PALAEOGEOGRAPHY 27

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Geological Cross-Section of the Wessel Rise, Eastern Arafura Basin

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GEOLOGICAL CROSS-SECTION OF THE

WESSEL RISE, EASTERN ARAFURA BASIN

BY

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Australian Petroleum Industry Research Association

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PLATE 1 STRUCTURAL CROSS-SECTION
(Location map, TWT Mesozoic Unconformity, Orthorhombic diagram, Elcho Island Stratigraphy, Subcrop beneath Mesozoic, McArthur Basin Cross-section.)

PLATE 2 SEISMIC LINE WM2 (INTERPRETED)

PLATE 3 SEISMIC LINE WM2 (UNINTERPRETED)

PLATE 4 SEISMIC LINE W3 EXT (INTERPRETED)

PLATE 5 SEISMIC LINE W3 EXT (UNINTERPRETED)

SUMMARY

The eastern Arafura Basin contains a sedimentary sequence over 12 km thick, comprising Mid Proterozoic, Cambrian, Ordovician, Devonian, Cretaceous and Tertiary aged sediments. Analysis is dependant on jump correlation to the well data that occurs outside the area in the Goulburn Graben, and to the outcrop in the Wessel Islands. The thicknesses present include up to 1 km of Mesozoic, 2 to 3.5 km of Lower Palaeozoic and over 9 km of Mid Proterozoic. The Mesozoic sequence thickens to the east, and the Palaeozoic and Proterozoic thicken to the north and northeast. Excellent source potential occurs within the Proterozoic and Lower Palaeozoic, and good potential exists for both seal and reservoir units within the Palaeozoic. Low geothermal gradients enhance the prospectivity of the Palaeozoic in this area. Very little structuring is evident in the Phanerozoic, but a major angular unconformity is present within the Mid Proterozoic sequence.

INTRODUCTION

DATA SET

WESSEL RISE MARINE SEISMIC SURVEY (Beaver Exploration, 1972: WM, W)

SCALE

The cross-section has been drawn at 1 : 100,000 scale with a vertical to horizontal exaggeration of 1. The total line length of the section is 300 km, and it has a maximum depth of 12 km.

HORIZONS DRAWN

A total of six horizons were carried on the seismic and drawn on the cross-section (Plate 1);

AGE	HORIZON NAME ON SECTION
1) Cretaceous/Tertiary	Base Cretaceous/Tertiary (Mesozoic unconformity)
2) Lower Cambrian	Top Buckingham Bay Sandstone
3) Lower Cambrian	Base Buckingham Bay Sandstone
4) Middle Proterozoic	Dolerite Sill(s) (?)
5) Middle Proterozoic	near Base Malay Road Group
6) Middle Proterozoic	Intra Middle Proterozoic reflectors

Additional to these reflectors, two horizons which onlap the Top Buckingham Bay Sandstone were mapped (Plate 1 - F-G, Plates 4 & 5). Within the Middle Proterozoic, angular reflectors were drawn which are overlain by an Intra Middle Proterozoic unconformity whose position is only shown approximately due to poor data quality. An Intra Middle Proterozoic high is shown at the eastern end of line A-B-C (Plates 1, 2 & 3).

TIME DEPTH PLOTS

No wells occur in this area, although in the Goulburn Graben there are several wells that show relevant data (Bradshaw, 1989).

RESULTS

DATING OF HORIZONS

As no wells occur in this area which could be tied to the seismic grid, the age and stratigraphy is dependant on the onshore outcrop of the Arafura and McArthur Basins and jump correlations to wells in the Goulburn Graben.

Proterozoic

The Middle Proterozoic Wilberforce Beds and Malay Road Group are equated with the McArthur and Roper Groups of the McArthur Basin (Jackson et al., 1988). Within the Malay Road Group is a unit labelled as Dolerite Sills (?). This is an interval of major contrast on seismic data, although no velocity data is available to assess whether it is a high or low velocity zone. Comparison with the onshore geology suggests that it could be an offshore equivalent of the extensive and massive Middle Proterozoic dolerite sill which is generally concordant with the sedimentary strata (pers. comm. K.Plumb, BMR December 1989). Alternatively it could be a low velocity zone of sedimentary origin.

Cambrian

On Elcho Island (Plate 1 - Location Map) trilobites with a Middle Cambrian age were recovered from the Elcho Island Formation (Plumb et al., 1976). This fauna equates with that recovered from the base of Arafura 1 (Bradshaw et al., 1990). The Buckingham Bay Sandstone contains Skolithos which suggests it is Palaeozoic rather than Proterozoic in age (Plumb et al., 1976).

Ordovician

An Early Ordovician sequence occurs in wells in the Goulburn Graben (Bradshaw et al., 1990), but does not crop out onshore. Estimates of the thickness of the Palaeozoic along section D-E-F-G (Plate 1) suggests that Ordovician rocks may be present.

Devonian

A Late Devonian sequence occurs in wells in the Goulburn Graben above an early Palaeozoic sequence (Bradshaw et al., 1990). Estimates of the thickness from the base of the Buckingham Bay Sandstone to the base of the Cretaceous/Tertiary (Mesozoic unconformity), when compared with thicknesses in the Goulburn Graben, suggest that a Devonian interval may be present at the northern end of section F-G (Plate 1) (See subcrop map - Plate 1).

Cretaceous/Tertiary

Undifferentiated Tertiary and Lower Cretaceous (Mullaman Beds) crop out along the Wessel Islands (Rix, 1964; Plumb, 1965).

TIME AND FACIES DIAGRAMS

As no well data is available, no time or facies diagrams were drawn.

HYDROCARBON PROSPECTIVITY

RESERVOIR

Untested potential reservoirs occur in the Buckingham Bay and Marchinbar Sandstones in the Cambrian. In the northern areas, karstic porosity may exist within Ordovician carbonates, and porous sands could occur in the Devonian. Reservoir quality is probably the main risk in the area, however the low geothermal gradient in this region may have acted to prevent porosity being destroyed by diagenesis (Bradshaw et al., 1990).

SEAL

In the Goulburn Graben seal is a major risk, however, in the eastern Arafura Basin the Raiwalla Shale could form an effective regional seal. Intra Devonian seals could also occur, and sealing units may occur in the basal Mullaman Beds in the Cretaceous.

SOURCE

In the McArthur Basin, TOC's of up to 8.68% and live oil were encountered in the Middle Proterozoic Velkerri Formation, which is an equivalent of the Malay Road Group. The Cambrian Raiwalla Shale which is 500 - 1000 m thick was probably deposited under marine conditions, but has not been tested for source rock quality. The Elcho Island Formation had up to 8.65 % TOC in Arafura 1 in the Goulburn Graben.

MATURATION

Maturation studies in the Goulburn Graben indicate that low geothermal gradients should occur in the eastern Arafura Basin, and that the lower Palaeozoic sequence should currently be in the oil window (Arafura 1 and Goulburn 1 - Bradshaw et al., 1990).

SHOWS

Numerous beach strandings are evident along the coastline of the Arafura Sea, stretching from Bathurst and Melville Island in the west to Elcho Island in the east (Fig. 2 - Bradshaw et al., 1990). Preliminary analysis by Roger Summons (BMR) indicate a Cretaceous or younger source for one sample from the Cobourg Peninsula, as suggested by McKirdy & Horvath (1976). Samples from Elcho Island, which is located in the eastern part of the basin where the Mesozoic is very thin and Palaeozoic and Proterozoic sediments dominate the section, have not been examined geochemically.

Arafura 1 in the Goulburn Graben has produced the most encouraging results encountering oil shows over a gross interval of 425 m in the Ordovician and Devonian. Dead oil occurred in Goulburn 1 in the Devonian, Ordovician and Cambrian.

STRUCTURE

Seismic data indicate that the major unconformities in the eastern Arafura Basin occurred during the Middle Proterozoic and in the early Mesozoic.

Middle Proterozoic rifting produced the Batten and Walker Troughs onshore, which extend offshore into the feature known as the Wessel Rise (Nicol, 1970). Seismic data show an angular unconformity between the Wilberforce Beds and the Malay Road Group, that may represent either a truncated surface of uniformly dipping strata or alternatively a series of rotated fault blocks (Plates 1, 2 & 3). Perhaps pre-dating or synchronous with this event is an intra Proterozoic high block at the eastern end of section A-B-C (Plates 1, 2 & 3), over which Middle Proterozoic to Mesozoic sediments thin. This high block could represent a regional dome shaped igneous intrusion, or simply be an uplifted Proterozoic fault block. The Wessel Rise feature at the western end of section A-B-C (Plates 1, 2 & 3), may have been initiated at the time of the development of the intra Proterozoic structural high. It does not show any significant reactivation since the Middle Proterozoic, and the overlying Palaeozoic and Mesozoic sediments do not appear to thin over the feature, suggesting that it had been peneplaned by the Palaeozoic.

Disconformably overlying the Middle Proterozoic sequence, is the Buckingham Bay Sandstone which is considered to be Early Cambrian in age. Thus a hiatus of over 900 m.y. occurs at this level that does not display any angular discordance, and which is not readily discernible on the seismic records (Plates 2, 3, 4 & 5). Within the Palaeozoic there are no major structural discordances along the line of the section, however on the eastern end of line WM 1 (north and parallel to line 2) there are localised deformations that may represent either intrusions or low angle thrusting associated with possible Early Cambrian evaporites (as found in the Amadeus Basin - Bradshaw, in press). Whether they are structural or intrusive features, they formed between the Ordovician and Cretaceous, as no thinning is evident within the Palaeozoic section, and no deformation occurs within the Mesozoic section. If they are intrusives, then they may correlate with the Early Permian dolerites that occur in Kulka 1 in the Goulburn Graben (Bradshaw et al., 1990), and the regional heating event which is recognised throughout many Palaeozoic basins of Australia during the latest Carboniferous to Early Permian. The absence of faulting within the Palaeozoic sequence indicates that the oblique extension and subsequent westward tilting experienced in the Goulburn Graben during the Permo-Triassic did not affect the eastern Arafura Basin.

The development of the Mesozoic unconformity in the eastern

Arafura Basin is loosely constrained between probable Ordovician and Devonian sediments and the Cretaceous sequence. A number of stacked unconformities occur along this horizon including the Ordovician Rodingan Movement (Bradshaw & Evans, 1988). The discordance across the Mesozoic unconformity is not as striking as occurs within the Goulburn Graben, although considerable onlap is present in the eastern part of the area where the Mesozoic section is thicker. Within the Mesozoic sequence there is no evidence of Tertiary folding due to collision tectonics in the Papuan Fold Belt, nor faulting due to the transtensional tectonics that occurred in the Morehead Sub-basin in the Cretaceous, even though both were prominent events that occurred in close proximity to the eastern Arafura Basin.

COMPARISON TO McARTHUR BASIN CROSS-SECTION

On Plate 1 is a schematic cross-section of the McArthur Basin showing the structural arrangement of the Roper Group (Malay Road Group equivalent) and McArthur Group (Wilberforce Beds equivalent). The configuration of this Middle Proterozoic sequence is very similar to that shown along section A-B-C (Plate 1), especially the angular unconformity within the Middle Proterozoic sequence. Thus the two areas have probably undergone similar tectonic evolutions, although as suggested by Jackson et al. (1988) the structural evolution of the McArthur Basin is complex and not yet satisfactorily resolved.

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PLATE 1

WESSEL RISE STRUCTURAL CROSS-SECTION

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WM-2
SP 1330

D

LINE WM-4 S.P. 1753-012 ← SW — 201°

WATER DEPTH 55m

S.P.1753

DEPTH km

MESOZOIC UNCONFORMITY
TOP BUCKINGHAM BAY SANDSTONE
BASE BUCKINGHAM BAY SANDSTONE
DOLERITE SILLS
INTRA MID-PROTEROZOIC UNCONFORMITY

B

W-3 EXT
SP 070

E

WATER DEPTH 49m

S.P.070

CRETACEOUS / TERTIARY
WESSEL GROUP - PALAEOZOIC
MALAY ROAD GROUP
WILBERFORCE BEDS

WM-4
SP 072

F

LINE W-3 EXT S.P. 001-537 ← SW — 223°

WATER DEPTH 49m

S.P. 001

DEPTH km

MESOZOIC UNCONFORMITY
TOP BUCKINGHAM BAY SANDSTONE
RAIWALLA SHALE ONLAP (?)
BASE BUCKINGHAM BAY SANDSTONE
DOLERITE SILLS

E

G

WATER DEPTH 40m

S.P. 637

CRETACEOUS / TERTIARY
WESSEL GROUP - PALAEOZOIC
MALAY ROAD GROUP
WILBERFORCE BEDS

SCALE 1cm=1000m

Horizontal
1:100000

Vertical
1:100000

Horizontal: Vertical=1:1

ORTHORHOMBIC DIAGRAM

Horizontal scale
1:1410000
1cm=14.1km

Vertical scale
1:75000
1cm=5.75km

V/H=1/5

TWT TO MESOZOIC UNCONFORMITY (TOP ARAFURA BASIN)

WESSEL RISE STRUCTURAL & LOCATION MAP

GOULBURN GRABEN
LYNDOCH 1
ROGER 1
MONEY SHOAL 1
TURNER 1
ARAFURA 1
GOULBURN 1
MONEY SHOAL BASIN
ARAFURA BASIN
CARPENTARIA BASIN
DARWIN
McARTHUR BASIN
DUKE 1
WESSEL FAULT ZONE
WALKER FAULT ZONE
NORTHERN TERRITORY
QLD
WA
SA
NSW
TAS
0 100 km

STRATIGRAPHIC COLUMN ELCHO ISLAND OUTCROP

THICKNESS 1.5 km

WESSEL GROUP
CAMBRIAN

ELCHO ISLAND FORMATION
MARCHINBAR SANDSTONE
RAIWALLA SHALE
BUCKINGHAM BAY SANDSTONE
MALAY ROAD GROUP / WILBERFORCE BEDS

TRILOBITE BEDS (MIDDLE CAMBRIAN)
DOLOMITIC SILTSTONE, GLAUCONITIC SANDSTONE AND SILTSTONE
QUARTZ SANDSTONE
SHALE AND FINE SANDSTONE, MINOR QUARTZ SANDSTONE
QUARTZ SANDSTONE
QUARTZ GREYWACKE, MINOR QUARTZ SANDSTONE
HOLOTHOS BEDS
MID-PROTEROZOIC

(Also Plumb et al, 1978)

SUBCROP BENEATH MESOZOIC UNCONFORMITY

McARTHUR BASIN CROSS-SECTION

ARAFURA SEA
GULF OF CARPENTARIA
(MALAY ROAD GROUP= ROPER GROUP EQUIVALENT. WILBERFORCE BEDS= McARTHUR GROUP EQUIVALENT)
ROPER AREA
McARTHUR AREA
EMU FAULT ZONE
ROPER GROUP
BROADMERE ANTICLINE
BATTEN TROUGH
BMR 680 m
AMOCO 3266 m
AMOCO CRC no 501
TAWALLAH GROUP
McARTHUR AND NATHAN GROUPS
3 km
100 km

SCHEMATIC CROSS-SECTION (AFTER JACKSON et al, 1988)

WM-4
SP 1435

B

A

LINE WM-2 S.P. 001-2128 ← NW — 299°

WATER DEPTH 59m

S.P. 001

DEPTH km

MESOZOIC UNCONFORMITY
TOP BUCKINGHAM BAY SANDSTONE
BASE BUCKINGHAM BAY SANDSTONE
DOLERITE SILLS
INTRA MID-PROTEROZOIC UNCONFORMITY
WALKER TROUGH / WESSEL RISE (PROTEROZOIC)
? INTRA PROTEROZOIC HIGH ?

C

WATER DEPTH 59m

S.P. 2100

CRETACEOUS / TERTIARY
WESSEL GROUP - PALAEOZOIC
MALAY ROAD GROUP
WILBERFORCE BEDS

PLATE No.1

Drafted by	Jeff Wilson
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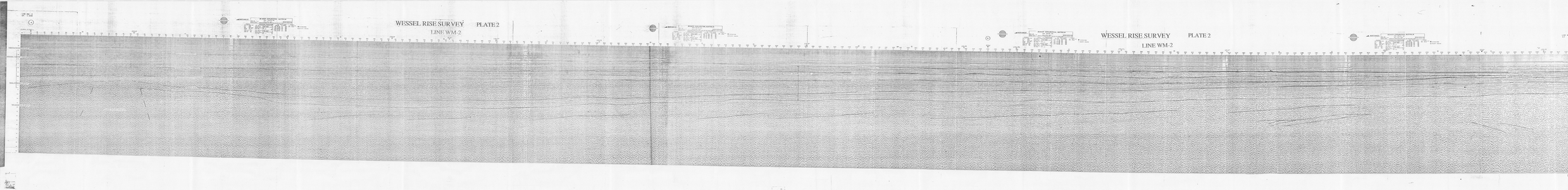
(Palaeogeographic Maps Project -Phase 2)	
Phanerozoic History of Australia Project 175A	

Plate 1 Structural X-Section
Stafford

WESSEL RISE SURVEY PLATE 2

LINE WM-2

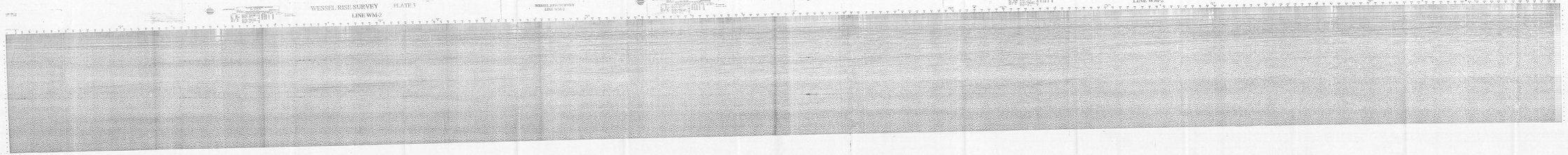


WESSEL RISE SURVEY PLATE 2

LINE WM-2

WESSEL RISE SURVEY PLATE 3

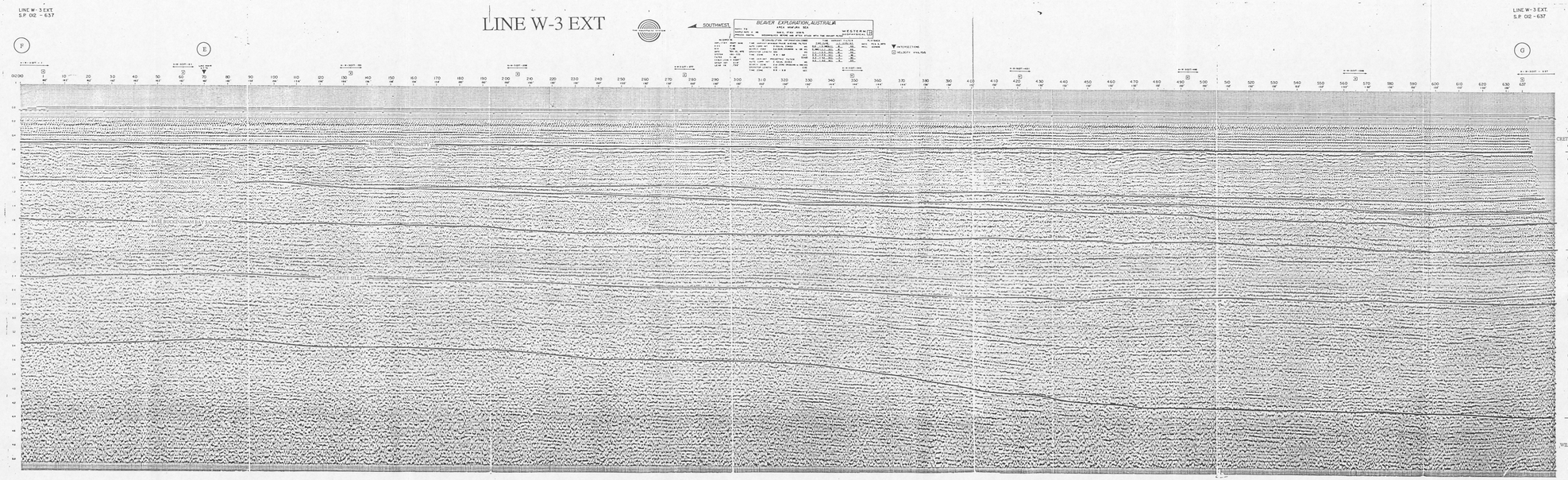
LINE WM-2



WESSEL RISE SURVEY

PLATE 4

LINE W-3 EXT



WESSEL RISE SURVEY: PLATE 5

LINE W-3 EXT.