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SOURCE ROCK EVALUATION OF WELL 30/7-3	
CONTRACTOR	
NORSK HYDRO A/S	
CONTRACTORS REF.	JOB NO.
Asbjørn Sæbøe	0-36/1

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SUMMARY Source rock evaluation on cuttings from well 30/7-3 is reported. The analyses used for the source rock evaluation were the following: Total Organic Carbon, (TOC), CR/CT ratio, Vitrinite Reflectance, Extractable Organic Matter, (EOM), Liquid Chromatographic Separation and Gas Chromatographic determination of saturated hydrocarbons.

The different analyses show that there is very little organic matter in the samples, apart from the interval from 3700 m - 3890 m, where an oil show is found. Vitrinite reflectance shows extended reworked material, especially towards the base of the well.

The different analyses suggest that the hydrocarbon generation zone must lie below the total depth of the well.

KEY WORDS

Source Rock

The samples for analysis were cuttings from different depths. The cuttings together with the drilling mud were canned on the rig and arrived in Trondheim for analysis 22nd Nov. 1976. With the samples were also canned samples of mud and the information that diesel oil had been added to the mud from the depth of 2420 m.

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INTRODUCTION

In the last decade our understanding of the processes of petroleum genesis has increased considerably. This has largely resulted from the advent of modern analytical techniques which have made possible the analysis of small quantities of organic matter in sediments. Also it is now appreciated that new techniques must be used if oil deposits located in difficult geological situations are to be found.

Philippi (1965) made a detailed study of the genesis of hydrocarbons in the Ventura and Los Angeles Basins of California. He found that the generation of hydrocarbons could be related to geothermal gradient and depth of burial. Similar conclusions have since been reached by a number of workers (e.g. Albrecht and Ourisson, 1969; Tissot et al, 1971). In addition laboratory studies have demonstrated the feasibility of generating hydrocarbons at the relatively low temperatures found in sedimentary sequences (e.g. Hoering and Abelson, 1963; Douglas et al, 1970).

In recent years interest has shifted to the development of techniques which could be used to define the degree of diagenesis of organic matter in sedimentary rocks and hence the zones of petroleum diagenesis. Parameters which have been used include coal rank or reflectance (Shibaoka et al 1973), spore colour (Staplin, 1969), cuttings gas analysis (Evans and Staplin, 1971; Le Tran, 1976) kerogen composition (McIver, 1967; Tissot et al 1971 and 1974) and, of course the nature of the sedimentary hydrocarbons themselves (Philippi 1965). In the following we will give a more detailed introduction to the types of analyses used in this work.

TOTAL ORGANIC CARBON (TOC)

The first requirement for generating oil or gas within a sedimentary basin is the presence of sufficient raw material in the form of sedimentary organic material. Under the most favorable conditions only about 10% of the organic matter in a sediment is converted to a soluble form. Since no more than 25% of this migrates from its point of origin, values of the present organic content of a sediment provide a good approximation of the amount of organic content initially available as source material for petroleum (Hunt and Jamieson 1956).

The concentration of TOC essential for petroleum generation in a non-reservoir rock is not well defined and probably varies from basin to basin. Nixon (1973) described the occurrence of source-bed properties of the Mowry Shale in relationship to the occurrence of oil reservoirs associated with the Mowry. The oil fields occur in areas where TOC is greater than 2% and often greater than 3%. Philippi (1965), in his study of the origin of Tertiary oils in California, found the average TOC value in the source rocks of the Los Angeles Basin to be 2.9% and of the Ventura Basin to be 2.1%. Baker (1962), in his study of the relationship of source-rocks and reservoirs in the Cherokee Group, found that in the Burbank Shale source-rock interval, TOC averaged 2.0%.

The minimum concentration of TOC which is essential for a non-reservoir formation to function as a source-rock is not known and is subject to interpretation for each case. Clearly the higher the concentration of non-structured marine organic matter the better the source-rock potential. Minimum TOC limits generally accepted as essential for a source-rock are 0.5% for shales and 0.2% for carbonates. Samples containing less TOC generally are not considered as source-rocks and further chemical analyses are not performed. Optical determination of maximum paleotemperature and possibly of organic kerogen type may, however, be of value.

C_R/C_T RATIO

It has frequently been shown that the diagenetic evolution of organic sedimentary material takes place by the formation of bitumen at the expense of kerogen (Philippi 1965; Welte 1966; Louis and Tissot 1967; Tissot, et. al. 1973). The production of bitumen is limited by the fact that, bitumen being richer in hydrogen than is kerogen, the latter must become prograssively carbon-enriched (cf graphitisation). It is therefore possible to form an idea of the degree of evolution of the kerogen by measuring the amount of bitumen it can still produce before reaching the graphitic stage.

Gransch and Eisma (1966) have with this reaction in mind, introduced the parameter C_R/C_T. By thermal treatment under standard conditions, they produced,from a sample of which the organic carbon content was known (C_T), the maximum amount of bitumen which was removed by a flow of inert gas. In the sample remained a carbonaceous residue (C_R) which is proportionally greater as the organic material is more evolved.

The ratio C_R/C_T is thus a measure of the degree of diagenetic evolution of the kerogen.

The determination of the C_R/C_T ratio is an empirical method. It is possible that it is influenced by inorganic matter. However, Gransch and Eisma (1966) showed that correspondence between the C_R/C_T ratios of coaly sediments and associated coal seams, and between C_R/C_T ratio and reflectance of vitrinite particles of some Liassic sediments, and the relation between C_R/C_T ratios and environment of Liassic sediments all indicate that the C_R/C_T ratios reflect properties that are inherent in the insoluble organic matter itself. The C_R/C_T ratio is concerned with the total insoluble organic matter in contrast to rank determinations such as translucency of pollen (Gutjahr, 1966) and reflectance of vitrinite particles (Teichmüller, 1958). Like the volatile matter and fixed carbon contents of coals it can only be used to indicate the temperature history if the insoluble organic matter represents one type i.e. either favourable (with respect to the generation of hydrocarbons) or unfavourable (e.g. humic coaly) matter.

The C_R/C_T ratio, however, has in many cases been used to indicate differences in the type of organic matter. If the C_R/C_T ratio is below 0.6 it indicates organic matter favourable to the generation of hydrocarbons. If samples of various sediment layers of one section are compared, the unfavourable organic matter (C_R/C_T ratio 0.6-0.8) can be distinguished from favourable. (Granch and Eisma, 1966). Generally, however, when the C_R/C_T ratio is above 0.6, rank determinations are necessary for the distinction between favourable and unfavourable organic matter.

In conclusion, for the interpretation of the C_R/C_T ratio three cases have to be distinguished:

1. The organic matter occurring in different sediments has attained the same degree of diagenesis; differences in the C_R/C_T ratios here represent different types of organic matter.

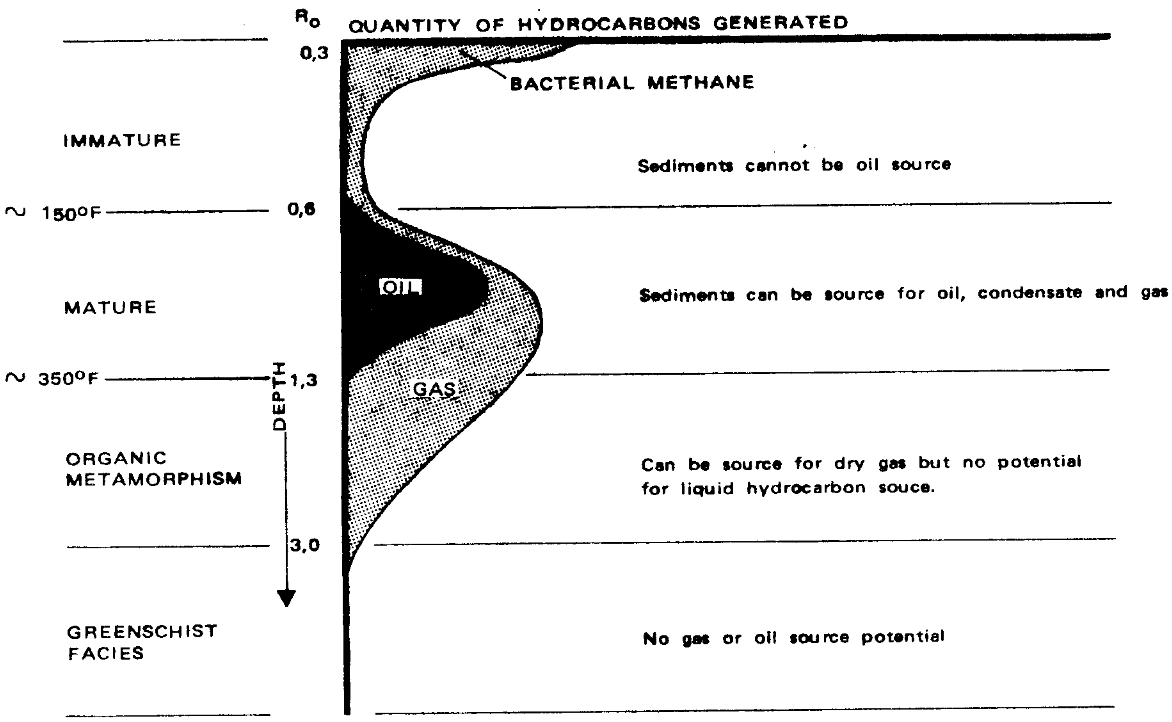
2. The organic matter occurring in different sediments is of the same type; differences in the C_R/C_T ratio here represent different degrees of diagenesis.

3. The organic matter occurring in different sediments represents different types and different degrees of diagenesis. Other parameters have to be used to establish the degree of diagenesis. When sporomorphes are present, transluscency measurements can be applied, or when vitrinite particles can be detected their reflection can be used.

VITRINITE REFLECTANCE

For many years coal petrographers have determined the extent of metamorphism of coal by determining the fraction of incident light reflected from a polished surface of the coal. The numerical value of the reflectance has been calibrated in terms of the degree of metamorphism, which in turn is determined by the time-temperature history of the sample. The same technique can be applied to the small fragments of organic matter which are dispersed in most geological samples. Vitrinite reflectance then, provides a method for determining the time-temperature history of geological formations, and thus can be used as a tool in petroleum exploration for determining the effects of organic metamorphism, i.e., the thermal maturity of the sediments being examined.

As can be seen in Fig. 1, the transition from immature to mature sediments with a temperature history adequate for oil generation is generally thought to occur at a temperature of about 150^{o}F, which corresponds to a Reflectance Value (R_0) of 0.6. If reflectance values are below 0.6, the generation of oil within that formation is unlikely. On the other hand, if the temperature has been above about 350^{o}F (R_0 = 1.3), any oil initially generated would have undergone thermal cracking, and gas not oil, would be the expected hydrocarbon product.



Schematic Diagram showing variations of type of Hydrocarbons as a function of Thermal Alteration.

FIGURE 1

If the temperature had been such that the reflectance of the dispersed organic matter had increased to a value greater than 3.0, even the gas would have been degraded, and graphite would be the major carbon-containing product.

It has been generally recognized that a lower temperature for a long period of time could bring about the same change as a higher temperature over a short period of time. In fact Connan (1974) showed that the time required for petroleum generation (realization of an $R_o = 0.6$) can be represented as a function of the threshold temperature as follows:

$$\log t = 3{,}014 \times \frac{1}{T} - 6.498$$

where t = time in 10^6 years

T = temperature in ^oK

Even though the "temperature" measured by vitrinite reflectance actually results from a combined effect of time and temperature, temperature still is the predominate factor because the rate of chemical reactions approximately doubles with each $10^{o}C$ increase in temperature. Since in the evaluation of a formation as a source-rock, the degree of organic transformation is the factor of interest, vitrinite reflectance is useful because it provides a measure of the degree of transformation regardless of the cause.

By measuring several values in a well, a paleotemperature profile can be constructed. By assuming the same reflectance gradient, the profile can be extrapolated below the lowest level actually sampled and probable depth intervals appropriate for oil generation and for preservation of gas as the only hydrocarbon can be estimated. In addition, a maximum feasible depth for drilling within a basin can be calculated. For basin survey purposes, where data from many wells are available, extrapolations based on as few as two points per well can provide useful information if both formations are well characterized.

EXTRACTABLE ORGANIC MATTER (EOM)

It is generally believed (Philippi, 1965; Nixon 1973) that no more than 25% of the petroleum formed in a source-rock migrates from it, and a source-rock can therefore be recognized by the petroleum left behind. The tacit assumption is made that migration of oil from a source-rock occurs only after the oil has been formed in a suitably high temperature regime, i.e., migration occurs late. Optical techniques for source-rock evaluation such as vitrinite reflectance, spore coloration and visual kerogen-type analysis indicate whether the conditions have been suitable for oil generation; whereas, the chemical techniques show whether oil actually has been generated.

Because determination of the amount and type of residual petroleum-like material provides the basis for direct source-rock determination, any petroleum product introduced to the cuttings during drilling can interfere with the determination. It is therefore important that samples of the drilling mud and any organic additive to the mud are provided along with the cuttings or core samples. Where it is possible, core samples or side wall cores should be used.

The bitumen extracted from sediments is often referred to as Extractable Organic Matter (EOM). The succession of organic matter from the time of deposition in a recent sediment to conversion to petroleum may be represented as follows:

Biopolymers - Biomonomers - Geopolymers - Geomonomers

The organic matter of living and recently dead organic systems consists of biopolymers. Biopolymers are degraded, primarily by hydrolysis, to biomonomers such as individual fatty acids and aminoacids. These biomonomers polymerize to geopolymers (kerogen) which then, upon being heated, decompose in part to geomonomers (petroleum-like hydrocarbons). Both biomonomers and geomonomers as well as heavier asphalt-like molecules are extractable; therefore, the presence of significant quantities of EOM are necessary but not sufficient for identification of a sediment as a source-rock.

It has been usual to give the EOM as ppm of whole rock (Nixon 1973; Philippi 1965) but lately authors have started to give the EOM as mg/g TOC. (Powell 1975; Albreckt et al 1976). An arbitrary classification based on the first system is given in Table I.

TABLE I

Classification based on EOM

EOM (ppm of whole rock)	Classification
200	Poor
200 - 1000	Adequate
1000	Rich

In his study of the Mowry, Nixon (1973) found values of EOM above 750 ppm and in many cases above 1000 ppm in the areas where the Mowry serves as a source-rock. Powell (1975) in his study of the Dampier Sub-basin, Western Australia, reckoned on more than 60 mg/g TOC of EOM for the sediments to have served as a source-rock, while Albrecht et al (1976) tended to go down to 50 mg/g TOC as their lower limit.

HYDROCARBON CONTENT (HC)

As was mentioned in the section on EOM, the soluble bitumen may contain biomonomers and asphaltic materials as well as the petroleum-like hydrocarbon fraction (geomonomers). Hydrocarbons (HC) are the portion of the bitumen of interest; consequently, separation of that fraction is necessary. Adsorption chromatography is used for separating the EOM into aliphatic, aromatic, and asphaltic fractions. The aliphatic and aromatic fractions together make up the petroleum-like hydrocarbon fraction; thus, the sum of these two fractions is referred to as Hydrocarbons (HC). Since the asphaltic fraction contains significant amounts of the elements Nitrogen, Sulphur and Oxygen, it sometimes is known as the NSO fraction. A high asphaltic, low hydrocarbon bitumen indicates an immature sediment.

Since the hydrocarbon portion of the bitumen extracted from a sediment is the petroleum-like portion, it is used as an important parameter in source-rock evaluation. As with EOM, the value of the HC can be given in different ways, either as ppm of whole rock, as mg/g TOC or as percent of EOM. Two interpretative schemes which often are used are those given by Philippi (1957) (Table II) and Baker (1972) (Table III).

TABLE II

Philippi Source-rock Rating

Hydrocarbons (ppm)	Interpretation
0 - 50	Very poor
50 - 150	Poor
150 - 500	Fair
500 - 1000	Good
1500 - 5000	Very good
>5000	Exceptional

TABLE III

Baker Source-rock Rating

Hydrocarbons (ppm)	Interpretation
0 - 50	Inadequate
50 - 1000	Common and Adequate
1000 - 6000	Best

Ratios of the various parameters are used for evaluating the source potential by many geochemists. For example, Philippi (1965) states that the HC (%)/TOC (%) ratio for a source-rock should be between 0.03 and 0.120. He assumes that the "oil" generated within a sediment is dissolved in the kerogen and migrates through the kerogen which acts like a wick. If the ratio is less than 0.03, the interpretation is that very little petroleum has been generated, whereas if the ratio is greater than 0.120 the kerogen is super-saturated indicating that migration has not occurred for some reason.

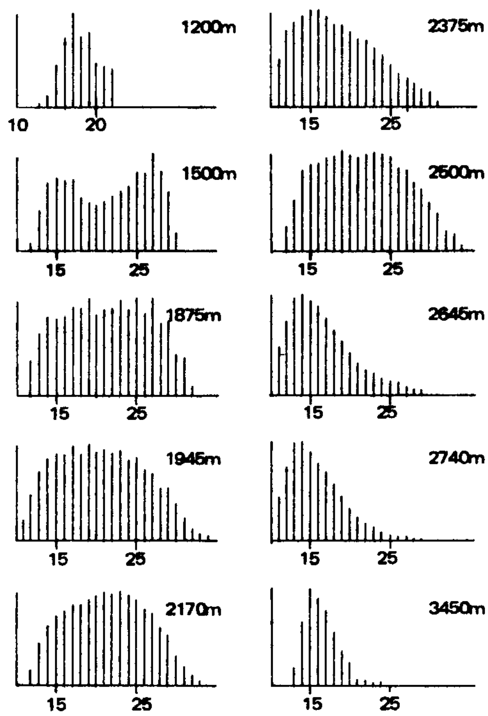
Nixon (1973) showed that not only does EOM increase with increasing maximum paleotemperature experienced by the formation, but the relative HC content of the EOM also increases. Although Nixon does not assign a critical value for HC/EOM ratio, his data suggest that in the Mowry Shale, hydrocarbons make up 35% or more of the bitumen in sediments which have matured to source-rock.

Powel (1975) reckoned on a minimum of 10% saturates (of EOM) in a source-rock.

NORMAL PARAFFIN DISTRIBUTION

More conclusive data useful in source-bed evaluation can be obtained by examining the distribution of normal paraffins within the aliphatic fraction of the hydrocarbons. The overall shape of the distribution changes with the maturity of the sample. Albrecht and Ourisson (1971) have illustrated the change by showing the results of analyses of samples taken from 1200 m (3937 ft.) to 3450 m (11,318 ft.) in a well in the Douala Basin of Africa (Fig. 2). In the shallowest samples, the paraffins are in the carbon-number region characteristic of biogenic systems; as the samples experienced higher temperatures at greater depths, higher carbon number paraffins form from the breakdown of kerogen. Finally, at greater depths the higher carbon-number paraffins are cracked to those of lower carbon number. Ultimately, of course, thermal cracking of the hydrocarbons occurs, resulting in the production of methane and residual graphite. The overall shape of the paraffin distribution, therefore, shows the degree of maturity of the sample and, coupled with the concentration of asphaltic material, allows speculation as to the maturity (gravity) of the oil generated in the sediment.

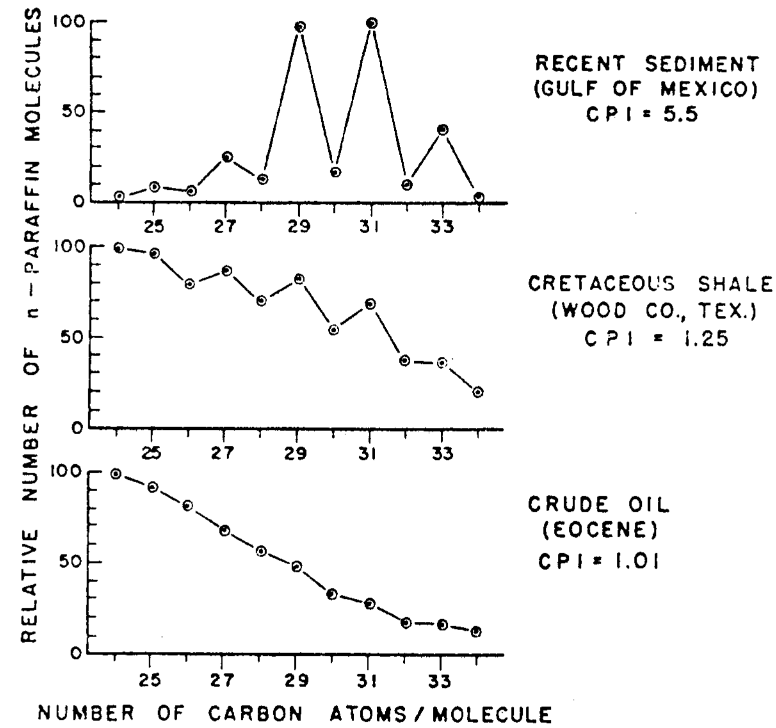
Carbon Preference Index (CPI) ---Bray and Evans (1965) reported that in recent sediments, as in biological systems, the normal paraffins are predominately those with odd numbers of carbon atoms, whereas in crude oils there is an approximately equal distribution of odd- and even-carbon-numbered paraffins (Fig. 3). The normal paraffins extracted from shales are found to have values intermediate between recent sediments and crude oils. A new parameter, Carbon Preference Index (CPI), was defined as a means of quantitatively expressing the ratio of odd- to even-carbon-numbered paraffins (Bray and Evans, 1961).



Variation of the distribution of n-alkanes with depth in the Upper Cretaccous sediments of the Douala Basin (Cameroon). Ordinate: Signal area; abseissa: number of carbon atoms.

(Albrecht and Ourisson, Angew. Chem., Int'l. Ed., 10,220 (1971))

FIGURE 2



Examples of *n*-paraffin distributions in sediments and crude oils.

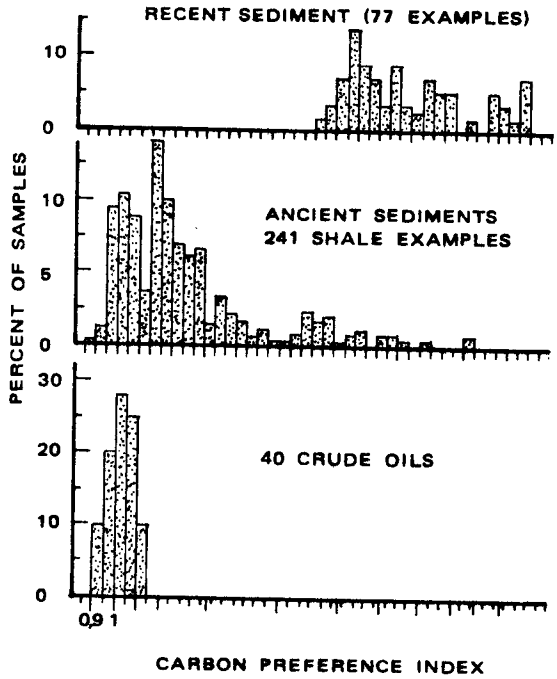
(Bray and Evans, AAPG Bull., 49, 249 (1965))

FIGURE 3

$$CPI = 1/2\left[\frac{\sum_{25}^{33}\text{Odd-Carbon Paraffins}}{\sum_{26}^{34}\text{Even-Carbon Paraffins}} + \frac{\sum_{25}^{33}\text{Odd-Carbon Paraffins}}{\sum_{24}^{32}\text{Even-Carbon Paraffins}}\right]$$

This number is simply the average ratio of odd-to-even carbon numbered normal paraffins over the molecular weight (carbon number) range of interest.

Distribution of CPI values for recent sediments, ancient sediments (shales and carbonates), and crude oils are shown in Figure 4. Since the values for crude oils range from 0.9 to 1.15 and since most of the petroleum generated within a sediment will still be there, CPI values for ancient sediments which have served as source beds should be within the range of 0.9 to 1.15.



Distribution of carbons preference indices in sediments and crude oils.

(Bray and Evans, AAPG Bull., 49, 250 (1965))

FIGURE 4

EXPERIMENTAL

The samples were washed with lukewarm water on a 0.125 mm sieve, and dried at $35^{\circ}C$. The cuttings were then sieved on a 2 mm sieve and the cuttings < 2 mm were used for the source-rock analysis. The samples from 2670 m to 3870 m contained such small amounts of cuttings < 2 mm that it was necessary to use cuttings up to 4 mm. The chance of having cavings in the samples is therefore greater in these samples than the others. After sieving, the samples were handpicked to remove any impurities before crushing and sieving. For further work, samples with a grain size of 0.063 - 0.125 mm were used.

TOC AND C_R/C_T

Aliquotes of the different samples were extracted ultrasonically in dichloromethane (DCM) for 10 min., filtered and dried in a vacuum oven at $50^{\circ}C$ for 3 hours. The samples were then weighed and treated with hot 6N HCl to remove carbonates, filtered and washed with water and organic solvents. Then dried again as before and weighed.

The TOC was then measured on a Carlo Erba elemental analyser. (Table IV). The C_R/C_T ratio was measured on an instrument developed in Norway by IKU. (Table IV).

EOM AND LIQUID CHROMATOGRAPHIC SEPARATION

The samples that contained enough material ($>$ 50 g) were extracted on soxhlet extractors for 48 h using DCM as solvent. Activated copper-foil was used to bind any free sulphur that was extracted. The EOM was separated on columns with 2/3 silica and 1/3 alumina using the following sequence of solvents: Hexane, benzene and methanol (Table V).

CARBON PREFERANCE INDEX (CPI)

The hexane eluates (saturated hydrocarbon fractions) were run on gas-chromatographs (Perkin Elmer F30 and Carlo Erba FTV 2150) using 25 m OV101 glas capillary columns with N_2 as carrier gas (0.6 ml/min.) The CPI and the pristane/phytane ratios were calculated from these chromatograms. (Table V).

VITRINITE REFLECTANCE

Upon receipt, the cutting samples were soaked in warm water and sieved thorugh 72 mesh to remove drilling mud. After oven drying at 40^{o} C, the cuttings were mounted in Bakelite resin blocks; care being taken during the setting in the plastic to avoid temperatures in excess of 100^{o}C. The samples were then ground, initially on a diamond lap followed by two grades of corundum paper. All grinding and subsequent polishing stages in the preparation were carried out using isoprpyl alcohol as lubricant since water leads to the swelling and disintigration of the clay fraction of the samples.

Polishing of the samples was performed on Selvyt cloths using three grades of alumina, 5/20, 3/50 and Gamma, followed by careful cleaning of the surface.

Reflectance determinations were carried out on a Leitz M.P.V. microphotometer under oil immersion, R.I. 1.516, at a wavelength of 546 nm. The field measured was varied to suit the size of the organic particle but was usually of the order of 2 micron diameter.

The surface of the polished block was searched by the operator for suitable areas of vitrinitic material in the sediment. The reflectance of the organic particle was determined relative to optical glass standards of known reflectance. Where possible, a minimum of twenty individual particles of vitrinite was measured although in many cases this number could not be achieved. The search for vitirinitic material was maintained for apporximately 45 minutes on each sample before termination if the operator considered that no more vitrinitic particles were likely to be located.

EXTRACTION OF DRILLING MUD

To get some knowledge of the organic additives in the drilling mud, some of this was extracted ultrasonically with hexane. The extract was then run on capillary g.c. columns under the same conditions as before.

RESULTS AND DISCUSSION

TOTAL ORGANIC CARBON (TOC)

TOC varies slightly over the whole sequence analysed. For the first 700 m (1820 - 2520 m) the approximate value is 1.3%. At 2570 begins a carbonate rich sequence and there is a sudden drop in the TOC to 0.3%. Below the carbonate sequence, there is a sudden rise in the TOC to 3.1% at 2720 m, and then it drops to a more normal value of 1.1%. There are other sudden sharp increases and decreases in the TOC values in the analysed samples. This can be caused by various reasons, such as sudden changes in the lithology (Powell, 1975; Albrecht et al, 1976). It is well known (Gehman 1962) that carbonate rich sequences give lower TOC values than shale sequences. Another reason for the sudden variations can be contamination from additives to the drilling mud, such as lignosulphonate. Over all, there is a fairly steady value of 0.6 - 1.4 over most of the well, and this value is above the minimum value reckoned for a possible source-rock.

C_R/C_T RATIO

C_R/C_T starts at a fairly low value of 0.3 at 1820 m. This is expected since we here will have a fairly immature sediment. The C_R/C_T value is fairly steady to a depth of approximately 2100 m (Table IV). At 2120 there is a sudden jump of 0.1. This jump coincides with the Eocene/Paleocene boundary.

At 2320 m there is again a sudden jump of 0.1 in the C_R/C_T ratio. Vitrinite reflectance measurements show that there are fairly large amounts of reworked material in most samples from this depth and down to the base of the well. From 2320 m - 2520 m the C_R/C_T value is steady around 0.5. At 2570 m we find, for the first time in this well, a C_R/C_T value of 0.6 or higher. This coincides with the Paleocene/Creteaseous boundary for this well. From 2570 m to the bottom of the well, the C_R/C_T ratio varies from 0.6 - 0.8, with a few exceptions 0,58 at 3500 m, 0,41 at 3650 m and 0,53 at 3990 m (Table IV). These few samples could then indicate the "true" value for the C_R C_R/C_T ratio. But because of the large amount of samples with C_R/C_T ratio between 0.6 and 0.8, together with the knowledge of extended reworked material it is very difficult to draw conclusions from the C_R/C_T measurements alone.

VITRINITE REFLECTANCE

The results of the vitrinite reflectance determinations are shown in Table VII of this report. Values underlined indicate what are considered to be the true reflectance for the sample in cases where there is contamination by reworked or caved material. The number in brackets following the value quoted for the vitrinite reflectance indicates the number of particles on which the determination is based.

Equivalent carbon contents, dry ash free, are quoted relative to data published by Teichmüller based on European coals (Fig. 5).

The vitrinite reflectance starts with a value of 0.4 at 1820 m. Most of the particles measured, seem allright, but there is a wide spread in the values, and those above 0.5 could perhaps be separated out and classed as reworked. The sample from 2020 m is good and gives a true value of 0.35. At 2320 m we find some particles with values around 0.3 but also some with far higher reflectance values (Table VII). The latter are reckoned as reworked.

At 2520 m we find particles with slightly higher values than before (0.44), and no reworked material is recorded. Since this depth is close to the Paleocene/Cretacous boundary, it was decided to do vitrinite reflectance measurements on the samples from the two next depths, 2570 m and 2670 m. These measurements show that we have reworked material in the samples from Cretaceous, while this was not found in the sample from 2520 m (Paleocene). We also find a quite sharp increase going down in the Cretaceous. At 2900 m we find a sample which gives an excellent reading on coal praticles (0.64), and we are quite confident that this is a true value. From 3100 m and down there are coal particles with reflectance of approx. 0.35. These are most probably particles which are additives to the drilling mud. There was no information on such an additive when the measurements were carried out but later we learned that lignosulphonate was added. This is expected to give a reflectance value of approximately 0.3.

The reflectance value of 0.76 at 3100 m could be a true value. It is a quite high value, but because the measurements were done on wisps, we feel that it is not reworked. On the other hand, the value of 0.92 at 3250 m, is definitly from reworked material. The reflectance values found for the samples from 3350 m, 3450 m, 3550 m and 3600 m are believed to be true.

At 3650 m we again find a very high value (0.98) and this is believed to be reworked material.

The reflectance values of 0.80 and 0.85 found for the samples from 3700 m and 3750 m might be a bit high, but there is no definite evidence that it is reworked material.

At 3800 m there are two definite classes of values (0.66 and 1.27). Here we believe that 0.66 is a true value and 1.27 from reworked material.

Two core samples were also measured (3818.50 m and 3824 m). Both the core samples showed slight exinite fluorescence and one particle at 3824 m gave a reading of 0.71. Apart from this all the measurements were on reworked material.

The measurements on the cuttings from 3940 m gave one reading of 0.75 and the rest at approx. 1.4. The latter are reworked material. Alle the samples measured from 3960 m and down to the base of the well show only reworked material. In most of the samples measured, very little organic material was reported.

EXTRACTABLE ORGANIC MATTER (EOM)

Looking at Table V, we see that most of the samples give an EOM value that would be rated as adequate for source-rock, and that the hydrocarbon content would be reckoned as poor to fair for most samples. There are a few exceptions, mainly from 3750 m to 3890 m, where the EOM must be rated rich and the hydrocarbon content good to very good. (Philippi 1957).

The latest ways of interpreting the EOM and hydrocarbon values (Powell, 1975, Albrecht et al, 1976), where EOM, saturates and hydrocarbons are expressed in mg/g TOC, can also be used. (Table VI).

Most of the well has EOM values which are smaller than what Powell (1975) reckoned to be the minimum value for a sediment to be a source-rock (60 mg/g TOC). The exception is the sequence from 3750 m to 3890 m which has very high values for the EOM. (Table VI).

We understand an oil show was found in this interval. If we plot the EOM, HC and Saturates as ppm of whole rock, as a function of depth, we find two other intervals that have a small increase in EOM, HC and Saturates. These intervals are 2950 m - 3200 m and 3200 m - 3350 m (Fig. 15). These increases in EOM, HC and Saturates coincides with an increase in TOC (Table IV and Fig. 15).

If we, however, plot EOM, HC and Saturates as mg/g TOC as a function of depth, these two intervals are not distinct. (Fig. 16).

NORMAL PARAFFIN DISTRIBUTION AND CPI VALUES

Since there was so small amounts of EOM in the samples from the first 300 m (1820 m - 2120 m), liquid chromatographic separation was not done on these samples (Table V). Because of this, the distribution of the normal paraffins is not known. At 2170 m, the normal paraffin distribution seems to have two maxima, one at nC_{16} and a smaller one at nC_{24} (Fig. 15). This shows that at this depth the organic matter is not well matured, and that some of the organic matter could have derived from algae.

Going down the well, the maximum at nC_{24} gradually decreases, and from 3200 m there is a very smooth distribution of the normal paraffins, with a maximum at nC_{16}. This shows that the organic matter has undergone changes, and from 3200 m, we have a matured sediment with a normal paraffin distribution normally found for crude oils (Fig. 15).

When working with cuttings there is always the possibility of contamination. This will particularly show up in the normal paraffin distribution and the CPI value.

Gas chromatograms of the saturated hydrocarbon fraction from samples of cuttings taken from depths just above and below where diesel oil was started to be added to the drilling mud, show very much the same pattern. This makes us fairly confident that there is very little contamination from the diesel oil in our samples.

The CPI values were calculated for the different samples, and showed a very constant value around 1.00. Most of the samples had very small amounts of higher n-alkanes (above nC_{25}) so it was difficult to calculate the CPI value with sufficient accuracy. Also we had to calculate the CPI on very few n-alkanes, since most samples did not show any evidence of n-alkanes above nC_{30}. Some capillary gas chromatograms are shown in Fig. 6 - 14.

ISOPRENOIDS

At the top of the well there are large amounts of pristane and phytane compared to nC_{17} and nC_{18} (Fig. 6). This shows that this is a fairly immature sediment. The ratios pristane/nC_{17} and phytane/nC_{18} decreases going down the well. At 2170 m we find 2.3 and 1.1 for the two ratios, while at 2570 m, the pristane/nC_{17} ratio is approx. 1.0. From 3200 m to the base of the well, the ratios pristane/nC_{17} and phytane/nC_{18} are those usually found for crude oil (0.5 and 0.3).

CONCLUSION

The results from the different analyses are plotted as function of depth in Figs. 15 and 16.

The Eocene (down to 2060 m) shows only negligeble variation for the different analyses. At the top of the Paleocene the C_R/C_T shows a sudden increase, while the results from other analyses are fairly constant, right through the Paleocene. At the boundary between Paleocene and Cretaceous, there is again a sharp increase in the C_R/C_T, and a drop in the TOC. EOM, HC and Saturates are fairly constant in this interval.

From 3000 m we start to get an increase in TOC, EOM, HC and Saturates. These measurements again show a low value at 3200 m, which is close to the Campanian/Santonian boundary. The interval between 3200 m and 3350 m again has higher values for the TOC, EOM, HC and Saturates. The vitrinite reflectance for these two intervals show that we are within the "oil window" and the normal paraffin distribution shows fairly matured organic matter. If we look at Fig. 16, where EOM, HC and Saturates are plotted as mg/g TOC as a function of depth, these two intervals are not so distinct. On the whole we conclude that matured organic matter is formed in these two intervals but the amount is negligible.

The different measurements show very little variation from 3500 m down to 3700 m. From 3700 m the EOM, HC and Saturates show large, very sudden increases, and there are large amounts of EOM, HC and Saturates in the interval between 3700 m and 3890 m. From the data we have from our analysis we interpret this interval as an oil show.

From 3890 m to the base of the well, the TOC shows very erratic values, and the vitrinite reflectance gives results that indicate only reworked material. The EOM, HC and Saturates are again very low and with small variations.

The conclusion from the different analysis on samples from this well, is that the hydrocarbon generation zone lies below the total depth of this well.

COMMENTS TO THE DIFFERENT ANALYSES.

Earlier experience with material from the North Sea shows that there is a large degree of reworked material. Because of this a fairly large number of samples were taken for vitrinite reflectanse, but still it was difficult to find samples that gave good readings. On top of the problem with reworking there is also the possiblity of cavings. If possible, we would suggest that sidewall cores are taken for this type of analysis.

As mentioned in the Results and Discussion part, very little weight was put on the C_R/C_T measurements. This was because all measurements of EOM etc. gave clear evidence that there was no source rock in the analysed interval. If, however, the evidence had not been so clear, optical means to get more knowledge of the organic matter would have been used, to help interpret the C_R/C_T measurements.

In the extraction of the sediment we have used dichloromethane (DCM), this to avoid benzene, with its carcinogenic effect, as much as possible. DCM will lower the value for EOM compared with the benzene/methanol mixture usually used. But since the loss normally will be from the NSO fraction, we still get the required information. Other institutions have also left the benzene/methanol mixture (i.e. IFP, SNPA and Philips Petroleum).

In this work we have not analysed for light hydrocarbons. Analysis of light hydrocarbons provides a rapid knowledge of the maturety of the sediment and this aids in the interpretation of the data. IKU can do this type of analysis, but since it was not requested by Norsk Hydro, and since it was not mentioned in the contract this analysing method was not used. Any show of light hydrocarbons will not be detected by the analysing methods used on samples from this well. We understand that a small gas-show was found at approx 2200 m.

On request from Norsk Hydro, total analysis for heavy hydrocarbons was done on all samples where there was enough material. A sequence of analyses of this type, with extraction, liquid chromatographic separation and CPI measurements of all the samples is very time consuming and expensive. We would therefore suggest that a screening method i.e. TOC is used on all samples and from this, the samples for further analyses can be picked.

If, however, the different companies wish to have a complete analysis of all the samples, we would be prepared to do this.

TABLE IV

Total Organic Carbon (TOC) and Carbon Residue/Total Organic Carbon ratio (C_R/C_T).

Sample	Depth (m)	TOC (%)	C_R/C_T
1	1820	1,52	0,30
2	1870	1,01	0,36
3	1920	1,47	0,36
4	1970	1,30	0,31
5	2020	1,31	0,32
6	2070	1,31	0,32
7	2120	1,40	0,42
8	2170	0,88	0,41
9	2270 Set A	1,58	0,43
10	2270 Set B	1,34	0,42
11	2320	1,01	0,54
12	2370	0,83	0,52
13	2420	1,75	0,52
14	2470	0,87	0,47
15	2520	0,83	0,56
16	2570	0,30	0,65
17	2670	0,34	0,60
18	2720	3,13	0,63
19	2800	1,16	0,76
20	2900	1,10	0,70
21	2950	0,60	0,69
22	3010	0,61	0,64
23	3050	2,18	0,78
24	3100	2,31	0,70
25	3150	1,35	0,77
26	3202	0,69	0,72
27	3250	3,92	0,77
28	3300	2,90	0,76
29	3350	0,71	0,69

Sample	Depth (m)	TOC (%)	C_R/C_T
30	3450	1,41	0,70
31	3500	0,89	0,58
32	3550	2,97	0,60
33	3600	0,67	0,61
34	3650	0,58	0,41
35	3700	0,76	0,65
36	3750	0,69	0,62
37	3800	0,77	0,74
38	3810	1,17	0,72
39*	3820		
40	3830	0,85	0,71
41	3840	0,66	0,68
42	3850	0,58	0,71
43	3870	1,19	0,63
44	3880	1,33	0,73
45	3890	1,05	0,71
46	3900	2,45	0,74
47	3940	1,59	0,75
48	3950	1,65	0,76
49	3960	1,33	0,77
50	3970	2,15	0,71
51	3980	0,89	0,76
52	3990	0,98	0,53
53	4000	0,60	0,74
54	4010	1,13	0,81
55	4020	0,89	0,78
56	4030	1,98	0,84
57	4040	1,28	0,84
58	3924 (Core)	1,03	0,81

* No returns of cuttings.

TABLE V

Extractable Organic Matter (EOM), Liquid Chromatographic Separation, Carbon Preferance Index (CPI) and Pristane/Phytane ratio.

Depth	EOM ppm of whole rock	Saturates ppm of whole rock	Nonsaturates ppm of whole rock	Methanol eluate ppm of whole rock	Hydrocarbons ppm of whole rock	CPI	Pristane / Phytane
1820 *	77						
1870 *	80						
1920 *	111						
1970 *	101						
2020 *	71						
2070 *	106						
2120 *	102						
2170	145	33	32	54	65	0,98	2,53
2270 Set A	210	39	45	84	84	0,98	1,85
2270 Set B	235	48	39	87	87	1.00	1.71
2320	205	34	34	69	68	0,98	1,59
2370	400	25	45	27	70		2,10
2420	100	12	19	36	31	1.01	2.21
2470	270	9	168	40	177	0.99	2.44
2520	325	106	79	101	185	1.03	1.46
2570	128	16	46	32	62		
2670	260	43	56	41	99	1.02	1.50
2720	344	61	80	177	141	0,98	1,71
2800	210	17	41	105	58		

Depth	EOM ppm of whole rock	Saturates ppm of whole rock	Nonsaturates ppm of whole rock	Methanol eluate ppm of whole rock.	Hydrocarbons ppm of whole	CPI	Pristane / Phytane
2900	356	58	90	82	148	1,01	2.34
2950	325	100	68	48	168	0,99	1.87
3010 **							
3050	820	208	274	146	482	1.00	1.89
3100 **							
3150	729	50	183	239	233	0,98	1.37
3202	157	23	63	56	86	0,96	1,74
3250	1180	82	270	276	352	1,01	1,51
3300 **							
3350	436	56	93	175	149	1,03	1,66
3450	456	62	129	151	191	1,02	1,80
3500	389	88	122	120	210	1,01	2,28
3550	430	81	174	101	255	0,99	1,78
3600	370	47	83	88	130	1,00	1,85
3650	333	37	48	61	85	1,01	1,47
3700	350	29	45	92	74	1,02	1,58
3750	2390	677	449	271	1126	1,00	1,87
3800	3338	1521	728	615	2249	0,99	1,91
3810	2300	750	743	801	1493	1,01	1,86
3820 **							
3830	970	204	224	216	428	0,99	1,74
3840	1250	526	284	292	810	1,01	1,55
3850	1863	493	389	295	882	0,99	1,16

Depth	EOM ppm of whole rock	Saturates ppm of whole rock	Nonsaturates ppm of whole rock	Methanol eluate ppm of whole rock	Hydrocarbons ppm of whole rock	CPI	Pristane/Phytane
3870	4447	702	809	809	1511	1,01	1,55
3880	5140	1737	1509	548	3246	1,00	1,44
3890	800	170	235	238	405	1.00	1.60
3900	1130	344	267	312	611	1.00	1.65
3940	440	137	107	168	244	1.00	1.33
3950	510	126	127	177	253	1,01	1,40
3960	760	88	116	181	304	1,01	1,40
3970	410	87	105	181	192	0,99	1,45
3980	310	60	52	111	112	0,99	1,43
3990	290	65	77	78	142	0,98	1,41
4000	210	59	36	60	95	0,99	1,42
4010	210	35	64	82	99	1,01	1,41
4020	240	43	56	68	99	1,00	1,41
4030	600	172	123	198	295	0,98	1,58
4040	350	91	62	106	153	1,01	1,61
3924 (core)	270	7	28	57	35	1.00	1.84

* Not enough sample for liquid chromatographic separation.

** Not enough sample for extraction.

TABLE VI

Extractable Organic Matter (EOM), Saturates and Total Hydrocarbons as a function of Total Organic Carbon.

Depth	EOM m /g TOC	Saturates m /g TOC	Total HC m /g TOC	Saturates % of EOM	Total HC % of EOM.
1820 *	5.1				
1870 *	7,9				
1920 *	7,6				
1970 *	7,8				
2020 *	5,4				
2070 *	8,1				
2120 *	7,3				
2170	16,3	3,8	7,4	23	45
2270 Set A	13,2	2,5	5,3	19	40
2270 Set B	17,5	3,6	6,5	20	37
2320	20,2	3,4	6,7	17	34
2370	48,2	3,0	8,4	6	18
2420	8,5	0,7	1,8	12	31
2470	31,0	1,0	20,3	3	66
2520	39,2	12,8	22,3	33	57
2570	42,7	5,3	20,7	13	48
2670	79,3	12,6	29,1	17	38
2720	11,0	1,9	4,5	18	41
2800	18,1	1,5	5,0	8	28
2900	32,4	5,3	13,5	16	42
2950	54,2	16,7	28,0	31	52
3010 **					
3050	37,6	9,5	22,1	25	59
3100 **					
3150	54,0	3,7	16,5	7	32
3202	22,8	3,3	12,5	15	55
3250	30.1	2,1	9,0	7	30
3300 **					
3350	61,4	7,9	21,0	13	34

Depth	EOM m /g TOC	Saturates m /g TOC	Total HC m /g TOC	Saturates % of EOM	Total HC % of EOM
3450	32,3	4,4	13,5	14	42
3500	43,7	9,9	23,6	23	54
3550	14,5	2,7	8,6	25	77
3600	55,2	7,0	19,4	13	35
3650	57,4	6,4	14,7	11	26
3700	46,1	3,8	9,7	8	21
3750	346,4	98,1	163,2	28	47
3800	433,5	197,5	292,1	46	67
3810	196,6	64,5	127,6	33	65
3820 **					
3830	114.1	24.0	48,4	21	41
3840	189,4	79,7	122,7	42	65
3850	325,2	85,0	152,1	26	47
3870	373,7	59,0	127,0	16	34
3880	386,5	130,6	244,1	34	63
3890	76,2	16,2	38,6	21	51
3900	46,1	14,0	24,9	30	54
3940	28,2	8,6	15,3	31	55
3950	30,9	7,6	15,3	25	50
3960	57,1	6,6	15,3	12	27
3970	19,1	4,0	8,9	21	47
3980	34,8	6,7	12,6	19	36
3990	29,6	6,6	14,5	22	49
4000	31,8	9,8	15,8	28	45
4010	18,5	3,1	8,8	17	47
4020	27,0	4,8	11,1	18	41
4030	30,3	8,7	14,9	29	49
4040	27,3	7,1	12,0	26	44
3924 Core	26,2	0,7	3,4	3	13

* Not enough sample for liquid chromatographic separation.

** Not enough sample for extraction.

TABLE VII

Vitrinite reflectance R_o No of particles measured in brackets.

Depth	Reflectance.									
1820		0,44(20)								
2020	0,35(16)									
2320	0,32(10)			0,65(8)						
2520		0,44(20)								
2570		0,44(14)			0,79(2)					
2670			0,50(4)			0,84(4)				
2900				0,64(22)Coal						
3100	0,36(20)Coal				0,75(5)					
3250	0,36(11)Coal						0,92(9)			
3350				0,68(20)						
3450	0,35(10)Coal			0,67(10)						
3550	0,35(23)Coal			0,67(5)						
3600	0,34(1)Coal			0,61(11)						
3650							0,98(6)			
3700	0,28(6)Coal					0,80(14)				
3750	0,22(7)Coal					0,85(13)				
3800	0,38(5)Coal			0,66(2)				1.27(9)		
3918*.50										1.42(20)
3924*					0,71(1)				1,38(20)	
3940	0,38(21)Coal				0,74(1)					
3960	0,36(20)Coal									

TABLE VII page 2

Depth		Reflectance.				
3980	0,37(5)Coal				1.39(16)	
4000				1.21(11)		
4020					1,30(21)	
4040		0,64(1)	1.11(19)			2.03(1)

x Core samples.

Fig. 5.

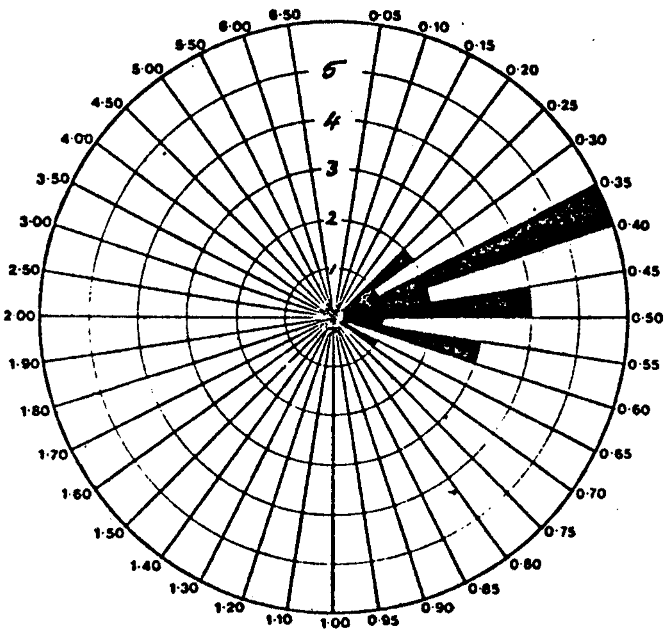
Details of the vitrinite reflectance measurements.

ORIGIN I.K.U.	SAMPLE Our Ref: A.S./J.M.J. Your Ref: 1820
LITHOLOGY Shale + Carbonate	
MINERALOGY	GENERAL COMMENTS Seems Satisfactory But Spread of Values Rather Wide. Spore Colour Suggests Lower Ro. Readings Probably Include Reworked Material
ORGANIC MATERIAL Moderate Organic Content. Particles of Vitrinite, Rather Rounded. Inertinite + Reworked Material Dominant	
APPEARANCE IN U.V. Green/Yellow + Orange Fluorescence From Spores	Geo-consultants Lt Ash House Bell Villas Ponteland Northumberland NE20 9BE Signature [signature] Date 15th Dec. 1976
EXINITE CONTENT IN U.V. Low	

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

0.36	0.65	0.47	0.39		
0.31	0.41	0.49	0.38		
0.38	0.57	0.51	0.27		
0.45	0.58	0.58	0.27		
0.39	0.45	0.36	0.43		

TOTAL No. OF PARTICLES MEASURED 20



REFLECTIVITY (%)		No. OF PARTICLES
R̄max.		
R̄aver.	0.44	20

EQUIVALENT CHEMICAL PARAMETERS DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
72		

ORIGIN	I.K.U.	SAMPLE	Our Ref: J.M. I.I.M.J. / Your Ref: 2020
LITHOLOGY	Shale + Carbonate		

MINERALOGY

GENERAL COMMENTS

ORGANIC MATERIAL
Low- Moderate Organic Content. Small, Isolated Particles Mainly of Reworked Vitrinite + Inertinite. A Few Rounded Particles of Possibly True Vitrinite.

APPEARANCE IN U.V.
Green/Yellow + Orange Fluorescence From Spores

EXINITE CONTENT IN U.V. Low

Signature [signature]

Geo-consultants Ltd
Ash House
Bell Villas
Ponteland
Northumberland
NE20 9BE

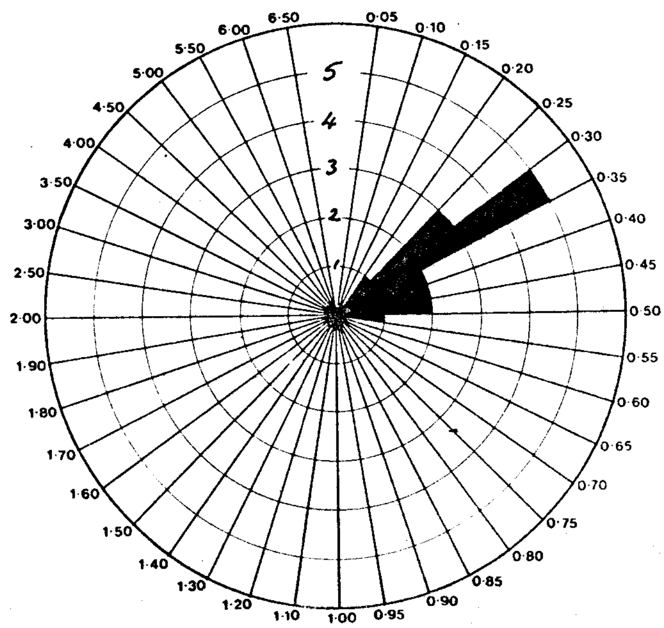
Date 15th Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

0·41	0·27	0·29	0·32		
0·46	0·36	0·50			
0·23	0·28	0·30			
0·40	0·32	0·33			
0·48	0·34	0·37			

TOTAL No. OF PARTICLES MEASURED 16

	REFLECTIVITY (%)	No. OF PARTICLES
R̄max.		
R̄aver.	0·35	16



EQUIVALENT CHEMICAL PARAMETERS DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
65		

ORIGIN I.K.U.	SAMPLE Our Ref: J.M./J.M.J. Your Ref: 2320
LITHOLOGY Mixed Shale Lithologies, Sandstone + Limestone	
MINERALOGY Shale Rather Pyritic	GENERAL COMMENTS Two Ro. Values. Interpretation Uncertain But Lower Value Favoured; Upper - Reworked.
ORGANIC MATERIAL Moderate Organic Content. Sandstone + Limestone Barren - All Readings on Shale. Small Particles + Wisps of Vitrinite But Mostly Reworked With Inertinite	
APPEARANCE IN U.V. Good Yellow Fluorescence From Spores	
EXINITE CONTENT IN U.V. Low - Moderate	Signature Date 15th Dec. 1976

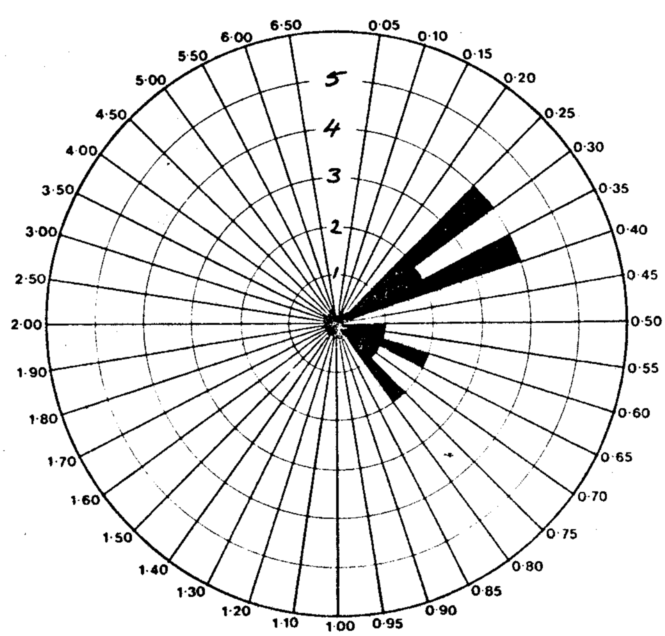
Geo • consultants Ltd
Ash House
Bell Villas
Ponteland
Northumberland
NE20 9BE

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546 nm.	1.516

0·31	0·78	0·28	0·50		
0·25	0·66	0·36	0·38		
0·75	0·60	0·27	0·37		
0·39	0·62	0·59			
0·71	0·31	0·28			

TOTAL No. OF PARTICLES MEASURED 18

REFLECTIVITY (%)		No. OF PARTICLES
$\bar{R}$max.		
$\bar{R}$aver.	0·32	10
	0·65	8



EQUIVALENT CHEMICAL PARAMETERS

DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
63 78		

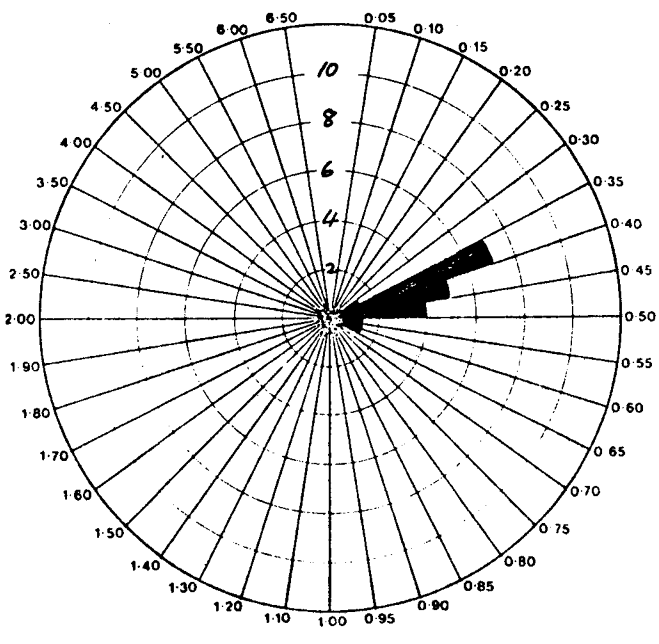
ORIGIN I.K.U.	SAMPLE Our Ref: J.M. / P.W Your Ref: 2520
LITHOLOGY Mixed Shale Lithologies	
MINERALOGY	GENERAL COMMENTS Seems Reliable Result
ORGANIC MATERIAL Variable Organic Content With Shale Lithology. Generally Low/Moderate with Inertinite + Reworked Vitrinite Dominant Ragged, Corroded Particles + Wisps	
APPEARANCE IN U.V. Yellow / Orange Fluorescence From Spores	Geo-consultants Ltd Ash House Bell Villas Ponteland Northumberland NE20 9BE
EXINITE CONTENT IN U.V. Moderate	Signature [signature] Date 15th Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

0·39	0·39	0·54	0·47		
0·42	0·39	0·37	0·41		
0·57	0·42	0·43	0·37		
0·36	0·47	0·34	0·42		
0·64	0·47	0·47	0·37		

TOTAL No. OF PARTICLES MEASURED 20

REFLECTIVITY (%)		No. OF PARTICLES
R̄max.		
R̄aver.	0·44	20



EQUIVALENT CHEMICAL PARAMETERS DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
72		

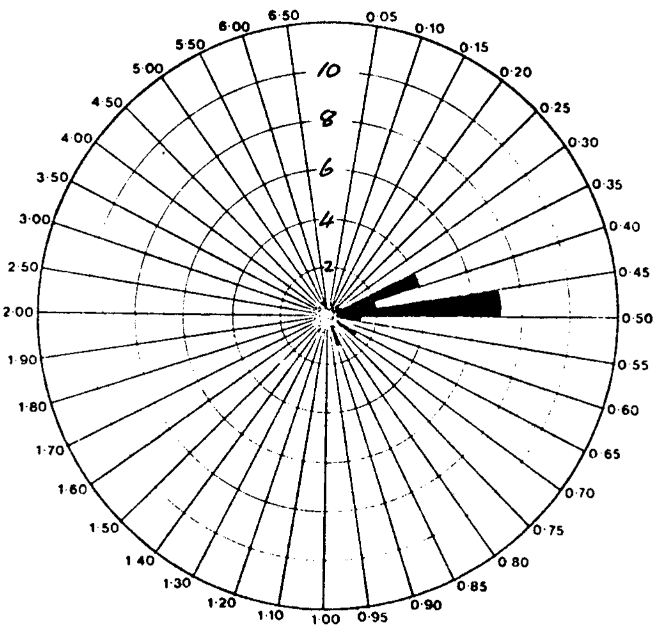
ORIGIN I.K.U.	SAMPLE Our Ref: J.M. /P.W. Your Ref: 2570
LITHOLOGY Shale + Chalk	
MINERALOGY Pyrite + Traces of Glauconite	GENERAL COMMENTS Seems Reliable. Higher Value Reworking.
ORGANIC MATERIAL Chalk - Virtually Barren Shale - Moderate Organic Content - Present As Small Inertinite Particles + Vitrinite Wisps. Rather Ragged + Corroded	
APPEARANCE IN U.V. Strong Carbonate Fluorescence + Yellow and Orange Spores	Geo-consultants Ltd Ash House Bell Villas Ponteland Northumberland NE20 9BE Signature [signature] Date 1st Oct. 1976
EXINITE CONTENT IN U.V. Moderate	

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546 nm.	1.516

0.89	0.42	0.39	0.46		
0.47	0.48	0.43			
0.47	0.45	0.68			
0.39	0.39	0.46			
0.35	0.47	0.50			

TOTAL No. OF PARTICLES MEASURED 16

REFLECTIVITY (%)		No. OF PARTICLES
$\bar{R}$max.		
$\bar{R}$aver.	0.44	14
	0.79	2



EQUIVALENT CHEMICAL PARAMETERS DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
72 80		

ORIGIN I.K.U.	SAMPLE Our Ref: A.S./P.W. Your Ref: 2670
LITHOLOGY Siltstone	
MINERALOGY	GENERAL COMMENTS
ORGANIC MATERIAL Low - Moderate Organic Content. Small Vitrinite Particles But Reworked Material And Inertinite Dominant.	
APPEARANCE IN U.V. Orange Fluorescence From Spores	Geo • consultants Ltd Ash House Bell Villas Ponteland Northumberland NE20 9BE
EXINITE CONTENT IN U.V. Low	Signature [signature] Date 15th Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

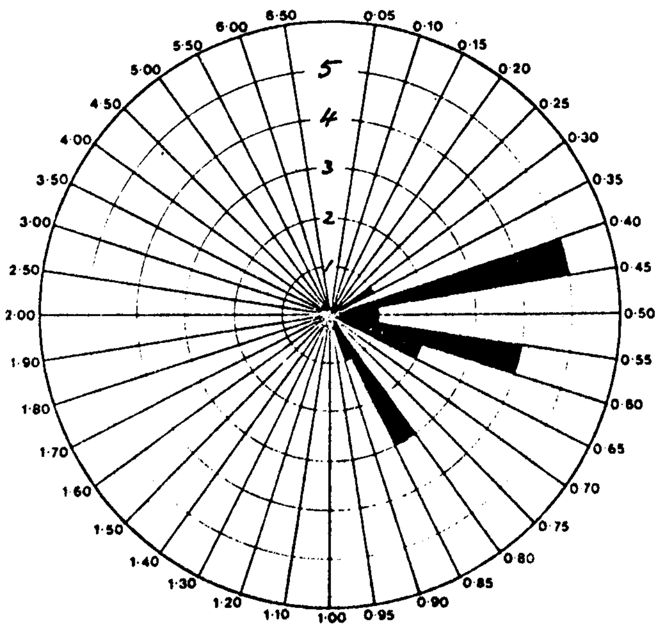
0·31	0·59	0·44	0·43		
0·81	0·44	0·47	0·44		
0·57	0·61	0·56	0·44		
0·61	0·87	0·50			
0·84	0·82	0·59			

TOTAL No. OF PARTICLES MEASURED 18

	REFLECTIVITY (%)	No. OF PARTICLES
$\bar{R}$max.		
$\bar{R}$aver.	0·50	14
	0·84	4

EQUIVALENT CHEMICAL PARAMETERS DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
73 81		



ORIGIN: I.K.U.	SAMPLE — Our Ref: J.M./P.W. — Your Ref: 2900
LITHOLOGY: Mixed Shale + Coal Particles	

MINERALOGY

GENERAL COMMENTS

Majority of Readings on Coal

ORGANIC MATERIAL

Moderate Organic Content. Almost Exclusively Ragged, Gnarled Particles of Inertinite + Reworked Vitrinite
Coal - Vitrinitic with a Little Inertinite

APPEARANCE IN U.V.

Yellow/Orange Fluorescence From Spores

EXINITE CONTENT IN U.V. Low

Signature [signature]

Geo-consultants Ltd
Ash House
Bell Villas
Ponteland
Northumberland
NE20 9BE

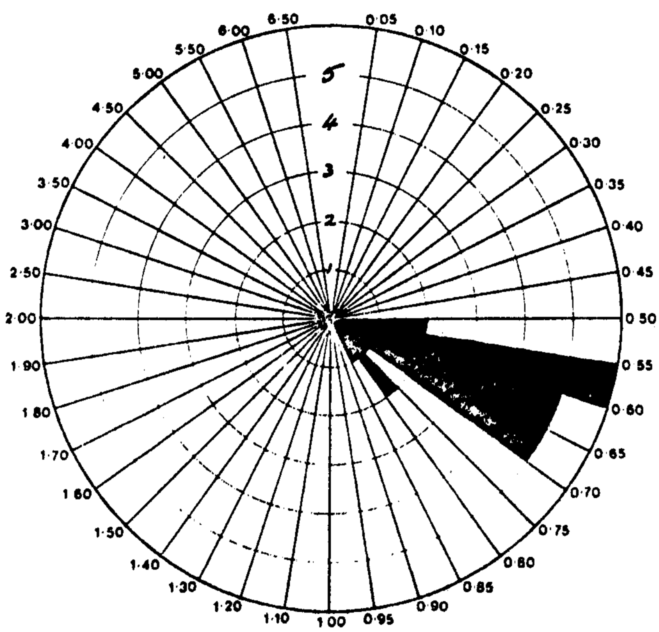
Date 15th Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

0·58	0·68	0·75	0·65	0·58	
0·55	0·81	0·68	0·69	0·59	
0·55	0·79	0·61	0·59		
0·51	0·71	0·64	0·63		
0·53	0·62	0·67	0·63		

TOTAL No. OF PARTICLES MEASURED 22

REFLECTIVITY (%)		No. OF PARTICLES
$\bar{R}$max.		
$\bar{R}$aver.	0·64	22



EQUIVALENT CHEMICAL PARAMETERS DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
77		

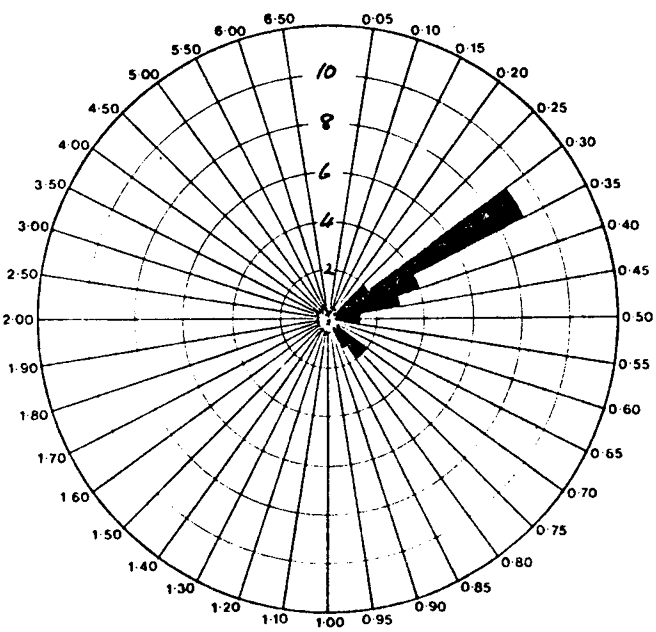
ORIGIN I.K.U.	SAMPLE Our Ref: A.S./P.W. Your Ref: 3100 5
LITHOLOGY Shale, Coal + Limestone Traces	
MINERALOGY	GENERAL COMMENTS
ORGANIC MATERIAL Limestone Barren. Rich in Coal Cuttings – Structureless Vitrinite with only Inertinite Traces. Some Carbargillite. Shale – Low/Mod. Content – Ragged Wisps + Particles Chiefly Inertinite + Reworked.	
APPEARANCE IN U.V. Yellow/Orange Fluorescence From Spores	Geo-consultants Ltd Ash House Bell Villas Ponteland Northumberland NE20 9BE
EXINITE CONTENT IN U.V. Low	Signature [signature] Date 15th Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

0·78	0·33	0·28	0·76	0·72	
0·33	0·33	0·32	0·50	0·35	
0·32	0·33	0·84	0·42	0·39	
0·32	0·35	0·42	0·32	0·46	
0·37	0·31	0·29	0·72	0·42	

TOTAL No. OF PARTICLES MEASURED 25

	REFLECTIVITY (%)	No. OF PARTICLES
$\bar{R}$max.		
$\bar{R}$aver.	0·36	20 Coal
	0·76	5



EQUIVALENT CHEMICAL PARAMETERS

DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
66 80		

ORIGIN I.K.U.	SAMPLE	Our Ref: J.M. / J.M.J. Your Ref: 3250
LITHOLOGY Shale + Coal		

MINERALOGY

GENERAL COMMENTS

ORGANIC MATERIAL

Coal - Low Rank, Vitrinitic But With Some Carbargilite Cuttings

Shale - Variable Lithologies. Corroded Particles + Wisps Mainly of Reworked Vitrinite

APPEARANCE IN U.V.

Orange Fluorescence From Spores

EXINITE CONTENT IN U.V. Low

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Ash House
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Northumberland
NE20 9BE

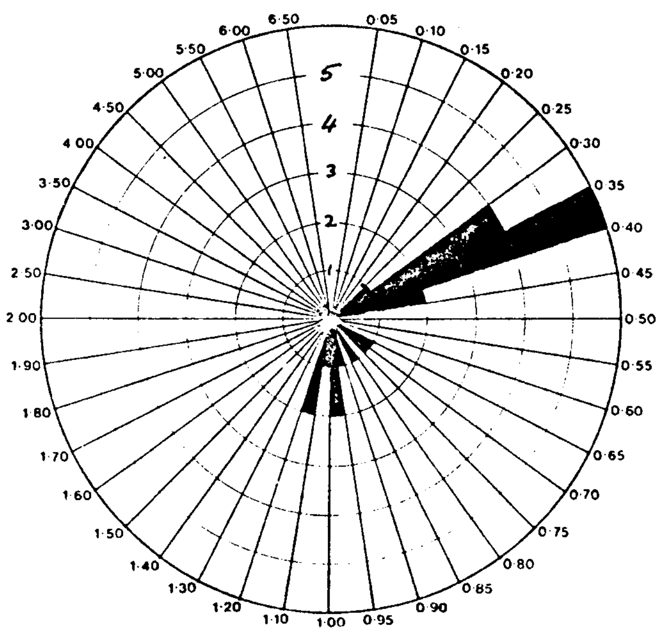
Signature [signature] Date 15th Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

1.12	0.94	0.36	0.36		
1.03	0.98	0.34	0.35		
1.15	0.71	0.39	0.34		
0.82	0.65	0.41	0.32		
0.97	0.29	0.42	0.38		

TOTAL No. OF PARTICLES MEASURED 20

	REFLECTIVITY (%)	No. OF PARTICLES
$\bar{R}$max.		
$\bar{R}$aver.	0.36	11 Coal
	0.93	9



EQUIVALENT CHEMICAL PARAMETERS
DRY ASH FREE

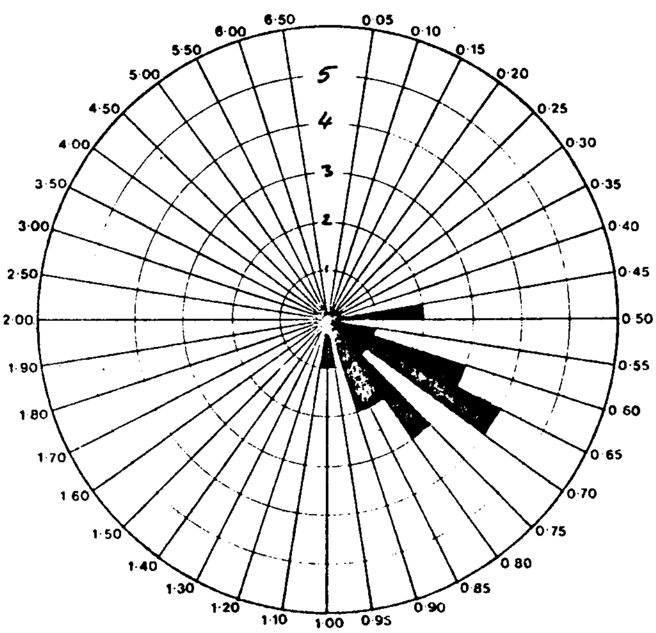
CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
66 83		

ORIGIN I.K.U.	SAMPLE Our Ref: J.M./J.M.J. Your Ref: 3350
LITHOLOGY Mixed Shale Lithologies	
MINERALOGY	GENERAL COMMENTS Seems Reliable
ORGANIC MATERIAL Low-Moderate Organic Content Small, Gnarled Particles and a Few Wisps. Some Inertinite + Reworked Vitrinite	
APPEARANCE IN U.V. Orange Fluorescence From Spores	**Geo-consultants Ltd** Ash House Bell Villas Ponteland Northumberland NE20 9BE
EXINITE CONTENT IN U.V. Trace	Signature [signature] Date 15th Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

0.85	0.56	0.76	0.67		
0.80	0.67	0.68	0.72		
0.85	0.76	0.62	0.81		
0.77	0.63	0.96	0.61		
0.45	0.65	0.49	1.06		

TOTAL No. OF PARTICLES MEASURED 20



	REFLECTIVITY (%)		No. OF PARTICLES
$\bar{R}$max.			
$\bar{R}$aver.	0.68		20

EQUIVALENT CHEMICAL PARAMETERS
DRY ASH FREE

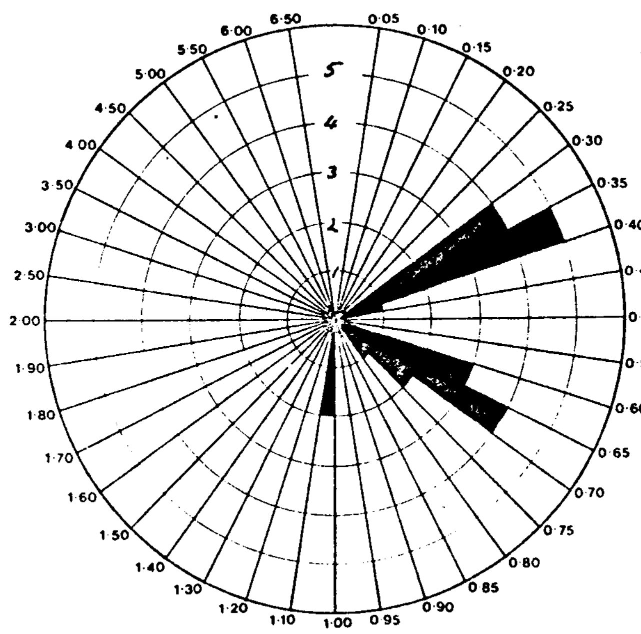
CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
78		

ORIGIN I.K.U.	SAMPLE Our Ref: A.S./P.W. Your Ref: 3450
LITHOLOGY Shale + Coal	
MINERALOGY	GENERAL COMMENTS
ORGANIC MATERIAL Low-Moderate Organic Content — Small Very Ragged Particles But With Inertinite Dominant. Coal (Low Ro.) — Vitrinitic with only Trace of Inertinite	
APPEARANCE IN U.V. Orange Fluorescence From Spore Fragments	Geo-consultants Ltd Ash House Bell Villas Ponteland Northumberland NE20 9BE
EXINITE CONTENT IN U.V. Low - Moderate	Signature [signature] Date 15th Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

0.68	0.67	0.37	1.07	0.68	
0.38	0.71	0.36	0.69	0.70	
0.33	0.31	0.42	0.62		
0.33	0.36	0.30	0.75		
0.63	0.39	1.04	0.61		

TOTAL No. OF PARTICLES MEASURED 22



	REFLECTIVITY (%)	No. OF PARTICLES
$\bar{R}$max.		
$\bar{R}$aver.	0.36	10 Coal
	0.67	10
	1.06	2

EQUIVALENT CHEMICAL PARAMETERS DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
66 78 85		

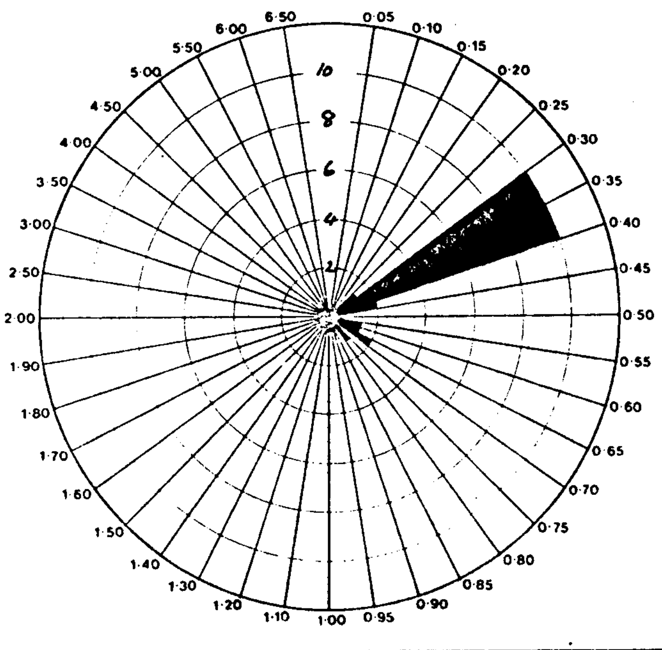
ORIGIN I. K. U.	**SAMPLE** Our Ref: J.M./P.W. Your Ref: 3550	
LITHOLOGY Shale, Coal + Carbargillite		
MINERALOGY	**GENERAL COMMENTS** Coal Appears Too Plentiful To Be Cavings	
ORGANIC MATERIAL Coal – Plentiful, Low Reflectance, Largely Vitrinite with Telinite Structure. Shale – Low Organic Content – Small Particles of Inertinite + Reworked Vitrinite.		
APPEARANCE IN U.V. Good Yellow Fluorescence From Spores + Resin in Coal. Orange Spores in Shale		
EXINITE CONTENT IN U.V. Low-Moderate	Signature [signature] Geo-consultants Ltd, Ash House, Bell Villas, Ponteland, Northumberland, NE20 9BE. Date 1st Dec. 1976	

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

0·38	0·30	0·32	0·34	0·39	0·42
0·39	0·33	0·32	0·33	0·38	0·69
0·39	0·35	0·77	0·35	0·59	0·62
0·30	0·38	0·30	0·34	0·36	
0·27	0·38	0·68	0·33	0·42	

TOTAL No. OF PARTICLES MEASURED 28

	REFLECTIVITY (%)	No. OF PARTICLES
R̄max.		
R̄aver.	0·35	23 Coal
	0·67	5



EQUIVALENT CHEMICAL PARAMETERS DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
65 78		

ORIGIN I.K.U.	SAMPLE Our Ref: J.M. / J.M.J. Your Ref: 3600

LITHOLOGY Mixed Shale Lithologies

MINERALOGY

ORGANIC MATERIAL
Low Organic Content. Particles and A Few Wisps Rather Corroded. Most Wisps Too Small for Determination. Inertinite + Reworked Material Dominant.

APPEARANCE IN U.V.
Orange Fluorescence from A Few Spores

EXINITE CONTENT IN U.V. Trace

GENERAL COMMENTS

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Bell Villas
Ponteland
Northumberland
NE20 9BE

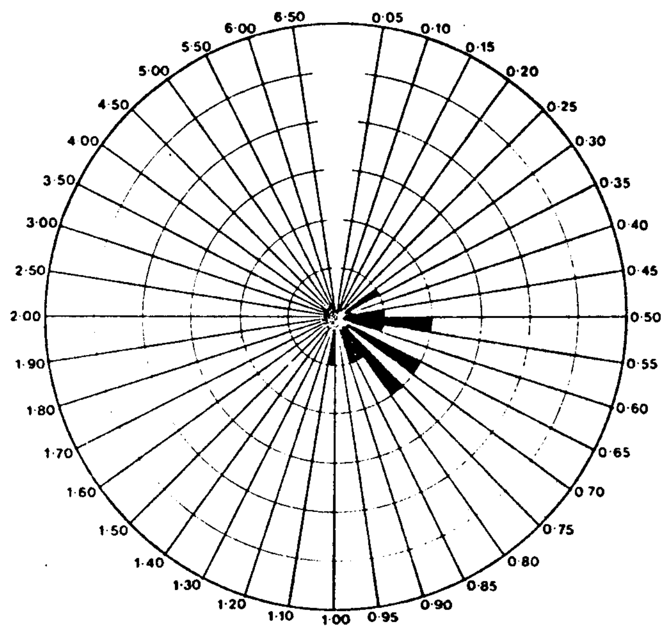
Signature [signature]
Date 15th Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm	1.516

0.75	0.46	0.85			
0.51	0.69	0.67			
0.34	0.77				
1.00	0.82				
0.59	0.52				

TOTAL No. OF PARTICLES MEASURED 12

	REFLECTIVITY (%)	No. OF PARTICLES
$\bar{R}$max.		
$\bar{R}$aver.	0.34	1
	0.61	11



EQUIVALENT CHEMICAL PARAMETERS
DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
64 77		

ORIGIN	I.K.U.	SAMPLE	Our Ref: A.S/J.M.J. Your Ref: 3650
LITHOLOGY	MIXED SHALE LITHOLOGIES		

MINERALOGY

ORGANIC MATERIAL
LOW ORGANIC CONTENT. SCATTERED PARTICLES OF VITRINITE + INERTINITE. RATHER CORRODED WITH A LOT OF REWORKING

APPEARANCE IN U.V.
ORANGE FLUORESCENCE FROM SPORES

EXINITE CONTENT IN U.V. LOW

GENERAL COMMENTS
READINGS PROBABLY ON REWORKED VITRINITE. LITHOLOGY LOOKS LOWER RANK THAN 1% AND SPORE FLUORESCENCE ALSO INDICATES LOW RANK.

Geo-consultants Ltd
Ash House
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Ponteland
Northumberland
NE20 9BE

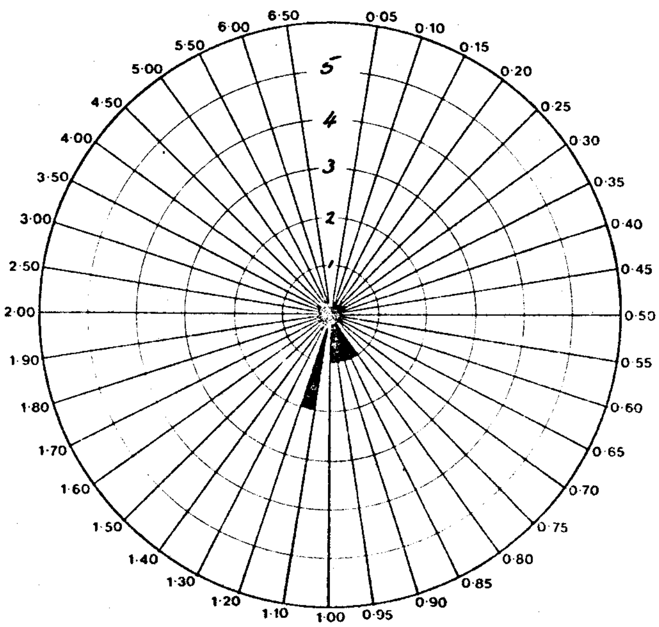
Signature [signature]   Date 15th Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546 nm.	1.516

1.16	0.89				
1.11					
0.96					
0.83					
0.91					

TOTAL No. OF PARTICLES MEASURED 6

	REFLECTIVITY (%)	No. OF PARTICLES
$\bar{R}$max.		
$\bar{R}$aver.	0.98	6



EQUIVALENT CHEMICAL PARAMETERS
DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
84		

ORIGIN	SAMPLE
I.K.U.	Our Ref: A.S./J.M.J. Your Ref: 3700

LITHOLOGY Shale + Coal

MINERALOGY

ORGANIC MATERIAL
Shale - Low Organic Content. A Few Particles + Wisps, Small + Corroded.
Coal - Only A Few Cuttings - Vitrinitic with Little Inertinite

APPEARANCE IN U.V. Overall Carbonate Fluorescence + Orange Spores

EXINITE CONTENT IN U.V. Trace

GENERAL COMMENTS

Geo-consultants Ltd
Ash House
Bell Villas
Ponteland
Northumberland
NE20 9BE

Signature [signature] Date 15th Dec 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

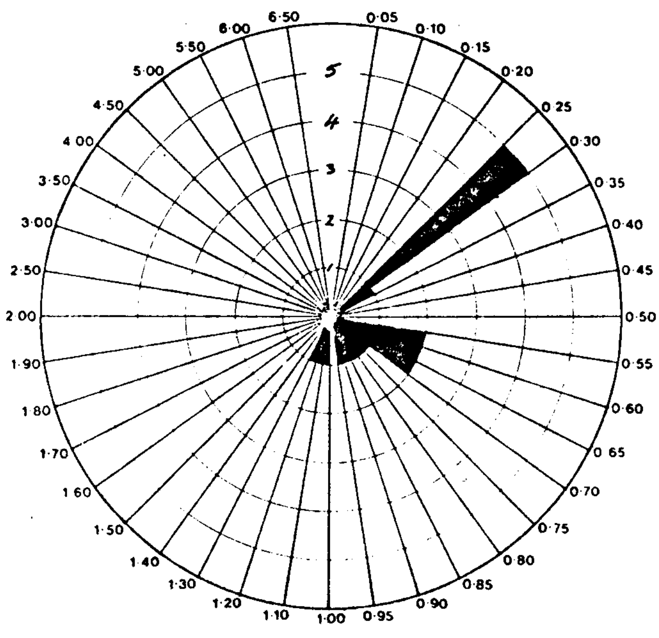
1.12	0.68	0.29	0.30		
1.22	0.56	0.59	0.28		
1.02	0.87	0.71	0.28		
0.79	0.63	0.29	0.80		
0.91	0.63	0.25	0.69		

TOTAL No. OF PARTICLES MEASURED 20

REFLECTIVITY (%)		No. OF PARTICLES
$\bar{R}$max.		
$\bar{R}$aver.	0.28	6 Coal
	0.80	14

EQUIVALENT CHEMICAL PARAMETERS
DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
61 81		



ORIGIN I.K.U.

SAMPLE Our Ref: A.S. / J.M.J.
Your Ref: 3750

LITHOLOGY Mixed Shale + Limestone

MINERALOGY

ORGANIC MATERIAL
Low – Moderate Organic Content.
Two Coal Cuttings Giving Low Reflectance Values
Shale – Rather Charred Small Particles + Wisps with a High Proportion of Inertinite + Reworking. Limestone Barren

APPEARANCE IN U.V. Orange Fluorescence From Spores. Some Hydrocarbons Present - Soluble in Immersion Oil

EXINITE CONTENT IN U.V. Low

GENERAL COMMENTS

Geo-consultants Ltd
Ash House
Bell Villas
Ponteland
Northumberland
NE20 9BE

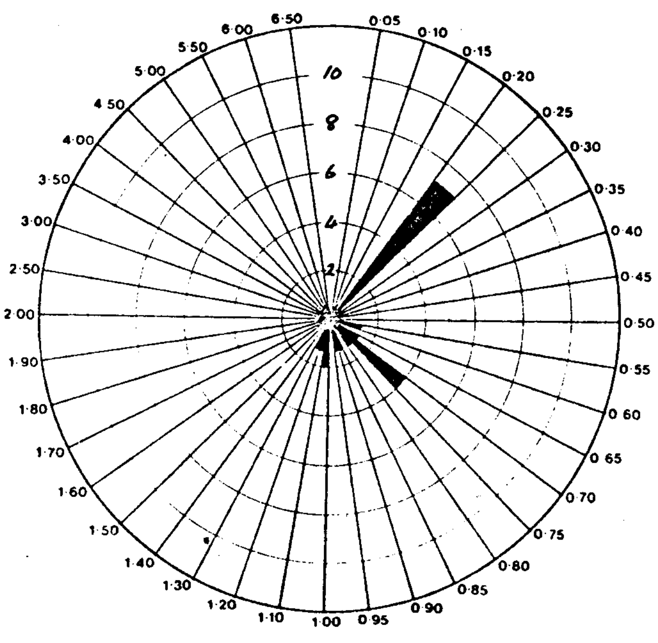
Signature [signature] Date 15th Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

0.70	0.85	1.12	0.24		
0.73	0.67	1.21	0.22		
0.58	0.72	1.04	0.21		
0.71	0.93	0.22	0.20		
0.78	1.07	0.23	0.23		

TOTAL No. OF PARTICLES MEASURED 20

	REFLECTIVITY (%)	No. OF PARTICLES
$\bar{R}$max.		
$\bar{R}$aver.	0.22	7 Coal
	0.85	13



EQUIVALENT CHEMICAL PARAMETERS
DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
58 82		

ORIGIN *I.K.U.*	SAMPLE Our Ref: *A.S./P.W.* Your Ref: *3800*

LITHOLOGY *Limestone, Shale, Cement + Coal*

MINERALOGY
Rather Pyrite Rich

GENERAL COMMENTS

ORGANIC MATERIAL
Limestone - Virtually Barren
Coal - Low Ro., Wholly Vitrinite
Shale - Low Organic Content - Small Charred Particles Probably Wholly Reworked. One Good Particle (Ro. 0.55) Located

APPEARANCE IN U.V. *Strong Carbonate Fluorescence. Nothing Organic*

EXINITE CONTENT IN U.V. *Nil*

Geo-consultants Ltd
Ash House
Bell Villas
Ponteland
Northumberland
NE20 9BE

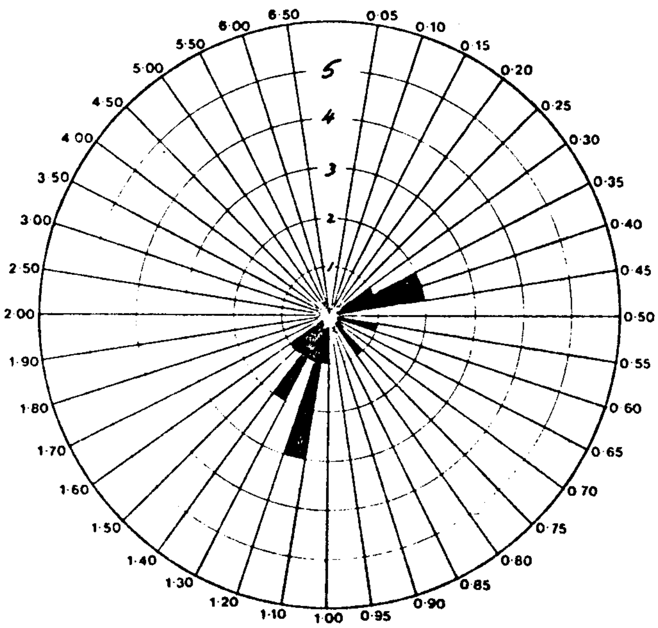
Signature [signature] Date *15th Dec. 1975*

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	*546nm.*	*1.516*

1.07	1.23	0.76	Coal 0.36		
0.55	1.17		0.34		
1.30	1.15		0.38		
1.17	1.45		0.41		
1.52	1.39		0.42		

TOTAL No. OF PARTICLES MEASURED *16*

REFLECTIVITY (%)		No. OF PARTICLES
R̄max.		
R̄aver.	0.38	5 Coal
	0.66	2
	1.27	9



EQUIVALENT CHEMICAL PARAMETERS
DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
68 78 87		

ORIGIN	I.K.U.	SAMPLE	Our Ref: J.M./J.M.J. Your Ref: 3918.5 Core

LITHOLOGY Light Shale

MINERALOGY

ORGANIC MATERIAL
Moderate Organic Content. Small Gnarled Particles of Vitrinite + Inertinite. Possibly Wholly Reworked. No low Reflectance Material

APPEARANCE IN U.V. Deep Orange Fluorescence From Spores

EXINITE CONTENT IN U.V. Trace

GENERAL COMMENTS

Geo-consultants Ltd
Ash House
Bell Villas
Ponteland
Northumberland
NE20 9BE

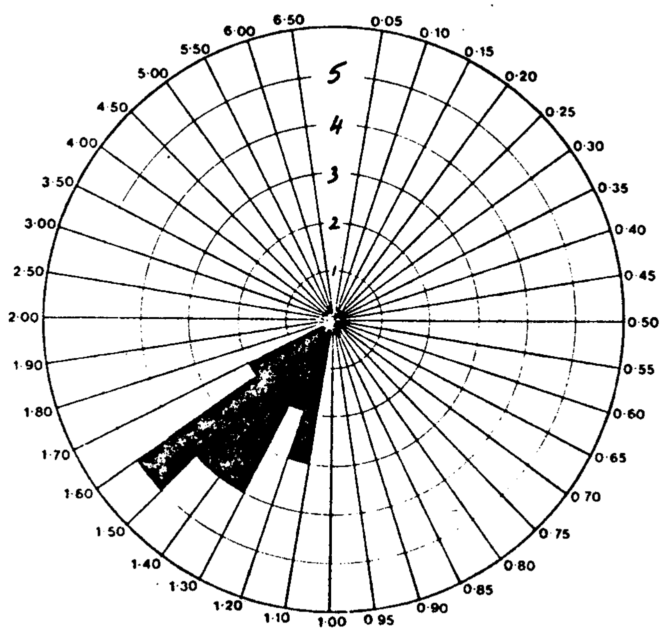
Signature [signature]
Date 15th Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546 nm.	1.516

1.28	1.37	1.41	1.19		
1.51	1.39	1.19	1.52		
1.16	1.56	1.29	1.67		
1.49	1.35	1.56	1.49		
1.52	1.31	1.42	1.64		

TOTAL No. OF PARTICLES MEASURED 20

REFLECTIVITY (%)		No. OF PARTICLES
$\bar{R}_{max.}$		
$\bar{R}_{aver.}$	1.42	20



EQUIVALENT CHEMICAL PARAMETERS
DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
88		

ORIGIN	I.K.U.
SAMPLE	Our Ref: J.M. / J.M.J. Your Ref: 3924
LITHOLOGY	Shale
	Core
MINERALOGY	
GENERAL COMMENTS	
ORGANIC MATERIAL	Moderate Organic Content. Gnarled, Rounded Particles of Reworked Vitrinite + Inertinite. Possibly No True Material
APPEARANCE IN U.V.	Orange / Red Fluorescence From Spore Specks
EXINITE CONTENT IN U.V.	Trace

Geo-consultants Ltd
Ash House
Bell Villas
Ponteland
Northumberland
NE20 9BE

Signature [signature]

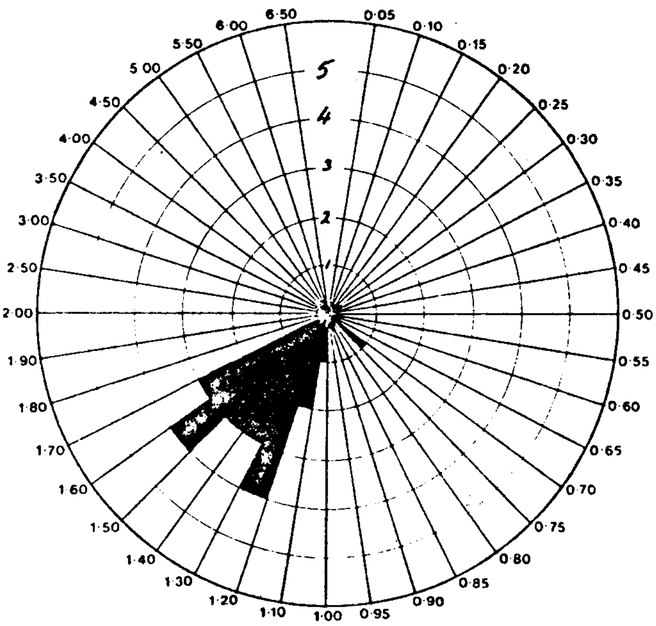
Date 15th Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

1.56	1.29	1.14	1.51	0.71	
1.27	1.22	1.56	1.31		
1.05	1.23	1.66	1.41		
1.62	1.33	1.14	1.35		
1.42	1.54	1.40	1.64		

TOTAL No. OF PARTICLES MEASURED 21

REFLECTIVITY (%)		No. OF PARTICLES
$\bar{R}$max.		
$\bar{R}$aver.	0.71	1
	1.38	20



EQUIVALENT CHEMICAL PARAMETERS
DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
79		

ORIGIN I.K.U.	SAMPLE Our Ref: A.S./J.M.J. Your Ref: 3940

LITHOLOGY Siliceous Shale + Coal

MINERALOGY

GENERAL COMMENTS

All Readings on Coal Save For The Single High Value - May Be True if Coal is Caved.

ORGANIC MATERIAL

Shale - Barren

Coal - Good Vitrinitic But With A Low Proportion of Inertinite

APPEARANCE IN U.V. Yellow / Orange Fluorescence From Spores

EXINITE CONTENT IN U.V. Low - Moderate

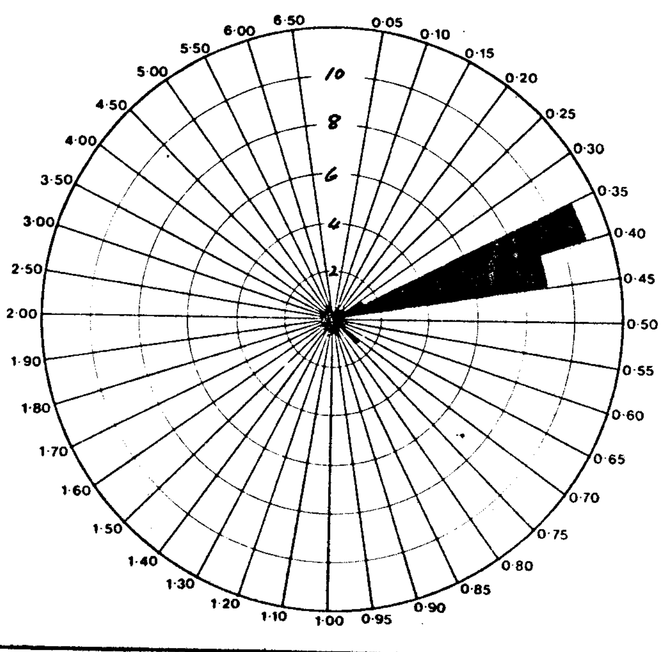
Geo-consultants Ltd
Ash House
Bell Villas
Ponteland
Northumberland
NE20 9BE

Signature [signature] Date 15th Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

0.42	0.37	0.35	0.39	0.36	
0.41	0.74	0.38	0.37	0.37	
0.40	0.42	0.36	0.36		
0.36	0.40	0.40	0.38		
0.33	0.41	0.41	0.41		

TOTAL No. OF PARTICLES MEASURED 22



REFLECTIVITY (%)		No. OF PARTICLES
R̄max.		
R̄aver.	0.38	21 Coal
	0.74	1

EQUIVALENT CHEMICAL PARAMETERS DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
68 79		

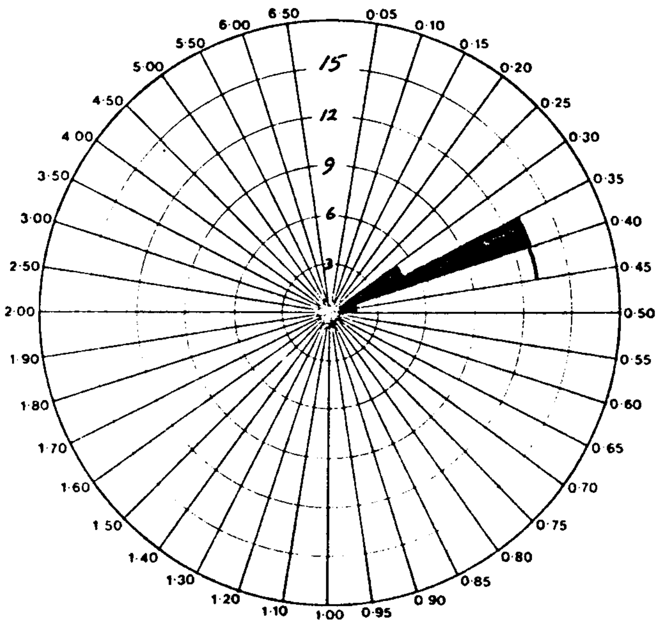
ORIGIN I.K.U.	SAMPLE Our Ref: J.M. / J.M.J. Your Ref: 3960
LITHOLOGY Siliceous Shale + Coal	
MINERALOGY Rather Pyritic	GENERAL COMMENTS
ORGANIC MATERIAL Shale - Barren; Coal - Vitrinitic with a small percentage of Inertinite	
APPEARANCE IN U.V. Orange Fluorescence from Spores	Geo-consultants Ltd, Ash House, Bell Villas, Ponteland, Northumberland, NE20 9BE
EXINITE CONTENT IN U.V. Trace	Signature [signature] Date 15th Dec 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

0·42	0·33	0·35	0·32		
0·41	0·36	0·37	0·34		
0·38	0·33	0·39	0·35		
0·36	0·35	0·39	0·37		
0·36	0·36	0·34	0·35		

TOTAL No. OF PARTICLES MEASURED 20

	REFLECTIVITY (%)	No. OF PARTICLES
$\bar{R}$max.		
$\bar{R}$aver.	0·36	20



EQUIVALENT CHEMICAL PARAMETERS DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
66		

ORIGIN	I.K.U.	SAMPLE	Our Ref: A.E / J.M.J. Your Ref: 3980
LITHOLOGY	Shale + Coal		

MINERALOGY

GENERAL COMMENTS

ORGANIC MATERIAL

Shale – 2 Lithologies – a) Silkeous – Barren, b) Soft Shale – Moderate Content of Particles of Vitrinite + Inertinite in About Equal Proportions.
Coal – Only A Few Cuttings – Vitrinitic

APPEARANCE IN U.V.

No Definite Fluorescence

EXINITE CONTENT IN U.V. Nil

Geo-consultants Ltd
Ash House
Bell Villas
Ponteland
Northumberland
NE20 9BE

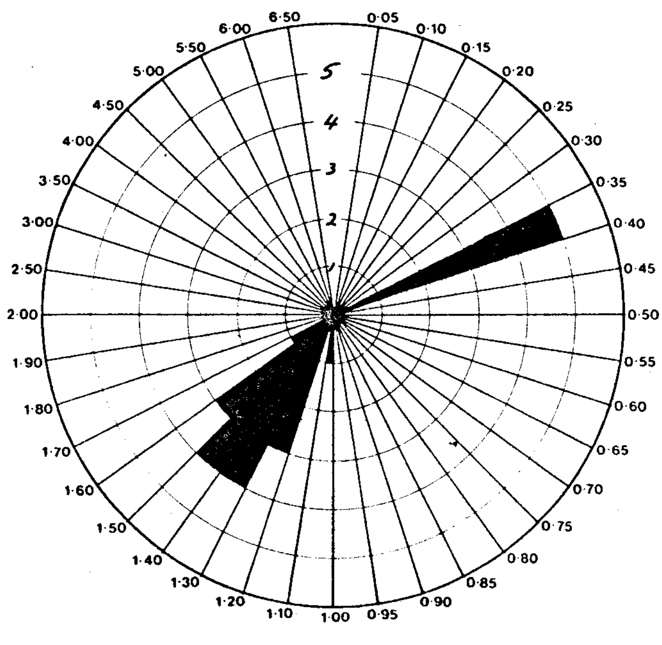
Signature

Date 15 Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546 nm.	1.516

1.41	1.38	1.44	1.32	0.35	
1.26	1.20	1.56	0.37		
1.62	1.51	1.36	0.39		
1.43	1.57	1.34	0.36		
1.47	1.06	1.25	0.36		

TOTAL No. OF PARTICLES MEASURED 21



	REFLECTIVITY (%)	No. OF PARTICLES
$\bar{R}$max.		
$\bar{R}$aver.	0.37	5
	1.39	16

EQUIVALENT CHEMICAL PARAMETERS DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
67		
88		

ORIGIN	I.K.U.	SAMPLE	Our Ref: J.M. / J.M.J. Your Ref: 4000
LITHOLOGY	Shale		

MINERALOGY

GENERAL COMMENTS

ORGANIC MATERIAL

Two Lithologies :-
a) Siliceous, Hard - Barren
b) Soft (2 Cuttings only) Moderate Content of Organic Particles - Reworked Vitrinite + Inertinite

APPEARANCE IN U.V.

No Fluorescence

EXINITE CONTENT IN U.V. Nil

Geo-consultants Ltd
Ash House
Bell Villas
Ponteland
Northumberland
NE20 9BE

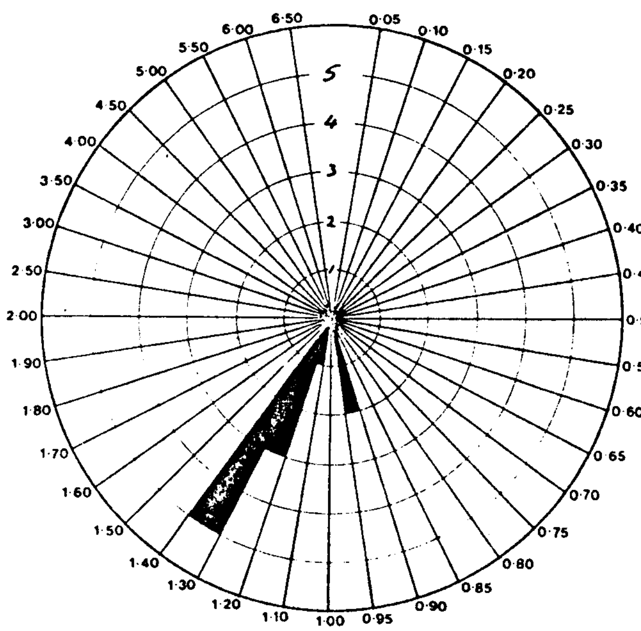
Signature [signature]
Date 15th Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

1.34	1.22	0.90			
1.35	1.21				
1.31	1.20				
1.35	1.18				
1.34	0.93				

TOTAL No. OF PARTICLES MEASURED 11

	REFLECTIVITY (%)	No. OF PARTICLES
$\bar{R}_{max.}$		
$\bar{R}_{aver.}$	1.21	11



EQUIVALENT CHEMICAL PARAMETERS
DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
87		

ORIGIN I.K.U.	SAMPLE Our Ref: A.S./J.M.J. Your Ref: 4020
LITHOLOGY Mixed Shale Lithologies	
MINERALOGY	GENERAL COMMENTS
ORGANIC MATERIAL Moderate Organic Content. Small, Gnarled Particles, Chiefly of Inertinite. Possibly All Reworked	
APPEARANCE IN U.V. No Fluorescence	
EXINITE CONTENT IN U.V. Nil	Signature Date 15th Dec. 1976

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Ash House
Bell Villas
Ponteland
Northumberland
NE20 9BE

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546nm.	1.516

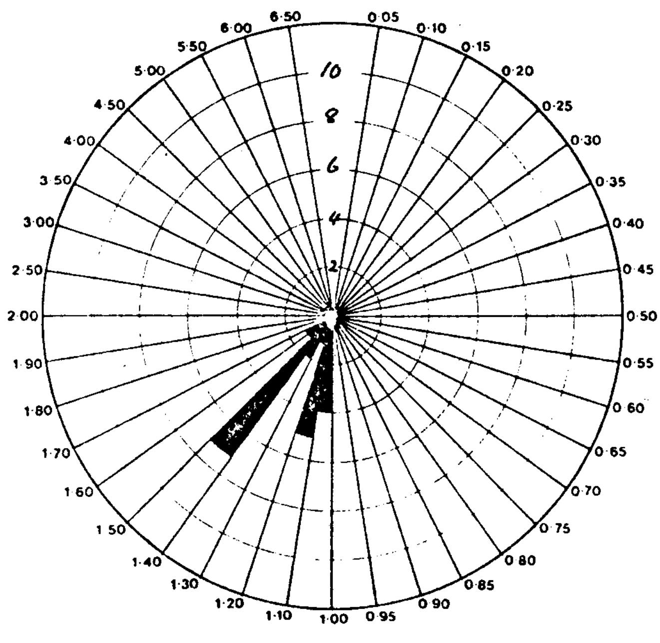
1.06	1.39	1.04	1.46	1.60	
1.15	1.41	1.24	1.16		
1.13	1.09	1.04	1.48		
1.47	1.47	1.47	1.14		
1.56	1.18	1.45	1.35		

TOTAL No. OF PARTICLES MEASURED 21

REFLECTIVITY (%)		No. OF PARTICLES
$\bar{R}$max.		
$\bar{R}$aver.	1.30	21

EQUIVALENT CHEMICAL PARAMETERS DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
87		



ORIGIN	I.K.U.	SAMPLE	Our Ref: A.S. / J.M.J.
			Your Ref: 4040

LITHOLOGY Mixed Shale Lithologies + Carbonate

MINERALOGY
Rather Pyritic

ORGANIC MATERIAL
Low Organic Content. Most Cuttings Barren. A Few Contain A Moderate Content of Inertinite Particles. Rather Corroded and Possibly Reworked

APPEARANCE IN U.V. Orange Fluorescence From Algae in One Cutting. Rest Barren

EXINITE CONTENT IN U.V. Trace

GENERAL COMMENTS

Geo-consultants Ltd
Ash House
Bell Villas
Ponteland
Northumberland
NE20 9BE

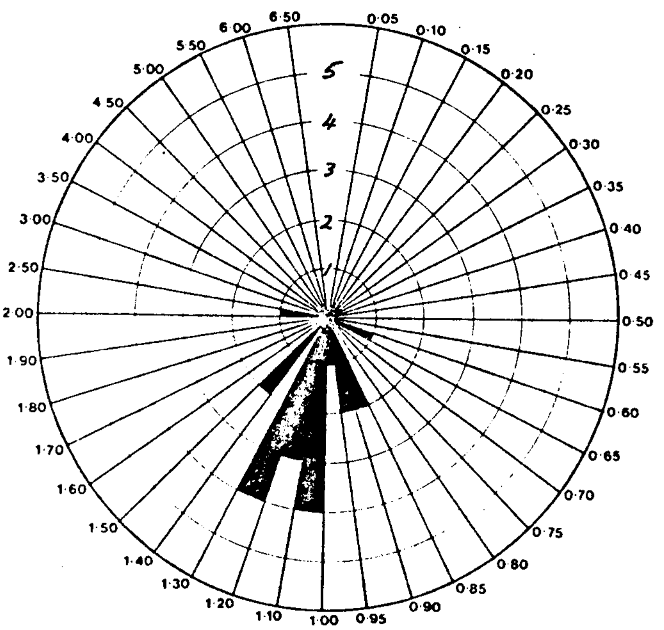
Signature [signature] Date 15th Dec. 1976

PREPARATION	WAVELENGTH	R.I. OF IMMERSION OIL
Isopropyl Alcohol	546 nm.	1.516

1.29	1.05	1.46	0.86	0.85	
1.01	1.20	1.16	0.94		
1.08	1.05	1.12	0.64		
1.26	1.42	1.07	0.96		
1.18	1.20	2.03	0.90		

TOTAL No. OF PARTICLES MEASURED 21

	REFLECTIVITY (%)	No. OF PARTICLES
$\bar{R}$max.		
$\bar{R}$aver.	0.64	1
	1.11	19
	2.03	1



EQUIVALENT CHEMICAL PARAMETERS DRY ASH FREE

CARBON (%)	VOLATILE MATTER YIELD (%)	CARBON RATIO
77 86 91		

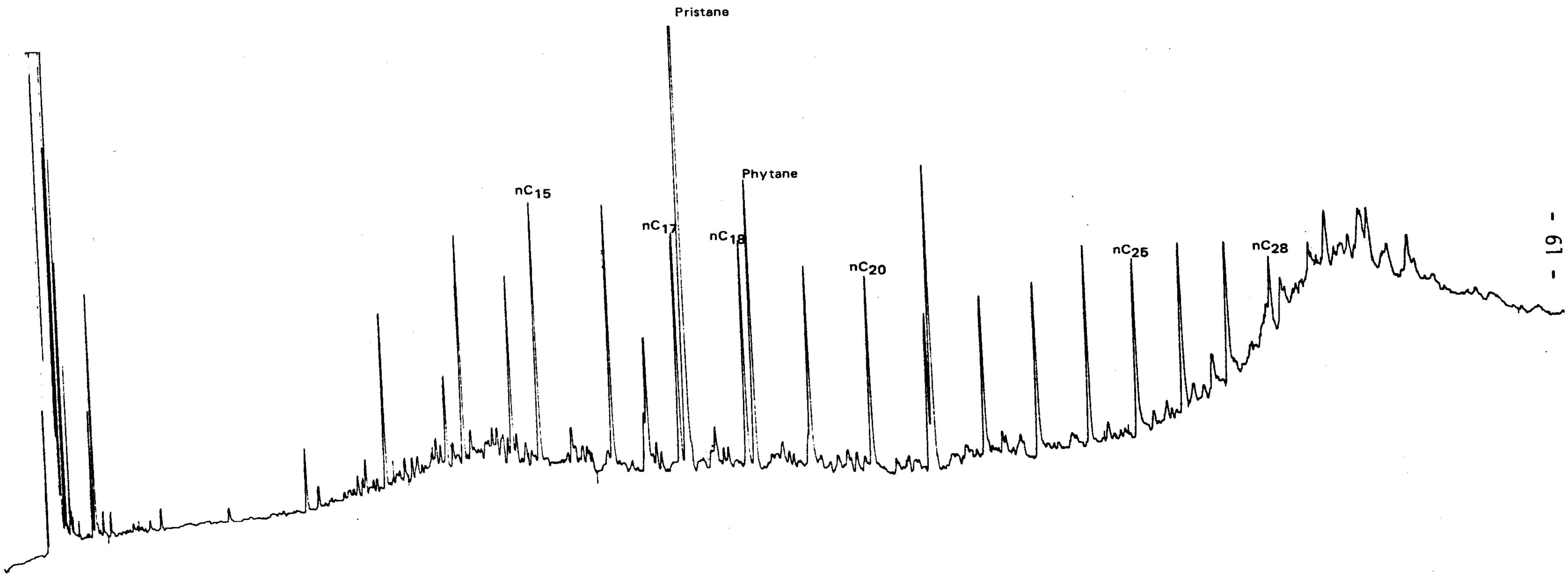


Fig. 6.

Capillary GC chromatogram of the saturate fraction at 2170 m.

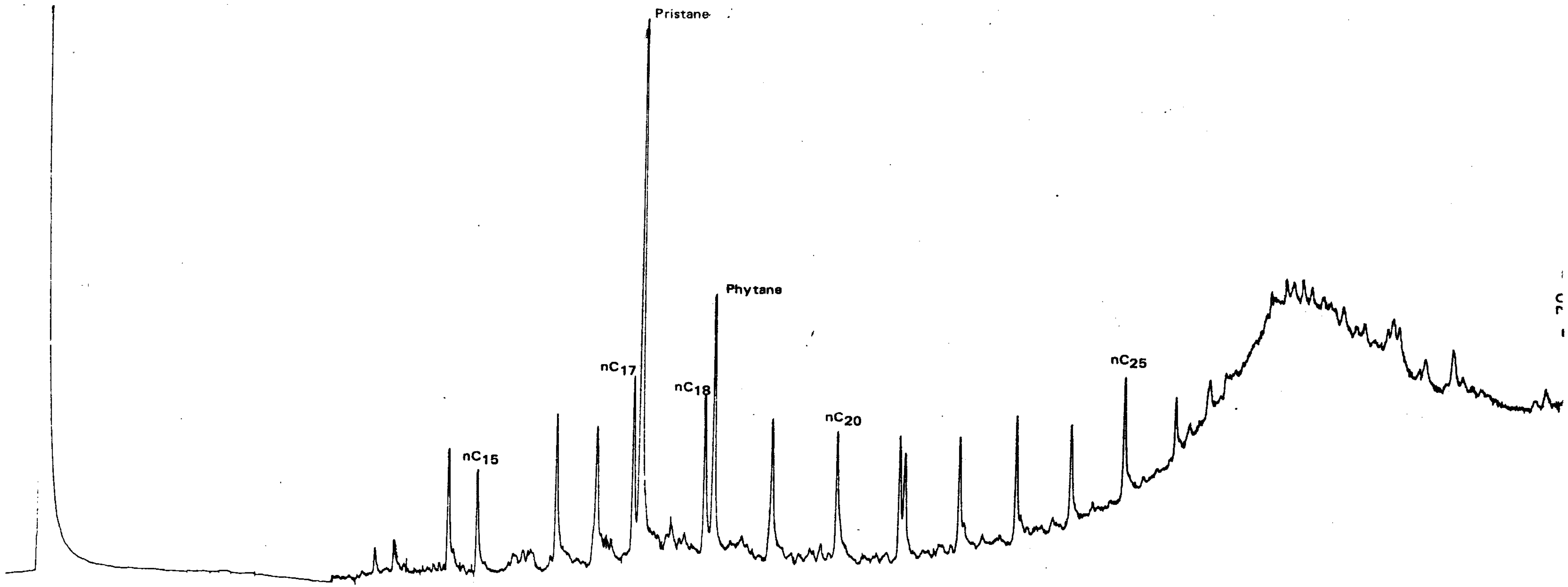


Fig. 7.

Capillary GC chromatogram of the saturate fraction at 2420 m.

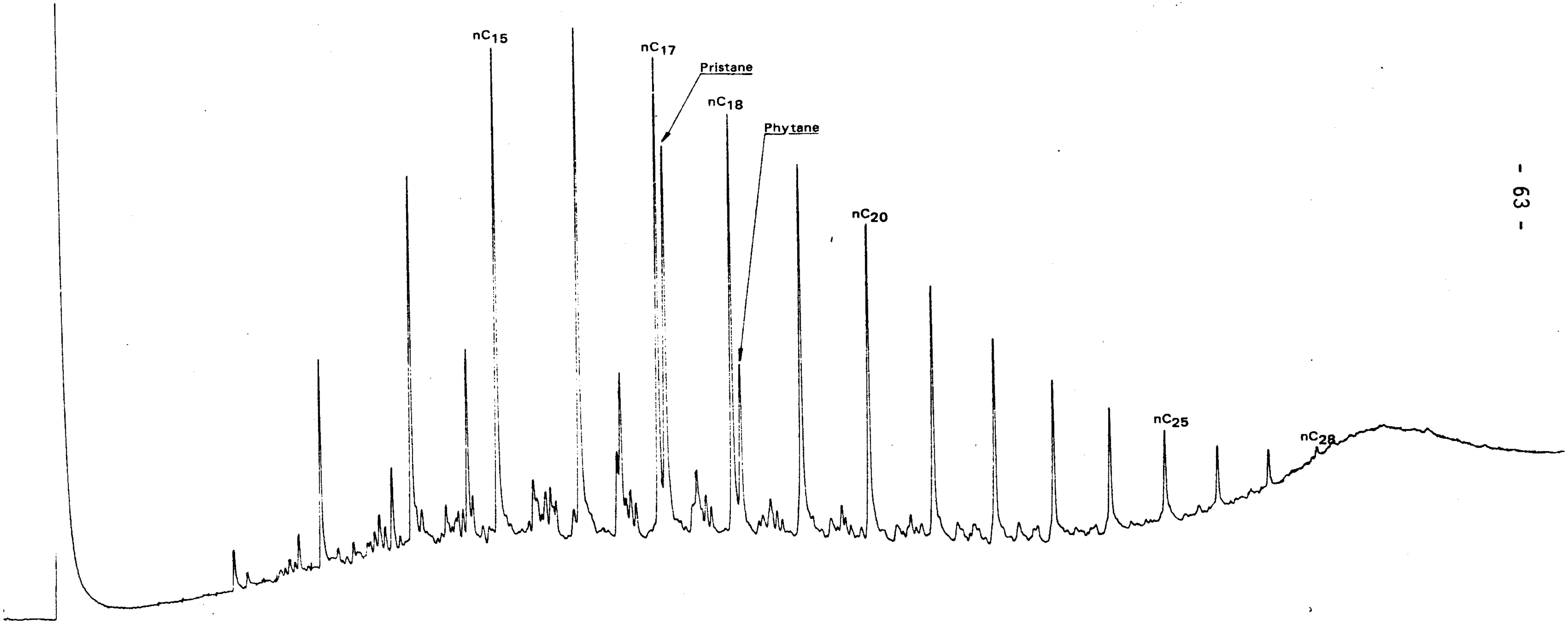


Fig. 8.

Capillary GC chromatogram of the saturate fraction at 2900 m.

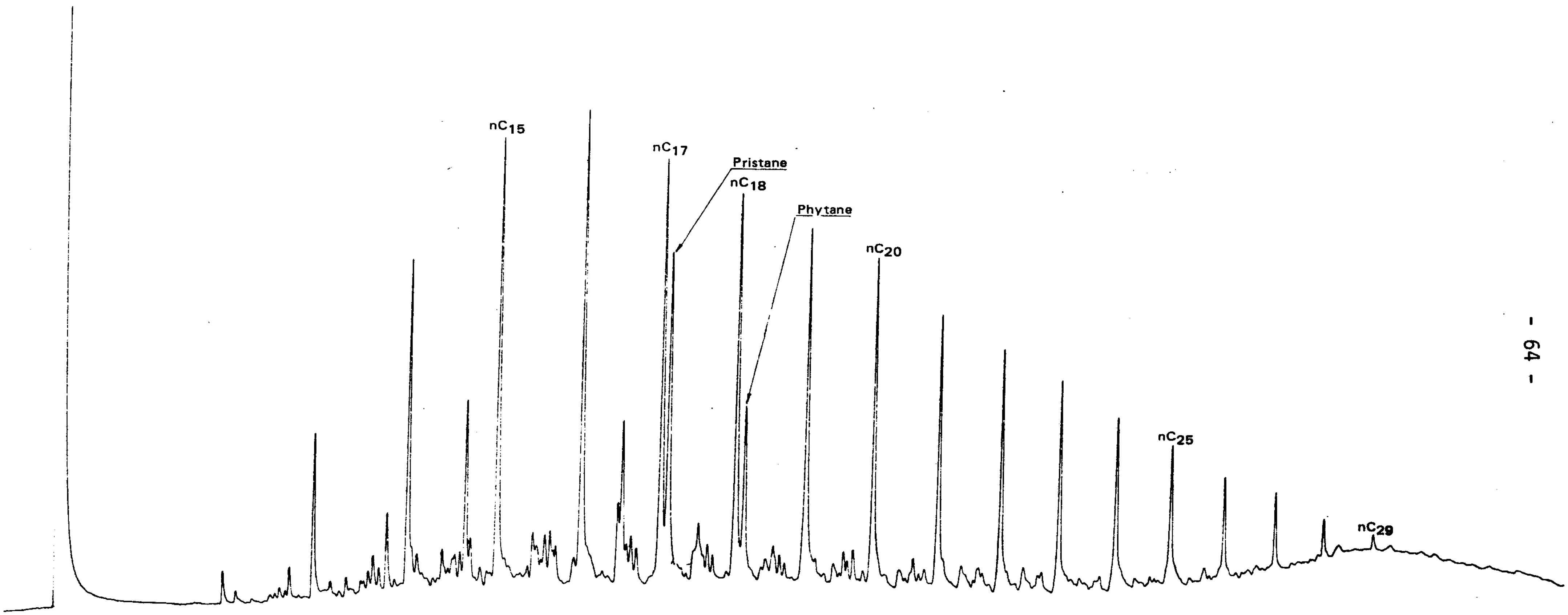


Fig. 9.

Capillary GC chromatogram of the saturate fraction at 3050 m.

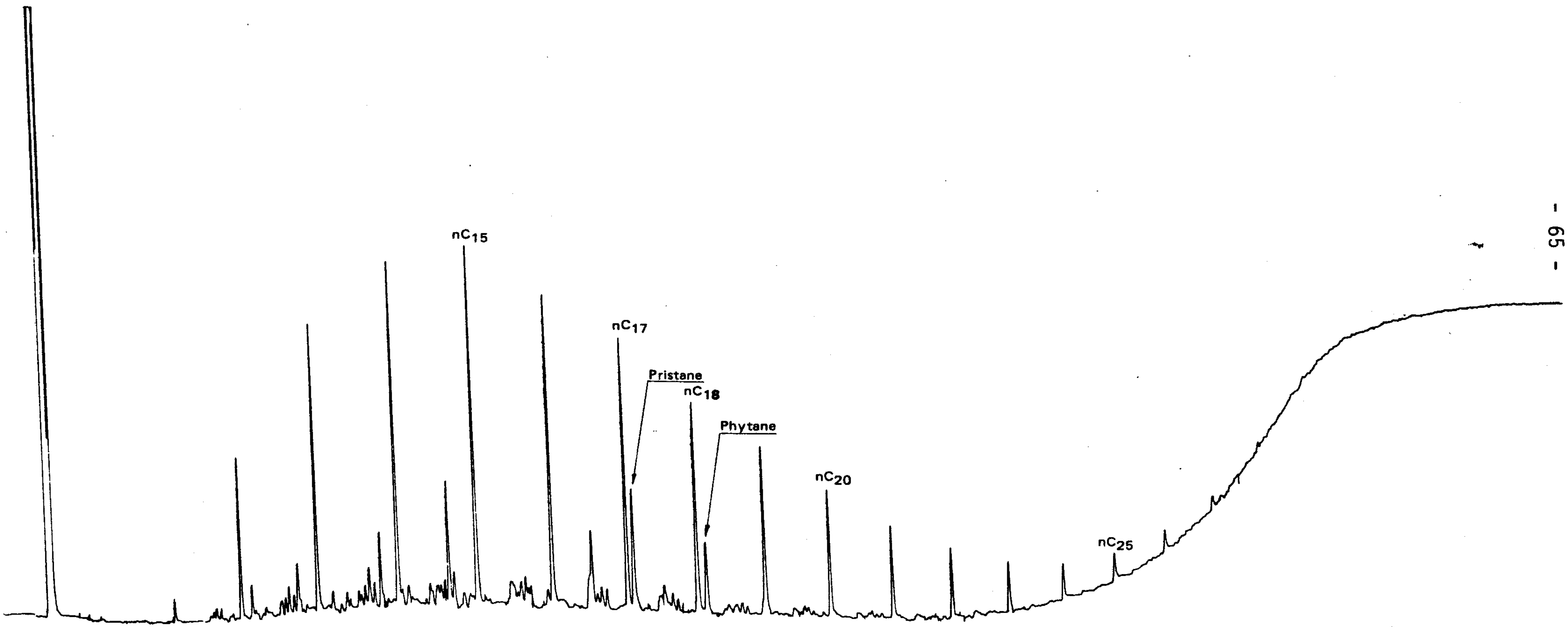


Fig. 10
Capillary GC chromatogram of the saturate fraction at 3350 m.

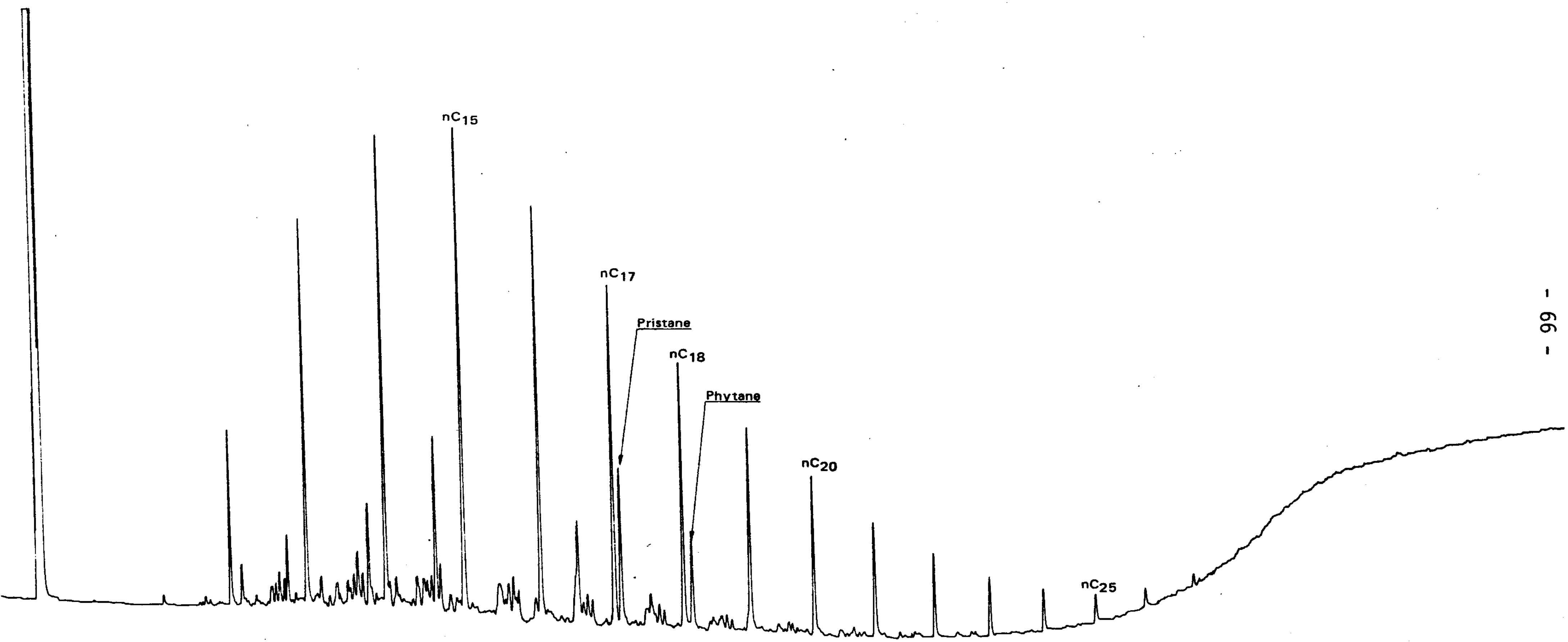


Fig. 11.

Capillary GC chomatogram of the saturate fraction at 3600 m.

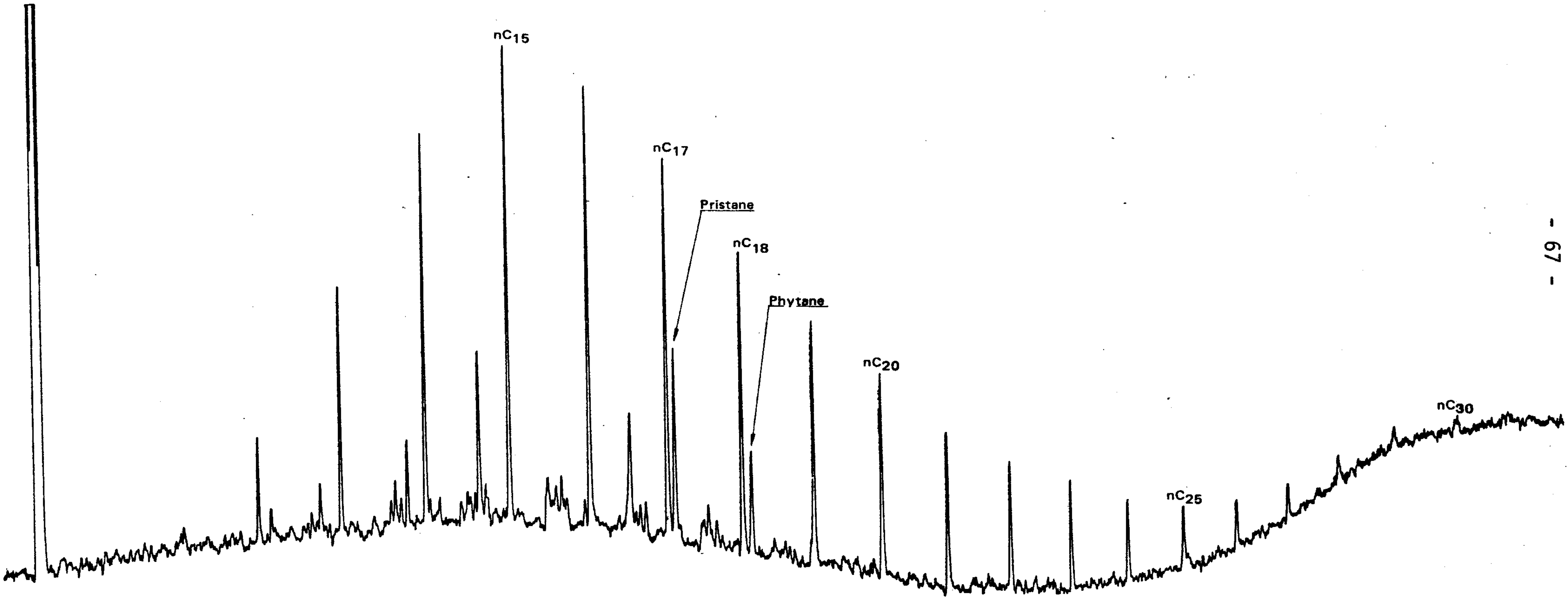


Fig. 12.

Capillary GC chromatogram of the saturate fraction at 3810 m.

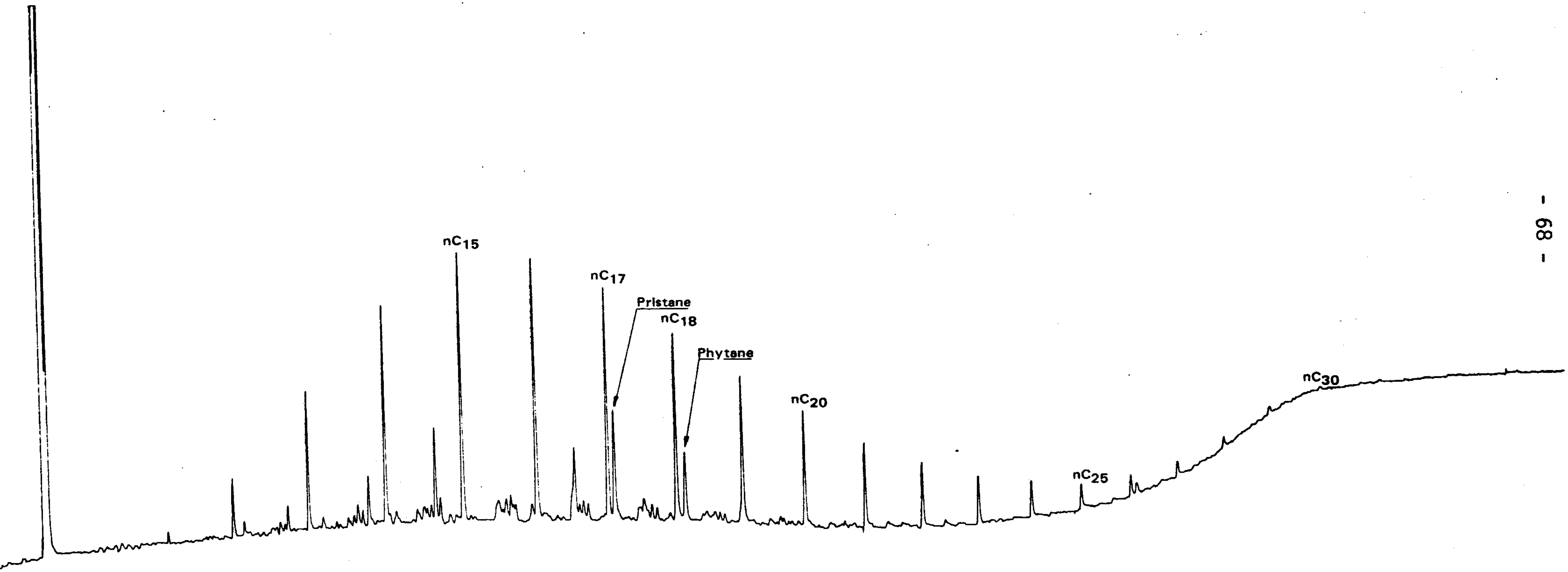


Fig. 13.

Capillary GC chromatogram of the saturate fraction at 3890 m.

Fig. 14.

Capillary GC chromatogram of the saturate fraction at 4010 m.

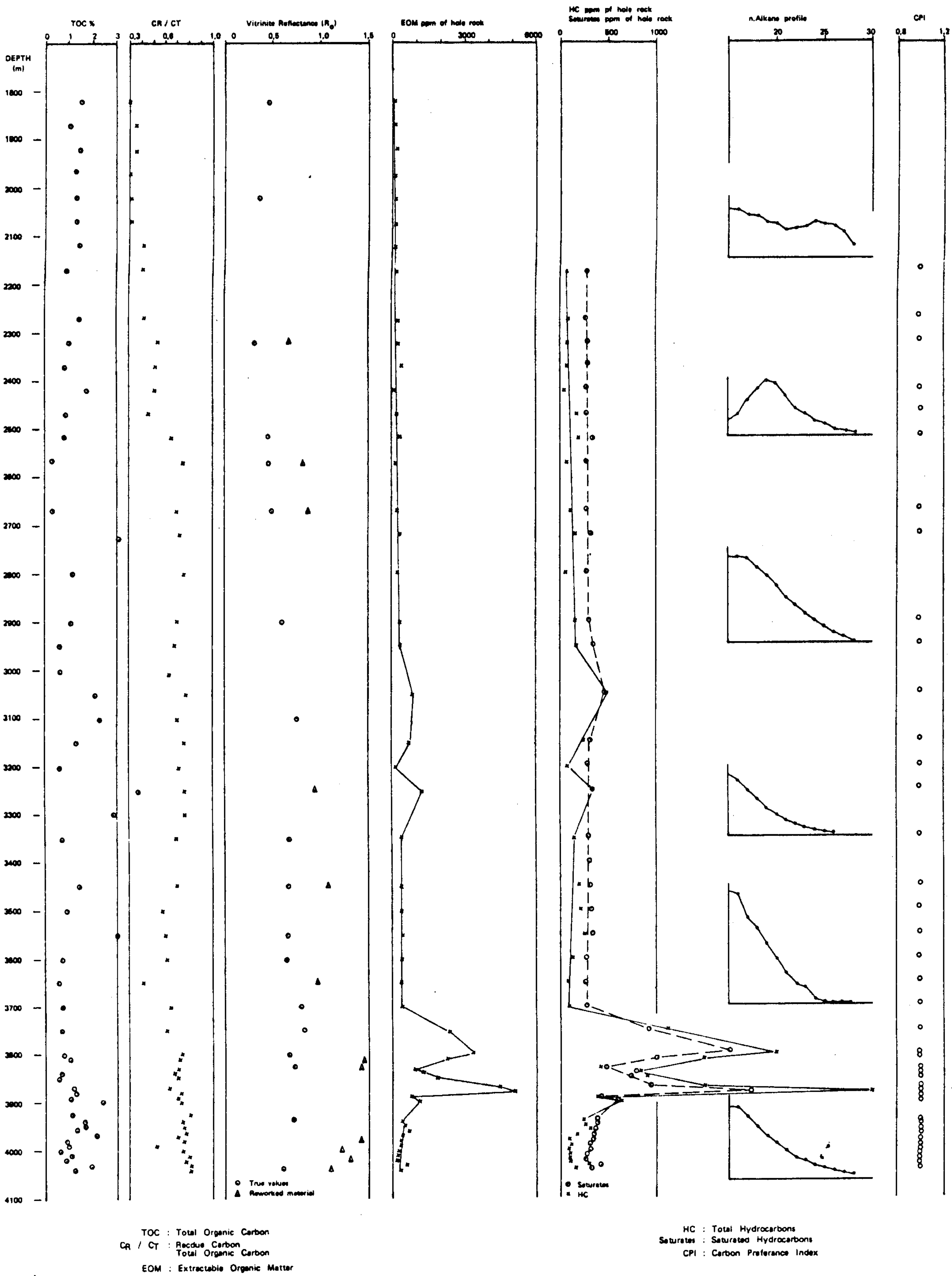
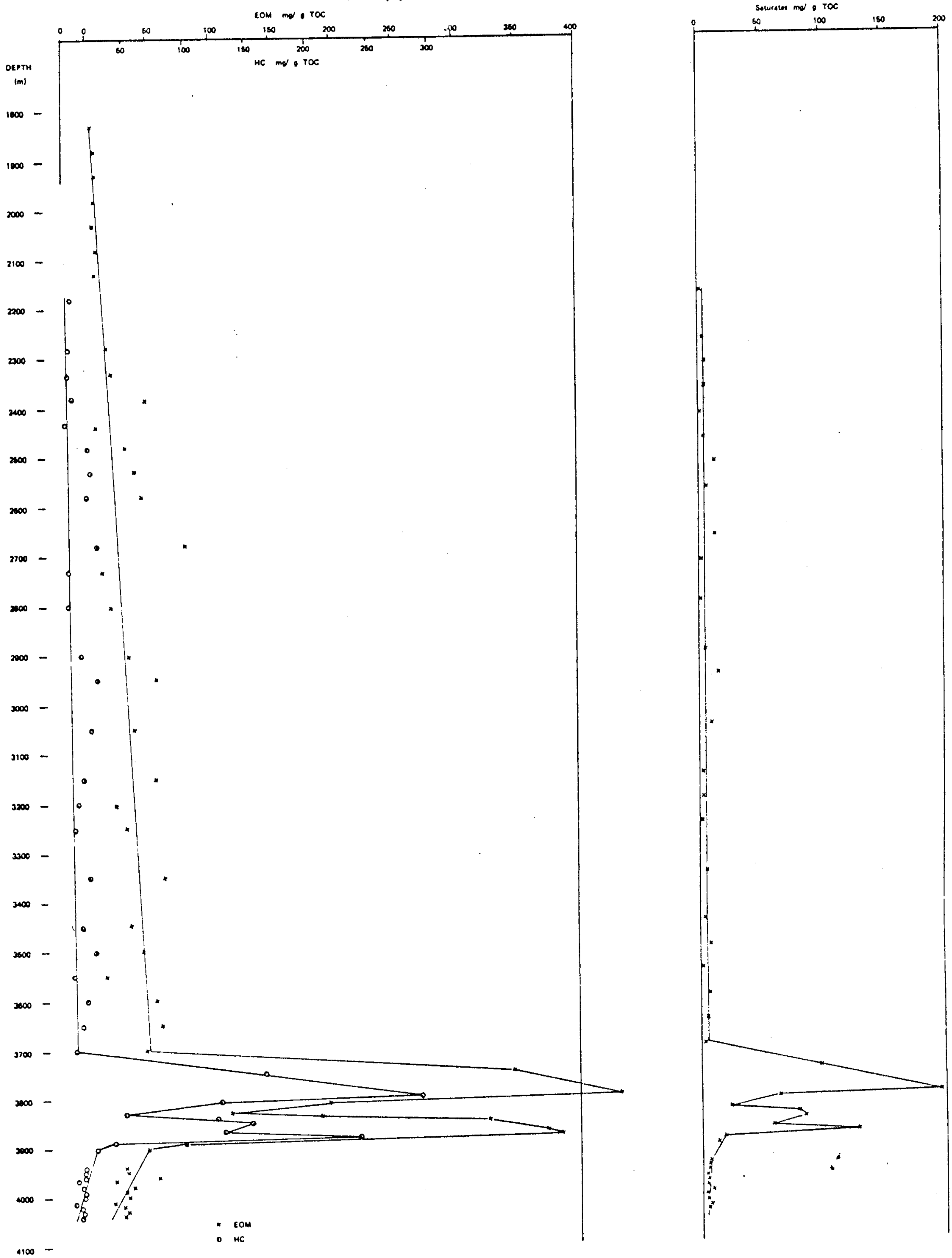


Fig. 15

Variation of TOC, C_R/C_T, vitrinite reflectance, EOM (ppm) hydrocarbons (ppm), n-alkane distribution and CPI with depth.



TOC : Total Organic Carbon
EOM : Extractable Organic Matter
HC : Total Hydrocarbons
Saturates : Saturated Hydrocarbons

Fig. 16
Variation of EOM (mg/g TOC), hydrocarbons (mg/g TOC) and Saturates (mg/g TOC) with depth.

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