# THE

# HYDROCARBON POTENTIAL

# OF

# EXPLORATION PERMIT EP-432

# ONSHORE PERTH BASIN

# WESTERN AUSTRALIA

**by**

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**for**

**EMPIRE OIL COMPANY (WA) LIMITED**

**October, 2004**

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# 1 INTRODUCTION

Exploration Permit EP-432 straddles the Beagle Ridge and Cadda Shelf and is favourably located to the west of and updip from the Walyering Gasfield in the Dandaragan Trough, onshore Perth Basin (Figure 1). It was awarded 100% to Gulliver Productions Pty Ltd, a wholly owned subsidiary of Empire Oil & Gas NL on 11th October, 2004 for an initial six year period. It consists of 27 graticular blocks covering an area of 1,998 sq kms.

The Perth Basin is a deep elongate trough which covers an area of some 45,000 sq kms onshore and 55,000 sq kms offshore. The basin contains up to 15,000 metres of Permian and Mesozoic marine and non-marine clastic sediments.

Exploration Permit EP-432 is situated some 100 kilometres north of the city of Perth. The Brand Highway, an all weather sealed road, runs north-south along the eastern margin of the permit. The Dampier-Perth and Dongara-Perth Natural Gas Pipelines transverses north-south along the eastern margin of the permit.

# 2 EXPLORATION HISTORY

In 1956, the BMR conducted aeromagnetic and gravity surveys in the Hill River area. These surveys defined the Dandaragan Trough to the east and the Beagle Ridge to the west.

WAPET conducted the first seismic surveys in the area in 1966 and 1967. They conducted further seismic surveys in 1973 and 1975. After a considerable period of inactivity, the first modern seismic was acquired by Arrow Petroleum in 1989 (146 km Duggan Seismic Survey) and 1990 (204 km Woolka Seismic Survey).

Some seven wells have been drilled in the permit. These consist of three stratigraphic wells (Hill River-1, -2 & -4) drilled by WAPET in 1962; Cadda-1 and Coomallo-1 drilled by WAPET in 1965 and 1974; Mullering-1 by Arrow Petroleum in 1992; and Cataby-1 by Discovery Petroleum in 1994.

Cataby-1 encountered a 2.5 metre sand at 1690 metres near the base of the Cattamarra Coal Measures. This sand had good oil shows and flowed approximately 25-30 bopd during a drill stem test. The reservoir pressure dropped during the test and the well was plugged and abandoned.

The Walyering Gasfield, discovered by Wapet in 1971, is located some 10 kilometres east of the permit. This gasfield commenced production in 1972 but declined rapidly and was shut in after only four months production.

# 3 REGIONAL GEOLOGY AND STRATIGRAPHY

The Perth Basin contains a sequence of up to 15,000 metres of Permian to Cretaceous sediments deposted between the Yilgarn PreCambrian Block to the east, the Indian continent to the

west, the Antarctic continent to the south and which opens to the north where joins with the Palaeozoic to Tertiary Carnarvon Basin (Figure 2).

The generalised stratigraphy of Exploration Permit EP-432 in the Perth Basin is illustrated in Figure 3. This is based on formations outlined by Playford et al (1976), Discovery Petroleum (1992) and the results of the Mullering-1 and Cataby-1 wells.

Pre-rift sedimentation began in the Perth Basin during the Permian to Early Triassic with intracratonic downwarping and mostly marine deposition. Marine environments were present in the Holmwood Shale, Carynginia Formation and Beekeeper Limestone with a high stand tract during the Artinskian Irwin River Coal Measures.

Rifting commenced towards the end of the Early Triassic. The marine Lower Triassic Kockatea Shale was swamped with initially deltaic deposits (Woodada Formation), and then fluvial to continental sedimentation (Lesueur Sandstone).

Rifting and non-marine sedimentation continued into the Jurassic with the continental red beds of the Eneabba Member and the swamp, marsh and lacustrine environments of the Cattamarra Coal Measures. Sedimentation slowed and a marine transgression (Cadda Formation) took place during the Bajocian.

Further rifting reactivated the basin margins and thick, fluvial and alluvial plain deposition of the Yarragadee and Parmelia formations covered the basin.

Breakup occured during the Valanginian with the post-rift marine sediments of the Cretaceous Warnbro and Coolenya groups onlapping the Intra-Valanginian Unconformity surface.

# 4 HYDROCARBON POTENTIAL

## *4.1 Reservoir/Seal*

### 4.1.1 Cattamarra Coal Measures

The primary objective in the permit is the Early Jurassic Cattamarra Coal Measures and Eneabba Members of the Cockleshell Gully Formation.

In the permit, the Cattamarra Coal Measures are composed of interbedded sandstones, shales siltstones and coals. In Cataby-1, the “L” Sands at the base of the Cattamarra Coal Measures vary from fine to coarse grained with porosities of 11-20% averaging 15%. Reservoir quality in the Cattamarra Coal Measures generally decreases to 4-15% in the Walyering Gasfield where they are deeply buried and silicified. These sands are laterally extensive (Enclosure 1) and were probably deposited in a braided stream environment.

Sandstone reservoirs of the Eneabba Member in Cataby-1 vary from fine to coarse grained with porosities of 10-18% averaging 13%.

In the Mullering-Cataby area, the “L” Sands and Eneabba Member sandstones are sealed by a 200 metre thick sequence of lacustrine and alluvial plain shales and siltstones within the lower part of the Cattamarra Coal Measures (Enclosure 1). These shales are thick enough to also provide lateral seal across the many crestal faults on the Mullering-Cataby anticlinorium complex.

## 4.2 Source

The carbonaceous shales within the Cattamarra Coal Measures in the Walyering Gasfield have organic contents ranging from 1.63 – 5.05% TOC with S2’s up to 9.3. A coaly shale in Walyering-2 has a TOC of 29.5% with an S2 of 66 (Discovery Petroleum 1993). These source rocks contain both humic and sapropelic organic matter and are interpreted to be capable of generating both oil and gas.

In Cataby-1, there are two main potential source rocks; the coaly unit from 1228-91 m (63 m thick) and the base of the Cattamarra Coal Measures from 1729-1830 m (101 m thick). The coaly unit has organic contents ranging from 2.78 – 9.2% TOC with S2’s up to 11.8. The carbonaceous shales at the base of the Cattamarra Coal Measures have organic contents ranging from 1.1 – 2.7% TOC with S2’s up to 7 (Cataby-1 WCR). These source rocks contain both humic and sapropelic organic matter and are interpreted to be capable of generating both oil and gas.

## 4.3 Maturity

The Cattamarra Coal Measures in the Walyering area have vitrinite reflectances ranging from 0.7 to 1.01 (Discovery Petroleum 1993). Therefore these source rocks are in the oil generation window (Figure 4). However, the Early Jurassic sandstones in Walyering are gas bearing rather than oil bearing. Maturation modelling shows that the source rocks of the Cattamarra Coal Measures are wholly within the gas generation window in the Dandaragan Trough to the east (Paran, 1995). It is interpreted that this gas migrates updip to the west and displaced the oil in the Walyering area further to the west into the Mullering-Cataby area. Major down-to-the-east faulting between the Mullering-Cataby area and the Walyering area, allows face loading of the “L” Sand and Eneabba Member reservoirs against the thermally mature, coaly and basal unit source rocks in the lower part of the Cattamarra Coal Measures.

## 4.4 Timing

Maturity modelling by Paran (1995) suggests that the source rocks in the lower part of the Cattamarra Coal Measures reached thermal maturity for oil generation during the Early Cretaceous, after the thick deposits of the Yarragadee and Parmelia formations were laid down.

Both the Mullering-Cataby anticlinorium and the Walyering Anticline show evidence of structural growth during the deposition of the Late Jurassic Yarragadee Formation. Therefore, timing of structural growth is ideal for oil migration into the structural complex. This is reinforced by the presence of hydrocarbons in the Walyering Anticline of similar timing.

# 5 SEISMIC INTERPRETATION

There is approximately 350 kilometres of 2D seismic data of 1989-1990 vintage over the permit. This seismic data has been interpreted by the last operator of EP-323, Discovery Petroleum, and their interpretation was submitted to Geological Survey when the area was relinquished. A copy of this interpretation is shown in Enclosure 2.

The quality of the 1989-1990 seismic data is of reasonable quality but the Mullering-Cataby anticlinorium is structurally very complex with considerable crestal faulting breaking up the anticline. Seismic line B89-440 over the Mullering Anticline (Figure 5) illustrates the complexity of the structure. Discovery Petroleum mapped ten leads over this anticlinorium (Enclosure 2). Potential recoverable reserves of these leads range from 5 – 10 million barrels with one example (the Updip Cataby Lead) shown in Table 1.

While the existing interpretation of the Mullering-Cataby anticlinorium is the best that can be done with the existing data, due to the complexity of the structure it is considered too risky to be used for determining the site of a drilling location. It is therefore recommended to acquire a 130 sq km 3D seismic survey over the Mullering-Cataby anticlinorium. The area of this proposed 3D seismic survey will be designed to cover Leads E, G, H and J plus the existing Mullering-1 and Cataby-1. Lead E is updip from Cataby-1 which recovered oil from the Early Jurassic and will be a key prospect if it can be confirmed. The 3D seismic survey will not cover, at this stage, Leads A, B, D and F to the southwest as these are beneath the surface limestones where seismic quality deteriorates rapidly. Before investing in the considerable cost of onshore 3D seismic, further work is required to determine if seismic quality beneath the surface limestones can be improved.

Interpretation of the 3D seismic survey can be tied to the Cataby well and the main objective "L" Sands mapped over the Mullering-Cataby anticlinorium to delineate multiple fault block prospects for future drilling. Only a 3D seismic survey will resolve the complex faulting over the Mullering-Cataby anticlinorium and reduce the structural risk of future drilling.

# 6 REFERENCES


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Discovery Petroleum NL, 1994. Cataby Well Completion Report.

Discovery Petroleum, 1992. Hydrocarbon Potential of EP-323, Perth Basin. *Unpub. Report.*

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Paran, J., 1995. Maturity Modelling and Iso-Maturity Maps of Cattamarra Coal Measures Member and Kockatea Shale in the EP-320 and EP-100(1) Areas, Northern Perth Basin. *Unpub. Report for Boral Energy Resources Limited.*

Playford, P.E., Cockbain, A.E. & Low, G.H., 1976. Geology of the Perth Basin, Western Australia. *Geological Survey of Western Australia, Bulletin* 124.

**TABLE 1**

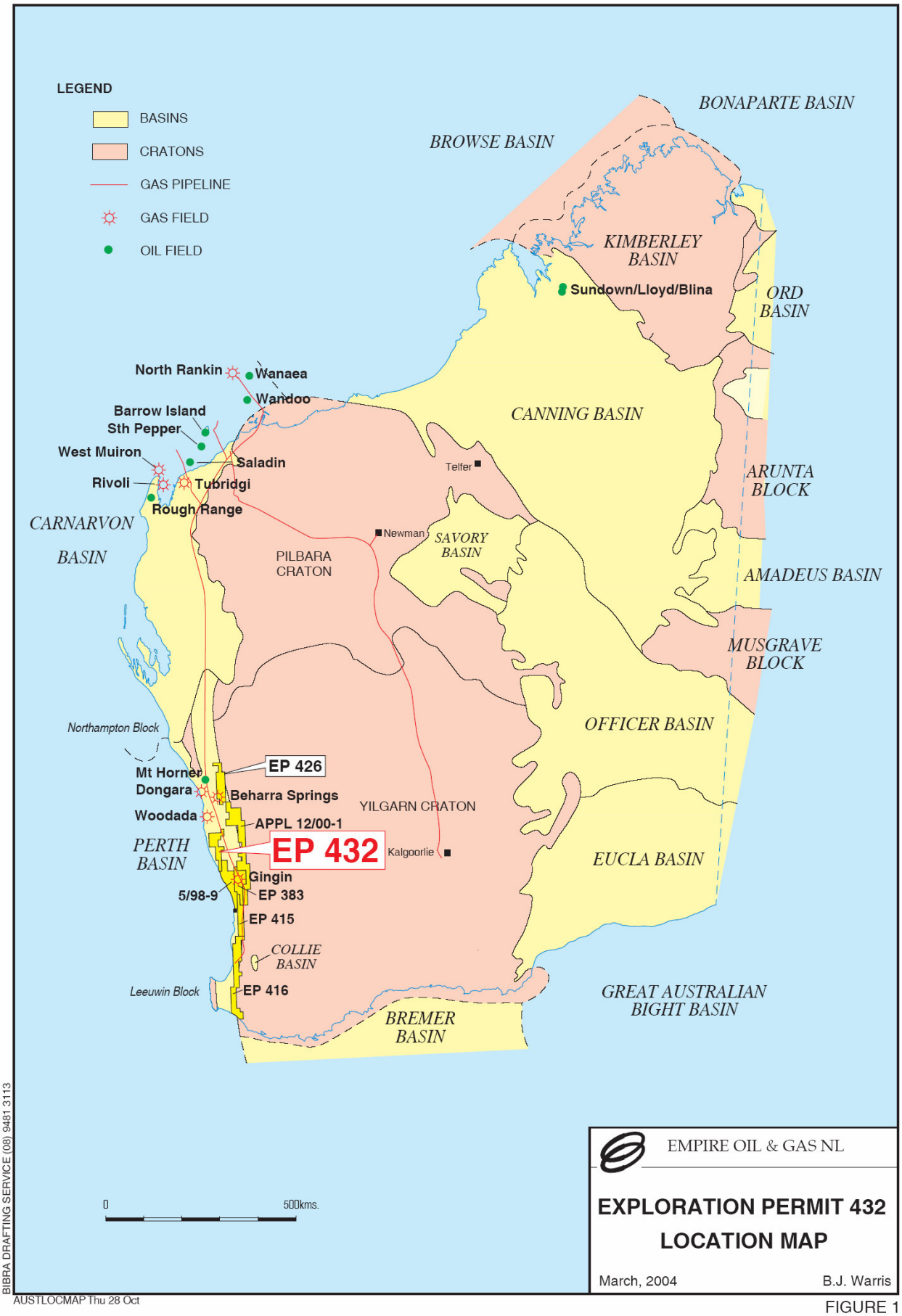
**POTENTIAL RESERVE ESTIMATE**

**EXPLORATION PERMIT EP-432**

**UPDIP CATABY PROSPECT**

**"L" & ENEABBA MEMBER SANDS**

| | |
|---|---|
| Area | 120 hectares |
| Maximum Gross Pay | 200 milliseconds<br>250 metres |
| Net Sand | 85 metres |
| Average Net Pay | 34 metres |
| Volume | 4,080 hectare-metres |
| Reservoir | Porosity = 15% (average)<br>Sw = 40%<br>FVF = 1.1 |
| Oil-in-Place | 5,170 barrels/hm<br>21.1 million barrels |
| Recovery Factor | 40% |
| Recoverable Oil Reserves | 8.4 million barrels |

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**EXPLORATION PERMIT 432**
**LOCATION MAP**

March, 2004 B.J. Warris

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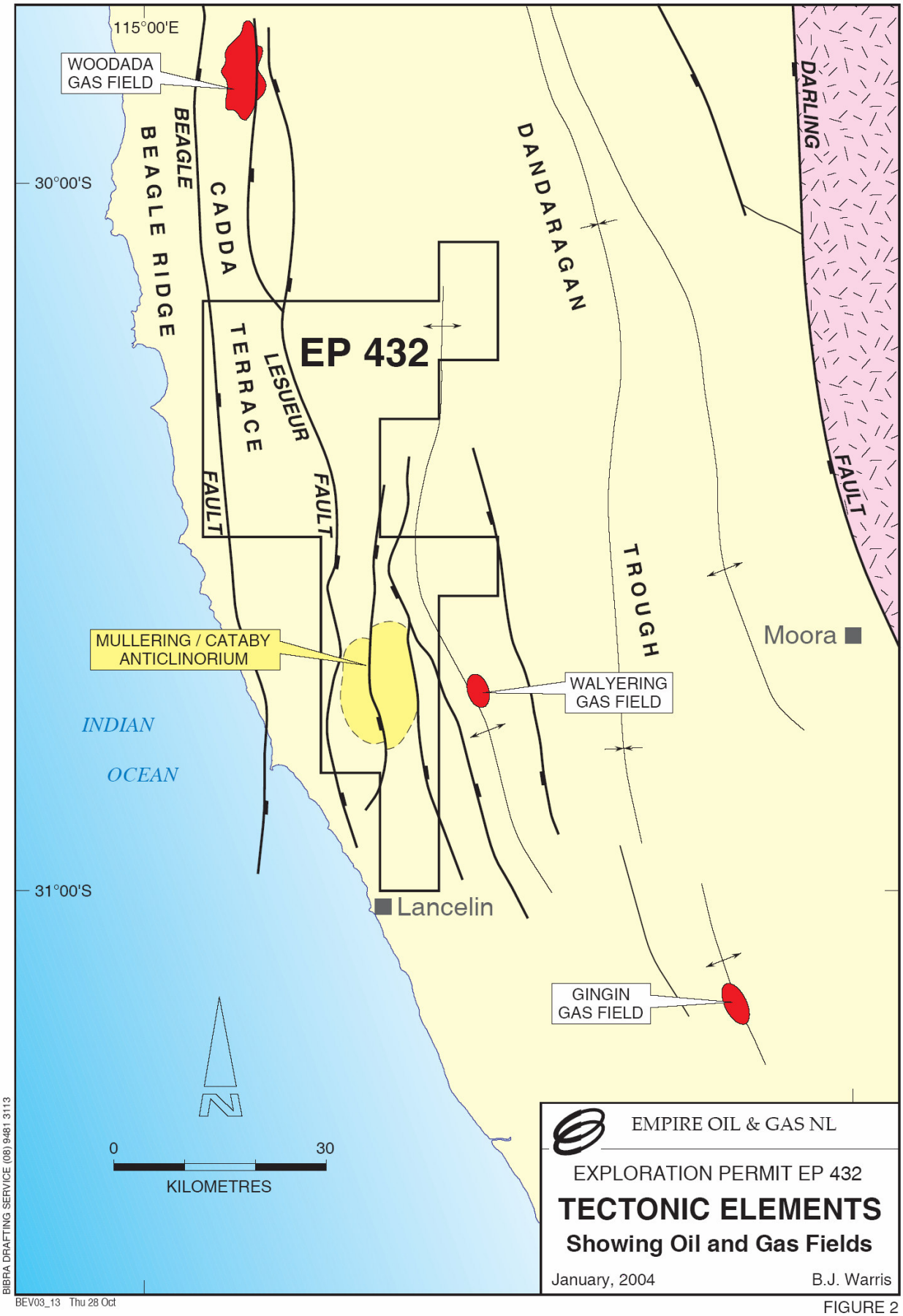
AUSTLOCMAP Thu 28 Oct

FIGURE 1


115°00'E
30°00'S
31°00'S
WOODADA GAS FIELD
BEAGLE RIDGE
BEAGLE
CADDA
TERRACE
LESUEUR
FAULT
FAULT
EP 432
DANDARAGAN
TROUGH
DARLING
FAULT
Moora
MULLERING / CATABY ANTICLINORIUM
WALYERING GAS FIELD
INDIAN
OCEAN
Lancelin
GINGIN GAS FIELD
N
0
30
KILOMETRES
EMPIRE OIL & GAS NL
EXPLORATION PERMIT EP 432
TECTONIC ELEMENTS
Showing Oil and Gas Fields
January, 2004
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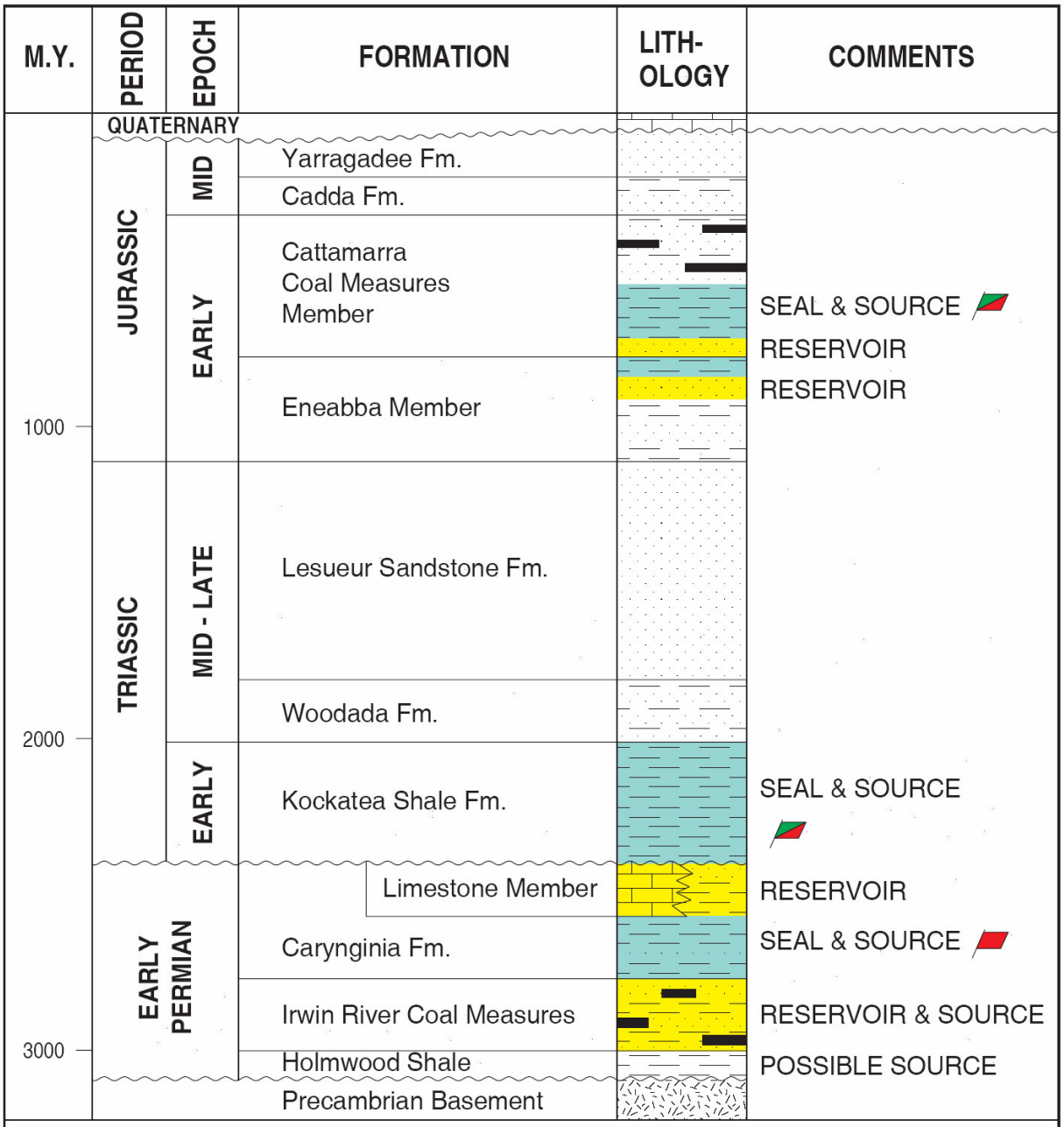
BEV03_13 Thu 28 Oct

FIGURE 2



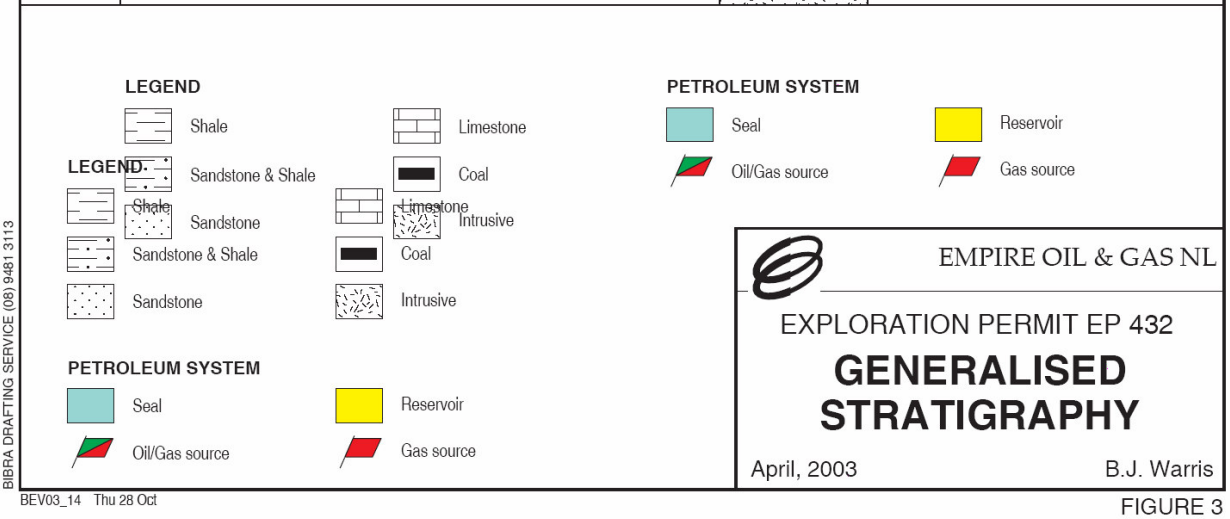




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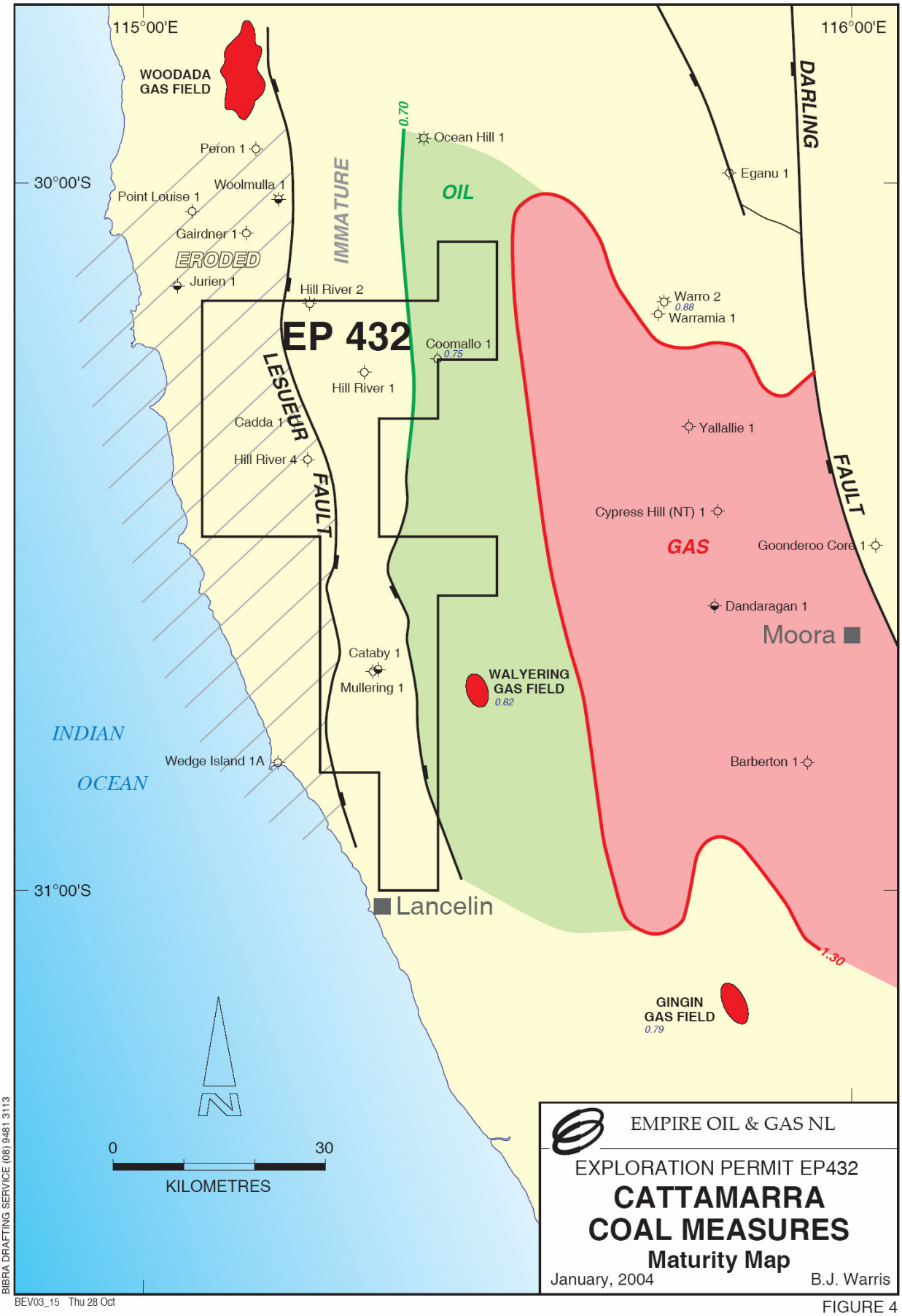
FIGURE 3


115°00'E
116°00'E
30°00'S
31°00'S
WOODADA GAS FIELD
Peron 1
Point Louise 1
Woolmulla 1
Gairdner 1
ERODED
Jurien 1
IMMATURE
0.70
Ocean Hill 1
OIL
Eganu 1
DARLING
FAULT
Hill River 2
EP 432
Coomallo 1
0.75
Hill River 1
LESUEUR
FAULT
Cadda 1
Hill River 4
Warro 2
0.88
Warramia 1
Yallallie 1
Cypress Hill (NT) 1
GAS
Goonderoo Core 1
Dandaragan 1
Moora
Cataby 1
Mullering 1
WALYERING GAS FIELD
0.82
INDIAN
OCEAN
Wedge Island 1A
Barberton 1
Lancelin
1.30
GINGIN GAS FIELD
0.79
N
0
30
KILOMETRES
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EXPLORATION PERMIT EP432
CATTAMARRA
COAL MEASURES
Maturity Map
January, 2004
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FIGURE 4

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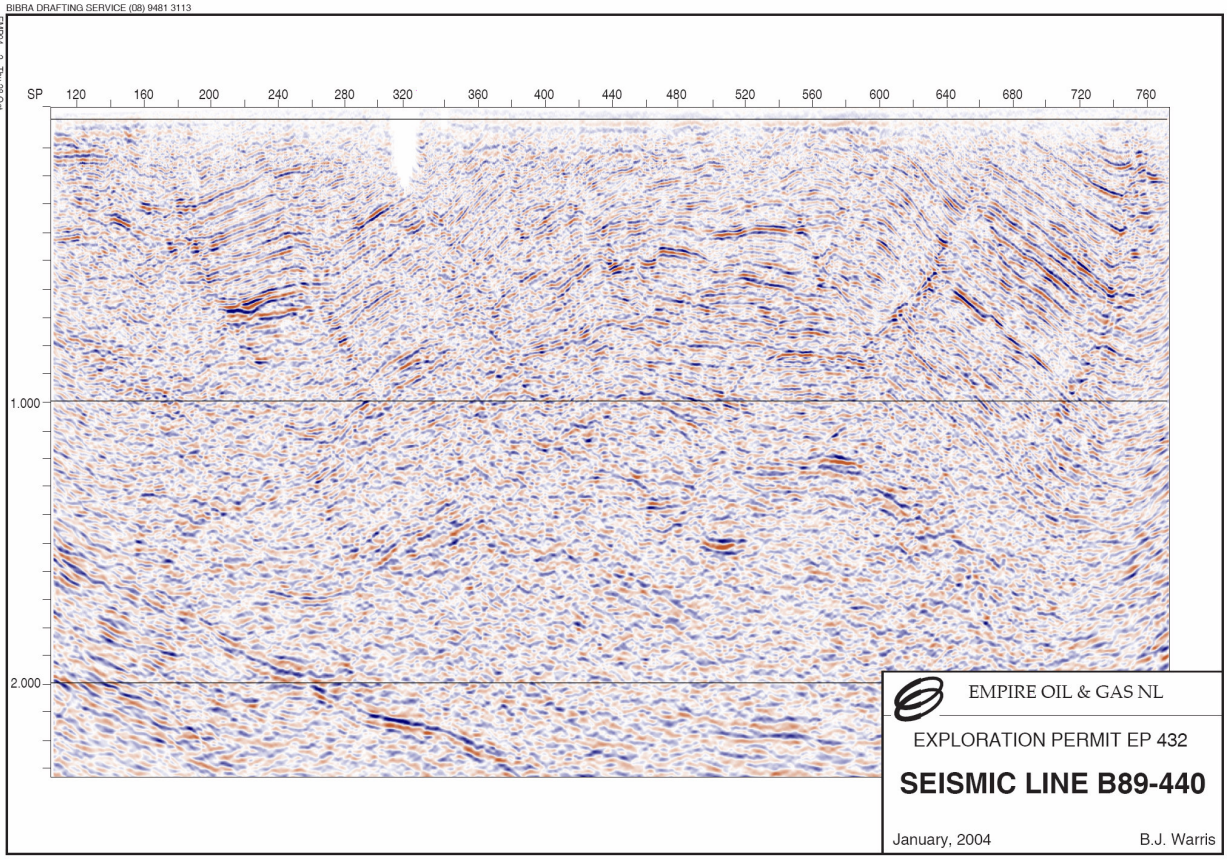
EMP04_2 Thu 28 Oct

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EXPLORATION PERMIT EP 432

**SEISMIC LINE B89-440**

January, 2004

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FIGURE 5

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# PERMIT EP 432

## Stratigraphic Correlation CATABY -1 TO WAYLERING-2

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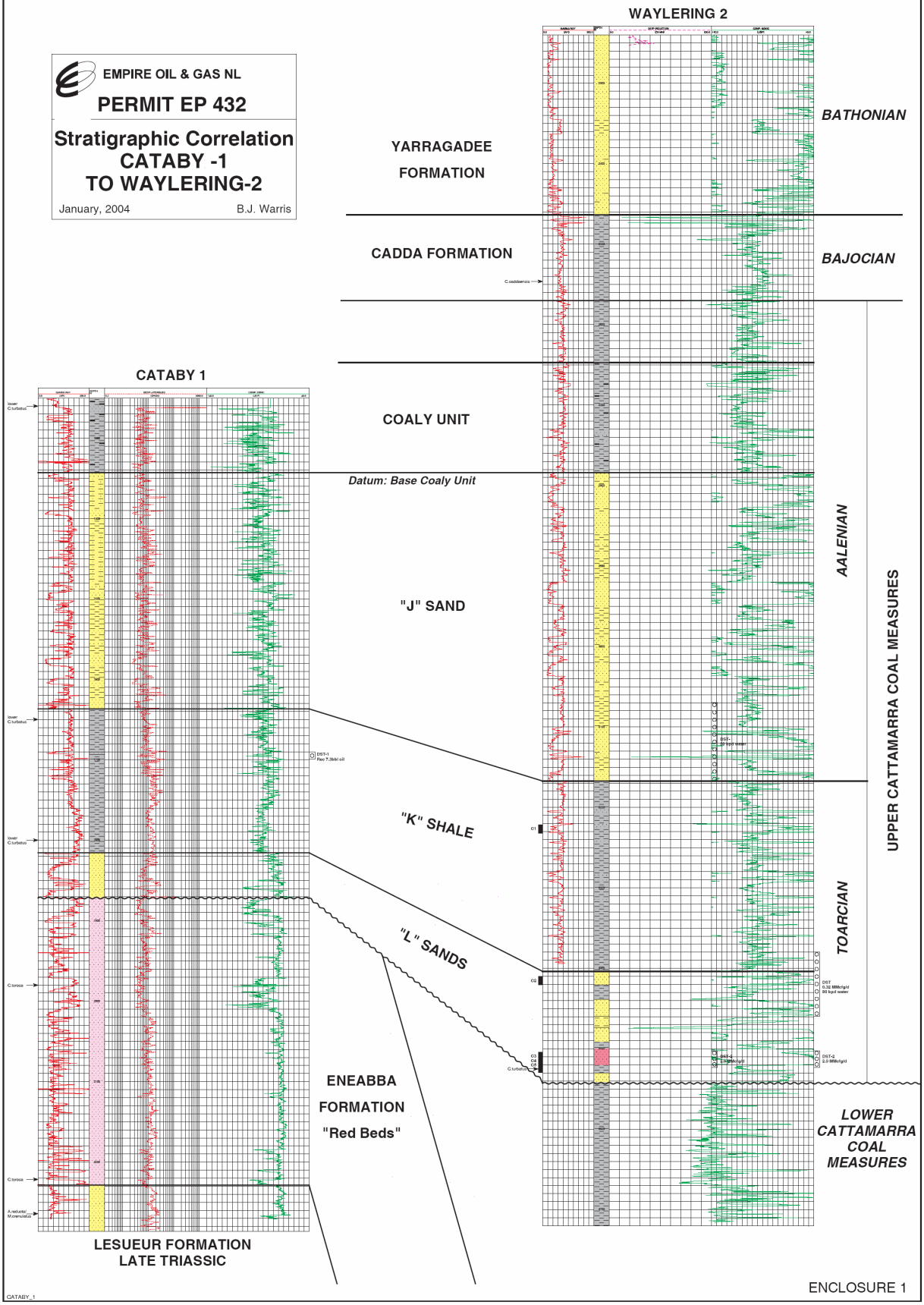
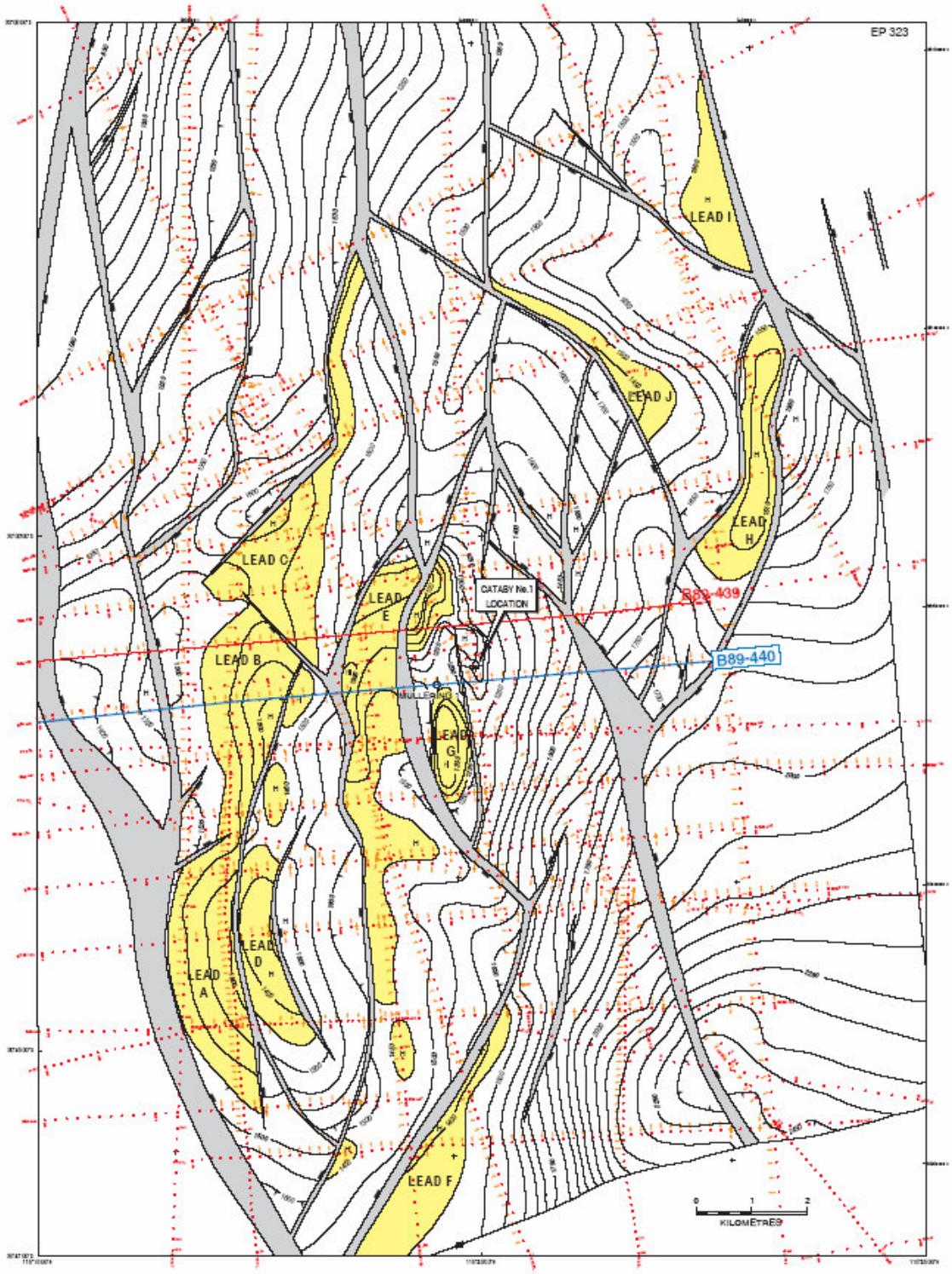



ENCLOSURE 1

CATABY_1




SCALE 1:50,000

0 1 2

KILOMETRES

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

SPHEROID

CENTRAL MERIDIAN 117 DEGREE

EMPIRE OIL & GAS NL

EXPLORATION PERMIT 432

TWO WAY TIME STRUCTURE MAP

**Near Top Cattamarra Coal Measures**

C.I. =50msec

Enclosure 2

After Discovery Petroleum N.L. 1994

BEV03_5