WCR

DUCK BAY-1

(W482)

ARCO-WOODSIDE

FEBRUARY 1964

PEP/44

G.B. ONSHORE

Completion Report

PE906923

This is an enclosure indicator page.
The enclosure PE906923 is enclosed within the container PE906918 at this location in this document.

The enclosure PE906923 has the following characteristics:

ITEM_BARCODE	= PE906923
CONTAINER_BARCODE	= PE906918
NAME	= Well Card
BASIN	= GIPPSLAND
PERMIT	= PEP/44
TYPE	= WELL
SUBTYPE	= WELL_CARD
DESCRIPTION	= Well Card, sheet 1 of 2, (enclosure from WCR) for Duck Bay-1
REMARKS	=
DATE_CREATED	= 28/02/64
DATE_RECEIVED	=
W_NO	= W482
WELL_NAME	= DUCK BAY-1
CONTRACTOR	=
CLIENT_OP_CO	= ARCO WOODSIDE PTY LTD

(Inserted by DNRE - Vic Govt Mines Dept)

PE906924

This is an enclosure indicator page.
The enclosure PE906924 is enclosed within the container PE906918 at this location in this document.

The enclosure PE906924 has the following characteristics:

ITEM_BARCODE	= PE906924
CONTAINER_BARCODE	= PE906918
NAME	= Well Card
BASIN	= GIPPSLAND
PERMIT	= PEP/44
TYPE	= WELL
SUBTYPE	= WELL_CARD
DESCRIPTION	= Well Card, sheet 2 of 2, (enclosure from WCR) for Duck Bay-1
REMARKS	=
DATE_CREATED	= 28/02/64
DATE_RECEIVED	=
W_NO	= W482
WELL_NAME	= DUCK BAY-1
CONTRACTOR	=
CLIENT_OP_CO	= ARCO WOODSIDE PTY LTD

(Inserted by DNRE - Vic Govt Mines Dept)

DUCK BAY-1.

PLEASE NOTE THE FOLLOWING ADJUSTMENTS TO STRATIGRAPHY :—

TAMBO RIVER Fm : 410'-510'

TOP / BASE? OF LATROBE VALLEY = APPROX 2700'.

B. HOCKING.
for JD.

W482

ARCO LIMITED / WOODSIDE (LAKES ENTRANCE)

OIL CO. N. L.

DUCK BAY NO. 1 WELL

FINAL WELL REPORT

by

Frank T. Ingram

ARCO LIMITED

2/54

SUMMARY

The DUCK BAY NO. 1 was designed as a stratigraphic well to investigate pre-Tertiary sediments in an area where the total section above basement was expected to be less than 5000 feet thick. The well was located 4 miles southwest of the town of Paynesville, Victoria, in Petroleum Exploration Permit No. 44.

The well was spudded on 15th February, 1964 and was plugged and abandoned as a dry hole on 28th February, 1964.

The base of the Tertiary section was found at 2684 feet. Below this a thin Mesozoic section 816 feet thick was encountered. Beneath the Mesozoic a section heretofore unknown in the Gippsland Basin was encountered. This new section consisted of Upper Paleozoic (Permian ?) volcanics from 3175 to 3500 feet and a non-marine sandstone unit of Upper Paleozoic (Lower Permian ?) age from 3500 to 4124 feet. Ordovician basement was found at 4124 feet.

No significant shows of hydrocarbons were detected, but the presence of Upper Paleozoic sediments in the well upgrades this part of the Gippsland Basin for future exploration.

Duck Bay 3/54

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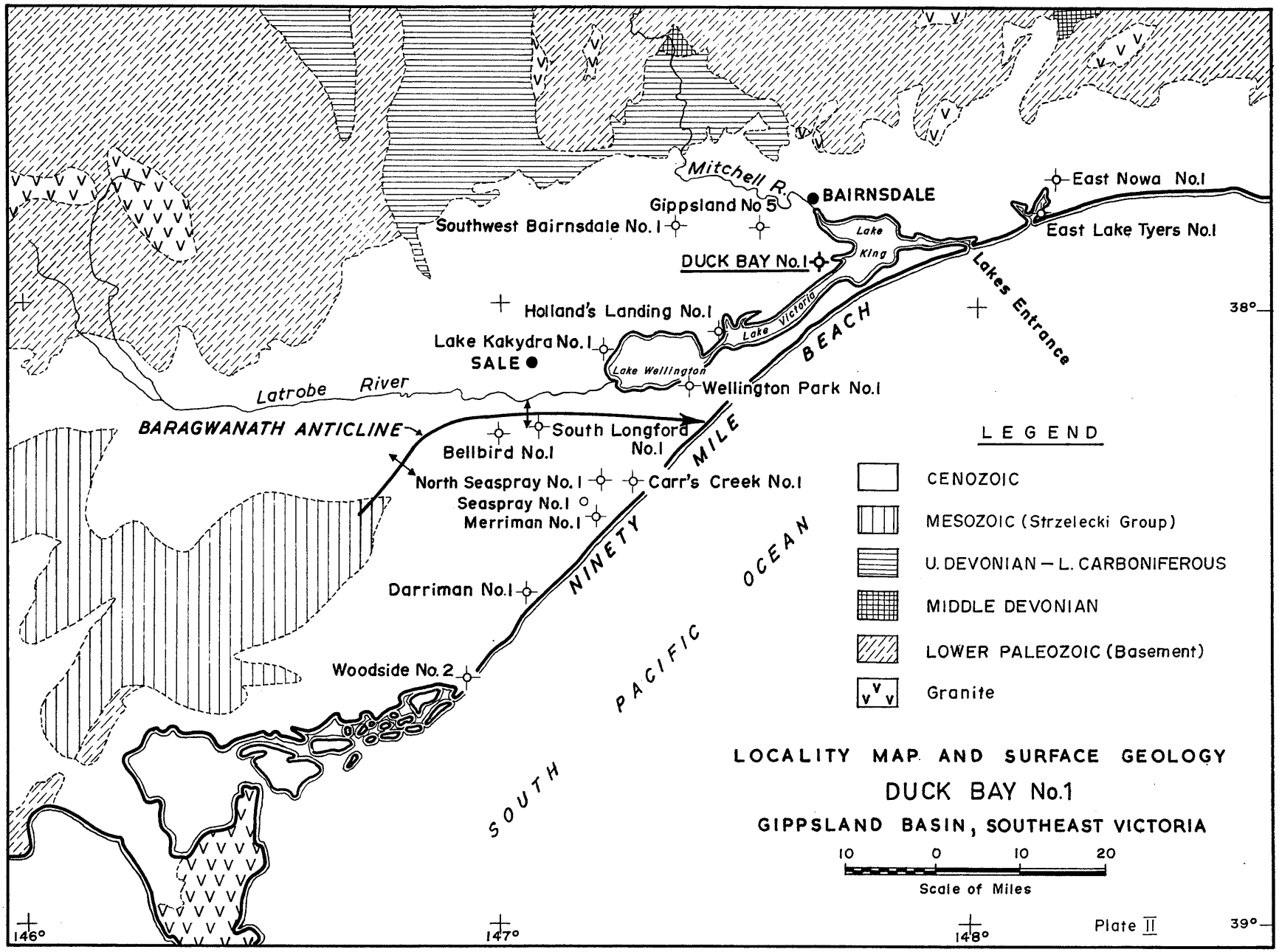
Mitchell R.
BAIRNSDALE
East Nowa No.1
Gippsland No.5
Southwest Bairnsdale No.1
East Lake Tyers No.1
Lake King
DUCK BAY No.1
Lakes Entrance
Holland's Landing No.1
Lake Victoria
38°
Lake Kakydra No.1
SALE
Lake Wellington
BEACH
Latrobe River
Wellington Park No.1
BARAGWANATH ANTICLINE
South Longford No.1
Bellbird No.1
MILE
North Seaspray No.1
Carr's Creek No.1
Seaspray No.1
Merriman No.1
NINETY
OCEAN
Darriman No.1
PACIFIC
Woodside No.2
SOUTH
LEGEND
CENOZOIC
MESOZOIC (Strzelecki Group)
U. DEVONIAN – L. CARBONIFEROUS
MIDDLE DEVONIAN
LOWER PALEOZOIC (Basement)
Granite
LOCALITY MAP AND SURFACE GEOLOGY
DUCK BAY No.1
GIPPSLAND BASIN, SOUTHEAST VICTORIA
10 0 10 20
Scale of Miles
146°
147°
148°
Plate II
39°

Duck Bay 4/54

Duck Bay 5/54

INTRODUCTION

In the Wellington Park No. 1 well on the southeast side of Lake Wellington 8,226 feet of Strzelecki Group sediments of Lower Cretaceous age were penetrated without reaching the base of the sequence. At Lakes Entrance, approximately 35 miles northeast of the Wellington Park No. 1, the Strzelecki Group is completely absent and Tertiary sediments rest on granite. Before the drilling of Duck Bay No. 1 very little was known about Mesozoic and older sediments between these two points.

Several previous wells in the Lake Victoria area penetrated the Tertiary sequence, but went only a few feet into the Strzelecki Group. A seismic survey of the Lake Victoria and Lake King area in 1962 yielded very little information about pre-Tertiary sediments. Because of the extensive overlap by Tertiary sediments in the Gippsland Basin, the Mesozoic sequence does not outcrop in the eastern part of the basin. Thus, in order to evaluate the eastern half of the basin it became necessary to program a stratigraphic well sufficiently deep to investigate the pre-Tertiary section down to basement.

The objectives of the Duck Bay No. 1 were :

1. To determine the nature and thickness of the Strzelecki Group. It was hoped that a porous basal sand would be present in the Strzelecki Group which might contain hydrocarbons, or encourage additional drilling.

2. To determine the nature and thickness of pre-Strzelecki Group sediments. The occurrence of marine Lower Cretaceous, Jurassic, Permian, Carboniferous and Middle Devonian sediments were all considered as possibilities in this regard.

3. To determine the structural attitude of the pre-Tertiary beds for comparison with seismic data.

4. To obtain velocity control for pre-Tertiary strata as well as for basement rocks.

Duck Bay 6/54

A location was picked where seismic data suggested the depth to the base of the Strzelecki Group would be about 3500 feet. No seismic reflection from basement rocks was obtained in this area, but it was predicted, after a study of the regional geology, that basement would be found between 4000 and 5000 feet.

Duck Bay 7/54

WELL HISTORY

WELL DATA

Well Name and Number	:	DUCK BAY NO. 1
Location	:	Latitude 37°56'45" South Longitude 147°39'36" East 4 miles southwest of Paynesville townsite
Name and Address of Tenement Holder	:	Arco Limited - Woodside (Lakes Entrance) Oil Co. N. L. 792 Elizabeth Street, Melbourne
Details of Petroleum Tenement	:	Petroleum Exploration Permit No. 44, Victoria
District	:	East Gippsland
Total Depth	:	4224 ft. Driller 4238 ft. Schlumberger
Date Drilling Commenced	:	February 15, 1964
Date Drilling Completed	:	February 26, 1964
Date Well Abandoned	:	February 28, 1964
Date Rig was Released	:	February 28, 1964
Drilling Time in Days to Total Depth	:	11 days
Elevation	:	Ground 68 feet Kelly bushing 79 "
Status	:	Abandoned
Cost	:	

Duck Bay 8/54

DRILLING DATA

Name and Address of Drilling Contractor	:	Reading and Bates (Australia) Pty. Ltd. 2 City Road Melbourne, S.C.4. Victoria	
Drilling Plant	:	Make	National
		Type	50
		Rated Capacity	7000 feet with 4½" drill pipe
		Rated Capacity	10,000 feet with 3½" drill pipe
		Motors	(2) General Motors 6-71 twin model diesel, 504 BHP each
Mast	:	Make	Lee C. Moore
		Type	131 feet Cantilever
		Rated Capacity	550,000 pounds
Pumps	:	Make	National
		Type	1 - C250 1 - C150-B
		Size	7½" x 15", 7¼" x 12"
		Pump Motors	Make: General Motors Type: 6-71 twin diesel BHP: 312
Blowout Preventer Equipment	:	Make	Cameron (2)
	:	Size	12"
		Series	900
		Make	Hydril
		Size	12"
		Series	900
Hole Sizes and Depths	:	22"	0 - 23 feet
	:	17½"	23 - 420 feet
		8¾"	420 - 4238 feet
Casing Details	:	Size	18⅝"
		Weight	78 lbs/ft
		Range	2
		Setting Depth	23 feet
		Size	13⅜"
		Weight	48 lbs/ft
		Grade	J-55
		Range	2
		Setting Depth	410'
Casing Cementing Details	:	Size	18⅝"
	:	Setting Depth	23 feet
		Quantity cement used	25 sax
		Cemented to	Surface
		Method Used	Poured from ready mix truck
		Size	13⅜"
		Setting Depth	410 feet
		Quantity cement used	380 sax
		Cemented to	Surface
		Method Used	Plug

Drilling Fluid : Type - Water base, bentonite, low pH

The spud mud used to drill the surface hole was a low weight low viscosity fresh water bentonite mud. After drilling out below the surface casing at 410 feet, a fresh water native mud was used down to about 2800 feet. Below 2800 feet the mud was treated with bentonite, caustic soda, tannin and C.M.C.

Below 2800 feet the viscosity was maintained at 47 to 60 sec/qt by the use of bentonite and tannin. The water loss below 2800 feet was maintained at 8 to 10 cc/30 min. by small additions of C.M.C. The pH was controlled at a low level of 8 to 9 by additions of caustic soda.

No lost circulation, or other unusual problems affecting the drilling fluid, were encountered.

The average analyses of the drilling fluid per 1000 feet are given below.

Interval	Viscosity sec/qt	Weight lbs/gal.	W.L. cc/30 min.	F.C.	pH
0 - 1000'	42	9.7	--		
1000 - 2000'	46	9.4	-		
2000 - 3000'	37	9.4	20	2/32	8
3000 - 4000'	51	10.0	9.1	2/32	8.5
4000 - 4238'	50	10.4	8.5	2/32	8.5

The following is a list of the mud and chemicals used during the drilling operation :

Material	Trade Name	Amount used
Bentonite	(Supercol)	6,750 lbs.
Tannin	(Lo Vis)	850 "
C.M.C.	(Cellucol & A.K.U.)	850 "
Caustic Soda		864 "
Lime		50 "

Water Supply :

A water bore was drilled on the edge of the location to a depth of 136 feet using a percussion type water boring rig. A string of 6" casing was driven to 128 feet and 8 feet of sand screen was set below the casing. A Pomona pump assembly was installed in the well and set at 60 feet.

At first the well failed to produce any water. The well was then cleaned out to the base of the screen where sand and clay was blocking the flow of water. After this the well produced at the rate of approximately 1000 barrels (42,000 gal.) per day.

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Duck Bay

Perforations and Shooting Record :

No perforation or shooting operations were performed.

Plugging Back :

The only plugs set were for the purpose of abandonment. The first plug was set at 2623 - 2723 feet with 40 sacks of cement, the second at 360 - 460 feet with 40 sacks of cement. A plug of 10 sacks of cement was set in the top of the 13⅜" casing. A ¼" steel plate was welded over the casing, and a 2" steel pipe with a marker 3 feet above ground was welded to the side of the casing.

Fishing Operations :

No fishing operations were performed.

Side-Tracked Hole :

The hole was not side-tracked.

LOGGING AND TESTING

Ditch Cuttings :

Cuttings were collected after passing over the shale shaker, then washed and placed in marked bags. The cuttings were collected each 10 feet while drilling, and each 5 feet while coring.

Coring :

The original schedule called for cutting 1 core in the Tertiary, 4 in the Strzelecki Group and 5 in the section below the Strzelecki Group. This schedule was somewhat changed to fit slightly different conditions than expected.

The first core was planned for the transition zone between the Lakes Entrance Formation and the Latrobe Valley Coal Measures. The recovery in this core was nil and a second core was taken immediately below the first, with recovery again nil.

The Strzelecki Group was much thinner than expected and only one core was taken in this section.

Cores 3 and 4 were taken to investigate the nature of the volcanic sequence; cores 6 and 7 were taken to investigate the stratigraphic nature of sandstones below the volcanics; and cores 8 and 9 were taken to verify the presence of basement rock.

A Hughes type "J" barrel with hard or soft core heads, was used for all coring. The total footage cored was 136 feet, and the total recovery was 81.5 feet, or 60%.

A brief resumé of the coring is presented in the following table :

Core No.	Interval	Length	Recovery
1	2320' - 2340'	20'	0
2	2340' - 2360'	20'	0
3	2831' - 2851'	20'	20'
4	3182' - 3202'	20'	20'
5	3393' - 3403'	10'	2'
6	3699' - 3709'	10'	9.5'
7	3880' - 3896'	16'	16'
8	4152' - 4162'	10'	10'
9	4214' - 4224'	10'	4'

See Appendix 4 for detailed descriptions of the cores.

Side-Wall Sampling :

Because of the presence of section not previously seen in the Gippsland Basin, and the poor recovery of conventional coring in the Tertiary section, it was planned to take 30 or more side-wall cores. However, only 13 side-wall shots were available from the logging contractor. Of the 13 side-wall cores attempted 12 were recovered. Recovery for individual cores was fair to good.

See Appendix 4 for descriptions of the side-wall cores.

Electrical and Other Logging :

The well was logged by Schlumberger from 410 feet to 4238 feet using a truck-mounted logging unit. The microlog, electrical log and sonic-gamma ray log were run over the above interval, and in addition a continuous dipmeter survey was made over the interval 1000 - 4220 feet. No difficulties were encountered while running these logs.

A lithologic log was prepared concurrently with the drilling operation.

The geological supervision of the well was performed by Arco Limited geologists - Frank Ingram and Gerald Fleit. The mechanical aspects of the drilling operation were under the direction of W. R. Gregoire, drilling engineer, on temporary assignment from The Atlantic Refining Company of the U.S.A.

Drilling Time and Gas Log :

The drilling time was recorded by a geolograph on the rig floor and also by a drilling time recorder used in conjunction with a Core Laboratories gas detector. The rig geolograph was used to compute the drilling rate curve shown on the composite log (Plate I).

A Core Laboratories portable gas detector was used to log the total gas in the drilling fluid from 40 feet to total depth. The drilling time and gas curve were recorded simultaneously on the same chart. The equipment performed satisfactorily.

Formation Testing :

There were no formation tests made in the Duck Bay No. 1 well. The Tertiary section, as indicated by the electrical log, contained only fresh water, and there were no indications of hydrocarbons or significant porosity in the pre-Tertiary strata. Also because of the enlarged hole below the Tertiary, an open-hole drill stem test in this section would have had little chance of success.

Deviation Surveys :

The hole deviation was determined by running a "Totco" device in the drill pipe on wire line, or by dropping the device in the drill pipe before starting a trip.

The deviation between 140 feet and 3880 feet varied from $\frac{1}{4}^{o}$ to $1\frac{1}{4}^{o}$. Below 3880 feet the deviation started to increase and at the last survey at 4152 feet it was $2\frac{1}{4}^{o}$.

No crooked hole or other adverse drilling conditions were encountered.

Temperature Surveys :

No temperature surveys were made.

Other Well Surveys :

No surveys, other than those listed above, were made.

G E O L O G Y

SUMMARY OF PREVIOUS WORK, GEOLOGICAL, GEOPHYSICAL AND DRILLING

Before conducting any drilling in the Duck Bay area logs, cores and reports of other wells in the area were studied. The most important of these were the Sperm Whale Head bore, Romani (M) bore, Amalgamated Oil Syndicate No. 1, Pelican Point No. 1, Bairnsdale No. 5 and the many shallow wells drilled in the vicinity of Lakes Entrance. The deepest of these wells is the Sperm Whale Head bore with a total depth of 3,111 feet.

No surface geological work was attempted in the Duck Bay area as the surface is covered by late Pliocene to recent sediments

which mask the underlying geology. Paleozoic rocks were studied on the north side of the basin where they form extensive outcrops in the high lands.

The Gippsland Basin was covered by a gravity survey in 1949 by the Robert H. Ray Co., and this work was later complemented by additional gravity and aeromagnetic surveys by the Bureau of Mineral Resources, Geology and Geophysics.

In 1962, a reflection seismic survey in the Lake Victoria and Lake King area was made by Austral Geo Prospectors Pty. Ltd. for Arco Limited and Woodside (Lakes Entrance) Oil Co. N. L. During this survey good reflections in the Tertiary section were obtained, but only poor to fair reflections were obtained from the pre-Tertiary strata.

Two refraction surveys were also made by the same seismic contractor west of the Duck Bay area.

SUMMARY OF THE REGIONAL GEOLOGY

The Gippsland Basin is one of several small basins along the southeast coast of Australia. The basin, as it is known today, had its greatest areal extent during Tertiary time. The basin proper, on shore, can be considered that area lying west of the Lakes Entrance granite high, south of the Tertiary - Paleozoic contact on the north side of the basin and east of a line between Wilson's Promontory and the town of Warragul.

The basin extends south-eastward off-shore where it is believed to contain a much greater thickness of Tertiary and possibly older sediments.

The Paleozoic in the subsurface is probably very much like the area of Paleozoic outcrops on the north side of the basin. Ordovician and Silurian sediments, altered by dynamic metamorphism and intruded by granite and other igneous rocks, probably underlie Mesozoic or Tertiary sediments around the margins of the basin. Highly folded marine strata of Middle Devonian age occur as erosional remnants north-east and south-west of the basin proper, and similar isolated remnants may exist in the subsurface. Overlying Middle Devonian and older rocks on the north side of the basin is a thick sequence of continental red shales, sandstones, conglomerates and volcanics of Upper Devonian - Carboniferous age. These beds are only slightly to moderately folded, and probably extend from the outcrop at least as far south as Lake Wellington.

Duck Bay 14/54

Until the drilling of Duck Bay No. 1 the only indication of Upper Paleozoic sediments in the Gippsland Basin was an isolated outcrop of conglomerate (or glacial tillite) on the south side of the Carrajung Uplift. The Duck Bay No. 1 well revealed the presence of 624 feet of Upper Paleozoic (Lower Permian ?) sediments overlain by 330 feet of volcanics of possible Permian age. The sediments and volcanics appear to increase in thickness southward, and a more complete section may exist under Bass Strait.

No sediments of Triassic age have been identified in the Gippsland Basin.

The late Jurassic and early Cretaceous times in the Gippsland Basin are represented by the Strzelecki Group. This unit was deposited in a great trough, oriented roughly east - west. The sequence consists of non-marine clastics with an estimated thickness of 10,000 - 20,000 feet in the Carrajung uplift. A total of 8,226 feet of this sequence was penetrated in the Wellington Park No. 1 well with no indication of reaching the base. The unit thins rapidly towards the northern margin of the trough so thatonly 485 feet is present in the Duck Bay No. 1.

In the Duck Bay No. 1 well the continuous dipmeter log indicates a slight angular unconformity between the Lower Cretaceous and Upper Paleozoic strata.

In Eocene time downwarping resulted in widespread deposition of the Latrobe Valley Coal Measures over s tructurally complex rocks ranging in age from Ordovician to Lower Cretaceous.

In the Duck Bay area the Lower Cretaceous and Upper Paleozoic strata have been tilted to the south-east, and Tertiary strata, with a regional dip to the south of about 200 feet per mile, overlie Lower Cretaceous beds dipping to the southeast at about 16°.

Further downwarping in Oligocene time produced a widespread transgression of the sea over the Gippsland Basin. Marine conditions existed until about Middle Pliocene during which time interval the Lakes Entrance Formation, Gippsland Limestone, Tambo River Formation and Jemmy's Point Formation were deposited.

From Upper Pliocene to recent time non-marine conditions prevailed in the area now forming the landward portion of the basin. During this time a widespread cover of sand, clay and gravel, known as the Haunted Hills Gravels and/or the Lake Wellington Formation, was deposited over the marine sediments.

Duck Bay 15/54

STRATIGRAPHIC TABLE

The following table illustrates the stratigraphic sequence penetrated by the Duck Bay No. 1 well.

TABLE I

Age		Name	Depth. (Ref. KB)	Thickness In Well	Thickness Corr. for dip	Lithology
TERTIARY	Upper Pliocene	Haunted Hills Gravels and/or Lake Wellington	300'	289'	289'	Sand, Clay and Lignite
	L. Pliocene	Jemmy's Point Formation	400'	100'	100'	Sand, Shells and Clay
	U. Miocene	Tambo River Formation	420'	20'	20'	Silty Marl and Shells
	Miocene	Gippsland Limestone	1900¼	1480'	1480'	Limestone and Marl
	Oligocene	Lakes Entrance Formation	2285'	385'	385'	Clay, Marl, Shale and Sand
	L. Oligocene to U. Eocene	Latrobe Valley Coal Measures	2684'	399'	399'	Sand
						UNCONFORMITY
MESOZOIC	L. Cretaceous	Strzelecki Group	3175'	491'	471'	Shale, Mudstone Siltstone
						UNCONFORMITY
PALEOZOIC	L. Permian?	Un-named	3500½	325'	298'	Volcanics
	L. Permian	Un-named	4124'/	624'	562'	Shaly Sandstone
						UNCONFORMITY
	Ordovician	Ordovician Undifferentiated		114'/		Slate and siliceous Sandstone with quartz veins

Duck Bay 16/54

STRATIGRAPHY

40 - 300 feet

Haunted Hills Gravels and/or Lake Wellington Formation

Upper Pliocene - Pleistocene

Sand, light gray to hellow, fine to coarse grained; Gravel; Clay, yellow to gray; and Lignite - non-marine.

300 - 400 feet

Jemmy's Point Formation

Lower Pliocene

Sand, fine to medium grained, with occasional coarse grains, sub-rounded; "Shells", predominantly Bryozoan, but with abundant Gastropoda, Pelecypoda and Foraminifera; and Marl, medium gray, silty, very fossiliferous, glauconitic.

The sand and"shells"occupy the upper half of the unit and grade downward into the marl. The "shells", except for the smaller forms, appear to have been thoroughly fragmented by wave action.

This formation is thinner than in the Lake Wellington - Seaspray area, where it ranges from 160 to 240 feet in thickness.

400 - 420 feet

Tambo River Formation

Upper Miocene

Marl, medium gray, silty, very fossiliferous.

This unit is lithologically similar to the overlying marl of the Jemmy's Point Formation but the micro fauna are indicative of Upper Miocene.

This unit, like the Jemmy's Point Formation, thickens westward, being on the order of 100 - 165 feet thick in the Lake Wellington - Seaspray area.

420 - 1900 feet

Gippsland Limestone

Miocene

420-510 feet : Marl, medium gray - brown, glauconitic, silty poorly consolidated, very fossiliferous. 510-1015 feet, Limestone, white, yellow and light brown, finely crystalline to fine-grained, very fossiliferous and often coquinoidal in upper half, friable to slightly hard, very porous in upper half, argillaceous and tight in lower half.

slightly glauconitic. 1015 - 1350 feet, interbedded Limestone as above and Marl, gray to gray green, friable, slightly glauconitic; 1350 - 1900 Claystone, light to medium gray, soft and sticky, slightly fossiliferous and glauconitic, calcareous; and minor Marl, gray to gray green, friable.

The Gippsland Limestone consists of several members which are recognized by their faunal content. No attempt has been made to show these members on the composite log as the lithological boundaries are not distinct, and the cuttings through this interval are invariably highly contaminated, making faunal boundary diatinctions difficult.

1900 - 2285 feet

Lakes Entrance Formation

Oligocene

1900 - 2190 feet : Claystone, light to medium gray, soft and sticky in cuttings, slightly fossiliferous and glauconitic, calcareous; and minor Marl, medium gray to gray green, friable.

2190 - 2240 feet : Shale, brown green and gray green, firm, moderately to very glauconitic and pyritic, fossiliferous, floating coarse sand grains common.

2240 - 2285 feet : Sand, dark green gray to medium brown, fine to coarse grained, glauconitic and pyritic, good to fair porosity, slightly argillaceous and micaceous, occasional carbonaceous material, gradational downward into ligneous sand.

The basal sand in the Lakes Entrance Formation is similar to that in the Lakes Entrance area except that in the Duck Bay No. 1 glauconite is less abundant. The basal sand is either absent or very thin in the Lake Wellington - Seaspray area, but the total thickness for the formation is much greater than in the Duck Bay No. 1.

The contact with the overlying Gippsland Limestone is lithologically not recognizable; the top at 1900 feet was determined from Foraminifera.

2285 - 2684 feet

Latrobe Valley Coal Measures

Lower Oligocene to Upper Eocene

Sand, fine to very coarse-grained; and Gravel, unconsolidated, mostly sub-angular grains, clean to very ligneous, fair to very good porosity; Brown Coal, brittle to soft, partly silty and shaly; and Clay (or Claystone).

The coal measures are only slightly thinner than in the Holland's Landing bore where they are 763 feet thick. The coal measures continue thinning eastward from the Duck Bay area and are completely absent in the Lakes Entrance area.

The thin dolomitic beds present in the Lake Wellington - Seaspray area are absent in the Duck Bay No. 1. Brown Coal, which constitutes a large percentage of the coal measures in the western half of the basin, is represented by only one significant seam in the Duck Bay No. 1.

The presence of clay (or claystone) in the lowdr part of the coal measures is suspected from the SP and gamma ray curves, although no clay was seen in the cuttings.

No fossils, other than spores, were found in the coal measures and the entire sequence is considered non-marine in origin.

The top of the coal measures is gradational into the basal sands of the Lakes Entrance Formation. The base of the coal measures, however, is in sharp, unconformable contact with the underlying Strzelecki Group.

2684 - 3175 feet

Strzelecki Group

Lower Cretaceous

Shale - Mudstone, dark green gray to dark brown, compact, often silty, carbonaceous; and Siltstone, light gray to light brown, argillaceous, carbonaceous, micaceous.

From 3100 to 3175 feet the cuttings become very clayey and the lithology in this interval may more correctly be called claystone.

The base of the Strzelecki Group is in sharp contact with the underlying volcanics. The continuous dipmeter survey suggests that the contact is an angular unconformity as the volcanics are dipping at about 28^{o} while dips in the Strzelecki Group average only 16^{o}.

The Strzelecki Group thickens very rapidly to the west. In the Wellington Park No. 1 a thickness of 8226 feet of this group was penetrated without reaching the base. As yet the stratigraphic position of the thin section found in the Duck Bay No. 1, in relation to the total Strzelecki Group, is not known. That is, it is not known if the Duck Bay No. 1 section correlates with the basal, upper or middle part of the

Strzelecki Group where the sequence is fully developed.

The Shale - Mudstone lithology is similar to that in the Lake Wellington - Seaspray area, but the gray-green graywackes, characteristic of the Strzelecki Group in the western part of the basin, are not present in the Duck Bay No. 1.

The carbonaceous material and the lack of Foraminifera or other fossils indicates a non-marine origin for the Strzelecki Group in the Duck Bay No. 1. However, preliminary investigations of core number 3 (2813 - 2851 feet) have revealed the presence of certain microfossils suggestive of a marine or brackish water environment during deposition.

3175 - 3500 feet

Volcanics (Un-named)

Upper Paleozoic - Permian (?)

Predominantly Basalt, strongly chloritized, dark green to black, very fine grained to aphanitic, soft to slightly hard, crumbly, fractured and slickensided, fractures often filled with calcite and/or chlorite, small black phenocrysts and light gray acicular crystals common. Minor Tuff (?), light brown to pink, very fine grained, with occasional glass shards; Breccia, brown, fine grained fragments up to 4" in diameter; and Volcanic Ash (?), dark brown to black, laminated, associated with breccia in core number 5.

By far the major rock type in this section is dark green, highly altered basalt. The Tuff, breccia and volcanic ash were seen in core number 5, in which the recovery was only 1¾ feet, and as a minor constituent of the cuttings.

Traces of dark red-brown shale and sandy siltstone with inclusions of volcanic material were seen in the cuttings from 3330 to 3380 feet. The electrical and sonic logs indicate that the volcanic section consists ofalternating layers of resistive material and relatively soft conductive materials. The differences in hardness and resistivity may be related only to the degree of alteration in the basalts, but they may also be due to shaly, bentonitic or tuffaceous material.

The degree of alteration in the basalts is evident from the rapid drilling rates of 2 to 6 minutes per foot through the volcanic section. The crumbly nature of the volcanics is reflected in the severe degree of caving which, at one point, has created a hole diameter of 18 inches.

The continuous dipmeter recorded in the volcanic section an average dip direction of S19°W at an average magnitude of 28°. This is similar to the average dip magnitude of 26° for the underlying Upper Paleozoic (Lower Permian ?) section, but the average dip directions differ by 42°.

Despite this difference in dip direction it appears that the bedding attitudes of the volcanics are more closely related to the underlying section than to the overlying Mesozoic section. For this reason the volcanics are believed to be of Upper Paleozoic (Permian ?).

Further indication of Upper Paleozoic age for the volcanics is the identification by the Mines Dept. of Victoria of a single Paleozoic spore from core number 5 (personal communication with J. Douglas, Mines Department of Victoria.)

3500 - 4124 feet

Un-named

Upper Paleozoic (Lower Permian ?)

Predominantly Sandstone, white to light gray, very fine to fine grained with occasional medium size grains, white argillaceous (sericitic) matrix, friable to slightly hard, generally tight, carbonaceous flakes and laminations common, slightly micaceous; with minor Shale, dark brown and medium gray; and Siltstone, light gray, partly slightly dolomitic.

The cuttings in this interval are highly contaminated by cavings of volcanics and younger sediments.

The age of these sediments has been determined by the identification of spores in core number 6 at 3699 - 3709 feet. No marine fossils have been found in these sediments, and judging by the presence of carbonaceous materials, it is probable that the sequence is non-marine in origin.

The presence of phosphatic pellets in core number 6 (see appendix 4) probably indicates a depositional environment with stagnant reducing conditions.

An Upper Paleozoic section has not been seen elsewhere in the Gippsland Basin, and its exact correlation with sediments in other basins has not been established. The Bureau of Mineral Resources favors a Lower Permian Age for this section in the Duck Bay No. 1, and suggests that it is correlative with the Lower Permian sediments in the eastern part of the Murray Basin.

Duck Bay 21/54

4124 - 4238 feet

Ordovician Undifferentiated

Ordovician

Slate, dark gray, metallic luster, dense, hard, well developed cleavage, partly silty, slightly pyritic; Siltstone, siliceous, hard, slightly argillaceous; and Sandstone, medium to dark gray, fine grained, siliceous, very hard. The cores are cut by numerous milky white to light gray quartz veins ⅛" to ¼" thick, and thin veins of black chert filling fractures.

This section exhibits the typical lithology of the thick sequence of Ordovician rocks, present north of the basin. These rocks have been altered by dynamic metamorphism and highly folded, and are regarded as basement in the Gippsland Basin.

S T R U C T U R E

The Duck Bay No. 1 was primarily a stratigraphic test and was not located on any known structure. Seismic work in the area had indicated only regional dips, generally to the south for the Tertiary, Mesozoic and pre-Mesozoic sediments. The location was selected so that strata of assumed Paleozoic age would be encountered at a shallow depth of about 3500 feet.

Considering the unknown nature of the pre-Tertiary strata and the poor quality of the seismic records below the Tertiary, the seismic interpretation was remarkably accurate. The information obtained from the Duck Bay No. 1 should be very useful in establishing better control during any future seismic surveys.

No recognizable seismic reflections were obtained from the top or within the Ordovician basement. True dips from cores in the Ordovician are difficult to distinguish from the well-developed cleavage. The apparent dips in cores Nos. 8 and 9 vary from 30 to 45°, and the continuous dipmeter suggests the direction of dip is northeast. The continuous dipmeter in this section, however, is probably not too reliable because of the distorted bedding and abundant quartz veins dipping at varying directions. The Ordovician, where exposed north of the basin, is typically highly contorted and invariably dipping at steep angles.

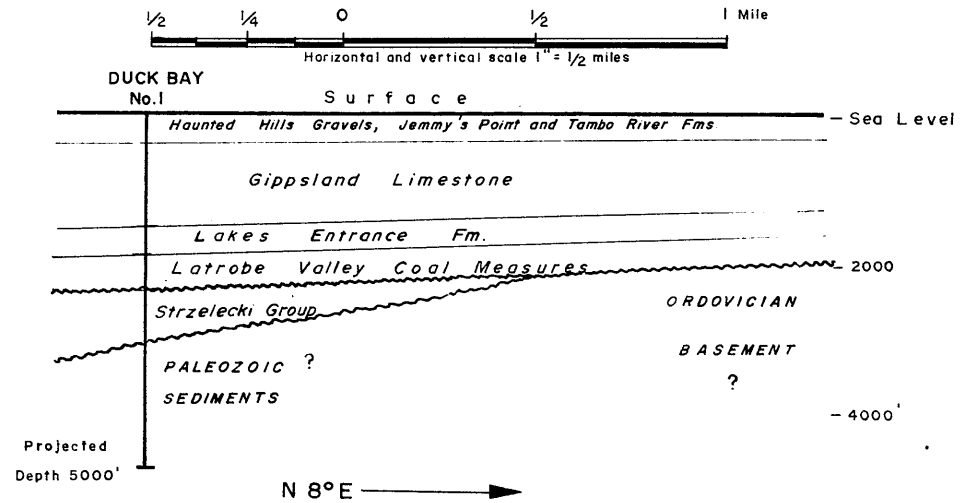
The continuous dipmeter indicates that the Upper Paleozoic section from 3559 to 3820 feet has an average dip of 25° at an

Duck Bay 22/54

ARCO LTD. / WOODSIDE (LAKES ENTRANCE) OIL CO. N. L.

GEOLOGIC CROSS-SECTION BEFORE AND AFTER DRILLING

DUCK BAY No. 1



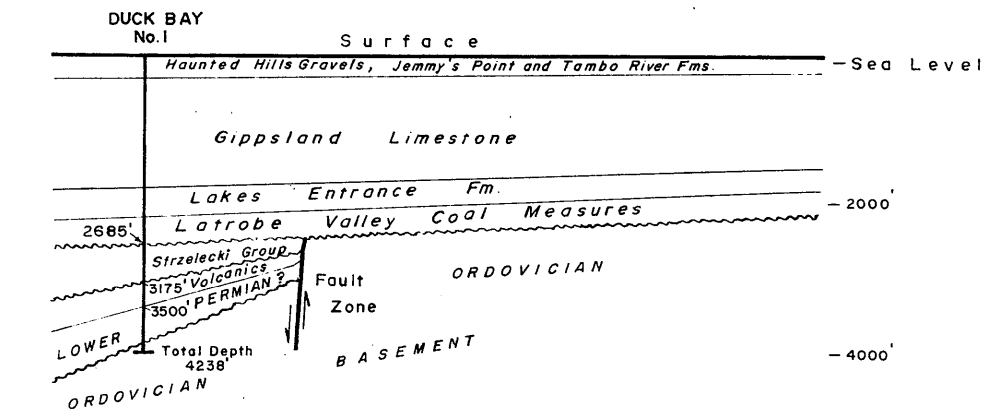


Fig. 2

average direction of S23°E. The basal part of the Upper Paleozoic section from 3863 feet to 4120 feet has divergent dips varying from northwest to south, but this is probably due to cross-bedding rather than tectonic movements.

The volcanic section from 3256 to 3466 feet has an average dip of 28° at an average direction of S19°W. It appears that the volcanic section is structurally closely associated with the sedimentary section below it, and therefore is probably Upper Paleozoic rather than Mesozoic in age. This reasoning, of course, is based on the assumption that the bedding inclination is due to tectonic movement, rather than being a depositional feature.

There appears to be a gentle, angular unconformity between the Lower Cretaceous sediments and the underlying volcanics and sediments. The average dip in the Lower Cretaceous is 16° at an average direction of S30°E. Thus, the angle of unconformity would be approximately 10°. If this interpretation is correct, and the above stratigraphic conditions exist over a substantial area, then theUpper Paleozoic section could be expected to increase in thickness at the rate of about 900 feet per mile in a southward direction.

The Tertiary section has a regional dip (established by well data) of about 200 feet per mile (or 2°) to the south. The angle of unconformity between the Tertiary and Mesozoic therefore is about 14°. This indicates that the Strzelecki Group, like the Upper Paleozoic section, thickens rapidly towards the coast.

Since the Upper Paleozoic, Lower Cretaceous and Tertiary beds have regional dips generally to the south, they have probably been subjected to similar tectonic movements. It is postulated that the Gippsland Basin came into existence in late Paleozoic time, and subsidence and uplift have been along east-west trends since that time.

RELEVANCE TO OCCURRENCE OF PETROLEUM

Several small gas shows were recorded in the Gippsland Limestone and in the top of the Latrobe Valley Coal Measures. The electrical and other logs indicate that these shows originated from porous zones with 100% water saturation. No formation tests were made in the intervals where the shows occurred because of the danger of sticking the test tools, and because of the indicated 100% water saturation.

The gas shows in the Gippsland Limestone probably originated in marine beds, but the gas in the coal measures is more likely of a carbonaceous origin.

The oil in the Lakes Entrance area occurs in the glauconitic sand at the base of the Lakes Entrance Formation. This section in the Duck Bay No. 1, although porous, appears to have 100% water saturation.

No gas shows were recorded in the Lower Cretaceous or Upper Paleozoic. The Strzelecki Group was completely lacking in reservoir beds, and the Upper Paleozoic section contained only very thin porous beds having at the best about 20% porosity. Both of these units are lacking in marine fossils, and appear to have been deposited in fresh or possibly brackish water.

Although the Duck Bay No. 1 was a dry hole the information gained from this well suggests that a definite petroleum potential exists in this area of the Gippsland Basin. The thickening of the Upper Paleozoic (probably Lower Permian) section southward possibly means the addition of marine sands and shales in that direction. The Permian in other areas of Australia (Tasmania, New South Wales, Queensland and South Australia) typically consists of interbedded units of marine and non-marine sediments. Also, the only commercial oil and gas found to date in Australia is believed to have originated in sediments of Permian age.

The mudstones of the Strzelecki Group should form an excellent cap rock for reservoir beds if present beneath the unconformity. Source beds and reservoir beds may well exist in the Upper Paleozoic section south of the Duck Bay No. 1, and a wide range of stratigraphic or combination structural-stratigraphic traps are possible in this area.

The sands of the Latrobe Valley Coal Measures in the well were completely flushed with fresh water (525 - 1050 ppm NaCl equivalent). Southwest, beyond the limits of the flushing action, these porous beds may contain hydrocarbon accumulations derived from Tertiary or older marine sediments.

POROSITY AND PERMEABILITY OF SEDIMENTS PENETRATED

Porous sands are present from about 120 feet down to 350 feet. A water bore at the well-site drilled to 136 feet had a capacity in excess of 1,000 barrels (42,000 gal.) per day.

The friable limestones in the upper part of the Gippsland Limestone in the interval 420 - 730 feet are very porous. Between 730 feet and 1500 feet there are several thin porous zones, the best of which occur from 1350 to 1500 feet.

From 1500 to 2240 feet the section is tight. The basal glauconitic sands of the Lakes Entrance Formation have fair to good porosity.

The true effective porosities of these sands are probably somewhat less than indicated by the microlog and sonic log due to argillaceous material in the matrix.

The sands of the Latrobe Valley Coal Measures have fair to excellent porosity. These sands have been flushed with fresh water, but the salinities of 700 to 1050 ppm in the Duck Bay No. 1 are greater than in the Lake Wellington - Seaspray area where they are only 300 to 400 ppm.

The mudstones of the Strzelecki Group are tight throughout.

The volcanic sequence from 3175 to 3500 feet has no intergranular porosity, but there may be some fracture porosity. The sonic log in this interval, however, does not show any cycle skipping indicative of open fractures.

The following table gives the porosity values for several horizons as determined by the microlog and sonic log. In addition the indicated NaCl equivalent concentrations are given.

CALCULATED POROSITIES, Rw AND EQUIVALENT SALINITIES FROM LOGS :

Depth	Porosity Microlog	Porosity Sonic Log	Rw	Equivalent Salinity
600'	40%	Not reliable	7.4 @ 88°	575 ppm
650'	37%	" "	7.2 @ 88°	600 "
1455'	34%	29%		No determination
1470'	40%	28%		possible (2)
1719'	33%	24%		"
1727'	35%	25%		"
2250'	38%	31%		No determination
2300'	39%	28 - 32%	3.3 @ 112°	1050 ppm
2400'	39%	28%	4.0 @ 112°	800 ppm
2600'	31%	28%	4.5 @ 118°	700 ppm
3505'	20%	11%	0.4 @ 128°	8200 ppm
3554'	23%	15 - 18%	0.62 @ 129°	5500 ppm
3628'	22%	13 - 14%	0.35 @ 130°	9800 ppm
3885'	No separation	19 - 21%(1)	0.4 @ 134°	7800 ppm
3948'	20%	22%	0.47 @ 135°	6800 ppm

(1) Possibly in error because of enlarged hole.

(2) Thin shaly beds

Porosity values calculated from the microlog are generally more accurate in the Tertiary section than in the Upper Paleozoic section. The sonic porosities, conversely, are more accurate in the consolidated sandstones of the Upper Paleozoic than in the Tertiary section.

The Rw and equivalent salinity determination of formation waters in many cases have been difficult to calculate because of the argillaceous nature of the reservoirs. This is especially true of the porous beds in the lower part of the Gippsland Limestone and all of the Lower Permian section. The true equivalent salinity of the formation water in the Lower Permian section is at least as high as 9,800 ppm where the greatest SP deflection was recorded at 3628 feet. The formation water resistivity (Rw) calculated by the formula $Rw = \frac{Ro}{F}$ at 3628 feet is in close agreement with the value calculated from the SP curve.

CONTRIBUTION TO GEOLOGICAL CONCEPTS RESULTING FROM DRILLING

The following information has been obtained from the drilling of Duck Bay No. 1 :

1. Overlying basement rocks of Ordovician age in the well is a section 624 feet thick of Upper Paleozoic sediments. These sediments were heretofore unknown in the Gippsland Basin, and their presence will influence future exploration in this area.
2. Overlying the Upper Paleozoic sediments in the well is a section of volcanic rocks 325 feet thick. The age of these volcanics is not well known, but are probably of Upper Paleozoic age also. These volcanics were encountered for the first time in the Duck Bay No. 1.
3. Unconformably overlying the volcanics is a thin section of the Strzelecki Group. This is the first time that any well in the Gippsland Basin has penetrated the base of the Strzelecki Group.
4. The glauconitic sand horizon that produces non-commercial oil from the Lakes Entrance area was present in the well, but contained only fresh water.
5. No significant shows of hydrocarbons were present, and the pre-Tertiary sediments were generally tight.
6. Pre-Tertiary strata dip generally to the south at angles from 16^{0} to 28^{0}, and a substantial increase in thickness of this strata is believed to take place to the south.
7. Ordovician basement rocks were found at 4124 feet.
8. The seismic reflection survey in the Duck Bay area was accurate.

even though the records from the pre-Tertiary section were of poor quality. The geological information gained from the Duck Bay No. 1 will be invaluable to any future seismic surveys in the area.

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DUDLEY, Paul H. 1959 Oil possibilities of the petroleum prospecting licence 212, in the South Gippsland Highlands, unpublished report for Victorian Oil N. L.

INGRAM, Frank T. 1962 Wellington Park No. 1 Well, final well report, unpublished report for Arco Limited and Woodside (Lakes Entrance) Oil Co. N. L.

APPENDIX 1

List & Interpretation of Electrical & other Logs

Duck Bay 28/54

APPENDIX 1

LIST AND INTERPRETATION OF ELECTRICAL AND OTHER LOGS

by Frank T. Ingram

The following logs were run in the Duck Bay No. 1 :

Log	Interval	Run	Scale
Electrical log	410' - 4237'	1	2" = 100' and 5" = 100'
Microlog-Caliper	410' - 4231'	1	2" = 100' and 5" = 100'
Sonic - Gamma Ray	410' - 4221'	1	2" = 100' and 5" = 100'
Continuous Dipmeter	1000' - 4220'	1	1" = 100' and 1' = 20'

The electrical log was useful for determining the formation boundaries, formation water resistivities, permeable beds and depth of invasion in the Duck Bay No. 1. It can be seen from the resistivity curves that the marine Tertiary section becomes progressively more shaly downward to 2185 feet. It can also be seen that there is no lithological break at the top of the Lakes Entrance Formation at 1900 feet.

The SP curve is normal, except through the Latrobe Valley Coal Measures where it is reversed because of the presence of formation waters more resistive than the mud filtrate. The formation waters in the coal measures appear to become less saline, and therefore more resistive, with depth. This increase in resistivity downward may, however, be due to a decrease in argillaceous material downward as suggested by the gamma ray curve.

The microlog offers a good visual means of locating porous beds in the well. The quantitative values of the porosity measured by the microlog are probably fairly accurate in the Tertiary section. However, in the Lower Permian section the porosities measured by the microlog appear too high. Note that in the Lower Permian section there is a filter cake build-up opposite the porous beds, even though the hole diameter is greatly enlarged.

The sonic log is a better tool than the microlog for determining porosity in the Lower Permian section. The porosities determined by the sonic log in the Tertiary section shown in Table 2 have been corrected for compaction and may be slightly in error.

Duck Bay 29/54

The gamma-ray curve in the coal measures exhibits low radioactivity for the sand and coal beds, as contrasted by the high radioactivity in the claystone beds. The mudstones in the Strzelecki Group are easily recognizable by their high level of radioactivity.

The radioactivity through the volcanic section is remarkably low, as basic igneous rocks of this type usually have a very high level of radioactivity.

In the Lower Permian section it can be seen on the gamma ray curve that the sandstones are shaly and there is little contrast, for the most part, in the level of radioactivity.

A Core Laboratories Inc. portable hot wire gas detector was used for continuous logging of the total gas in the drilling fluid. The drilling rate curve was computed from the geolograph located on the rig floor.

A lithologic sample log was prepared concurrently with the drilling operation.

Duck Bay 30/54

VELOCITY SURVEY
of the
ARCO LIMITED - WOODSIDE (LAKES ENTRANCE) OIL CO. N.L.

DUCK BAY NO. 1
VICTORIA

Prepared by
VICTOR BYCHOK - ARCO LIMITED

A Schlumberger Sonic survey was conducted in the Arco - Woodside Duck Bay No. 1 to measure interval times for computing sub-surface velocities. The survey was conducted on 26th February, 1964, for the measured interval from 4229 feet to 410 feet. Total elapsed logging time was 4 hours.

As surface casing had been set to a depth of 410 feet prior to the sonic survey, it was necessary to compute the sub-surface velocity for the interval from the ground level to 410 feet (-331 ft.) on the basis of seismic refraction velocities measured in the nearby area. The average velocity for this near surface interval computed from the seismic refraction data was 5500 feet per second.

LOCATION OF WELL

Latitude 37°56'45" South
Longitude 147°39'36" East
Petroleum Exploration Permit No. 44 - Victoria
K.B. Elevation 79 feet Ground Elevation 68 feet
Total Depth Surveyed : 4229 feet
Casing Record 13⅜" set at 410 feet (-331 feet)

Duck Bay 31/54

VELOCITY DATA

DATUM PLANE = SEA LEVEL

Dgd	Tgd	Δ Dgd	Δ Tgd	Vav	Vi
0	-				
		331	0.060		5500
331	0.060			5500	
		500	0.068		7353
831	0.128			6492	
		500	0.065		7692
1331	0.193			6896	
		490	0.061		8033
1821	0.254			7169	
		380	0.055		6909
2201	0.309			7123	
		404	0.053		7623
2605	0.362			7196	
		488	0.051		9569
3093	0.413			7489	
		328	0.027		12148
3421	0.440			7775	
		628	0.047		13366
4049	0.487			8318	
		101	0.007		14428
4150	0.494			8401	

Explanation of abbreviations

Dgd	Measured depth of sonde from datum plane = feet
Tgd	Measured vertical time from datum plane = seconds
Δ Dgd	Difference in depth between interval depth = feet
Δ Tgd	Difference in time between interval times = seconds
Vav	Average velocity - feet per second
Vi	Interval velocity - feet per second

Paleontological Reports

APPENDIX 2

Duck Bay 32/54

APPENDIX 2

PALEONTOLOGICAL REPORTS

REPORT ON TERTIARY STRATIGRAPHY IN DUCK BAY NO. 1 WELL

by

J. B. Hocking

Cuttings, side wall cores, and Cores Nos. 1 and 2 from Arco - Woodside's Duck Bay No. 1 well have been examined. Unfortunately the high degree of contamination in most cuttings samples prevented accurate determinations of formation boundary depths.

Sidewall core samples were taken at 2254 ft, 2273 ft, 2290 ft, 2300 ft, 2312 ft, 2347 ft, 2370 ft, 2450 ft, 2600 ft, and 2670 ft, and showed virtually no contamination by drilling mud. Core Nos. 1 and 2 - taken at 2320-2340 ft. and 2340-2360 ft. respectively - have very limited recovery and could not be used for biostratigraphic determinations.

The stratigraphy, based on both foraminiferal content and the microscopic examination of sediments, is outlined below in drilled order.

40 - 310 feet : Haunted Hills Group

Clayey sands and gravels. Faunas are lacking.

310 - 410 feet : Jemmy's Point Formation

Greenish brown calcareous sands - between 310 and 350 feet - overlie mid-grey sandy marls - from 350 to 410 feet. These sediments contain glauconite which has been partially oxidised to limonite.

Both the sands and marls are quite shelly, the gastropod Turritella sp. being common. Foraminifera include Cancris phillipinensis, Nonion victoriense, and common miliolids (typical shallow water forms), representing a Kalimnan assemblage.

410 - ~~420~~ 510 feet : Tambo River Formation

A grey, partially glauconitic, sandy marl between 410 and 420 fee feet differs from those directly above it only in that it contains fragments of bryozoa and occasional pieces of the worm tube Ditrupa sp. Also the microfauna contains Orbulina universa, but is otherwise the same as that given above. It appears from the

transitional nature of the faunal assemblage that the age is Mitchellian. Buck Bay 33/54

510 BH
~~420~~ - 1900 feet : Gippsland Limestone

These sediments are represented by the typical limestone/marl sequence, the proportion of clay - and hence marl - increasing downwards.

Organic material is more abundant in the upper parts of the section. Bryozoan fragments are particularly common between 420 and 1070 feet and less so between 1070 and 1390 feet. In the dark grey clayey marls between 1390 and 1900 feet, only a few chalky bryozoan remains are found.

All stages - namely the Bairnsdalian, Balcombian, Batesfordian and Longfordian - are recognized. The diagnostic Batesfordian form Lepidocyclina sp. occurs below 1280 feet: its lower limit is indeterminate due to down-hole contamination by the species, but it is probably the Batesfordian - Longfordian boundary which is at approximately 1390 feet. Globigerina woodi is the most diagnostic planktonic species found in the Longfordian clayey marls.

1900 - 2280 feet : Lakes Entrance Formation

The formation is divided into three main lithologies; from 1900 to 2190 feet, a light brownish grey (green when wet) puggy marl; from 2190 to 2240 feet, as above, but becoming sandy (including grains of glauconite and pyrite); and from ~~2190~~ 2240 BH to 2280 feet, fine micaceous sand containing traces of glauconite and pyrite.

The marls contain a typical Janjukian foraminiferal assemblage (of Carter's Faunal Unit 5) which includes the diagnostic planktonic species Globigerina ampliapertura euapertura.

The basal sands are barren, and a Faunal Unit 4 assemblage, which might be expected here (Hocking and Taylor, 1964) has not been isolated.

2700 BH
2280 - approx. ~~3800~~ feet : Latrobe Valley Coal Measures

Fine micaceous sands between 2280 and 2520 feet contain fragments of brown coal, and are often quite gravelly (especially in Cores 1 and 2). No foraminifera were found in these sediments.

The uppermost bed of brown coal is encountered at approximately 2520 feet. It appears to be a major seam approximately 60 feet thick, although it may well be broken by small sand intercalations. A comparable thickness of coal is found in the adjacent Sperm Whale Head (Boole Poole No. 1) bore.

Duck Bay 34/54

Below the brown coal a further sequence of sands is developed which also fails to yield any foraminifera.

Summary Table

Rock Unit	Depth (ft)	Faunal Unit and Local Tertiary Stage (after Carter, 1964)
	- 40 -	
Haunted Hill Group		
	310	
Jemmy's Point Formation		Kalimnan
	410	
Tambo River Formation		Mitchellian
	420	
		F. U. 9-11 — Bairnsdalian - Batesfordian
Gippsland Limestone	1280 – 1390	'Lepidocyclina' horizon
		F. U. 6-9 — Longfordian
	1900	
Lakes Entrance Formation	2190	F.U. 5 — Janjukian
		?F.U. 4
	2280	
Latrobe Valley C.M.		Anglesean
	Approx. 2800	

References :

CARTER, A.N., 1964 — Tertiary Foraminifera from Gippsland, Victoria and their Stratigraphic Significance. Geol.Surv.Vic. Memoir 23, in press.

Duck Bay 35/54

HOCKING, J. B. and TAYLOR, D.J., 1964 — The Initial Marine Transgression in the Gippsland Basin, Victoria. A.P.E.A. Journal, 1964, in press.

J.B.HOCKING,
Geologist.

Duck Bay 36/54

PALEONTOLOGICAL REPORTS

PALYNOLOGICAL EXAMINATION of DUCK BAY NO. 1 BORE CORES

by

John Douglas

Core samples from Arco - Woodside Duck Bay No. 1 bore were treated by the hydrofluoric acid-Schulzes solution method, and the residues examined under the microscope.

Results of examination :

Core No.	Depth (feet)	Microfossils	Age	Type of sedimentation indicated
3	2839 - 41	Microflora including Ceratosporites equalis, dissaccate gymnosperm pollens etc.	Lower Cretaceous	Non marine
4	3190 - 94	None isolated.	?	?
5	3393 - 3403	?	?	?
6	3699 - 3704	Microflora including Nuskoisporites gondwanensis cf. cirratriradites splendens	Upper Palaeozoic	Non marine
7	3880 - 3896	None isolated		

A lower Cretaceous microflora from Core 3 (2839-41 feet) contains forms described by Dettmann (1963), but in insufficient numbers to correlate reliably with Mesozoic microfloras obtained from other Gippsland cores.

No microfossils were isolated from Core 4 (3190-94 feet) which appears to be igneous rather than sedimentary in nature. A further sample from Core 5 (3393-3403 feet) is being prepared because although much fragmentary plant material is present no diagnostic microfossils have been noted. As this core is near the Palaeozoic Mesozoic boundary (see discussion on Core 6 below), precise knowledge of its geological age and nature is important.

Duck Bay 37/54

Core 6 (3699-3704) contains relatively poorly preserved microfossils including Nuskoisporites gondwanensis, and cf. Cirratriradites splendens and other fragments, all of which indicate Upper Palaeozoic sedimentation. Both forms have been described from the Permian Greta Coal Measures of N.S.W., and Nuskoisporites has also been described from the Permian of Western Australia, and Queensland.

No indication of marine sedimentation has been found. This is the first record of Permian sediments beneath the Mesozoic sediments of eastern Victoria.

John Douglas.
GEOLOGIST.

Duck Bay 38/54

PRELIMINARY PALEONTOLOGICAL REPORT

by

E. A. HODGSON,
Bureau of Mineral Resources

Core 6 (3708 feet) from Duck Bay No. 1 was submitted by Arco Limited for study and determination of its age.

Dr. G.R.J. Terpstra examined part of the core for Foraminifera but found none.

Another piece was treated for extraction of spores and pollens. It contained relatively abundant Nuskoisporites triangularis together with Ginkgocycadophytus sp., rare striate pollen and the spores Leiotriletes directus and Verrucosisporites c.f. pseudoreticulatus. The assemblage is of Permian age; probably lower Permian in view of the abundance of Nuskoisporites triangularis. In contrast to many of the lower Permian rocks of the Murray Basin, no algae or Acritarchs were observed in this sample. The absence of marine organisms suggests that Core 6 is of non-marine origin.

(E. A. HODGSON)
Geologist

11th March, 1964.

Duck Bay 39/54

ADDITIONAL PRELIMINARY PALEONTOLOGICAL NOTES

by
P. R. Evans,
Bureau of Mineral Resources

A note concerning the Permian age of c. 6 (3708 feet) from Arco - Woodside Duck Bay No. 1 Well, Gippsland Basin, was compiled by B.A. Hodgson on 11th March, and a copy was forwarded to the company. Hodgson has since examined other core material from the well in order to determine the limits of the Permian sequence. His results are incorporated im B.M.R. Records 1964/50, which is at present being typed.

In summary Hodgson has obtained the following results :

CORE 3 (2831-32 feet) : Uppermost Jurassic or lowermost Cretaceous. Palynological criteria defining the Jurassic/Cretaceous boundary are not yet recognized. This sample is probably to be correlated with the top of the Blythesdale Group of the Great Artesian Basin. It is unusual in that it contains microfossils suggestive of a brackish or perhaps marine facies. It is possibly older than the reported marine Cretaceous of Bengworden South No. 1 (Hollands Landing).

CORE 4 (3197-99 feet) and CORE 5 (3393-94 feet)
Altered olivine basalt (W.B.Dallwitz, pers. comm.).

CORE 6 (3708 feet) and CORE 7 (3390-92 feet)? ← (3880 - 3896 Core 7) : Lower Permian. Only fragmentary specimens were obtained from core 7. The assemblages of these cores are relatable to Lower Permian deposits in the Murray Basin. However they differ from the Murray Basin sections in the absence of any algae and acritarchs which might indicate a marine or brackish facies.

CORE 8 (4153-55 feet), CORE 9 (4215-17 feet) : Barren. A not surprising result in view of the metamorphosed state of the rocks.

(P. R. Evans)
Geologist

Duck Bay No 1

PALYNOLOGICAL REPORT ON CORE SAMPLES FROM WELLS SUNK IN THE GIPPSLAND BASIN

by M.E. Dettmann 14/11/1966
for Esso Exploration.

Core samples taken from seven wells sunk by Woodside and partners in the Gippsland Basin yielded microfloras (see Tables 1 and 2) that provide a basis for correlation of the well sequences, both with each other and with sequences from elsewhere in the Gippsland Basin. The wells and the intervals investigated comprise: Carrs Creek No.1 between 4522 and 5507 feet; North Seaspray No.1 between 3484 and 3771 feet; Duck Bay No.1 between 2831 and 3896 feet; Seaspray No.1 between 4872 and 5556 feet; Lake Reeve No.1 between 6080 and 6635 feet; Bellbird No.1 between 995 and 2245 feet; and Woodside South No.1 between 3279 and 5816 feet. The majority of the samples yielded identifiable spores and pollen grains, but the concentration and preservation of the plant microfossils ranged from good in some samples to poor in others. As outlined below the microfloras obtained from the sediments investigated conform with Lower Permian, Lower Cretaceous, and Lower Tertiary microfloral assemblages that have been described from Australian deposits by Balme (1964), Dettmann (1963), and Harris (1965).

Carrs Creek No.1 well

The samples from 5500-07 feet and 5360-80 feet yielded poor concentrations of poorly preserved spores and pollen. Species present in the lower samples include Cicatricosisporites australiensis (Cookson) and Aequitriradites spinulosus (Cookson & Dettmann) which indicate a Cretaceous age.

The uppermost sample examined (4522-32 feet) yielded a more diverse microflora in which Dictyotosporites speciosus Cookson & Dettmann is a component. This species indicates the presence of the Speciosus Assemblage that is Valanginian-Aptian in age (Dettmann 1963). The Speciosus Assemblage

has been subdivided on the basis of Cyclosporites hughesi (Cookson & Dettmann) and Crybelosporites striatus (Cookson & Dettmann), neither species of which was observed in the Carrs Creek section. However, the presence of D. speciosus does enable correlation of sediments in Carrs Creek No.1 well at 4522-32 feet with at least part of the following sequences:- Wellington Park No.1 well between 3818 and 9019 feet, Rosedale No.1 well between 2469 and 4476 feet, and Tarwin Meadows No.1 well between 600 and 3945 feet (Dettmann 1965a, 1965b, 1966a).

North Seaspray No.1 well

Only two samples were submitted for examination. The upper one (from 3484-504 feet) provided a meagre microflora composed of species that range from Jurassic to Tertiary times. The lower sample (from 3765-71 feet) contains a rich assemblage of spores and pollen grains. Species present include Triorites edwardsii Cookson & Pike, Tricolpites gillii Cookson, and Dacrydiumites ellipticus Harris. The combined occurrence of these three species provides evidence for the existence of Harris's (1965) Triorites edwardsii Assemblage which is considered to be of Middle Paleocene age but may extend into the Upper Cretaceous. Similare microfloras have been reported from sediments at 4705-22 feet in Merriman No.1 well, from 5415-25 feet in Golden Beach No.1 well and equivalents (see Dettmann 1966b).

Duck Bay No.1 well

Permian spores and pollen grains were extracted from samples of core nos. 6 and 7 (3699-709 feet, 3880-96 feet). Species observed include Punctatisporites gretensis Balme & Hennelly, Calamospora diversiformis Balme & Hennelly, Leiotriletes directus Balme & Hennelly, Nuskoisporites spp., and Vestigisporites rudis Balme & Hennelly. Punctatisporites gretensis is considered by Balme (1964) and Evans (1963) to signify an early Permian age and thus the beds between 3699 and 3896 feet in Duck Bay No.1 well can

be considered to be of a similar age.

A lower Cretaceous (Valanginian-Aptian) microflora was obtained from core no.3 (2831-51 feet). This microflora contains Dictyotosporites speciosus and thus conforms with the Speciosus Assemblage. Furthermore, Cooksonites variabilis Pocock indicates the presence of the older category of this assemblage and suggests correlation of the beds with those at 2567-72 feet in Tarwin Meadows No.1 well, at 6945 feet in Wellington Park No.1 well, and at 3977 feet in Bengworden South No.1 well (Dettmann 1965a, 1965b).

Seaspray No.1 well

Poorly preserved microfloras were obtained from the two core samples examined (4872-85 feet and 5536-56 feet). The lower sample yielded Coptospora paradoxa (Cookson & Dettmann), the index of Dettmann's (1963) Paradoxa Assemblage of Aptian-Albian age. The upper sample did not provide C. paradoxa but the combined presence of Reticulatisporites pudens Balme and Crybelosporites striatus and the absence of angiospermous grains suggests conformity of the microflora with the Paradoxa Assemblage. On this basis the sediments between 4872 and 5556 feet in Seaspray No.1 well may be correlated with beds in Woodside No.1 well at 5950-55 feet, Woodside No.2 well between 4114 and 4256 feet, and Woodside No.3 well at 5586 feet (see Dettmann 1959; 1963, p.121).

Lake Reeve No.1 well

The Aptian-Albian Paradoxa Assemblage was identified in the sample from 6080-96 feet and accordingly these horizons are correlated with those between 4872 and 5556 feet in Seaspray No.1 well.

Poorly preserved plant microfossils were obtained from core no.3 at 6620-35 feet. The only stratigraphically significant species identified is Aequitriradites spinulosus that provides evidence for a Lower Cretaceous age.

Seaspray No.1		Duck Bay No.1			North Seaspray No.1		Carrs Creek No.1			
c.3 5536-56'	c.2 4872-85'	c.7 3880-96'	c.6 3699-709'	c.3 2831-51'	c.6 3765-71'	c.5 3484-504'	c.8 5500-07'	c.6 5360-80'	c.4 4522-32'	
		+	+							Punctatisporites gretensis
		+	+							Calamospora diversiformis
		+	+							Leiotriletes directus
		+								Acanthotriletes ramosus
		+								Cirratriradites splendens
			+							Laevigatosporites vulgaris
		+	+							Nuskoisporites gondwanensis
		+	+							Nuskoisporites rotatus
		+	+							Vestigisporites rudis
							+			Aequitriradites spinulosus
				+					+	Dictyotosporites speciosus
+	+						+		+	Cicatricosisporites australiensis
				+						Cooksonites variabilis
+	+			+			+			Leptolepidites verrucatus
+	+									Klukisporites scaberis
	+			+					+	Reticulatisporites pudens
	+			+						Foraminisporis wonthaggiensis
									+	Foraminisporis asymmetricus
									+	Rouseisporites reticulatus
	+									Crybelosporites striatus
+										Coptospora paradoxa
					+				+	Laevigatosporites ovatus
					+					Trilites tuberculiformis
					+					Cyathidites splendens
					+					Verrucatosporites speciosus
					+					Dacrydiumites ellipticus
					+					Phyllocladidites mawsonii
					+					Nothofagidites emarcida
					+					Proteacidites subscabratus
					+					Proteacidites adenanthoides
					+					Tricolporites microreticulatus
					+					Tricolpites gillii
					+					Triorites edwardsii

Table 1. Distribution of selected spores and pollen grains in Carrs Creek No.1, North Seaspray No.1, Duck Bay No.1, and Seaspray No.1 wells.

+ = species present.

Woodside South No.1								Bellbird No.1			Lake Reeve No.1		
c.24 5800-16'	c.23 5452-69'	c.21 4990-5010'	c.18 4332-52'	c.14 3489-509'	c.13 3279-99'			c.4 2235-45'	c.3 1719-24'	c.1 995-1000'	c.3 6620-35'	c.2 6080-96'	
+	+	+	+	+	+					+	+		Aequitriradites spinulosus
+	+	+	+	+	+				+	+			Dictyotosporites speciosus
					+							+	Cicatricosisporites australiensis
		+	+	+	+								Januasporites spinulosus
									+				Klukisporites scaberis
		+	+							+	+		Leptolepidites verrucatus
		+											Foraminisporis wonthaggiensis
+													Foraminisporis dailyi
		+			+								Foraminisporis asymmetricus
									+				Reticulatisporites pudens
					+								Rouseisporites reticulatus
					+								Rouseisporites radiatus
					+								Rouseisporites simplex
					+					+		+	Cyathidites punctatus
				+	+					+			Crybelosporites striatus
					+								Pilosisporites parvispinosus
					+							+	Coptospora paradoxa
					+							+	Trilobosporites trioreticulosus
										+			Trilites cf. T. tuberculiformis
												+	Cicatricosisporites hughesi
												+	Cicatricosisporites pseudotripartitus
												+	Laevigatosporites ovatus

Table 2. Distribution of selected spores in Lake Reeve No.1, Bellbird No.1, and Woodside South No.1 wells.

+ = species present

A PALYNOLOGICAL REPORT ON

ARCO-WOODSIDE DUCK BAY NO.1 WELL

by

P.R. Evans and E.A. Hodgson

Records 1964/50

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SUMMARY

Seven core samples from Duck Bay No.1 Well have been examined for spores and pollens. They indicate that, below a Tertiary sequence, the well penetrated lowermost Cretaceous or uppermost Jurassic sediments overlying altered olivine basalt, which in turn overlies a Lower Permian, non-marine sequence.

INTRODUCTION

Arco-Woodside Duck Bay No.1 Well was drilled during February 1964 at Latitude 37°56' 45" South, Longitude 147°39'36" East in the Gippsland Basin to a total depth of 4125 feet.

It was drilled to determine the Mesozoic sequence, especially basal Mesozoic, and to investigate the pre-Mesozoic section. Soon after the well was completed, Core 6(3708 feet) was submitted by the company for palynological examination and was found to contain spores of Lower Permian age. This record outlines results obtained from an examination of further cores from the well to determine the limits of the Permian sequence (Plate 1).

OBSERVATIONS

Core 3 (2831 - 32 feet)

This sample, a fine-grained siltstone, contained many moderately well preserved microfossils.

Spores and Pollens

Sphagnumsporites sp.
Cyathidites spp.
Baculatisporites comaumensis (Cookson)
Neoraistrickia truncatus (Cookson)
Leptolepidites verrucatus Couper
Ischyosporites sp.
Lycopodiumsporites circolumenus Cookson and Dettmann
Lycopodiumsporites rosewoodensis de Jersey
Dictyotosporites sp. Cookson and Dettmann
Contignisporites cooksonii (Balme)

Murospora cf. florida (Balme)
Disaccites spp.
Podocarpidites sp.
Microcachyridites antarcticus Cookson
Tsugaepollenites segmentatus (Balme)
Classopollis torosus (Reissinger)
Ginkgocycadophytus sp.

Microplankton

Micrhystridium sp.
Gen.et sp. indet., cf. "form A" Cookson and Eisenack 1960.

The presence of Neoraistrickia truncatus, Lycopodiumsporites circolumenus and Dictyotosporites sp. indicates that this core is of uppermost Jurassic or lowermost Cretaceous age. The few specimens of Micrhystridium sp. observed in the sample suggest that it is of marine or brackish origin.

The sample was characterised by a great abundance of small (about 30µ diameter) ring like bodies of uncertain origins which compare closely with "Form A" Cookson and Eisenack (1960). The Duck Bay specimens differ only in size from Cookson and Eisenack's forms which averaged 43-52 µ in diameter. Cookson and Eisenack found "Form A" in the Wrotham Park Sandstone of the Carpentaria Basin in Queensland, high in the Blythesdale Group at Oodnadatta, South Australia, and in the Birdrong Formation of the Carnarvon Basin, Western Australia. Each of these horizons is a precursor of widespread Aptian marine deposits and they are generally regarded as Lower Cretaceous in age. "Form A" has not yet been recorded from undoubtedly marine sediments and may, perhaps, be a brackish water indicator.

Core 4 (3197-99 feet) and Core 5 (3393-94 feet)

Samples of these cores were examined by Mr. W.D. Ballwitz who considered them to be an "altered olivine basalt" (pers.comm.). The presence of associated red-brown shales, indicated on the graphic log, suggests that the basalt was subaerially extruded.

Core 6 (3708 feet)

Leiotriletes directus Balme and Hennelly
Verrucosisporites cf. V. pseudoreticulatus Balme and Hennelly
Nuskoisporites triangularis Mehta (relatively abundant)
Ginkgocycadophytus sp.
Striatiti spp.

The assemblage is of Permian age; probably Lower Permian in view of the abundance of Nuskoisporites triangularis.

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Core 7 (3390-92 feet)

A few fragmentary specimens of Nuskoisporites triangularis, Leiotriletes directus and Granulatisporites micronodosus Balme and Hennelly were present in this sample and indicate that at this depth the well was still in Permian rocks.

An abundance of Nuskoisporites typifies the Lower Permian of the Murray Basin (Evans, 1962; Evans in Wright and Stuntz, 1963). In contrast to these Lower Permian rocks, no algae or acritarchs were observed in the Duck Bay Cores 6 and 7. The absence of these organisms suggests that the samples are probably of non-marine origin.

Core 8 (4153-55 feet).

Barren

Core 9 (4215-17 feet)

Barren

COMMENTS

In view of these observations, the well section can probably be subdivided as in Plate 1.

The Lower Permian at Duck Bay is the first indication of the existence of beds of such age in the Gippsland Basin.

The age of the volcanics is indeterminate other than within the limits Lower Permian - Upper Jurassic.

The Mesozoic section is apparently the same age as the core samples from 7785 and 8862 feet in Woodside No.2 Well which were palynologically examined by Dettmann (1959) who considered them to be "pre-Albian (probably Neocomian-Aptian or possibly uppermost Jurassic (Cookson and Dettmann 1958))".

This is the first record of lowest Cretaceous-uppermost Jurassic sediments in Victoria to perhaps have marine or brackish connections. Webb (1961) considered that marine Cretaceous beds were penetrated by the Bengworden South No.1 (Holland's Landing) Well at a depth of 3949-4004 feet (T.D.) on the basis of foraminiferal evidence supplied by D.J. Taylor of the Victorian Mines Department. A sample from a depth of 3977 feet in this well, part of the material originally studied by Crespin (1941), was examined in the present investigation. No microplankton were observed in it and the spores which it contained indicate that it is probably younger than Core 3 of Duck Bay No.1 Well.

Duck Bay 5/6

REFERENCES

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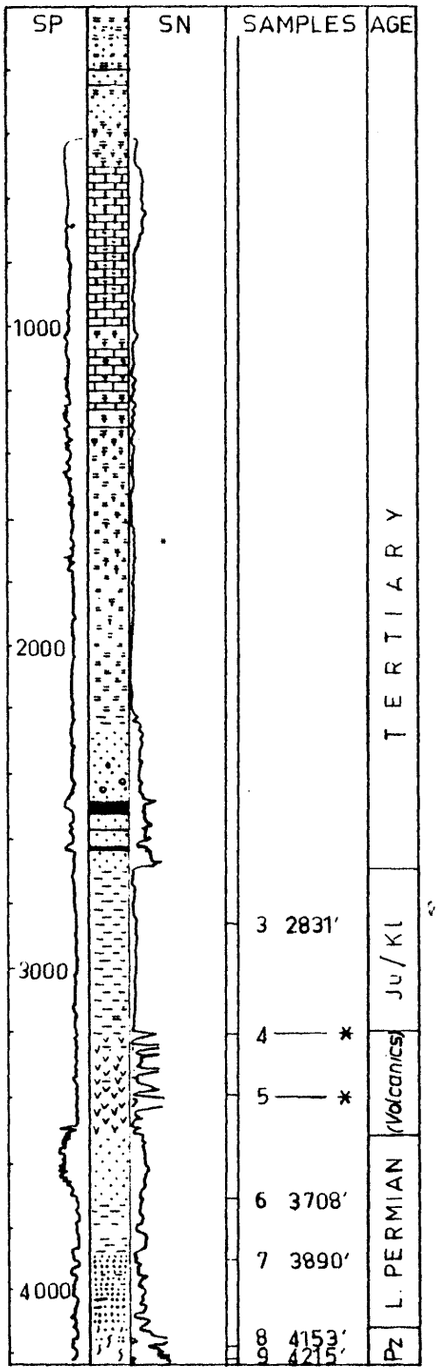
Duck Bay. 6/6

Plate 1

ARCO-WOODSIDE DUCK BAY No.1 WELL

37° 56' 45" S
147° 39' 36" E
KB 79'
GL 68'



Reference

- Sandstone
- Siltstone
- Shale
- Claystone
- Marl
- Limestone
- Coal
- Conglomerate
- Slate
- Volcanics

* *Petrologically examined by W.B. Dallwitz*

To Accompany Record 1964/50
Bureau of Mineral Resources Geology & Geophysics. April 1964.

M/S/28 π

Core Descriptions

APPENDIX 3

Duck Bay 40/54

APPENDIX 3

CORE DESCRIPTIONS

CONVENTIONAL CORES

CORE NO. 1. 2320' - 2340' (20'), recovered 3 pebbles, quartz, sub-rounded, ½" to 1½" in diameter.

CORE NO. 2. 2340' - 2360' (20'), recovered 1' of compressed cavings.

CORE NO. 3. 2831' - 2851' (20'), recovered 20'.

2831' - 2851', Shale - Mudstone, dark green-gray to dark brown, compact, conchoidal fracture, carbonaceous and micaceous, homogeneous, apparent dip 0 - 5°.

CORE NO. 4. 3182' - 3202' (20'), recovered 20'.

3182' - 3202', Basalt, dark green, very fine grained, highly altered and chloritized, blocky and crumbly, abundant steeply inclined calcite filled fractures in upper 10', no reliable dip determination.

CORE NO. 5. 3393' - 3403' (10'), recovered 1⅝'.

3393' - 3394⅝', Interbedded Basalt, medium green to buff, very fine grained to aphanitic, often with a find network of accicular crystals, highly altered and chloritic, crumbly and slickensided, Breccia, angular fragments up to 4" in diameter; and minor laminated volcanic ash (?), dark brown to black. No reliable dip determination.

CORE NO. 6. 3699' - 3709' (10'), recovered 9½'.

3699' - 3708½', Sandstone, light gray with white argillaceous (tuffaceous?) matrix, very fine to firm grained, slightly hard, carbonaceous fragments and laminations, slightly micaceous, moderate cross-bedding, tight, reliable dips of 15 - 20°, no shows.

CORE NO. 7. 3880' - 3896' (16'), recovered 16'.

(Drilling break 3874' - 3880')

3880' - 3896', Sandstone, medium gray, fine grained with occasional medium-grained bands, quartzose with white argillaceous (tuffaceous?) matrix, abundant dark grey rock fragments, slightly hard, rare carbonaceous laminations, poor porosity, slightly cross-bedded, apparent dips of 0 - 10°, no shows.

CORE NO. 8. 4152' - 4162' (10'), recovered 10'.

4152' - 4158', Slate, dark gray with a hard, metallic lustre.

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partly silty, dense and hard, very slightly pyritic, well developed slaty cleavage dipping at 80 - 90°, quartz veins ⅛" to ¼" thick parallel to and cutting the apparent bedding are common, occasional euhedral quartz crystals associated with the quartz veins, one steeply inclined fracture with minor displacement, possible dip of 30°.

4158' - 4162', Shale, dark grey to black, crumbly, no visible bedding, possibly fault gouge.

CORE NO. 9, 4214' - 4224' (10'), recovered 4'.

4214' - 4218', Interbedded Slate, dark gray, often laminated, dense; Siltstone, medium to dark grey, siliceous, hard, slightly argillaceous; and Sandstone, medium to dark grey, siliceous, hard, fracture filled with light gray quartz or black chert, occasional irregular masses of quartz, bedding obscured by cleavage, possible dip 45°.

Duck Bay 42/54

SIDE-WALL CORES

Attempted 13, Recovered 12

Core No.	Depth	Recovery	Description
1	2245'	½"	Sand, dark green gray, moderately glauconitic and pyritic, fine grained, poor-fair porosity, no show.
2	2254'	1½"	Sand, medium brown, fine grained, unconsolidated, slightly micaceous, slightly carbonaceous, fair porosity, odor of H_2S, no show, glauconitic.
3	2273'	1½"	Sand, medium brown, fine grained, moderately glauconitic, unconsolidated, slightly micaceous, slightly carbonaceous, fair porosity, odor of H_2S, no show.
4	2290'	1'	Sand, light brown to light gray, fine grained, unconsolidated, non-glauconitic, slightly pyritic, slightly carbonaceous, fair porosity, no show.
5	2300'	½"	Sand, light gray, very fine to fine grained, argillaceous, fair porosity, no show.
6	2312'	1½"	Sand, light brown, fine grained, carbonaceous fragments common, 1 thin carbonaceous lamination, fair to good porosity, no show.
7	2347'	1½"	Sand, light brown, fine grained, slightly ligneous, fair to good porosity, no show.
8	2370'	¾"	Sand, dark brown, fine to medium grained, very ligneous, poor to fair porosity, unconsolidated and poorly sorted, no show.
9	2450'	1½"	Sand, medium gray, very fine to fine grained, clean, unconsolidated, slightly micaceous, fair to good porosity, no show.

Duck Bay 43/54

Core No.	Depth	Recovery	Description
10	2600'	2"	Sand, light gray, fine to medium grained, poorly sorted, angular to subangular, white argillaceous matrix, fair to good porosity, no show.
11	2618'	No recovery	
12.	2670'	1"	Sand and Gravel, light gray to white, unconsolidated, quartzose, subangular, 1 pebble ½" in diameter, good porosity, no show.
13.	3505'	1"	Sandy Tuff (?), white to light gray, crumbly, appears deeply weathered, very little quartz, poor porosity, no show.

(1)

MINES DE
VICTORIA

PETROLEUM ACT 1958 (SECTION 45).

RECORD OF WORK AT ....DUCK BAY NO. 1..... bore on
*Petroleum Exploration Permit)
~~*Petroleum Prospecting Licence~~) Number No. 44 during week
*Petroleum Mineral Lease)
ending 22nd February 19.64

* Strike out words not applicable.

DEPTH	DESCRIPTION OF STRATA
20' - 300'	Sand, Clay and Lignite.
300' - 350'	Sand, Shells and Clay
350' - 550'	Marl, shelly
550' - 1050'	Limestone
1050' - 1420'	Limestone and Marl
1420' - 2240'	Clay and Marl
2240' - 2260'	Shale, brn., gry. and grn., fissile, vy. glauconitic and pyritic
2260' - 2450'	Shale and Sand, med. - vy. cse. gd. and pebbly
2450' - 2770'	Sand, Coal and Clay
2770' - 3000'	Shale, Mudstone and Siltstone, brn. - gry., carbonaceous
3000' - 3525'	Volcanics, Tuff, Basalt, w/minor Rhyolite (?) and Breccia
3525' - 3709'	Mostly Sandstone, wh. - gry., v.f. - med. gd., friable - sly. hd. w/white clay (tuffaceous?) matrix, tight. Cuttings in this interval contain an average 50% volcanics which may be interbedded w/the sandstone or they could be only cavings

NOTES BY DRILLER IN CHARGE: (State in notes whether water, gas or petroleum has been met with, and, if so, give depth and nature of occurrence, also depth to which casing has been inserted and cemented.) For CORES, see attachment.

SHOWS : 1475' - 1515' 7 units total gas
1565' - 1595' 8 " " "
2290' - 2320' 15 units (plus) with 10 units of heavy hydrocarbons

REMARKS : Spudded 11.30 a.m. Feb. 15. Drilled 17½" hole from surface to 420'. Set 13⅜" J-55 48 lb. casing at 410' and cement to surface w/380 sacks of cement. Drilled 420'-3709' w/8¾" bit.

Top of Latrobe Valley Coal Measures at approx. 2450'
~~" " first coal seam~~ " " 2500'
~~" " Mesozoic section~~ " " 2770'
Age of Volcanics and underlying sediments unknown as yet.

Signed Victor Bychok
Legal Manager, ARCO LIMITED Co.
Date 26/2/64

N.B. The Act also requires the Minister to be notified immediately water, gas or petroleum is encountered.

Analyses of water, gas and oil should be submitted if available.

Attachment to record of work for DUCK BAY NO. 1 - week ending 22nd February, 1964.

CORES :

No.	1	2320' - 2340' rec. 3 pebbles only
"	2	2340' - 2360', no recovery
"	3	2831' - 2851', rec. 20', Mudstone, dk. gry. slightly silty, dense, flat dip
"	4	3182' - 3202', rec. 20', Tuff, med. - dk. grn., v.f.gd. - aphanitic, often with network of acicular cream colored minerals in a green matrix
"	5	3393' - 3403', rec. 1¾', Tuff, Breccia and laminated volcanic Ash
"	6	3699' - 3709', rec. 9.5', Sandstone, med. gry., f.gd., sly. hd., dips of 15 - 20°.

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(2)

MINES DEPARTMENT
VICTORIA

PETROLEUM ACT 1958 (SECTION 45).

RECORD OF WORK AT ....DUCK BAY NO. 1........ bore on

*Petroleum Exploration Permit)
~~*Petroleum Prospecting Licence~~) Number ..44.......during week
~~*Petroleum Mineral Lease~~)

ending ..4th March...... 19.64....

* Strike out words not applicable.

DEPTH	DESCRIPTION OF STRATA
4224' Driller ~~4238' Schlumberger~~	3709' - 4128' Predominantly Sandstone, white - light gray, argillaceous (tuffaceous?), very fine to medium grained, tight; Siltstone, brown to medium gray, argillaceous: and Shale, dark brown to medium gray, firm
	4128' - 4224' (Driller) Slate, dark gray, steely luster, slightly hard; with inter-bedded Siltstone and Sandstone, medium/to to dark gray, siliceous, hard.
CORES : As per	details attached

NOTES BY DRILLER IN CHARGE: (State in notes whether water, gas or petroleum has been met with, and, if so, give depth and nature of occurrence, also depth to which casing has been inserted and cemented.) SHOWS : None TESTS : None

LOGS ES Log, 410'-4237' Microlog, 410'-4231', Sonic - Gamma Ray Log, 410'-4221', Continuous dipmeter log 1000'-4221'

REMARKS : Set plug @ 2633'-2733' with 40 sacks cement (E. log)
" " " 2190'-2290' with 40 sacks cement (E. log)
" " " 360'-460' with 40 sacks cement (E.Log)
" " " 4'-29' below surface with 10 sacks cement

Cut off casing 4' below surface, and welded 1/4" plate over casing. Welded on 2" pipe to side of casing with nameplate 3' above ground. Well plugged and abandoned. Released rig at 12.00 noon Feb. 28, 1964

Signed ....Victor Bychok....

Legal Manager, ..ARCO LIMITED...... Co.

Date ..4../..3../..64..

N.B. The Act also requires the Minister to be notified immediately water, gas or petroleum is encountered.

Analyses of water, gas and oil should be submitted if available.

Mr Humphreys }
Mr Kenley } Copy for your files.

5.3.64

Attachment to Record of Work for DUCK BAY NO. 1
(P.E.P.44) for week ending 4th Mar.1964

CORES : No. 7 - 3880' - 3896', rec. 16' : Sandstone, medium gray, fine grained, mostly quartz in a white tuffaceous (?) matrix, slightly carbonaceous, poor porosity, dips of 0 - 10°.

No. 8 - 4152' - 4162', rec. 10' : Slate, dark gray with hard metallic luster, partly silty, dense, well developed cleavage, milky white quartz veins $\frac{1}{8}$" to $\frac{1}{4}$" thick parallel to and cutting bedding, often anastomosing, cleavage dipping 80 - 90°, bedding 30°

No. 9 - 4214' - 4224', rec. 4' : Interbedded Slate, dark gray and siliceous Siltstone and Sandstone, medium to dark gray, hard, veins of irregular masses of milky quartz and black chert, common, possible dip 45°

Side-wall Cores : Attempted 13, recovered 12, no show

Petrological Reports

APPENDIX 4

Duck Bay 44/54

APPENDIX 4

PETROLOGICAL REPORTS

TWO SPECIMENS FROM DUCK BAY NO. 1 WELL EAST GIPPSLAND

(Sylvia Whitehead)

1. CORE NO. 4. 3,190 feet : A dark greenish grey rock. Relatively soft and friable with numerous slickensided surfaces. It is cut by veins of calcite and one of microcrystalline quartz.

   In undisturbed parts of the rock away from the slickensided surfaces, a fine grained basaltic texture is reasonably well preserved but original minerals have all been altered and replaced.

   Crushed fragments temporarily mounted in clove oil contained serpentine, chlorite, fine fibrous amphibole probably uralite replacing pyroxene, very fine grained iron oxide (some magnetite) and a soft clay mineral.

   Conclusion : Serpentinised or chloritised basic igneous rock. Probably originally a basalt, but the possibility of intrusive dolerite cannot be excluded.

2. CORE NO. 6. 3,704 feet : Composed of poorly sorted quartz grains and grey rock fragments up to 2 mm in size cemented by a finer grained matrix. Minor pyrite is present as very fine grained aggregates and there are traces of black carbonaceous material.

   Thin Section (M.776) : Composed predominantly of semi-rounded to angular quartz grains and rock fragments (commonly 0.2 - 0.4 mm but some larger) with rare rounded tourmaline grains and a few muscovite flakes cemented mainly by very fine grained sericite or hydromica. Clastic rock fragments include :

   Sericite schist
   Quartz-sericite schist
   Carbonaceous shale, slate or phyllite
   Minor chert or microcrystalline quartz
   Sericitic fragments of undetermined origin.

Duck Bay 45/54

Proportions vary from place to place, but in general quartz grains are rather more abundant than rock fragments. Detrital grains are closely packed, many are in contact or have only a thin film of sericite between them.

Post-depositional changes : Interstitial material, probably originally clay has recrystallised to very fine grained sericite or hydro-mica.

Softer sericitic rock fragments have yielded and by solid flow have adapted to the shape of adjacent harder quartz grains.

There has been very limited re-growth of secondary quartz around some of the detrital quartz grains. This has filled a few interstices forming small patches of quartz mosaic. Locally, quartz grains in contact have become welded together by pressure solution and recrystallisation.

Heavy mineral grains separated from the crushed rock in bromoform include :

Opaque grains	- pyrite and some ilmenite altered to leucoxene.
Tourmaline	- common, generally well rounded.
Zircon	- common, well rounded and some prismatic crystals.
Garnet	- Rare, generally angular.
Rutile	- very rare.

Very rare phosphatic granules or pellets were observed in one heavy mineral assemblage but not in another.

Chemical tests indicated the presence of very minor phosphate.

Conclusion :
Siliceous grit with some rock fragments. The presence of pyrite indicates deposition in a reducing environment.

There is no evidence of metamorphism other than that which may be attributed to load due to depth of burial.

Comparison with specimens from other drill holes :
Some of the quartz-sericite and sericitic rock fragments in this specimen are similar to some rock fragments in a specimen from North Seaspray No. 1 well (core 6 - thin section M.592) but fragments of definite volcanic origin present in the rock from

Duck Bay 46/54

North Seaspray No. 1 were not noted in this specimen. Feldspar grains are also absent from this specimen.

In the heavy mineral assemblages, biotite and apatite common in the specimen from North Seaspray No. 1 were not observed in the one from Duck Bay No. 1 well.

Except for the absence of biotite the heavy minerals from this specimen are similar to those from specimens of grit from Merriman No. 1 well, but as there are no unusual diagnostic minerals, this is probably of little significance.

MELBOURNE
March, 1964

Duck Bay 47/54

PETROLOGICAL REPORT

by
J. B. Hocking,
Department of Mines, Victoria.

DUCK BAY NO. 1

Core 7

Sample Details : Depth 3880' - 3896'
Recovery 16'

Megascopic Examination

The rock is essentially a medium-grained grey quartz sandstone with appreciable white mica. Small pieces of dark grey material, usually less than 3 mm. in length, appear to be shale fragments.

Minor shearing of the rock is indicated by the occurrence of small cracks and the small-scale faulting of some of these cracks. It is also suggested by the slickensiding of carbonaceous material where it is found concentrated in very thin discontinuous laminations with flakes of white mica.

Microscopic Examination

In thin section the rock consists of grains of quartz and other minerals set in a sericitic matrix.

Quartz is by far the most abundant mineral, and occurs as sub-angular grains with a maximum size of approximately 0.5 mm. The majority of the grains - those constituting the framework of the rock - are 0.2 mm. or less. Minute inclusions of tourmaline may occur in the quartz.

Subordinate minerals include feldspar, muscovite, tourmaline and zircon. The feldspar consists mostly of orthoclase, although rare occurrences of plagioclase (andesine) are noted. Mica (muscovite) occurs as thin elongate flakes which in many cases are 'bent' around quartz grains, presumably as a result of compaction of the sediment. They often show partial alteration with a resulting loss of their characteristic cleavage and birefringence.

The accessory minerals tourmaline and zircon occur as sub-rounded grains. The former is represented by the pleochroic green brown variety while the latter is colourless.

Duck Bay 48/54

Rock fragment grains are sub-rounded, and consist of fine-grained sediments such as shale and siltstone.

Grain boundaries and other minute cracks in the rock are in some cases filled with an unidentifiable brown-black disseminated substance which is assumed to be carbonaceous. It is irregularly distributed throughout the section either as aggregates, or else as small specks associated with sericite.

The matrix comprises between 20% and 30% of the rock, and consists of sericitic aggregates together with minute flakes of much-altered muscovite and very small quartz grains. The sericite shows a rough alignment with the outlines of the larger quartz grains - in much the same way as do the large muscovite flakes. Although the sericite may have been derived in part from an original clay matrix, examples of its alteration from feldspar are observed.

The quartz (and occasional feldspar) grains forming the framework of the rock are in many cases reasonably well-spaced such that in the absence of sericite the rock would have very good porosity. In its present state, however, the effective porosity appears to be low. The thin section revealed irregular pores of appreciable size, although it is feared that some at least of these pores may have been developed during preparation of the section. The porosity as measured - a <u>true</u> porosity, as these pores are not interconnected - is 25%.

Core 6

Sample Details : Depth 3699' - 3709'
Recovery 9.5'

Megascopic Examination

The rock is a fine-grained grey quartz sandstone which is appreciably micaceous. Some cores are dark grey as a result of colouring by carbonaceous material. Very fine discontinuous carbonaceous laminations vaguely suggest small-scale bedding with dips of between 25° and 30°. Rock (usually shale) fragments up to 3 cm. long lie roughly parallel to this 'bedding'.

The sandstone is tight and hence its effective porosity appears to be negligible.

Duck Bay 49/54

Microscopic Examination

The mineral composition of Core 6 is identical to that of Core 7. The amount of carbonaceous matter is greater, however, and aggregates of all sizes occur throughout.

Another fundamental difference is that of grain size. The grain size range is the same as that for Core 7 (indicating the close genetic relationship between the two), but the majority of grains in Core 6 are 0.1 mm. or less (compared with 0.2 mm. or less in Core 7).

Micro-bedding is suggested by the approximate alignment within the sericitic matrix, this being in accordance with that of elongate quartz grains, of mica flakes, and 'threads' of carbonaceous material.

The measured (true) porosity is approximately 10%. The pores are small and are unconnected.

Comment on Cores Nos. 6 and 7

The mineral assemblage of these sandstones is typical of granitic rocks. The paucity of feldspar is to be expected in view of its tendency to weather rapidly (sericite being a typical product of such weathering).

Deposition in an estuarine or terrestrial environment, under the influence of very gentle current action, is suggested by :

(1) the presence of carbonaceous material;
(2) minute laminations showing vague bedding; and
(3) only an average sorting of grains.

The source of the shale fragments is unknown.

Core 8

Sample Details : Depth 4152' - 4162'
Recovery 10'

Megascopic Examination

The rock studied is a very tight grey sandstone. It is traversed by veins of quartz.

Microscopic Examination

In thin section it is a fine-grained micaceous silty sandstone.

Quartz is the most common mineral. The grains are sub-angular and rarely exceed 0.2 mm., while most are less than 0.1 mm. A mosaic of granular quartz, occupies small irregular cracks which are occasionally 'macro-faulted'.

Duck Bay 50/54

Mica is common also. Fresh muscovite is rare, and has usually been altered to a dusty brown (presumably more iron-rich) variety. The mica flakes are thin and elongate, and are arranged in a sub-parallel fashion. Most of them are buckled to a small extent.

Feldspar, tourmaline (pleochroic, and either green-brown or green-blue), apatite and ilmenite are rare. Calcite on the other hand, is not uncommon and occurs as sub-rounded to sub-angular grains.

The matrix of the rock consists of sericite as well as small flakes of much-altered mica and very small quartz grains.

Porosity is very low.

Comments

The mica flakes appear to be secondary, hence they show excessive elongation relative to the average grain size. Their alignment and buckling suggests limited shearing of the rock induced by structural deformation or low-grade metamorphism.

The rock is very similar to Ordovician bedrock found in other eastern Gippsland bores.

B. HOCKING
Geologist

Duck Bay 51/54

PETROLOGICAL REPORT

by

K. G. Bowen,
Department of Mines, Victoria

DUCK BAY NO. 1

Core 4

Sample Details : Depth 3182' - 3202'
Recovery 20'

Megascopic Examination

The rock is a drab grey-green in colour with numerous small black glassy phenocrysts, generally randomly orientated, occasionally the phenocrysts show a parallel orientation, but the direction of the orientation with respect to the bore hole cannot be determined.

The core is intersected by several slickensided surfaces and is traversed by carbonate veins up to ¼" in thickness. Examination of the groundmass with a lens or low power binocular microscope shows that it contains numerous whitish acicular crystals.

Microscopic Examination

In thin section it consists of strongly pleochroic phenocrysts set in a ground mass which is predominantly chloritic.

The phenocrysts have a maximum size of 1.5 mm. and frequently show typical amphibole cross sections, but with only one cleavage direction. The mineral is intensely pleochroic from yellow to dark green, it is optically negative with a 2V of 0^0 or nearly so, it has a refractive index of approximately 1.60, and is considered to be a biotite pseudomorph after amphibole. The biotite is frequently completely or almost completely chloritized, often with a narrow rim of biotite unaltered. The unchloritised biotite crystals are frequently zoned with a narrow dark green border which is more highly birefringent than the paler green core.

The ground mass is now almost completely composed of chlorite. No fresh feldspar can be detected, only the somewhat hazy outlines of what were probably original feldspar laths. These laths, like the ground mass are now essentially composed of a chlorite mineral.

Duck Bay 52/54

The intense chloritization has tended to mask the original texture. From what can still be observed however, this texture was probably basaltic with phenocrysts set in a felted mass of feldspar crystals.

Rock Type

The intense chloritization which has tended to destroy the original texture and has made determination of the feldspar impossible also means that the rock cannot be named for certainty and the term meta-basalt is suggested as being that most applicable. The presence of original amphibole is unusual in a basaltic rock but is not unknown. The mineral association would also be characteristic of the lamprophyres, the texture however is more typical of the basalts rather than that of the lamprophyres. In the sections and core examined no textures or structures to suggest a pyroclastic origin were observed.

Core 5

Sample Details — Depth 3393' - 3403'
Recovery 1.75'

Megascopic Examination

Identical to Core 4 together with a dark grey to black aphanitic rock with numerous slickensided surfaces.

The rock has a very irregular fracture, the surfaces of which together with the slickensided surfaces are frequently coated with a thin white film. Some material also appears to be transitional between the two types.

Microscopic Examination

Rock Type - Metabasalt.

Identical in hand specimen to material from Core 4, and was not examined further.

Rock Type - Vitric tuff.

In thin section consists of quartz crystals, glassy basalt fragments containing indeterminate feldspar laths, fragments of brown glass showing perlitic textures and hexagonal cracks reminiscent of columnar jointing in basalt, interbedded in a groundmass composed predominantly of occasionally faintly birefringent brown glass, which in some sections contains abundant iron ore crystals. Occasional large irregular blebs of structureless serpentine occur and the rock is traversed by thin veins of

Duck Bay 53/54

colourless chloritic material. The quartz grains are angular in shape and do not appear to be of detrital origin.

Age

Volcanic activity occurring elsewhere in Victoria during the interval represented by these cores (i.e. pre-Strzelecki Group and post Permian) is unknown and it is not possible therefore to correlate with other areas. The arkoses of the Strzelecki Group characteristically have a chlorite cement considered by Edwards and Baker (1942) to have formed during lithification by the action of connate waters, and it appears probable, that the chlorite in the volcanics was formed in the same manner. The underlying Permian sediments have a predominantly sericitic cement, so that these sediments were unaffected by the process of chloritization and were therefore completely lithified by the time of the extrusion of the volcanics and their subsequent chloritisation.

If one accept s this rather tenuous evidence then it seems likely that the volcanics represent basal igneous activity before the commencement of Mesozoic sedimentation.

Reference

Edwards, A.B. and Baker, G., 1943 Jurassic Arkose in Southern Victoria. Proc.Roy.Soc.Vic. Vol. 55, Pt. 2. pp. 195-228.

N. BOWEN,
Geologist.

Page

ILLUSTRATIONS

TABLES

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

Date: 7th JULY, 1965

CORE ANALYSIS RESULTS

2nd copy.

Notes:- (i) Unless otherwise stated, the porosities and permeabilities were determined on two small plugs (V & H) cut at right angles from the core or sample. Ruska porosimeter and permeameter were used, with air at 30 p.s.i.g. and dry nitrogen, respectively, as the saturating and flowing media. (ii) Residual oil and water saturations were determined using Sozhlet type apparatus. (iii) Acetone test precipitates and fluorescence of solvent after extraction are recorded as, nil, trace, fair, strong or very strong.

Well or Area	Core or Sample No.	Depth in ft. From:- To:-	Lithology	Effective Porosity in % by Vol.		Absolute Permeability in Millidarcys		Avg. density in gms./cc.		Fluid Saturation in % Pore Space		Acetone Test		Solvent after Extraction		Remarks
				V	H	V	H	Dry Bulk	APPARENT Grain	Water	Oil	Colour	Precip-itate	Colour	Fluor.	
DUCK BAY NO. 1	1 & 2	2320'-2340' 2340'-2360'	RECOVERY FOR BOTH CORES	NIL												
"	3	2846' 2848'	SHALE	17	N.D.	N.D.	N.D.	2.49	3.00	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	
"	4	3187' 3189'	SANDSTONE	24	26	"	22 *	2.32	3.10	48	Nil	Nil	Nil	Nil	Nil	* Fractures visible
"	5	3393'0" 3394'9"	SILTSTONE & SHALE	29	20	"	N.D.	2.32	3.08	49	"	Pale Yellow	Nil	Nil	Trace	
"	6	3704' 3706'	SANDSTONE	9	9	Nil	Nil	2.50	2.74	9	"	"	"	"	"	
"	7	3892' 3894'	SANDSTONE	13	13	"	"	2.35	2.70	10	"	Trace	"	"	Nil	
"	8	4159' 4162'	SHALE & CONGLOMERATE	6	9	"	N.D.	2.61	2.82	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	
"	9	4217' 4218'	SILTSTONE & SHALE	1	1	"	Nil	2.65	2.67	48	Nil	Nil	Nil	Nil	Trace	

Additional Informations: CORE 4: Greenish colour, badly fractured, calcareous bands, dark minerals.

CORE 5: Dark minerals present.

General File No. 62/399
Well File No. 64/4014

TABLE 1. ANALYTICAL RESULTS

Lab. No.	Well	Core	Depth (m)	Formation	Age	Remarks	Total Extract (ppm)	Ali-phatic Fraction (ppm)	Arom-matic Fraction (ppm)	Polar Frac-tion (ppm)	Organic Carbon (%)	Reflectance (%)
78479	Duck Bay-1	3	862.9	Strzelecki Group	L. Cretaceous	Shale-mudstone (grey slightly carb.)	170	32	51	48	1.05	0.16
78480	"	6	1127.5	Unnamed	L. Permian	Sandstone (v. fine, grey, argillaceous matrix, slightly carb.)	242	41	51	69	0.45	0.65

† Cuttings
Values in parentheses are more uncertain

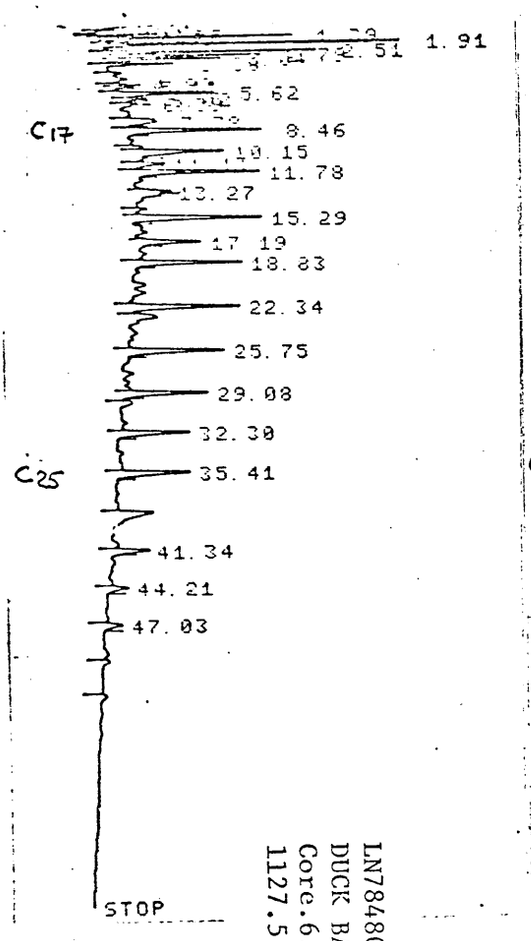
- insufficient vitrinite present for measurement

CONFIDENTIAL

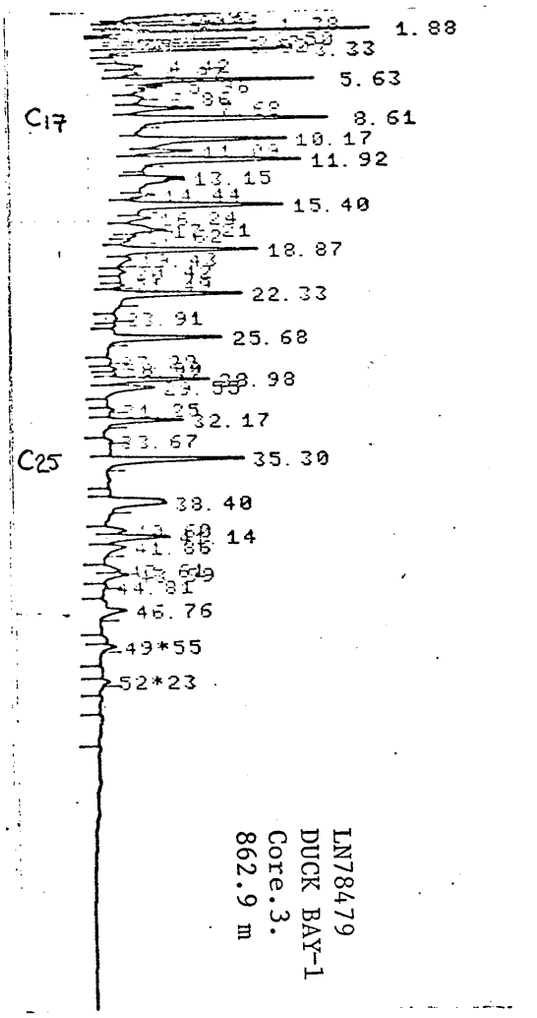
TABLE 2. DISTRIBUTIONS OF REFLECTANCE MEASUREMENTS (R_o 0.20-1.55)

Lab. No.	No. of readings in reflectance group																											R_o (%) average	No. of readings
	.20	.25	.30	.35	.40	.45	.50	.55	.60	.65	.70	.75	.80	.85	.90	.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	
78479													3	3	1														0.86	7
78480						1	1	7	12	19	4	6																	0.65	50

Reading numbers in parentheses not used to obtain mean



LN78480
DUCK BAY-1
Core.6.
1127.5 m



LN78479
DUCK BAY-1
Core.3.
862.9 m

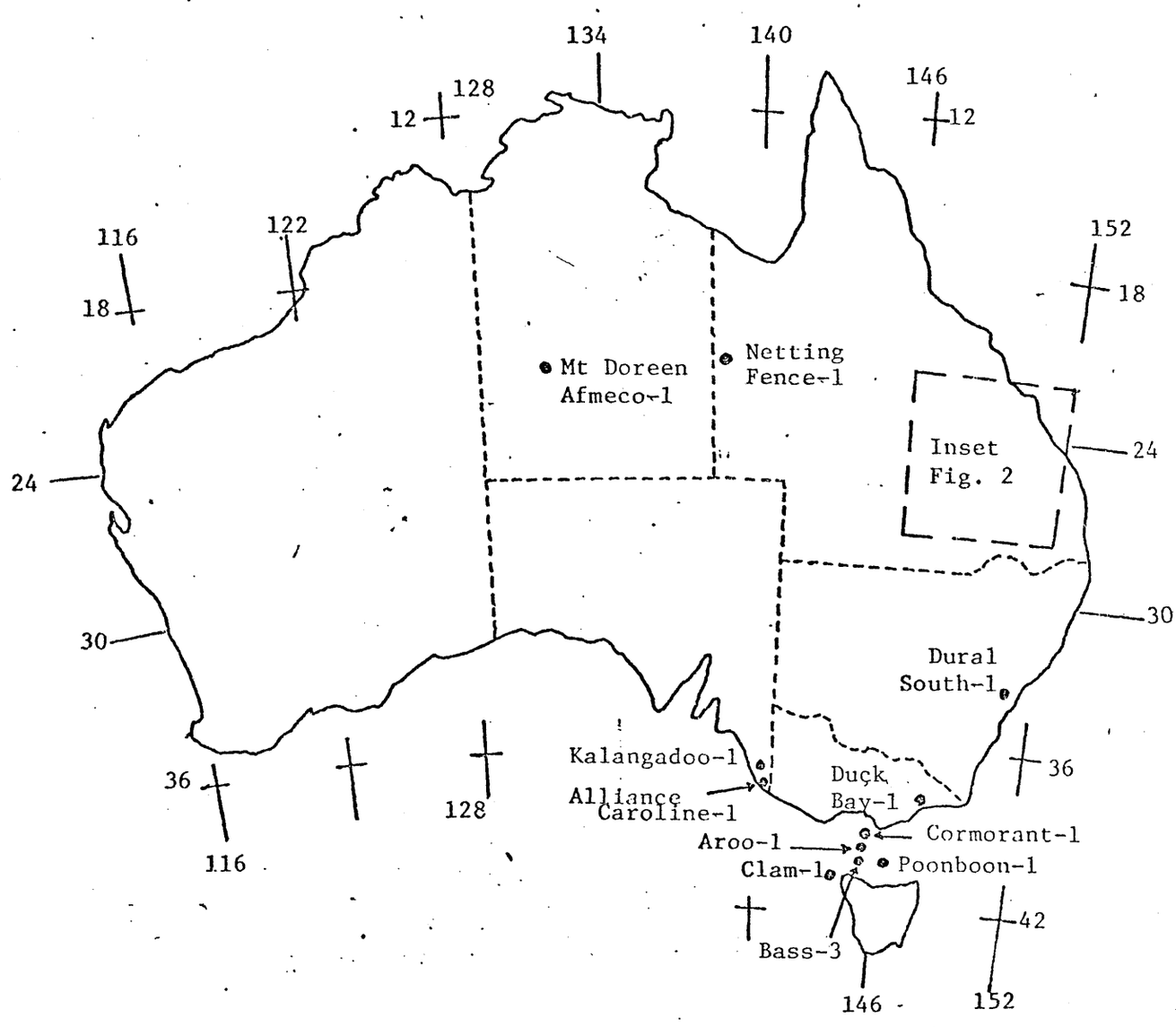


FIG. 1 Approximate locations of Exploration Wells

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

CNR CONSTITUTION AVENUE AND ANZAC PARADE, CANBERRA
Postal address: P O Box 378, Canberra City, A.C.T. 2601
Please address all communications to the Director

Telephone: 499111
Telegrams: BUROMIN
Telex: 62109

Department of National Development

In reply please quote: 76/780
77/196

8 August 1979

The Director,
Geological Survey of Victoria,
Department of Minerals and Energy,
107 Russell Street,
MELBOURNE VIC 3000

Dear Sir,

I am enclosing the results of source rock analysis carried out by CSIRO for BMR on core samples from Duck Bay-1, as part of BMR's ongoing source rock study program.

We request that the analysis be held on a confidential basis until it has been reported on, either by BMR or in publications in which BMR has joint authorship.

Yours sincerely,

M. Henley

E. R. Smith

(E.R. SMITH)
Acting Assistant Director (Petroleum Exploration)

VIC.

RESTRICTED INVESTIGATION REPORT 1030R

Batch 2

CSIRO

SS289I

INSTITUTE OF EARTH RESOURCES

SOURCE ROCK ANALYSES ON SAMPLES FROM THE OTWAY, SYDNEY, BOWEN, SURAT, BASS, GIPPSLAND, GEORGINA AND NGALIA BASINS

A REPORT TO THE BUREAU OF MINERAL RESOURCES, CANBERRA

N.M. RAPHAEL AND J.D. SAXBY

CSIRO FUEL GEOSCIENCE UNIT
P.O. Box 136
NORTH RYDE, NSW
AUSTRALIA 2113

JUNE 1979

1. INTRODUCTION

This report contains the results of organic geochemical analyses carried out by C.S.I.R.O. on forty five core samples, four samples of cuttings and one surface sample supplied by the B.M.R. (December, 1978) from wells (location - BMR map reference) in the following sedimentary basins:

Otway basin: - Kalangadoo-1 (37°34'40''S, 140°41'40''E-310) Clam-1 (40°51'52''S, 144°12'55''E-478), Alliance Caroline-1 (37°56'30''S, 140°54'30'' E-386)

Sydney basin: - Dural South-1 (33°42'37''S, 151°01'02'' E-361)

Bowen basin: - Warrinilla-1 (25°06'49''S, 148°33'14''E-128), Warrinilla-2 (25°03'33''S, 148°33'10''E-272), Glentulloch-1 (25°47'17''S, 148°42'27''E-42), Cometside-1 (24°39'30''S, 148°48'06''E-206), Purbrook-1 (24°37'10''S, 148°48'20''E-139),Rolleston-1 (24°33'47''S, 148°37'52''E-173), Warrinilla North-1 (24°52'49''S, 148°31'50''E-140),Purbrook South-1 (24°49'30''S, 148°46'40''E-219), Bandanna-1 (25°06'40''S, 148°17'20''E-120).

Surat basin: - Westgrove-3 (25°34'00''S, 148°26'00''E-46)

Bass basin: - Bass-3 (39°59'51''S, 145°16'57''E-390), Aroo-1 (39°47'30''S, 145°26'48''E-657), Poonboon-1 (40°08'00''S, 145°55'00''E) Cormorant-1 (39°34'23''S, 145°31'36''E).

Gippsland basin: - Duck Bay-1 (37°56'45''S, 147°39'36''E-201).

Georgina basin: - Netting Fence-1 (22°56'05''S, 138°02'06''E-229).

Ngalia basin: - Mt Doreen Afmeco-1 (22°17'45''S, 131°14'45''E).

A surface sample from Joadja, 29 km S.W. of Mittagong in the Sydney basin, was also supplied.

The approximate location of each well is shown in Figs. 1 & 2.

2. METHODS AND RESULTS

2.1 Extractable Organic Matter

A portion of each sample was ground to produce approximately 75% less than 70 μm which was then extracted in a soxhlet with purified chloroform for a minimum of six hours. Evaporation of the solvent under nitrogen gave the total extract. That part of the total extract soluble in petroleum ether was transferred to a 5 cm x 1 cm column of florisil and eluted with petroleum ether. This eluate, after evaporation of the ether, is the aliphatic fraction which was analysed by gas chromatography for hydrocarbons in the n-C_{15} to n-C_{35} boiling range (Fig. 3).

Further dissolution of the total extract with benzene and its subsequent elution from the same florisil column produces the aromatic fraction. Methanol is then similarly used to obtain the polar fraction. Thus:

Total extract(ppm)	= aliphatic fraction(ppm)	+ aromatic fraction(ppm)	+ polar fraction(ppm)	+ residue, losses and materials remaining on the column.

The probable error in the values (expressed as ppm of the original sample) depends on the weight of core extracted and the nature of the extract. However, the following ranges probably represent the maximum errors:

Total extract	±	60 ppm
Aliphatic fraction	±	10 ppm
Aromatic fraction	±	20 ppm
Polar fraction	±	100 ppm

The separation achieved on the short florisil columns is not perfect and it should not be assumed that these fractions contain solely aliphatic, aromatic or polar compounds respectively. In Table 1, most samples demonstrated that, within experimental error, the sum of the three fractions was equal to the total extract. However, the following samples did not show this pattern:

Group 1 - Lab. No.: 78454, 78468, 78474, 78475, 78476, 78477, 78490, 78493, 78496.

Group 2 - Lab. No.: 78469, 78470, 78471, 78489, 78494, 78495, 78498.

The extracts from Group 1 samples contained a considerable residue that did not redissolve in petroleum ether, benzene or methanol. Most of these contained an appreciable amount of sulphur in all fractions and especially in the residue. The remaining samples which gave an appreciable insoluble residue were coaly in nature. In the case of Group 2 samples evaporative losses of more volatile material in the extracts were appreciable and difficult to control. As with data in previous reports, all results are single determinations on the samples as received. Samples and extracts vary greatly and in some cases further CSIRO-BMR collaborative work is desirable so that the most meaningful conclusions can be drawn.

2.2 Total Organic Carbon

This was determined using a Leco analyser on a sample of ground core which had previously been treated with 5N HCl to remove carbonates. Results are shown in Table 1 and in most cases the error is ± 0.05%.

2.3 Reflectance

Part of each core was crushed to -0.7 mm and the carbonaceous material was concentrated by froth flotation. The floated material was mounted in cold setting resin, ground and polished. Measurements of reflectance were difficult on some samples because of a lack of readily identifiable vitrinite. However, where possible mean average values at 546 n.m. with an oil of refractive index 1.515 are listed in Table 1. Distributions of these measurements are seen in Tables 2 and 3. Some of the samples showed a considerable range of reflectance values but for most samples a probable error of ± 0.05%, corresponding to twice the standard error of the mean, would be reasonable.

3. ACKNOWLEDGEMENTS

Essential contributions to this work were made by the following North Ryde staff: A. Bennett (reflectance); K. Riley and N. Watson (carbon analysis); and G. Hansen, V. Hutchings and Eric Murray (sample preparation).

ENCLOSURES

Enclosures . . . . .

PE602057

This is an enclosure indicator page.
The enclosure PE602057 is enclosed within the container PE906918 at this location in this document.

The enclosure PE602057 has the following characteristics:

ITEM_BARCODE	= PE602057
CONTAINER_BARCODE	= PE906918
NAME	= Composite Well Log
BASIN	= GIPPSLAND
PERMIT	=
TYPE	= WELL
SUBTYPE	= COMPOSITE_LOG
DESCRIPTION	= Composite Well Log, sheet 1 of 2, (enclosure from WCR) for Duck Bay 1
REMARKS	=
DATE_CREATED	= 28/02/64
DATE_RECEIVED	=
W_NO	= W482
WELL_NAME	= Duck Bay-1
CONTRACTOR	= Arco Ltd/Woodside
CLIENT_OP_CO	= Arco Ltd/Woodside

(Inserted by DNRE - Vic Govt Mines Dept)

PE602058

This is an enclosure indicator page.
The enclosure PE602058 is enclosed within the container PE906918 at this location in this document.

The enclosure PE602058 has the following characteristics:

ITEM_BARCODE	= PE602058
CONTAINER_BARCODE	= PE906918
NAME	= Composite Well Log
BASIN	= GIPPSLAND
PERMIT	=
TYPE	= WELL
SUBTYPE	= COMPOSITE_LOG
DESCRIPTION	= Composite Well Log, sheet 2 of 2, (enclosure from WCR) for Duck Bay 1
REMARKS	=
DATE_CREATED	=
DATE_RECEIVED	=
W_NO	= W482
WELL_NAME	= Duck Bay-1
CONTRACTOR	= Arco Ltd/Woodside
CLIENT_OP_CO	= Arco Ltd/Woodside

(Inserted by DNRE - Vic Govt Mines Dept)

PE907029

This is an enclosure indicator page.
The enclosure PE907029 is enclosed within the container PE906918 at this location in this document.

The enclosure PE907029 has the following characteristics:

ITEM_BARCODE	= PE907029
CONTAINER_BARCODE	= PE906918
NAME	= Duck Bay 1 velocity survey graph
BASIN	= GIPPSLAND
PERMIT	= PEP44
TYPE	= WELL
SUBTYPE	= VELOCITY_CHART
DESCRIPTION	= Duck Bay 1 Velocity Survey graph (enclosure from WCR)
REMARKS	=
DATE_CREATED	= 26/02/64
DATE_RECEIVED	=
W_NO	= W482
WELL_NAME	= Duck Bay-1
CONTRACTOR	= Arco-Woodside
CLIENT_OP_CO	= Arco-Woodside

(Inserted by DNRE - Vic Govt Mines Dept)

PE907030

This is an enclosure indicator page.
The enclosure PE907030 is enclosed within the container PE906918 at this location in this document.

The enclosure PE907030 has the following characteristics:

ITEM_BARCODE	= PE907030
CONTAINER_BARCODE	= PE906918
NAME	= Duck Bay 1 velocity survey graph
BASIN	= GIPPSLAND
PERMIT	= PEP44
TYPE	= WELL
SUBTYPE	= VELOCITY_CHART
DESCRIPTION	= Duck Bay 1 Time Depth Graph, with age listed alongside (enclosure from WCR)
REMARKS	= also has age listed alongside
DATE_CREATED	=
DATE_RECEIVED	= 31/07/86
W_NO	= W482
WELL_NAME	= Duck Bay-1
CONTRACTOR	= SCHLUMBERGER
CLIENT_OP_CO	= ARCO/WOODSIDE LTD

(Inserted by DNRE - Vic Govt Mines Dept)

PE905451

This is an enclosure indicator page.
The enclosure PE905451 is enclosed within the container PE906918 at this location in this document.

The enclosure PE905451 has the following characteristics:

ITEM_BARCODE	= PE905451
CONTAINER_BARCODE	= PE906918
NAME	= Duck Bay 1 Generalised Strat. Column (Gippsland B)
BASIN	= GIPPSLAND
PERMIT	= PEP44
TYPE	= WELL
SUBTYPE	= STRAT_COLUMN
DESCRIPTION	= Duck Bay 1 Generalised Stratigraphic Column for Gippsland Basin. Plate 2 of WCR
REMARKS	=
DATE_CREATED	=
DATE_RECEIVED	=
W_NO	= W482
WELL_NAME	= Duck Bay-1
CONTRACTOR	= Arco-Woodside
CLIENT_OP_CO	= Arco-Woodside

(Inserted by DNRE - Vic Govt Mines Dept)

PE604529

This is an enclosure indicator page.
The enclosure PE604529 is enclosed within the container PE906918 at this location in this document.

The enclosure PE604529 has the following characteristics:

ITEM_BARCODE	= PE604529
CONTAINER_BARCODE	= PE906918
NAME	= Mud Log (with lithology)
BASIN	= GIPPSLAND
PERMIT	= PEP/44
TYPE	= WELL
SUBTYPE	= MUD_LOG
DESCRIPTION	= Mud log with Lithological Descriptions, page 1 of 3, (enclosure from WCR) for Duck Bay-1
REMARKS	=
DATE_CREATED	= 28/02/64
DATE_RECEIVED	=
W_NO	= W482
WELL_NAME	= DUCK BAY-1
CONTRACTOR	= READING AN D BATES P/L
CLIENT_OP_CO	= ARCO WOODSIDE PTY LTD

(Inserted by DNRE - Vic Govt Mines Dept)

PE604530

This is an enclosure indicator page.
The enclosure PE604530 is enclosed within the container PE906918 at this location in this document.

The enclosure PE604530 has the following characteristics:

ITEM_BARCODE	= PE604530
CONTAINER_BARCODE	= PE906918
NAME	= Mud Log (with lithology)
BASIN	= GIPPSLAND
PERMIT	= PEP/44
TYPE	= WELL
SUBTYPE	= MUD_LOG
DESCRIPTION	= Mud log with Lithological Descriptions, page 2 of 3, (enclosure from WCR) for Duck Bay-1
REMARKS	=
DATE_CREATED	= 28/02/64
DATE_RECEIVED	=
W_NO	= W482
WELL_NAME	= DUCK BAY-1
CONTRACTOR	=
CLIENT_OP_CO	= ARCO WOODSIDE PTY LTD

(Inserted by DNRE - Vic Govt Mines Dept)

PE604531

This is an enclosure indicator page.
The enclosure PE604531 is enclosed within the container PE906918 at this location in this document.

The enclosure PE604531 has the following characteristics:

ITEM_BARCODE	= PE604531
CONTAINER_BARCODE	= PE906918
NAME	= Mud Log (with lithology)
BASIN	= GIPPSLAND
PERMIT	= PEP/44
TYPE	= WELL
SUBTYPE	= MUD_LOG
DESCRIPTION	= Mud log with Lithological Descriptions, page 3 of 3, (enclosure from WCR) for Duck Bay-1
REMARKS	=
DATE_CREATED	= 28/02/64
DATE_RECEIVED	=
W_NO	= W482
WELL_NAME	= DUCK BAY-1
CONTRACTOR	=
CLIENT_OP_CO	= ARCO WOODSIDE PTY LTD

(Inserted by DNRE - Vic Govt Mines Dept)

PE906919

This is an enclosure indicator page.
The enclosure PE906919 is enclosed within the container PE906918 at this location in this document.

The enclosure PE906919 has the following characteristics:

ITEM_BARCODE	= PE906919
CONTAINER_BARCODE	= PE906918
NAME	= Index Map
BASIN	= GIPPSLAND
PERMIT	= PEP/44
TYPE	= WELL
SUBTYPE	= MAP
DESCRIPTION	= Index Map (enclosure from WCR) for Duck Bay-1
REMARKS	=
DATE_CREATED	= 28/02/64
DATE_RECEIVED	= 31/07/86
W_NO	= W482
WELL_NAME	= DUCK BAY-1
CONTRACTOR	= GEODRAFTING SERVICES
CLIENT_OP_CO	= ARCO WOODSIDE PTY LTD

(Inserted by DNRE - Vic Govt Mines Dept)

PE906920

This is an enclosure indicator page.
The enclosure PE906920 is enclosed within the container PE906918 at this location in this document.

The enclosure PE906920 has the following characteristics:

ITEM_BARCODE	= PE906920
CONTAINER_BARCODE	= PE906918
NAME	= Cross Section C'
BASIN	= GIPPSLAND
PERMIT	= PEP/44
TYPE	= WELL
SUBTYPE	= CROSS_SECTION
DESCRIPTION	= Cross Section C' (enclosure from WCR) for Duck Bay-1
REMARKS	=
DATE_CREATED	= 23/01/64
DATE_RECEIVED	= 31/07/86
W_NO	= W482
WELL_NAME	= DUCK BAY-1
CONTRACTOR	= GEODRAFTING SERVICES
CLIENT_OP_CO	= ARCO WOODSIDE PTY LTD

(Inserted by DNRE - Vic Govt Mines Dept)

PE906921

This is an enclosure indicator page.
The enclosure PE906921 is enclosed within the container PE906918 at this location in this document.

The enclosure PE906921 has the following characteristics:

ITEM_BARCODE	= PE906921
CONTAINER_BARCODE	= PE906918
NAME	= Cross Section B'
BASIN	= GIPPSLAND
PERMIT	= PEP/44
TYPE	= WELL
SUBTYPE	= CROSS_SECTION
DESCRIPTION	= Cross Section B' (enclosure from WCR) for Duck Bay-1
REMARKS	=
DATE_CREATED	= 23/01/64
DATE_RECEIVED	= 31/07/86
W_NO	= W482
WELL_NAME	= DUCK BAY-1
CONTRACTOR	= GEODRAFTING SERVICES
CLIENT_OP_CO	= ARCO WOODSIDE PTY LTD

(Inserted by DNRE - Vic Govt Mines Dept)

PE906922

This is an enclosure indicator page.
The enclosure PE906922 is enclosed within the container PE906918 at this location in this document.

The enclosure PE906922 has the following characteristics:

ITEM_BARCODE	= PE906922
CONTAINER_BARCODE	= PE906918
NAME	= Cross Section A'
BASIN	= GIPPSLAND
PERMIT	= PEP/44
TYPE	= WELL
SUBTYPE	= CROSS_SECTION
DESCRIPTION	= Cross Section A' (enclosure from WCR) for Duck Bay-1
REMARKS	=
DATE_CREATED	= 23/01/64
DATE_RECEIVED	= 31/07/86
W_NO	= W482
WELL_NAME	= DUCK BAY-1
CONTRACTOR	= GEODRAFTING SERVICES
CLIENT_OP_CO	= ARCO WOODSIDE PTY LTD

(Inserted by DNRE - Vic Govt Mines Dept)