, the Pretty Hill Sandstone and Unit 2 of the Eumeralla formation from the basement highs (Encl. 1a, b and 2a).

The Hawkesdale area is north of the present Upper Cretaceous Sherbrook group pinch-out, although it is likely that at least the southern part of the area was originally covered by thin Upper Cretaceous deposits.

Several phases of deposition, uplift and erosion during the Lower Tertiary resulted in the present day situation of very thin and irregularly preserved sequences of Wangerrip and Nirranda groups. The marine upper Tertiary Heytesbury group covers the area uniformly. Thin, irregular, recent to Pleistocene volcanics outcrop all over the area.

Stratigraphic control for the Tertiary and Mesozoic sequence in this area is based on the Woolsthorpe -1, Moyne Falls -1 and Hawkesdale -1 exploration wells and additional control for the Tertiary and the top of the Otway group is provided by the Kangerton-5 (TD 1150 ft.), MacArthur-3 (TD 2507 ft.) and Branxholme-1 (TD 1510 ft.) waterbores. The seismic horizons tied in with the Woolsthorpe-1 well could be correlated over the Woolsthorpe and Hawkesdale areas and are also recognised on the seismic sections of the Branxholme area. No reliable correlation of the Lower Cretaceous reflections could be made between the northern margin of the embayment and the old, poor quality seismic data in the Pretty Hill-Eumeralla area to the south.

4.2.2 Target zones and correlations

The target zone in the Hawkesdale No. 1 well was the Pretty Hill Sandstone. This formation was known from previously drilled wells to have excellent reservoir characteristics. Seismic showed the Pretty Hill Sandstone to be present in a small and complicated wedge out/fault trap on the south-eastern side of a basement high complex and this trap was tested by Hawkesdale. The trap was most likely formed soon after deposition of the Pretty Hill Sandstone and still in the Lower Cretaceous. The present regional dip of the basement (Horizon D, Encl. 1c) and of the base of the Eumeralla formation (Horizon P, Encl. 1b) is most likely also a palaeo dip and hence the trap is probably favourably located updip from an area where possible source rocks in the Basal unit could have generated hydrocarbons.

An Electrical Log correlation of the Otway group of the Pretty Hill-1, Moyne Falls-1, Hawkesdale-1 and Woolsthorpe-1 wells (Encl. 2c) illustrates the rapid changes in thickness and lithology of especially the lower part of the Otway group in this area. In the Hawkesdale No. 1 well the Eumeralla formation and the Pretty Hill Sandstone were more or less as predicted, but the Basal unit differed considerably from the prognosis. Based on the findings of Woolsthorpe-1 the Basal unit was expected to be about 1,100 feet thick and to have thick palludal shales at least in the top half of the interval. As it turned out the Basal unit has a thickness of 1,757 feet in Hawkesdale No. 1 and is almost entirely volcanic. Only the lower 138 feet of the Basal unit consists of sediments. The 405 feet and 505 feet of Basal unit shales encountered in the Woolsthorpe No. 1 and Casterton No. 1 respectively are most likely not deposited in the Hawkesdale area which therefore could have originated as an early Cretaceous paleohigh.

The well prognosis and the actual section encountered are shown on Enclosure 2b. The correlations between Hawkesdale No. 1 and Pretty Hill No. 1, Moyne Falls No. 1 and Woolsthorpe No. 1 are illustrated in the cross section included as Enclosure No. 2a.

Enclosures 1b and 1c show the location of Hawkesdale No. 1 in relation to the structural contours of seismic horizons P and D which are correlated with the base of the Eumeralla formation and the top of the Palaeozoic basement respectively.

4.3 Stratigraphic Table - Hawkesdale No. 1 FT 456 ASL

Age	Rock Unit	Top (ft. below R.T.)	Thickness (feet)
Recent to ? Pleistocene	Newer Volcanics	12 (surface)	73
	Unconformity		
Middle Miocene to Upper Oligocene	Heytesbury group	85	985
Middle Miocene	Port Campbell Limestone	85	235(?)
Middle to Lower Miocene	Gellibrand Marl	320(?)	490(?)
Middle Miocene to Oligocene	Clifton formation	810	260
	Unconformity		
Lower Cretaceous to (?) Jurassic	Otway group	326m 1070 -614'	4638
Lower Cretaceous	Eumeralla formation (Unit 1 & 2)	1070	2058
	Unconformity (?)		
Lower Cretaceous	Pretty Hill Sandstone	953 3128 -2672'	823
? Lower Cretaceous to ? Jurassic	Basal unit	1024 3951	1757
	Unconformity		
Lower Palaeozoic	Basement	1740 5708 -5252'	112+

T.D. 5820 feet

4.4 Lithological Description

Newer Volcanics		(Recent to ? Pleistocene)
Surface - 85 feet	:	Basalt, dark greenish-grey, vesicular, fine crystalline, very weathered to yellow-brown especially in upper 50 feet.
Heytesbury group		(Middle Miocene to Oligocene)
85-(?)320 feet	:	Port Campbell Limestone (Middle Miocene) Limestone, Wackestone, Packstone in part, buff and light yellow-brown, very porous and permeable, bioclastic, slightly cemented, crumbly break, very friable.
		(No cuttings were recovered from the interval 165-460 feet due to the complete loss of circulation. Marly clay attributed to the Gellibrand Marl, was recovered from the stabiliser from about 350 feet. This indicates that the base of the Port Campbell Limestone is higher than 350 feet. The prognosed depth of 320 feet is maintained as the approximate depth of the Gellibrand Marl).
(?)320-810 feet	:	Gellibrand Marl (Middle to Lower Miocene)
		Marl, medium grey, very argillaceous, slightly silty and fine sandy, very fossiliferous, unconsolidated, plastic, (minor glauconite).
810-1070 feet	:	Clifton formation (Middle Miocene to Oligocene)
810-1040 feet	:	Limestone, Packstone, very porous and permeable, light grey-green to buff, bioclastic, only slightly cemented, crumbly break, very friable.
1040-1070 feet	:	Limestone, Packstone, very porous and permeable, yellow-brown, ironcoated bioclasts, slightly cemented crumbly break, friable with Quartz, light yellow-brown, medium to coarse, rounded.

Otway group (Lower Cretaceous to (?) Jurassic)

1070-3128 feet : Eumeralla formation (Lower Cretaceous)

1070-1430 feet : Clay, light to medium grey-green, chloritic, silty to fine sandy in places, slightly carbonaceous, slightly consolidated, moderately soft. (About 20% of the sediment is silt and less than 10% is very fine sand, mostly clear, angular quartz and minor feldspars and lithic grains).

1430-1590 feet : 75% Clay, light to medium grey-green, chloritic, silty, slightly fine sandy in places, carbonaceous, slightly consolidated, moderately soft.

25% Sandstone, light grey-green, very fine to medium, subangular, poorly to moderately sorted, quartzose, slightly chloritic and lithic, silty, slightly consolidated, friable.

1590-2812 feet : Clay to Claystone, light to medium grey-green, chloritic, silty, fine sandy in places, carbonaceous, thinly laminated in places, slightly consolidated, soft to moderately hard.

The minor sand fraction is mostly very fine, subangular, quartzose with only minor content of lithic fragments. Coal seams, present throughout, are a few inches to a few feet thick. The thickest seams are present at 1734', 2035', 2086', 2153', 2243', 2286', 2463-2470', all depths related to the depth scale on the resistivity log.

2812-2864 feet : Sequence of three altered igneous dikes with Claystone-Sandstone in intervals 2823-2832 feet and 2847-2852 feet.

Igneous rock, fine grained inequigranular granitic dike (50% quartz, 40% feldspar, 10% biotite).

Sandstone/Claystone, light to medium grey-green, very fine, chloritic, consolidated, moderately hard.

2864-2984 feet : Claystone, medium to dark grey, silty and fine sandy in places, carbonaceous, micaceous in part, consolidated, moderately hard.

Sandstone (minor), tight, light to medium grey-green sublithic, argillaceous, silty, carbonaceous, very fine, cemented, friable.

2984-3048 feet : Igneous dike Granite, granular sedimentary appearance.

3048-3128 feet : Claystone, light to medium greenish-grey, silty to fine sandy, carbonaceous, micaceous, consolidated, moderately hard.

Sandstone, light grey-brown, quartzose, silty, poorly to moderately sorted, subangular, very fine to coarse, carboniferous, slightly cemented, friable.

3128-3951 feet : Pretty Hill Sandstone (Lower Cretaceous)

3128-3271 feet : 90% Sandstone, 5-20% estimated porosity, light green-grey, quartzose to sublithic in part, micaceous, fine to medium, moderately to well sorted, subangular, slightly to moderately cemented, very friable.

10% Claystone, medium grey-green, very chloritic fine sandy and silty in part, micaceous, carbonaceous, consolidated, moderately hard.

3271-3312 feet : 85% Claystone, medium grey, silty, carbonaceous, micaceous, fine sandy in part, consolidated, moderately hard.

15% Sandstone, 10-15% estimated porosity, quartzose, argillaceous, silty, micaceous, slightly to moderately cemented, friable.

3312-3457 feet : 90% Sandstone, 10-20% estimated porosity, light grey, quartzose, slightly micaceous, silty in part, fine, moderately to well sorted, subangular to subrounded, slightly to moderately cemented, moderately hard, friable.

10% Claystone, medium grey, silty, fine sandy in part, micaceous, carbonaceous, consolidated, moderately hard.

3457-3492 feet	:	Argillaceous Sandstone/sandy Claystone, light to dark grey, quartzose, micaceous, carbonaceous very fine, moderately sorted, soft to moderately hard.
3492-3600 feet	:	Sandstone, 20-30% estimated porosity, moderate to very high permeability, light greenish-grey, quartzose, slightly silty and argillaceous in part medium (fine to coarse in part), sorted, subangular to subrounded, slightly consolidated, loose to very friable. Accessory components : garnet, light to medium translucent pink, fine, angular; chlorite; mica. Low to high angle cross-beds (see description Core No. 1).
3600-3622 feet	:	Claystone, medium to dark grey, silty and fine sandy, carbonaceous, micaceous, consolidated, moderately hard, with Sandstone laminae, white, quartzose, very fine, sorted, slightly cemented, friable.
3622-3951 feet	:	Sandstone, 10-30% estimated porosity, fair to high permeability, light grey to medium grey-green, quartzose, fine to medium, subangular to subrounded, moderately to well sorted, quartzose (sublithic in part), silty and argillaceous in part, slightly cemented, friable. Accessory components : pink translucent garnet, chlorite, mica, carbonaceous matter.
3951-5708 feet	:	Basal unit (? Lower Cretaceous - ? Upper Jurassic).
3951-4107 feet	:	Tuff, red brown, completely altered, zeolitic, with glass shards and lithic fragments, tightly cemented, soft to moderately hard, interbedded with basaltic flows, multicoloured, vesicular, altered.
4107-4138 feet	:	Olivine Basalt, red-brown to greenish-black, vesicular, altered, hard.

4138-4290 feet	: Tuff, red brown to dark brown, zeolitic, vesicular, partly waterlaid with well rounded quartz and carbonaceous matter, tight, moderately soft to moderately hard, probably interbedded with volcanic (basaltic) flows.
4290-4550 feet	: Basalt, red-brown to greenish-black, altered to moderately fresh, fine crystalline, altered olivine phenocrysts, alternating with volcanic grits and tuffs, red brown, altered, with glass shards and other altered multicoloured vesicular volcanic rock types.
4550-4846 feet	: Tuff and Grit, red-brown, altered, zeolitic, with glass shards, crystal fragments (epidote, chlorite, olivine, minor quartz etc), vesicular, moderately soft, probably alternating with volcanic flows.
4846-4872 feet	: Basalt, red-brown to dark grey, altered to moderately fresh, vesicular, hard.
4872-5036 feet	: Tuff and Grit, red-brown, altered, vesicular, zeolitic, with glass shards and crystal fragments, moderately soft, probably interbedded with tuffaceous sediments (with rounded quartz) and some volcanic flows.
5036-5100 feet	: Basalt, dark brown-black, altered to moderately fresh, slightly altered olivine phenocrysts, hard, probably alternating with volcanic grits and tuffs.
5100-5218 feet	: Volcanic, light grey-green, almost completely altered to chloritic clay, vesicular with dark green vesicle infill, moderately soft (probably altered basic volcanic rock).
5218-5304 feet	: Tuff, red brown to grey, very altered, zeolitic, with rounded lithic fragments, tight, moderately hard, alternating with Basalt, dark greenish-black, olivine phenocrysts, moderately fresh, hard.

5304-5384 feet	:	Volcanic, light grey green, almost completely altered to chloritic clay, vesicular with light to dark green irregular vesicle infill (probably altered basic volcanic rock).
5384-5570 feet	:	Volcanic, mixture of altered rock types, grey-brown to purple-brown, clusters of small white and transparent phenocrysts, partly tuffaceous with glass shards.
5570-5669 feet	:	Sandstone-Siltstone-Shale, light grey to black, very carbonaceous, very fine sandy (quartzose), micaceous, consolidated, moderately hard, friable.
5669-5708 feet	:	Claystone-Siltstone, light grey-green, very chloritic, sericitic, slightly consolidated, soft to moderately hard. Probably reworked basement.
5708-5820 feet	:	Basement (Lower Palaeozoic).
5708-5820 feet	:	Phyllite and Quartzite, medium greenish-grey, chloritic and sericitic. Irregular banding, probably sedimentary, ½-2 inches in thickness. Poorly developed fracture slaty cleavage parallel to the banding with small tight parasitic folds. Banding and cleavage system have a 55^{o} dip in core No. 4.

T.D. 5820 feet

4.5 Contribution to geological concepts resulting from drilling:

Hawkesdale No. 1 was located on a flank of one of the structurally high basement blocks indicated by gravity and seismic along the northern margin of the Otway Basin. The well was designed to test the hydrocarbon prospects of a small wedge-out/fault trap at Pretty Hill Sandstone level. The results of Hawkesdale No. 1 contribute to an understanding of the palaeogeography and geology of the northern part of the Tyrendarra Embayment. The more important factors are summarized as follows:

(a) The upper 1,000 feet of Eumeralla formation penetrated in Hawkesdale No. 1 are almost entirely soft and friable. as reflected by the extremely fast penetration rates and the low velocities recorded on the integrated sonic log and during the velocity survey. The sediments are mainly soft chloritic clays. The lower part of the Eumeralla formation in the Hawkesdale No. 1 well is only slightly consolidated. The lack of induration of the Eumeralla formation in Hawkesdale No. 1 and Moyne Falls No. 1 wells when compared with the more indurated sediments of the same stratigraphic intervals in the nearby Woolsthorpe No. 1 well, may indicate a lack of appreciable overburden after Lower Cretaceous deposition on the Hawkesdale-Moyne Falls basement high. It is likely that this high was a growing structure during at least part of the Lower Cretaceous and has probably remained high since then.

(b) Hawkesdale No. 1 drilled through a monotonous sequence of Eumeralla formation. It is not possible to make a distinction between the two units although palynology indicates that sediments of both units occur in the well. Consequently little can be said about diachronism within the Eumeralla formation in the northern Tyrendarra Embayment.

(c) Hawkesdale No. 1 penetrated 823 feet of Pretty Hill Sandstone, which is the target reservoir of the Lower Cretaceous sequence. Good reservoir characteristics were encountered in all wells that penetrated this formation. In Hawkesdale No. 1 the bulk of the sequence (some 700 feet) of Pretty Hill Sandstone consists of quartz sandstone with high porosities and permeabilities (some 700 feet) of Pretty Hill Sandstone consists of quartz sandstone with high porosities and permeabilities (up to about 30% and 5 Darcy respectively); at least in this part of the basin the Pretty Hill Sandstone constitutes an excellent reservoir and remains a valid exploration target.

(d) Hawkesdale No. 1 penetrated 1,757 feet of Basal unit, which prior to drilling was expected to be about 1,100 feet. The sequence penetrated consists of 1,619 feet of volcanic tuffs and flows, 99 feet of carbonaceous clastics and 39 feet of presumably reworked basement. The thick carbonaceous clastics (potential source rocks) which were encountered at the top of the Basal unit in the Casterton No. 1 and Woolsthorpe No. 1 wells are missing in the Hawkesdale-Moyne Falls area. In Hawkesdale No. 1 source rock potential in the Basal unit is restricted to the 99 feet of paralic carbonaceous clastics. This downgrades the Basal unit as a source formation at least in this part of the Tyrendarra Embayment.

(e) Hawkesdale No. 1 penetrated 2,058 feet of Eumeralla formation. The sequence has relatively far more fine grained clastics than in most other wells and provides a good seal over the Pretty Hill Sandstone reservoir. The sandstones in the Eumeralla formation are tight due to zeolite-chlorite cementation.

(f) Hawkesdale No. 1 tested a small but valid pinchout/fault trap of Pretty Hill Sandstone against the slope of a structurally high basement block. Although most conditions for an accumulation of hydrocarbons seem to be fullfilled (down to basin slope, reservoir, early trap, seal), only a minor oil show was encountered in the Pretty Hill Sandstone.

(g) The presence of four granitic dikes within the lower part of the Eumeralla formation in the interval 2,812-3,048 feet is unique in the Otway Basin. The dikes were first noted on the Gamma Ray - Sonic log where anomalous high radio activities were recorded. Due to the crumbly nature the rock desintigrated while drilling through and the loose grained cuttings were attributed to a sandstone interval. Three side wall cores were taken and strong mineral fluorescence was observed. Although it has a granular - sedimentary appearance in part it is very likely that the rock occurs as igneous dikes. This implies a granitic intrusive phase that is of Lower Cretaceous or younger age unknown so far in the basin. No contact metamorphism is observed in the contact zones of the under - and overlying sediments.

V REFERENCES

BAXMANN, B. 1969 : Regional Review of the Seismic Data in the Woolsthorpe - Hawkesdale and Branxholme areas in the Otway Basin. Unpublished Report, Shell Development (Australia) Pty. Ltd. Report No. 105.

DATA ANALYSIS PTY. LTD., 1969 : Final Report on a Geochemical Survey in the Hawkesdale, Woolsthorpe and Branxholme Areas of the Otway Basin, Western Victoria. Unpublished Report for Shell Development (Australia) Pty. Ltd.

DETTMANN, M.E., 1969 : Palynological zonation of Lower Cretaceous sediments of the Otway Basin, Victoria. Unpublished Report for Shell Development (Australia) Pty. Ltd.

GEOPHYSICAL SERVICE INTERNATIONAL 1969 : Final Report Hawkesdale Seismic Survey. Unpublished Report for Shell Development (Australia) Pty. Ltd.

GEOSURVEYS OF AUSTRALIA PTY. LTD., 1969 : Hawkesdale Gravity Survey, P.E.P. 5, Victoria. Unpublished Report for Shell Development (Australia) Pty. Ltd.

LESLIE, R.B., 1965 : Petroleum Exploration in the Otway Basin. Proc. viii th Commonwealth Mining and Met., Congr. 5., pp. 203-216.

POLL, J.J.K., 1969 : Prospect Appraisal of the Hawkesdale Area, Otway Basin. Unpublished Report Shell Development (Australia) Pty. Ltd. Report No. 101.

SHELL DEVELOPMENT (AUSTRALIA) PTY. LTD., 1969 : Application for exploration drilling subsidy, Hawkesdale -1 and Moyne Falls -1 wells. Otway Basin. Victoria. Unpublished Report, Shell Development (Australia) Pty. Ltd.

WHITE, A.H. and RIBIS, R.A., 1968 : Review of Otway group prospects in the Otway Basin. Unpublished Report, Shell Development (Australia) Pty. Ltd. Report No. 91.

WELL COMPLETION REPORTS

Exploration Wells

Casterton No. 1, 1965 : Well completion Report Planet Exploration Company Pty. Ltd.

Garvoc No. 1, 1968 : Well completion Report Interstate Oil Ltd.

Hawkesdale No. 1, 1970 : Well Completion Report Shell Development (Australia) Pty. Ltd.

Pretty Hill No. 1, 1962 : Well completion Report Frome-Broken Hill Pty. Ltd.

Woolsthorpe No. 1, 1968 : Well completion Report Interstate Oil Ltd.

Waterbores

Kangerton No. 5 : Department of Mines, Victoria.

Macarthur No. 3, 1967 : Completion Report Department of Mines, Victoria.

APPENDIX I

LIST OF SCHLUMBERGER LOGS

RUN IN HAWKESDALE NO. 1

LOG	RUN NO.	DATE	INTERVAL (ft)	SCALE
IES	1	13.12.1969	3,838-1,222	1 and 5
	2	28.12.1969	5,810-3,600	1 and 5
BSGRC	1	28. 1.1969	5,800-1,222	1 and 5
FDCG	1	13.12.1969	3,838-2,400	1 and 5
CDM	1	28.12.1969	5,806-1,222	2 and 5

APPENDIX IA

INTERPRETATION COMMENTS ON WELL LOGS OF HAWKESDALE NO. 1

by

Schlumberger Seaco Inc.

CONTENTS

INTERPRETATION COMMENTS WELL LOGS OF
HAWKESDALE NO. I.

I. LOGS AVAILABLE

Induction Electrical Log Run 2 3600' - 5810'
Run 1 1222' - 3838'
Comp Formation Density Gamma Ray Run 1 2400' - 3838'
B.H. Comp Sonic Gamma Ray Run 1 1222' - 5800'

II. BOREHOLE FLUIDS

Run 1	Freshwater Q - broxin mud
	Rm = 2.26 at 90°F = 1.45 at 136°F
	Rmf = 2.00 at 64°F = 0.97 at 136°F
	Rmc = 2.93 at 64°F = 1.4 at 136°F
Run 2	Freshwater Q - broxin mud
	Rm = 2.37 at 54°F = 0.80 at 160°F
	Rmf= 1.71 at 62°F = 0.64 at 169°F
	Rmc= 2.68 at 58°F = 0.95 at 169°F

III. METHOD

The available logs afford comparative hydrocarbon detection by the usual porosity/resistivity crossplot method. We have selected readings where beds show uniformity over more than 5' and where SP and gamma ray indicate that the formations are relatively free of shale. However, the sands from 2810' - 3050' show radioactivity independently of shale content. For this crossplot method to work it is necessary that lithology (Δt_m or ρ_m) remain approximately constant and that formation water resistivity also remains approximately constant. For this later reason we have split the total length surveyed into two zones above and below 4000' where a marked change of water salinity occurs as shown by the SP.

Tables 1 and 2 give values read from the logs.

IV DISCUSSION

Figure 1 is the crossplot of Ril versus ρ_b for the interval above 4000'. Two lines have been drawn. One covers points 1 and 2 and the other line the remaining point. It is evident from the SP that points 1 and 2 are fresher water than the remainder and hence accounts for the need for two lines. There are no hydrocarbon indications. Rw values are as shown on the figure. Using ρ_m = 2.65 we can thus determine a density termed porosity φ_D and values are then listed in Table 1.

Figure 2 is the crossplot of Ril versus Δt for the interval below 4000'. The density log was not run below 3838'. We find that a fairly wide scatter of points occurs indicating variable lithology with Δtm ranging from 39 to 53 in secs/ft. We have drawn a mediam dotted line with solid lines for upper and lower limits of Δtm.

Within this variation of Δtm no evidence of hydrocarbons is noted with the possible exception of point 15. However, this point 15 corresponds to a Δt of 135 m secs/ft and hence we believe that this may be due to cycle shipping or serious lack of compaction. We seriously doubt it to be due to hydrocarbons.

As found for Moyne Falls the Δtm values are extremely low and would indicate that dense material (dolomite?) is probably present along with the sand. This complex lithology therefore requires more than just the sonic for porosity determination and we would strongly recommend the neutron and density logs rather than the sonic for this purpose. Hence no porosity values have been estimated.

Since matrix is variable we would like to have been able to crosscheck these results by comparison of induction (Ril) and microlaterolog reading. A microlaterolog/microlog would thus have considerably improved this interpretation.

V DIPMETER

Our interpretation comments have been made on the plotted results.

There is strong evidence of an unconformity at 4840' although it could be higher because the control above this depth is poor. Above 4840' deposition appears to have been persistently from the NE.

There is some evidence of a fault about 1800' although again the control is poor.

Because control arrows are limited we cannot be very certain of this interpretation. The higher resolution dipmeter would have given much better results and is to be preferred.

VI CONCLUSIONS

1. No evidence of hydrocarbons is found

2. The Sonic should be replaced by neutron and density

3. This interpretation would have been improved if a microlaterolog/microlog had been run

4. The dipmeter gives useful geological information on structure and stratigraphy.

HUGH CROCKER

INTERPRETATION : HAWKESDALE 1

TABLE 1

Nº	IES DEPTH	RIL	ρ_B	Δt	ϕ_D
1	2862	4.0	2.24	100	25
2	3020	7.0	2.32	97.5	20
3	3090	2.4	2.2	114	27
4	3153	2.4	2.2	116	27
5	3263	2.5	2.19	114	28
6	3317	2.0	2.17	117	29
7	3345	2.0	2.16	116	29.5
8	3450	1.6	2.11	115?	33
9	3497	1.7	2.13	120	31.5
10	3695	2.0	2.18	-	28.5
11	3810	2.2	2.2	108	27
12	3880	3.2	-	102	-
13	3945	2.7	-	104	-

TABLE IA-1

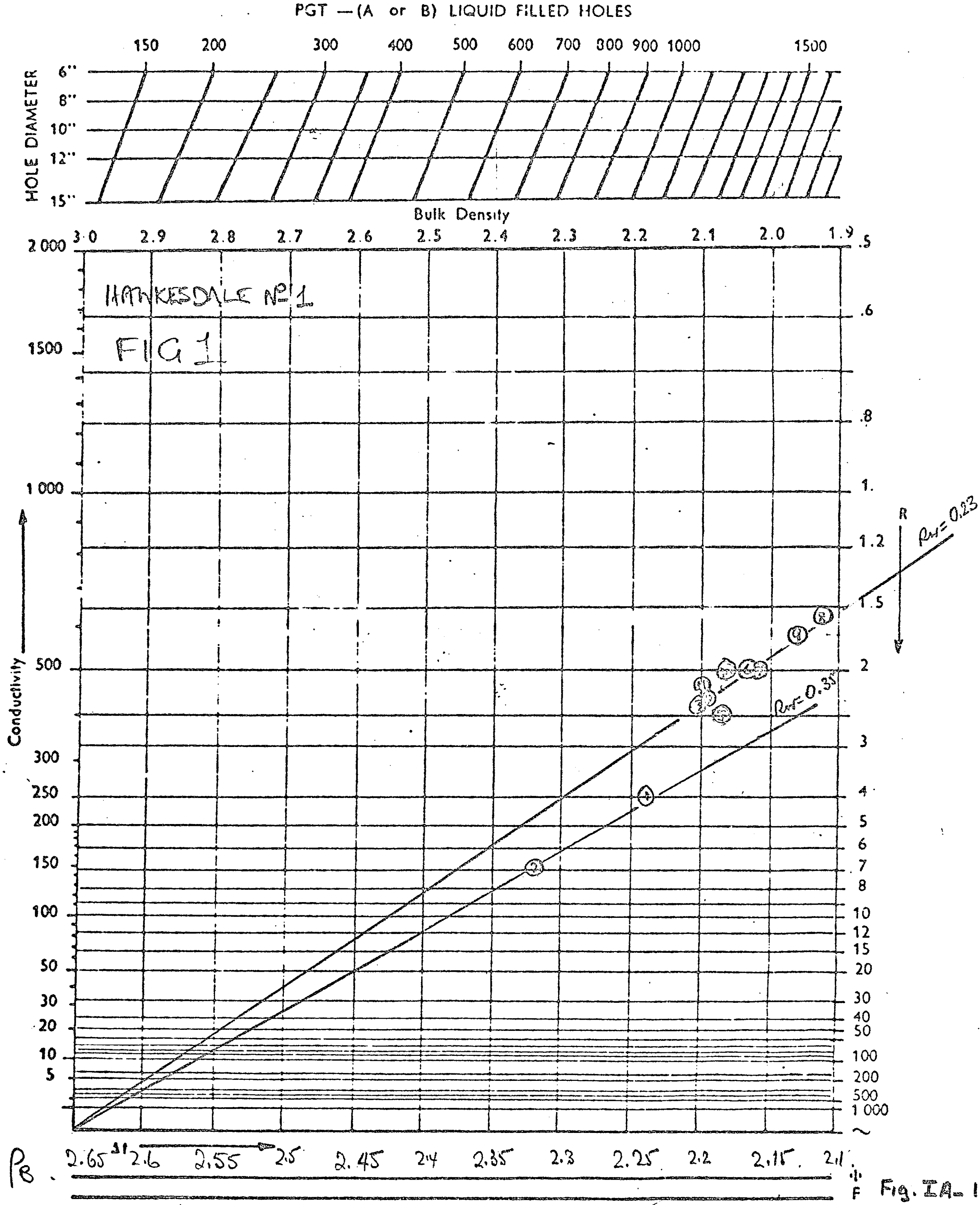
INTERPRETATION : HAWKESDALE 1

TABLE 2

Nº	IES DEPTH	RIL	ρB	ΔT
14	4117	57		50
15	4147	1.3		132
16	4156	2.7		100
17	4185	5		83
18	4212	4		75
19	4217	2.7		98
20	4294	11		67
21	4393	100		53
22	4480	7		83
23	4575	1.5		100
24	4632	1.5		106
25	4700	2.7		91
26	4790	1.4		112
27	4862	68		63
28	4930	1.2		113
29	5015	2		93
30	5049	11.5		59.
31	5205	2.2		92.5
32	5285	40		52
33	5404	17.5		63
34	5533	7.5		75

TABLE IA-2

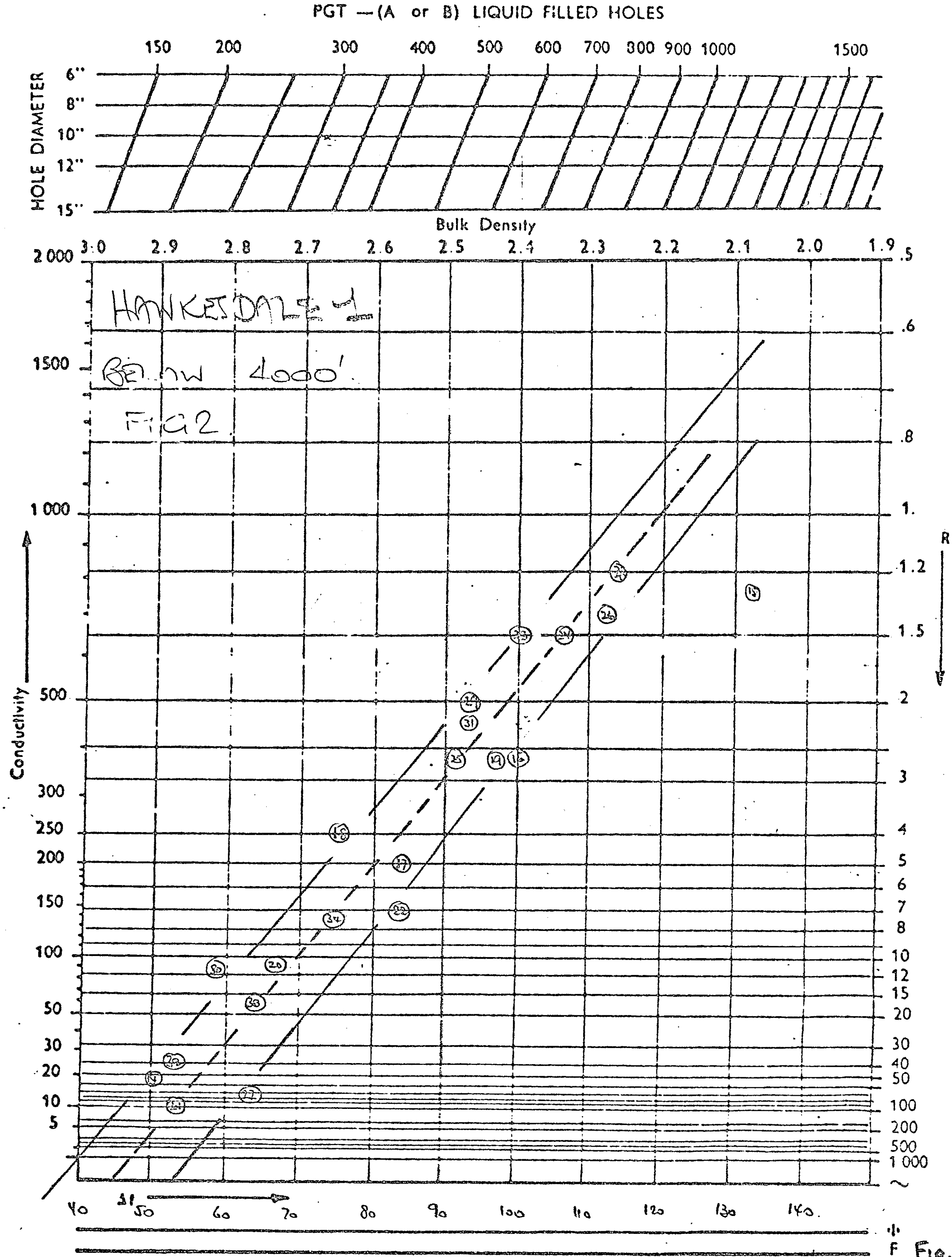
GRID FOR SONIC — RESISTIVITY OR FD — RESISTIVITY PLOTS



Grid for Resistivity vs Sonic or vs Formation Density Plot

F = .62

GRID FOR SONIC — RESISTIVITY OR FD — RESISTIVITY PLOTS



Grid for Resistivity vs Sonic or vs Formation Density Plot

Fig. IA-2

F = .62

APPENDIX II

CORE AND SIDEWALL CORE DESCRIPTIONS

HAWKESDALE NO. 1

by Shell Development (Australia) Pty. Ltd.

CONTENTS

PE907922

This is an enclosure indicator page.
The enclosure PE907922 is enclosed within the container PE905809 at this location in this document.

The enclosure PE907922 has the following characteristics:

ITEM_BARCODE =	PE907922
CONTAINER_BARCODE =	PE905809
NAME =	Core Photograph
BASIN =	OTWAY
PERMIT =	PEP 5
TYPE =	WELL
SUBTYPE =	CORE_PHOTO
DESCRIPTION =	Core Photograph, Core 1 of Hawkesdale-1, Pretty Hill Sandstone, 3538-3596', (Figure II-1 of WCR) for Hawkesdale-1
REMARKS =	
DATE_CREATED =	
DATE_RECEIVED =	
W_NO =	W570
WELL_NAME =	HAWKESDALE-1
CONTRACTOR =	Shell Development (Australia) Pty Ltd
CLIENT_OP_CO =	Shell/Frome-Broken Hill

(Inserted by DNRE - Vic Govt Mines Dept)

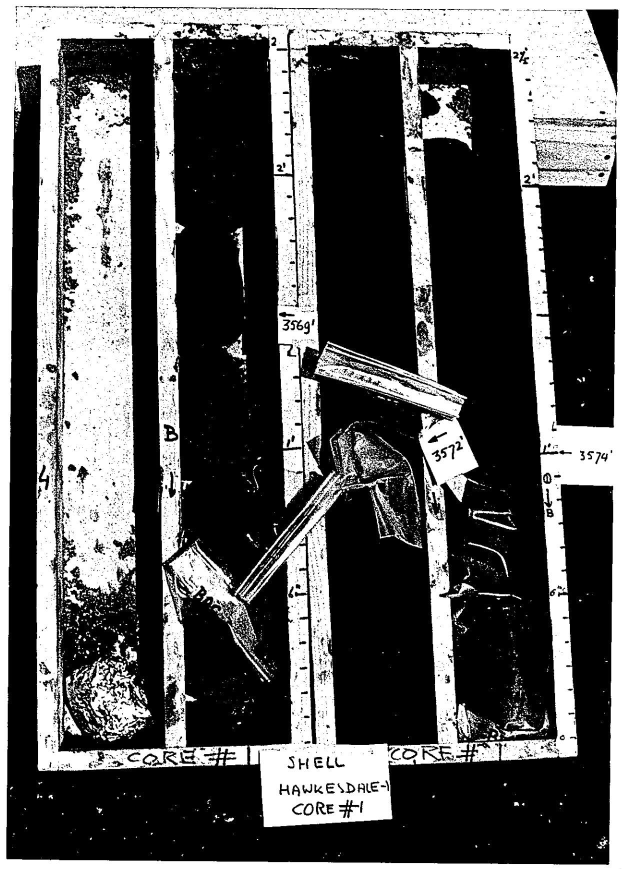


Fig. II-1 Core 1 of Hawkesdale No. 1
Pretty Hill Sandstone (3,538-3,596 feet)

PE907923

This is an enclosure indicator page.
The enclosure PE907923 is enclosed within the container PE905809 at this location in this document.

The enclosure PE907923 has the following characteristics:

ITEM_BARCODE =	PE907923
CONTAINER_BARCODE =	PE905809
NAME =	Core Photographs
BASIN =	OTWAY
PERMIT =	PEP 5
TYPE =	WELL
SUBTYPE =	CORE_PHOTO
DESCRIPTION =	Core Photograph, Core 3 of Hawkesdale-1, Pretty Hill Sandstone (Figure II-2 of WCR) for Hawkesdale-1
REMARKS =	
DATE_CREATED =	
DATE_RECEIVED =	
W_NO =	W570
WELL_NAME =	HAWKESDALE-1
CONTRACTOR =	Shell Development (Australia) Pty Ltd
CLIENT_OP_CO =	Shell/Frome-Broken Hill

(Inserted by DNRE - Vic Govt Mines Dept)

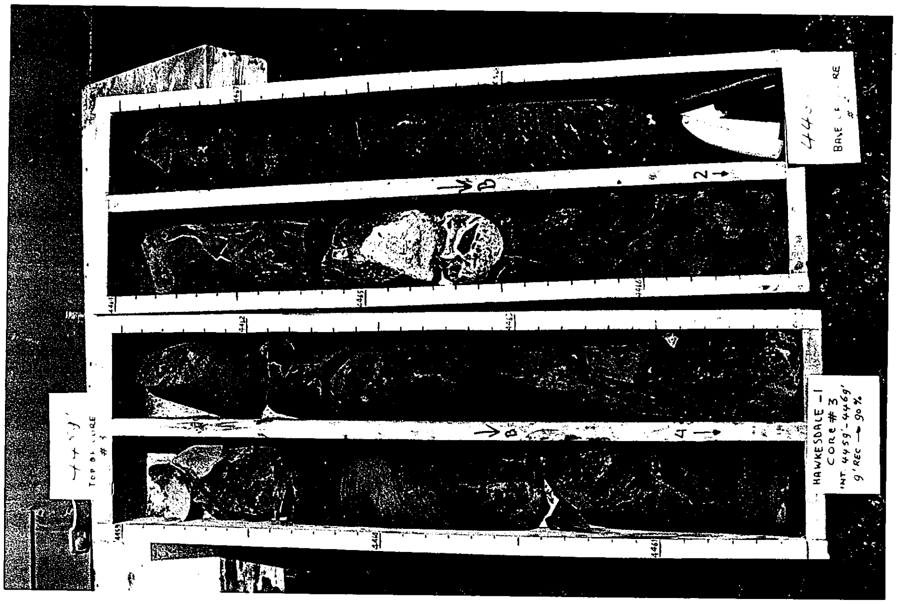


Fig. II-2 Core 3 of Hawkesdale No. 1
Volcanics of the Basal unit of the Otway group.

Fig. II-3 Core 4 of Hawkesdale No. 1
Palaeozoic basement.

1. DESCRIPTION OF CORES:

Core No. 1 3,568 - 3,596 feet. Cored 28 feet, recovered 7.25 feet (26%).

Sand to sandstone, 20-25% estimated porosity, good to high permeability, very light greenish-grey, quartzose, silty and argillaceous in part, medium (fine to coarse in part), sorted, subangular to subrounded, slightly consolidated, trace of cement, loose to very friable.

Accessory components : Garnet, light to medium translucent pink, fine, angular to subangular; Chlorite, green, fine; small coal fragments; and Mica.

Low to high angle cross beds ¼" - few inches thick. The grainsize varies between beds from medium to coarse. The top of the core is coarse grained (3,568 - 3,570 feet), the lower part is mostly medium grained.

Hydrocarbons Pale yellow-brown fluorescence (pin point and patches), mainly on core surface. Gas/ oil smell in places.

Core No. 2 3,597 - 3,603 feet. Cored 6 feet, recovered 0 feet (0%).

No recovery, probably due to loose or very friable sands which slipped through the core barrel catchers when pulling out.

Core No. 3 4,459 - 4,469 feet. Cored 10 feet, recovered 9 feet (90%).

4,459 - 4,464 feet : Basalt, greenish to brownish black with red brown ironoxide patches, fine crystalline with dark green phenocrysts, rims of serpentinite and ironoxide around some phenocrysts. Some chloritic matter in cracks.

4,464 - 4,467 feet Basalt, red brown altered, dark green phenocrysts as above, abundant smaller phenocrysts (augite?), vesicular.

4,467 - 4,468 feet Basalt, as interval 4,459 - 4,464'.

Core No. 4   5,749 - 5,765 feet.   Cored 16 feet, recovered 16 feet (100%).

5,749 - 5,751 feet Phyllite, medium to dark greenish grey, chloritic and sericitic, banded with Quartzite, light greenish grey, slightly chloritic. Irregular banding, probably sedimentary, ½ - 2 ins. in thickness. Poorly developed fracture and slaty cleavage parallel to the banding with small tight parasitic folds. Banding and cleavage system have a 55° dip.

5,751 - 5,765 feet Quartzite as above with thin phyllitic bands at intervals 5,752' 8". 5,753', 5,754', 5,755', 5,757' 6", 5,759' and 5,764'.

2. DESCRIPTION OF SIDEWALL CORES

1,245 feet	Clay, light to medium greenish grey, chloritic, coaly, slightly consolidated, moderately soft.
1,322 feet	Clay, light to medium greyish green, very chloritic, silty, few fine sand grains, slightly consolidated, moderately soft.
1,442 feet	Clay, medium greenish-grey, very chloritic, silty, slightly carbonaceous, consolidated, moderately soft.
1,519 feet	Clay, medium greenish-grey, chloritic, silty, slightly carbonaceous, consolidated, moderately soft (minor mica).
1,570 feet	Clay, medium grey-green, silty, very fine sandy, chloritic, slightly carbonaceous, consolidated, moderately soft.
1,657 feet	Clay, medium green-grey, chloritic, slightly silty, slightly carbonaceous, consolidated, moderately soft.
1,714 feet	Clay, medium green-grey, chloritic, slightly silty, slightly coaly, consolidated, moderately soft.
1,771 feet	Clay, light to medium greyish-green, chloritic, slightly silty, slightly carbonaceous, consolidated, moderately soft.
1,844 feet	Claystone, light grey, slightly silty, slightly carbonaceous, finely laminated, consolidated, moderately hard.
1,918 feet	Claystone, light to medium grey, slightly silty, slightly chloritic, laminated, consolidated, moderately hard.
2,018 feet	Claystone, light to medium grey green, fine sandy, silty, coaly, chloritic, pocket of fine sand with white cement, consolidated moderately hard.
2,072 feet	Claystone, medium to dark greenish-grey, chloritic, slightly silty, slightly carbonaceous, consolidated, moderately hard.
2,140 feet	Claystone, light to medium grey, chloritic, slightly silty, finely laminated, consolidated, moderately hard.

2,204 feet	Sandstone, 5-10% estimated porosity, light to medium grey-green, very fine quartzose, very argillaceous, silty, consolidated, moderately hard, with dark grey green clay laminae.
2,271 feet	Sandstone, 5-10% estimated porosity, light to medium grey-green, very fine quartzose, very argillaceous. carbonaceous, consolidated, moderately hard, friable.
2,325 feet	Claystone, medium to dark greenish-grey, slightly silty, carbonaceous, consolidated, moderately hard.
2,380 feet	Claystone, light greyish-green, silty, fine sandy, slightly coaly, consolidated, moderately hard.
2,456 feet	Claystone, light to dark greyish-green, slightly silty, very coaly, consolidated, moderately hard. Part of the sample is Coal, brownish-black.
2,467 feet	Coal, black, slightly argillaceous in part.
2,520 feet	Claystone, medium to dark grey, slightly carbonaceous, consolidated, moderately hard.
2,576 feet	Claystone, dark grey, carbonaceous, consolidated, moderately hard.
2,630 feet	Claystone, light to medium grey and light to medium greyish green, silty, slightly fine sandy in part, consolidated, moderately hard.
2,684 feet	Sandstone, 5-10% estimated porosity, light grey-green very fine to fine quartzose, very argillaceous, silty, slightly carbonaceous, slightly cemented, consolidated, very friable. Part of sample: Claystone, dark grey, silty.
2,751 feet	Claystone, light greyish green, slightly silty and fine sandy, chloritic, consolidated, moderately hard.
2,800 feet	Claystone, medium to dark green-grey, slightly silty, slightly carbonaceous, consolidated, moderately hard. Thin laminae of Sandstone, light grey, fine quartzose, argillaceous, silty, consolidated, friable.
2,819 feet	Granite, fine grained, inequigranular with sedimentary (arkosic) appearance in places. The three main mineral components are quartz, feldspar and biotite (50%, 40% and 10% resp.) The potash : plagioclase ratio is 3:1. The rock has a crumbly break.

2,838 feet — Granite, basically the same as 2,819 ft although biotite is more prolific, although commonly altered to chlorite. The granular appearance is more evident. The rock is rather crumbly.

2,850 feet — Sandstone/Claystone, no visible porosity, light to medium grey-green, very fine, chloritic, consolidated, moderately hard.

2,878 feet — Claystone, medium to dark grey-brown, fine sandy and silty, very carbonaceous, micaceous, consolidated, moderately hard.

2,913 feet — Claystone, dark grey, carbonaceous, consolidated, moderately hard, finely laminated.

2,944 feet — Sandstone, no visible porosity, light to medium grey-green, sublithic, argillaceous, carbonaceous, very fine, cemented, friable.

2,972 feet — Claystone, medium to dark grey, very fine sandy (sublithic), carbonaceous, consolidated, moderately hard, laminated with Sandstone, 10% estimated porosity, light grey, very fine, sublithic, friable.

3,004 feet — Conglomerate of igneous rock fragments, clay, quartz sandstone and dark lithic fragments, white and dark grey mottled, no visible porosity. The sandstone is quartzose, light grey white, cemented, consolidated, moderately hard.

3,036 feet — Granite, fine to medium grained, partly sedimentary appearance (arkosic). Main texture and composition point to a granitic dike.

3,095 feet — Claystone, light to medium greenish-grey, sandy and micaceous in part, consolidated, moderately hard.

3,132 feet — Sandstone, 5-10% estimated porosity, light brownish grey-green, quartzose to sublithic, argillaceous, very micaceous, fine, moderately sorted, moderately cemented, moderately hard.

3,159 feet — Sandstone, 10-20% estimated porosity, light greenish-grey, quartzose, micaceous, fine to medium, well-sorted, subangular, slightly cemented, very friable.

3,220 feet	Claystone, medium grey-green, very chloritic, fine sandy, silty and micaceous; with Sandstone, medium grey, quartzose, very micaceous, argillaceous, cemented, moderately hard, friable.
3,278 feet	Sandstone, 10-15% estimated porosity, quartzose, argillaceous, micaceous, slightly to moderately cemented, laminated, friable.
3,299 feet	Claystone, medium grey, carbonaceous, slightly silty and micaceous, consolidated, moderately hard.
3,309 feet	Claystone, medium grey, silty, carbonaceous, slightly micaceous, fine sandy in part, consolidated, moderately hard.
3,340 feet	Claystone, medium grey, silty, fine sandy (quartzose), micaceous, carbonaceous in part, consolidated, moderately hard.
3,396 feet	Sandstone, 15-20% estimated porosity, light grey, quartzose, fine, very well sorted, subangular to subrounded, minor mica, slightly cemented, moderately hard and friable.
3,463 feet	Sandstone, no visible porosity, dark grey, very argillaceous, quartzose to sublithic, very micaceous, slightly carbonaceous, very fine, moderately sorted, consolidated, soft to moderately hard.
3,475 feet	Sandstone, 5-10% estimated porosity, light to medium grey, quartzose, very argillaceous, micaceous, slightly carbonaceous, very fine, consolidated, moderately hard.
3,486 feet	Sandstone, 20-25% estimated porosity, light grey, quartzose, medium, subangular to subrounded, moderately sorted, almost no cement, slightly consolidated, very friable (minor mica, coal and pink garnets).
3,494 feet	Sandstone, 20-30% estimated porosity, light grey, quartzose, medium, well sorted, subrounded to subangular, slightly consolidated, very friable. Accessory components : pink garnets, chlorite etc.
3,506 feet (2 samples)	Sandstone, 25-30% estimated porosity, good to high permeability, light grey, quartzose, medium, well sorted, subrounded, trace of cement only, unconsolidated to slightly consolidated, very friable. Accessory components pink garnets, chlorite etc.

3,604 feet	Silty Claystone, dark grey with white sandstone laminae. The claystone is carbonaceous, sandy, micaceous, consolidated and moderately hard. The sandstone is fine, quartzose, has a 10% estimated porosity, contains pink garnets, is moderately cemented and friable. The lamination is contorted.
3,611 feet	Claystone, silty, fine sandy, carbonaceous, consolidated, moderately hard with Sandstone laminae, white, quartzose, very fine, sorted, 10-15% estimated porosity, slightly cemented, friable. The lamination is irregular in thickness.
3,626 feet	Sandstone, 10-15% estimated porosity, medium grey to white, laminated, quartzose, slightly cemented, friable. The dark laminae are argillaceous, micaceous and carbonaceous. Part of the sample is quartz sandstone, white, fine to medium, subangular, moderately cemented, friable. Pink translucent garnets throughout.
3,698 feet	Sandstone, 10-15% estimated porosity, light grey-white, quartzose, medium, moderately sorted, subangular, moderately cemented, very friable. Accessory components : pink translucent garnets and chlorite.
3,774 feet	Sandstone, 20% estimated porosity, light to medium grey-green, quartzose to sublithic, fine to medium, chloritic, slightly cemented, very friable with abundant pink translucent garnets throughout.
3,810 feet	Sandstone, 30% estimated porosity, very high permeability, light grey-white, quartzose, medium, well sorted, subangular to subrounded, trace of cement, slightly consolidated, very friable. Light to dark pink translucent garnets throughout.
3,840 feet	Sandstone, 15-20% estimated porosity, light grey-white, quartzose, very fine to medium, poorly sorted, slightly cemented, slightly consolidated, very friable. Accessory components : light to medium pink translucent garnet, some lithic fragments and chlorite.
3,884 feet	Sandstone, 15-20% estimated porosity, light grey, quartzose, medium, moderately sorted, subrounded, slightly cemented, slightly consolidated, very friable. Accessory components : light to medium pink translucent garnets, some lithic fragments and chlorite.

3,895 feet — **Sandstone**, 20-25% estimated porosity, light grey-white, quartzose, fine to coarse, subangular to subrounded, moderately sorted, trace of cement only, slightly consolidated, very friable. Accessory components : light to medium pink translucent garnet, pyrite, some lithic fragments and coal.

3,925 feet — Argillaceous **Sandstone** to sandy **Claystone**, no visible porosity, medium grey-green, very chloritic, sublithic, fine to coarse very poorly sorted, well rounded, consolidated, moderately hard.

3,948 feet *Pretty Hill* — **Sandstone**, 25-30% estimated porosity, high permeability, light grey-white, quartzose, subrounded, well sorted, no cement, only slightly consolidated, very friable. Accessory components : light to medium pink translucent garnets and some lithic fragments.

3,977 feet *Casterton* — **Tuff**, red brown (iron stain) and white mottled, completely altered, zeolitic, glass shards, lithic fragments, tightly cemented, soft to moderately hard.

4,090 feet — **Tuff**, red brown (iron stain), very altered, zeolitic, medium to very coarse well rounded quartz grains, rounded vesicles with chlorite infill, tight, soft to moderately hard.

4,148 feet — **Tuff**, red brown (iron stain), very altered, zeolitic, lithic fragments, some well rounded quartz grains, tight, soft to moderately hard.

4,205 feet — **Tuff**, red brown to black, zeolitic, ? carbonaceous, some well rounded sand grains, lithic fragments, tight, soft to moderately hard.

4,270 feet — **Tuff**, red brown (iron stain), zeolitic, round vesicles with chlorite infill, lithic, vesicles with ?zeolite, tight, soft to moderately hard.

4,318 feet — **Volcanic**, severely altered, high proportion of amygdules and veins (approx. 50%) enclosed by hematitic clay. The amygdules consist of colorless to very pale green fibrous chlorite.

4,618 feet — **Volcanic rock, ?tuff**, red brown, altered, zeolitic, small rounded vesicles with chloritic substance, tight, moderately hard.

4,676 feet — Tuff, red brown, very altered, zeolitic, pockets of ?zeolite, chloritic rock fragments, tight, moderately hard.

4,930 feet — Tuff, red brown, very altered, zeolitic, rounded chloritic vesicles, some rounded quartz grains, lithic rock and crystal fragments (?epidote) tight, moderately hard.

5,015 feet — Volcanic, red brown and grey green, very altered, devitrified glass, zeolitic, tight, moderately hard.

5,160 feet — Volcanic, micro crystalline chloritic base that surrounds common amygdules of colourless to pale brown chlorite. The isotropic nature of the material suggests that it may be glassy.

5,240 feet — Tuff, red brown to grey, very altered, zeolitic, rounded lithic fragments, tight, moderately hard.

5,481 feet — Volcanic, severely chloritised ranging from green to light brown. The chlorite encloses in parts augite, plagioclase and a chloritic replacement of olivine.

5,627 feet — Carbonaceous Sandstone, light grey to black, less than 5% estimated porosity, quartzose, very fine, consolidated, moderately hard, friable.

5,643 feet — Carbonaceous Siltstone, medium grey, no visible porosity, quartzose, very fine sandy, micaceous, consolidated, friable.

5,690 feet — Shale, light grey-green, very chloritic, silty, consolidated weathered or reworked basement.

Sed. section of Casterton

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

CORE ANALYSIS RESULTS

NOTE: (i) Unless otherwise stated, porosities and permeabilities were determined on two plugs (V&H) cut vertically and horizontally to the axis of the core. Ruska porosimeter and permeameter were used with air and dry nitrogen as the saturating and flowing media respectively. (ii) Oil and water saturations were determined using Soxhlet type apparatus. (iii) Acetone test precipitates are recorded as Neg., Trace, Fair, Strong or Very Strong.

WELL NAME AND NO. HAWKESDALE NO. 1

DATE ANALYSIS COMPLETED 17th January, 1970

Core No.	Sample Depth		Lithology	Average Effective Porosity two plugs (% Bulk Vol.)	Absolute Permeability (Millidarcy)		Average Density (gm/cc.)		Fluid Saturation (% pore space)		Core Water Salinity (p.p.m. NaCl)	Acetone Test	Fluorescence of freshly broken core
	From	To			V	H	Dry Bulk	Apparent Grain	Water	Oil			
1	3570'		Sst; m.gr. to c.gr, arg.	32	5,093	N.D.	1.82	2.68	83	Nil	N.D.	Neg.	Nil
1	3572'		Sst; m.gr. arg.	32	2,036	2,209	1.81	2.64	78	Nil	N.D.	Neg.	Nil
1	3575'		Sst; m.gr. v. arg.	26	64	308	2.01	2.70	79	Nil	N.D.	Neg.	Nil
3	4462'	4462'4"	Volc; weathered	11	N.D.	Nil	2.68	3.02	95	Nil	N.D.	Neg.	Nil
4	5755'8"	5756'	Slst; aren-calc.	5.7	N.D.	N.D.	2.59	2.75	62	Nil	N.D.	Neg.	Nil

Remarks: - Core No. 2 - no recovery.

General File No. ~~62/599~~ 69/1414
Well File No. 69/2032

TABLE II-

APPENDIX IIA

PETROGRAPHIC DESCRIPTION OF SELECTED CORES OF IGNEOUS ROCKS FROM SHELL'S HAWKESDALE -1 WELL, OTWAY BASIN

by

J. Barry Hocking

Geological Survey of Victoria

CONTENTS

PETROGRAPHIC DESCRIPTION OF SELECTED CORES OF IGNEOUS ROCKS FROM SHELL'S HAWKESDALE -1 WELL, OTWAY BASIN

by

J. Barry Hocking,

Geological Survey of Victoria

1. INTRODUCTION

Conventional and sidewall core samples from Shell's Hawkesdale 1 well in the Otway Basin were submitted for thin-sectioning and petrographic examination. The specimens can be divided into two categories, the granitic rocks and the volcanic rocks.

2. GRANITIC ROCKS

S.W.C. 23, 2819 feet (V.M.D. Slide No. 9930)

Despite the granular-sedimentary appearance of this rock, especially under low magnification, there is evidence to suggest that it is a fine-grained, inequigranular granite, and is possibly a dyke rock.

Approximately 25 to 30 percent of the thin-section has a normal granitic appearance, with interlocking, approximately equigranular crystals of medium size, whereas in the remaining, more granular areas the fusion of crystals is also evident, though more subtle. The three main mineral components are quartz, feldspar and biotite which are in granitic proportions, namely 50, 40 and 10 percent respectively. The potash: plagioclase ratio is roughly 3:1.

In the granular areas the quartz is up to 3.2 mm and ranges down to less than 0.05 mm. The feldspar, of comparable size range, consists mostly of orthoclase and subordinate perthite which are frequently kaolinised, or else of plagioclase (calcic oligoclase) which is often sericitised. The biotite is relatively fresh and appears as irregularly-shaped crystals up to 1.5 mm long, with frequent buckling. Black iron ore, believed to be ilmenite, is commonly associated.

In view of the evidence above, and the lack of any definite features suggesting that the rock is sedimentary - such as mud matrix, particle rounding, carbonaceous inclusions, etc. - it is concluded that the rock is granitic.

S.W.C. 22, 2838 feet (V.M.D. Slide No. 9931)

This specimen is basically the same as that at 2819 feet, although biotite is more prolific (approximately 20 to 25 percent) and is more commonly altered to chlorite and has a higher amount of associated iron ore. The granular appearance is also more evident, and only 5 to 10 percent of the medium-grained, normal-textured granite is apparent.

3. VOLCANIC ROCKS

S.W.C. 12, 4318 feet (V.M.D. Slide No. 9932)

The thin-section is of a severely altered volcanic rock consisting of a high proportion of amygdules and veins (approximately 50 percent) enclosed by red black hematitic clay. The amygdules consist of colorless to very pale green fibrous chlorite. Chlorite also lines the walls of many of the larger cavities and veins which are filled predominantly with a colorless low-birefringence mineral believed to be a zeolite. Also scattered through the thin-section are a small number of subhedral fractured augite crystals.

Core 3, 4462 ft. 6 in. (V.M.D. Slide No. 9933)

This is the least altered of the volcanic samples, and is an inequigranular-porphyritic, fine-grained, holocrystalline rock with pilotaxitic texture. Mineral constituents include phenocrysts of iddingsite-chlorite (estimated 20%) and a groundmass of pyroxene (20%), feldspar (35%), iron ore (25%) and minor chlorite.

The phenocrysts are up to 1.2 mm and are commonly euhedral with hexagonal outlines. The outer part, and sometimes the entire crystal, consists of red-brown or orange iddingsite which is strongly pleochroic and has micaceous cleavage (type IV of Baker & Haggerty, 1967, p. 260). It is closely allied to the saponite mineral group. The cores of the crystals are of a later-stage - chloritic - alteration product which is pale aqua-coloured to colorless. It is obvious that the phenocrysts were originally olivine.

Pyroxene crystals are of augite which are sometimes up to 0.8 mm, though they appear mostly as groundmass laths averaging 0.1 mm length. Feldspar does not occur as laths, but instead as somewhat amorphous interstitial material. Iron ore is rather abundant as very small anhedral crystals of hematite.

Core 3, 4465 feet (V.M.D. Slide No. 9934)

This specimen, only 2½ feet deeper than that described above, is similar but more altered. The groundmass is comprised of appreciable hematite which encloses crystals of augite and lath-shaped feldspars which are entirely kaolinised. In addition, almost 40 percent of the thin-section is occupied by interconnected veins, generally filled by zeolite and epidote, and amygdules of very pale brown chlorite.

S.W.C. 6, 5160 feet (V.M.D. Slide No. 9935)

The larger part of the thin-section consists of an apparently hypocrystalline base that surrounds common amygdules (again about 40 percent) of colorless to very pale brown chlorite displaying various growth forms. The base is also of light brown chlorite, which is microcrystalline, with associated finely-disseminated iron ore. The overall isotropic nature of the material suggests that it may be partially glassy.

The remainder of the thin-section is occupied by almost colorless crystalline chlorite that is free of amygdules.

S.W.C. 4, 5481 feet (V.M.D. Slide No. 9936)

The specimen is yet another severely chloritised volcanic rock. The chlorite, ranging from green to light brown, possesses many growth forms. Minor red brown hematite is also present. In parts the chlorite encloses fresh crystals of augite, plagioclase feldspar and, in one case, a subhedral green brown chloritic replacement of olivine. The plagioclase (maximum 0.4 mm, average 0.15 mm) exhibits Albite twinning which characterises it as labradorite, though sometimes the twinning is masked by chloritisation.

4. REVIEW OF VOLCANICS

4.1 Classification

It appears likely that the volcanic rocks described above belong to the one genetic sequence, though they differ in terms of degree of alteration. The parent rock is an olivine basalt.

4.2 Alteration

The thin-sections described cover a range of alteration stages. In a generalised manner the intensity of alteration increases from the 5610 ft. sample through those at 4462 ft., 4465 ft., 5841 ft. and 4318 ft. respectively. Olivine is altered directly to chlorite, or through an intermediate iddingsite stage. Feldspar is more persistent, but eventually goes to kaolinite and then chlorite. The most stable of the minerals is augite which is present in all samples.

Chlorite itself is sometimes altered to hematite by oxidation. At an advanced stage, following crystallisation of the rock, vein fillings of chlorite, zeolite and epidote were formed.

Alteration of the type described "must be seen as continuous, intermediate to low temperature, cooling phenomena" (Baker & Haggerty, 1967, p. 272). It is not possible to determine, on the evidence available, at what geological time the alteration took place.

4.3 Comparison with other Otway Basin volcanics

There is a definite similarity between the volcanics described above and those from other wells in the western Victorian part of the Otway Basin, namely Moyne Falls 1, Woolsthorpe 1, Casterton 1 and Pretty Hill 1. Since the age of the Casterton material has been established by radiometric dating to be Mesozoic, the petrographic and generalised stratigraphic correlation between these rocks suggests that all are probably Mesozoic. Remarks along similar lines have already been made by the author (Hocking, 1968). Some of the petrographic similarities between the Hawkesdale and other material is as follows:

(i) Hawkesdale 1, 4462 ft. 4 in. is almost identical to Moyne Falls 1, 2413-24 feet (V.M.D. Slide No. 9926) with the minor difference that the olivine phenocrysts in the latter are altered to pale green saponite mineral instead of red brown iddingsite (= saponite). In the latter there is also minor medium-grained titanaugite, found also in Pretty Hill 1, Core 22 (V.M.D. Slide No. 8823);

(ii) Woolsthorpe 1, 6418 feet (V.M.D. Slide No. 9419) is also very similar to the above, though some fresh olivine is still present (see CORRECTION), and it alters directly to chlorite. It has already been pointed out that the Woolsthorpe samples bear a close resemblance to those from Casterton 1, Cores 20 and 21 and Pretty Hill 1, Cores 22 and 23 (Hocking, 1968);

(iii) other common features are the widespread chloritisation, the less common occurrence of hematite, the abundant fine-grained iron ore in the fresher material, the presence of vesicles or veins in a number of samples that are filled with chlorite or zeolite, and the uniformity of crystal size (e.g. feldspar laths between 0.1 and 0.15 mm) and size range; these volcanics are distinctly finer-grained than the typical Cainozoic basalts.

5. REFERENCES

Baker, I. & Haggerty, S.E., 1967. The alteration of olivine in basaltic and associated lavas. Part II; Intermediate and low temperature alteration.

Contr. Mineral and Petrol., 16: 258-273

Hocking, J.B., 1968. Preliminary petrographic description of sidewall cores of volcanics from 6398-6428 feet in Interstate's Woolsthorpe 1 well.

Geol. Surv. Vict. unpubl. rept. 1968/22; also in Woolsthorpe 1 well completion report (Interstate Oil Ltd.)

6. CORRECTION

The writer wishes to record a correction to the text of the description of volcanics from Woolsthorpe 1 well (Hocking, 1968). The majority of the phenocrysts in the 6418 ft. sample (V.M.D. Slide No. 9419) actually consist of olivine, not augite or pigeonite. In addition to fresh olivine there are a number of crystals of chloritised olivine, totalling about 25 percent in all. Relatively fresh olivine is also found in the 6418 ft. sample (V.M.D. Slide No. 9418).

J.B. HOCKING

8th April 1970

APPENDIX III

PALAEONTOLOGICAL REPORT

SHELL/FROME HAWKESDALE NO. 1 WELL

by

Shell Development (Australia) Pty. Ltd.

Geological Laboratory

CONTENTS

1. SUMMARY

The Tertiary sequence in Hawkesdale-1 has been biostratigraphically zoned as follows:

? feet - approx 500 feet BDF	- Zonule D	Middle Miocene
approx 500 feet - 650 feet BDF	- Zonule E	Middle Miocene
650 feet - 720 feet BDF	- Zonule F	Lower Miocene
720 feet - approx 800 feet BDF	- Zonule G	Lower Miocene
approx 800 feet - 960 feet BDF	- Zonule H	Lower Miocene
960 feet - 1070 feet BDF	- Zonule I	Oligocene

No <u>in situ</u> foraminifera were found below 1070 feet.

2. INTRODUCTION

Selected cutting samples between 450 feet and 1070 feet in Hawkesdale-1 were analysed on foraminiferal content. The stratigraphically significant species are documented below. The zonation used is that of Taylor (1966) for the Gippsland, Bass and Otway Basins, which has been outlined in SDA Report 96.

Cutting samples were taken over 30 foot intervals above 1000 feet, and over 10 foot intervals below that depth. Mud contamination and downhole caving, together with the large sampling interval, produced mixing of faunas, and consequently time boundaries cannot be drawn with much accuracy, and some determinations remain doubtful.

No in situ foraminifera were found in random checks of the Otway group below 1070 feet.

3. THE FORAMINIFERAL SUCCESSION

Due to lost circulation, no samples were available above 400 feet.

430-480 feet: Zonule D: Middle Miocene. The planktonic fauna includes *Orbulina universa*, *O. suturalis*, *Globigerina woodi*, *Globigerina bulloides*, *G. apertura*, *Biorbulina bilobata*, and very rare *Globigerinoides glomerosus circularis*. The presence of *O. universa* in association with the last-named species indicates Zonule D (Middle Miocene).

570-600 feet: Zonule E: Middle Miocene. The fauna is dominated by *Globigerinoides bisphericus*, with *Globigerinoides glomerosus glomerosus*. Other significant forms are *Biorbulina bilobata*, *Globigerinoides transitorius*, *Orbulina suturalis*, *Globorotalia conica* and *G. barisanensis*.

630-660 feet: transitional Zonule E to Zonule F: Middle to Lower Miocene boundary. The boundary between the two zonules lies within this sample interval, and so material from both units is present. The *Globigerinoides glomerosus* group from Zonule E is still represented; *Globigerinoides bisphericus*, dominant in Zonule F, is numerous. Several varieties of *Globigerinoides trilobus* are present suggesting a Lower Miocene age for the fauna. Other species include *Globigerinoides ruber*, *Globigerina woodi*, *Globigerina apertura*, *Globigerina cf. euapertura*, and *Carpenteria rotaliformis*.

3. THE FORAMINIFERAL SUCCESSION (Cont'd)

690-720 feet: probably low in Zonule F: Lower Miocene. Globigerinoides bisphericus is less numerous than above, and Globigerina woodi, G. apertura and Globigerinoides immaturus appears. The Globigerinoides glomerosus is rare.

750-780 feet: Zonule G: Lower Miocene. Globigerinoides trilobus is abundant and Globigerinoides bisphericus rare, indicating Zonule G. Globigerina apertura and G. woodi are the only other abundant forms.

Zonules G and H, the lowest Miocene units, are defined and distinguished not on the highest appearance of an index species, but on the disappearance of Globigerinoides trilobus in Zonule H, with the continued presence of Globigerina woodi. Consequently Zonule H is difficult to identify in cuttings because Globigerinoides trilobus tends to cave from the zone above.

810-840 feet: probable Zonule H: Lower Miocene. Globigerina woodi is far more abundant than Globigerinoides trilobus, suggesting that the sample is in Zonule H. Globigerina apertura, and rare specimens of Globigerina cf. euapertura also occur.

870-900 feet: Zonule H: Lower Miocene. The dominance of Globigerina woodi and G. apertura, with only minor Globigerinoides trilobus, indicates H.

930-960 feet: probable Zonule H: Lower Miocene. A heavily contaminated fauna at this depth contains the same species as above, and is probably still within H.

960-1000 feet: Zonule I: Oligocene. Globigerina euapertura, the index species for Zonule I, is present in very small numbers. Globorotalia opima continuosa and Globorotalia cf. opima (after Bolli) occur rarely. Globigerina sp. cf. ciperoensis, a designation covering probably several small species in Zonule I, becomes fairly numerous in this and lower samples. Globigerina bulloides is more abundant. Globigerinoides trilobus and Globigerina woodi remain common, presumably due to caving.

1000-1010 feet. A fauna similar to that above, but with Globigerina bulloides becoming more abundant, and Globigerina euapertura present in small numbers.

1040-1050 feet: Zonule I: Oligocene. Globorotalia opima opima (after Jenkins, not Bolli) occurs in small numbers.

1060-1070 feet: Zonule I: Oligocene. Globorotalia "opima continuosa" (after Jenkins) and rare Globorotalia cf. kugleri occur, in a fauna dominated by Globigerina apertura and Globigerina bulloides, with a large amount of Miocene caving.

No in situ foraminifera were found below 1070 feet.

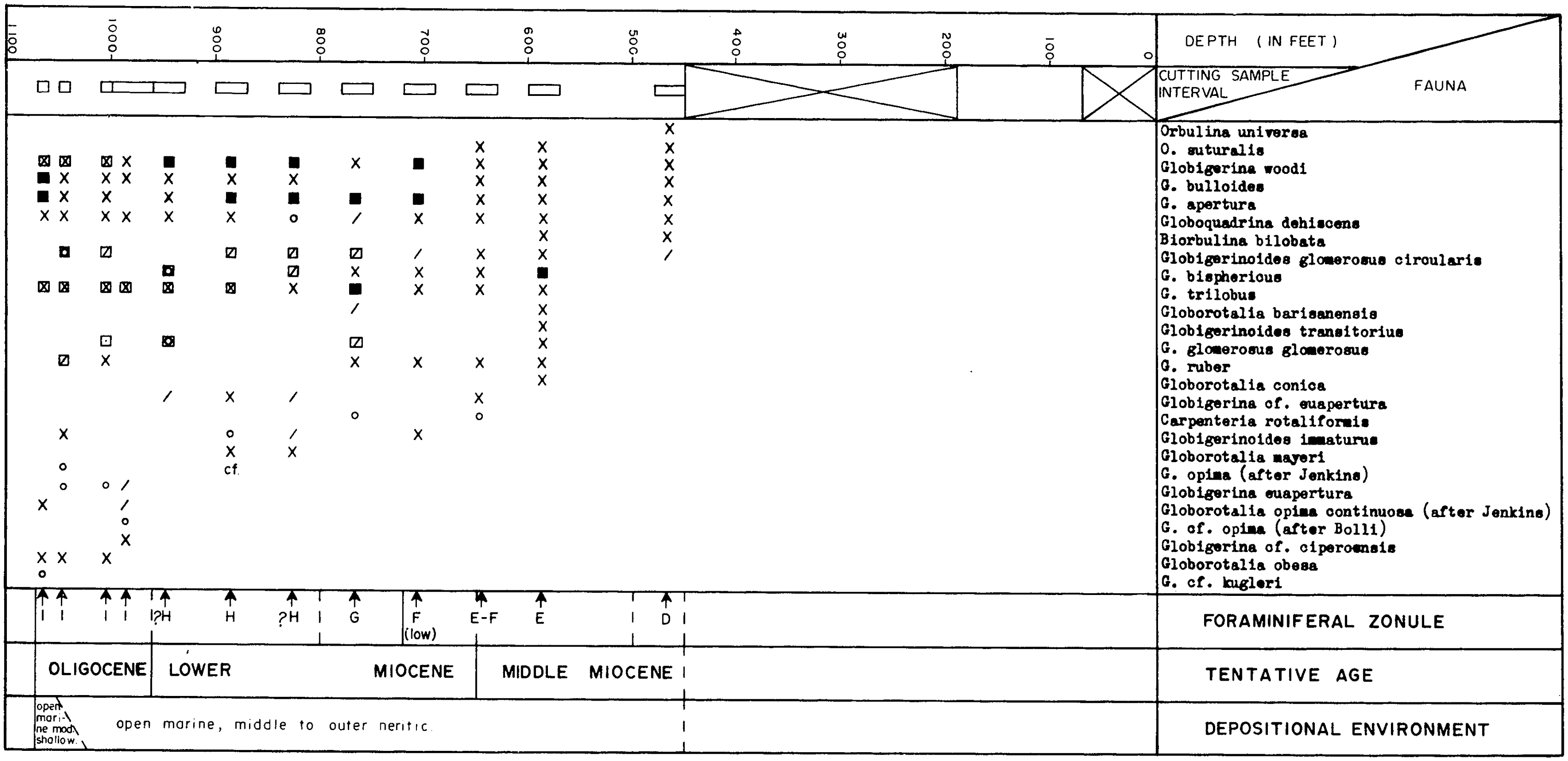
FOOTNOTE.

Taylor (personal communication January 1970) has recently indicated that Globorotalia kugleri is confined to Zonule H (Lower Miocene), and does not occur in Zonule I (Oligocene) as indicated by M.E. Wade (1964) and other workers. Consequently the presence of Globorotalia cf. kugleri in the sample at 1060-1070 feet may cast some doubt on the Zonule I determination, although other species support this determination.

4. CONCLUSIONS

The Heytesbury Group in Hawkesdale-1 consists of the normal Middle Miocene to Oligocene sequence found elsewhere in the Otway Basin. The Oligocene is approximately 100 feet thick in Hawkesdale-1 in contrast to Moyne Falls-1, in which no such Oligocene was recognized.

Because of the poor quality of the cuttings and the lack of other sample control, the zone boundaries given and the Oligocene determination should be treated with a certain amount of caution.



LEGEND

Specimen frequency

- • *1 specimen*
- / *2 - 5 specimens*
- o *6 - 20 specimens*
- ● *21 - 100 specimens*
- ■ *> 100 specimens*
- X *qualitative determination only*
- cf. *"comparable with"*
- □ *definite or probable caving.*

SHELL DEVELOPMENT (AUSTRALIA) PTY. LTD.

OTWAY BASIN

HAWKESDALE – 1

DISTRIBUTION OF FORAMINIFERA

Author: M. Apthorpe	Date: March, 1970.
Report: W.C.R. / Fig. III-1	Drawing No. 4123

APPENDIX IV

PALYNOLOGICAL REPORT

HAWKESDALE NO. 1, 1,245-5,690 FEET

by

Dr. M.E. Dettmann - University of Queensland

CONTENTS

PALYNOLOGICAL REPORT ON HAWKESDALE No.1 WELL, 1245 - 5690 FEET

1. INTRODUCTION

Twenty three samples of cores taken from Hawkesdale No.1 well in the Otway Basin have been examined palynologically in an attempt to date the sediments occurring between 1245 feet and 5690 feet. Samples investigated include sidewall cores from the Eumeralla formation (1245 - 3095 feet), the Pretty Hill sandstone (3159 - 3925 feet), and from thin carbonaceous horizons within and below a volcanic sequence (4025 - 5690 feet).

The samples were prepared for palynological examination by procedures involving the use of hydrofluoric acid, zinc bromide, and ultrasonic vibration (see Dettmann 1968a). The ultimate residues were examined for the yield and preservation quality of the contained plant microfossils. All but the lowest two samples of the Eumeralla formation were found to contain abundant and diverse plant microfossil suites in a fair to good state of preservation (see Table 1). Several samples from the upper part of the Pretty Hill sandstone also yielded reasonably well preserved plant microfossils in sparse to fair concentrations. However, samples from the lower portion of the formation were found to be almost completely devoid of plant material (Table 1). Samples taken from below the Pretty Hill sandstone at 5627 feet and 5634 feet were found to contain moderately carbonized plant matter, including common to sparse spores and pollen grains whilst horizons at 4025 feet and 5690 feet failed to yield plant material of any description (Table 1).

Detailed qualitative and quantitative analyses of the spore-pollen floras was carried out after the residues were further treated with Schulze solution followed by brief immersion in 1% ammonium hydroxide. Residues from the Eumeralla formation and the Pretty Hill sandstone were subjected to the Schulze treatment for 1 - 3 minutes; those from 5627 feet and 5634 feet for 10 - 15 minutes.

An assessmant of the microfloral evidence indicates that the sequence incorporates strata of ?late Jurassic and Lower Cretaceous age, and that it may be subdivided in terms of the spore-pollen zonation scheme outlined by Dettmann and Playford (1969) and Dettmann (1969 a,b). The Eumeralla formation includes sediments attributable to the Crybelosporites striatus Subzone (1245 - 1442 feet) and to the Foraminisporis asymmetricus Unit of the Cyclosporites hughesi Subzone (1714 - 2878 feet). Zonal attribution of the Pretty Hill sandsone is less securely based, owing to paucity of contained microfloras; however, there is some evidence that horizons at 3340 feet and 3475 feet are probably within the Murospora florida Unit of the Cyclosporites hughesi Subzone. Sediments at 5627 feet and 5634 feet, beneath a volcanic sequence, are of uppermost Jurassic or lowermost Cretaceous age; their microfloras contain insufficient diagnostic species for more precise age determination.

Microfloras of the Eumeralla formation and the Pretty Hill sandstone are composed chiefly of land derived plant microfossils, including spores, pollen grains, and wood and cuticular material. Some samples also yielded occassional examples of forms of uncertain derivation but possibly referable to the Acritarcha. Reworked spores and pollen grains were also noted in the majority of samples; these occur rarely and include forms of Permian, Triassic, and early Cretaceous age.

Microfloras obtained from sediments at 5627 feet and 5634 feet beneath the volcanic sequence, are composed entirely of land derived plant microfossils and include significant proportions (up to 30%) of reworked Permian and Triassic spores and pollen grains.

2 MICROFLORAL CONTENT AND AGE OF SAMPLES

The plant microfossil assemblages identified in the samples are tabulated below with reference to their quantitative and qualitative content; the quantitative estimates are expressed in the following terms:- Ab (abundant) - numerical representation of a particular species totals at least 5% of total microflora, C (common) - numerical representation of a species forms 1 - 5 % of total microflora, and R (rare) - numerical representation of a species is less than 1% of total microflora.

A. 1245 - 1442 feet

1245 feet

An abundant and diverse assemblage of well preserved plant microfossils was obtained from the sample. Types identified include:

Spores:	Aequitriradites spinulosus (Cookson & Dettmann)	R
	Baculatisporites comaumensis (Cookson)	R
	Ceratosporites equalis Cookson & Dettmann	R
	Cicatricosisporites australiensis (Cookson)	C
	C. hughesi Dettmann	R
	Concavissimisporites cf. penolaensis Dettmann	R
	Crybelosporites striatus (Cookson & Dettmann)	R
	Cyathidites australis Couper	Ab
	C. minor Couper	Ab
	C. punctatus (Delcourt & Sprumont)	C
	Dictyophyllidites crenatus Dettmann	R
	Dictyotosporites filosus Dettmann	R
	D. speciosus Cookson & Dettmann	R
	Foraminisporis asymmetricus (Cookson & Dettmann)	R
	F. wonthaggiensis (Cookson & Dettmann)	R
	F. dailyi (Cookson & Dettmann)	R
	Leptolepidites verrucatus Couper	R
	Lycopodiumsporites austroclavatidites (Cookson)	C
	L. eminulus Dettmann	R
	Matonisporites cooksoni Dettmann	R
	Neoraistrickia truncata (Cookson)	R
	Pilosisporites notensis Cookson & Dettmann	R
	Stereisporites antiquasporites (Wilson & Webster)	Ab
	Velosporites triquetrus (Lantz)	R
Pollen:	Araucariacites australis Cookson	Ab
	Alisporites grandis (Cookson)	Ab
	A. similis (Balme)	Ab
	Classopollis cf. classoides Pflug	C
	Cycadopites nitidus (Balme)	C
	Microcachryidites antarcticus Cookson	Ab
	Podocarpidites cf. ellipticus Cookson	Ab
Incertae Sedis:	Schizosporis reticulatus Cookson & Dettmann	R
	S. spriggi Cookson & Dettmann	R

__1442 feet__

The sample yielded abundant, reasonably well preserved spores and pollen grains. Species identified include:

Spores:	Baculatisporites comaumensis (Cookson)	Ab
	Ceratosporites equalis Cookson & Dettmann	C
	Cicatricosisporites australiensis (Cookson)	C
	C. hughesi Dettmann	R
	Crybelosporites striatus (Cookson & Dettmann)	R
	Cingutriletes clavus (Balme)	R
	Cyclosporites hughesi (Cookson & Dettmann)	R
	Cyathidites australis Couper	Ab
	C. minor Couper	C
	C. punctatus (Delcourt & Sprumont)	R

	Dictyotosporites speciosus Cookson & Dettmann	C
	D. complex Cookson & Dettmann	R
	Foraminisporis asymmetricus (Cookson & Dettmann)	C
	F. dailyi (Cookson & Dettmann)	R
	F. wonthaggiensis (Cookson & Dettmann)	R
	Ischyosporites punctatus Cookson & Dettmann	C
	Klukisporites scaberis (Cookson & Dettmann)	R
	Kuylisporites lunaris Cookson & Dettmann	R
	Leptolepidites verrucatus Couper	C
	Lycopodiumsporites austroclavatidites (Cookson)	Ab
	L. eminulus Dettmann	R
	L. facetus Dettmann	R
	L. nodosus Dettmann	R
	Neoraistrickia truncata (Cookson)	C
	Pilosisporites parvispinosus Dettmann	R
	Rouseisporites reticulatus Pocock	R
	Stereisporites antiquasporites (Wilson & Webster)	Ab
	Velosporites triquetrus (Lantz)	R
Pollen:	Alisporites grandis (Cookson)	Ab
	A. similis (Balme)	R
	Araucariacites australis Cookson	C
	Classopollis cf. classoides Pflug	C
	Cycadopites nitidus (Balme)	R
	Microcachryidites antarcticus Cookson	Ab
	Podosporites microsaccatus (Couper)	Ab
	Podocarpidites cf. ellipticus Cookson	Ab
	Tsugaepollenites dampieri (Balme)	C
Incertae Sedis:	Schizosporis reticulatus Cookson & Dettmann	R
	S. spriggi Cookson & Dettmann	R
Remanie:	Aratrisporites sp. - Triassic	R
	Lundbladispora denmeadi (de Jersey) - Triassic	R
	Striatites spp. - Permian, Triassic	R

Both samples yielded Dictyotosporites speciosus together with Crybelosporites striatus and are thus referred to the Crybelosporites striatus Subzone of Lower Albian age (see Dettmann 1969a). The lower sample (1442 feet) also yielded Cyclosporites hughesi which suggests that the horizon is near the base of the C. striatus Subzone.

B. 1714 - 2878 feet

1714 feet

Abundant plant material was extracted from the sample and the following species of fairly preserved plant microfossils were identified:

Spores:	Baculatisporites comaumensis (Cookson)	Ab
	Ceratosporites equalis Cookson & Dettmann	R
	Cicatricosisporites australiensis (Cookson)	C
	Cyathidites australis Couper	Ab
	C. minor Couper	Ab
	Cyclosporites hughesi (Cookson & Dettmann)	R
	Dictyotophyllidites crenatus Dettmann	C
	Dictyotosporites complex Cookson & Dettmann	C
	D. speciosus Cookson & Dettmann	C
	Foraminisporis dailyi (Cookson & Dettmann)	C
	F. wonthaggiensis (Cookson & Dettmann)	R
	Klukisporites scaberis (Cookson & Dettmann)	C
	Lycopodiumsporites austroclavatidites (Cookson)	C
	L. eminulus Dettmann	C
	L. facetus Dettmann	R
	Leptolepidites verrucatus Couper	C
	L. major Couper	C
	Neoraistrickia truncata (Cookson)	R
	Pilosisporites notensis Cookson & Dettmann	C
	Stereisporites antiquasporites (Wilson & Webster)	C
Pollen:	Alisporites grandis (Cookson)	Ab
	A. similis (Balme)	C
	Araucariacites australis Cookson	C
	Classopollis cf. classoides Pflug	Ab
	Microcachryidites antarcticus Cookson	Ab
	Podosporites microsaccatus (Couper)	R
	Podocarpidites cf. ellipticus Cookson	C
Incerate Sedis:	Schizosporis reticulatus Cookson & Dettmann	C
	S. spriggi Cookson & Dettmann	R

2018 feet

A rich assemblage of reasonably well preserved spores and pollen grains was extracted from the sample. Species identified include:

Spores:	Aequitriradites spinulosus (Cookson & Dettmann)	R
	A. verrucosus (Cookson & Dettmann)	R
	Baculatisporites comaumensis (Cookson)	C
	Cicatricosisporites australiensis (Cookson)	Ab
	Couperisporites tabulatus Dettmann	R
	Coronatispora foveolata Dettmann	R
	Cyathidites australis Couper	Ab
	C. minor Couper	Ab
	Cyclosporites hughesi (Cookson & Dettmann)	R

	Dictyophyllidites crenatus Dettmann	C
	Dictyotosporites speciosus Cookson & Dettmann	R
	Foraminisporis asymmetricus (Cookson & Dettmann)	R
	F. wonthaggiensis (Cookson & Dettmann)	C
	Klukisporites scaberis(Cookson & Dettmann)	R
	Kuylisporites lunaris Cookson & Dettmann	R
	Leptolepidites verrucatus Couper	C
	L. major Couper	R
	Lycopodiumsporites austroclavatidites (Cookson)	C
	L. nodosus Dettmann	R
	Pilosisporites notensis Cookson & Dettmann	C
	P. parvispinosus Dettmann	C
	Rouseisporites reticulatus Pocock	R
Pollen:	Alisporites grandis (Cookson)	C
	Araucariacites australis Cookson	C
	Classopollis cf. classoides Pflug	C
	Microcachryidites antarcticus Cookson	A
	Podosporites microsaccatus (Couper)	C
	Podocarpidites cf. ellipticus Cookson	A
Incertae Sedis:	Schizosporis spriggi Cookson & Dettmann	R

2325 feet

An abundant and diverse plant microfossil assemblage was obtained from the sample. The following species were identified:

Spores:	Aequitriradites spinulosus (Cookson & Dettmann)	C
	A. verrucosus (Cookson & Dettmann)	C
	Baculatisporites comaumensis (Cookson)	A
	Ceratosporites equalis Cookson & Dettmann	R
	Cicatricosisporites australiensis (Cookson)	R
	Cooksonites variabilis Pocock	R
	Couperisporites sp.	C
	Cyathidites australis Couper	A
	C. minor Couper	C
	Dictyophyllidites crenatus Dettmann	R
	Dictyotosporites speciosus Cookson & Dettmann	R
	Foraminisporis asymmetricus (Cookson & Dettmann)	C
	F. dailyi (Cookson & Dettmann)	R
	F. wonthaggiensis (Cookson & Dettmann)	C
	Klukisporites scaberis (Cookson & Dettmann)	R
	Kuylisporites lunaris Cookson & Dettmann	C
	Lycopodiumsporites austroclavatidites (Cookson)	C
	L. circolumenus Cookson & Dettmann	R
	Neoraistrickia truncata (Cookson)	R
	Pilosisporites notensis Cookson & Dettmann	C
	P. parvispinosus Dettmann	R

	Rouseisporites reticulatus Pocock	R
Pollen:	Alisporites grandis (Cookson)	C
	Araucariacites australis Cookson	C
	Classopollis cf. classoides Pflug	C
	Microcachryidites antarcticus Cookson	Ab
	Podocarpidites cf. ellipticus Cookson	Ab
Incertae Sedis:	Schizosporis reticulatus Cookson & Dettmann	R
	S. spriggi Cookson & Dettmann	R
	Spheripollenites psilatus Couper	Ab
Acritarcha:	Michrystridium sp.	Ab

2576 feet

The spore-pollen content of the sample is rich, both in numerical representation and in types present. The following species were observed:

Spores:	Baculatisporites comaumensis (Cookson)	Ab
	Ceratosporites equalis Cookson & Dettmann	C
	Cicatricosisporites australiensis (Cookson)	R
	Cyclosporites hughesi (Cookson & Dettmann)	R
	Cyathidites australis Couper	Ab
	C. asper (Bolkhovitina)	C
	C. minor Couper	C
	Cooksonites variabilis Pocock	R
	Couperisporites sp.	R
	Dictyophyllidites crenatus Dettmann	R
	Dictyotosporites speciosus Cookson & Dettmann	C
	Foraminisporis wonthaggiensis (Cookson & Dettmann)	R
	Klukisporites scaberis (Cookson & Dettmann)	R
	Kuylisporites lunaris Cookson & Dettmann	R
	Leptolepidites verrucatus Couper	Ab
	Lycopodiumsporites austroclavatidites (Cookson)	Ab
	L. circolumenus Cookson & Dettmann	R
	L. eminulus Dettmann	Ab
	L. nodosus Dettmann	R
	Neoraistrickia truncata (Cookson)	R
	Stereisporites antiquasporites (Wilson & Webster)	Ab
	Trilites cf. tuberculiformis Cookson	C
	Velosporites triquetrus (Lantz)	R
Pollen:	Alisporites grandis (Cookson)	C
	Araucariacites australis Cookson	C
	Classopollis cf. classoides Pflug	C
	Cycadopites nitidus (Balme)	Ab
	Microcachryidites antarcticus Cookson	Ab
	Podocarpidites cf. ellipticus Cookson	C

2800 feet

Plant material extracted from the sample includes abundant woody tissue together with the following diverse assemblage of spores and pollen grains:

Spores:	*Aequitriradites spinulosus* (Cookson & Dettmann)	R
	Baculatisporites comaumensis (Cookson)	Ab
	Ceratosporites equalis Cookson & Dettmann	Ab
	Cicatricosisporites australiensis (Cookson)	C
	Couperisporites tabulatus Dettmann	R
	C. sp.	R
	Contignisporites cooksoni (Balme)	R
	Cooksonites variabilis Pocock	R
	Cyathidites australis Couper	Ab
	C. minor Couper	Ab
	Dictyotosporites speciosus Cookson & Dettmann	R
	Foraminisporis asymmetricus (Cookson & Dettmann)	R
	F. wonthaggiensis (Cookson & Dettmann)	C
	Januasporites spinulosus Dettmann	R
	Kuylisporites lunaris Cookson & Dettmann	R
	Leptolepidites verrucatus Couper	R
	Lycopodiumsporites austroclavatidites (Cookson)	C
	L. circolumenus Cookson & Dettmann	R
	Pilosisporites notensis Cookson & Dettmann	C
	Rouseisporites reticulatus Pocock	R
	Sestrosporites pseudoalveolatus (Couper)	R
	Stereisporites antiquasporites (Wilson & Webster(	Ab
Pollen:	*Alisporites grandis* (Cookson)	Ab
	A. similis (Balme)	C
	Araucariacites australis Cookson	C
	Classopollis cf. *classoides* Pflug	Ab
	Cycadopites nitidus (Balme)	R
	Microcachryidites antarcticus Cookson	C
	Podosporites microsaccatus (Couper)	R
	Podocarpidites cf. *ellipticus* Cookson	Ab
Incertae Sedis:	*Schizosporis reticulatus* Cookson & Dettmann	R

2878 feet

A diverse plant microfossil assemblage containing the following species of spores, pollen grains, and organisms of uncertain derivation was extracted from the sample:

Spores:	*Aequitriradites spinulosus* (Cookson & Dettmann)	R
	A. verrucosus (Cookson & Dettmann)	R

	Baculatisporites comaumensis (Cookson)	Ab
	Ceratosporites equalis Cookson & Dettmann	R
	Cicatricosisporites ludbrooki Dettmann	Ab
	C. hughesi Dettmann	R
	Coronatispora perforata Dettmann	R
	Contignisporites cooksoni	R
	Cooksonites variabilis Pocock	R
	Cyclosporites hughesi (Cookson & Dettmann	R
	Cyathidites australis Couper	Ab
	C. minor Couper	Ab
	C. punctatus (Delcourt & Sprumont)	C
	Dictyophyllidites crenatus Dettmann	Ab
	Dictyotosporites speciosus Cookson & Dettmann	C
	Foraminisporis asymmetricus (Cookson & Dettmann)	R
	F. wonthaggiensis (Cookson & Dettmann)	C
	Ischyosporites punctatus Cookson & Dettmann	R
	Klukisporites scaberis (Cookson & Dettmann)	C
	Kraeuselisporites linearis (Cookson & Dettmann)	R
	Leptolepidites major Couper	R
	L. verrucatus Couper	C
	Lycopodiacidites asperatus Dettmann	R
	Lycopodiumsporites austroclavatidites (Cookson)	C
	L. circolumenus (Cookson & Dettmann)	R
	L. eminulus Dettmann	C
	Neoraistrickia truncata (Cookson)	C
	Pilosisporites notensis Cookson & Dettmann	C
	Rouseisporites reticulatus Pocock	C
	Sestrosporites pseudoalveolatus (Couper)	R
	Velosporites triquetrus (Lantz)	R
POllen:	Alisporites grandis (Cookson)	C
	A. similis (Balme)	C
	Araucariacites australis Cookson	C
	Classopollis cf. classoides Pflug	C
	Cycadopites nitidus (Balme)	C
	Microcachryidites antarcticus Cookson	Ab
	Podocarpidites cf. ellipticus Cookson	Ab
	Podosporites microsaccatus (Couper)	C
	Tsugaepollenites dampieri (Balme)	R
Incertae Sedis:	Schizosporis reticulatus Cookson & Dettmann	R
	S. spriggi Cookson & Dettmann	C
Remanié:	Lundbladispora denmeadi (de Jersey) - Triassic	R
	Murospora florida (Balme) - early Cretaceous	R

Spore-pollen assemblages extracted from samples between 1714 feet and 2878 feet contain Dictyotosporites speciosus, Cyclosporites hughesi, and Foraminisporis asymmetricus. These species diagnose the presence of the early Cretaceous Foraminisporis asymmetricus Unit of the Cyclosporites hughesi Subzone (see Dettmann 1969a). The representation of Cooksonites variabilis in samples between 2325 feet and 2878 feet suggests that the horizons are within the basal portion of the Foraminisporis asymmetricus Unit.

C. 2913 - 3278 feet

2913 feet

An extremely sparse assemblage of fairly preserved spores and pollen grains was extracted from the sample. One to several representatives of the following species were observed:

Spores: Baculatisporites comaumensis (Cookson)
Cicatricosisporites australiensis (Cookson)
Cyclosporites hughesi (Cookson & Dettmann)
Cyathidites australis Couper
Leptolepidites verrucatus Couper
Lycopodiumsporites austroclavatidites (Cookson)
Neoraistrickia truncata (Cookson)
Pollen: Araucariacites australis Cookson

3095 feet

This sample was found to be devoid of plant microfossils.

3159 feet

Sparse palnt material including isolated examples of the following spore-pollen species was obtained from the sample:

Spores: Baculatisporites comaumensis (Cookson)
Cyathidites australis Couper
C. minor Couper
Foraminisporis dailyi (Cookson & Dettmann)
Lycopodiumsporites austroclavatidites (Cookson)
Pollen: Microcachryidites antarcticus Cookson

3278 feet

The sample provided a small residue of plant material. The following spore-pollen types occur rarely and are fairly preserved:

Spores: Aequitriradites spinulosus (Cookson & Dettmann)
Ceratosporites equalis Cookson & Dettmann
Cooksonites variabilis Pocock
Cyathidites australis Couper
C. minor Couper
Foraminisporis wonthaggiensis (Cookson & Dettmann)
Lycopodiumsporites austroclavatidites (Cookson)
Pollen: Alisporites similis (Balme)
Classopollis cf. classoides Pflug
Microcachryidites antarcticus Cookson

Samples between 2913 feet and 3278 feet yielded extremely sparse microfloras that provide insufficient evidence for precise zonal attribution of the sediments. However, it is evident that the horizons are within the Cyclosporites hughesi Subzone because of the presence of Cyclosporites hughesi at 2913 feet and of Cooksonites variabilis at 3278 feet.

D. 3340 - 3475 feet

3340 feet

A small residue containing good concentrations of plant microfossils was obtained from the sample. Species observed include:

Spores:	Aequitriradites spinulosus (Cookson & Dettmann)	C
	Baculatisporites comaumensis (Cookson)	C
	Ceratosporites equalis Cookson & Dettmann	C
	Cicatricosisporites australiensis (Cookson)	R
	Cooksonites variabilis Pocock	R
	Cyathidites australis Couper	Ab
	C. minor Couper	Ab

	Dictyotosporites speciosus Cookson & Dettmann	R
	Dictyophyllidites crenatus Dettmann	C
	Foraminisporis dailyi (Cookson & Dettmann)	C
	F. wonthaggiensis (Cookson & Dettmann)	R
	Klukisporites scaberis (Cookson & Dettmann)	R
	Leptolepidites verrucatus Couper	R
	Lycopodiumsporites austroclavatidites (Cookson)	C
	L. nodosus Dettmann	R
	Murospora florida (Balme)	R
	Pilosisporites notensis Cookson & Dettmann	C
Pollen:	Alisporites grandis (Cookson)	Ab
	A. similis (Balme)	Ab
	Araucariacites australis Cookson	C
	Microcachryidites antarcticus Cookson	C
	Podosporites microsaccatus (Couper)	C
	Podocarpidites cf. ellipticus Cookson	Ab
Incertae Sedis:	Schizosporis reticulatus Cookson & Dettmann	C
	S. spriggi Cookson & Dettmann	R

3475 feet

Reasonably well preserved spores and pollen grains occur frequently in the residue together with minor wood and cuticular material. The following types were identified:

Spores:	Aequitriradites spinulosus (Cookson & Dettmann)	R
	Baculatisporites comaumensis (Cookson)	Ab
	Ceratosporites equalis Cookson & Dettmann	C
	Cicatricosisporites ludbrooki Dettmann	R
	Cooksonites variabilis Pocock	R
	Crybelosporites sp.	R
	Cyclosporites hughesi (Cookson & Dettmann)	R
	Cyathidites australis Couper	Ab
	C. minor Couper	Ab
	Dictyotosporites speciosus Cookson & Dettmann	R
	Leptolepidites verrucatus Couper	R
	L. major Couper	R
	Lycopodiumsporites austroclavatidites (Cookson)	Ab
	L. circolumenus Cookson & Dettmann	R
	L. facetus Dettmann	R
	L. nodosus Dettmann	C
	L. eminulus Dettmann	R
	L. reticulumsporites (Rouse)	C
	Matonisporites cooksoni Dettmann	R
	Neoraistrickia truncata (Cookson)	C
	Stereisporites antiquasporites (Wilson & Webster)	Ab
Pollen:	Alisporites grandis (Cookson)	C
	A. similis (Balme)	C

	Araucariacites australis Cookson	Ab
	Classopollis cf. classoides Pflug	R
	Cycadopites nitidus (Balme)	C
	Microcachryidites antarcticus Cookson	Ab
	Podocarpidites cf. ellipticus Cookson	Ab
Remanié:	Aratrisporites sp. - Triassic	R

Samples from 3340 feet and 3475 feet are clearly within the early Cretaceous Cyclosporites hughesi Subzone because of their content of Dictyotosporites speciosus and Cyclosporites hughesi. The presence of Murospora florida at 3340 feet further suggests that the strata may be within the Murospora florida Unit. However, only one example of Murospora florida was found and the possibility that it has been reworked needs to be considered.

E. 3506 - 4025 feet

Several samples within the interval 3506 - 4025 feet have been investigated (see Table 1). All failed to yield spores and pollen grains although several provided small quantities of wood and cuticular material.

F. 5627 - 5634 feet

5627 feet

Abundant carbonaceous matter including moderately carbonized spores, pollen grains, and wood and cuticular fragments was obtained from the sample. The following types were identified:

Spores:	Aequitriradites verrucosus (Cookson & Dettmann)	R
	Baculatisporites comaumensis (Cookson)	C
	Biretisporites spectabilis Dettmann	R
	Ceratosporites equalis Cookson & Dettmann	Ab
	Cicatricosisporites australiensis (Cookson)	R

	Cyathidites australis Couper	Ab
	C. minor Couper	C
	Foraminisporis wonthaggiensis (Cookson & Dettmann)	R
	Kraeuselisporites linearis (Cookson & Dettmann)	R
	Leptolepidites verrucatus Couper	Ab
	L. major Couper	C
	Lycopodiumsporites austroclavatidites (Cookson)	C
	L. eminulus Dettmann	Ab
	Neoraistrickia truncata (Cookson)	C
	Osmundacidites wellmanii Couper	C
	Stereisporites antiquasporites (Wilson & Webster)	Ab
Pollen:	Araucariacites australis Cookson	C
	Classopollis cf. classoides Pflug	R
	Cycadopites nitidus (Balme)	C
	Microcachryidites antarcticus Cookson	Ab
	bisaccate grains gen. et sp. indet.	Ab
Remanié:	Lundbladispora denmeadi (de Jersey) - Triassic	R
	Aratrisporites spp. - Triassic	Ab
	striatitid bisaccate grains - Permian/Triassic	Ab

5634 feet

A small quantity of plant material was obtained from the sample. Spores and pollen grains observed are carbonized and are referable to the following types:

Spores:	Cyathidites spp.	Ab
	Baculatisporites comaumensis (Cookson)	C
	Leptolepidites verrucatus Couper	Ab
Pollen:	trisaccate grains	Ab
	Cycadopites nitidus (Balme)	C
Remanié:	Aratrisporites spp. - Triassic	Ab
	Lundbladispora denmeadi (de Jersey) - Triassic	C
	Guthorlisporites cancellosus Playford & Dettmann - Triassic	C
	striatitid bisaccate grains - Permian/Triassic	C

The sample from 5627 feet yielded a microflora containing Cicatricosisporites australiensis, Biretisporites spectabilis, Kraeuselisporites linearis, and Aequitriradites verrucosus. These species are well documented from Lower Cretaceous strata and also occur in horizons that may be of uppermost Jurassic age (see Evands 1966, Dettmann 1968b). Reworked types occur in minor, but significant proportions

(5%) in the assemblage. Types identified are believed to have derived from Triassic and possibly Permian sediments.

The assemblage from 5634 feet yielded a higher proportion (30%) of reworked Triassic/Permian forms together with types that are widely distributed in Australian Jurassic and Cretaceous sediments.

3 CONCLUSIONS

Microfloral evidence indicates that sediments in Hawkesdale No.1 well, 1245 - 5634 feet range in age from uppermost Jurassic or lowermost Cretaceous to lower Albian.

The Eumeralla formation (sampled between 1245 feet and 3095 feet) is shown to include horizons of the Crybelosporites striatus Subzone (1245 - 1442 feet) and the Foraminisporis asymmetricus Unit (1714 - 2878 feet) of the Cyclosporites hughesi Subzone. The basal part of the Eumeralla formation (2913 - 3095 feet) and the upper portion of the Pretty Hill sandstone (3159 - 3278 feet) are also within the Cyclosporites hughesi Subzone but insufficient evidence has been obtained to ascertain which unit of the C. hughesi Subzone is represented. Horizons of the Pretty Hill sandstone between 3340 feet and 3475 feet are tentatively assigned to the Murospora florida Unit, but underlying strata representing the basal portion of the Pretty Hill sandstone could not be dated by palynological means.

Sediments (5627-34 feet) occurring below a volcanic sequence are considered to be of uppermost Jurassic or lowermost

Cretaceous age; these also contain significant proportions of reworked Triassic and Permian plant microfossils.

Recycled spores and pollen grains of Triassic and Permian age also occur spasmodically throughout productive horizons of the Pretty Hill sandstone and the Eumeralla formation; whilst early Cretaceous reworked types were found near the base of the Eumeralla formation.

The Hawkesdale microfloras are composed dominantly of land-derived spores and pollen grains with minor representation of possible aquatic forms (Schizosporis, Michrystridium) at certain horizons of the Pretty Hill sandstone and the Eumeralla formation.

The Hawkesdale sequence may be correlated on microfloral evidence with the Lower Cretaceous sequences developed in Eumeralla No.1, Pretty Hill No.1, and Moyne Falls No.1 wells. The top of the Eumeralla formation in Hawkesdale No.1 is within the Crybelosporites striatus Subzone and is thus older than upper horizons of the same formation in Pretty Hill No.1, Eumeralla No.1 (both Tricolpites pannosus Zone), and Moyne Falls No.1 (Coptospora paradoxa Zone) (see Dettmann 1969a, 1970). Underlying sediments of the Hawkesdale development of the Eumeralla formation (1714 - 2878 feet) are referable to the Foraminisporis asymmetricus Unit and are thus correlative with middle portions of the Eumeralla formation in Eumeralla No.1 (7225 - 7717 feet) and Moyne Falls No.1 (1802 - 2022 feet) and the basal horizons of the same formation in Pretty Hill No.1 (5935-47 feet)

(Dettmann 1969a, 1970). The Rouseisporites reticulatus Unit which occurs in the lower intersections of the Eumeralla formation in Eumeralla No.1 (8143 - 9890 feet) and Moyne Falls No.1 (2166 - 2330 feet) has not been detected in Pretty Hill No.1, and if represented in Hawkesdale No.1 would be restricted to about 200 feet of sediments at the base of the formation.

The age limits of the Pretty Hill sandstone in Pretty Hill No 1 and Hawkesdale No.1 have not been assessed accurately due to paucity of palynological data. Available evidence indicates that the formation includes horizons of the Cyclosporites hughesi Subzone (including the Murospora florida Unit) in both wells and possible representation of the Crybelosporites stylosus Zone in Pretty Hill No.1 (see Dettmann 1969a).

4. REFERENCES

Dettmann, M.E. 1968a. Palynological report on Interstate Woolsthorpe No.1 well, 4300 feet - 6380 feet. Unpubl. report submitted to Shell Development (Australia) Pty. Ltd. 9/9/68.

Dettmann, M.E. 1968b. Palynological report on core 10, B.O.C. Legendre No.1 well, Western Australia. Ibid. 19/9/68.

Dettmann, M.E. 1969a. Palynological zonation of Lower Cretaceous sediments of the Otway Basin, Victoria. Ibid. 25/7/69.

Dettmann, M.E. 1969b. Palynological zonation of the Otway Group. Ibid. 1/12/69.

Dettmann, M.E. 1970. Palynological report on Moyne Falls

No.1 well, 1289 - 3050 feet. Ibid. 12/2/1970.

Dettmann, M.E. and Playford, G. 1969. Palynology of the Australian Cretaceous - a review; in Stratigraphy and Palaeontology. Essays in Honour of Dorothy Hill (K.S.W. Campbell Ed.); Chapter 9; 174-210. Aust. Nat. Univ. Press, Canberra.

Evans, P.R. 1966. Mesozoic stratigraphic palynology in Australia. Aust. O. Gas J. 12, 58-63.

18th March, 1970.

Mary E. Dettmann,
Department of Geology,
University of Queensland,
St. Lucia, Queensland.

EXPLANATION OF TABLE 1

Preservation and zonal attribution of plant microfossil assemblages in sidewall cores of Hawkesdale No.1 well, 1245 - 5690 feet.

Abbreviations:

Yield expresses frequency of spores and pollen grains in the palynological residues as follows:-

Ab = abundant
C = common
Sp = sparse
B = barren

Colour and Preservation. Spores, pollen, wood and cuticle present in the residues are denoted by their colour (col.) and quality of preservation (pres.) thus:-

DY = dark yellow
LBr = light brown
Br = brown
Bl = black
good = well preserved
fair = fairly preserved
poor = poorly preserved

Spore-pollen Zones are those defined by Dettmann and Playford (1969) and Dettmann (1969a,b).

TABLE IV-1

Depth (ft)	Yield	Spore-Pollen Col.	Spore-Pollen Pres.	Wood Col.	Wood Pres.	Cuticle Col.	Cuticle Pres.	Spore-Pollen Zone	Stratigraphy	
1245 380	Ab	DY-LBr	Good-Fair	Br-Bl	Fair	DY-LBr	Fair	*Crybelosporites striatus* Subzone	Eumeralla Formation	Otway Group
1442 440	"	"	"	"	"	"	"			
1714 522	"	"	Fair	"	"	"	"	*Foraminisporis asymmetricus* Unit		
2018 615	"	"	"	"	"	"	"			
2325 709	"	"	"	"	"	"	"			
2576 785	"	"	"	"	"	"	"			
2800 853	"	"	"	"	"	"	"			
2878 877	"	"	"	"	"	"	"			
2913 888	Sp	"	"	"	"	"	"	*Cyclosporites hughesi* Subzone (unit indeterminate)		
3095 943	B	—	—	—	—	—	—			
3159 963	Sp	DY-LBr	Fair	Br-Bl	Fair	DY-LBr	Fair		Pretty Hill Sst	
3278 999	"	"	"	"	"	"	"			
3340 1018	C	"	"	"	"	"	"	? *Murospora florida* Unit		
3475 1059	"	"	"	"	"	"	"			
3506 1069	B	—	—	—	—	—	—	indeterminate		
3698 1127	"	—	—	—	—	—	—			
3810 1161	"	—	—	Br-Bl	Fair	—	—			
3895 1187	"	—	—	"	"	Br	Poor			
3925 1196	"	—	—	"	Poor	—	—			
4025 1227	"	—	—	—	—	—	—			
5627 1715	Ab	Br-Bl	Poor	Bl	Poor	Br	Poor	lowermost Cretaceous or uppermost Jurassic	Basal Unit	
5634 1717	Sp	"	"	"	"	"	"			
5690 1734	B	—	—	—	—	—	—	indeterminate		

APPENDIX V

VELOCITY SURVEY OF HAWKESDALE NO. 1 WELL

by

Shell Development (Australia) Pty. Ltd.

(G.E. Watkins)

MELBOURNE, MARCH 1970.

CONTENTS

TABLE 1 - WELL INFORMATION

NAME OF WELL:	Hawkesdale No. 1
DATE OF SURVEY:	29th December, 1969
LOCATION:	2 miles north of Hawkesdale, Victoria, in P.E.P.5
COORDINATES:	Latitude 38° 04' 54" S Longitude 142° 17' 55" E
ELEVATION (ROTARY TABLE):	456 feet above mean sea level
GROUND ELEVATION AT THE WELL:	444 feet above mean sea level
DATUM PLANE:	400 feet above mean sea level
INTERVAL SURVEYED:	1221' to 5810' below R.T.
TOTAL DEPTH:	5820' below R.T.
CASING RECORD:	$9^5/8$" to 1221' below R.T.

TABLE 2 - ARRIVAL TIMES TO THE PRINCIPAL HORIZONS

HORIZON	DEPTH BELOW DATUM (FEET) (400 ft. above M.S.L.)	ARRIVAL TIME (SECS.) (one way time)
END OF CASING	1165'	$.192^{5}$
INTERBEDDED SAND AND SHALE	2644'	$.390^{3}$
NEAR TOP PRETTY HILL SANDSTONE	3044'	$.435^{4}$
NEAR TOP VOLCANICS	3889'	$.529^{8}$
VOLCANICS	4494'	$.578^{7}$
VOLCANICS	5204'	$.631^{5}$
NEAR TOP BASEMENT	5664'	$.667^{5}$
TOTAL DEPTH	5754'	$.672^{6}$

TABLE 3. COMPARISON OF SONIC LOG AND WELL SURVEY DATA

DEPTH BELOW DATUM	AVERAGE VERTICAL TIME	Δ T CHECK SHOTS	Δ T SONIC	DIFFERENCE	INTERVAL
1165	.1925				
		.0600	.0655	-.0055	479
1644	.2525				
		.0581	.0645	-.0064	500
2144	.3106				
		.0797	.0633	+.0164	500
2644	.3903				
		.0451	.0447	+.0004	400
3044	.4354				
		.0944	.0930	+.0014	845
3889	.5298				
		.0489	.0526	-.0037	605
4494	.5787				
		.0278	.0329	-.0051	330
4824	.6065				
		.0250	.0375	-.0125	380
5204	.6315				
		.0360	.0370	-.0010	460
5664	.6675				
	Δ T TOTALS	.4750	.4910	-.0160	

INTRODUCTION

The Shell-Frome Hawkesdale No. 1 well velocity survey was carried out on 29th December, 1969 by G.S.I. Party 827 using the recording equipment which they already had in the area in connection with the Portland-Macarthur land seismic survey. This equipment consisted of a 24-channel T.I. Series 9000 Seismic Amplifier and Digital Field System complete with camera and auxiliary equipment. The well geophone used was a three component well shooting seismometer manufactured by the Technical Instrument Company and borrowed from the Bureau of Mineral Resources in Canberra. A summary of the principal information relevant to the well survey is given in Table 1.

DESCRIPTION OF THE SURVEY

Shotholes were drilled at distances of 1,000 feet from the well in both the east and west directions as shown in the layout diagram of Figure V-1. In each direction three holes were available separated by 50 feet so as to prevent any interconnection arising from caving or cavity building. As a check on the hole condition a reference geophone was planted in the ground near the well and the time to this geophone was compared with the time to the uphole geophone for each shot. The results of these comparisons show that the condition of the shotholes remained good throughout the survey.

All depth measurements to the well geophone were made using the Schlumberger depth indicator. Eleven station levels, comprising the principal horizons of interest as shown in Table 2, were occupied as the geophone was run into the well and these were shot using the holes to the west. In each case the geophone was lowered past the required level and brought back up onto station in order to eliminate the possibility of slack in the cable. Check shots at eight of these levels were shot from the east as the geophone was pulled out of the well. In some instances (1221, 3100 and 3945 feet levels) a shot was repeated where the first shot was of low energy.

The explosive used was I.C.I. Geophex made up in cylinders 2 feet long and each containing 5 lbs. of dynamite. Shooting began with an initial charge of 5 lbs. but this was increased to 10 lbs. because of low levels of energy. This was further increased to 25 lbs. for stations within the volcanic sequence (below 3945 feet). All machinery and generators on the well site were shut down for the duration of the survey.

In order to take maximum advantage of the three component well geophone and the 24 channel T.I. 9000 amplifier system the recording parameters were arranged as follows:-

(a) A fixed gain recording mode was used throughout the survey.

(b) The recording filters were an out low cut and a high cut of 168 c.p.s.

(c) Traces 1, 2, 4, 5, 7, 8, 9, 10, 11, 13, 14, 15, 16 were used to monitor the geophone vertical component at four different gain settings in groups as

- (i) 1, 2, 4 - gain range 80-93 db
- (ii) 5, 7, 8 - gain range 70-86 db
- (iii) 9, 10, 11 - gain range 66-80 db
- (iv) 13, 14, 15, 16 - gain range 60-73 db

(d) Traces 17 to 20 monitored one of the horizontal components while traces 21 to 24 monitored the other horizontal component. These traces were recorded with gain settings in the range 60-73 db.

(e) Trace 4 was used for the time break.

(f) Trace 6 was used for the uphole seismometer.

(g) Trace 12 was used for the reference geophone.

RESULTS OF VELOCITY SURVEY

The quality of the records obtained throughout the survey was generally good with the exception of those for the 2700 foot level which both had extraneous energy riding just ahead of the first arrival. One of the records for the 5810 foot level was not picked because of the low energy level recorded.

The complete results of the well survey are set out on a calculation sheet (S.D.A. Report No. 109 Encl. 1). In order to minimise the various elevation corrections necessary to refer all the shots to a fixed datum, this datum was taken as 400 feet above Mean Sea level. A weathering shot from shothole E indicated that the replacement velocity used in making this correction should be 6,000 feet per second. On the basis of this velocity and a detonation velocity for the Geophex of approximately 20,000 feet per second the effective shot position used in the well computation was taken as $^1/3$ from the bottom of the Geophex charge.

It will be noted that there is some variance in the times obtained for the check shots on the two sides of the well. However, this variance is consistent in that the shots from the east of the well always took less time than those from the west.

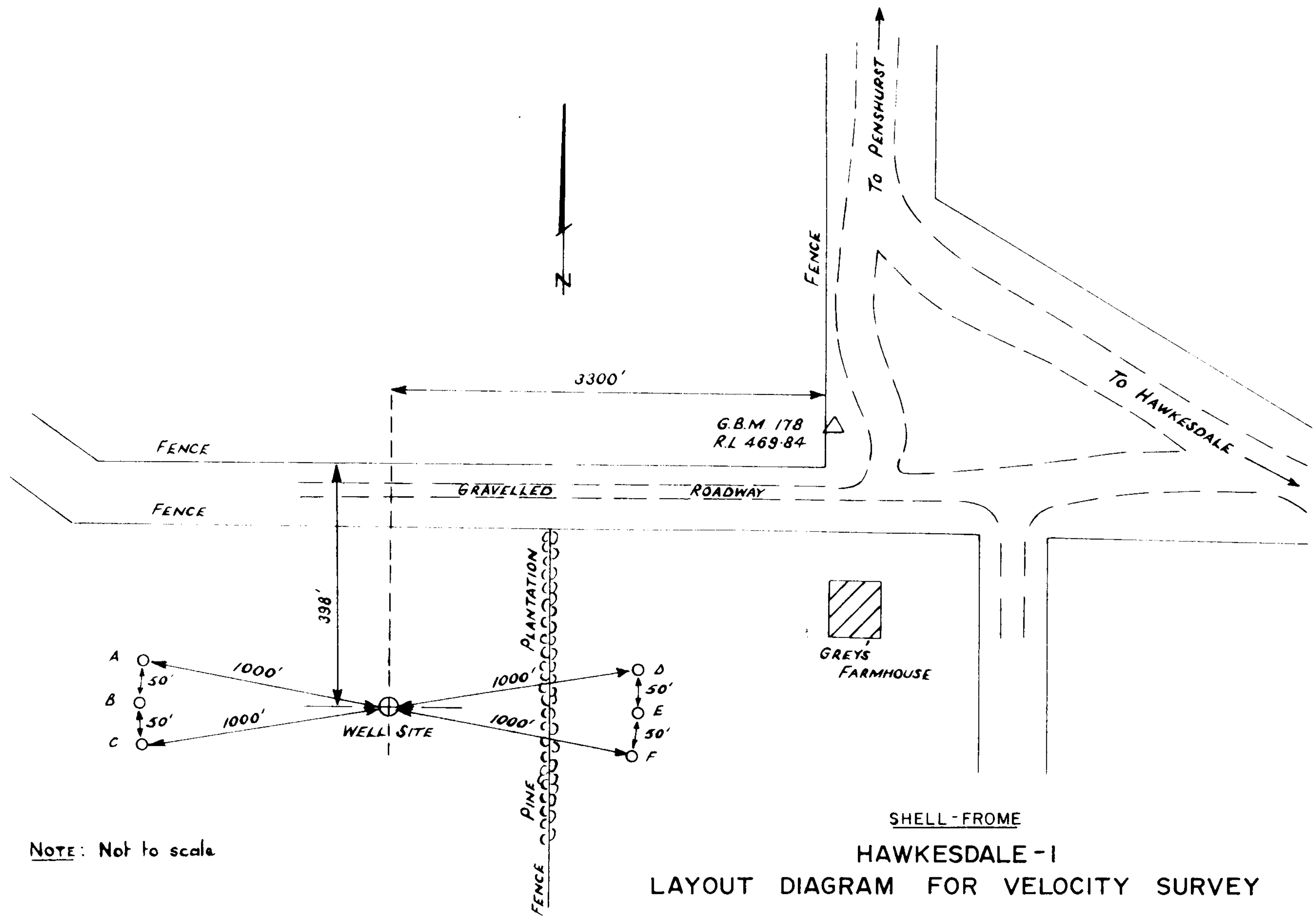
SONIC LOG INTEGRATION

A comparison between the velocity survey data and the integrated sonic log data is given in Table 3. In order to integrate both sets of data into a single time-depth plot, a tie point was established at 3,044 feet below datum. The vertical times from the velocity survey were used as reference values and the differences observed from comparison with the integrated sonic log were then distributed linearly over each check shot interval. The only exception to this was in the interval 1,165 feet to 2,644 feet which was considered as a single unit because of the apparently low readings obtained for the check shots at the 1,644 and 2,144 foot levels. Neither of these levels represents a significant horizon.

The time-depth curve for the well velocity and integrated sonic log data is presented as Enclosure 1d. This also includes plots of average and interval velocities versus depth. Following velocity function has been computed for the Hawkesdale No.1 well:-

Datum to 4,090'	$V_z = 5580 + 1.0\ z$
4,090' to total depth	$V = 13{,}600$ feet per second (constant velocity)

A plot of the time-depth curve corresponding to this velocity function is included as Enclosure 1e.



NOTE: Not to scale

SHELL-FROME

HAWKESDALE-1
LAYOUT DIAGRAM FOR VELOCITY SURVEY

Fig V-1 Drg. No. 4111

APPENDIX VI

DETAILS OF DRILL STEM TESTING

SHELL/FROME HAWKESDALE NO.1

HAWKESDALE NO. 1

Details of Drill Stem Testing

During the drill of the well 2 attempts were made to carry out an open hole drill stem test. As test No. 1 failed because no packer seat was obtained, a second attempt was made to obtain a seat about 27 feet higher. However, the second test failed for the same reason.

	Attempt No. 1	Attempt No. 2
Date :	12.12.1969	12.12.1969
Interval :	3528 - 3603 feet	3501 - 3603 feet
Reason for Test :	To obtain a sample of formation fluids after the occurrence of minor oil shows in conjunction with good porosity in a core cut in the Pretty Hill Sandstone reservoir.	
Well depth :	3603 feet	same
Hole conditions :	8¾" open hole	same
Type of test :	single packer, bottom hole	same
Drill pipe and collar data :	4½" OD drillpipe and 6½" OD drillcollars	same
Packer :	7¾" set at 3528 feet	7¾" set at 3501 feet
Choke size :	1" top, ¾" bottom	1" top, ¾" bottom
Watercushion :	Nil	Nil

	Attempt No. 1 (Cont'd)	Attempt No. 2 (Cont'd)
Test stem assembly :	2.4' Anchor Shoe 4' BT running case 44' Perforated tailpipe 26.57' Drill collar 6" 0.66' X/O Sub 6.1 7¾" packer 2.36' safety joint 3.3' jar 4' BT running case 5.2' Hydro spring 4.66' Dual CIP valve 2' Handling sub and choke ass. 90' 6½" drill collars 1 reversing sub. 194' Total	52.64 drill collars 6" Same assembly except for one more drill collar on top of the perforated tailpipe. 220.07' Total
Calculated pressure of mud column :	1880 psi	1855 psi
Duration of test :	Set packer 6.35 am. Open tool 6.36 am. Fluid level in annulus dropped immediately No packer seat	Set packer 1.05 pm. Open tool 1.15 pm. Fluid level in annulus dropped. No packer seat
Results :	Nil	Nil
Pressure Chart readings :	Initial Hydrostatic 1805 psi. (Top) Final Hydrostatic 1805 psi. (Top)	1818 psi. (Top) 1867 psi. (Bottom) 1818 psi. (Top) 1867 psi. (Bottom)