RESTRICTED INVESTIGATION REPORT 1709R

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INSTITUTE OF ENERGY AND EARTH RESOURCES

DIVISION OF MINERAL PHYSICS AND MINERALOGY

AN INTERPRETATION OF ANOMALOUS REFLECTANCE DATA
FROM DURROON #1 WELL, T -15-P, BOOBYALLA
SUB-BASIN, BASS BASIN, OFFSHORE
TASMANIA

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A REPORT TO THE TASMANIA DEPARTMENT
OF MINES

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JULY, 1987

366002

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July 1987

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ABSTRACT:

The Durroon #1 well, Boobyalla Sub-Basin, Bass Basin, offshore Tasmania, yields an anomalous vitrinite depth/reflectance trend. Six reflectance values, recorded from a ~300 well section immediately above an unconformity between the Upper Cretaceous/Lower Tertiary Eastern View Coal Measures and the Lower Tertiary Otway Group, plot on the high reflectance side of the depth/reflectance trend calculated from the remaining ten reflectance values. The inclusion of recycled vitrinite(secondary vitrinite), or inertinite, reflectance measurements in the reflectance calculations is the most likely explanation for the anomalous vitrinite reflectance values recorded for Durroon #1 well.

1. INTRODUCTION:

Reflectance data for Durroon #1 were forwarded to the CSIRO Division of Mineral Physics and Mineralogy by Mr. Peter W. Baillie, Tasmanian Department of Mines, for comment on the anomalous depth/reflectance relationship exhibited by this petroleum exploration well. In addition to the reflectance data, a structural and stratigraphic summary of the Durroon Basin(offshore Boobyalla Sub-Basin), prepared by T. Luskin and D. K. Hobday, was also provided.

The Durroon #1 well is located at 40°32'03"S/147°12'49"E in the southern portion of T-15-P, Boobyalla(Durroon) Sub-basin, Bass Basin, offshore northern Tasmania(Figure 1). Durroon #1 encountered 1450m of Upper Cretaceous to Lower Tertiary Eastern View Coal Measures, separated from the underlying Lower Cretaceous Otway Group by a rift unconformity: igneous material is recorded at about 1592m(pers comm. P. W. Baillie). The TD for Durroon #1 is in the Otway Group at 3024m(Nicholas et al., 1981).

Kantsler et al.(1978) and Nicholas et al.(1981) have discussed the thermal maturation of the Bass Basin. Recently, the Bureau of Mineral Resources, Geology and Geophysics(Canberra, A.C.T.) has published a review of petroleum accumulations in the Bass Basin, Tasmania and Victoria(Ozimic et al., 1987).

2. REFLECTANCE ANALYSIS:

Baillie(1987) has presented fifteen vitrinite reflectance values for the Durroon #1 well; these data are listed in Table 1. The two reflectance analyses on core material(Cores #3 and #5) were carried out by the CSIRO Fuel Geoscience Unit, North Ryde, N.S.W.(Saxby et al., 1980), as part of collaborative source rock study with the BMR. The remaining reflectance analyses were carried out on ditch cuttings (DC) samples; four analyses(1306m-1416m) by ANALABS(A Division of Macdonald Hamilton & Co. Pty. Ltd.), Welshpool, W.A., and nine analyses by AMDEL(Australian Mineral Development Laboratories), Frewville, S.A. Reference to Saxby et al.(1980) reveals that a third core sample(Core #4) was examined by the CSIRO Fuel Geoscience Unit; this value has been included in Table 1, despite the fact that it represents the result of only a single vitrinite reflectance measurement.

Figure 2 illustrates the depth/reflectance for Durroon #1. There is a marked discontinuity in the depth/reflectance trend in the region of the unconformity that constitutes the boundary between the Eastern View Coal Measures (Upper Cretaceous to Lower Eocene) and the underlying Otway Group(Lower Cretaceous). If the reflectance data for the interval 1141-1443m represent a separate reflectance population, i.e. recycled vitrinite or inertinite(?), the remaining data points appear to define a normal depth/reflectance trend. Furthermore, data for the three core samples are part of this normal trend.

Figure 3 is a semilogarithmic diagram, i.e. logarithm to the base 10 of the vitrinite reflectance versus depth. It is assumed that for a constant geothermal gradient this diagram yields a linear depth/reflectance relationship. If the data represent two reflectance populations, regression analysis, using the least squares best fit method, permits the following depth reflectance relationships to be derived:-

(1) Indigenous Vitrinite.

$Log_{10}Rm_o\% = -0.62304210 + 0.00014991 \times Depth(N = 9: r^2 = 0.95803879)$

Surface Intercept Rm_o = 0.238%: Maximum loss by erosion = 506.5m(?)

Depth/reflectance gradient($Log_{10}Rm_o\%/km = 0.14991$)

(2) Recycled Vitrinite/Inertinite(?).

$Log_{10}m_o\% = -0.50311572 + 0.00017826 \times Depth(N = 6: r^2 = 0.34829166)$

Surface Intercept Rm_o = 0.314%: Maximum loss by erosion = 1099m(?)

Depth/reflectance gradient($Log_{10}rm_o\%/km = 0.17826$)

The depth/reflectance gradients, calculated for the two reflectance populations, are broadly similar to those calculated from the neigbouring Gippsland Basin reflectance data(Kantsler et al., 1978) and reflectance data from the North West Shelf, Western Australia, e.g. West Tryal Rocks #1(pers. comm., A. J. R. Bennett). If a vitrinite reflectance value of 0.5% is regarded as indicating the onset of thermal maturity for hydrocarbon generation, organic matter in Durroon #1 well is capable of generating oil below 2148m. Extrapolation of the depth/reflectance trend illustrated in Figure 3, assuming a constant geothermal gradient, suggests that the onset of the main oil generation zone occurs below 3122m(Rm_o = 0.7%), the base of the oil window(Rm_o = 1.0) occurs below 4000m and gas/condensate may be generated as deep as 5000m.

3. DISCUSSION OF VITRINITE DEPTH/REFLECTANCE TREND:

Dow(1977) has listed the common source of vitrinite reflectance errors encountered when analysing dispersed organic matter(DOM) in sedimentary rock samples. Caved material(retombe'), inadequate surface polish and contamination by drilling mud additives or lost circulation material(LCM) tend to yield reflectance values that are less than the correct value; whereas, recyled material(see below) and oxidized, or altered, material(remanie') tend to yield reflectance values that are greater than the correct value. Natural variation between vitrinite submaceral populations, statistical errors and technical errors in reflectance measurement procedure can yield reflectance values that are less than, or greater than, the correct value. The problem of contamination of the sample by caved material or drilling mud additives can be avoided by confining vitrinite reflectance analyses to core material; although sidewall core(SWC) material collected from labile sedimentary rocks can be badly contaminated by these materials. In core material the lowest reflectance humic(vitrinite plus inertinite) component present in the total DOM reflectogram can usually be assigned to indigenous vitrinite(Bostick, 1974; Castano and Sparks, 1974). However, in practice, the most common type of petroleum exploration well sample available for analysis is the ditch cuttings (DC) interval.

Vitrinite reflectance analyses were carried out on only three core samples (1618m, 2485m and 2946m) from Durroon #1 well. One of the core reflectance values(2485m) is based on only a single reflectance measurement; the other core reflectance values are based on about 50 individual reflectance measurements. Reference to Saxby et al.(1980) reveals that the reflectance value for the core sample from 1618m is based on individual reflectance measurements that range over only three 1/2V stages(0.05% Rm_o class interval), which suggests a standard deviation of about +/-0.02 to 0.03%. The reflectance value for the core sample from 2946m is based on individual reflectance measurements that range over eight 1/2V stages, implying a standard deviation of +/-0.06 to 0.07%. The reflectogram, i.e. histogram of frequency versus reflectance expressed as 0.05%

reflectance class intervals, for this sample exhibits a negative skew, indicative of the presence of a subordinate low reflectance component(liptinite?). It is possible that the true vitrinite reflectance value for this sample is slightly higher than the recorded value of 0.69%.

Only one(2924m) of the thirteen ditch cuttings sample reflectance values is based on more than 30 individual reflectance measurements, and only a further three(1306m, 2360m and 2924m) of the ditch cuttings sample reflectance values are based on 20, or more, individual reflectance measurements. With the exception of the sample at 2056m, for which N = 17, the remaining ditch cuttings sample reflectance values are based on less than 10 individual reflectance measurements. The standard deviations for the ditch cuttings sample reflectance values range from acceptable values of +/-0.02 to 0.04% to less than acceptable values of +/-0.08 to 0.10%.

In attempting to decide which of the Durroon #1 well reflectance values are most likely to constitute reliable data, a balance must be achieved between the number of individual reflectance measurements(N) used to calculate the mean vitrinite reflectance in oil(Rm_o%) and the scatter of these individual reflectance measurements as indicated by the standard deviation(+/-S). It appears that the most reliable reflectance data are represented by the values obtained on cores #3(1618m) and #5(2946m) and the ditch cuttings samples from below 2000m. The six anomalous vitrinite reflectance values recorded from the interval 1141-1443m are, with the exception of the sample from 1306m(N = 20), based on an average of less than 10 individual reflectance measurements. As these six reflectance values appear to be both anomalous and of a lesser reliability, it is valid to exclude them from the calculation of the vitrinite depth/reflectance trend for the Durroon #1 well.

The suppression of vitrinite reflectance by associated liptinite rich material and, by extension, other hydrogen rich material, including migrated oil, can further complicate the interpretation of vitrinite reflectance data(Hutton and Cook, 1980; Hutton et al., 1980; Newman and Newman, 1982; Walker et al., 1983; Price and Barker, 1985). In the absence of maceral analyses, to determine the organic matter type, for the Durroon #1 well samples it is not possible to assess whether vitrinite reflectance suppression by liptinite has influenced the vitrinite reflectance data for this well.

The vitrinite depth/reflectance relationship in the Durroon #1 well is clearly anomalous. Reference to Dow(ibid) suggests three possible models for this type of depth/reflectance trend, namely (1) the presence of an igneous intrusive, (2) the presence of a geologically young, reverse, fault, or (3) the presence of recycled vitrinite(remanie' = secondary organic matter) as the dominant component of the vitrinite population.

For model (1) Dow(1977) notes that, as a general rule, contact(thermal) metamorphism influences the thermal maturity of the intruded country rock to a maximum of about twice the thickness of the igneous intrusion. The influence of contact metamorphism is often more marked below the igneous body than above due to the insulating effect of the intrusion. A very thick igneous intrusive body, i.e. ~150m, would be required to produce the anomalous vitrinite reflectance values over the ~800m(830-1620m) section of Durroon #1. Igneous material was recorded at about 1592m; however, the magnitude of this igneous body was not indicated. Unless this igneous body is intrusive and of magnitude indicated above it is unlikely that model 1 could be invoked to account for the Durroon #1 vitrinite depth/reflectance profile.

For model (2) Dow(1977) notes that the vertical displacement of reverse faulting can be estimated by projection of the two maturation profiles, from above and below the fault, on a semilogarithmic depth/reflectance diagram(Figure 2). Although a rift unconformity was recorded at 1450m, between the Eastern View Coal Measures and the older Otway Group, no information was provided to suggest any reverse movement along this discontinuity. For a normal fault, or unconformity, the displacement of the two maturation profiles is in the opposite sense to that for a reverse fault(Dow, 1977). Also, for a reverse fault, it appears that the two maturation profiles should exhibit the same depth/reflectance gradient above and below the fault; this does not appear to be the case for the Durroon #1 well(see Figure 3).

For model (3) the vitrinite component of the DOM from sedimentary rocks would need to be dominated by recycled vitrinite. In samples containing abundant DOM, the indigenous vitrinite component is usually fairly obvious either by direct inspection of the sample under the microscope, or by inspection of the total humic component(vitrinite plus inertinite reflectogram); the lowest reflectance humic component represents indigenous vitrinite, provided that contamination by caved material or drilling mud additives is minimal. If the absolute amount of vitrinite is very small and the DOM grain size is very small, the influence of recycled, oxidized or altered vitrinite may be such that it leads to an erroneous vitrinite reflectance determination(Bostick, 1974, Casstano and Sparks, 1974). Dow(1977) notes that secondary, or recycled, vitrinite typically yields maturation profiles with a steeper slope than that for an indigenous vitrinite maturation profile(see Figure 3).

Inspection of the Durroon #1 depth/reflectance profile, taken together with the fact that most reflectance values in the upper part of the well are, with one exception, based on less than 10 reflectance measurements, suggests that model (3) may provide the best explanation of the anomalous depth/reflectance values. This interpretation is illustrated in Figure 3.

4. CONCLUSIONS:

The anomalous vitrinite reflectance values for the interval 1141-1443m in Durroon #1 well are most probably due to the presence of recycled, or altered, vitrinite(remanie'), or inertinite, in ditch cuttings samples and the inclusion of this material in the reflectance measurements for indigenous vitrinite. However, re-examination of the samples, including qualitative liptinite autofluorescence and quantitative maceral analyses, would be required to confirm the veracity of this explanation.

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TABLE 1:

REFLECTANCE DATA FOR DURROON #1 WELL, BASS BASIN, TASMANIA:

DEPTH (m)	FORMATION	SAMPLE TYPE	ANALYST	Rmo%	+/-S	N	RANGE
529	EASTERN VIEW COAL MEASURES (UPPER CRETACEOUS TO LOWER TERTIARY)	DC	AMDEL	0.31	0.02	8	0.28-0.33
830		DC	AMDEL	0.32	0.02	4	0.29-0.35
1141		DC	AMDEL	0.52	0.04	8	0.46-0.58
1306		DC	ANALABS	0.54	0.08	20	0.38-0.67
1342		DC	ANALABS	0.49	0.07	7	0.41-0.61
1379		DC	ANALABS	0.54	0.06	5	0.47-0.63
1416		DC	ANALABS	0.57	0.09	7	0.46-0.68
1443		DC	AMDEL	0.61	0.04	7	0.56-0.66
1450	UNCONFORMITY BETWEEN EAST VIEW COAL MEASURES AND OTWAY GROUP						
1618	OTWAY GROUP (LOWER CRETACEOUS)	[a]CORE #3	CSIRO	0.38		50	
1745		DC	AMDEL	0.42	0.07	4	0.30-0.50
2056		DC	AMDEL	0.44	0.04	17	0.35-0.50
2360		DC	AMDEL	0.57	0.08	24	0.43-0.71
2665		DC	AMDEL	0.60	0.06	33	0.45-0.70
2485		[b]CORE #4	CSIRO	0.54		1	
2924			AMDEL	0.67	0.10	24	0.49-0.82
2946		[c]CORE #5	CSIRO	0.69		49	

[a]Saxby et al.(1980) use the BMR value of 2695.9m(5564') for Core #3.

[b]Saxby et al.(1980) use the BMR value of 2567.0m(8422') for Core #4.

[c]Saxby et al.(1980) use the BMR value of 3024.2m(9922') for Core #5.

The BMR values(Saxby et a.,1980) are ~78m deeper than the values quoted by Baillie(1987). Therefore, in Table 1, Core #4 is assigned a depth of 2485m.

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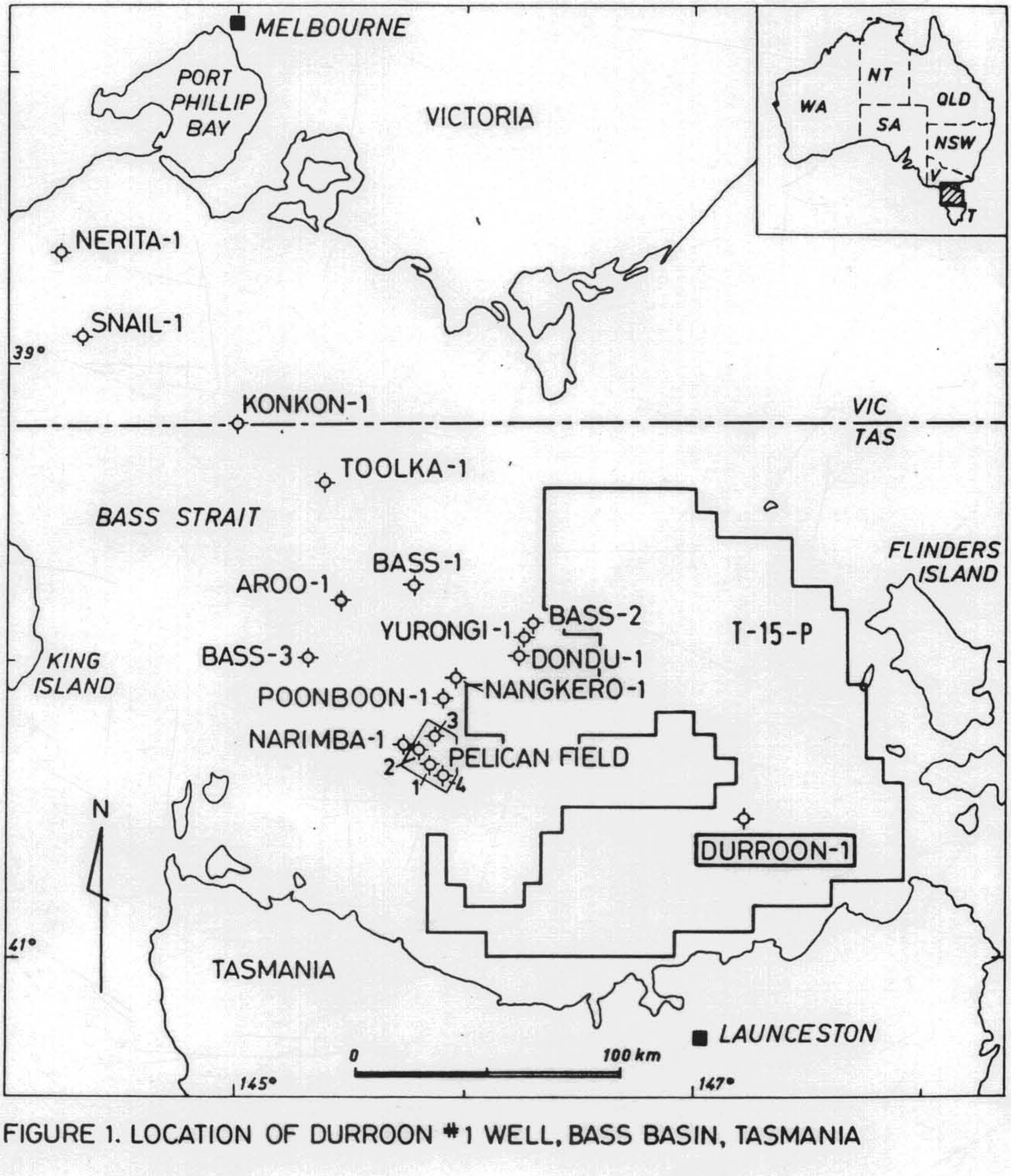
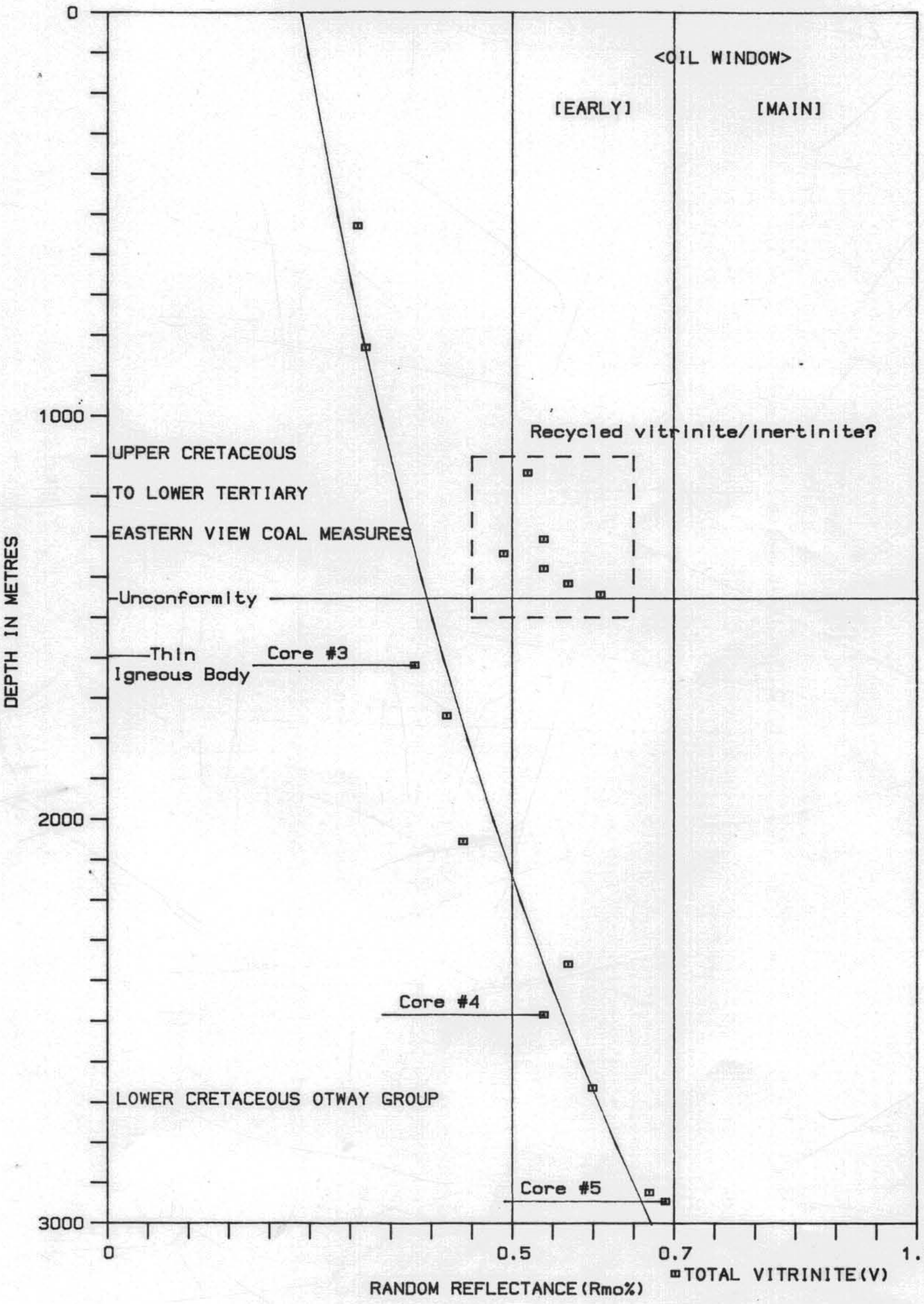


FIGURE 1. LOCATION OF DURROON #1 WELL, BASS BASIN, TASMANIA

5 cm

FIGURE 2: DEPTH/REFLECTANCE RELATIONSHIP FOR
DURROON #1 WELL

(T-15-P, BASS BASIN/BOOBYALLA SUB-BASIN, TASMANIA)



5 cm

FIGURE 3: DEPTH/REFLECTANCE RELATIONSHIP FOR
DURROON #1 WELL

(T-15-P, BASS BASIN/BOOBYALLA SUB-BASIN, TASMANIA)