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DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

PETROLEUM SEARCH SUBSIDY ACTS

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SAMPHIRE MARSH No. 1 WELL WESTERN AUSTRALIA

OF

WEST AUSTRALIAN PETROLEUM PTY LIMITED

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COMMONWEALTH OE AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

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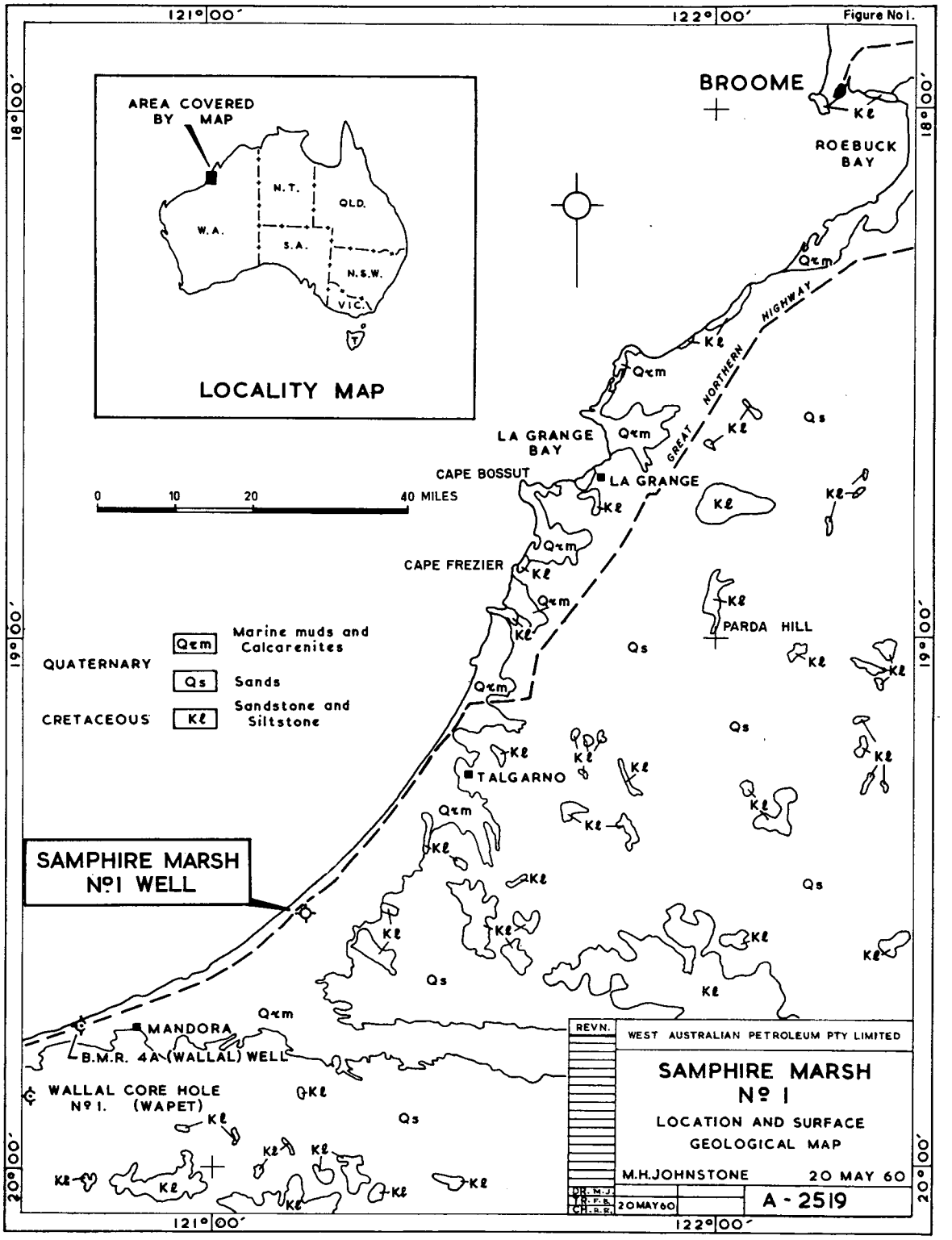
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QUATERNARY
Qem Marine muds and Calcarenites
Qs Sands
CRETACEOUS
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M.H.JOHNSTONE
20 MAY 60
DR. M.J.
TR. F.B.
CH. R.R.
20 MAY 60
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SAMPHIRE MARSH NO. 1 WELL

COMPLETION REPORT

by

M.H. Johnstone
West Australian Petroleum Pty Limited

SUMMARY

Samphire Marsh No. 1 Well was drilled to a total depth of 6664 feet as a stratigraphic and structural test in the South Canning Basin.

The drill passed through 120 feet of Quaternary silt and limestone, 2124 feet of Mesozoic sandstone and siltstone, 1811 feet of Permian marine beds, partly of glacial origin, and 2541 feet of Lower Ordovician shale with sandstone at the base. The drill encountered Precambrian granite at 6610 feet, confirming the geophysical estimate of depth to basement.

None of the sediments present in the well are considered likely to be a source for hydrocarbon accumulations. No signs of hydrocarbons were seen in this well.

WELL HISTORY

General Data

Well name and number:	Samphire Marsh No. 1
Location:	Lat. 19° 31' 07.6"S Long. 121° 10' 50.8"E
Name and address of petroleum tenement holder:	West Australian Petroleum Pty Limited Box C 1580, G.P.O., Perth, Western Australia
Petroleum tenement:	Licence to Prospect 53H
District:	South Canning Basin, Western Australia
Total depth:	6664 feet
Plug back depth:	2357 feet
Date spudded:	18th February 1958
Date completed:	4th May 1958
Drilling time:	The time taken to drill intervals of five feet was taken throughout the drilling of the well. One-foot drilling time was taken during coring. For details see Plate 2.
Elevation:	Derrick Floor - 28 feet above M.S.L. Ground - 16 feet above M.S.L. (including 2 feet of earth fill)
Status:	From 2357-2527 feet a cement plug was set across the shoe of the 10 3/4 inch casing. The well was completed as an artesian water well. (see appendix B).

Drilling Data

Drilling contractor:	Oil Drilling and Exploration Ltd.
Rig type, rating:	National 100 Rig (Rig No. 4), rating 11,000 feet using 4 1/2 inch drill pipe.
Hole size, casing:	20 inch hole was drilled to 597 feet. 22 inch conductor pipe was set at 22 feet and 577 feet of 16 inch casing was cemented at 593 feet. 13 3/4 inch hole was drilled to 2480 feet and 2441 feet of 10 3/4 inch casing was cemented at 2458 feet. 9 7/8 inch hole was drilled then to total depth. There were no fishing operations during drilling.
Drilling mud:	A clay-base mud was used for drilling (for details see Plate 1.)

Ditch Cuttings

Samples were collected at 10-foot intervals from the surface to 6190 feet and at 5-foot intervals in the slow drilling section from 6190 feet to T.D. Five-foot samples were taken while coring.

Coring

Twelve cores were cut using a Hughes Type "J" core barrel with hard formation core heads.

Of a total of 126 feet of formation cored, 77 feet (61%) recovered. For detailed core descriptions see appendix A.

Logging

The following Schlumberger logs were run:

Electrical logs:	Run ES1	2475	-	592 feet,	4th March 1958.
	ES2	5053	-	2458 feet,	29th March 1958.
	ES3	6665	-	4940 feet,	3rd May 1958.
Section gauge:	SG1	2466	-	592 feet,	4th March 1958.
Temperature log:		2427	-	110 feet,	6th March 1958.

Formation Tests

No formation test was carried out; for formation fluid reference is made to appendix B.

Deviation Records

See composite well log, Plate 1.

REGIONAL GEOLOGICAL SETTING

The Samphire Marsh No. 1 Well is located near the coast in the southern part of the Canning Basin, 130 miles south-west of Broome.

Outcrop along the coastal strip south of Broome is poor. Most of the land surface is covered with red sand which is formed into large dunes only a few miles inland from the coast. Protruding through this blanket of sand are low ridges and flat-topped hills of lateritised (ferruginised, silicified, and leached) silty sandstones of Mesozoic age. Bedding in these essentially paralic sediments is very poorly developed, but they appear to be sub-horizontal. Along the coast, depressions in the lateritised surface of the Mesozoic sediments have been filled with fossiliferous marine muds and calcarenites of recent age. These outcropping formations give no indication of the structures developed in the underlying Palaeozoic rocks.

To investigate the southern portion of the Canning Basin where there was no evidence of structure in outcrop geophysical surveys were undertaken. An aerial magnetometer survey and a semi-detailed gravity survey were conducted, and linear trends picked up by both these surveys paralleled the Precambrian trends in the King Leopold Ranges, to the north of the Canning Basin, and in the Pilbara Block to the south. This indicated that either

(a) the sedimentary cover was practically featureless and these surveys were only recording variations in the nature of the Precambrian basement, or

(b) structures developed in the sedimentary cover are aligned parallel to the existing Precambrian trends.

A strong, linear feature delineated by both the aeromagnetic and gravity surveys lies just south-west of Mandora Homestead. It has the pronounced Precambrian north-west trend and appears to represent a major down-to-the-north-east fault. To examine this feature further, a refraction profile was shot across it and this shows that the Precambrian basement is only 2,000 feet below sea level to the south-west of the feature, and is probably deeper than 9,000 feet on the north-east side. The B.M.R. Stratigraphic Well No. 4A (Wallal), drilled on the south-west side of this fault, encountered Precambrian rocks at 2,192 feet below sea level after penetrating a normal Mesozoic sequence and a much-reduced Permian succession.

Seismic reflection surveys were carried out as a follow-up to several weak anomalies revealed by the gravity and magnetic surveys. These indicated that the sedimentary section over the south-western part of the Canning Basin was essentially flat-lying but that some structure was present towards the southern margin of the basin. Semi-detailed reflection seismic surveys in the Samphire Marsh area indicated the presence of a large anticlinal nose containing several minor culminations at its north-western end. This anticlinal nose was found to be coincident with a pronounced positive gravity anomaly.

Velocities encountered in refraction profiles in the South Canning Basin suggested that the superficial flat-lying Mesozoic rocks are underlain by Permian sediments, and that these, in turn, are underlain by older sediments which rest on the Precambrian basement. From the nature of the refractors recorded it was suspected that the section beneath the Permian would contain carbonate rocks. Thus it was thought that either Devonian or Ordovician rocks would be most likely to underlie the Permian.

The Samphire Marsh No. 1 well was located on the above-mentioned anticlinal

nose in a structurally high area near the southern margin of the Canning Basin, the main objective being to examine the nature and hydrocarbon content of these older Palaeozoic rocks. It was considered that information gained from the drilling of this well would be of great assistance in assessing the depositional and structural history of the area and hence in assessing its oil-potential.

STRATIGRAPHY

Below are discussed briefly the various rock types (and their depositional environments) which were penetrated in the Samphire Marsh test.*

The section encountered in the well is tabulated below:-

Age	Formation	Depth D.F.	Reduced Level	Thickness
Quaternary	Alluvial silt	14'	+14'	13'
	Bossut Formation	27'	+ 1'	107'
L. Cretaceous	Broome Sandstone	134'	− 106'	425'
Jurassic	Jarlemai Siltstone	559'	− 531'	301'
	Alexander Formation	860'	− 832'	302'
	Wallal Sandstone	1162'	−1134'	1096'
Permian	Grant Formation	2258'	− 2230'	1811'
Lower Ordovician		4069'	− 4041'	2541'
Precambrian	Granite	6610'	−6582'	54'+

Alluvial Silt (14 - 27 feet)

The thirteen feet of calcareous silt penetrated immediately beneath the built-up drilling platform is a product of the recent marine regression along the Eighty Mile Beach. The grey silty salt flats between the coastal dune ridges and the inland red sandy desert were apparently covered by the sea until recently. One of the largest of these is the samphire-covered plain to the north of Mandora Homestead, where the test was drilled.

The regression took place in stages with several periods of stillstand during which sandy beach ridges were built up just above the high tide level. These successive beach ridges are now sand dunes lying parallel to the present coastline and up to two miles inland. One of these ridges lies just to the south-east of the rig site. Excavations near the dune revealed a richly fossiliferous shellbank on the north-western (seaward) side of the dune in an identical position to the present-day shellbanks which lie above mean sea level.

This fossil shellbank proved to be an excellent source of road-building material.

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* The correlations of the strata penetrated with formations exposed on the surface or cut in other wells are those of the author of the completion report and do not necessarily represent the views of the Bureau of Mineral Resources. The subject is discussed in Veevers, J.J. and Wells, A.T., 1961 - The Geology of the Canning Basin, Western Australia. Bur.Min.Resour. Aust.Bull. 60 (in press).

Bossut Formation (27 - 134 feet)*

This sequence of brown-grey, fine to coarse grained calcarenite with lenses of greenish-white calcilutite probably represents the basal transgressive phase of the marine incursion discussed above. The formation contains abundant pelecypods, gastropods, foraminifera and bryozoa of recent aspect. Although no definite age has been assigned to this formation it is probably Pleistocene to Recent and could be the local equivalent of the Coastal Limestone of the Perth Basin. It occurs as infilling of old valleys in the pre-Pleistocene topography, and underlies the whole of the samphire-covered salt marsh.

Examination of samples from seismic shot holes near the edge of the marsh shows that the lateritic profile developed beneath the red sand of the pindan scrub country continues beneath the Bossut Formation. Away from the edge of the marsh, the depth to the pisolitic limonite zone and the underlying mottled zone gradually increases showing that the Bossut Formation merely filled in a pre-existing valley and active erosion of the old land surface did not occur.

Pisolitic limonite was encountered in the Samphire Marsh well from 150 feet to 170 feet.

Broome Sandstone (134 - 559 feet)

This unit of fine to coarse grained sandstone of Lower Cretaceous age is a continental deposit. It contains minor amounts of siltstone, usually in small lenses, but the predominant sedimentary type varies from coarse sandstone to fine conglomerate.

Jarlemai Siltstone (559 - 860 feet)

This widespread marine deposit of Upper Jurassic age is easily recognisable in wells in the South Canning Basin. It is a sequence of glauconitic siltstone and fine, silty sandstone, which separates the overlying coarse, poorly-sorted Broome Sandstone from the coarse, well-sorted sandstone of the underlying Alexander Formation. The siltstone unit from 768 feet to 816 feet is a useful electrical log marker which can be traced in all the wells in the area.

Abundant belemnites are found in this formation.

Alexander Formation (860 - 1162 feet)

This marine unit of Upper Jurassic age is separated from the overlying Jarlemai Siltstone by an increase in grainsize rather than a difference of depositional type. Hence the break between the two formations cannot be picked on the electrical log but must be taken from the lithology of the cuttings. It is mainly a coarse, well-sorted, slightly silty sandstone with small beds of siltstone; glauconite and pyrite are abundant. The main fossils are belemnites and poorly-preserved pelecypods. Pyritised wood fragments occur in the lower coarse siltstone unit of this formation.

Crespin (appendix D) suggests a Lower Cretaceous age for both the Jarlemai Siltstone and the Alexander Formation.

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* Name referred to by Traves, Casey and Wells (1956, p.33) but the formation is defined for the first time in Appendix C of this report.

Wallal Sandstone (1162 - 2258 feet)*

A thick sequence of coarse sandstone with minor siltstone lenses underlies the Alexander Formation.

The thickest section of this sandstone formation is that penetrated in the Samphire Marsh No. 1 well where the formation consists predominantly of coarse sandstone and fine conglomerate, with thin beds and lenses of grey carbonaceous siltstones and black lignite. This continental deposit is very uniform in character - the monotony is only broken by occasional thin highly-resistive beds, probably calcareous sandstones.

Below 2090 feet, thinly bedded carbonaceous siltstones and lignites become more dominant and the unit shows much more evidence of distinct alternation of depositional types. From this point downwards, a considerable amount of the coarse sand mentioned in the description of the cuttings must be taken as caving from above.

Although there was caving of these unconsolidated formations while drilling was in progress, some samples were thought to be sufficiently representative of the formation being drilled to be suitable for palynological determination. Balme (appendix D) assigns an Oxfordian or Kimeridgian age to a sample from 1260 to 1270 feet. Samples from near the base of the formation (from 2190 to 2200 feet and from 2240 to 2250 feet) are assigned a Middle Jurassic age.

Grant Formation (2258 - 4069 feet)

The Mesozoic is underlain by 1811 feet of Lower Permian (Sakmarian) marine glacial and fluvioglacial sediments. The predominant lithology of this sequence is a massively bedded, glacially-derived greywacke-siltstone containing quartz grains of all sizes scattered through a silt matrix. Pebbles of granite, quartzite, chert, jasper, limestone, and other Precambrian rock-types are scattered sporadically in the greywacke lithology. In some beds, the pebbles constitute sufficient of the total rock for it to be called conglomerate.

In sharp contrast to the predominant greywacke-siltstone are thin beds of white, fine to very fine grained, thinly-bedded sandstone. These beds have a slightly calcareous cement but still show considerable porosity and permeability. They are generally lacking in pebble material and probably represent periods when the sorting of bottom sediments by ocean currents was dominant over the influx of terrigenous material. The basal 239 feet of sandstone of the Grant Formation is a very fine-grained, clean sand of this type.

Palynological examination of cores 1 and 2 (Balme, appendix D) indicates a Lower Permian age for these glacially-derived sediments. Thus they are equivalent to the Grant Formation of the Fitzroy Trough and the Braeside Tillite and the Paterson Formation of the south-eastern Canning Basin.

There is some doubt as to the identity of the upper 115 feet of Permian. A characteristic pebble-bearing greywacke-siltstone of the Grant Formation first appears at 2373 feet. Although samples in this zone are poor, because of excessive sand from the overlying Wallal Sandstone in the mudstream, it is thought that the light grey calcareous claystone and siltstone

* New formation, defined in Appendix C of this report.

in the interval 2258-2373 feet could be Upper Permian in age. This may be the case since in B.M.R. No. 4A at Wallal, 30 miles southwest of Samphire Marsh, the shallow Precambrian basement was overlain by 112 feet of Grant Formation and 185 feet of uppermost Upper Permian rocks under a Mesozoic cover. Whatever the age of the rock unit from 2258-2373 feet the character of the electrical log (Plate 1) leaves little doubt that the base of the Mesozoic is at 2258 feet and that the unit from 2258-2373 feet grades into the first greywacke bed of the Grant Formation.

Lower Ordovician (4069 - 6610 feet)

The sequence is composed mainly of thinly laminated grey-green shale. Within the shale are thin contorted lenses of very fine, calcareous, glauconitic sandstone containing grains of orange-coloured microcline. Other thin lenses are of grey, finely recrystallized limestone, in some beds of which the original calcarenite texture can be seen. In the upper part of the section, these calcarenite lenses contain many rolled fragments of fossils, especially thoracic segments of trilobites. The action of bottom currents has apparently sorted most of the fossil fragments into the arenite lenses. The lenses show intricate contortions and minor rupture of bedding planes, probably caused by wholesale movement of the sediments in an unconsolidated state. The deposit as a whole closely resembles the present-day mud flat sediments in the area and appears to have been deposited in a shallow sea, well within the limit of wave-base erosion. The environment of deposition was well oxidised, there being no sign of pyrite within these shaly sediments. Cores from this part of the section had none of the 'sulphide' odour usually associated with silty cores. The proportions of the various rock-types vary in different parts of this essentially homogeneous formation.

(i) From 4069 feet to 4929 feet, the recrystallised calcarenite and fine sandstone lenses are present in roughly equal proportions, and together constitute 20% to 30% of the whole rock.

(ii) From 4929 feet to 5163 feet, the sandstone is virtually absent and the limestone forms 20% of the rock.

(iii) From 5163 feet to 5368 feet, the limestone forms 40% of the rock, and again the sandstone is absent.

(iv) From 5368 feet to 5404 feet, only minor amounts of limestone occur in the shale.

(v) Below 5404 feet, the depositional type gradually changes. Micaceous siltstones are interbedded with the shales in proportions which increase with increasing depth. The fine sandstones become more pronounced and merge with the siltstones so that, although the overall sedimentation becomes coarser, the essential homogeneity of the deposit is retained. Throughout this zone, the colour of the shales and siltstones changes gradually. Reddish and chocolate-coloured lenses appear at 5450 feet and become increasingly dominant with depth.

At 6162 feet, a major change occurs. The lower 448 feet of the Ordovician sedimentation is a hard, well-cemented, siliceous and dolomitic sandstone. Beds within this unit vary from fine to coarse grained and the colour varies from grey-green to pink and tan.

Even this unit is transitional, being micaceous and silty near the top (and containing some poorly-preserved fossils) but changing to a reddish, slightly arkosic, kaolinitic sandstone at the base. The cement varies from calcareous to dolomitic to siliceous and renders most of the formation impervious. A thin zone from 6344 feet to 6399 feet, with a porosity of less than 6%, is the only pervious part of the whole Ordovician section.

Precambrian Granite (6610 - 6664 feet)

The hole bottomed in a coarse-grained, uniform, microcline - plagioclase - hornblende - quartz granite, which is traversed by calcite veins bordered by zones of metasomatic replacement. The granite is presumed to be part of the Precambrian metamorphic complex which underlies the South Canning Basin. *

STRUCTURE AND TECTONIC HISTORY

Structural Evidence in the Well

All cores from Samphire Marsh No. 1 show flat dips, indicating that the well was in a structurally undisturbed position.

No evidence of faulting was seen in the well. Very thin vertical veins of white calcite were noted occasionally in the Ordovician section. This evidence of very minor tensional stress is also seen in the underlying Precambrian granite where metasomatic alteration of the plagioclase and hornblende is associated with it. Thin calcite veins are also found in the lower 300 feet of the Grant Formation.

Temperature Gradient

The rate of increase of temperature with depth can sometimes be used to indicate the tectonic history of an area. Heiland (1946, p. 847) states that the normal temperature gradient varies between 1°F. for every 50 feet of depth and 1°F. for every 64 feet of depth. He considers that, in an area which has only had a thin cover of sediments over the granitic crust throughout its geological history, the heat emitted by the crust is rapidly dissipated through the sedimentary mantle. In areas of thick sedimentation, the great thickness of relatively poor heat-conducting unconsolidated sediments acts as a blanket, storing the heat emitted from the granitic shell. Hence the temperature gradient is higher than normal in areas which have, or used to have, a great thickness of sedimentary rocks and lower than normal in areas where there was never more than a thin veneer of sediments. From the bottom hole temperature readings made by Schlumberger, we find that the bottom hole temperature at the base of the Mesozoic (2480 feet) is 129°F. and that in the Precambrian granite is 160°F. Hence the gradient in the Palaeozoic is 1°F. for each 135 feet of depth - much lower than normal. This low gradient could also be a function of the conductivity of these well-consolidated rocks.

Palynological Evidence of Depth of Burial

Balme (appendix D) mentions the presence of well-preserved hystrichosphaerids

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* Samples of the granite from the bottom of the well were analysed by Dr. Evernden and Dr. Compston, Australian National University. A potassium/argon age of the biotite of 480 million years was determined by Evernden; this is a minimum figure because of the possibility of argon loss during alteration of the granite. A "total rock" rubidium/strontium determination by Compston indicated an age not older than 700 million years and not younger than 500 million years, the older figure being regarded as more likely. The rubidium-strontium determination is based on the assumption that the sample has remained a closed system for rubidium and radiogenic strontium; this assumption is not necessarily invalidated by the addition of alkaline earths during metasomatism. The figures suggest an age late in the Proterozoic or very early in the Palaeozoic. (pers. comm.)

in the upper part of the Ordovician sequence (Core 4). He uses their state of preservation as evidence that the Ordovician was never covered by more than 6000 - 7000 feet of sedimentary load.

RELEVANCE TO OCCURRENCE OF PETROLEUM

Both the Mesozoic and Permian rocks are considered to be genetically unsuitable for the generation of hydrocarbons.

The Lower Ordovician shale section has no porosity. It was deposited in a well-oxidised, shallow-water marine environment, so it is unlikely to be a source for hydrocarbon accumulations. Only a portion of the basal sandstone from 6344 feet to 6399 feet shows any porosity. Both electrical logs and a core cut in this interval show it to be water-bearing.

No signs of hydrocarbons were seen in this well.

CONTRIBUTION TO GEOLOGICAL CONCEPTS

The presence of Lower Ordovician rocks in Samphire Marsh No. 1 adds considerably to our knowledge of the extent of and type of sedimentation associated with the Ordovician sea in the Canning Basin.

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APPENDIX A

CORE DESCRIPTIONS

by

V. Pudovskis

West Australian Petroleum Pty Limited

2457 - 2477 feet CORE NO. 1 - Recovery 11 feet

QUARTZ GREYWACKE, medium to dark grey, poorly sorted; subrounded quartz sand grains, very fine to very coarse, are scattered in poorly sorted silt matrix, with pebbles of granite and quartzite up to 2 inches and some white, angular grains of decomposed feldspar; slightly micaceous; at the top of the core 1/4 inch of SILTSTONE, dark grey to medium grey, very fine; occasional aggregates of pyrite crystals; firm to hard, massive. Flame test negative. No fluorescence. No shows of oil or gas. Dip approximately 2°. Sp. Gr. 2.34 (without big pebbles).

3410 - 3425 feet CORE NO. 2 - Recovery 7 feet

QUARTZ GREYWACKE, dark to medium grey, slightly micaceous, consists of very fine siliceous silt matrix with some scattered angular and subangular quartz sand grains from very fine to coarse, with occasional angular granite pebbles, with light grey beds up to 1 1/2 inches grading into calcareous SILTSTONE containing brown crystals of chlorite; some aggregates of fine crystals of pyrite are scattered through the rock; lenticular marcasitic patches are very common. Greywacke contains abundant dark grey pellets of shale, oriented approximately parallel to bedding, and white spots - probably decomposed feldspar. Rock is hard, compact, very poorly bedded to massive. Some lenses contain dark brownish-grey carbonaceous plant remains. One internal cast of a gastropod was observed in the core. Foraminifera are abundant. No good bedding plane could be observed, but dip seems flat. Flame test negative. No fluorescence. No shows of oil or gas. Sp. Gr. 2.44.

3833 - 3849 feet CORE NO. 3 - Recovery 10 feet

4 feet QUARTZ SANDSTONE, white, fine-grained, well-sorted, quartz grains subangular, some feldspar and jasper grains, slightly calcareous and probably kaolinitic cement, massive, friable, porous; fresh tasting.

3 feet QUARTZ SANDSTONE, as above, slightly micaceous, firm, well bedded, strongly crossbedded, with fragments and thin lenses up to 2mm. of black coal; some closed fractures. Sp. Gr. 2.16.

3 feet QUARTZ SANDSTONE, as 4 feet above, with some grains up to medium size, poorly bedded, friable to very friable. Flame test negative; no shows of oil or gas; no fluorescence. No reliable dip could be observed.

4087 - 4097 feet CORE NO. 4 - Recovery 8 feet

SHALE, dark to medium green-grey, micaceous, slightly calcareous, thinly laminated, fissile, hard, interbedded with lenses and beds up to 2 inches of LIMESTONE, light brownish grey, fine crystalline, with occasional mica flakes. Limestone beds and lenses are mostly contorted, in places showing plastic flow contortions and minute faults. Some limestone lenses contain abundant fragments of trilobites. Shale beds in places contain graptolites and some ostracods. Minute fractures, in places showing slickensiding, are filled with thin veins of white amorphous calcite. Because of contorted lenses no reliable dip could be observed, but very probably the dip is low. Flame test negative. No fluorescence. Sp. Gr. shale - limestone 2.56, Sp. Gr. limestone 2.57. No shows of oil or gas. Probably Emanuel Formation equivalent.

4435 - 4445 feet CORE NO. 5 - Recovery 8 feet

80% SHALE, dark green-grey, slightly micaceous, dense, fissile; grading in part into fine micaceous SILTSTONE; interbedded with thin lenses and beds, no more than 1 1/2 inches thick of

10% (a) LIMESTONE, greyish white, fine-grained crystalline (in part a recrystallized calcarenite), containing abundant fragments of trilobites (seen as cross-sections).

10% (b) SANDSTONE, greenish grey, very fine-grained (grading to siltstone), non-porous with abundant glauconite and an orange mineral (possibly a feldspar), often very micaceous; with a well-developed calcareous cement.

Both the limestone and the sandstone beds occur as thin beds and as jumbled, contorted lenses showing the effects of slumping and distortion immediately after deposition while the sediments were still plastic. The shale and siltstone beds contain numerous compactional slickenside structures from depositional compaction. Some later minor fractures are filled with white calcite.

Fossils include ostracods, numerous thoracic segments and two whole pygidia of trilobites and a flat gastropod.

Sp.Gr. of Shale 2.6. Sp.Gr. of Limestone 2.7. Negative flame, no odour, no shows of oil or gas.

4933 - 4940 feet CORE NO. 6 - Recovery 5 feet

80% SHALE, as in core No. 5, dark green-grey, micaceous, dense, fissile, interbedded with thin lenses and very contorted beds of

20% LIMESTONE, light brownish grey and greenish grey, fine crystalline; with greenish lenses grading into CALCILUTITE. Both shale and limestone contain trilobite fauna. Some limestone beds contain abundant brachiopods. Negative flame test, no odour, no shows of oil or gas. Sp. Gr. (Shale) 2.66. Dip flat.

5432 - 5442 feet CORE NO. 7 - Recovery Nil

5532 - 5544 feet CORE NO. 8 - Recovery 3 feet

70% SHALE, dark grey and dark brown-grey, with occasional thin

lenses with chocolate brown colour, some lenses grading into very fine SILTSTONE, micaceous to very micaceous, slightly calcareous, thinly bedded, fissile, with occasional tubular pyritic nodules; slickensiding common; poorly fossiliferous, only occasional algae (?) and some unidentified fragments of shell; probably occasional graptolites, 4 carbonaceous fragments observed in the core. (Sp.Gr. 2.53). Interbedded with thin (up to 2 inches) very contorted beds, nodules and occasional breccia beds.

30% LIMESTONE, light brown-grey and greenish grey, fine crystalline, probably recrystallised CALCARENITE; some greenish beds grading into CALCILUTITE, occasional glauconite grains; in parts some greenish beds contain silt, very fine sand grains and mica flakes, occasional lenses grading into fine very calcareous SANDSTONE, very occasional unidentified fossil fragments. Sp.Gr. 2.69. Dip flat. Flame test negative. No shows of oil or gas.

5849 - 5859 feet <u>CORE NO. 9 - Recovery 10 feet</u>

10% Thinly interlaminated SHALE, and

30% SILTSTONE, dark grey-green (when wet) and dark grey (when dry) micaceous to very micaceous, with abundant white and green mica partings; bedding planes are contorted, mostly wavy. This sequence is inter-laminated with

40% SANDSTONE, green-grey, very fine - grading into quartz SILTSTONE, micaceous, very calcareous with abundant calcitic cement, with green grains (glauconite?) and orange-coloured grains; non-porous; section interbedded with contorted beds up to 3 inches of

20% LIMESTONE, light brown-grey, fine to medium crystalline, micaceous, sandy and silty, hard; some of these beds grade into SANDSTONE, very calcareous, very fine, micaceous with white and green mica, with green grains of glauconite? or chlorite? and orange-coloured grains of an unidentified mineral. In parts, limestone appears as large irregular nodules. Some very fine closed fractures. Only very rare fossil fragments (brachiopods?) observed in the core. Some carbonaceous fragments of graptolites (?). Dip very probably flat. Flame test negative. No shows of oil or gas. Sp.Gr. 2.68 (shale and siltstone and sandstone). Sp.Gr. 2.66 (limestone grading into sandstone).

6182 - 6184 feet <u>CORE NO. 10 - Recovery 2 feet</u>

90% SANDSTONE, light to medium grey, fine to very fine-grained, angular quartz grains, pyritic, non-porous, hard, calcareous and dolomitic grading into DOLOMITE, fine, crystalline, sandy. Sandstone in places contains siliceous cement and looks like quartzite; with 10% very contorted partings and lenses up to 8 mm. of dark grey micaceous SHALE, some thin veins of white calcite. Core fairly fossiliferous, containing brachiopods and some graptolites. Flame test negative. No shows of oil or gas. Dip probably flat. Sp.Gr. 2.66.

6387 - 6397 feet <u>CORE NO. 11 - Recovery 10 feet</u>

10 feet QUARTZ SANDSTONE, with beds grading from dark to light brownish red, fine to medium grained, with some thin beds grading into coarse sandstone, poorly to moderately sorted, quartz grains sub-angular to

sub-rounded, non-porous, micaceous, with kaolinitic and calcareous cement; some hard medium and light-brown red beds contain calcitic cement in patches; crossbedded; brown and red sandstone contains occasional thin lenses of light grey-green, very micaceous, calcareous SILTSTONE, and hard light green-grey lenses up to 1/2 inch, of SANDSTONE, fine to coarse grained, with calcareous and some siliceous cement. Size of mica flakes varies from fine to coarse; light-coloured beds are harder than dark-coloured; closed, nearly vertical fractures are filled with thin, about 1 mm., veins of white calcite. Some very micaceous, clayey partings indicate slight slickensiding. Because of crossbedding no reliable dip could be observed. No fossils observed. Flame test negative; no shows of oil or gas. Sp.Gr. (light-coloured) 2.59, (dark-coloured) 2.51. Rock resembles lower part of Emanuel Formation in B.M.R. No. 3, Prices Creek.

6659 - 6664 feet <u>CORE NO. 12 - Recovery 3 feet</u>

100% GRANITE, pinkish, very coarse grained, even grained, dense, non-porous, with vertical fractures filled with white calcite. Consists of a granitic-textured crystalline aggregate of subhedral pinkish-orange MICROCLINE (40%) associated with white PLAGIOCLASE (30%) and subhedral greenish black HORNBLENDE (20%) and minor bluish to clear quartz (10%). Contains small (1 inch diameter) xenoliths of fine-grained hornblende granite and (in samples) hematitic quartzite. A zone 1 inch wide on each side of a minor calcite vein shows metasomatic alteration of the plagioclase to yellow-green SAUSSURITE and of the hornblende to a deep green aggregate of SERICITE and CHLORITE. This rock resembles the granitic cores of the large anticlinal structures in the eastern Pilbara area, south of Port Hedland. Sp.Gr. 2.69; No shows of oil or gas.

APPENDIX B

FORMATION FLUID

Prior to releasing the rig, several zones of the Jurassic were perforated to provide an artesian water well for Anna Plains Station.

Four perforations per foot were made in the 10 3/4 inch casing over the interval 900 - 924 feet. The initial water flow was 3000 gallons per hour but this steadily decreased, then stabilised at 500 gallons per hour.

Perforation of the interval 1090 - 1102 feet with 48 shots increased production to 720 gallons per hour and yet another perforation, this time of the interval 730 - 742 feet increased the flow to 850 gallons per hour.

An analysis of fluid from the interval 900 - 924 feet is given below:

Lab. No:	9021
Reaction	Neutral
pH	7.6
Appearance	-
Colour	-
Odour	-
Ferrous iron	-

Grains per gallon

Total soluble salts (by evaporation)	127
Sodium chloride (calculated from chloride)	91

APPENDIX C

DEFINITIONS OF NEW FORMATION NAMES

BOSSUT FORMATION

This formation, previously referred to by Traves, Casey & Wells (1956, p.33), is here defined for the first time.

The definition was prepared by A.W. Linder in 1956 for the Western Australian Committee on Stratigraphic Nomenclature.

NAME	:	BOSSUT FORMATION (Named for Cape Bossut; long. 121°37'E, lat. 18°43'S).
REFERENCE	:	WAPET Annual Report by Party GC, 1954 (unpub.)
DISTRIBUTION	:	Coastal exposures at Port Hedland, Pardoo, headlands north of Eighty Mile Beach, including Cape Bossut, to Cape Villaret, headlands on west coast of Dampier Land.
MAP REFERENCE	:	4 mile sheets; Pender, Broome, La Grange, Mandora, Port Hedland, in preparation by Wapet.
LITHOLOGY	:	Quartzose calcarenite, calcarenite, calcareous oolite as lithified dune, beach and off-shore bar deposits.
CONTACTS	:	Overlies 'Frezier Sandstone' and 'Parda Formation' with an erosional disconformity.
AGE	:	Recent (based on coral determinations).

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LINDER, A.W., & DREW, B.J., in McWHAE, J.R.H., PLAYFORD, P.E., LINDER, A.W., GLENISTER, B.F., & BALME, B.E.	1958	The stratigraphy of Western Australia J. geol. Soc. Aust. 4(2), 161pp.
TRAVES, D.M., CASEY, J.N., and WELLS, A.T.	1956	The geology of the South-Western Canning Basin, Western Australia. Bur.Min. Resour.Rep. 29.

WALLAL SANDSTONE (New Name)

Definition by J.R.H. McWhae

Definition: The name Wallal Sandstone is proposed for the sequence of sandstone with subordinate siltstone, conglomerate and lignitic beds which occurs in the western part of the Canning Basin conformably underlying a generally fine-grained marine siltstone-sandstone unit of Upper Jurassic age (Alexander Formation) and unconformably overlying Permian and Carboniferous sediments (also Palaeozoic dolomite breccia in the case of Frome Rocks No. 1

Well, WAPET). The type section of the formation is taken as that occurring in the Bureau of Mineral Resources Stratigraphic Well No. 4A (Wallal) (19° 44' S., 120° 44 1/2' E.) between 915 and 1927 feet.* The name of the formation is derived from Wallal Station, on which this well was drilled.

The following is a general description of the section from 915 to 1927 feet:

Alexander Formation: claystone, hard calcareous, overlies conformably -

Wallal Sandstone (1012')		Thickness Feet
915' to 1650'	Sandstone, light grey to green grey, coarse-grained, poorly sorted, slightly consolidated. Also minor beds of fine-grained sandstone; claystone, black, carbonaceous; siltstone; lignite in thin seams. Pyrite nodules, pyritic sandstone nodules and pyritized wood fragments are common.	735
1650' to 1800'	Sandstone, white friable, medium to coarse-grained, moderately-sorted, subangular to subrounded grains and with negligible cement.	150
1800' to 1927'	Claystone and siltstone, light grey with some sandstone beds. The sandstone is white, friable, medium to coarse-grained as above and occurs in beds from 1822' to 1833' and from 1852' to 1869'. The basal siltstone-sandstone beds are very micaceous and pyritic, with carbonaceous fragments.	127
	Unconformably underlying the above is shale, black, micaceous, carbonaceous, of Permian age.	

Stratigraphic Relationships, Distribution and Thickness

The Wallal Sandstone rests with apparent conformity beneath fine-grained marine clastics apparently of Upper Jurassic age (Alexander Formation) and rests unconformably on Palaeozoic sediments. It can be correlated readily by its lithology, electrical and gamma ray-neutron log character, and age in the following wells:

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* The formal name Wallal Sandstone has not been recognised as a separate formation by Bureau of Mineral Resources geologists in the BMR 4A Wallal Stratigraphic Bore, nor has the name been used in Veevers, J.J., and Wells, A.T., (1961), "The Geology of the Canning Basin, Western Australia", Bur.Min.Resour.Aust.Bull. 60.

Well	Top feet	Bottom feet	Thickness feet	Underlying Unit
B.M.R. 4 Wallal	917	1410	493+	Bottom not reached.
B.M.R. 4A Wallal	915	1927	1012	Permian
WAPET Wallal Corehole 1	700	1014	314+	Bottom not reached.
WAPET Samphire Marsh 1	1162	2258 (or 2373?)	1094 (or 1211?)	Permian
WAPET Goldwyer 1	1042	1535	493	Permian
WAPET Roebuck Bay 1	970	1567	597	Permian
WAPET Barlee 1	1062	1594	532	Carboniferous
WAPET Fraser River 1	425	718	293	Permian (?)
WAPET Dampier Downs 1	484	1037	553	Permian
WAPET Frome Rocks 1	547	734	187	Carboniferous or older (dolomite breccia)
WAPET Thangoo 1	814	1380	566	Permian
WAPET Thangoo 1A	827	1405	578	Permian

No cores were cut in the Wallal Sandstones in WAPET Samphire Marsh 1 and the base is not clearly defined, probably being at 2258 feet but 2373 feet being a possible alternative. In B.M.R. 4 and 4A (Wallal), on the other hand, ten cores were cut at intervals of approximately 100 feet and the upper and lower limits of the formation (in 4A) can be seen clearly in the electrical logs. Few cores were taken of the Wallal Sandstone in the remaining WAPET wells. It is for these reasons that the type section of the Wallal Sandstone is referred to B.M.R. 4A (Wallal) Well.

No certain correlation can be made between the Wallal Sandstone, a sub-surface unit defined largely by electrical logs, with the outcropping sandstone formations, but the following correlations are possible: Jurgurra, Mudjalla and Callawa Sandstones.

Fossils and Age:

Fossils are rare in this unit with the exception of plant spores and other microfloral remains. Determinations by Mr. B.E. Balme suggest an age range from Bathonian or Bajocian to Kimeridgian. Some microplankton and arenaceous foraminifera are present.

Environment of Deposition: The unit appears to have been deposited in a paralic, largely shallow-water, marine environment due to the presence of some marine microfossils and minor calcareous cement through the section.

Repository of cores and electric logs: All cores and electrical logs from the type section in the Bureau of Mineral Resources Stratigraphic Well No. 4A (Wallal) are stored by the Bureau of Mineral Resources, Canberra.

APPENDIX D

PALAEONTOLOGICAL REPORTS

FORAMINIFERA FROM SAMPHIRE MARSH NO. 1, CANNING BASIN

By Irene Crespin, Bureau of Mineral Resources

Cores and cuttings from the surface down to the depth of 4,100 feet were examined for foraminifera. Only three cores were available. Core 1 was taken at the depth of 2,457-2,477 feet, Core 2 from 3,410-3,425 feet and Core 3 from 3,833-3,848 feet. The cuttings from the surface down to 600 feet and from 2,000 feet down to 4,100 feet were examined by D.J. Belford and his observations are noted in this report. Foraminifera of both Lower Cretaceous and Permian age were found in the well. The Permian species found in Core 2 are referred to the Grant Formation of the Fitzroy Basin. No reference is made to the stratigraphical units of the Canning Basin in which the well is situated (see Traves, Casey and Wells, 1956).

A summary of the lithology together with the microfauna recognised in the samples is given below. Unless indicated, all samples are represented by cuttings.

0-600 feet	Conglomerate, sandstone, quartz greywacke and friable sand. No foraminifera.
600-740 feet	Grey sandstone. No foraminifera.
740-750 feet	Sandstone with some glauconite and a few foraminifera with tests stained brown and partly replaced with pyrite (*Robulus* sp., *R.* cf. *gunderbookaensis* (Crespin)).
750-790 feet	Sandstone with some glauconite and with fragments of belemnites.
790-800 feet	Grey silty sandstone with abundant glauconite grains and glauconitic replacements of foraminifera and radiolaria. Foraminifera: *Haplophragmoides* sp. Radiolaria: *Cenosphaera* sp. *Dictyomitra* aff. *australis* Hinde *Porodiscus* sp.
800-890 feet	Sandstone, with a little glauconite. No recognizable fossils.
890-900 feet	Glauconitic sandstone with abundant glauconitic replacements of radiolaria (*Cenosphaera* sp., *Dictyomitra* aff. *australis*).
900-1,090 feet	Sandstone with foraminifera rare (Haplophragmoides sp. at 1,040-1,050 feet).

1,090-1,200 feet	Hard brown, pyritic sandstone with tests of Haplophragmoides sp. at 1,090-1,100 feet and 1,130-1,140 feet, and several tests of Haplophragmoides chapmani Crespin, at 1,140-1,150 feet. Fragments of Belemnites at 1,140-1,150 feet.
1,200-1,600 feet	Friable sandstone with several tests of foraminifera (Ammobaculites fisheri Crespin, A. minimus Crespin, Haplophragmoides chapmani) at 1,490-1,500 and at 1,540-1,550 feet (? derived).
1,600-2,000 feet	Coarse pebbly sandstone with single tests of Ammobaculites fisheri at 1,840-1,850 feet and 1,990-2,000 feet (? derived).
2,000-2,190 feet	Sandstone with occasional pebbles. No foraminifera.
2,190-2,200 feet	Carbonaceous quartz sand. No foraminifera.
2,200-2,460 feet	Quartz greywacke. No foraminifera.
2,457-2,477 feet	CORE 1. 11 feet recovery. Quartz greywacke. No foraminifera.
2,490-3,410 feet	Sandstone, loose sand, siltstone and greywacke. No foraminifera.
3,410-3,425 feet	CORE 2. 7 feet recovery. Samples were taken from four sections of the core. (1) From near the depth tag at the bottom of the core. Siltstone with small quartz pebbles and numerous tests of arenaceous foraminifera on fractured surface of core. Foraminifera abundant in washings. Hippocrepinella biaperta Crespin (common) Hyperammina callytharraensis Crespin (common) Hyperammina elegans Cushman and Waters (common) Hyperammina expansa (Plummer) (few) Involutina cf. nitida (Parr) (few) Reophax sp. (rare) (2) 1 foot above sample 1. A 3-inch band of fine brownish calcareous siltstone. No foraminifera. (3) Middle of core section. Grey siltstone with small quartz pebbles, a little pyrite and numerous tests of arenaceous foraminifera on fractured surface of core. Foraminifera abundant in washings. Hippocrepinella biaperta Crespin (Very common) Hyperammina callytharraensis Crespin (common) Hyperammina expansa (Plummer) (common) Hyperammina hadzeli Crespin (few) Involutina cf. nitida (Parr) (common and crushed) Proteonina arenosa Crespin (very common) Reophax asperus Cushman and Waters (common) Reophax sp. nov. aff. R. expiatus Plummer (common)

Thuramminoides sphaeroidalis Plummer (few)
Thuramminoides teicherti (Parr) (rare)

(4) Top of core. Reddish sandy siltstone with arenaceous foraminifera, not as common as in sample 3.

Hippocrepinella biaperta Crespin
Hyperammina callytharraensis Crespin
Hyperammina expansa (Plummer)
Involutina cf. nitida (Parr)
Reophax sp.
Thuramminoides sphaeroidalis Plummer

3,833-3,849 feet — CORE 3. 10 feet recovery. Cream sandstone consisting of clear, angular quartz grains of almost uniform size and shape. No foraminifera.

3,900-4,100 feet — Sandstone and siltstone. No foraminifera.

Note on the Foraminifera

No foraminifera were found in the cuttings until the depth of 750-750 feet, after which they were noted down to the sample at 1,990-2,000 feet. However it is possible that the tests occurring below the depth of 1,200 feet may be derived by caving from the higher beds.

The samples from 740 feet down to 900 feet with foraminifera and abundant glauconitic replacements of radiolarian tests are Lower Cretaceous in age and may be correlated with the lower Gearle Siltstone or the Windalia Radiolarite of the Carnarvon Basin. Fragments of belemnites occur at 750-790 feet and at 1,140-1,150 feet. The species of arenaceous foraminifera recorded have been described by Crespin (1944, 1953).

The hard brown pyritic sandstone between 1,090 feet and 1,200 feet, which contains tests of Haplophragmoides may be the equivalent of the Muderong Formation of the Carnarvon Basin. This hard band may represent a time break.

No foraminiferal evidence for the age of the beds between 1,200 feet and the second core taken at 3,410-3,425 feet is available. Arenaceous foraminifera of Lower Permian age are abundant in Core 2 at 3,410-3,425 feet, and the general assemblage is of interest because the beds in which they occur are considered to belong to the Grant Formation of the Fitzroy Basin.

Two distinct assemblages are present. The first, sample (1), is dominated by tests of Hyperammina callytharraensis which is common at the type locality for the Callytharra Formation, Carnarvon Basin. Sample (3) from the middle of the core section, is dominated by tests of Hippocrepinella biaperta, Reophax asperus, a new species of Reophax, and Proteonina arenosa. Hyperammina callytharraensis is fairly common. The genus Hippocrepinella has not previously been found in the Permian of Western Australia; but the species H. biaperta Crespin has been described from beds low in the Permian sequence of northern Tasmania. Proteonina arenosa Crespin is very common in beds of the Artinskian Madeline Formation of the south-east Carnarvon Basin, from whence it was described. Up to the present no foraminifera have been found in the surface tillitic beds of the Grant Formation of the Fitzroy Basin nor in the Braeside Tillite of the Canning Basin. A few forms, not very well preserved, have been found in the stratigraphically equivalent beds of the Lyons Group, Carnarvon Basin, and in the Nangetty formation of the Irwin Basin. However, these specimens provide no evid-

ence for a long distance correlation with the subsurface beds in the Samphire Marsh No. 1 well which have been referred to the Grant Formation.

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PALYNOLOGICAL EXAMINATION OF

SAMPLES FROM SAMPHIRE MARSH No. 1

by

B.E. Balme

University of Western Australia

Six samples of cuttings and cores from the Samphire Marsh No. 1 Well were received for palynological examination. All these, with the exception of a graptolite-bearing shale, yielded spores and pollen grains which, within fairly broad limits, allow the sediments to be dated. Evidence obtained from cuttings must always be somewhat suspect as contamination is almost unavoidable and when dealing with microfossils as small as spores, even minor contamination may cause serious misinterpretation of microfloral evidence.

Sample 1

Cuttings including coaly fragments and carbonaceous shale.

Interval: 1260 - 1270 feet

Quality of separation: Good

Microfloral List

Lycopodiales

Lycopodiumsporites austroclavatidites (Cookson)

Filicinae

Gleichenia-type spores
Cyathidites minor Couper
C. australis rimalis Balme
Cicatricosisporites cooksoni Balme
Osmundacidites comaumensis (Cookson)
Microreticulatisporites telatus Balme

Coniferophyta and Caytoniales

Araucariacites australis Cookson
Pityosporites spp.
Caytonipollenites pallidus (Reissinger)
Zonalapollenites dampieri Balme
Z. trilobatus Balme
Classopollis torosus (Reissinger)

Dinoflagellata

Gymnodinium sp. cf. G. crystallinum Deflandre
Wanaea sp.
? Gonyaulax sp.
Pareodina aphelia Cookson and Eisenack

Remanié types

Spores of Permian and probable Upper Devonian age occur occasionally in the slides.

Environment of Deposition

Probably at least partly marine.

Age

The assemblage is of Upper Jurassic age, and in both its spore and dinoflagellate content resembles those from the lower part of the Jarlemai Siltstone in the Broome artesian bores. Comparisons may also be drawn with microfloras from the Dingo Claystone and Learmonth Formation in the Carnarvon Basin.

An Oxfordian or Kimeridgian age is suggested.

Sample 2

Cuttings, including coaly material and grey shale.

Interval: 2,190 - 2,200 feet

Quality of separation: Good

Microfloral List

Filicinae

Cyathidites minor Couper
C. australis rimalis Balme
C. crassiangulatus Balme
Concavisporites jurienensis Balme
Ischyosporites sp.
Laevigatisporites cf. L. neddeni (Potonie)

Coniferophyta

Zonalapollenites dampieri Balme
Z. segmentatus Balme
Pityosporites spp.

Classopollis torosus (Reissinger)
Inaperturopollenites turbatus Balme

Environment of Deposition: Probably continental.

Age

The microflora is certainly Jurassic although it differs somewhat from any previously examined. Abundant specimens of Concavisporites and the presence of Inaperturopollenites turbatus and Zonalapollenites segmentatus suggest a pre-Oxfordian age. On the other hand the assemblage appears younger than any from the Cockleshell Gully Formation in the Perth Basin.

A Middle Jurassic age is tentatively suggested.

Sample 3

Cuttings: grey sandy siltstone

Interval: 2,240-2,250 feet.

Quality of Separation: Microfossils poorly preserved.

Microfloral List

Filicinae

Cyathidites minor Couper
C. australis rimalis Balme
Concavisporites jurienensis Balme

Coniferophyta

Zonalapollenites dampieri Balme
Pityosporites spp.
Classopollis torosus (Reissinger)
Inaperturopollenites turbatus Balme

Environment of Deposition: No evidence of marine origin.

Age

Although spores were plentiful their preservation was not good and precise identification of many of the specimens impossible. The assemblage is basically similar to that in sample 2 and may also be of Middle Jurassic age.

Sample 4

Grey sandy siltstone.

Interval: Core 1; 2,457 - 2,477 feet

Quality of Separation: Good

Microfloral List

Pteridophyta

Punctatisporites gretensis Balme and Hennelly
Cirratriradites spp.
C. splendens Balme and Hennelly
Leiotriletes sp.
Apiculatisporites cornutus Balme and Hennelly
Granulatisporites n. sp.

Spermatophyta

? Cycadophyta

Entylissa sp. cf. E. cymbatus Balme and Hennelly

? Pteridospermae

Nuskoisporites gondwanensis Balme and Hennelly
Vestigisporites sp. cf. V. rudis Balme and Hennelly
cf. Potoniesporites sp.
Lunatisporites sp. – Lueckisporites (s.l.)
Pityosporites n. sp.

Environment of Deposition: Probably continental.

Age:

The assemblage is of Lower Permian age and is considered to be no younger than lower Artinskian. The most abundant genera are Nuskoisporites, Potoniesporites and Punctatisporites, all of which are abundant in the upper part of the Grant Formation in the Fitzroy Basin. A correlation with the Grant Formation is clearly indicated and the sample is, therefore, considered to be of Sakmarian age.

Sample 5

Grey sandy siltstone.

Interval: Core 2; 3,410 - 3,425 feet.

Quality of separation: Spores rare, preservation fair.

Microfloral List:

Pteridophyta

Punctatisporites gretensis Balme and Hennelly
P. sp.
Leiotriletes sp.

Spermatophyta

Nuskoisporites sp.
Pityosporites n. sp.

Environment of Deposition: Probably continental.

Age:

The assemblage is insufficiently diverse to yield clear direct evidence as to its age. However, the forms listed are all typically Permian and this sample is also considered to come from the Grant Formation.

Sample 6

Black shale with graptolites.

Interval: Core 4

Age: Lower Ordovician.

This sample yielded on maceration a fairly rich assemblage of hystrichosphaerids. At least five forms bearing various types of spinose ornament were present. These were fairly distinctive species and may be of some value in recognising Ordovician strata in the absence of invertebrate fossils.

Definite spores were absent, although certain small, smooth spherical bodies could represent primitive, alete, cutinised spores.

The presence of well-preserved hystrichosphaerids and other organic entities in the sample is of some interest in that it implies a simple structural history for the area. The substances of which these organisms are composed, although they are resistant chemically, are destroyed fairly easily by physical processes such as temperature and pressure. It is likely therefore that the Ordovician sediments have never been deeply buried during their geological history. The maximum cover in the Ordovician was probably never more than about 6,000 - 7,000 feet.

CONODONTS FROM SAMPHIRE MARSH NO. 1

by

Brian F. Glenister & W.M. Furnish

State University of Iowa, Iowa City, Iowa

Five cores from Samphire Marsh No. 1 Well were digested in a 20% concentration of acetic acid. Cores 4 and 6 provided satisfactory residues which yielded numerous specimens of a large variety of conodont species. Cores 8, 10 and 11 produced only small residues, and these were barren of microfossils.

Core 4, 4,087-4,097 feet

Drepanodus arcuatus Pander, 1856
Drepanodus homocurvatus Lindström, 1954
Drepanodus subarcuatus Furnish, 1938
Drepanodus suberectus (Branson & Mehl), 1933
Oistodus abundans Branson & Mehl, 1933
Oistodus inaegualis Pander, 1856
Oistodus longiramis Lindström, 1954
Paltodus comptus Branson & Mehl, 1933
Scolopodus quadraplicatus Branson & Mehl, 1933
Scandodus n. sp.
Gothodus n. sp.
Oepikodus smithensis Lindström, 1954
Periodon sp.
Prioniodus elegans Pander, 1856
Roundya sp.
n. gen. aff. *Roundya*
?*Trichonodella* sp.

Core 6, 4,933-4,940 feet

Scolopodus rex Lindström, 1954
?*Prioniodina* sp.

Core 8, 5,532-5,544 feet

Barren

Core 10, 6,182-6,184 feet

Barren

Core 11, 6,387-6,397 feet

Barren

The conodont fauna recovered from Core 4 closely resembles that of the Roebuck Dolomite in the Broome area (Glenister & Glenister, 1958). Many of the Samphire Marsh species are also found in the, as yet undescribed, abundant and varied conodont faunas of the Emanuel Formation. The closest known affinities with foreign faunas are with those of the Lower Ordovician of south-central Sweden (Lindström, 1954) and comparable strata in the Southern Uplands of Scotland (Lamont & Lindström, 1957).

The most distinctive elements of the Samphire Marsh fauna are the species of Gothodus and Oepikodus. Comparable forms occur in both the late Tremadocian and Arenigian portions of the Planilimbata Limestone of Sweden, and a similar age may be assigned to the conodont-bearing strata of the Samphire Marsh section. The Arenigian age is the more probable, and a divergence as great as early Tremadocian or Llanvirnian is considered unlikely.

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PRELIMINARY REPORT ON LOWER PALAEOZOIC

FOSSILS OF SAMPHIRE MARSH No. 1

by

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Lower Palaeozoic fossils were determined (Tomlinson 1958) in the following cores of Samphire Marsh No. 1, Western Australia:

CORE 4 (4,087 - 4,097 feet)	-	Lower Ordovician - Arenigian Early ½ Arenig
CORE 5 (4,435 - 4,445 feet)	-	Lower Ordovician - Arenigian
CORE 6 (4,933 - 4,940 feet)	-	Lower Ordovician - possibly Arenigian, but perhaps uppermost Tremadocian.
CORE 8 (5,532 - 5,544 feet)	-	Lower Ordovician - Tremadocian
CORE 9 (5,849 - 5,859 feet)	-	Lower Ordovician - Lower Tremadocian OR late Upper Cambrian Early Arenig
CORE 10 (6,182 - 6,184 feet)	-	Ditto

There was no recovery from Core 7 (5,432 - 5,442 feet), and Core 11 (6,387 - 6,397 feet) contained no visible fossils.

The Samphire Marsh sequence provides a number of new records of fossils, both for Western Australia and for Australia as a whole. Most important is the discovery of a determinable graptolite, Tetragraptus cf. similis (Hall), at the top of the sequence, which provides a ceiling, and excludes the possibility of a Middle Ordovician age.

As in other Ordovician sequences of northern Australia, the fossiliferous horizons can be dated within wide limits only. Moreover, the Samphire Marsh fossils are so unusual that none can be compared directly with the few described Ordovician fossils from northern Australia, and few are comparable with undescribed Upper Cambrian and Ordovician fossils known to me.

Correlation is complicated by the large proportion of undescribed genera: at least three can be detected from a preliminary study, and more may be revealed when the faunas are studied in detail. A further difficulty arises from the occurrence of three fossils outside the known stratigraphic ranges of these, or similar, fossils.

Fossil content and ages of cores

The accompanying table summarizes the fossil content and estimated ages of Cores 4, 5, 6, 8, 9 and 10. The results of palaeontological examination are set out in more detail below.

In the table, fossils are arranged in the order of first appearance. Generic identification is not always possible, and therefore many of the fossils are referred to higher taxonomic categories. It is not intended to imply that identical fossils occur in neighbouring cores; on the contrary, with few exceptions, the genera in every core are distinct, but no more exact identification of these fossils is possible at present.

CORES 9 & 10

Core 10 contains only one fossil (apart from the ubiquitous "worm" castings) -- the inarticulate brachiopod Lingulella. Core 9 contains a more varied fauna: Lingulella (probably a different species from that in Core 10) is supplemented by an orthoid brachiopod (Orusia?), a ribeirioid (cf. Genus B.), and trilobites.

Age: None of the fossils permits exact dating. They indicate an age within the limits of late Upper Cambrian and early Tremadocian (lowermost Ordovician). Lingulella is a long-ranging genus and by itself is not diagnostic; Orusia, if confirmed, would indicate a Cambrian age, although superficially similar brachiopods are known in the early Ordovician; the ribeirioid (cf.Genus B), if judged by Australian standards would favour a Cambrian age, but, once again, similar forms are known in the early Ordovician of North America and southern Manchuria; finally, the trilobites, ordinarily the most reliable index fossils, are too fragmentary to identify. Palaeontological evidence for age, therefore, is inconclusive, but Core 9 cannot be younger than early Tremadocian, and may be older. The stratigraphic relationship of Core 10 to Core 9 - about 320 feet lower in well compacted sediments - strongly suggests that Core 10, at least, is of Cambrian age.

CORE 8

Two species only can be detected in Core 8 - the ribeirioid Technophorus? and the solenopleurid trilobite Hystricurus. This is the only core in which brachiopods are absent. Ostracods are also missing (an important difference from the younger cores).

Age: Core 8 is dated as "Ordovician - Tremadocian". The presence of Hystricurus establishes the lower Ordovician age and excludes the possibility of a Cambrian age. Hystricurus is known to range into the Arenigian, although most of the described species are Tremadocian.

Hystricurus is a genus of world-wide distribution. In Australia it is known to occur in Victoria (Singleton in Lindner, 1953) and in the Northern Territory (unpublished); both are considered to be Tremadocian in age. As the species are not described, no comparison with the Samphire Marsh forms is possible at present.

Within the Samphire Marsh sequence, Hystricurus occurs at two levels; the upper level (Core 5, q.v.) is reliably dated as Arenigian, and the occurrence of Hystricurus at this

TABLE - Lower Palaeozoic fossils in Samphire Marsh No. 1

10 6182-6184 ft	9 5849-5859 ft.	8 5532-5544 ft.	9 4933-4945 ft.	5 4435-4445 ft.	4 4087-4097 ft.	Cores / Fossils
						annelid? castings
						Lingulella (brach.)
						Orusia? (brach.)
						ribeirioid cf. genus B
						trilobites indet.
						Technophorus? (rib.)
						Hystricurus (tril.)
						possible graptolite fragments
						aff. Ptychopyge (tril.)
						aff. Kayseraspis (tril.)
						inarticulate brachiopods indet.
						orthoid brachiopods indet.
						pliomerid trilobites indet.
						asaphid trilobites indet.
						ostracods indet.
						beyrichioid ostracods indet.
						Pseudotechnophorus? (tril.)
						cf. Tropidodiscus (gast.)
						pliomerid trilobite, n. gen.
						aff. Asaphus raniceps (Dalman) (tril.)
						Lachnostoma? (tril.)
						Scolopodus (con.)
						cheirurid? trilobite (immature)
						aff. Goniophora (pel.)
						Temnograptus? (grapt.)
						oboloid brachiopod indet.
						Ctenodonta? (pel).
						pelecypods indet.
						gastropods indet.
						Plumulites (mach.)
						illaenid trilobite indet.
						Dionide? (tril.)
						Tetragraptus cf. similis (Hall) (grapt.)
						conodonts indet.
Upper Cambrian or early Tremadocian (Ordovician)		Ordovician (Tremadocian)	Ordovician (late Tremadocian or early Arenigian)	Ordovician (Arenigian)		Age / Fossils

level probably corresponds to the upper limit of the known range of the genus. Core 8 is 1,087 feet below Core 5, and this relationship strongly suggests a Tremadocian age for Core 8.

The ribeirioid Technophorus? is close to a form occurring in the Alice Springs area and dated by Öpik (1956, p.47) as "possibly Tremadocian or Upper Cambrian".

The absence of ostracods, which are common in all the higher cores (4, 5, and 6), may have stratigraphic significance, as ostracods are not known to occur in rocks older than late Tremadocian.

Finally, the stratigraphic interval of 592 feet between Core 8 and Core 6, which is not younger than early Arenigian, also strongly suggests a Tremadocian age for Core 8.

A Tremadocian (as distinct from an Arenigian) age for the Samphire Marsh specimens thus seems probable.

CORE 6

The fossils of Core 6 present a striking change from Core 8. Hystricurus and Technophorus? are absent and are replaced by a varied fauna of asaphid and pliomerid trilobites, ostracods, and possible graptolites. All these groups make their first appearance in this core. Fragmentary brachiopods are also present. Unlike Cores 4 and 5, Core 6 contains no molluscs.

At least three genera of asaphids are present (indicated by pygidia): one of these cannot be determined at present; another (aff. Ptychopyge) is almost certainly new; and the third (with a barbed terminal spine), though provisionally assigned to Kayseraspis, may prove to belong to a different genus when studied in detail. Asaphid cranidia and free cheeks are also present but cannot yet be assigned to the pygidia mentioned above. Another cranidium (not listed) seems to have some of the characters of an asaphid combined with the glabellar furrows characteristic of another family - the Remopleurididae. The pliomerid trilobites are too fragmentary for generic identification. The ostracods are extremely small (probably immature instars), and even the family is in doubt. The graptolites are too fragmentary for determination.

Age: Because of the lack of firm identifications, the exact age of Core 6 is in doubt. The presence of ostracods, however, gives a lower limit: ostracods are not known to occur in rocks older than late Tremadocian.

The trilobites do not permit an exact age determination. Asaphids are, of course, zone fossils in Europe, where the species are well known. In the present sample, however, even the genera are uncertain, and thus these trilobites cannot yet be used for exact dating. The presence of a Ptychopyge-like trilobite may suggest an Arenigian age, and Kayseraspis, if confirmed, would indicate an early Arenigian age (Harrington, 1938). But caution is needed in dating rocks by undescribed asaphids: Kayseraspis, for example, is one of a number of superficially similar genera whose combined ranges cover the whole of lower Ordovician time.

The other fossils in the core are useless in dating.

Core 6 is 488 feet below Core 5 which is not younger than middle Arenigian. Core 6 is thus unlikely to be younger than early Arenigian.

It is concluded that Core 6 should be placed near the Tremadocian - Arenigian boundary, and no more precise dating is possible at present.

CORE 5

In general aspect, the fauna of Core 5 bears some resemblance to that of Core 6: both cores contain asaphid and pliomerid trilobites, for example. On the other hand, the asaphids in Core 5 are almost certainly generically distinct from those in Core 6, and Core 5 contains, in addition, a pelecypod (aff. Goniophora), a bellerophontacean gastropod (cf. Tropidodiscus), and a probable ribeirioid (Pseudotechnophorus?); it also contains a probable cheirurid trilobite (the only member of the family in the Samphire Marsh collection) and a Hystricurus (present in Core 8, but absent in Core 6). A beyrichioid ostracod, the earliest undoubted graptolite (Temnograptus?), and a very large conodont (Scolopodus), are also present. Orthoid brachiopods, as usual in the Samphire Marsh cores, are too fragmentary for determination.

The pliomerid trilobites are more numerous and better preserved than in Core 6, and all the cranidia indicate the presence of a new genus.

Age: The trilobites give a reasonably reliable date - within the Arenigian but not younger than middle Arenigian. One of the asaphids is a cranidium close to Asaphus s.s. and is somewhat reminiscent of A. raniceps (Dalman), an Arenigian species of the Baltic region. An asaphid pygidium (immature) in this sample recalls Lachnostoma Ross from the late Canadian (Arenigian) of Utah, U.S.A. (Ross, 1951). In this sample, the presence of Hystricurus excludes the upper levels of the Arenigian.

With one exception, the other fossils support the Arenigian age but do not provide evidence for any narrower age determination - the beyrichioid ostracod, the cheirurid trilobite, and the multiramous dichograptid Temnograptus?. The exception is the probable ribeirioid Pseudotechnophorus?, whose only other known occurrence is in the Tremadocian of southern Manchuria (Kobayashi, 1933).

Core 5 is 338 feet below Core 4, which cannot be younger than late Arenigian, and therefore Core 5 must be placed below the top of the Arenigian. This confirms the conclusion indicated by the presence of the trilobite Hystricurus.

CORE 4

A few fossils of Core 4 are similar to forms in Core 5: the pelecypod aff. Goniophora, a beyrichioid ostracod, and the graptolite Temnograptus?. Most of the fossils, however, are different. Asaphid trilobites are rare; pliomerid trilobites are absent; and illaenid and dionidid trilobites make their first (and only) appearance. The pelecypods show more variety (Ctenodonta and perhaps two other genera); orthoid brachiopods are apparently absent; and the core contains the only machaeridian (Plumulites) noted in the bore.

The most notable feature of the fauna is the presence of a graptolite well enough preserved to permit a tentative specific identification (Tetragraptus cf. similis (Hall)). This identification is based on a single fragment.

Age: T.similis (Hall) is a long-ranging species of middle and late Arenigian age (Zones of Didymograptus extensus and D.hirundo of the British scale), and the core may be dated within the limits of these zones. The graptolite also provides an upper limit for the age of the core and of the known Ordovician sequence of Samphire Marsh sediments: Middle Ordovician is excluded.

With one exception, the shelly fauna does not dispute the age determination given by the graptolite, although it does not permit any more precise dating. The exception is the trilobite Dionide?, which is unknown below the Middle Ordovician in the Northern Hemisphere (Whittington, 1952). Its presence suggests that Core 4 should be placed high in the Arenigian, and, moreover, that Dionide appears in Australia somewhat earlier than elsewhere.

Faunal Summary

At least thirty species of shelly fossils can be distinguished in the lower Palaeozoic sequence of Samphire Marsh No. 1 (4,087 - 6,184 feet). Most of the species occur in the upper part of this sequence - 4,940 feet (Core 6) and above. Below this depth, fossils are rare and are not nearly so varied as in the upper levels.

Faunal changes. In general, each of the six cores has a distinctive fauna. The long intervals between the cores make it impossible to decide whether the changes are gradual or abrupt.

Two important changes in the faunas are evident: the first occurs between Core 10 and Core 9, and the second between Core 8 and Core 6. The first change is indicated by the appearance in Core 9 of the orthoid brachiopods, ribeirioids, and trilobites - a marked contrast to the monotonous Lingulella fauna of Core 10. The second change is marked by the incoming in Core 6 of asaphid and pliomerid trilobites, ostracods, and, perhaps, graptolites, all of which are absent in the lower levels. The occurrence of an illaenid and a dionidid trilobite in Core 4 is unique and may indicate a third change.

Novelty of the faunas. Of the thirty odd species of shelly fossils in the Samphire Marsh sequence, none can be assigned to the "Larapintine" species of central Australia (apart from the Prices Creek nautiloids, and the brachiopod Spanodonta, the Larapintine fossils are the only described Ordovician fossils from northern Australia). On the generic level, only three fossils can be assigned with confidence to described genera - the inarticulate brachiopod Lingulella (Cores 9 and 10), the machaeridian Plumulites (Core 4), and the solenopleurid trilobite Hystricurus (Cores 6 and 8). All are long-ranging genera and unsuitable for exact stratigraphy. Two other doubtful generic determinations - the bellerophontacean gastropod Tropidodiscus (Core 5) and the trilobite Dionide (Core 4) - might be confirmed if better material were available.

Even a preliminary study is enough to establish that at least three new genera are present - the pelecypod aff. Goniophora (Core 4), the Ptychopyge - like trilobite (Core 6), and the pliomerid (Core 5). The trilobite in Core 6 that seems to combine the characters of a remopleuridid and an asaphid is also probably new. The beyrichioid ostracods in Cores 4 and 5 do not fit well into described genera, and may also be new. These ostracods were originally identified as "cf. Bollia", but a further study reveals a structure of the border that excludes that genus.

Extension of known stratigraphic range. Three of the fossils of the Samphire Marsh sequence occur at levels outside the known stratigraphic range of these, or similar, fossils, and, taken alone, could give misleading age determinations. They are: the trilobite Dionide? and the pelecypod aff. Goniophora (both in Core 4), and the ribeirioid Pseudotechnophorus? (Core 5).

Dionide is not known to occur in rocks older than Llanvirnian (early Middle Ordovician) in the Northern Hemisphere (Whittington, 1952), and its present occurrence in the late Arenigian is somewhat earlier than elsewhere. In New South Wales it occurs in the early Upper Ordovician (Öpik, 1951).

Goniophora-like pelecypods range from Upper Ordovician to Devonian (Isberg, 1934). The Samphire Marsh specimens have well-developed teeth, and the fossil, if occurring alone, would most probably be taken to indicate a Devonian age.

Pseudotechnophorus is described from the Wanwanian (basal Ordovician) of southern Manchuria (Kobayashi, 1933), and the occurrence of a very similar form in the Arenigian of Western Australia provides a marked upward extension of its known range.

In dealing with these anomalies, I have disregarded the evidence of these fossils in favour of other groups which are more reliable index fossils.

The pelecypod aff. Goniophora and the trilobite Dionide? are associated with the graptolite Tetragraptus cf. similis. Graptolite species provide the standard correlation scale, and the ranges of other fossils are adjusted to agree with that scale. The present occurrence of a Dionide-like trilobite thus appears to be the earliest record of the genus and of the family Dionididae. The occurrence of the pelecypod aff. Goniophora is best regarded as throwing new light on the imperfectly known history of Ordovician pelecypods.

A final judgement on the apparently anomalous occurrence of Pseudotechnophorus cannot be given at present.

Correlation

Discussion of Ordovician faunas and correlation is complicated by the current use of two different time-scales - (1) the North American scale, used by Öpik (in Guppy & Öpik, 1950) and Teichert & Glenister (1954); and (2) the European scale, used by Öpik (in Traves, 1955) and in the present report. In the present report it is understood that Tremadocian and Arenigian together correspond to Canadian (Lower Ordovician), but no exact coincidence of boundaries is implied, and the position of the Tremadocian-Arenigian boundary in relation to the Canadian sequence is not known. Arenigian is used in the restricted sense - Zone 6 of the British scale (Didymograptus bifidus), included in Arenigian by some authors, is here excluded. Zone 6 (Lower Llanvirnian) is here regarded as the base of Middle Ordovician.

Dating and thickness of sequence

The Samphire Marsh sequence includes at least 2,097 feet of fossiliferous lower Palaeozoic sediments, represented in Cores 4, 5, 6, 8, 9 and 10. The sequence covers probably the whole of Lower Ordovician time (both Tremadocian and Arenigian), and, in addition, some Upper Cambrian may be present at the base.

The estimated ages for the six cores are shown in the Table (above). In the two uppermost cores, palaeontological evidence alone gives a reasonably accurate date. In the lower cores, where no described species can be detected, precise dating is not possible, and the palaeontological evidence is supplemented by observations on the stratigraphic distance between the cores.

The presence of a specifically identifiable graptolite (Tetragraptus cf. similis (Hall)) in the highest core of the sequence (Core 4) provides a ceiling: the latest possible date is Arenigian, and Middle Ordovician is excluded.

The Arenigian part of the sequence is at least 358 feet thick and (if Core 6 should in future prove to be Arenigian in age) may be at least 853 feet thick. Insufficient samples are available to estimate the thicknesses of the Tremadocian and possible Upper Cambrian, but the minimum thickness of Tremadocian plus possible Upper Cambrian is 652 feet. If Core 6 should in future be included in the Tremadocian part of the sequence, this minimum would be correspondingly increased to 1,251 feet.

Comparison with other areas

No faunal comparison is possible at present with the Prices Creek area, W.A., although it is not impossible that some correspondence will emerge when the Prices Creek faunas are described. In a brief fossil list, Öpik (in Guppy & Öpik, 1950) mentions the presence of the trilobite Xenostegium in Stage II and dichograptids, ostracods, conodonts, and bellerophontacean gastropods in Stage III. Core 6 contains a Xenostegium-like trilobite (here provisionally referred to Kayseraspis), and the fossil groups mentioned above as occurring in Stage III are all present in Cores 4 and 5. Nevertheless, the absence of nautiloids from the Samphire Marsh sequence is noteworthy. According to present estimates, the pliomerid and illaenid trilobites of the Prices Creek sequence (Stages IV and V) are younger (Middle Ordovician) than those of the Samphire Marsh sequence (Cores 4, 5 and 6).

The upper part of the Samphire Marsh sequence (Cores 4 to 6) is probably the time-equivalent of Stages II and III of the Prices Creek sequence. According to Öpik (in Guppy & Öpik, 1950), Stage IV is Chazyan (Middle Ordovician) in age and is thus younger than the youngest part of the Samphire Marsh sequence. Teichert & Glenister (1954) have suggested an earlier date for this Stage - late Canadian. In any case, Stage V (Gap Creek Dolomite) is younger than any known horizon in the Samphire Marsh sequence.

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Plate I

COMPANY. WEST AUSTRALIAN PETROLEUM PTY. LTD.

COMPOSITE WELL LOG

SAMPHIRE MARSH No. I

WELL NUMBER.

REGION. CANNING BASIN

COUNTRY. WESTERN AUSTRALIA

FILE No. C-2573

LOCATION:
LATITUDE 19° 31' 07·6" S.
LONGITUDE 121° 10' 50·8" E.
CO-ORDINATES:
YARDS EAST
YARDS NORTH
ELEVATION DERRICK FLOOR FT. 28
ELEVATION GROUND FT. 15
TOTAL DEPTH FROM DERRICK FLOOR FT. 6664
PLUG BACK FROM DERRICK FLOOR FT. 2357
DATE SPUDDED. 18 FEB. 1958
DATE COMPLETED 4 MAY 1958
COMPILED BY: M.H. JOHNSTONE
LITHOLOGY BY: V. PUDOVSKIS, M.H. JOHNSTONE, R.M.L. ELLIOTT

ELECTRIC LOG DATA RUN NUMBER	1	2	3
DATE	4 MAR. 1958	29 MAR. 1958	3 MAY 1958
INTERVAL RECORDED	2475'– 592'	5053–2458'	6665'-4940'
MUD NATURE	CLAY BASE	CLAY BASE	CLAY BASE
MUD RESISTIVITY	1·25 at 84°	1·75 at 75°	1·8 at 94°
MUD RESISTIVITY B.H.T.	0·86 at 129°	0·98 at 139°	1·08 at 160°
MUD-WEIGHT	78	80	76·5
MUD-VISCOSITY	54	44	60
MUD-WATER LOSS	7·4	7·0	6·8
MUD - pH	11	11	11

OTHER LOG COVERAGE: SECTION GAUGE 2466'- 592'
TEMPEPATURE LOG: 2427'- 110'

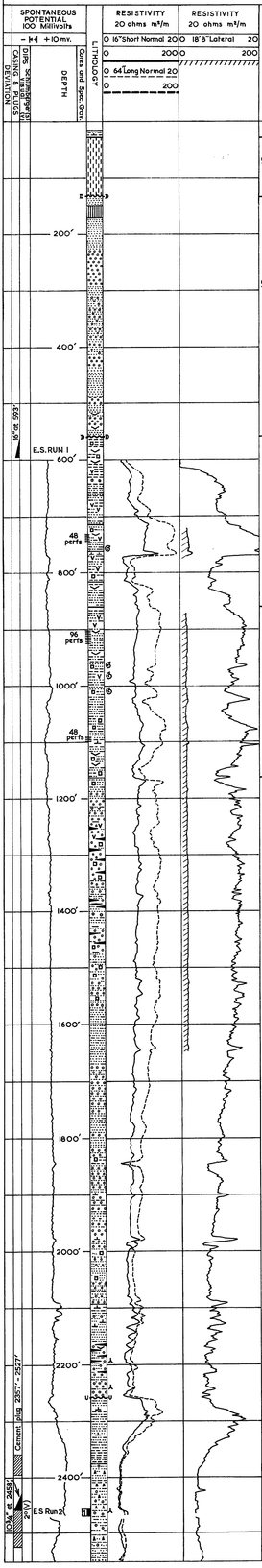
CONGLOMERATE
SANDSTONE, QUARTZITIC
TILLITE
SANDSTONE
SILTSTONE
CLAYSTONE
SHALE
CALCARENITE
CALCILUTITE
LIMESTONE
DOLOMITE
CARBONACEOUS MATTER
GRANITE
LATERITE
U UNCONFORMABLE CONTACT
CONFORMABLE CONTACT
D DISCONFORMABLE CONTACT
ARKOSIC
CALCAREOUS
FOSSILIFEROUS
GLAUCONITIC
MICACEOUS
OOLITIC
PYRITIC
CORE (RECOVERY BLACK)
2·6 SPECIFIC GRAVITY
48 NUMBER OF PERFORATIONS
CASING SHOE

SPONTANEOUS POTENTIAL 100 Millivolts — 4 +10 mv.

RESISTIVITY 20 ohms m²/m — 0 16" Short Normal 20 — 0 200; 0 64" Long Normal 20 — 0 200

RESISTIVITY 20 ohms m²/m — 0 18'6" Lateral 20 — 0 200

DEPTH — Core and Spec. Grav. — LITHOLOGY — LITHOLOGIC DESCRIPTION



14'- 27' Calcareous alluvial silt

27'- 134' BOSSUT FORMATION (PLEISTOCENE – RECENT)
Calcarenite: light-brownish-grey, sandy, fine-to-coarse-grained, with lenses of white to green Calcilutite in the lower part. Pelecypods, gastropods, foraminifera, bryozoa.

134'- 559' BROOME SANDSTONE (LOWER CRETACEOUS)
Sandstone: light-yellow to light-grey, fine-to coarse-grained, moderately sorted, sub-angular to sub-rounded, in a yellowish clay matrix; moderately porous to very porous; containing numerous beds of
Conglomerate: with pebbles of quartz and jasper to 20mm. in limonitic cement.
The upper surface of the Broome Sandstone is lateritised; the ferruginous zone occurs from 150'- 170' and the mottled and siliceous zones are from 170'- 190'

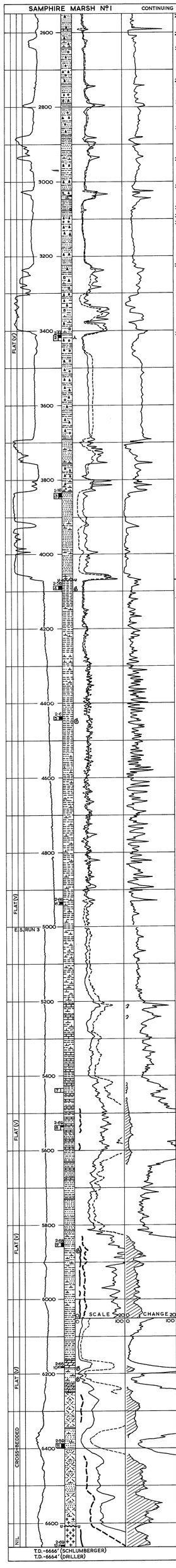
559'- 860' JARLEMAI SILTSTONE (UPPER JURASSIC)
Siltstone: brown-grey, coarse, micaceous, sandy, glauconitic in part, with pyrite nodules (the pyrite in fine crystals)
712'- 768' Sandstone: silty, fine-to medium-grained, sub-to well-rounded, brownish-grey, friable to well cemented (calcareous), glauconitic lenses, pyritic. abundant belemnites.
780'
768'- 816' Siltstone: brown, coarse, sandy, glauconitic, pyritic.
816'- 860' Siltstone: very sandy, very glauconitic.

860'- 1162' ALEXANDER FORMATION (UPPER JURASSIC)
Sandstone: light-grey, coarse-grained, well-sorted, porous, with Siltstone, medium-grey, micaceous, glauconitic.
960'- 990' Sandstone: coarse, silty, very glauconitic, felspathic, with pelecypods.
990'- 1020' Sandstone: silty, with belemnites.
abundant pyrite nodules
1100'- 1162' mainly Siltstone: grey-brown, coarse, sandy, with fossil wood.

1162'- 2258' WALLAL SANDSTONE (UPPER TO MIDDLE JURASSIC)
Sandstone: light-grey, fine-to medium-grained (in upper part), silty, with nodules of pyrite. Below 1200', sandstone is coarse-grained ranging into fine conglomerate. Silty, micaceous, and fine sandstones interbedded with the coarse beds.
1250'- 1330' Sandstone: contains fragments of carbonised wood and lignite. The carbonaceous beds are associated with very coarse parts of the formation. Kaolinitic, slightly calcareous cement is common.
mainly fine Conglomerate
pebbles of felspar
occasional pebbles of granite
2090'- 2258' Fine conglomerate with silty matrix, and Siltstone: grey-brown to black, carbonaceous, micaceous, with beds of lignite.
carbonised fragments of plant fossils

2258'- 4069' GRANT FORMATION
2258'- 2373' LOWER PERMIAN
Siltstone: grey-brown, slightly sandy, calcareous and (?) dolomitic, interbedded with Mudstone: white, calcareous to very calcareous.
2373'- 2620' Greywacke: medium- to dark-grey, poorly-sorted, with quartz grains from fine to coarse size scattered in a siltstone matrix; with pebbles of granite, etc., up to 2 inches in diameter.

SAMPHIRE MARSH No I — CONTINUING C-2573 — Plate I



2590'- 2594' Sandstone: fine, non-porous, very calcareous, micaceous.
2620'- 2641' Sandstone: fine, porous, slightly calcareous.
2641'- 2876' Siltstone: sandy, grading into Greywacke as in 2373'- 2620'
2741'- 2748' Sandstone: fine, very calcareous, micaceous, slightly porous.
2790'- 2801' Sandstone: fine, hard, micaceous, thinly-bedded, very calcareous.
2876'- 2941' zone containing beds of Sandstone fine-to very fine-grained, silty, felspathic, with calcareous cement.
2941'- 3023' Siltstone: grading into Greywacke and light-grey, silty, non-porous, very fine Sandstone.
3023'- 3046' Sandstone: fine to medium, felspathic, with carbonaceous lenses, pebbles of granite, etc.
3046'- 3072' Siltstone: very fine, light-grey.
3072'- 3077' Sandstone.
3077'- 3223' Siltstone: light-grey, fine, silicified, very hard, with pyritic nodules and veinlets of secondary quartz. Siltstone contains lenses and beds of greywacke and fine, non-porous sandstone.
3223'- 3408' Sandstone: white, very fine-to fine-grained, poorly sorted, non-porous, with calcareous cement, pyritic interbedded with coarse Siltstone and friable, micaceous Greywacke with pebbles of granite etc.
3408'- 3690' Greywacke: medium grey, micaceous, with siliceous silt matrix, containing pebbles of granite etc; interbedded with chloritic, calcareous Siltstone, and fine-grained, slightly felspathic Sandstone.
bedding poorly developed, formation is massive.
3690'- 3755' Sandstone: white, fine to very fine, well sorted, slightly calcareous, with some very calcareous beds, grading into medium-grained, poorly sorted Sandstone.
3755'- 3830' Greywacke: silty, poorly sorted, grading into silty Sandstone, with very calcareous beds; many granite pebbles.
3830'- 4052' Sandstone: white, fine-grained, friable, porous, massive, grading into medium-grained sandstone; interbedded with white, fine-grained, thin-bedded, cross-bedded.
4052'- 4069' Sandstone: as in 3830'- 4052' calcareous

4069'- 6610' "NAMBEEP FORMATION" (LOWER ORDOVICIAN)
4069'- 4929' Shale: dark to medium green-grey, micaceous, slightly calcareous, thinly laminated, fissile; containing contorted (ripple marking) lenses of fine crystalline Limestone (recrystallised calcarenite) with occasional mica flakes and abundant thoracic segments and pygidia of trilobites. Ostracods, brachiopods, graptolites present. Minor lenses of Sandstone: very fine-grained, with calcareous cement and well rounded grains of green glauconite (?) or chlorite (?) and orange microcline.
CORE 4: Trilobites, graptolites, ostracods, conodonts.
CORE 5: Trilobites, ostracods, conodonts, gastropods, graptolites.
cuttings from 4069'- 4929' contain abundant fragments of graptolites, trilobites, etc.
4929'- 5163' Shale and Recrystallised Calcarenite as in 4069'- 4929' with the calcareous material comprising up to 25% of the formation.
CORE 6: Trilobites and brachiopods.
5163'- 5368' Shale and Recrystallised Calcarenite as in 4069'- 4929' with the calcarenite and limestone comprising up to 40% of the formation.
5368'- 5404' Shale and minor Recrystallised Calcarenite
5404'- 5628' Shale: dark green-grey to chocolate, grading into Siltstone; dark grey, very micaceous, calcareous with lenses constituting 30% of the formation of Recrystallised Calcarenite and Calcilutite and minor glauconitic fine sandstone lenses.
CORE 8: Trilobites, poor ? brachiopods.
5628'- 5730' Shale, Siltstone and Recrystallised Calcarenite with up to 30% of Sandstone: very fine, glauconitic, with grains of orange microcline.
5730'- 5814' Sandstone: tan to red, very fine grained, micaceous, calcareous, slightly glauconitic with abundant orange microcline. Interbedded with shale and siltstone.
5814'- 6110' Sandstone: green-grey grading into micaceous Siltstone: very calcareous; interbedded with green-grey micaceous Siltstone and Shale with minor Recrystallised Calcarenite which grades into calcareous sandstone. Grains of glauconite (or chlorite ?) and orange microcline are common.
CORE 9: Brachiopods, possible graptolites.
6110'- 6162' Sandstone, Shale and Siltstone with 5% Limestone.
6162'- 6247' Sandstone: grey-green to white to pink, micaceous, sometimes very glauconitic, dolomitic, grading into sandy Dolomite. Containing lenses of Siltstone.
CORE 10: Brachiopods, graptolites.
6247'- 6344' Sandstone: brown-red, fine to coarse, poorly sorted, with siliceous and calcareous cement; brown mica.
6344'- 6399' Sandstone: brown-red, slightly porous, kaolinitic.
6399'- 6610' Sandstone: white to pink, fine to medium, slightly micaceous, with transparent siliceous cement, and white opaque calcareous and kaolinitic cement. White calcite veins.
Red, slightly arkosic at base.

6610'- T.D. PRECAMBRIAN GRANITE
Microcline - plagioclase-hornblende-quartz granite

Plate 2

ENCLOSURE
FILE No. C-2576

WEST AUSTRALIAN PETROLEUM PTY. LTD.

DRILLING TIME AND GAS LOG
SAMPHIRE MARSH No.1

KIMBERLEY DISTRICT
WESTERN AUSTRALIA

NEW BIT
CORE BIT

DATE. from 18 Feb. 1958 to 4 May 1958
DEPTH. 0' to 6664'