# DEPARTMENT OF MINERALS AND ENERGY

# BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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## A REINTERPRETATION OF THE SEISMIC SURVEY RESULTS IN THE LAURA BASIN, QUEENSLAND





BY

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## ABSTRACT

The results of the seismic surveys recorded during 1963 and 1968 for Marathon Petroleum and Crusader Oil in the Laura Basin, north Queensland have been reinterpreted. Seismic reflections which dip almost continuously from 0.6 to 4.0 seconds reflection time may come from the base of and within an 8000 m thick sequence of Permo-Carboniferous sediments. These sediments may underlie the flat-lying Mesozoic Laura Basin sediments and overlie the heavily folded Carboniferous-Devonian sediments in the Hodgkinson Basin. Further seismic investigation of this area is recommended since a thick Permo-Carboniferous sedimentary section here could be prospective for hydrocarbons.

CONTENTS

## INTRODUCTION

The seismic information in the Laura Basin was examined as part of a regional review of geophysical surveys in the Carpentaria, Laura, and Olive River Basins (Pinchin, 1973).

The Laura Basin lies in the east of Cape York Peninsula in Queensland. The northern part of the basin extends under Princess Charlotte Bay, the southern part lies under the flat, thickly alluviated plain of the Normanby drainage basin. The region has a semi-monsoonal climate, the vegetation is open savannah grasslands, and the only industry is beef cattle raising. Geological and geophysical field work is restricted to the dry season from April to December.

Regional geological mapping has been done by the Bureau of Mineral Resources (BMR) and the Geological Survey of Queensland (de Keyser & Lucas, 1968; Willmott, Whitaker, Palfreyman & Trail, 1973). The history of petroleum exploration in the basin is summarized below:

| | |
|---|---|
| 1962 | Marina No 1 well drilled for Marathon Petroleum Australia Ltd. (Mines Administration Pty. Ltd., 1962) |
| 1963 | Marina Plains seismic survey for Marathon Petroleum Australia Ltd. (Burke, Harwood & Vind, 1963) |
| 1968 | Breeza Plains seismic survey for Crusader Oil N.L. (United Geophysical Corporation, 1969) |
| 1970 | Breeza Plains No. 1 and Lakefield No. 1 wells drilled for Crusader Oil N.L. (Hardy, 1970). |

## GEOLOGY

The geological data shown in Figure 1 are taken from the maps of de Keyser & Lucas (1968) and Willmott et al. (1973), and a summary of their descriptions of the geology follows.

The onshore part of the Laura Basin contains a maximum thickness of 900 m of Mesozoic sediments; it unconformably overlies the northern part of the Palaeozoic Hodgkinson Basin. The boundaries of the Laura Basin are the Precambrian metamorphic rocks and intrusive granites of the Coen Inlier to the west, and the sediments of the Hodgkinson Basin and some Permian intrusive granites to the south and east. The offshore northern limit of the basin is unknown. The three exploration wells in the Laura Basin reached the following formations:

| | | |
|---|---|---|
| Marina No 1 | Basalt | at 1130 m |
| Breeza Plains No 1 | Permian sandstone etc. | at 933 m |
| Lakefield No 1 | Granite | at 921 m. |

Stratigraphy

The stratigraphy of the Laura Basin area is summarized in Table 1. The Little River Coal measures have been seen only in a narrow fault-bounded block associated with the Palmerville Fault; the Permian sediments in Breeza Plains No 1 have not been named, but they are not correlatable with the Little River Coal Measures (Hardy, 1970). Numerous small shows of oil or gas in the Jurassic section were encountered in Marina No 1; Breeza Plains and Lakefield wells found good reservoir sands in the Jurassic and Cretaceous, but only fresh water was recovered.

Structure

The Hodgkinson Basin sediments, particularly the Hodgkinson Formation, have been significantly disturbed and folded by the tectonic movements in the Tasman Geosyncline, the western side of which is marked by the Palmerville Fault complex. The Mesozoic sediments of the Laura Basin are relatively flat-lying and continue across the Palmerville Fault with very little displacement. The geological cross-section across the southern margin of the basin constructed by de Keyser & Lucas is shown in Figure 2. The main feature of this cross-section is that the Jurassic Dalrymple Sandstone lies unconformably on the Hodgkinson Formation to the east of the Palmerville Fault, and overlies the Proterozoic metamorphics to the west.

SEISMIC RESULTS

Seismic lines 1, 3, 4 and 5 of the Marina Plains survey are shown in Figure 1 and the seismic sections from Lines 1 and 5 are shown in Figures 4 and 5.

The Marina Plains and the Breeza Plains seismic surveys both used analog recording of single-fold, split-spread reflection data, using 5 to 10 kg of explosive per shot in a single hole 20 to 25 m deep. They recorded a good reflection from a horizon estimated to be near the top of the Jurassic Dalrymple Sandstone, which also corresponds to a refractor of velocity 4000 m/s. This reflector occurs at about 740 m depth and is fairly flat-lying throughout most of the survey area. It rises to 400 m at the east and west margins of the basin. All other reflections are weaker and less continuous. About 600 m below the Jurassic reflector the seismic sections show an angular unconformity below which reflections dip to the north and east.

Refraction profiles were recorded during the Marina Plains Survey. Profile 1 measured a velocity of 5454 m/s at 1400 m average depth dipping $2\frac{1}{2}^{o}$ to the north, and profile 2 measured a velocity of 5945 m/s at about 2000 m average depth, dipping $6^{o}$ to the north.

United Geophysical Corporation (1968) mapped an anticlinal structure on their 'A' horizon with about 30 m of closure over an area of 9 km by 3 km, elongate in a north-south direction, at a depth of about 520 m. They did not map any of the deeper dipping events, and on the evidence of the refraction data they assumed that the prospective sedimentary section had an average thickness of about 1000 m and a maximum thickness of 2000 m.

NEW SEISMIC INTERPRETATION

On the seismic sections (Figs. 4 and 5), reflections can be seen dipping to the north and east from an angular unconformity at about 0.6 seconds. On the section in Figure 5 they reach a maximum reflection time of about 4.0 seconds (8000 m depth) at the west side of the Palmerville Fault. The reflections on the east side of the fault also dip towards the fault, but reach a depth of only 3500 m. The true dip of the events on the west of the Palmerville Fault is about $10^{o}$ in a northwesterly direction.

The fair continuity of these reflections suggests that they come from well stratified geological layers, probably sedimentary. A possible interpretation of these dipping reflections is shown in Figure 3. The Hodgkinson Formation is greatly folded and faulted (de Keyser & Lucas, 1968); thus it is unlikely to be the source of these smooth reflections. A sedimentary source for these reflections would therefore overlie the Hodgkinson Formation and underlie the Permian sediments encountered in Breeza Plains No. 1 well. Thus it is possible that sediments of Permian to Carboniferous age, with which the Little River Coal Measures are perhaps associated, occur in a deep, narrow (45 km wide) belt.

This interpretation can be questioned on three main points:

(1) Lakefield No. 1 well encountered granite at 921 m, but this could be an igneous intrusion of limited areal extent.

(2) The refraction profiles measured high velocities, usually associated with igneous or metamorphic rocks or with Precambrian sediments, at relatively shallow depths. These could be igneous intrusions or basalt layers within the sediments.

(3) The gravity profile along Cross-section C-D does not show the negative anomaly that would be expected if a wedge of less dense sediments extends down to 8000 m. Computer models of possible gravity profiles across C-D have been tried, but crustal thinning at the continental margin and density variations within the crust cause large and unknown gravity anomalies which may mask any anomaly caused by variations in sedimentary thickness.

CONCLUSIONS

A possible interpretation of the deep seismic reflections in the northern part of the Laura Basin is that Permo-Carboniferous sediments occur below the Jurassic sediments to a depth of 8000 m and overlie the Hodgkinson Formation. But the existing refraction and gravity data appears to contradict this hypothesis. Seismic reflection data of better quality in the Laura Basin are needed to resolve this question, especially since proof of thick sediments here would enhance the petroleum prospects of the area.

ACKNOWLEDGEMENTS

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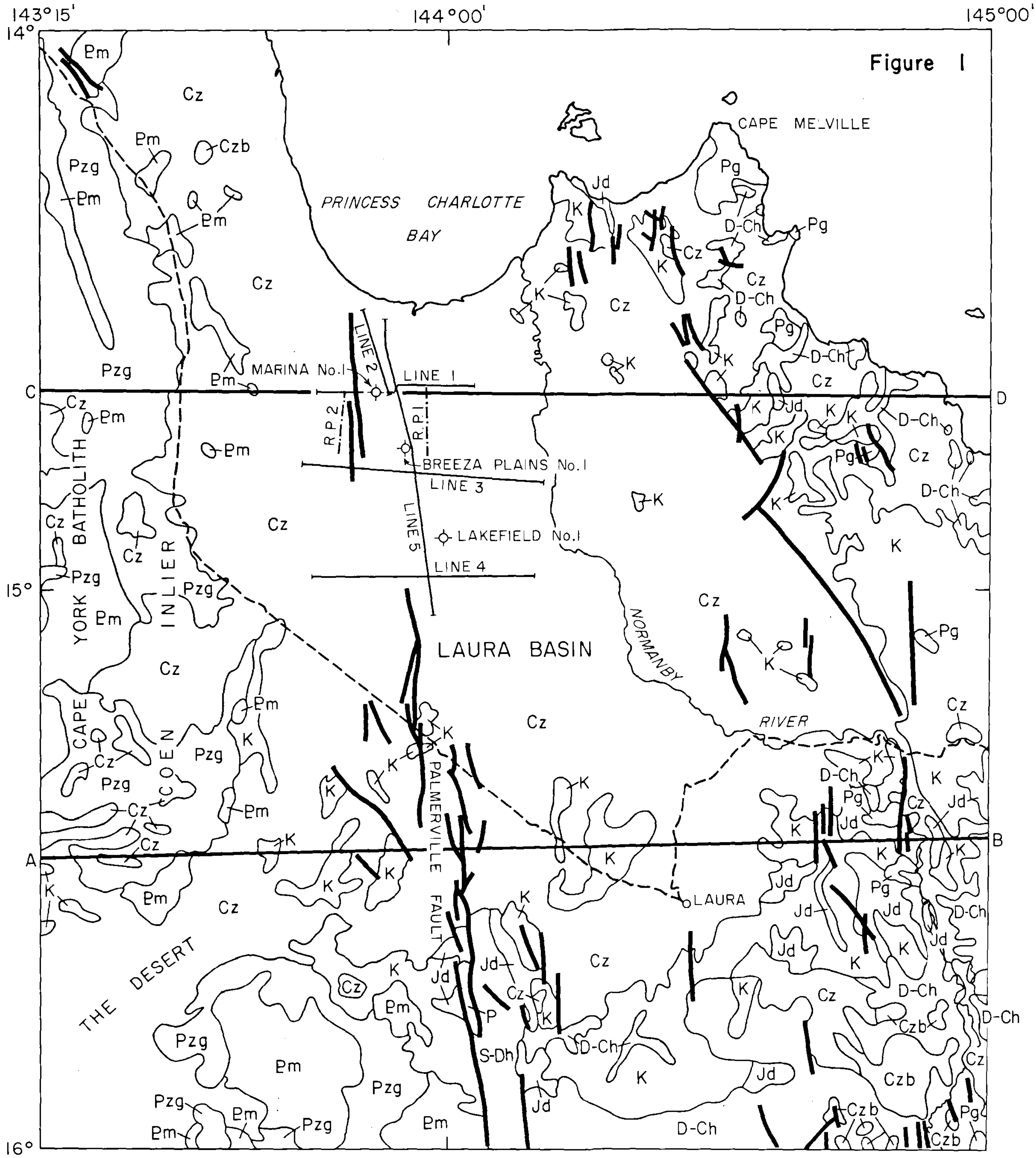
TABLE 1. STRATIGRAPHY OF THE LAURA BASIN AREA (AFTER HARDY, 1970; KEYSER & LUCAS, 1968)

| Era | Period | Formation | Approximate Regional Thickness | Regional Lithology | |
|---|---|---|---|---|---|
| Cainozoic | Quaternary to Tertiary | - | 50-100 m | Sand, peat, gravel, clay, olivine basalt | |
| | Tertiary | - | 15-60 m | Sandstone, clay, and gravel | |
| | | | UNCONFORMITY | | |
| Mesozoic | Early Cretaceous | Wolena claystone | 60-80 m | Soft grey marine claystone | Laura Basin sediments |
| | | Battle Camp Shale | 200 m | Shale, sandstone, siltstone, conglomerate, often glauconitic and limonitic | |
| | Late Jurassic to Early Cretaceous | Battle Camp Sandstone | 200 m | | |
| | Jurassic | Dalrymple Sandstone | 550+ m | Sandstone, conglomerate, shale, coal | |
| | | | UNCONFORMITY | | |
| Palaeozoic | Permian | Little River Coal Measures | ? | Siltstone, sandstone, shale, coal | |
| | | | UNCONFORMITY | | |
| | Devono-Carboniferous | Hodgkinson Formation | 7000 m | Greywacke, slate, shale, volcanics, limestone, and conglomerate | Hodgkinson Basin sediments |
| | | | UNCONFORMITY | | |
| | Siluro-Devonian | Chillago Formation | ? | Chert, limestone, sandstone, greywacke, siltstone, volcanics | |
| | | | UNCONFORMITY | | |
| Precambrian | Proterozoic | Dargalong, Coen and Holroyd Metamorphics | ? | Schist, gneiss, quartzite etc. | |




# GEOLOGICAL SKETCH MAP OF LAURA BASIN

| | | |
|---|---|---|
| Cz | ☐ | CAINOZOIC SEDIMENTS |
| Czb | ☐ | CAINOZOIC VOLCANICS |
| K | ☐ | CRETACEOUS SEDIMENTS |
| Jd | ☐ | JURASSIC DALRYMPLE SANDSTONE |
| P | ☐ | PERMIAN SEDIMENTS |
| Pg | ☐ | PERMIAN GRANITES |
| D-Ch | ☐ | MIDDLE DEVONIAN-LOWER CARBONIFEROUS? HODGKINSON FORMATION |
| S-Dh | ☐ | UPPER SILURIAN-LOWER DEVONIAN CHILLAGOE FORMATION |
| Pzg | ☐ | LOWER PALAEOZOIC ADAMELLITES OF CAPE YORK BATHOLITH |
| Ꞓm | ☐ | PROTEROZOIC METAMORPHICS |

FAULT

EXPLORATION WELL

REFLECTION LINE, MARINA PLAINS SURVEY

REFRACTION PROFILE

A—B CROSS SECTION

GRADED ROAD

GEOLOGY FROM DE KEYSER AND LUCAS, 1968 AND WILLMOTT ET AL, 1971

10 0 10 20 30 40 KILOMETRES

*To Accompany Record No. 1973/128*

D55/B3-1

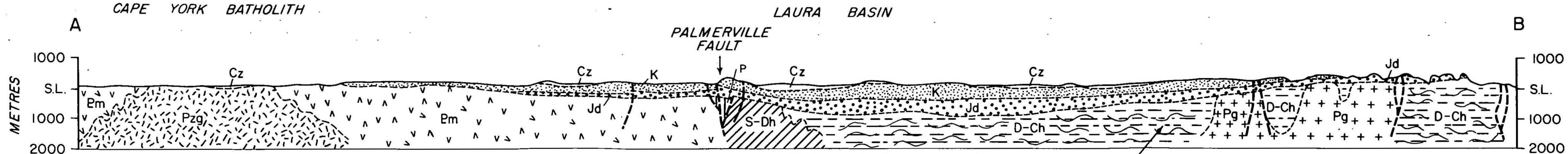



Fig. 2. GEOLOGICAL CROSS-SECTION FROM DE KEYSER AND LUCAS (1968)

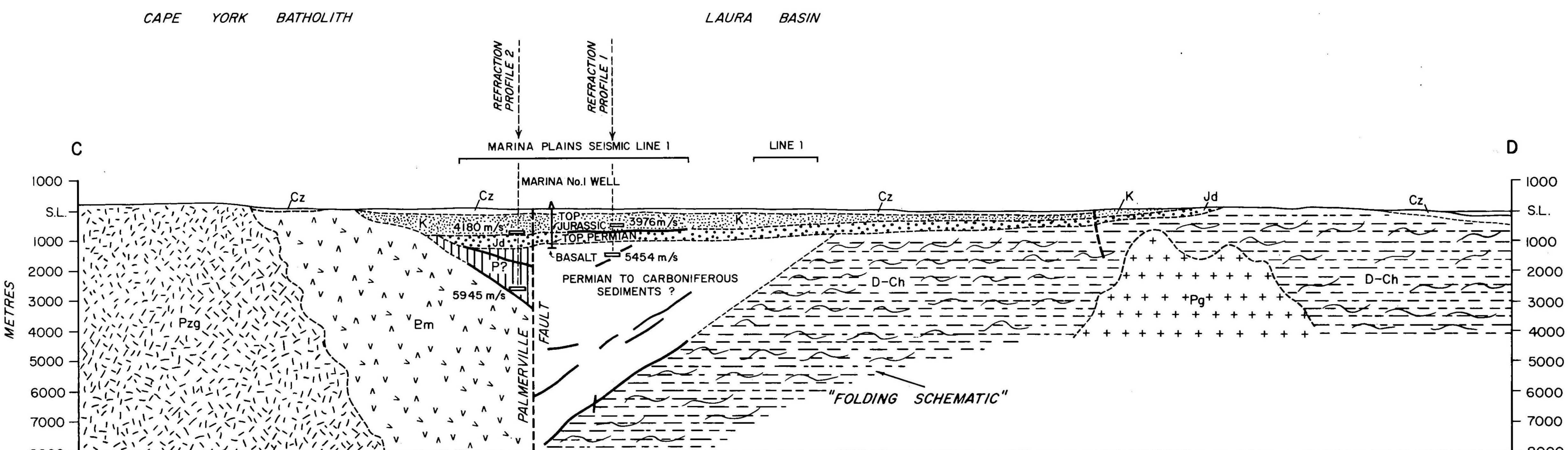



Fig. 3. INTERPRETED CROSS-SECTION

| | |
|---|---|
| Cz | CAINOZOIC SEDIMENTS |
| K | CRETACEOUS SEDIMENTS |
| Jd | JURASSIC DALRYMPLE SANDSTONE |
| P | PERMIAN SEDIMENTS |
| Pg | PERMIAN GRANITES |
| D-Ch | MIDDLE DEVONIAN - LOWER CARBONIFEROUS ? HODGKINSON FORMATION |
| S-Dh | UPPER SILURIAN - LOWER DEVONIAN CHILLAGOE FORMATION |
| Pzg | LOWER PALAEOZOIC ADAMELLITES OF CAPE YORK BATHOLITH |
| Ꝑm | PROTEROZOIC METAMORPHICS |

FAULT

SEISMIC REFRACTING HORIZON

SEISMIC REFLECTING HORIZON

INFERRED BOUNDARY

10 5 0 10 20km   V/H = 4

D55/B3-2

Figure 4


To Accompany Record No. 1973/128

CORRECTED
RECORD SECTION

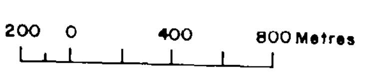
RECORDING INFORMATION

*Magnetic recorder : G.G.Co.*
*Amplifiers : G.G.Co. JMH*
*Filters : ?*
*AGC : S.S.*
*Geophones : EVS-2 20Hz*
*Geophone station interval : 33·5m*
*Geophone pattern : 18 in line at 4·5m*
*Charge size : 10kg*
*Hole depth : 26m*
*Shot pattern : single holes*

PLAYBACK INFORMATION

*Filters : L16-KK60*
*AGC : S.S.*
*Compositing : 3 trace mix 15-70-15*

HORIZONTAL SCALE




SEISMIC SECTION,
LINE 1

RECORDED BY : *General Geophysical Co. 1962*
SECTION BY : *Bureau of Mineral Resources Playback Centre SIE MS42*

D55/B3-3


→ NORTH

Figure 5

CORRECTED
RECORD SECTION

RECORDING INFORMATION
*Magnetic recorder : G.G.Co.*
*Amplifiers : G.G.Co. JMH*
*Filters : ?*
*AGC : S.S.*
*Geophones : EVS-2 20Hz*
*Geophone station interval : 33·5m*
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*Shot pattern : single holes*

PLAYBACK INFORMATION
*Filters : L16-KK60*
*AGC : S.S.*
*Compositing : 3 trace mix 15-70-15*

HORIZONTAL SCALE

200 0 400 800 Metres

# SEISMIC SECTION, LINE 5

RECORDED BY : *General Geophysical Co. 1962*
SECTION BY : *Bureau of Mineral Resources Playback Centre SIE MS42*

D55/B3-4