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GIPPSLAND BASIN.

BIGNOSE NO. 1



# Organic petrology of a suite of samples from Bignose No. 1

Keiraville Konsultants Pty Ltd

KEIRAVILLE KONSULTANTS. (A.C. COOK) JULY 1984.

A report prepared for

Shell Development of Australia Limited

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7 Dallas Street,
Keiraville, N.S.W. 2500,
Australia

July 1984

Source Rock Analysis Box.

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Contents

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## Introduction

Eleven cuttings samples and twenty one core samples were received from Shell Development of Australia Limited for petrological examination of the contained organic matter. These samples covered a depth interval from 2822.5 m to 3863 m and probably range in age from the Lower Tertiary down to Upper Cretaceous.

Short descriptions of the organic matter in each sample, together with vitrinite reflectance data and descriptions of rock-types, are given in Appendix 1. Appendix 2 contains a summary of maceral occurrence and abundance. Maceral analyses are listed in Table 1. This report draws together petrological data for the suite of samples and develops an interpretation of the source potential of, and the extent to which hydrocarbons are likely to have been generated from, the sequence drilled at the location of Bignose No. 1. Estimates of the thermal history and the probable timing of maturation are also made.

## Experimental Methods

Samples were mounted in cold-setting polyester resin and polished "as received", so that whole-rock samples rather than concentrates of organic matter were examined. This method is preferred to the use of demineralised concentrates because of the greater ease, with whole-rock samples, of identifying first generation vitrinite. The whole-rock method also permits the examination of maceral associations. The sidewall core samples were lightly crushed with a mortar and pestle to give adequate impregnation of the mounting resin in the case of samples that show mechanical damage or mud-invasion. For these reasons, most of the sidewall cores were crushed.

The cuttings samples and some of the sidewall cores, are relatively heterogeneous lithologically and the relative abundances of rock types found after mounting (and crushing where necessary) are given in Appendix 1. Crushing the samples probably results in an overestimation of the proportion of both clastic and coal end member lithologies. Some of the grains reporting as coal are probably derived from phytoclasts isolated during the coring and crushing processes from a clastic matrix.

Vitrinite reflectance measurements were made using immersion oil of refractive index 1.518 (at 546nm and 23°C) and spinel and garnet standards of 0.42%, 0.917% and 1.726% reflectance. Fluorescence-mode observations were made on all samples and provide supplementary evidence concerning organic matter type, and exinite abundance and maturity. For fluorescence-mode a 3mm BG 3 excitation filter was used with a TK400 dichroic mirror and a K490 barrier filter. A Leitz MPV 1.1 photometer mounted on a Leitz Orthoplan was used for photometric work. A separate Opak illuminator is normally used for examination in fluorescence-mode but flourescence-mode observations can be made while the photometer illuminator is mounted.

Maceral counts were made using a Swift point count stage with a step length generally set at 0.05 mm and with 0.5 mm between traverses. These distances had to be changed for some samples where only small amounts of material were available. 500 points in macerals + minerals were counted for each block. The methods of sampling are such that normal measures of precision cannot readily be transferred from the sample to the population sampled. However, experience suggests that for both cuttings and sidewall cores systematic errors are not likely to be significant. Point counts were made using both reflected white light and fluorescence-mode illumination for each field counted. This practice is considered to be more accurate and informative as compared with making consecutive counts, one in each mode.

## Vitrinite Reflectance

The sample set provides excellent control over the variation of the vitrinite reflectance as a function of depth over the 1040.5 m of interval sampled. The mean maximum vitrinite reflectances range from 0.45% at 2839.5 m (SWC) to 0.86% at 3429 m (SWC). All samples contain measurable vitrinite and reflectance measurements were limited by vitrinite abundance for none of the samples. The vitrinite population is well defined in all cases and the range of reflectances found for each sample is normal. Below 3700 m no significant increase in reflectance was found. The profile resembles that for Volador in the absence of a rise in reflectance near T.D. In the case of Bignose the interval drilled below the peak reflectance is much smaller than that for Volador and the extent of the anomaly is much smaller than that for Volador. Thus significance of this lack of an increase is less easily assessed for

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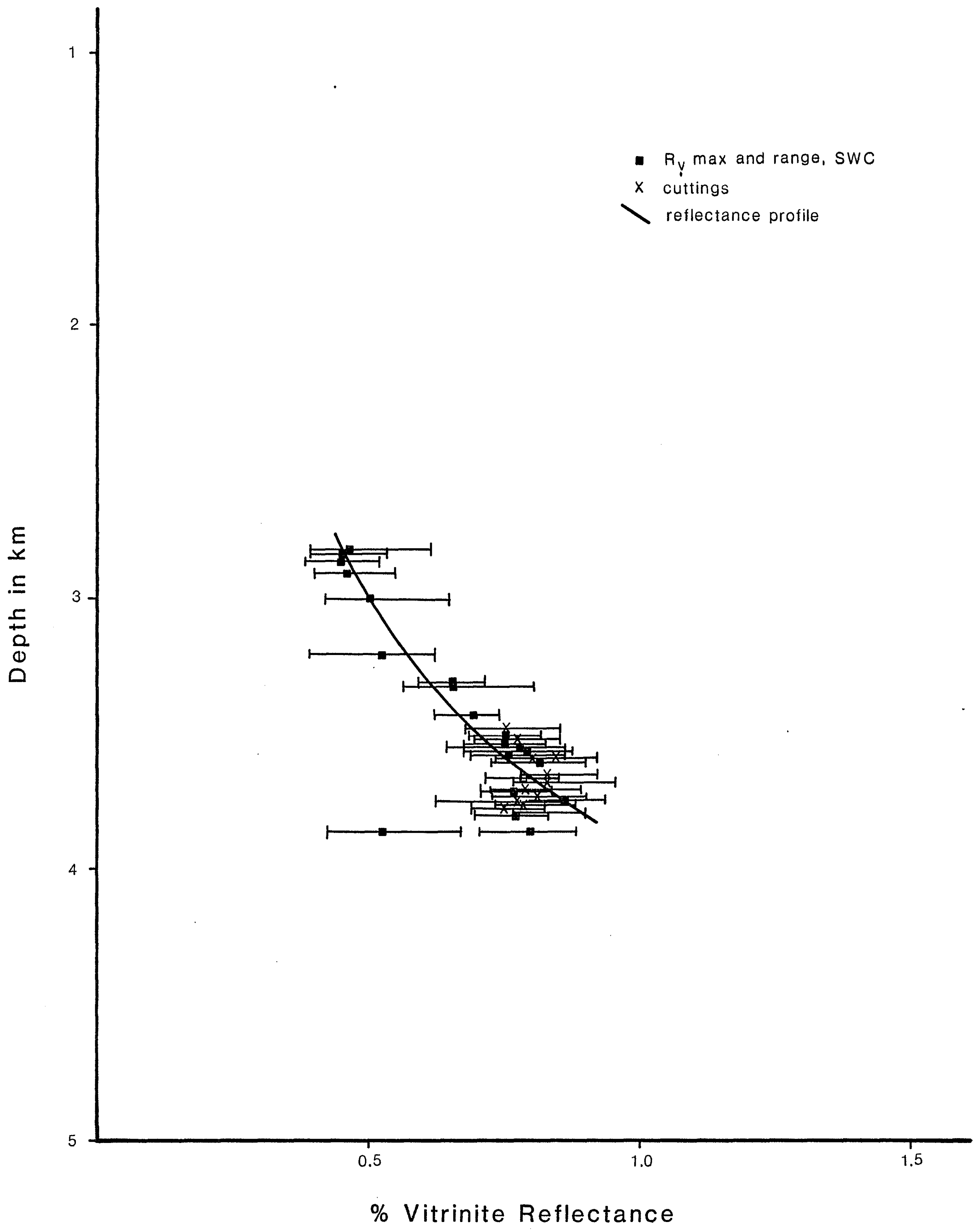

Depth in km
1
2
3
4
5
0.5
1.0
1.5
% Vitrinite Reflectance
$R_v$ max and range, SWC
X cuttings
reflectance profile

Bignose. The results for the samples fall on a consistent trend down to about 3700 m with departures from the trend being due to minor type effects. However, the maturation level at 3800 m is very similar for all three wells and the possibility that a pattern similar to Volador would have been found for Bignose if the latter had been drilled to the same depth as Volador cannot be discounted. The trend from 2839.5 m to 3729 m gives a reflectance gradient, of 0.54%/km. This is unusually high for reflectance gradients found in the distal offshore Gippsland Basin and is much greater than those for the intervals sampled in Volador No. 1 and Basker No. 1.

Bignose No. 1 entered the oil mature zone at about 3000 m (depth to 0.50% $\bar{R}_V$max) and is near the base of the principal zone of oil generation ($\bar{R}_V$max 0.90%) at 3900 m. The reflectance gradient at the 0.5% vitrinite reflectance horizon is 0.37%/km. and that at the 0.7%/km. horizon is 0.50%/km.

Exinite fluorescence colours and intensity show a systematic change over the interval sampled with the colours and intensities being consistent with the vitrinite reflectance data. Near T.D. in Volador most of the exinite does not fluoresce. This is not the case for Bignose or Basker, but as noted above, if Bignose were drilled to the same depth as Volador similar properties might be found.

Weak oil cuts from vitrinite (typically from telocollinite but also from some desmocollinite) are common where the vitrinite reflectance exceeds about 0.70%. Secondary fluorescence from desmocollinite probably due to oil impregnation is typical at reflectances in excess of 0.65%. Micrinitization of part of the vitrinite is common but is typically not prominent in the higher rank part of the section. Micrinitization of exinite macerals was noted but micrinite is developed more commonly in association with vitrinite as compared with exinite. Exsudatinite is present in the sample from 3576 m.

## Organic Matter Type

The composition of the organic matter is summarized in Table 1 and in Figures 2a and 2b. Appendix 1 includes brief sample descriptions and maceral relative abundances are tabulated in Appendix.2.

The organic matter assemblage can be assigned to the Lower Eastern View facies (chiefly sub-facies A) of Smith and Cook (1984). The assemblage is generally similar to those described for Volador and Basker except that in Bignose (as in Basker) few lithologies representative of subfacies B were found. The coals are generally vitrinite-rich and exinite is typically the second most abundant maceral (Figures 2a and b). Inertinite is commonly the least abundant maceral group but the inertinite population is diverse in both maceral species and reflectance. The maceral assemblage in the dispersed organic matter (d.o.m.) is similar to that in the coals but the ratio of vitrinite to exinite and to inertinite is generally less for the d.o.m. than for the coals. For many samples, the distinction between coal and d.o.m. is both difficult and arbitrary. Thin coals having a high content of "dirt bands" and highly carbonaceous shales are typical of the Lower Eastern View facies (Smith and Cook, 1984) so that assignment of lithologies to the categories coal, shaly coal and carbonaceous shale becomes highly sensitive to sample type, sample preparation and the specific interval sampled (see Appendix 1 for the descriptions of samples over the interval sampled).

The vitrinite is dominated by telocollinite but desmocollinite is also an important component (Plates 3 and 4). Some of the desmocollinite shows weak fluorescence (Plate 3). Telocollinite fluorescence is very weak and in some smples is obscured by oil-cuts.

Within the exinite group of macerals suberinite (Plates 4 and 6) is the most abundant maceral in many samples (Table 1). The diminished importance of suberinite in some of the deeper samples is probably due to convergence of its optical properties with those of vitrinite as a result of coalification rather than to the primary absence of suberinite in the deeper part of the section. However, suberinite is not abundant in some of the shallower samples. Of the "classic" exinite macerals, sporinite (Plates 3, 5 and 7) is dominant over cutinite (Plates 1 and 3). Cutinite is a significant component of most samples but is rarely dominant. Resinite is locally abundant but is typically present in smaller amounts (Plate 1). In the deeper samples much of the vitrinite is resinous and as noted above, the presence of resinous vitrinite may have caused some of the dispersion of reflectance data from the overall reflectance trend.

Inertinite present comprises semifusinite (Plate 2) and inertodetrinite (Plate 2). Sclerotinite does not appear to be present and macrinite is either absent or not prominent.

Mineral fluorescence is weak near the top of the section sampled and becomes weak to moderate near T.D.

Table 1 Maceral analyses

| Sample No. | Depth | Vitrinite | Exinite | Inertinite | Clay/ Quartz | Pyrite | Carbonate | Total |
|---|---|---|---|---|---|---|---|---|
| 18888 | 2822.5 | 4 | 1 (Tr) | 4 | 89 | Tr | 2 | 100 |
| 18889 | 2839.5 | 3 | 2 | 3 | 91 | 1 | - | 100 |
| 18890 | 2874 | 6 | 9 (Tr) | 3 | 82 | Tr | Tr | 100 |
| 18891 | 2912.5 | 8 | 5 | 1 | 85 | 1 | - | 100 |
| 18892 | 3004 | 9 | 4 (1) | 14 | 67 | 6 | Tr | 100 |
| 18893 | 3212 | 2 | Tr | 1 | 96 | 1 | - | 100 |
| 18894 | 3318.5 | 57 | 19 (6) | 20 | 4 | Tr | Tr | 100 |
| 18895 | 3335 | 73 | 12 | 5 | 10 | Tr | - | 100 |
| 18896 | 3458 | 38 | 10 (1) | 5 | 46 | 1 | - | 100 |
| 18897 | 3492 | 79 | 13 (6) | 5 | 3 | Tr | - | 100 |

( ) Suberinite

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Table 1 Maceral analyses

| Sample No. | Depth | Vitrinite | Exinite | Inertinite | Clay/ Quartz | Pyrite | Carbonate | Total |
|---|---|---|---|---|---|---|---|---|
| 18898 | 3517 | 26 | 13 (4) | 2 | 59 | Tr | Tr | 100 |
| 18899 | 3534 | 75 | 13 (7) | 5 | 6 | Tr | 1 | 100 |
| 18900 | 3537.5 | 77 | 6 (2) | 7 | 10 | Tr | Tr | 100 |
| 18901 | 3542 | 28 | 5 (1) | 1 | 66 | - | - | 100 |
| 18902 | 3567 | 9 | 3 (Tr) | 1 | 86 | Tr | 1 | 100 |
| 18903 | 3569 | 12 | 2 (Tr) | 1 | 85 | Tr | - | 100 |
| 18904 | 3576 | 70 | 7 (2) | 4 | 19 | Tr | - | 100 |
| 18905 | 3589.5 | 41 | 8 (4) | 2 | 48 | 1 | Tr | 100 |
| 18906 | 3591 | 25 | 8 (1) | 3 | 64 | Tr | - | 100 |
| 18907 | 3657 | 60 | 15 (10) | 3 | 22 | Tr | - | 100 |

( ) Suberinite

Table 1 Maceral analyses

| Sample No. | Depth | Vitrinite | Exinite | Inertinite | Clay/ Quartz | Pyrite | Carbonate | Total |
|---|---|---|---|---|---|---|---|---|
| 18908 | 3658 | 63 | 7 (1) | 4 | 26 | Tr | - | 100 |
| 18909 | 3685 | 54 | 12 (6) | 3 | 30 | - | 1 | 100 |
| 18910 | 3712 | 29 | 9 (2) | 5 | 54 | 1 | 2 | 100 |
| 18911 | 3713.5 | 52 | 16 (8) | 2 | 30 | Tr | Tr | 100 |
| 18912 | 3728 | 40 | 10 (3) | 4 | 44 | 0.5 | 1.5 | 100 |
| 18913 | 3729 | 50 | 10 (3) *3 | Tr | 40 | Tr | - | 100 |
| 18914 | 3730 | 79 | 9 (3) | 9 | 3 | - | - | 100 |
| 18915 | 3759 | 38 | 7 (4) *2 | Tr | 52 | 1 | 2 | 100 |
| 18916 | 3759.5 | 36 | 8(Tr) | 3 | 49 | 4 | - | 100 |
| 18917 | 3765.5 | 64 | 11 (4) *5 | Tr | 24 | 1 | - | 100 |

* Resinite

( ) Suberinite

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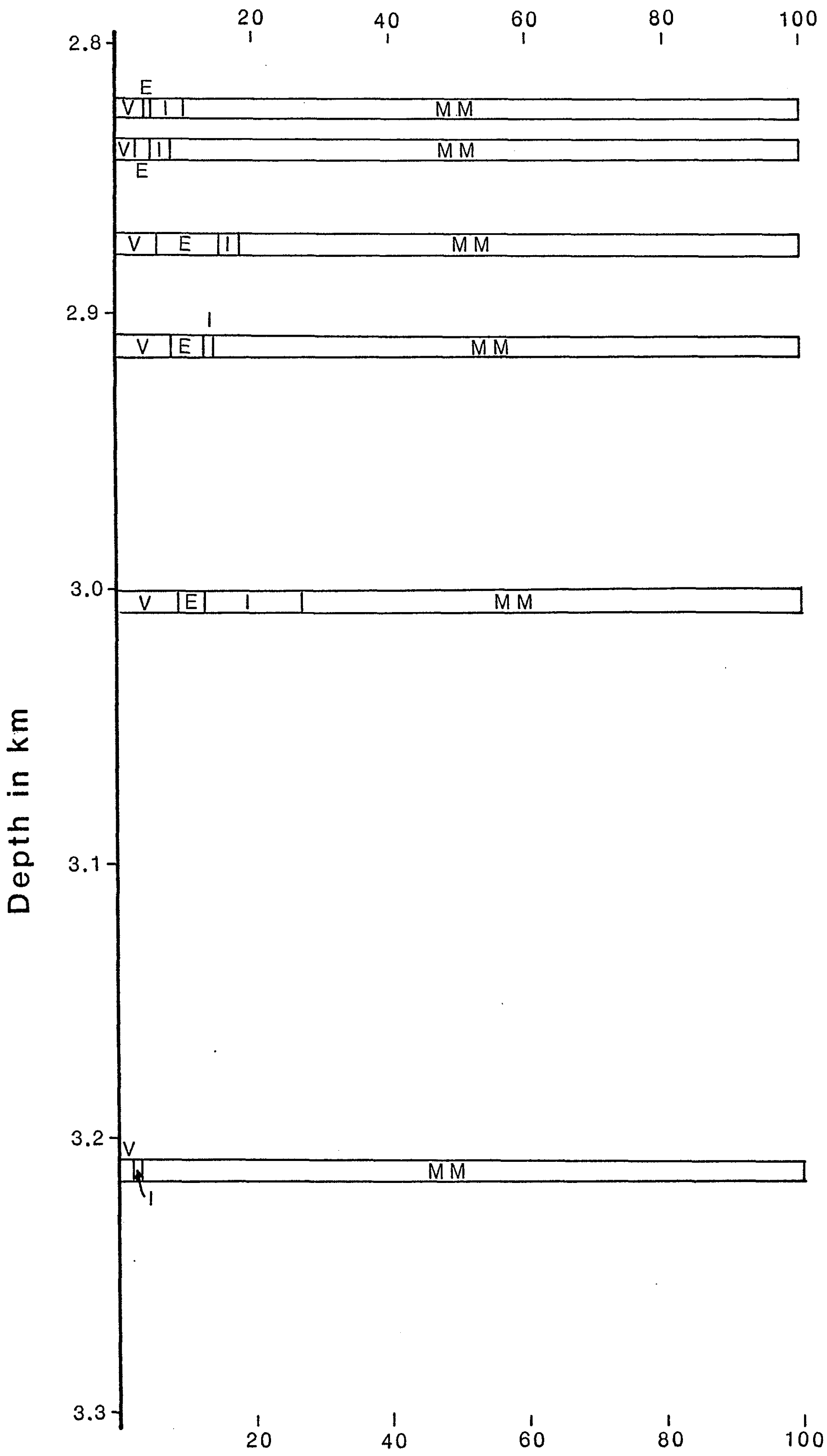
Table 1 Maceral analyses

| Sample No. | Depth | Vitrinite | Exinite | Inertinite | Clay/ Quartz | Pyrite | Carbonate | Total |
|---|---|---|---|---|---|---|---|---|
| 18918 | 3796 | 13 | 7 (Tr) | 1 | 77 | 2 | - | 100 |
| 18919 | 3796 | 34 | 10 (6) | 1 | 53 | 1 | 1 | 100 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

( ) Suberinite

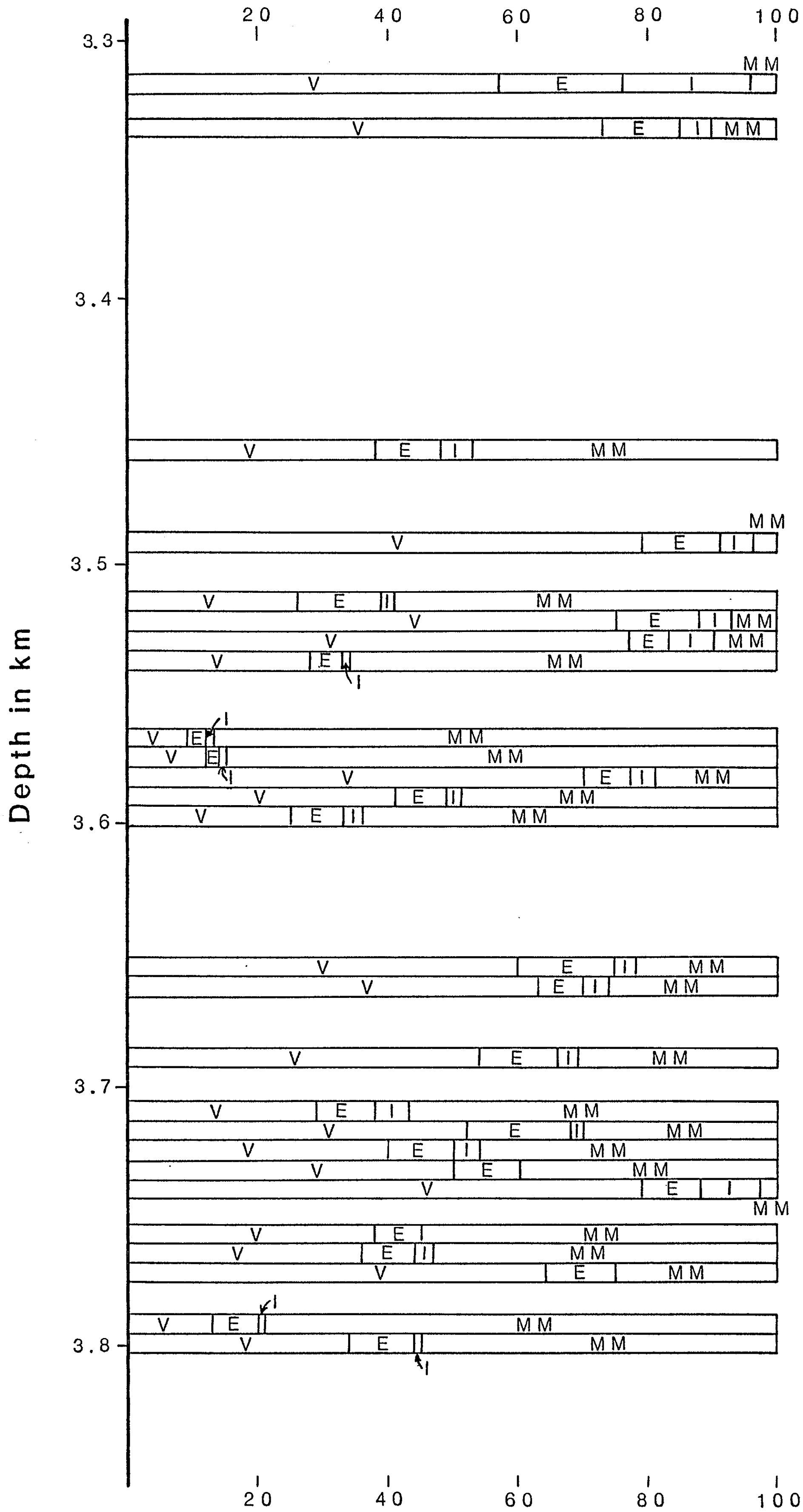
BIGNOSE NO. 1

Figure 2a



BIGNOSE NO.1

Figure 2b



Pyrite (Plates 4, 7 and 8) is abundant in many of the samples. Marine influence may have influenced much of the section in Bignose. The carbonate present appears to be calcium dominated and siderite is not a prominent component. Thus most of the iron is present as pyrite rather than as siderite.

The organic matter in the sequence is preferentially associated with coal and shaly coal although the sample preparation methods may lead to an overestimation of the proportion of organic matter occurring in these lithologies. A relatively small proportion of the organic matter occurs as d.o.m. and it is probable that most lithologies with a high d.o.m. content are associated with coals or shaly coals. This observation applies to exinite as well as to vitrinite. Inertinite is probably the most widely distributed of the maceral groups and shows some bias towards occurring in the d.o.m.

## Thermal History

The reflectance gradient is markedly above average for the distal offshore Gippsland Basin. The depth to the 0.6% level is relatively shallow for the distal offshore areas but is similar to that found in the proximal offshore areas. The reflectance profile shows more evidence of increasing gradients down section than those for Volador and Basker. Assuming that a significant portion of the section in Bignose is Upper Cretaceous in age, this difference is likely to be significant. The increase in reflectance gradient suggests that at Bignose, pre-Latrobe unconformity coalification was significant. Nevertheless, prior to the deposition of the post-Latrobe unconformity cover, even the deepest part of the section sampled would, at most, have been marginally mature. With the development of the post-Latrobe sedimentary cover, temperatures would have risen rapidly, probably with the major increase occurring during the later part of the Tertiary. The lower part of the section sampled is now in its most active phase of oil generation.

## Hydrocarbon Source Potential

Coals and coal related lithologies are abundant in the sequence sampled. Bulk elemental analyses of the organic matter will tend to report within the field of Type III organic matter but will be biased towards the perhydrous side of the Seyler coal band. Exinite content is moderately high but suberinite is the dominant exinite component in many of the samples where exinite content is very high. Vitrinite : exinite ratios of between 3:1 and 2:1 are common and some lower values occur. Elemental analyses for these samples will plot at intermediate positions between Type III and Type II organic matter on a van Krevelen diagram.

Live oil is clearly present at many intervals and is selectively associated with the coals. It is not as distinctive in the Bignose section as in those at Volador or Basker. Oil cuts were not noted from the epiclastic sedimentary rocks and fluorescence intensity of the mineral matrix is relatively weak. It is not clear whether these differences indicate less generation of oil at Bignose or more efficient migration. The pausity of mineral fluorescence at Bignose appears to be anomalous.

As with Volador and Basker, the assessment of the oil generating potential of the section at Bignose No. 1 is strongly dependent upon the assessment of the potential of the coal seams for both generation and migration. The organic matter in the Basker section is similar to that described by Smith and Cook (1984) from currently productive parts of the Gippsland Basin. Some probable marine influences are present but the organic matter is essentially terrestrial in origin. As with the oils in other parts of the Gippsland Basin, liquid hydrocarbons at Bignose are likely to be sourced predominantly from terrestrial higher plant material occurring as coals and in coal-related lithologies.

## Conclusions

Bignose No. 1 entered the oil window at about 3000 m ($\bar{R}_V$max 0.50%) and is near the base of the principal zone of oil generation ($\bar{R}_V$max 0.90%) at about 3700 m. The vitrinite gradient increases from 2800 m to 3700 m and the interval gradient of 0.54%/km is above average for the distal offshore Gippsland Basin. Below 3700 m reflectance does not appear to increase.

Organic matter is abundant and is largely coal or coal-related, but is capable of generating significant amounts of liquid hydrocarbon. Some marine influence is present but the organic matter is terrestrial in origin. Live oil was noted seeping from some of the coal samples during examination in fluorescence-mode but this was not as prominent a feature as in Volador or Basker.

Reference

Smith, G.C. and Cook, A.C., 1984. Petroleum Occurrence in the Gippsland Basin and its relationship to rank and organic matter and type. APEA, J., 24, pp. 300-320.

## PLATES

The Plates have been printed from photomicrographs using 35 mm transparencies. All the photomicrographs were taken using oil immersion. Objectives having nominal magnifications of 20, 32, 50 or 125 are available. Magnification is indicated by the field width given in the Plate captions. The photographs are oriented towards the exinite group of macerals, for which fluorescence mode is essential. Matching pairs of reflected light and fluorescence-mode photographs are in close registration, the plane-slip and dichroic illuminators being in the same illuminator housing. The plates are arranged in depth order.

## CAPTIONS

Key

V - vitrinite
- T - telocollinite
- D - desmocollinite

E - exinite
- S - sporinite
- C - cutinite

I - inertinite
- ID - Inertodetrinite
- SF - semifusinite

M - mineral matter

P - pyrite

H - polyester mounting resin

R.L. reflected white light    Fl. fluorescence-mode

Plate 1. 3458 m SWC

Longitudinal section of leaf with cutinite and leaf resinite. The mesophyll is preserved as vitrinite. The leaf is associated with shaly coal.

$\bar{R}_V$max 0.69%. Fl., field width 0.22 mm.

Plate 2.

As for Plate 1, but in reflected light.

Plate 3. 3492 m Ctgs

Sporinite and vitrinite in a field containing vitrite, clarite and duroclarite. Cutinite fluorescence is weak.

$\bar{R}_V$max 0.75%. Fl., field width 0.34 mm.

Plate 4.

As for Plate 3, but in reflected light.

Plate 5. 3537.5 m SWC

Ornamented megaspore occurring in clarite.

$\bar{R}_V$max 0.75%. Fl., field width 0.22 mm.

Plate 6.

As for Plate 5, but in reflected light. Numerous silt-size grains of quartz are present.

Plate 7. 3729 m SWC

Shaly coal containing major vitrinite and abundant exinite (lipto-detrinite and sporinite). Exinite fluorescence is more intense as compared with that in the deeper samples from Volador but similar to that from equivalent depths. Blue show-through indicates the location of pyrite.

$\bar{R}_V$max 0.86%. Fl., field width 0.34 mm.

Plate 8.

As for Plate 7, but in reflected light.

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| K.K. No. | Depth (m) | $\bar{R}_V$max | Range | N | Exinite Fluorescence (Remarks) |
|---|---|---|---|---|---|
| 18888 | 2822.5 SWC | 0.46 | 0.39-0.61 | 28 | Sparse sporinite and cutinite, yellow, common phytoplankton, greenish yellow and yellow, common liptodetrinite, greenish yellow and yellow, rare fluorinite, green, sparse suberinite, dull orange. (Siltstone>claystone>coal>shaly coal. Coal is vitrite>clarite. D.o.m. abundant, I>V>E. Inertinite and vitrinite abundant, exinite common. Sparse pyrite and common carbonate.) |
| 18889 | 2839.5 SWC | 0.45 | 0.39-0.53 | 30 | Common cutinite, yellow orange to dull orange, common sporinite, yellow orange, rare phytoplankton, green yellow. (Silty claystone. D.o.m. abundant, I>V>E. All macerals abundant. Abundant pyrite.) |
| 18890 | 2874 SWC | 0.45 | 0.38-0.52 | 27 | Abundant sporinite, yellow to orange, abundant cutinite and liptodetrinite, greenish yellow and yellow, rare fluorinite in coal, green, rare resinite in coal, greenish yellow, rare telalginite, greenish yellow, suberinite sparse in coal, dull orange to weak brown, sparse vitrinite, weak brown. (Claystone>coal. Coal is vitrite, V>E. D.o.m. abundant, E>V>I. All three maceral groups abundant.) |
| 18891 | 2912.5 SWC | 0.46 | 0.40-0.55 | 30 | Abundant cutinite, bright yellow to dull orange, common sporinite, yellow orange, common suberinite, brown, sparse fluorinite, green, rare telalginite, yellow. (Claystone>silty claystone>coal. Coal, sparse, V>E, vitrite>clarite. D.o.m. abundant, V>E>I. Vitrinite and exinite abundant, inertinite common. Common pyrite.) |
| 18892 | 3004 SWC | 0.50 | 0.42-0.65 | 28 | Common sporinite, cutinite and liptodetrinite, dull yellow and yellow to orange, fluorinite rare in coal, greenish yellow, sparse telalginite, bright yellow, common suberinite, dull orange, common vitrinite, weak brown. (Siltstone and shaly coal. D.o.m. abundant, I>V>E. All three macerals abundant. Abundant pyrite.) |
| 18893 | 3212 SWC | 0.52 | 0.39-0.62 | 26 | Sparse cutinite, orange to dull orange, rare resinite, bright green yellow to yellow. (Sandstone>siltstone>coal>claystone. Coal, sparse, V>E, vitrite>clarite. D.o.m. abundant, V>I>E. Vitrinite and inertinite abundant, exinite sparse. Sparse iron oxides. Abundant pyrite.) |
| 18894 | 3318.5 SWC | 0.64 | 0.59-0.71 | 25 | Abundant sporinite, greenish yellow and yellow to orange, abundant liptodetrinite and cutinite, yellow to orange, abundant suberinite, dull orange to weak brown, abundant vitrinite, weak brown, common resinite, yellow, rare fluorinite, green. (Coal, clarite>duroclarite>vitrinite>inertite, V>I>E. Sparse pyrite. Relict cellular texture in vitrinite.) |
| 18895 | 3335 SWC | 0.65 | 0.56-0.80 | 28 | Abundant sporinite and cutinite, yellow to dull orange, abundant suberinite, brown, common resinite, green to yellow and brown, sparse fluorinite, green. (Coal>>claystone. Coal abundant, V>E>I. Clarite>duroclarite>vitrite. D.o.m. abundant, V>I>E. Vitrinite and inertinite abundant, exinite common. Sparse pyrite.) |

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| K.K. No. | Depth (m) | $\bar{R}_v$max | Range | N | Exinite Fluorescence (Remarks) |
|---|---|---|---|---|---|
| 18896 | 3458 SWC | 0.69 | 0.62-0.74 | 30 | Abundant sporinite and liptodetrinite, yellow to orange, abundant cutinite, greenish yellow and yellow to orange, common resinite, yellow, common suberinite, dull orange, abundant vitrinite, weak brown. (Shaly coal>>coal. Coal is vitrite>>clarite=or>inertite. V>>I>E. D.o.m. abundant, (in shaly coal). V>E>I, All three maceral groups abundant. Common pyrite.) |
| 18897 | 3492 Ctgs | 0.75 | 0.67-0.85 | 28 | Abundant sporinite, yellow to dull orange, abundant suberinite, brown, common cutinite, yellow to dull orange, common cutinite, yellow to dull orange, common resinite, bright yellow and dull orange to brown, rare fluorinite, bright green. (Coal>>claystone. Coal abundant, V>E>I, clarite>vitrite>duroclarite>durite=fusite. D.o.m. abundant where present, V>E>I. Vitrinite and exinite abundant, inertinite common. Sparse pyrite.) |
| 18898 | 3517 SWC | 0.76 | 0.68-0.82 | 27 | Abundant cutinite and liptodetrinite, yellow and orange to dull orange, abundant suberinite, dull orange to weak brown, common sporinite, orange to dull orange, common resinite, yellow, rare fluorinite green. (Shaly coal>> coal. Coal is vitrite>clarite, V>I. D.o.m. abundant, V>E>>I. All three maceral groups abundant. Rare pyrite.) |
| 18899 | 3534 Ctgs | 0.77 | 0.69-0.85 | 30 | Abundant resinite, green and dull orange to brown, abundant suberinite, brown, common to abundant sporinite, yellow orange to dull orange, common cutinite, orange to dull orange, rare alginite A, yellow. (Coal>>claystone> siltstone. Coal abundant, V>E>I. Duroclarite>vitrite> clarite>clarodurite. D.o.m. abundant where present, V>E>I. Vitrinite and exinite abundant, inertinite common. Common siderite, rare pyrite.) |
| 18900 | 3537.5 SWC | 0.75 | 0.63-0.82 | 29 | Abundant suberinite, weak brown, common cutinite, orange to dull orange, sparse sporinite, yellow and orange to dull orange, rare resinite, orange, rare fluorinite, green, rare telalginite, yellow, common liptodetrinite, yellow and orange to dull orange, abundant vitrinite, weak brown. (Coal, vitrite>clarite>duroclarite>inertite, V>I>E. Sparse pyrite.) |
| 18901 | 3542 SWC | 0.79 | 0.64-0.86 | 28 | Abundant sporinite and common cutinite, yellow to orange, abundant suberinite, brown, common resinite, yellow and dull orange to brown, sparse exsudatinite, dull orange. (Claystone>coal. Coal abundant, V>E, vitrite> clarite. D.o.m. abundant, V>E>>I. Vitrinite and exinite abundant, inertinite sparse.) |

BIGNOSE NO. 1

| K.K. No. | Depth (m) | $\bar{R}_v$max | Range | N | Exinite Fluorescence (Remarks) |
|---|---|---|---|---|---|
| 18902 | 3567 SWC | 0.80 | 0.67-0.87 | 27 | Sparse cutinite, orange to dull orange, sparse suberinite, weak brown, common sporinite and liptodetrinite, yellow to dull orange, rare resinite, dull orange, rare fluorinite, green. (Siltstone with minor coal and carbonate. Coal vitrite. D.o.m. abundant, V>E>I. Vitrinite and exinite abundant, inertinite common. Sparse pyrite.) |
| 18903 | 3569 SWC | 0.76 | 0.68-0.86 | 28 | Common suberinite, brown, common sporinite, yellow to orange, common cutinite, yellow orange to dull orange, common resinite, bright yellow, yellow and dull orange. (Coal>siltstone>sandstone. Coal abundant, V>E, vitrite>clarite. D.o.m. abundant, V>I>E. Vitrinite abundant, inertinite and exinite common. Sparse pyrite.) |
| 18904 | 3576 Ctgs | 0.85 | 0.70-0.92 | 29 | Abundant cutinite, yellow to orange, common sporinite and liptodetrinite, rare yellow, typically orange to dull orange, sparse resinite, dull orange, rare fluorinite, green, rare exsudatinite in coal, bright yellow, suberinite abundant in coal, weak brown. (Coal>shaly coal>siltstone. Coal, vitrite>clarite>duroclarite>inertite, V>E>I. D.o.m. abundant, V>E>I. Vitrinite and exinite abundant, inertinite sparse as d.o.m. Sparse pyrite. Vitrinite is frequently micrinitized and occasionally resinous. Weak oil cuts in some coal.) |
| 18905 | 3589.5 Ctgs | 0.81 | 0.73-0.88 | 40 | Abundant suberinite, brown, abundant sporinite and common cutinite, orange to dull orange, common resinite, green to yellow, dull yellow and brown. (Coal>claystone>sandstone>siltstone. Coal abundant, V>E>I, vitrite>clarite>duroclarite>clarodurite=vitrinertite V=vitrinertite I. D.o.m. abundant, V>E>I. Vitrinite and exinite abundant, inertinite common. Rare siderite. Sparse pyrite.) |
| 18906 | 3591 SWC | 0.83 | 0.72-0.90 | 25 | Abundant sporinite and cutinite, yellow and orange to dull orange, common liptodetrinite, yellow and orange to dull orange, common resinite, greenish yellow and yellow, common suberinite, weak brown, common vitrinite, weak brown, rare fluorinite, green. (Shaly coal>coal>siltstone. Coal, vitrite>clarite>inertite, V>E>I. D.o.m. abundant, V>E>I. Vitrinite and exinite abundant, inertinite common. Some vitrinite grains heavily micrinitized. Sparse pyrite.) |
| 18907 | 3657 Ctgs | 0.83 | 0.78-0.92 | 30 | Abundant suberinite, brown, abundant sporinite and common cutinite, orange to dull orange, sparse resinite, yellow to brown. (Coal>claystone>siltstone>sandstone. Coal abundant, V>E>I. Duroclarite>vitrite>clarite>fusite>vitrinertite I. D.o.m. abundant, V>E>I. Vitrinite and exinite abundant, inertinite sparse. Sparse siderite and pyrite.) |

BIGNOSE NO. 1

| K.K. No. | Depth (m) | $\bar{R}_v$max | Range | N | Exinite Fluorescence (Remarks) |
|---|---|---|---|---|---|
| 18908 | 3658 SWC | 0.78 | 0.71-0.85 | 25 | Abundant sporinite and cutinite, orange to dull orange, common liptodetrinite, orange to dull orange, common suberinite, weak brown, rare resinite, yellow to orange, rare exsudatinite in coal, yellow. (Coal>shaly coal. Coal, clarite>vitrite>duroclarite, V>E>I. D.o.m. abundant, V>E>I. Vitrinite and exinite abundant, inertinite common. Rare pyrite. Weak oil cuts in some coal. Vitrinite rarely resinous.) |
| 18909 | 3685 Ctgs | 0.83 | 0.76-0.95 | 30 | Abundant suberinite, brown, abundant sporinite and common cutinite, orange to dull orange, sparse resinite, dull orange to brown. (Coal>siltstone>shaly coal>claystone>sandstone. Coal abundant, V>E>I. Vitrite>duroclarite>clarite>clarodurite. Shaly coal, sparse, V>E>>I. D.o.m. abundant, V>E>I. Vitrinite and exinite abundant, inertinite sparse. Sparse carbonate and pyrite.) |
| 18910 | 3712 Ctgs | 0.79 | 0.72-0.89 | 25 | Abundant sporinite and cutinite, orange to dull orange, common liptodetrinite, orange to dull orange, sparse resinite, yellow, abundant suberinite, weak brown, abundant vitrinite, weak brown. (Coal>shaly coal>sandstone>siltstone>carbonate. Coal, vitrite>clarite>duroclarite>vitrinertite(I)>inertite, V>E>I. D.o.m. abundant, V>E>I. Vitrinite and exinite abundant, inertinite common to abundant. Vitrinite frequently heavily micrinitized and sometimes resinous. Abundant pyrite and sparse iron oxides.) |
| 18911 | 3713.5 SWC | 0.76 | 0.70-0.83 | 28 | Abundant suberinite, brown, abundant sporinite and common cutinite, orange to dull orange, rare alginite A, yellow orange. (Coal>shaly coal. Coal abundant, V>E>I, clarite>duroclarite>vitrite. Shaly coal abundant, V>E>>I.) |
| 18912 | 3728 Ctgs | 0.81 | 0.72-0.90 | 30 | Abundant sporinite and cutinite, orange to dull orange, abundant suberinite, dull orange to weak brown, sparse fluorinite in coal, greenish yellow to orange, rare telalginite, yellow, rare exsudatinite, yellow, rare resinite, yellow, abundant vitrinite, weak brown. (Coal>shaly coal>siltstone>claystone. Coal, vitrite>clarite>duroclarite>clarodurite, V>E>I. D.o.m. abundant, V>E>I. Vitrinite and exinite abundant, inertinite common, sparse pyrite.) |
| 18913 | 3729 SWC | 0.86 | 0.80-0.93 | 28 | Abundant suberinite, brown, abundant sporinite, orange to dull orange, common cutinite, bright yellow to brown, common resinite, green and brown. (Coal>claystone. Coal abundant, V>E, vitrite>clarite. D.o.m. abundant, V>E>>I. Vitrinite and exinite abundant, inertinite rare. Weak oil cuts from vitrinite. Sparse pyrite.) |

BIGNOSE NO. 1

| K.K. No. | Depth (m) | $\bar{R}_V max$ | Range | N | Exinite Fluorescence (Remarks) |
|---|---|---|---|---|---|
| 18914 | 3730 Ctgs | 0.77 | 0.62-0.85 | 30 | Abundant sporinite and cutinite, orange to dull orange, abundant suberinite, weak brown to black, common liptodetrinite, yellow to orange, sparse resinite, yellow, rare fluorinite, green, abundant vitrinite, weak brown. (Coal, vitrite>clarite>duroclarite>vitrinertite (V), V>I>E. Suberinite present, but fluorescence is often too weak to detect. Rare pyrite.) |
| 18915 | 3759 | 0.79 | 0.73-0.88 | 40 | Abundant suberinite, brown, abundant sporinite and common cutinite, bright yellow and dull orange to brown. (Coal>claystone>siltstone>sandstone. Coal abundant, V>E>I, vitrite>clarite>duroclarite. D.o.m. abundant, V>E>>I. Vitrinite and exinite abundant, inertinite rare. Rare carbonate. Common pyrite.) |
| 18916 | 3759.5 Ctgs | 0.75 | 0.68-0.82 | 30 | Abundant sporinite, yellow and orange to dull orange, abundant cutinite and liptodetrinite, orange to dull orange, rare resinite, yellow to orange, rare telalginite, yellow, sparse suberinite, weak brown. (Shaly coal>coal. Coal is vitrite>inertite>vitrinertite (I). V>I. D.o.m. abundant, V>E>I. Vitrinite and exinite abundant, inertinite common. Abundant pyrite). |
| 18917 | 3765.5 SWC | 0.83 | 0.75-0.90 | 25 | Abundant suberinite, brown, abundant resinite, orange to dull brown, common sporinite and sparse cutinite, orange to dull orange. (Coal>claystone. Coal abundant, V>E, vitrite>clarite. D.o.m. abundant, V>E>>I. Vitrinite and exinite abundant, inertinite sparse. Common pyrite). |
| 18918 | 3796 SWC | 0.77 | 0.69-0.83 | 30 | Abundant sporinite and cutinite, yellow and orange to dull orange, common liptodetrinite, orange to dull orange, sparse resinite, yellow to orange, rare telalginite, yellow. (Shaly coal>coal. Coal is vitrite. D.o.m. abundant, V>E>I. Vitrinite and exinite abundant, inertinite sparse. Abundant pyrite.) |
| 18919 | 3863 SWC | 0.79<br>0.52 | 0.70-0.88<br>0.42-0.67 | 39<br>41 | Abundant suberinite and common resinite, brown, common cutinite and sporinite, yellow orange to dull orange. (Coal>claystone>siltstone>shaly coal>sandstone. Coal abundant, V>E, cutinite>clarite. Shaly coal sparse, V>E>>I. D.o.m. abundant, V>E>>I. Vitrinite abundant, exinite common, inertinite sparse. Two reflectance populations are present in the vitrinite. The higher mode comprises only about 20% of the vitrinite but is considered to be representative of the rank. The lower mode comprises about 80% of the population and has a lower reflectance, partly due to the presence of non-fluorescing suberinite and resinite-like material. Some corpocollinite occurs in the lower reflectance mode. The occurrence of the two modes is considered to be due to type-related effects. Common carbonate. Abundant pyrite). |

| DEPTH IN METRES | SAMPLE TYPE | ORGANIC – SUB/BIT'INITE: SUBERINITE | BITUMINITE | LENSES OF BITUMINITE | DIFFUSE BITUMINITE | INTERGRANULAR BITUMINITE | PATCHES OF BITUMINITE | VITRINITE A: LAYERS | VITRINITE A: LENSES | VITRINITE A: DETRITAL | VITRINITE B: LAYERS | VITRINITE B: LENSES | VITRINITE B: DETRITAL | LIPTINITE: SPORINITE | CUTINITE | RESINITE | LIPTODETRINITE | ALG: A | ALG: B | PHYTOPLANKTON (DINO/ACR.) | EXSUDATINITE | INERT.: SCLEROTINITE | FUSINITE + Semifusinite | MACRINITE | MICRINITE | INORG.: CLAY/QUARTZ | FRAMBOIDAL PYRITE | AGGREGATES OF PYRITE | CRYSTALS OF PYRITE | CARBONATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2822.5 | SWC | − | − | | | | | + | | + | / | | + | / | / | | + | | | ?+ | | | + | * | / | * | | | / | + |
| | Coal | + | | | | | | * | | | / | | | + | / | − | * | | | | | | | | | * | | | / | |
| 2839.5 | SWC | | | | | | | * | | | + | | | + | + | | | | | / | | | * | + | | * | | | * | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2874 | SWC | | | | | | | * | | / | + | | / | * | * | | * | − | | − | | | * | | | * | | | − | |
| | | / | | | | | | * | | | + | | | | | / | | | | | | | | | * | * | | | | |
| 2912.5 | SWC | | | | | | | * | | | + | | | + | * | / | | − | | | | | / | + | | * | | | / | |
| | COAL | + | | | | | | * | | | | | | | | | | | | | | | | | | / | | | + | |
| 3004 | SWC | / | | | | | | * | | / | * | | / | + | + | | + | | | | | | * | * | | | | | * | |
| | SHALY COAL | / | | | | | | * | | * | * | | * | + | + | / | + | / | | | | | * | * | | | | | * | |
| 3212 | SWC | | | | | | | * | | | + | | | | / | − | | | | | | | / | / | | * | | | * | |
| | COAL | | | | | | | * | | | | | | | / | | | | | | | | | | | | | | | |
| 3318.5 | SWC | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Coal | * | | | | | | * | | * | * | | * | * | * | + | * | | | | | | * | | + | * | | | / | |
| 3335 | SWC | + | | | | | | * | | | + | | | / | + | | | | | | | | * | * | | * | | | / | |
| | COAL | * | | | | | | * | | | * | | | * | * | + | | | | | | | * | * | | + | | | − | |
| 3458 | SWC (coal) | + | | | | | | * | | | | | | | | | | | | | | | | * | | + | | | | |
| | Shaly coal | + | | | | | | * | | * | * | | * | * | * | + | * | | | | | | | * | | * | | | / | |



LEGEND

* ABUNDANT (>2%) + COMMON (0.5-2%) / SPARSE (0.1-0.5%) − RARE (<0.1%)

Bignose No. 1

| DEPTH IN METRES | SAMPLE TYPE | ORGANIC: SUB/BIT'INITE: SUBERINITE | BITUMINITE | LENSES OF BITUMINITE | DIFFUSE BITUMINITE | INTERGRANULAR BITUMINITE | PATCHES OF BITUMINITE | VITRINITE A: LAYERS | VITRINITE A: LENSES | VITRINITE A: DETRITAL | VITRINITE B: LAYERS | VITRINITE B: LENSES | VITRINITE B: DETRITAL | LIPTINITE: SPORINITE | CUTINITE | RESINITE | LIPTODETRINITE | ALG A | ALG B | PHYTOPLANKTON (DINO/ACR.) | EXSUDATINITE | INERT.: SCLEROTINITE | FUSINITE | MACRINITE | MICRINITE | INORG.: CLAY/QUARTZ | FRAMBOIDAL PYRITE | AGGREGATES OF PYRITE | CRYSTALS OF PYRITE | CARBONATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3492 | Ctgs | | | | | | | * | | | * | | | * | / | | | | | | | | + | / | | * | | | | |
| | COAL | * | | | | | | * | | | * | | | * | + | + | | | | | | | * | * | | + | | / | | |
| 3517 | Shaly coal SWC | * | | | | | | * | | | * | | | + | * | + | * | | | | | | + | | | * | | / | | |
| | Coal | * | | | | | | * | | | | | | / | / | | | | | | | | | | | * | | | / | |
| 3534 | Ctgs. | / | | | | | | * | | | * | | | * | / | | | | | | | | / | / | | * | | | | |
| | COAL | * | | | | | | * | | | * | | | * | + | * | | | | | | | * | + | + | + | | - | | - |
| 3537.5 | SWC | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Coal | * | | | | | | * | + | | * | + | | / | + | - | + | - | | | | | * | + | + | * | | / | | |
| 3542 | SWC | * | | | | | | * | | | * | | | * | + | + | | | | | / | | / | / | | * | | | | |
| | COAL | + | | | | | | * | | | | | | + | / | + | | | | | | | - | - | | / | | | | |
| 3567 | SWC | / | | | / | | | * | | * | * | | * | + | + | - | + | | | | | | + | | | * | | | / | + |
| | Coal | | | | | | | * | | | | | | | | | | | | | | | | | | | | | | |
| 3569 | SWC | + | | | | | | * | | | * | | | + | + | + | | | | | | | + | / | | * | | | / | |
| | COAL | + | | | | | | * | | | * | | | + | / | + | | | | | | | | - | | - | | | - | |
| 3576 | Ctgs | / | | | | | | * | | * | * | | * | + | * | | + | | | | | | / | | | * | | | / | |
| | Coal | * | | | | | | * | | | * | | | / | + | | / | + | | | - | | * | | - | * | | | / | |
| 3589.5 | Ctgs. | + | | | | | | * | | | * | | | + | + | / | | | | | | | / | / | | * | | | / | |
| | COAL | * | | | | | | * | | | * | | | * | + | + | | | | | | | + | + | | / | | | - | / |



LEGEND

* ABUNDANT (>2%)  + COMMON (0.5-2%)  / SPARSE (0.1-0.5%)  – RARE (<0.1%)

| DEPTH IN METRES | SAMPLE TYPE | ORGANIC: SUB/BIT'INITE: SUBERINITE | BITUMINITE | LENSES OF BITUMINITE | DIFFUSE BITUMINITE | INTERGRANULAR BITUMINITE | PATCHES OF BITUMINITE | VITRINITE A: LAYERS | VITRINITE A: LENSES | VITRINITE A: DETRITAL | VITRINITE B: LAYERS | VITRINITE B: LENSES | VITRINITE B: DETRITAL | LIPTINITE: SPORINITE | CUTINITE | RESINITE | LIPTODETRINITE | ALG: A | ALG: B | PHYTOPLANKTON (DINO/ACR.) | EXSUDATINITE | INERT.: SCLEROTINITE | FUSINITE | MACRINITE | MICRINITE | INORG.: CLAY/QUARTZ | FRAMBOIDAL PYRITE | AGGREGATES OF PYRITE | CRYSTALS OF PYRITE | CARBONATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3591 | SWC | / | | | | | | * | | | * | | | * | * | / | + | | | | | | + | | | * | | | – | |
| | Coal | + | | | | | | * | | | * | | | | | + | | | | | | | + | | * | * | | | – | |
| 3657 | Ctgs. | + | | | | | | * | | | * | | | * | +/ | | | | | | | | / | – | | * | | | / | |
| | COAL | * | | | | | | * | | | * | | | * | + | / | | | | | | | * | + | | / | | | +/ | +/ |
| 3658 | SWC | – | | | | | | * | | * | * | | * | + | + | | / | | | | | | + | | | * | | – | | |
| | | + | | | | | | * | | * | * | | * | + | + | / | / | | | | – | | * | | * | * | | – | | |
| 3685 | Ctgs | * | | | | | | * | | | * | | | + | / | – | | | | | | | / | / | | * | | | | / |
| | COAL | * | | | | | | * | | | * | | | * | + | / | | | | | | | + | + | | / | | | | – |
| 3712 | Ctgs | / | | | | | | * | | * | * | | * | + | + | – | / | | | | | | + | | | * | | * | | |
| | Coal | * | | | | | | * | | | * | | | * | + | / | / | | | | | | * | | | + | | / | | |
| 3713.5 | SWC | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | COAL | * | | | | | | * | | | * | | | * | + | | | – | | | | | * | + | | * | | | | |
| 3728 | Ctgs | / | | | | | | * | | * | * | | * | + | + | – | – | | | | | | + | | | * | | + | | + |
| | Coal | * | | | | | | * | | | * | | | + | * | / | + | | | | | | * | | | + | | / | | – |
| 3729 | SWC | * | | | | | | * | | | * | | | * | + | – | | | | | | | – | – | | * | | | | |
| | COAL | * | | | | | | * | | | * | | | * | + | + | | | | | | | | | | + | | | / | |
| 3730 | Ctgs | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Coal | | * | | | | | | * | | | * | | | * | * | / | + | | | | – | | * | | / | * | | | / | |

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LEGEND

* ABUNDANT (>2%)   + COMMON (0.5-2%)   / SPARSE (0.1-0.5%)   – RARE (<0.1%)

Bignose No. 1

| DEPTH IN METRES | SAMPLE TYPE | ORGANIC: SUB/BIT'INITE: SUBERINITE | BITUMINITE | LENSES OF BITUMINITE | DIFFUSE BITUMINITE | INTERGRANULAR BITUMINITE | PATCHES OF BITUMINITE | VITRINITE A: LAYERS | A: LENSES | A: DETRITAL | VITRINITE B: LAYERS | B: LENSES | B: DETRITAL | LIPTINITE: SPORINITE | CUTINITE | RESINITE | LIPTODETRINITE | ALG: A | ALG: B | PHYTOPLANKTON (DINO/ACR.) | EXSUDATINITE | INERT.: SCLEROTINITE | FUSINITE | MACRINITE | MICRINITE | INORG.: CLAY/QUARTZ | FRAMBOIDAL PYRITE | AGGREGATES OF PYRITE | CRYSTALS OF PYRITE | CARBONATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3759 | Ctgs. | * | | | | | | * | | | * | | | * | / | / | | | | | | | | – | | * | | | / | |
| | COAL | * | | | | | | * | | | * | | | * | + | * | | | | | | | – | – | | + | | | – | – |
| 3759.5 | SWC. | / | | | | | | * | | * | * | | * | * | * | – | * | – | | | | | * | | + | * | | * | | |
| | SHALY COAL/COAL | | | | | | | * | | | | | | | | | | | | | | | * | | | * | | + | | |
| 3765.5 | SWC | | | | | | | * | | | * | | | + | / | / | | | | | | | – | – | + | * | | | + | |
| | COAL | + | | | | | | * | | | + | | | / | | * | | | | | | | | | | / | | | / | |
| 3796 | SWC | | | | | | | * | | * | * | | * | * | * | / | + | | | | | | + | | | * | | * | | |
| | SHALY COAL/COAL | | | | | | | * | | | | | | | | | | | | | | | | | | | | / | | |
| 3863 | SWC | * | | | | | | * | | | + | | | + | + | – | | | | | | | / | / | | * | | | * | + |
| | COAL | * | | | | | | * | | | + | | | – | – | + | | | | | | – | | | | / | | | + | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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LEGEND

* ABUNDANT (>2%)  + COMMON (0.5-2%)  / SPARSE (0.1-0.5%)  – RARE (<0.1%)