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GeoChem Laboratories (U.K.) Limited

GEOCHEMICAL SERVICE REPORT

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Prepared for

SAGA PETROLEUM A.S.

GEOCHEMICAL EVALUATION OF SAGA'S 6507/11-1 WELL

HALTEN BANK, OFFSHORE NORWAY

May 1982

CHESTER STREET · CHESTER CH4 8RD · ENGLAND

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GEOCHEMICAL EVALUATION OF SAGA'S 6507/11-1 WELL
HALTEN BANK, OFFSHORE NORWAY

SUMMARY

The section between 1000 metres and 3139 metres (T.D.) has been evaluated.

Apart from scattered fair and good interbeds at 1540-1710± metres the shales and mudstones above 2510± metres have a poor hydrocarbon potential, chiefly for gas.

Silty shales and coals occurring at 2680-2730± metres in a sequence of sandstones and shales are, per unit volume, a rich but immature gas/condensate source.

The abundant coals and dark grey shales between 2730± metres and 3139 metres have an excellent potential for gas and associated condensate or light oil. They are immature on-structure although hydrocarbon generation will have commenced in their down dip lateral equivalents, if they occur below 3600± metres.

Good shows of condensate were detected at 2120-2510± metres and further shows of wet gas/condensate are present down to 2730± metres. The strong shows of relatively dry gas occurring below 2730± metres are partly indigenous and partly due to a diffusion of gases into the section.

Off structure lateral equivalents of the richer sediments at 2680-3139± metres are, if mature, a possible source of the hydrocarbon shows.

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INTRODUCTION

This report presents a geochemical evaluation of the section between 1000 metres and 3139 metres in the Saga 6507/11-1 well, drilled in the Halten Bank Concessions, offshore Norway.

The analytical format employed in this report, specified by Saga, was designed to investigate the hydrocarbon source potential of the section and to detect shows of migrated hydrocarbons.

This project was authorised by T.O. Throndsen, Saga Petroleum A.S., Hovik, Oslo.

A. ANALYTICAL

Pressurised condensate samples at 2401 metres and 2526 metres plus a total of one hundred and twenty five (125) canned cuttings samples were received from the 1000-3139 metre interval in 6507/11-1. They were composited over intervals of thirty (30) metres down to 1500 metres and over fifteen (15) metres below this depth. The samples were assigned the Geochem job number 616.

The samples were clean down to 2750 metres but below this depth they were contaminated with grease.

Geochem were requested (contract 18th December 1981) to screen the samples at intervals of 30 metres using the light hydrocarbon, organic carbon and mini pyrolysis analyses. The screen results were submitted to Mr. T.O. Throndsen who selected samples for subsequent analyses. Saga also supplied vitrinite reflectance data.

Geochem were also required to undertake specified tests, (including API gravity and GOR) on the produced fluids. On inspection, however, the containers were found to be at atmospheric pressure. Loss of hydrocarbons due to damaged valve seatings is suspected (metal swarf and thread tape was visible in the valves). The number of analyses performed upon the condensate samples was, therefore, limited to two C_4-C_{20} chromatograms (free of charge) two detailed gasoline range analyses, two chromatographic separations, two paraffin-naphthene hydrocarbon analyses, two branched/cyclic hydrocarbon analyses, two aromatic hydrocarbon analyses, two mass fragmentograms (m/e 239 and 253 were not measureable) four C_{15+} carbon isotope determinations and two methane carbon isotope ratio determinations.

Follow-up analyses on the cuttings samples, with the exception of the C_4-C_7 analyses, were performed in accordance with the telex of 16th April 1982. Ten of the twelve specified gasoline range analyses (dictated by the abundance of hydrocarbons) were run.

The data are presented in tables 1 to 12 and graphically in figures 1 to 12. A brief description of the analytical techniques is included in the back of this report.

B. GENERAL INFORMATION

Ten (10) copies of this report, together with the kerogen slides, have been forwarded to T.O. Throndsen, Saga Petroleum A.S., Oslo. A copy of the data has been retained by Geochem for future consultation with authorised Saga personnel.

The remaining sample material will be returned to Saga as requested.

The results of this study are proprietary to Saga Petroleum A.S.

RESULTS AND DISCUSSION

Each of the parameters relevant to the evaluation of the section between 1000 metres and 3139 metres will be considered separately and then combined to form the "Conclusions".

Well logs were not available for this study.

A. ZONATION

This zonation is based upon the abundance of light hydrocarbons and organic carbon, and a consideration of the dominant lithologies. Eight (8) zones are recognised.

Zone A 1000 metres down to 1400± metres, is dominated by sandstones although significant amounts of basalt and traces of shell debris are also present in the samples.

Traces (less than 735 ppm) of dry gas are present within this zone.

Zone B^1 (1400-1710± metres) consists of yellowish brown and brownish grey mudstones, interbedded sandstones (above 1520± metres) and basalt (at 1480-1550± metres). In order to preserve the soft mudstones the last traces of drilling mud were not removed during the sample washing process. They were however excluded from follow-up analyses.

The C_1-C_4 hydrocarbons apart from kicks of 2838 ppm and 1174 ppm, are sparse (130-885 ppm) and dry (less than 23.6% C_{2+} hydrocarbons). They have isobutane to normal butane ratios of 0.79-2.95 which have little significant at such low levels of abundance. Traces (less than 34 ppm) of gasoline range hydrocarbons are present.

Zone B^2 (1710-1910± metres) is composed of light olive grey (shaly below 1770± metres) mudstones.

Negligible volumes (53-479 ppm) of dry gas, containing less than

24.1% C_{2+} hydrocarbons, are present within this zone.

Zone B^3 (1910-2120± metres) is a sequence of light greenish grey and olive grey shales and shaly mudstones. Interbeds of greyish red mudstone are also present below 1990± metres.

A modest improvement in light hydrocarbon abundances is apparent within this interval. They range from 53 ppm up to 6988 ppm (at 2065± metres) and commonly exceed 1000 ppm. At 2110± metres the C_1-C_4 hydrocarbons are very wet (83.5%) but elsewhere are dry containing less than 25.5% C_{2+} hydrocarbons.

Zone C lies between 2120± metres and 2510± metres. Medium-olive grey shaly mudstones overlie at 2250± metres an interval of medium grey shales. Interbeds of sandstone and anhydrite are present in the shales at 2370-2430± metres.

This zone is rich in light hydrocarbons; the C_1-C_4 fraction commonly exceeds 10,000 ppm (10835-38799 ppm) above 2150± metres and below 2330± metres. Apart from a kick of 13332 ppm at 2170± metres and of 15190 ppm at 2245± metres the intervening sediments are 'poorer' at (181)1101-9519 ppm. Above 2300± metres the gases, with few exceptions are extremely wet (43.6-98.4%). In general they are somewhat drier (61.5-84.4% C_{2+} hydrocarbons), but still very wet, below this depth. Isobutane to normal butane ratios drop below unity (0.38-0.60) within this zone. At 2300-2370± metres the C_5-C_7 hydrocarbons are of fair abundance (5251-8693 ppm). Above and below this interval they are, however, good to very good (11428-48651 ppm).

Zone D^1 (2510-2730± metres) is composed of sandstones within which are interbeds of medium-dark grey shale and, below 2680± metres, coal or shaly coal.

Gaseous hydrocarbons increase in abundance from 5501-8506 ppm (21200 ppm at 2575 metres) above 2610± metres to 10969-99426 ppm below this depth. There is, however, no corresponding increase in the gasoline fractions which remain fair (1100-8977 ppm) throughout. Gas wetness diminishes from 65.1-83.4% to 47.7-49.7% below 2690± metres. The ratio of isobutane to normal butane increases from 0.50 up to 0.92% and is highest in the basal 30± metres.

Zone D^2 extends from 2730± metres down to total depth at 3139 metres. Coals are dominant at 2770-2820± metres and occur as scattered interbeds in the underlying shale/sandstone sequence. The shales are generally dark grey (slightly carbonaceous) but are more commonly medium-dark brownish grey below 3040± metres.

Zone D^2 is rich in hydrocarbon gases; they range in abundance from (9187 ppm) 26677 ppm up to 303211 ppm at 2861± metres. Apart from kicks of wetter than average gas above 2876± metres to the C_1-C_4 fraction is marginally wet to wet (26.0-48.4%). Isobutane to normal butane ratios (0.94-6.62) are significantly higher than those in Zones C and D^1. Gasoline range hydrocarbons exceed 1000 ppm at 2730-2760± metres (1223-3070 ppm) at 2840-2880± metres (1223-1948 ppm) and with one exception below 3080± metres (758-1399 ppm); they are otherwise poor (less than 978 ppm).

B. AMOUNT AND TYPE OF ORGANIC MATTER

The amount of organic matter within a sediment is measured by its organic carbon content. Average shales contain approximately one percent organic carbon, and this is the standard to which these samples will be compared.

Organic matter type influences not only source richness but also the character of the hydrocarbon product (oil, gas) and the response of the organic matter to thermal maturation. Richness and oiliness decrease in the order: amorphous-algal-herbaceous-woody. Wood has a primary (but not exclusive) potential for gas whilst inertinitic (oxidised, mineral charcoal) material has only a limited hydrocarbon potential.

Yellowish brown and brownish grey mudstones at 1540-1710± metres have above average (1.11-3.37%) organic carbon contents although the mudstones within Zones B^1 and B^2 are generally poor to fair (0.35-0.94% organic carbon). Apart from interbeds of mudstone (at 1910-2000± metres) and shale (at

2060-2085± metres) with values of 0.51-0.64% the shaly mudstones within Zone B^3 are poor (less than 0.50% organic carbon).

Organic carbon contents in the shaly mudstones of Zone C improve from poor to fair (0.06-0.56%) above 2180± metres to "average" (0.88-1.40%) below this depth. Their organic matter, with few exceptions is largely composed of inertinite and wood, with significant amounts of amorphous (poor quality) debris. Herbaceous kerogen is a minor fraction of the total organic matter but algal material is sparse. Amorphous organic matter is relatively abundant in the shales/mudstones at 2225-2310± metres. It is however grainy in appearance and of poor quality.

Medium-brownish grey shales containing above average (1.10-2.98% organic carbon) amounts of a mixed, herbaceous, woody inertinitic and algal (± amorphous), organic assemblage are present (above 2680± metres) in Zone D^1. Within the basal 50± metres of this zone are very good and rich (15.88-52.84% organic carbon) silty shales and coals. Organic matter in these richer sediments chiefly consists of woody and herbaceous material, with lesser amounts of inertinitic, and traces of amorphous debris.

Rich (23.3-61.08% organic carbon) coals and shaly coals are abundant above 2990± metres in Zone D^2. They are interbedded with good (1.59-8.56% organic carbon) dark grey and brownish grey shales. The dark grey shales are more abundant and richer (6.3-16.6% organic carbon) below 2990± metres. The richer sediments contain dominantly woody and inertinitic kerogen although significant amounts of herbaceous and traces of amorphous material are also present below 2820± metres.

C. LEVEL OF THERMAL MATURATION

The level of thermal maturation has been assessed by the visual kerogen (spore colour) technique. Additional vitrinite data, based upon a suite of sidewall cores, were supplied by the client.

Maturation indices, derived from spore colour, range from 1+ to 2- at 2140± metres up to a maximum value of 2- at 2980± metres.

Amorphous and herbaceous organic matter is marginally mature (minor hydrocarbon generation) at 2- but the corresponding value for woody and inertinitic kerogen is 2. The analysed sediments, since they contain dominantly inertinitic or woody debris are immature. A marked odd carbon preference (indicating immaturity) in the paraffins extracted from the sediments in Zone D^2 supports this conclusion.

The vitrinite reflectance data, when plotted against depth, show an irregular trend which increases from 0.3% Ro at 1700± metres up to 0.48% at 3100± metres. A maturation index of 2- normally correlates with a vitrinite reflectance of 0.45% Ro. There is, thus, a good agreement between the two methods used to assess thermal maturity in this well section.

The sediments are immature on-structure and are realising a small fraction of their hydrocarbon potential. Minor hydrocarbon generation, from the marginally mature but less abundant herbaceous kerogen could be expected below 3000± metres. An extrapolation of the vitrinite reflectance trend suggests that the woody kerogen should achieve marginal maturity if it is buried to below 3600± metres (0.53% Ro) off structure.

D. SOURCE RICHNESS

Preliminary assessments of source richness are based upon the abundance of light hydrocarbons and organic carbon.

Potential source rocks are absent in Zone A. The distribution of light hydrocarbons indicates that Zones B^1 and B^2 have a poor hydrocarbon potential; Zone B^3 is poor to fair but out of place migrated hydrocarbons have enhanced the abundances in Zones C, D^1 and D^2. Zone D^2 is apparently very good to rich nonetheless.

Organic carbon contents indicate that the Zone B^1 mudstones improve from fair to good at 1530± metres. Within Zone B^2 the shaly mudstones are, at best, fair source rocks, Zone B^3 is poor with fair interbeds (chiefly above 2020± metres). Zones D^1 is fair to good but improves to very good to rich below 2680± metres and Zone D^2 is a potentially rich hydrocarbon source.

The pyrolysis analysis is used to measure source richness at optimum maturity. Interbeds of fair and good mudstone, yielding 2070-4301 ppm pyrolysate are present in the basal 150± metres of Zone B^1. With this exception Zones B^1 to C are poor, generating less than 2000 ppm pyrolysate. The shales lying above

2680± metres in Zone D^1 are rather variable in richness but are commonly fair or good (242-4909 ppm pyrolysate) source rocks. Below this depth the interbeds of silty shale, shaly coal and coal are rich yielding 12605-43218 ppm pyrolysate. Even richer shales and coals (10026-96947 ppm pyrolysate) are present within Zone D^2 although the brownish grey shales below 2900± metres are poor or in the basal 30± metres good (4052-4909 ppm pyrolysate) source rocks.

Selected mudstones and shaly mudstones from Zone C yielded 160-1526 ppm C_{15+} hydrocarbons which, from the anomalously high (41.7-66.3%) hydrocarbon to total extract ratios, appear to be largely non indigenous. Chromatograms of the paraffin-naphthene fraction confirm that they are mainly drilling introduced contaminants from the mud system and clearly unrelated to source richness. An odd carbon preference is evident in the paraffins extracted from the silty shales/coals at 2711± metres in Zone D^1 but the naphthenic baseline, again, shows a substantial proportion of drilling introduced hydrocarbons. The source indigenous hydrocarbons in this sample are estimated to be 500-600 ppm - corresponding to a good source potential. Excluding the lowermost sample at 3086± metres, which is contaminated, the dark grey shales and shaly coals within Zone D^2 yielded 409-2858 ppm C_{15+} hydrocarbons. The very strong pristane peak and marked odd carbon paraffin preference indicate a significant contribution from immature indigenous hydrocarbons. Drilling contamination, represented by the baseline humps, is estimated to be less than 500 ppm in these samples. Indigenous hydrocarbon abundances, estimated at 250-1500 ppm indicate good to very good, probably rich source rocks within Zone D^2.

Chromatograms of the pyrolysate (pyrolysis-GC analysis) are used to deduce the character (gas, condensate, oil) of potential hydrocarbon products. Mudstones occurring within Zones B^1 to C yielded traces in which methane is suceeded by a limited distribution of light, non paraffinic, hydrocarbons. They have a potential for gas and associated liquids. Medium grey and brownish grey shales at 2480-2600± metres generated methane and an abundance of heavier hydrocarbons extending out to nC_{15}. These sediments would generate gas and condensate in the mature state. The rich dark grey shales, shaly coals and coals within Zones D^1 and D^2 produced traces resembling the above but containing an additional series of double peaks, terminating at nC_{25}-nC_{27}; a primary potential for gas with associated condensate or light oil is indicated.

To summarise:

- Zones B^1 to C, apart from scattered fair and good mudstones at 1575-1710± metres, have a poor potential for gas and associated liquids.
- the leaner brownish grey shales in Zones D^1 and D^2 contain good interbeds at 2515± metres and at 3107-3139± metres but are more commonly a poor gas and condensate source.
- rich dark grey shales and coals are abundant in Zones D^1 and D^2. They have an excellent potential for gas and associated condensate or light oil.
- the sediments are immature or effectively immature on-structure and are, therefore, realising a small fraction of their ultimate hydrocarbon potential.

E. MIGRATED HYDROCARBONS

Sandstones representing potential reservoir facies are abundant at 1000-1440± metres, at 2540-2770± metres and as interbeds in shaly or coaly sequences below 2820± metres.

The light hydrocarbons are sparse and the gases dry above 2100± metres - migrated hydrocarbons are not indicated. Within Zone C (2120-2510± metres) however, the rich wet gases suggest probable condensate shows (see below). Although the hydrocarbon gases are abundant in Zone D^1 and particularly so in Zone D^2 the gasoline fractions are relatively poor. Gas wetness data indicates shows of wet gas (heavier liquid hydrocarbons are no suspected) in Zone D^1 and strong shows of marginally wet (very wet at 2831± metres and at 2876± metres) gas in Zone D^2. A marked increase in the isobutane to normal butane ratios in Zone d^2 suggests that the gases are associated with the coals in this interval. The abundance of these gases, however indicates hydrocarbons are diffusing into the section, most probably from mature equivalents of the Zone D^2 coals down dip.

Between 160 ppm and 1526 ppm C_{15+} hydrocarbons, commonly exceeding 40% of the total extract, were recovered from the Zone C shales and mudstones. Chromatograms of the paraffin-naphthene fraction, however, show them to be largely drilling introduced (see Section D). Traces from the sediments below 2240± metres display a limited number of paraffins which have a marked front end bias. These hydrocarbons are believed to be the heavy residue from shows of wet gas/condensate found in this interval. Heavy hydrocarbons extracted from the Zone D^1 and D^2 sediments chiefly consist of source indigenous species and not migrated crude oil.

Combining the light and heavy hydrocarbon data:

- apart from traces of gas in basal Zone B^3 (diffusion halo ?) out of place migrated hydrocarbons were not detected above 2100± metres.
- good shows of wet gas/condensate, in shales and mudstones (and sands at 2370-2430± metres) are present in Zone C (2120-2510± metres).
- fair and, below 2610± metres, good shows of wet gas occur in Zone D^1 (sandstones and shales).
- strong shows of marginally wet gas (very wet at 2831± metres and at 2861± metres) in Zone D^2 (2730-3139 metres) are partly indigenous (the shaly coals and coals are rich but immature) and partly migrated - hydrocarbon generation is believed to be taking place in more mature equivalents of the Zone D^2 sediments off structure.
- migrated crude oil was not detected although traces of these hydrocarbons could be masked by the drilling introduced contamination found in most of the analysed sediments.

The analysed sediments within Zones A to C are, apart from a few fair and good interbeds in basal Zone B^1, poor source rocks. On-structure they are immature and even their off structure lateral equivalents, if mature, could not source the shows found in Zones C to D^2. The (silty) shales, shaly coals and coals within Zones D^1 and D^2 are a very good or rich potential source for gas and associated liquids. They are, however, immature although minor hydrocarbon generation could be expected in their lateral equivalents off structure if buried to below 3600± metres.

Stable carbon isotope ratios of methane were measured in the produced fluids and in the gases associated with selected sediments (the number of analyses possible were limited by the abundance of methane). Carbon isotope ratios of $-32.6^{o}/oo$ to $-45.7^{o}/oo$ were obtained from the airspace gases in Zone C and similar values were obtained in Zone D^2 (-32.3 to $-45.5^{o}/oo$, $-51.0^{o}/oo$ at 2816± metres). The corresponding values for the condensates produced at 2401 metres and at 2526 metres were -37.6°/oo and -42.6°/oo, respectively. These values and those derived from the shows in Zone C fall within the range of values measured in the, largely indigenous, gases in Zone D^2. Thus, the methane carbon isotope data suggest a loose correlation between the shows of wet gas/condensate, the produced fluids and the coaly facies in Zone D^2 (and D^1). The range of values also indicates that the various hydrocarbon shows were produced by mature source rocks and are not biogenic in their origin.

Detailed gasoline range (C_4-C_7) analyses were performed upon selected sediments in order to study possible relationships between shows and potential sources. Adjacent samples were selected where the specified sediment was too lean for a successful analysis. Gross C_4-C_7 hydrocarbon type distributions reveal that the shows between 2125± metres and 2250± metres are loosely correlated. They differ from those in the underlying Zone C sediments which on this criterion also differ from the samples of produced condensate at 2401 metres and at 2526 metres. For example the high aromatic hydrocarbon contents of the latter are not matched in the hydrocarbons associated with the sediments. Outstanding in the detailed analyses are the very high abundances of methylcyclohexane, which suggest an underlying similarity between the shows and the produced condensates in Zones C and D^1. The lack of detailed correlations, in the gasoline fraction, between the wet gas/condensate shows in Zones C and D^1 and the coaly sediments in Zone d^2 may be due to migrational effects.

Because the shows are of wet gas or condensate and, therefore limited mainly to the C_{15-} fraction, correlations based upon the C_{15+} fraction are somewhat tenuous (further hindered by drilling contaminants). However, paraffins extracted from the richer shales and coals in basal Zone D^1 and D^2 display a strong odd carbon preference, suggesting that they are immature and therefore indigenous, and an intense pristane peak. This latter feature is also present in the corresponding fractions from the produced condensate samples but is less obvious in the shows. It would appear, therefore that the condensates and the "coals" in Zones D^1 and D^2, or more probably their mature equivalents down dip, are loosely correlated by this parameter.

The dominance of pristane is also apparent in the branched/cyclic alkane chromatograms produced by selected coaly sediments in Zones D^1 and D^2. These traces also display an abundance of heavier hydrocarbons in the sterane/triterpane region which were not detected in the corresponding fractions from the condensates at 2401 metres and 2526 metres. Allowing for this difference the produced fluids correlate, rather poorly, with the silty shale at 2711± metres.

Mass fragmentograms of the C_{15+} branched/cyclic alkane fraction from selected silty shales and coals in Zones D^1 and D^2 were compared with those from the analagous fraction in the two condensate samples. Steranes and triterpanes are sparse in the condensate samples and although fragmentograms were run at m/e 239 and 253 the resulting traces were too 'noisy' to yield meaningful results. Correlations based upon fragmentograms at m/e 191 and 217 may also be affected by the sparsity of steranes in the condensates. An overall similarity is, however apparent at m/e 191 in all of the traces but the higher hopanes are relatively sparse, for land plant derived organic matter, in the sediments and are only slightly more abundant in the condensates. Significant differences are apparent at m/e 217. Cholestanes are sparse in hydrocarbons extracted from the sediments of Zones D^1 and D^2 (strongest in the silty shale at 2711± metres) but are relatively abundant in the condensates. There is thus a tenuous correlation between the produced condensates and the silty shales and coals below 2680± metres or, more correctly, their mature equivalents down dip. Detailed differences in the fragmentograms suggest that a minor facies change may occur off structure.

Chromatograms of the C_{15+} aromatic hydrocarbon fraction are complex. Variations in the proportions of for example the dimethyl naphthalenes and the phenanthrenes indicate changes in the inferred organic matter type between the silty shales and the coals below 2680± metres. Allowing for possible losses of "heavy ends" during migration these hydrocarbons differ from the aromatic fractions in the two condensate samples, which also differ from each other.

Samples of the produced condensate at 2401 metres and at 2526 metres yielded carbon isotope ratios of $-28.6^{o}/oo$ for the C_{15+} saturated hydrocarbons and $-26/6^{o}/oo$ and $-26.8^{o}/oo$ respectively for the aromatic fractions. These pairs of values are sufficiently close to suggest a common source type for the two fluids. When compared to the corresponding values obtained from the richer sediments within Zones D^1 and D^2 they indicate a good correlation between the condensates and the silty shales. The coals at 2981± metres have an almost identical value ($-28.7^{o}/oo$) for the saturates but have a lighter (-27.3) aromatic ratio; they cannot, therefore, be eliminated as a possible condensate source. Coals represented by the sample at 2861± metres, are isotopiclly lighter than those at 2981± metres, suggesting a change in organic facies.

Insufficient liquid hydrocarbons were present in the pressurised condensate samples (see Introduction) to allow a 20-120°C distillation. Chromatograms of the C_4-C_{20} fraction were run to ascertain the range of hydrocarbons in these fluids. These traces show that the condensate samples have a similar distribution of C_4-C_{20} hydrocarbons although a closer inspection of the non normal paraffinic and aromatic hydrocarbons reveals that the two fluids are not identical. The differences (minor) are attributed to variations in inferred source type.

Summarising:

- samples of the produced condensate at 2401 metres and at 2526 metres have closely similar gross characteristics but differ in analytical detail.

- these fluids although they resemble the hydrocarbon shows associated with the sediments in Zones C and D^1 differ in their detailed gasoline range analyses.

- analytical data derived from the C_{15+} hydrocarbons indicate a generalised correlation between the produced condensate and a selection of the richer sediments occurring below 2680± metres. Silty shales represented by the sample at 2711± metres offer the best correlation.

F. CONCLUSIONS

Eight (8) zones are recognised between 1000 metres and 3139 metres in the 6507/11-1 well.

Zone A (1000-1400± metres) is dominated by sandstones and therefore has no source potential.

Zone B^1 (1400-1710± metres) is largely composed of brownish grey or yellowish brown mudstones. At 1540-1710± metres the mudstones have above average (1.11-3.37%) organic carbon contents and subsequent analyses indicate fair and good interbeds within this interval. With this exception the Zone B^1 mudstones are poor.

Zone B^2, 1710± metres down to 1910± metres, consists of light olive grey shaly mudstones. They have fair (0.53-0.85%) organic carbon contents but are shown by the pyrolysis analyses to have a poor hydrocarbon potential.

Zone B^3 (1910-2120± metres) is composed of shales and mudstones. The sediments are dominantly light greenish grey in colour although interbeds of olive grey and greyish red mudstone are present below 1990± metres. Apart from a few greenish grey mudstones above 2030± metres at 0.5-0.82% organic carbon the sediments are lean with values of less than 0.5%. The Zone B^3 sediments are poor imature source rocks and have a limited potential for gas.

Zone C lies between 2120± metres and 2510± metres. Olive grey shaly mudstones pass below 2250± metres to a medium grey shale unit. Interbeds of sandstone and anhydrite are present in the shales at 2370-2430± metres. Although the shales and mudstones below 2180± metres have slightly above average (0.88-1.40%) organic carbon contents their immature organic matter, consisting chiefly of inertinite and wood, has a negligible hydrocarbon potential. They are rated as a poor immature source for gas and associated liquids.

Zone D^1 (2510-2730± metres) is a sequence of sandstones, shales and, below 2680± metres silty shales and coals (shaly). The shales, generally brownish grey, have above average (1.10-2.98% organic carbon) contents of a mixed, herbaceous, woody, inertinitic and algal (± amorphous), organic assemblage. Mainly woody and herbaceous organic matter is present in the silty shales and coals; they are rich containing 15.9-52.8% organic carbon. The sediments are immature and the hydrocarbons associated with them represent a small proportion of their ultimate potential. Thus, Zone D^1 has a poor to fair hydrocarbon potential above 2680± metres. The coals and shales below this depth are a potentially rich, but immature source for gas and condensate or light oil.

Zone D^2 (2730-3139± metres, T.D.) is a sequence of sands, coals, shaly coals and dark grey or brownish grey shales. Coals are dominant at 2770-2820± metres whereas the shales are most abundant below 2990± metres. Organic carbon contents in the shales above 2990± metres vary between 1.59% and 8.56% but increase to 6.3-16.6% below this depth. The coals contain 23.3-61.08% organic carbon and, like the richer shales, their organic matter is chiefly composed of woody, inertinitic and herbaceous debris. Apart from the brownish grey interbeds, which are poor, the shales are a good to very good, and the coals and shaly coals a rich, potential source for gas and associated condensate or light oil. Hydrocarbon generation has only just been initiated in these sediments. Minor hydrocarbon generation can be expected if their off structure lateral equivalents are buried to below 3600± metres.

Migrated hydrocarbons were not detected above 2100± metres. Good shows of condensate are, however, present in Zone C (2120-2510± metres) and further shows of wet gas/condensate occur in Zone D^1, notably below 2610± metres. Strong shows of dry to marginally wet (very wet at 2820-2880± metres) gas were detected in Zone D^2. Their abundance indicates that they are a mixture of source indigenous hydrocarbons and of gases which have diffused into the section, most probably from more mature equivalents of the richer Zone D^2 sediments. The high isobutane to normal butane ratios, a feature of this zone, may be a function of source type but could also indicate comparative immaturity - suggesting a localised movement of hydrocarbons.

Correlations between the various shows of wet gas/condensate and their potential source rocks are not obvious. Gasoline range analyses indicate an underlying similarity (based upon the abundance of methyl cyclohexane) between the shows in Zones C and D^1 and the two produced fluids, but not with the corresponding fractions from the richer Zone D^2 sediments.

Heavy hydrocarbons are sparse, because the shows are of wet gas or condensate, and correlations based upon these hydrocarbons are, therefore, tenuous. An intense pristane peak in the C_{15+} hydrocarbons extracted from the silty shales and coals within Zones D^1 and D^2 is also apparent in the corresponding fraction from the condensate samples at 2401 metres and 2526 metres. These sediments, or more correctly their mature equivalents off structure, certainly have the richness and organic matter type to be the source of the condensates although the correlation is not particularly good.

The C_{15+} hydrocarbons from the condensates produced at 2401 metres and at 2526 metres lack some of the heavier components found in extracts from the silty shales and coals in Zones D^1 and D^2. The losses presumably occur during migration. Correlations based upon the C_{15+} branched/cyclic and aromatic hydrocarbons, however, although they indicate a generalised relationship between source rock and condensate, differ in detail; this is also true of the massfragmentograms. The latter notably at m/e 217 show cholestane peaks which are strong in the condensates but are weak in the hydrocarbons extracted from the Zone D^1 and D^2 sediments. Carbon isotope ratios of the C_{15+} hydrocarbon fractions, however, do indicate a good correlation between the condensate and the silty shales at 2711± metres; and a slightly inferior match with the coals at 2981± metres. Methane carbon isotopes although less precise, also suggest that the condensate was generated in the more mature equivalents of the silty shales and coals within Zones D^1 and D^2.

TABLE 1
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	G S A Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
616-001	1000m	A 85% Sand, unconsolidated, fine-med grained, subrounded to subangular, mostly quartz, clear. Poorly sorted. White B 10% Basalt, blocky, hard. Dark grey C 5% Shell fragments Minor pyrites Minor L C M - metal turnings	N9 N3	
616-002	1030m	A 95% Sand, as 616-001A B 5% Basalt, as 616-001B Minor shell fragments and pyrites Minor L C M - metal	N9 N3	
616-003	1060m	A 80% Sand, as 616-001A B 15% Basalt, as 616-001B C 5% Shell fragments Minor L C M - metal turnings	N9 N3	
616-004	1090m	A 80% Sand, as 616-001A B 15% Basalt, as 616-001B C 5% Shell fragments L C M - metal turnings	N9 N3	
616-005	1120m	A 75% Sand, as 616-001A B 20% Basalt, as 616-001B C 5% Shell fragments L C M - metal	N9 N3	
616-006	1150m	A 75% Sand, as 616-001A B 20% Basalt, as 616-001B C 5% Shell fragments L C M - metal	N9 N3	
616-007	1180m	A 75% Sand, as 616-001A B 20% Basalt, as 616-001B C 5% Shell fragments Minor pyrites L C M - metal	N9 N3	
616-008	1210m	A 80% Sand, as 616-001A B 15% Basalt, as 616-001B C 5% Shell fragments Minor pyrites Minor L C M - metal turnings	N9 N3	
616-009	1240m	A 75% Sand, as 616-001A B 20% Basalt, as 616-001B C 5% Shell fragments Minor pyrites Minor L C M - metal turnings and mica	N9 N3	
616-010	1270m	A 75% Sand, as 616-001A B 20% Basalt, as 616-001B C 5% Shell fragments Minor pyrites Minor L C M	N9 N3	
616-011	1300m	A 75% Sand, as 616-001A B 25% Basalt, as 616-001B Minor L C M	N9 N3	

Abbreviations = **a**renaceous, **a**rgillaceous, **c**alcareous, **C**ut, **d**olomitic, **F**luorescence, **f**oraminifera, **f**ossiliferous
Lost **C**irculation **M**aterial, **m**oderately, **o**ccasionally, **s**lightly, **v**ery

TABLE 1
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
616-012	1330m	A 85% Sand, unconsolidated, fine to med grained, subrounded to subangular, mostly quartz. Clear. Poorly sorted. White	N9	
		B 15% Basalt, blocky, hard. Dark grey	N3	
		Minor L C M		
616-013	1360m	A 80% Sand, as 616-012A	N9	
		B 20% Basalt, as 616-012B	N3	
		Minor L C M		
616-014	1390m	A 80% Sand, as 616-012A	N9	
		B 20% Basalt, as 616-012B		
		Minor shell fragments		
		Minor L C M		
616-015	1420m	A 55% Sand, as 616-012A	N9	
		B 35% Silty mudstone, blocky, soft to mod hard, non-calc. Med to med brownish grey	N5-5Y5/1	0.47
		C 10% Basalt, as 616-012B	N3	
		Minor shell fragments		
		Minor L C M		
616-016	1450m	A 98% Silty mudstone, as 616-015B	N5-5Y5/1	0.35
		Minor sand and basalt		
616-017	1480m	A 65% Mudstone, blocky, soft to mod hard, non-calc, sl silty. Mod caved. Med olive grey	5Y5/1	0.61
		B 20% Sand, unconsolidated, med to coarse grained, subrounded, clear. White	N9	
		C 15% Basalt, blocky, hard. Dark grey to greyish black	N3-2	
		Minor shell fragments		
616-018	1500m	A 65% Mudstone, as 616-017A. Minor caving	5Y5/1	0.60,0.58
		B 25% Sand, as 616-017B	N9	
		C 10% Basalt, as 616-017C	N3-2	
		Minor L C M		
616-019	1515m	A 70% Mudstone, as 616-017A. Minor caving	5Y5/1	0.86
		B 20% Basalt, as 616-017C	N3-2	
		C 10% Sand, as 616-017B	N9	
		Minor L C M		
616-020	1530m	A 80% Mudstone, as 616-017A. Minor cavings	5Y5/1	0.94
		B 15% Basalt, as 616-017C	N3-2	
		C 5% Sand, as 616-017B	N9	
		Minor L C M		
616-021	1545m	A 75% Mudstone, blocky, calc, soft. Med olive grey	5Y5/1	1.35
		B 25% Basalt, as 616-017C	N3-2	
		Minor sand and drilling mud (5Y5/1 - med olive grey)		
616-022	1560m	A 98% Mudstone, blocky, soft, calc. Med olive to med brownish grey	5Y5/1-5YR5/1	1.61
		Minor drilling mud and quartzite		

Abbreviations = **a**renaceous, **a**r**g**illaceous, **calc**areous, **Cut**, **dol**omitic, **Fluor**escence, **foram**inifera, **foss**iliferous **L**ost **C**irculation **M**aterial, **mod**erately, **occ**asionally, **sl**ightly, **v**ery

TABLE 1
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
616-023	1575m	A 85% Mudstone, blocky, soft, calc. Med olive to med brown grey B 15% Drilling mud Minor basalt and quartzite	5Y5/1-5YR5/1	1.71
616-024	1590m	A 85% Mudstone, blocky, soft, v sl calc to non-calc. Med olive to med brown grey B 15% Drilling mud Minor basalt	5Y5/1-5YR5/1	1.59,1.62
616-025	1605m	A 80% Mudstone, as 616-024A. Minor cavings B 20% Drilling mud Minor basalt	5Y5/1-5YR5/1	1.22
616-026	1620m	A 50% Mudstone, as 616-024A. Minor cavings B 50% Drilling mud	5Y5/1-5YR5/1	1.25
616-027	1635m	A 98% Mudstone, blocky to platy, soft, v sl calc to non-calc. Sl silty. Med yellowish brown Minor drilling mud	10YR5/2	3.37
616-028	1650m	A 98% Mudstone, blocky to platy, soft, v sl calc to non-calc. Sl silty. Pale yellowish brown Minor drilling mud and L C M	10YR6/2	2.49
616-029	1675m	A 98% Mudstone, as 616-028A. Minor cavings Minor drilling mud	10YR6/2	2.43,2.39
616-030	1690m	A 98% Mudstone, as 616-028A. Minor cavings Minor drilling mud	10YR6/2	
616-031	1705m	A 98% Mudstone, as 616-028A. Minor cavings Minor drilling mud	10YR6/2	1.11
616-032	1720m	A 98% Mudstone, as 616-028A. Mod caved	10YR6/2	0.85
616-033	1735m	A 98% Mudstone, blocky to platy, soft, v sl calc to non-calc, sl silty. Minor cavings. Med yellowish grey to pale yellowish brown. Minor drilling mud.	5Y6/2-10YR6/2	0.67
616-034	1750m	A 98% Mudstone, as 616-033A. Minor cavings	5Y6/2-10YR6/2	0.60
616-035	1765m	A 98% Mudstone, as 616-033A. Minor cavings	5Y6/2-10YR6/2	0.59
616-036	1780m	A 98% Shaly mudstone, platy to blocky, soft, non-calc. Mod caved. Patchy iron staining. Greenish grey	5GY6/1	0.64,0.66
616-037	1795m	A 98% Shaly mudstone, as 616-036A. Mod caved	5GY6/1	0.53
616-038	1810m	A 98% Shaly mudstone, as 616-036A. Mod caved	5GY6/1	0.68
616-039	1825m	A 98% Shaly mudstone, platy to blocky, soft non-calc. Mod caved. Light olive grey	5Y5/2	0.64

Abbreviations = **arenaceous**, **argillaceous**, **calcareous**, **Cut**, **dolomitic**, **Fluorescence**, **foraminifera**, **fossiliferous**
Lost Circulation Material, **moderately**, **occasionally**, **slightly**, **very**

TABLE 1
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
616-040	1840'	A 98% Shaly mudstone, platy to blocky, soft, non-calc. Light olive grey Mod caved Minor other mudstone and drilling mud	5Y5/2	0.47
616-041	1855m	A 98% Shaly mudstone, as 616-040A. Mod caved Minor other mudstone Minor L C M	5Y5/2	0.47
616-042	1870m	A 98% Shale, thinly fissile to platy, soft non-calc. Mod caved. Light olive grey Minor limestone Minor L C M	5Y5/2	0.47,0.50
616-043	1885m	A 98% Shale, as 616-042A. Mod caved Minor mudstone	5Y5/2	0.53
616-044	1900m	A 98% Shale, platy, soft to mod hard, non-calc. Minor cavings. Olive to light olive grey Minor mudstone and sandstone	5Y4/1-5Y5/2	0.68
616-045	1915m	A 65% Shale, platy, soft to mod hard, non-calc. Minor cavings. Light greenish green	5G8/1	0.19
		B 35% Shaly mudstone, blocky to platy, mod hard, non-calc. Mod caved. Greenish grey. Mod caved Minor other mudstone Minor L C M	5GY6/1	0.54
616-046	1930m	A 50% Shaly mudstone, as 616-045B. Mod caved	5GY6/1	0.64
		B 50% Shale, as 616-045A. Mod caved Minor other mudstone	5G8/1	0.10
616-047	1945m	A 50% Shaly mudstone, as 616-045B. Mod caved.	5GY6/1	0.56,0.56
		B 50% Shale, as 616-045A. Mod caved Minor other mudstone	5G8/1	0.08
616-048	1960m	A 65% Shale, as 616-045A. Mod caved	5G8/1	0.11
		B 35% Shaly mudstone, as 616-045B. Mod caved	5GY6/1	0.60
616-049	1975m	A 55% Shale, as 616-045A. Mod caved	5G8/1	0.05
		B 45% Shaly mudstone, as 616-045B. Mod caved	5GY6/1	0.59,0.61
616-050	1990m	A 55% Shale, as 616-045A. Mod caved	5G8/1	0.13
		B 40% Shaly mudstone, as 616-045B. Mod caved	5GY6/1	0.50
		C 5% Shaly mudstone, blocky to subfissile, soft to mod hard, non-calc. Med greyish red.	10R5/2	0.06
616-051	2005m	A 55% Shaly mudstone, as 616-045B. Mod caved.	5GY6/1	0.50
		B 25% Shale, as 616-045A. Minor cavings	5G8/1	0.08
		C 20% Shaly mudstone, as 616-050C. Minor cavings	10R5/2	0.04,0.04

Abbreviations = arenaceous, argillaceous, calcareous, Cut, dolomitic, Fluorescence, foraminifera, fossiliferous
Lost Circulation Material, moderately, occasionally, slightly, very

TABLE 1
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	G S A Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
616-052	2020m	A 55% Shaly mudstone, platy, soft to mod hard, non-calc. Mod caved. Light greenish grey	5G8/1	0.12
		B 30% Shaly mudstone, blocky to platy, soft to mod hard, non-calc. Mod caved. Light brownish to olive grey	5GY6/1-5Y4/1	0.82
		C 15% Shaly mudstone, blocky to subfissile, soft to mod hard, non-calc. Med yellowish brown. Minor cavings	10YR5/2	0.15
616-053	2035m	A 70% Shaly mudstone, as 616-052B. Mod caved.	5GY6/1-5Y4/1	0.38
		B 20% Shaly mudstone, as 616-052C. Minor cavings	10R5/2	0.09
		C 10% Shaly mudstone, as 616-052A. Mod caved.	5G8/1	0.06
616-054	2050m	A 70% Shaly mudstone, as 616-052B. Mod caved	5GY6/1-5Y4/1	0.27
		B 15% Shaly mudstone, as 616-052C. Minor cavings	10R5/2	0.08
		C 15% Shaly mudstone, as 616-052A. Mod caved	5G8/1	0.09
616-055	2065m	A 75% Shale, platy to blocky, soft to mod hard, non-calc. Minor cavings. Med grey	N5	0.51
		B 15% Shaly mudstone, as 616-052C	10R5/2	0.03
		C 10% Shaly mudstone, as 616-052A Minor other mudstone	5G8/1	0.10
616-056	2080m	A 50% Shale, as 616-055A. Mod caved	N5	0.62,0.64
		B 20% Shaly mudstone, blocky to platy, soft to mod hard, non-calc. Mod caved. Olive grey	5Y4/1	0.23
		C 15% Shaly mudstone, blocky, soft, non-calc. Light greenish grey	5GY8/1-5G8/1	0.05
		D 5% Shaly mudstone, blocky, soft to mod hard, non-calc. Minor cavings. Med greyish red. Minor other mudstone	10R5/2	0.08
616-057	2095m	A 70% Shale, platy to blocky, soft to mod hard, non-calc. Mod caved. Light olive grey to light olive brown	5Y5/2-5Y5/6	0.10
		B 20% Shaly mudstone, as 616-056D. Mod caved	10R5/2	0.02,0.04
		C 10% shaly mudstone, as 616-056C. Mod caved Minor other mudstone IRON STAINED SAMPLE	5GY8/1-5G8/1	0.15
616-058	2110m	A 60% Shaly mudstone, as 616-056B. Mod caved	5Y4/1	0.31
		B 15% Shale, as 616-055A	N5	0.44
		C 15% Shaly mudstone, as 616-056D. Minor cavings	10R5/2	0.12
		D 10% Shaly mudstone, as 616-056C. Mod caved. Minor other mudstone	5GY8/1-5G8/1	0.09

Abbreviations = arenaceous, argillaceous, calcareous, Cut, dolomitic, Fluorescence, foraminifera, fossiliferous
Lost Circulation Material, moderately, occasionally, slightly, very

TABLE 1
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
616-059	2125m	A 75% Shaly mudstone, blocky to platy, soft to mod hard, non-calc. Mod caved. Med to olive grey	N5-5Y4/1	0.24,0.24
		B 20% Shaly mudstone, blocky, soft to mod hard, non-calc. Med greyish red	10R5/2	0.06
		C 5% Shaly mudstone, blocky, soft, non-calc. Light greenish grey	5GY8/1-5G8/1	0.07
		Minor other mudstone		
616-060	2140m	A 90% Shaly mudstone, as 616-059A. Abundantly caved	N5-5Y4/1	0.49
		B 10% Shaly mudstone, as 616-059B. Mod caved	10R5/2	0.07
		Other caved mudstone		
616-061	2155m	A 85% Shaly mudstone, blocky to platy, soft to mod hard, non-calc. Minor cavings Med to olive grey	N5-5Y5/1	0.35
		B 15% Drilling mud (N5-5Y5/1 - Med to olive grey)		
		Minor other mudstone		
616-062	2170m	A 98% Shaly mudstone, as 616-061A. Mod caved	N5-5Y5/1	0.56,0.55
		Minor drilling mud		
616-063	2185m	A 98% Shaly mudstone, as 616-061A. Minor cavings	N5-5Y5/1	1.06
		Minor drilling mud		
616-064	2200m	A 98% Shaly mudstone, as 616-061A. Minor cavings	N5-5Y5/1	1.25
		Minor drilling mud and L C M		
616-065	2215m	A 98% Shaly mudstone, as 616-061A. Minor cavings	N5-5Y5/1	1.03
		Minor drilling mud		
616-066	2230m	A 98% Shaly mudstone, as 616-061A. Mod caved	N5-5Y5/1	1.00
		Minor drilling mud		
616-067	2245m	A 98% Shaly mudstone, as 616-061A. Abundantly caved.	N5-5Y5/1	1.12
		Minor other mudstone and drilling mud		
616-068	2260m	A 98% Shale, fissile, soft to mod hard, non-calc. Minor cavings. Med grey	N5	0.88
		Minor drilling mud		
616-069	2290m	A 98% Shale, as 616-068A. Minor cavings	N5	1.18,1.16
		Minor drilling mud		
616-070	2305m	A 98% Shaly mudstone, platy to blocky, soft to mod hard, non-calc. Mod caved. Med grey	N5	1.06
		Minor drilling mud and L C M		
616-071	2320m	A 98% Shaly mudstone, as 616-070A Mod caved	N5	1.07
616-072	2335m	A 98% Shaly mudstone, as 616-070A. Mod caved	N5	1.19

Abbreviations = arenaceous, argillaceous, calcareous, Cut, dolomitic, Fluorescence, foraminifera, fossiliferous
Lost Circulation Material, moderately, occasionally, slightly, very

TABLE 1

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GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
616-073	2350m	A 98% Shale, platy, soft to mod hard, non-calc. Minor cavings. Med grey	N5	1.16
616-074	2365m	A 98% Shale, as 616-073A. Minor cavings Minor drilling mud and L C M - mica	N5	1.42,1.36
616-075	2380m	A 75% Shale, as 616-073A. Mod caved B 25% Sand, unconsolidated, v fine grained subrounded to subangular. Clear. White	N5 N9	1.02
616-076	2395m	A 55% Shale, as 616-073A. Mod caved B 40% Sand, as 616-075B C 5% Anhydrite, blocky, soft. White	N5 N9 N9	0.91
616-077	2410m	A 60% Shale, as 616-073A. Mod caved B 30% Anhydrite, as 616-076C C 10% Sand, as 616-075B	N5 N9 N9	0.96
616-078	2425m	A 60% Shale, as 616-073A. Mod caved B 35% Sand, as 616-075B C 5% Anhydrite, as 616-076C	N5 N9 N9	1.12
616-079	2440m	A 75% Shale, as 616-073A. Mod caved B 25% L C M - cement	N5	1.05
616-080	2455m	A 85% Shale, as 616-073A. Mod caved B 15% L C M - cement	N5	1.02,0.98
616-081	2470m	A 95% Shale, as 616-073A. Mod caved B 5% L C M - cement	N5	1.06
616-082	2485m	A 90% Shale, as 616-073A. Mod caved B 10% Drilling mud	N5	1.09
616-083	2500m	A 90% Shale, platy, soft to mod hard, non-calc. Mod caved. Med grey B 10% Drilling mud Minor sand and L C M - cement	N5	1.24
616-084	2515m	A 98% Shale, platy to subfissile, soft to mod hard, sl silty, non-calc. Med to brownish grey Minor sand and coal Minor drilling mud	N5-5YR4/1	2.14
616-085	2545m	A 50% Shale, as 616-084A. Mod caved B 50% Sand, unconsolidated, med grained, subangular, fairly well sorted, clear White L C M - paint	N5-5YR4/1 N9	1.11
616-086	2560m	A 80% Sand, as 616-085B B 20% Shale, as 616-084A. Mod caved Minor L C M - cement, paint and metal	N9 N5-5YR4/1	1.30,1.26
616-087	2575m	A 80% Sand, as 616-085B B 20% Shale, as 616-084A. Mod caved L C M - paint and metal	N9 N5-5YR4/1	1.10
616-088	2590m	A 90% Sand, as 616-085B B 10% Shale, as 616-084A. Minor cavings Minor other shale, minor L C M	N9 N5-5YR4/1	1.36

Abbreviations = **arenaceous, argillaceous, calcareous, Cut, dolomitic, Fluorescence, foraminifera, fossiliferous Lost Circulation Material, moderately, occasionally, slightly, very**

TABLE 1
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
616-089	2605m	A 95% Sand, unconsolidated, med grained, subangular, fairly well sorted, clear White	N9	
		B 5% Shale, platy to subfissile, soft to mod hard, sl silty, non-calc. Med to brownish grey. Mod caved Minor L C M	N5-5YR4/1	1.70
616-090	2620m	A 95% Sandstone, partly unconsolidated, fine-med grained, subangular, fairly well sorted, clear. Pale milky cut White	N9	
		B 5% Shale, as 616-089B. Mostly caved L C M - metal and paint. Minor drilling mud	N5-5YR4/1	1.66
616-091	2635m	A 95% Sandstone, as 616-090A. Pale milky cut	N9	
		B 5% Shale, as 616-089B. Mostly caved L C M - metal turnings and paint	N5-5YR4/1	1.56
616-092	2650m	A 95% Sandstone, as 616-090A. Pale milky cut	N9	
		B 5% Shale, as 616-089B. Mod caved L C M - paint and metal turnings	N5-5YR4/1	1.64,1.68
616-093	2665m	A 90% Sandstone, as 616-090A. Pale milky cut	N9	
		B 10% Shale, as 616-089B. Mod caved Minor other shale L C M - metal turnings	N5-5YR4/1	2.98
616-094	2681m	A 85% Sand, mostly unconsolidated, fine-med grained, subangular, well sorted, clear White	N9	
		B 10% Shale, platy to subfissile, soft to mod hard, non-calc. Med to brownish grey	N5-5YR4/1	1.22
		C 5% Shaly coal, platy to blocky, brittle. Greyish black to dark grey Minor anhydrite Minor L C M	N2-3	40.40
616-095	2696m	A 85% Sand, as 616-094A	N9	
		B 10% Shaly coal, as 616-094C. Mod caved	N2-3	52.84
		C 5% Shale, as 616-094B. Mod caved Minor L C M - metal turnings, paint and mica	N5-5YR4/1	2.10
616-096	2711m	A 40% Silty shale, blocky to subfissile, soft, non-calc. Dark brownish grey	5YR3/1	15.88
		B 30% Sand, as 616-094A	N9	
		C 30% Coal, blocky, brittle. Greyish black to dark grey. Minor other shale	N2-3	47.86
616-097	2726m	A 65% Sand, as 616-094A	N9	
		B 20% Silty shale, as 616-096A	5YR3/1	18.00
		C 15% Coal, as 616-096C Minor mudstone L C M - metal turnings	N2-3	43.88

Abbreviations = arenaceous, argillaceous, calcareous, Cut, dolomitic, Fluorescence, foraminifera, fossiliferous Lost Circulation Material, moderately, occasionally, slightly, very

TABLE 1
ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	G S A Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
616-098	2741m	A 50% Sand, mostly unconsolidated, fine-med grained, subangular, well sorted, clear White	N9	
		B 35% Shale, platy, soft to mod hard, non-calc. Mod caved. Dark to med dark grey	N3-4	8.56
		C 15% Shale, silty, platy to blocky, soft to mod hard, non-calc. Med grey	N5	1.26
		Minor coal and other shale		
		L C M - metal turnings		
616-099	2756m	A 45% Shale, as 616-098B. Minor cavings	N3-4	22.03,23.28
		B 45% Sand, as 616-098A	N9	
		C 10% Coal, blocky, brittle. Greyish black to dark grey	N2-3	28.08
		Minor other shale		
		L C M - metal and cement		
616-100	2771m	A 98% Coal, as 616-099C	N2-3	46.18
616-101	2786m	A 80% Coal, as 616-099C	N2-3	58.16
		B 20% Sand, as 616-098A	N9	
616-102	2801m	A 98% Coal, as 616-099C	N2-3	61.08
		Minor sand		
616-103	2816m	A 98% Coal, as 616-099C	N2-3	50.42
		Minor sand		
616-104	2831m	A 85% Shaly coal, platy to blocky, brittle Greyish black to dark grey	N2-3	32.30
		B 15% Sand, as 616-098A	N9	
		Minor shale		
616-105	2846m	A 50% Shaly coal, as 616-104A. Minor cavings	N2-3	50.86,50.74
		B 25% Sand, as 616-098A	N9	
		C 25% Shale, platy, soft to mod hard, non-calc. Med to med brownish grey	N5-5YR5/1	3.30
616-106	2861m	A 75% Shaly coal, as 616-104A. Minor cavings	N2-3	45.66
		B 15% Sand, as 616-098A	N9	
		C 10% Shale, as 616-105C	N5-5YR5/1	2.74
		Minor mud		
616-107	2876m	A 85% Shaly coal, as 616-104A. Minor cavings	N2-3	35.96
		B 10% Sand, as 616-098A	N9	
		C 5% Shale, as 616-105C. Mod caved	N5-5YR5/1	0.92
616-108	2891m	A 98% Coal, platy to blocky, brittle, arg. in part. Mod caved. Greyish black to dark grey	N2-3	34.14,36.30
		Minor sand		
616-109	2906m	A 90% Shaly coal, as 616-104A. Minor cavings	N2-3	23.30
		B 10% Sand, as 616-098A	N9	
		Minor shale		
616-110	2921m	A 80% Shaly coal, as 616-104A. Minor cavings	N2-3	27.00
		B 20% Shale, platy to subfissile, soft to mod hard, non-calc. Med to med brownish grey	N5-5YR5/1	1.65
		Minor sandstone		

Abbreviations = arenaceous, argillaceous, calcareous, Cut, dolomitic, Fluorescence, foraminifera, fossiliferous
Lost Circulation Material, moderately, occasionally, slightly, very

TABLE 1

ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	G S A Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
616-111	2936m	A 70% Shaly coal, platy to blocky, brittle Greyish black to dark grey. Minor cavings	N2-3	47.08
		B 20% Sand, mostly unconsolidated, fine-med grained, subangular, well sorted, clear. White	N9	
		C 10% Shale, platy to subfissile, soft to mod hard, non-calc. Med to med brownish grey	N5-5YR5/1	1.66
		Minor L C M		
616-112	2951m	A 85% Shaly coal, as 616-111A. Minor cavings	N2-3	59.68,59.86
		B 15% Sand, as 616-111B	N9	
		Minor shale		
		Minor L C M		
616-113	2966m	A 85% Shaly coal, as 616-111A. Minor cavings	N2-3	47.08
		B 15% Sand, as 616-111B	N9	
		Minor shale		
		Minor L C M		
616-114	2981m	A 90% Shaly coal, as 616-111A. Minor cavings	N2-3	40.24
		B 10% Sand, as 616-111B	N9	
		Minor shale		
		Minor L C M		
616-115	2996m	A 70% Shale, platy to subfissile, soft to mod hard, sl silty, non-calc. Med dark grey	N4	1.59
		B 30% Shale, blocky to subfissile, mod hard non-calc. Sl carbonaceous. Dark grey	N3	16.66
		Minor sand and other shale		
616-116	3011m	A 75% Shale, as 616-115A. Mod caved	N4	11.41
		B 25% Shale, as 616-115B. Minor cavings	N3	1.36
		Minor limestone and sand		
616-117	3026m	A 45% Shale, platy, soft to mod hard, non-calc. Dark to med dark grey	N3-4	6.26,6.36
		B 35% Sand, unconsolidated, fine-med grained subangular, well sorted, clear. White	N9	
		C 20% Coal, blocky, brittle, vitreous lustre Greyish black	N2	46.92
		Minor other shale and limestone		
616-118	3041m	A 70% Shale, platy, mod hard, non-calc, sl. carbonaceous? Minor cavings. Dark grey	N3	13.30
		B 25% Shale, platy to subfissile, soft to mod hard, non-calc. Sl silty. Med dark to brownish grey	N4-5YR4/1	1.31
		C 5% Coal, as 616-117C.	N2	44.12
		Minor sand and other shale		
616-119	3056m	A 60% Shale, as 616-118A. Minor cavings	N3	9.44,9.45
		B 40% Shale, as 616-118B	N4-5YR4/1	1.91
		Minor coal, mostly caved		
616-120	3071m	A 55% Shale, as 616-118A. Minor cavings	N3	11.24
		B 30% Shale, as 616-118B	N4-5YR4/1	1.01
		C 15% Sand, as 616-117B. Minor coal.	N9	

Abbreviations = arenaceous, argillaceous, calcareous, Cut, dolomitic, Fluorescence, foraminifera, fossiliferous Lost Circulation Material, moderately, occasionally, slightly, very

TABLE 1

ORGANIC CARBON RESULTS AND GROSS LITHOLOGIC DESCRIPTIONS

GEOCHEM SAMPLE NUMBER	DEPTH	GROSS LITHOLOGIC DESCRIPTION	GSA Colour Code	TOTAL ORGANIC CARBON (Wt. % of Rock)
616-121	3086m	A 75% Shale, platy to subfissile, soft to mod hard, non-calc. Sl silty. Med dark to brownish grey. Mod caved	N4-5YR4/1	1.16
		B 20% Shale, platy, mod hard, non-calc, sl carbonaceous? Mod caved. Dark grey	N3	13.52
		C 5% Sand, unconsolidated, fine-med grained subangular, well sorted, clear. White	N9	
		Minor coal		
616-122	3101m	A 70% Shale, as 616-121A. Mod caved	N4-5YR4/1	1.62,1.62
		B 30% Shale, as 616-121B. Mod caved	N3	7.71
		Minor coal and sandstone		
616-123	3116m	A 65% Shale, as 616-121A. Mod caved	N4-5YR4/1	2.06
		B 35% Shale, as 616-121B. Mod caved	N3	3.65
		Minor coal		
616-124	3131m	A 55% Shale, platy, mod hard, brittle, non-calc. Minor cavings. Med dark to med grey	N4-5	3.12
		B 45% Sand, mostly unconsolidated, fine grained, subangular, clear. White	N9	
		Minor other shale		
616-124A	3139m	A 80% Shale, as 616-0124A	N4-5	2.12
		B 20% Sand, as 616-124B	N9	
		Minor other shale		
		Minor L C M		

Abbreviations = arenaceous, argillaceous, calcareous, Cut, dolomitic, Fluorescence, foraminifera, fossiliferous
Lost Circulation Material, moderately, occasionally, slightly, very

TABLE 2A

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN AIR SPACE GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
616-001	1000	18	1	1	0	0	20	2	10.7	0	1.13
616-002	1030	6	0	0	0	0	6	0	0.0	0	0.00
616-003	1060	2	0	0	0	0	2	0	0.0	0	0.00
616-004	1090	9	0	0	0	0	9	0	0.0	0	0.00
616-005	1120	7	0	0	0	0	7	0	0.0	0	0.00
616-006	1150	11	0	0	0	0	11	0	0.0	0	0.00
616-007	1180	31	0	0	0	0	31	0	0.0	0	0.00
616-008	1210	9	0	0	0	0	9	0	0.0	0	0.00
616-009	1240	11	0	0	0	0	11	0	0.0	0	0.00
616-010	1270	8	0	0	0	0	8	0	0.0	0	0.00
616-011	1300	6	0	0	0	0	6	0	0.0	0	0.00
616-012	1330	7	0	0	0	0	7	0	0.0	0	0.00
616-013	1360	2	0	0	0	0	2	0	0.0	0	0.00
616-014	1390	7	0	0	0	0	7	0	0.0	0	0.00
616-015	1420	3	0	0	0	0	3	0	0.0	0	0.00
616-016	1450	11	1	0	0	0	11	1	5.3	0	0.00
616-017	1480	3	4	0	0	0	7	4	53.1	0	0.00
616-018	1500	10	1	1	0	0	11	1	12.1	0	0.00
616-019	1515	4	0	0	0	0	4	0	0.0	0	0.00
616-020	1530	5	0	0	0	0	5	0	0.0	0	0.00
616-021	1545	2096	12	24	5	3	2139	43	2.0	0	1.88
616-022	1560	29	0	0	0	0	29	0	0.0	0	0.00
616-023	1575	35	0	1	0	0	36	1	2.7	0	0.00
616-024	1590	9	0	0	0	0	9	0	0.0	0	0.00
616-025	1605	8	0	0	0	0	8	0	0.0	0	0.00
616-026	1620	55	3	0	0	0	58	3	4.8	0	0.00
616-027	1635	7	0	0	0	0	7	0	0.0	0	0.00
616-028	1650	7	0	0	0	0	7	0	0.0	0	0.00
616-029	1675	59	1	0	0	0	60	1	1.4	0	0.00
616-030	1690	12	0	0	0	0	12	0	0.0	0	0.00

TABLE 2 A

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN AIR SPACE GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
616-031	1705	8	0	0	0	0	8	0	0.0	0	0.00
616-032	1720	85	1	1	0	0	87	2	2.2	0	0.00
616-033	1735	6	0	0	0	0	6	0	0.0	0	0.00
616-034	1750	8	0	0	0	0	8	0	0.0	0	0.00
616-035	1765	6	1	0	0	0	7	1	13.8	0	0.00
616-036	1780	24	0	0	0	0	24	0	0.0	0	0.00
616-037	1795	15	0	0	0	0	15	0	0.0	0	0.00
616-038	1810	26	0	0	0	0	26	0	0.0	0	0.00
616-039	1825	7	0	0	0	0	7	0	0.0	0	0.00
616-040	1840	13	0	0	0	0	13	0	0.0	0	0.00
616-041	1855	10	4	0	0	0	14	4	29.6	0	0.00
616-042	1870	30	0	0	0	0	30	0	0.0	0	0.00
616-043	1885	11	0	0	0	0	11	0	0.0	0	0.00
616-044	1900	20	2	0	0	0	22	2	10.1	0	0.00
616-045	1915	2370	73	6	3	3	2455	85	3.5	0	1.12
616-046	1930	15	0	0	0	0	15	0	0.0	0	0.00
616-047	1945	23	1	0	0	0	25	1	5.6	0	0.00
616-048	1960	2388	103	9	2	1	2503	115	4.6	30	1.61
616-049	1975	3165	128	11	2	1	3306	142	4.3	0	1.54
616-050	1990	2523	162	14	2	1	2702	179	6.6	0	1.64
616-051	2005	11	0	0	0	0	11	0	0.0	0	0.00
616-052	2020	967	57	9	1	1	1034	68	6.5	0	1.68
616-053	2035	613	106	32	4	2	757	143	19.0	0	2.24
616-054	2050	3344	204	75	18	26	3667	323	8.8	3	0.67
616-055	2065	5527	570	437	73	95	6702	1175	17.5	9	0.76
616-056	2080	4842	667	614	109	152	6384	1542	24.2	121	0.71
616-057	2095	23	0	0	0	0	23	0	0.0	0	0.00
616-058	2110	14	0	0	0	0	14	0	0.0	0	0.00
616-059	2125	16318	3123	4015	1692	3493	28642	12324	43.0	12012	0.48
616-060	2140	34	18	79	41	67	239	205	85.7	326	0.61

TABLE 2A

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN AIR SPACE GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	iC_4 / nC_4
616-061	2155	38	36	322	422	588	1405	1366	97.3	4639	0.72
616-062	2170	12	5	26	19	29	90	79	87.0	401	0.65
616-063	2185	21	5	3	0	0	29	8	27.7	0	0.00
616-064	2200	21	5	3	2	4	35	14	40.1	4	0.37
616-065	2215	12	0	0	0	0	12	0	0.0	0	0.00
616-066	2230	38	3	6	9	18	73	36	48.7	0	0.50
616-067	2245	4579	1204	2689	1142	2136	11750	7171	61.0	16392	0.53
616-068	2260	771	253	654	372	623	2673	1902	71.2	8777	0.60
616-069	2290	8	1	2	1	3	16	7	47.3	0	0.47
616-070	2305	6	0	0	0	0	6	0	0.0	0	0.00
616-071	2320	1771	1524	1786	551	899	6532	4760	72.9	1922	0.61
616-072	2335	1853	911	2061	669	1160	6654	4800	72.1	2745	0.58
616-073	2350	4077	1446	2411	724	1156	9814	5737	58.5	2279	0.63
616-074	2365	6378	3786	3222	757	1390	15533	9155	58.9	3979	0.54
616-075	2380	5225	3524	4021	1208	2071	16048	10824	67.4	6266	0.58
616-076	2395	3694	2832	3297	1161	1958	12941	9248	71.5	6328	0.59
616-077	2410	2588	1743	2012	749	1253	8344	5757	69.0	4558	0.60
616-078	2425	3866	1464	2610	1322	2235	11497	7631	66.4	7553	0.59
616-079	2440	1117	658	1716	911	1605	6008	4891	81.4	4939	0.57
616-080	2455	5197	3637	5459	1627	2907	18827	13630	72.4	6570	0.56
616-081	2470	3352	3228	5972	1894	3335	17780	14428	81.1	8203	0.57
616-082	2485	4690	3525	5440	1672	2938	18264	13574	74.3	7870	0.57
616-083	2500	8272	6607	11303	3754	6659	36595	28323	77.4	16081	0.56
616-084	2515	868	726	1679	653	1290	5216	4349	83.4	5988	0.51
616-085	2545	1684	1170	1179	239	478	4749	3066	64.5	2240	0.50
616-086	2560	1623	1906	2359	534	1038	7460	5837	78.2	3747	0.51
616-087	2575	4808	5205	5806	1190	2151	19160	14352	74.9	5009	0.55
616-088	2590	1698	1987	2054	344	678	6761	5063	74.9	3186	0.51
616-089	2605	1791	1876	1626	270	518	6082	4291	70.5	1166	0.52
616-090	2620	3676	4268	3765	638	1136	13482	9807	72.7	1348	0.56

TABLE 2A

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN AIR SPACE GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	iC_4 / nC_4
616-091	2635	2131	3017	3070	521	899	9637	7507	77.9	1084	0.58
616-092	2650	2469	3434	3317	556	922	10699	8230	76.9	1146	0.60
616-093	2665	22490	10802	4462	553	893	39200	16710	42.6	786	0.62
616-094	2681	82	56	29	0	0	166	85	50.9	0	0.00
616-095	2696	48493	30162	10075	1069	1232	91031	42537	46.7	2130	0.87
616-096	2711	44522	26184	7459	780	807	79753	35231	44.2	1778	0.97
616-097	2726	15046	9441	3009	368	367	28231	13185	46.7	912	1.00
616-098	2741	67736	40216	11849	1541	1621	122964	55228	44.9	2666	0.95
616-099	2756	53679	33665	12563	1671	1176	102753	49074	47.8	1864	1.42
616-100	2771	71931	41954	9738	924	486	125032	53102	42.5	131	1.90
616-101	2786	13333	10963	2395	301	176	27167	13834	50.9	129	1.71
616-102	2801	58973	32090	4902	494	219	96677	37704	39.0	59	2.26
616-103	2816	38687	22074	5181	705	311	66958	28271	42.2	375	2.27
616-104	2831	5376	21576	2571	327	140	29991	24614	82.1	44	2.34
616-105	2846	69965	39959	7186	1183	536	118829	48864	41.1	823	2.21
616-106	2861	178946	93940	13543	2772	1125	290327	111381	38.4	1668	2.46
616-107	2876	10137	60233	35879	9809	1397	117455	107318	91.4	1639	7.02
616-108	2891	52957	26807	4092	945	357	85158	32200	37.8	410	2.65
616-109	2906	50608	17738	1741	390	144	70620	20012	28.3	100	2.70
616-110	2921	41994	20495	3110	622	247	66468	24474	36.8	351	2.52
616-111	2936	39296	17019	2242	449	208	59214	19918	33.6	450	2.16
616-112	2951	71306	38220	7806	1245	551	119128	47822	40.1	220	2.26
616-113	2966	108319	57962	13463	1890	816	182449	74130	40.6	763	2.32
616-114	2981	28725	12491	2805	502	254	44777	16052	35.8	258	1.98
616-115	2996	39076	20736	5730	979	531	67051	27975	41.7	569	1.84
616-116	3011	34861	14028	4262	816	516	54483	19622	36.0	545	1.58
616-117	3026	48735	26047	7256	1087	662	83787	35052	41.8	672	1.64
616-118	3041	28401	15150	5363	930	451	50294	21893	43.5	375	2.06
616-119	3056	50471	27190	5309	925	498	84392	33921	40.2	569	1.86
616-120	3071	71826	36141	9238	1649	851	119705	47879	40.0	662	1.94

TABLE 2A

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN AIR SPACE GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
616-121	3086	42735	20283	4674	908	514	69114	26379	38.2	899	1.77
616-122	3101	23927	10981	2496	514	305	38223	14296	37.4	524	1.69
616-123	3116	3134	334	78	16	10	3571	437	12.2	11	1.58
616-124	3131	19594	4538	1379	320	235	26066	6471	24.8	529	1.36
616-124A	3139	22263	6487	2606	584	455	32395	10132	31.3	723	1.28

TABLE 2B

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN CUTTINGS GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	iC_4 / nC_4
616-001	1000	142	3	2	3	3	155	12	8.0	0	1.05
616-002	1030	315	4	4	2	1	326	11	3.5	0	1.15
616-003	1060	725	3	3	1	1	733	8	1.2	0	0.86
616-004	1090	166	10	3	0	0	179	13	7.2	0	0.00
616-005	1120	218	7	4	2	2	233	15	6.6	0	1.15
616-006	1150	135	5	3	2	2	147	11	7.8	0	0.96
616-007	1180	369	10	7	8	4	397	28	7.1	0	1.77
616-008	1210	133	5	3	2	1	144	11	7.8	0	1.15
616-009	1240	99	3	2	2	1	108	9	8.3	0	1.61
616-010	1270	105	5	3	2	1	116	11	9.3	0	1.15
616-011	1300	134	4	3	2	1	144	10	7.1	0	1.44
616-012	1330	110	0	0	0	0	110	0	0.0	0	0.00
616-013	1360	130	4	4	2	1	141	11	7.6	0	1.44
616-014	1390	230	3	2	2	1	239	8	3.5	0	1.44
616-015	1420	196	3	3	2	1	205	9	4.5	0	1.15
616-016	1450	105	5	4	2	2	118	13	11.0	0	1.34
616-017	1480	173	4	3	3	2	186	12	6.7	0	1.64
616-018	1500	121	8	11	9	11	160	39	24.2	20	0.79
616-019	1515	140	15	11	2	2	170	30	17.7	12	0.99
616-020	1530	201	19	25	9	9	263	62	23.7	0	0.97
616-021	1545	612	23	40	13	11	699	87	12.4	15	1.18
616-022	1560	123	10	20	9	7	169	47	27.5	30	1.29
616-023	1575	787	14	34	9	6	849	63	7.4	17	1.50
616-024	1590	343	20	39	12	10	424	81	19.1	34	1.25
616-025	1605	1063	25	52	14	11	1165	103	8.8	14	1.31
616-026	1620	76	10	5	3	2	95	20	20.7	0	1.44
616-027	1635	176	8	19	21	7	232	56	24.2	9	2.95
616-028	1650	218	11	17	24	9	279	61	21.8	24	2.76
616-029	1675	141	8	7	9	6	172	30	17.7	7	1.61
616-030	1690	108	6	6	3	2	125	18	14.1	10	1.30

TABLE 2B

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN CUTTINGS GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
616-031	1705	183	8	11	6	6	214	30	14.2	9	0.98
616-032	1720	351	13	14	9	6	393	42	10.7	0	1.48
616-033	1735	385	8	8	3	2	406	21	5.1	0	1.15
616-034	1750	329	7	5	5	3	349	19	5.5	5	2.05
616-035	1765	239	12	8	9	4	273	34	12.4	7	2.07
616-036	1780	47	3	3	1	1	56	9	15.3	0	1.54
616-037	1795	100	14	6	2	1	123	23	18.4	0	1.44
616-038	1810	61	4	5	2	1	73	12	16.6	0	1.38
616-039	1825	53	4	7	1	1	67	14	20.5	0	1.54
616-040	1840	35	3	2	0	0	40	6	14.1	0	1.15
616-041	1855	54	11	5	0	0	71	16	23.0	0	0.00
616-042	1870	36	3	4	1	1	45	9	19.4	0	1.54
616-043	1885	38	9	3	1	1	53	14	27.2	15	1.54
616-044	1900	35	10	3	1	1	49	14	29.4	6	1.73
616-045	1915	465	35	7	3	2	512	47	9.1	0	1.72
616-046	1930	79	18	4	0	0	100	21	21.5	0	0.00
616-047	1945	204	25	5	2	2	238	34	14.2	0	1.15
616-048	1960	1114	44	6	0	0	1164	50	4.3	0	0.00
616-049	1975	1155	68	16	4	2	1245	91	7.3	137	1.96
616-050	1990	745	76	18	2	2	842	97	11.5	18	1.15
616-051	2005	790	76	20	3	3	892	103	11.5	11	1.27
616-052	2020	662	89	149	22	22	942	281	29.8	7	1.00
616-053	2035	65	0	0	0	0	65	0	0.0	0	0.00
616-054	2050	89	20	14	5	7	135	46	34.3	0	0.80
616-055	2065	87	28	83	31	58	286	199	69.5	9	0.54
616-056	2080	54	14	50	24	47	190	135	71.3	40	0.52
616-057	2095	24	2	2	1	1	30	6	19.3	1	1.15
616-058	2110	52	19	56	78	179	384	332	86.5	1866	0.44
616-059	2125	177	52	77	94	214	613	436	71.1	7909	0.44
616-060	2140	409	320	3848	4630	7745	16954	16544	97.6	46703	0.60

TABLE 2B

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN CUTTINGS GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	iC_4/nC_4
616-061	2155	66	25	305	1540	2982	4918	4852	98.7	41693	0.52
616-062	2170	322	209	2299	3566	6846	13242	12920	97.6	48250	0.52
616-063	2185	118	30	667	2353	4381	7549	7431	98.4	53661	0.54
616-064	2200	89	52	98	475	1051	1765	1676	95.0	28003	0.45
616-065	2215	63	29	234	782	1548	2656	2593	97.6	30096	0.51
616-066	2230	68	43	84	247	585	1027	959	93.3	22982	0.42
616-067	2245	138	65	486	874	1878	3440	3302	96.0	31230	0.47
616-068	2260	94	74	138	315	752	1372	1279	93.2	27774	0.42
616-069	2290	174	149	1094	1492	2801	5710	5536	97.0	34594	0.53
616-070	2305	35	13	21	30	77	175	140	79.7	5251	0.38
616-071	2320	95	95	760	733	1304	2987	2892	96.8	5136	0.56
616-072	2335	94	80	419	444	843	1880	1786	95.0	4826	0.53
616-073	2350	98	66	271	201	386	1021	924	90.4	3077	0.52
616-074	2365	270	281	791	402	791	2535	2265	89.3	4714	0.51
616-075	2380	305	140	624	659	1244	2973	2668	89.7	8369	0.53
616-076	2395	236	119	542	702	1253	2852	2616	91.7	7423	0.56
616-077	2410	217	112	512	630	1126	2598	2381	91.7	6871	0.56
616-078	2425	162	81	428	699	1328	2698	2536	94.0	10015	0.53
616-079	2440	51	32	144	373	778	1377	1326	96.3	8807	0.48
616-080	2455	109	127	665	719	1448	3068	2959	96.4	8606	0.50
616-081	2470	127	148	877	1093	2213	4458	4331	97.2	10497	0.49
616-082	2485	99	112	661	789	1657	3317	3218	97.0	8942	0.48
616-083	2500	75	78	415	513	1122	2203	2128	96.6	7510	0.46
616-084	2515	47	10	37	54	137	285	238	83.5	2989	0.39
616-085	2545	335	51	224	144	284	1038	704	67.8	1439	0.51
616-086	2560	283	56	194	158	355	1046	763	73.0	1974	0.45
616-087	2575	246	191	737	316	550	2040	1794	87.9	1582	0.57
616-088	2590	269	96	342	163	358	1228	959	78.1	1871	0.46
616-089	2605	307	44	130	68	151	698	392	56.1	1176	0.45
616-090	2620	146	90	398	194	374	1202	1056	87.9	1560	0.52

TABLE2 B

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN CUTTINGS GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
616-091	2635	148	94	423	229	438	1332	1183	88.9	1494	0.52
616-092	2650	150	115	528	269	493	1554	1404	90.4	1456	0.54
616-093	2665	191	446	876	190	308	2012	1820	90.5	744	0.61
616-094	2681	1317	2792	1922	384	578	6993	5676	81.2	1100	0.66
616-095	2696	1473	3606	2425	401	490	8396	6923	82.5	1146	0.82
616-096	2711	919	3390	2180	278	379	7146	6227	87.1	598	0.73
616-097	2726	239	913	704	103	145	2105	1866	88.6	461	0.72
616-098	2741	366	569	389	69	98	1490	1125	75.5	405	0.71
616-099	2756	3155	2984	1031	139	126	7436	4281	57.6	432	1.10
616-100	2771	9651	8012	4402	455	232	22751	13100	57.6	134	1.97
616-101	2786	2175	5555	2331	245	148	10455	8280	79.2	223	1.65
616-102	2801	79425	7404	3025	323	145	90322	10898	12.1	109	2.23
616-103	2816	9852	7680	3292	430	171	21424	11572	54.0	260	2.52
616-104	2831	7925	6944	1697	230	110	16906	8981	53.1	262	2.08
616-105	2846	3243	4280	1340	218	113	9194	5951	64.7	400	1.93
616-106	2861	5919	5306	1295	259	106	12885	6966	54.1	280	2.45
616-107	2876	7951	6468	2022	458	153	17051	9100	53.4	303	2.98
616-108	2891	9265	6773	1889	397	127	18452	9187	49.8	135	3.12
616-109	2906	7425	5203	1195	253	101	14176	6751	47.6	193	2.51
616-110	2921	8258	5497	1291	251	106	15403	7145	46.4	37	2.36
616-111	2936	2975	2773	752	168	96	6764	3789	56.0	478	1.75
616-112	2951	6159	4967	1520	247	118	13011	6851	52.7	261	2.10
616-113	2966	9720	7275	3033	388	147	20563	10844	52.7	79	2.63
616-114	2981	7014	4395	1226	184	93	12912	5898	45.7	175	1.99
616-115	2996	2215	1558	556	88	60	4477	2262	50.5	111	1.47
616-116	3011	812	1433	804	157	112	3318	2506	75.5	257	1.40
616-117	3026	5544	5534	2532	368	196	14173	8629	60.9	271	1.88
616-118	3041	7324	3970	1250	169	93	12806	5482	42.8	96	1.81
616-119	3056	5244	2513	658	113	49	8577	3333	38.9	48	2.33
616-120	3071	4307	1728	465	103	39	6642	2334	35.1	316	2.65

TABLE 2B

CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS IN CUTTINGS GAS

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
616-121	3086	2239	1338	511	97	68	4252	2014	47.4	185	1.41
616-122	3101	6863	2846	895	177	107	10889	4026	37.0	234	1.66
616-123	3116	3099	1522	660	169	166	5616	2517	44.8	1744	1.02
616-124	3131	164	180	161	50	57	611	447	73.2	870	0.87
616-124A	3139	70	116	180	47	53	466	396	84.9	464	0.89

TABLE 2C

TOTAL CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS (1A + 1B)

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	iC_4 / nC_4
616-001	1000	160	4	3	4	4	175	15	8.3	0	1.06
616-002	1030	320	4	4	2	1	332	11	3.4	0	1.15
616-003	1060	727	3	3	1	1	735	8	1.2	0	0.86
616-004	1090	175	10	3	0	0	188	13	6.8	0	0.00
616-005	1120	225	7	4	2	2	241	15	6.4	0	1.15
616-006	1150	146	5	3	2	2	157	11	7.3	0	0.96
616-007	1180	400	10	7	8	4	428	28	6.6	0	1.77
616-008	1210	141	5	3	2	1	152	11	7.4	0	1.15
616-009	1240	110	3	2	2	1	119	9	7.6	0	1.61
616-010	1270	114	5	3	2	1	124	11	8.7	0	1.15
616-011	1300	140	4	3	2	1	150	10	6.8	0	1.44
616-012	1330	117	0	0	0	0	117	0	0.0	0	0.00
616-013	1360	132	4	4	2	1	143	11	7.4	0	1.44
616-014	1390	237	3	2	2	1	246	8	3.4	0	1.44
616-015	1420	199	3	3	2	1	208	9	4.4	0	1.15
616-016	1450	116	5	4	2	2	130	14	10.5	0	1.34
616-017	1480	177	8	3	3	2	192	16	8.3	0	1.64
616-018	1500	131	8	12	9	11	171	40	23.4	20	0.79
616-019	1515	144	15	11	2	2	174	30	17.4	12	0.99
616-020	1530	205	19	25	9	9	268	62	23.3	0	0.97
616-021	1545	2708	35	64	18	13	2838	130	4.6	15	1.32
616-022	1560	151	10	20	9	7	198	47	23.6	30	1.29
616-023	1575	821	15	34	9	6	885	63	7.2	17	1.50
616-024	1590	352	20	39	12	10	433	81	18.7	34	1.25
616-025	1605	1071	25	52	14	11	1174	103	8.7	14	1.31
616-026	1620	131	12	5	3	2	153	23	14.7	0	1.44
616-027	1635	183	8	19	21	7	239	56	23.5	9	2.95
616-028	1650	225	11	17	24	9	286	61	21.2	24	2.76
616-029	1675	200	9	7	9	6	231	31	13.5	7	1.61
616-030	1690	120	6	6	3	2	138	18	12.8	10	1.30

TABLE 2C

TOTAL CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS (1A + 1B)

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
616-031	1705	191	8	11	6	6	221	30	13.7	9	0.98
616-032	1720	435	14	15	9	6	479	44	9.2	0	1.48
616-033	1735	392	8	8	3	2	412	21	5.0	0	1.15
616-034	1750	337	7	5	5	3	356	19	5.4	5	2.05
616-035	1765	245	13	8	9	4	280	35	12.5	7	2.07
616-036	1780	71	3	3	1	1	80	9	10.7	0	1.54
616-037	1795	116	14	6	2	1	138	23	16.4	0	1.44
616-038	1810	87	4	5	2	1	99	12	12.2	0	1.38
616-039	1825	61	4	7	1	1	74	14	18.4	0	1.54
616-040	1840	47	3	2	0	0	53	6	10.7	0	1.15
616-041	1855	64	15	5	0	0	85	20	24.1	0	0.00
616-042	1870	66	3	4	1	1	74	9	11.6	0	1.54
616-043	1885	49	9	3	1	1	63	14	22.7	15	1.54
616-044	1900	54	12	3	1	1	71	17	23.4	6	1.73
616-045	1915	2835	108	13	6	4	2967	131	4.4	0	1.36
616-046	1930	94	18	4	0	0	115	21	18.6	0	0.00
616-047	1945	227	26	5	2	2	263	35	13.4	0	1.15
616-048	1960	3502	147	15	2	1	3667	165	4.5	30	1.61
616-049	1975	4319	197	27	6	3	4552	233	5.1	137	1.83
616-050	1990	3268	238	31	4	3	3545	276	7.8	18	1.34
616-051	2005	801	76	20	3	3	903	103	11.4	11	1.27
616-052	2020	1629	146	158	23	22	1977	348	17.6	7	1.02
616-053	2035	678	106	32	4	2	821	143	17.5	0	2.24
616-054	2050	3433	225	88	23	33	3802	369	9.7	3	0.69
616-055	2065	5614	597	520	104	153	6988	1374	19.7	18	0.68
616-056	2080	4897	681	664	133	199	6574	1677	25.5	161	0.67
616-057	2095	47	2	2	1	1	53	6	10.8	1	1.15
616-058	2110	66	19	56	78	179	398	332	83.5	1866	0.44
616-059	2125	16496	3175	4092	1786	3707	29255	12759	43.6	19921	0.48
616-060	2140	444	338	3928	4671	7812	17193	16749	97.4	47029	0.60

TABLE 2C

TOTAL CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS (1A + 1B)

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
616-061	2155	104	60	627	1962	3570	6323	6219	98.4	46332	0.55
616-062	2170	334	214	2325	3585	6875	13332	12998	97.5	48651	0.52
616-063	2185	139	35	670	2353	4381	7578	7439	98.2	53661	0.54
616-064	2200	110	57	101	477	1055	1800	1690	93.9	28007	0.45
616-065	2215	76	29	234	782	1548	2669	2593	97.2	30096	0.51
616-066	2230	106	46	91	256	602	1101	995	90.4	22982	0.42
616-067	2245	4717	1269	3176	2015	4014	15190	10474	68.9	47623	0.50
616-068	2260	864	328	791	687	1375	4045	3181	78.6	36551	0.50
616-069	2290	182	150	1096	1494	2803	5725	5543	96.8	34594	0.53
616-070	2305	41	13	21	30	77	181	140	77.2	5251	0.38
616-071	2320	1866	1620	2546	1283	2203	9519	7652	80.4	7058	0.58
616-072	2335	1947	990	2480	1113	2004	8533	6587	77.2	7571	0.56
616-073	2350	4175	1512	2681	926	1542	10835	6661	61.5	5356	0.60
616-074	2365	6648	4067	4013	1159	2181	18068	11420	63.2	8693	0.53
616-075	2380	5530	3665	4645	1866	3316	19021	13491	70.9	14635	0.56
616-076	2395	3929	2951	3840	1862	3211	15793	11864	75.1	13751	0.58
616-077	2410	2804	1855	2524	1379	2379	10942	8137	74.4	11428	0.58
616-078	2425	4028	1545	3037	2021	3563	14195	10167	71.6	17568	0.57
616-079	2440	1168	690	1859	1284	2384	7385	6217	84.2	13747	0.54
616-080	2455	5306	3764	6124	2346	4355	21895	16589	75.8	15176	0.54
616-081	2470	3479	3375	6849	2987	5548	22238	18759	84.4	18700	0.54
616-082	2485	4789	3636	6101	2460	4595	21581	16792	77.8	16812	0.54
616-083	2500	8347	6686	11719	4267	7781	38799	30452	78.5	23590	0.55
616-084	2515	914	736	1716	707	1428	5501	4587	83.4	8977	0.50
616-085	2545	2018	1221	1403	383	763	5787	3769	65.1	3679	0.50
616-086	2560	1906	1962	2553	692	1393	8506	6600	77.6	5721	0.50
616-087	2575	5054	5396	6543	1506	2701	21200	16146	76.2	6590	0.56
616-088	2590	1966	2083	2395	507	1036	7988	6022	75.4	5057	0.49
616-089	2605	2098	1920	1756	337	669	6780	4682	69.1	2342	0.50
616-090	2620	3821	4358	4163	832	1510	14684	10863	74.0	2909	0.55

TABLE 2C

TOTAL CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS (1A + 1B)

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
616-091	2635	2279	3111	3493	750	1337	10969	8690	79.2	2578	0.56
616-092	2650	2619	3549	3845	825	1415	12253	9634	78.6	2602	0.58
616-093	2665	22681	11248	5339	743	1201	41212	18531	45.0	1530	0.62
616-094	2681	1398	2848	1951	384	578	7159	5760	80.5	1100	0.66
616-095	2696	49966	33768	12499	1471	1722	99426	49460	49.7	3277	0.85
616-096	2711	45441	29575	9639	1058	1186	86899	41458	47.7	2376	0.89
616-097	2726	15286	10354	3713	472	511	30336	15051	49.6	1373	0.92
616-098	2741	68102	40785	12238	1611	1719	124454	56352	45.3	3070	0.94
616-099	2756	56834	36649	13594	1810	1302	110189	53355	48.4	2296	1.39
616-100	2771	81581	49965	14140	1380	717	147783	66202	44.8	265	1.92
616-101	2786	15508	16518	4727	546	324	37622	22114	58.8	353	1.68
616-102	2801	138397	39494	7927	817	364	186999	48602	26.0	168	2.25
616-103	2816	48540	29754	8472	1135	481	88382	39843	45.1	635	2.36
616-104	2831	13302	28520	4268	557	250	46897	33595	71.6	306	2.23
616-105	2846	73208	44238	8526	1402	649	128023	54815	42.8	1223	2.16
616-106	2861	184865	99246	14838	3031	1231	303211	118347	39.0	1948	2.46
616-107	2876	18088	66701	37901	10266	1550	134507	116419	86.6	1943	6.62
616-108	2891	62222	33580	5982	1342	484	103610	41387	39.9	545	2.77
616-109	2906	58033	22941	2935	643	245	84796	26763	31.6	293	2.62
616-110	2921	50252	25992	4400	873	353	81871	31619	38.6	388	2.47
616-111	2936	42271	19791	2994	617	304	65978	23707	35.9	928	2.03
616-112	2951	77465	43187	9326	1492	669	132139	54674	41.4	481	2.23
616-113	2966	118038	65237	16496	2278	963	203012	84974	41.9	841	2.36
616-114	2981	35739	16886	4031	687	347	57689	21950	38.0	434	1.98
616-115	2996	41291	22294	6286	1067	591	71528	30237	42.3	680	1.81
616-116	3011	35673	15461	5066	973	628	57801	22128	38.3	803	1.55
616-117	3026	54279	31581	9788	1455	858	97960	43681	44.6	943	1.70
616-118	3041	35725	19120	6613	1099	544	63100	27375	43.4	471	2.02
616-119	3056	55714	29702	5967	1038	547	92968	37254	40.1	616	1.90
616-120	3071	76134	37869	9703	1752	889	126347	50213	39.7	978	1.97

TABLE 2C

TOTAL CONCENTRATION (VOL. PPM OF ROCK) OF C_1 - C_7 HYDROCARBONS (1A + 1B)

GEOCHEM SAMPLE NUMBER	DEPTH	C_1 Methane	C_2 Ethane	C_3 Propane	iC_4 Isobutane	nC_4 Butane	TOTAL C_1 - C_4	TOTAL C_2 - C_4	% GAS WETNESS	TOTAL C_5 - C_7	$\frac{iC_4}{nC_4}$
616-121	3086	44974	21621	5185	1005	582	73367	28393	38.7	1085	1.73
616-122	3101	30791	13827	3391	692	412	49112	18321	37.3	758	1.68
616-123	3116	6233	1856	738	185	176	9187	2954	32.2	1754	1.05
616-124	3131	19758	4718	1540	369	291	26677	6918	25.9	1399	1.27
616-124A	3139	22334	6603	2786	630	508	32862	10528	32.0	1187	1.24

TABLE 3

DETAILED GASOLINE (C4-C7) ANALYSIS

GEOCHEM SAMPLE NUMBER	059	061	067	072	075	125
DEPTH	2125	2155	2245	2335	2380	2401
isobutane	1.41	1.30	0.74	11.39	3.81	1.41
n-butane	2.03	2.70	2.46	5.80	8.06	4.48
isopentane	4.01	7.91	5.75	8.10	5.06	5.12
n-pentane	2.48	3.89	1.27	10.79	6.13	6.94
2,2-dimethylB	0.90	0.96	0.31	0.81	1.12	0.22
cyclopentane(CP)	1.64	2.68	1.00	1.54	1.75	1.02
2,3-dimethylB	1.04	1.31	0.17	0.77	0.72	0.64
2-methylP	10.22	7.84	9.39	6.65	6.54	4.26
3-methylP	6.83	4.36	4.98	3.24	3.18	2.59
n-hexane	4.44	2.02	4.48	6.87	8.02	7.81
methylCP(MCP)	5.33	5.32	7.90	4.35	5.37	6.24
2,2-dimethylP	5.00	0.81	1.11	0.51	0.36	0.36
2,4-dimethylP	0.00	0.00	0.00	0.00	0.00	0.00
2,2,3-trimethylB	0.00	0.00	0.00	0.00	0.00	0.00
benzene	0.71	1.78	0.74	0.90	0.67	3.01
cyclohexane(CH)	5.57	6.44	8.95	4.22	4.43	8.41
3,3-dimethylP	0.00	0.00	0.00	0.00	0.00	0.00
1,1-dimethylCP	0.00	0.00	0.00	0.00	0.00	0.00
2-methylH	6.21	8.52	4.84	3.33	5.73	3.58
2,3-dimethylP	0.00	0.00	0.00	0.00	0.00	0.00
3-methylH	5.12	3.55	2.70	2.64	4.43	2.24
1,c,3-dimethylCP	1.67	1.12	1.09	1.92	3.00	1.10
1,t,3-dimethylCP	1.61	2.01	1.05	1.88	2.15	0.96
1,t,2-dimethylCP	5.07	6.15	6.29	2.43	3.16	2.05
3-ethylP	0.28	0.00	0.71	0.00	0.00	0.00
n-heptane	5.76	5.08	9.72	8.40	7.93	6.91
methylCH(MCH)	18.81	19.24	21.28	11.90	16.17	16.77
1,c,2-dimethylCP	0.90	2.85	1.50	0.68	0.76	1.31
toluene	2.94	2.16	1.60	0.87	1.47	12.57
ABUNDANCE	3542	34695	40187	7815	7976	6251
MCP/benzene	7.55	2.98	10.71	4.86	8.00	2.07
MCP/MCH	0.28	0.28	0.37	0.37	0.33	0.37
CH/MCP	1.05	1.21	1.13	0.97	0.82	1.35
iP/nP	1.61	2.03	4.53	0.75	0.82	0.74
%n-PARAFFINS	14.72	13.69	17.92	31.86	30.14	26.14
%iso-PARAFFINS	41.04	36.54	30.68	37.45	30.94	20.42
% NAPHTHENES	40.60	45.82	49.05	28.92	36.78	37.86
% AROMATICS	3.64	3.95	2.34	1.77	2.14	15.58

TABLE 3

DETAILED GASOLINE (C4-C7) ANALYSIS

GEOCHEM SAMPLE NUMBER	083	126	087	096	106	121
DEPTH	2500	2526	2575	2711	2861	3086
isobutane	3.12	0.43	5.14	15.71	6.26	9.98
n-butane	4.07	1.29	9.99	26.18	21.27	40.61
isopentane	13.87	3.12	5.05	8.15	25.06	14.74
n-pentane	6.76	4.81	16.14	6.88	8.57	6.73
2,2-dimethylB	0.39	0.19	0.49	0.37	0.20	0.41
cyclopentane(CP)	1.72	1.37	1.47	0.97	0.59	1.11
2,3-dimethylB	0.33	0.22	0.61	0.30	0.07	0.20
2-methylP	7.47	3.82	6.07	5.39	4.85	3.98
3-methylP	3.96	2.38	3.75	2.17	2.90	1.39
n-hexane	9.05	7.70	7.54	2.54	5.93	3.11
methylCP(MCP)	5.68	6.19	6.77	5.83	4.62	3.93
2,2-dimethylP	0.81	0.36	0.86	0.67	0.07	0.20
2,4-dimethylP	0.00	0.00	0.00	0.00	0.00	0.00
2,2,3-trimethylB	0.00	0.00	0.00	0.00	0.00	0.00
benzene	1.03	2.88	1.30	1.12	0.23	0.42
cyclohexane(CH)	7.32	8.80	5.83	2.17	1.19	1.24
3,3-dimethylP	0.00	0.00	0.00	0.00	0.00	0.00
1,1-dimethylCP	0.00	0.00	0.00	0.00	0.00	0.00
2-methylH	2.65	2.74	2.00	2.69	3.40	0.80
2,3-dimethylP	0.00	0.00	0.00	0.00	0.00	0.00
3-methylH	2.37	2.84	1.94	1.94	5.80	0.64
1,c,3-dimethylCP	1.29	1.48	0.88	0.52	0.71	0.44
1,t,3-dimethylCP	1.25	1.36	0.86	0.37	0.69	0.45
1,t,2-dimethylCP	1.99	2.49	2.11	4.86	1.75	1.51
3-ethylP	0.60	0.00	0.61	0.00	0.00	0.00
n-heptane	4.94	9.00	3.59	1.50	2.51	3.31
methylCH(MCH)	16.94	20.66	15.12	8.45	2.79	4.19
1,c,2-dimethylCP	1.96	0.49	0.06	0.00	0.00	0.00
toluene	0.43	15.40	1.84	1.20	0.56	0.61
ABUNDANCE	9165	278	2045	267	1213	862
MCP/benzene	5.51	2.15	5.19	5.20	20.00	9.42
MCP/MCH	0.34	0.30	0.45	0.69	1.66	0.94
CH/MCP	1.29	1.42	0.86	0.37	0.26	0.32
iP/nP	2.05	0.65	0.31	1.18	2.92	2.19
%n-PARAFFINS	24.82	22.80	37.25	37.10	38.28	53.76
%iso-PARAFFINS	35.58	16.09	26.52	37.40	48.60	32.33
% NAPHTHENES	38.14	42.83	33.09	23.19	12.33	12.88
% AROMATICS	1.47	18.28	3.14	2.32	0.79	1.03

TABLE 4
KEROGEN TYPE AND MATURATION

GEOCHEM SAMPLE NUMBER	DEPTH	ORGANIC MATTER DESCRIPTION					THERMAL MATURATION INDEX
		TYPES 40%; 10–40%; 10%	REMARKS	REWORKED (%)	PARTICLE SIZE	PRESERV-ATION	
616-060A	2140m	I;W-Am**-H;Al	H at 2- **grainy, poor quality, disseminated	-	F-M	F	1+ to 2-
616-062A	2170m	I;Al-W-Am**-H;-	minor H at 1+ and 2- **as 060A	-	M-C	G	1+ to 2- max
616-064A	2200m	I-W;Am**-H-Al;-	**as 060A	-	M	G	1+/1+ to 2-
616-066A	2230m	I;Am**-W-H;Al	**as 060A	-	M	F	1+ to 2-
616-068A	2260m	Am**;I-W;H-Al	**as 060A	-	F-M	P-F	1+ to 2-
616-070A	2305m	-;I-Am**-W-H;Al	**as 060A	-	F-M	F	1+ to 2-
616-072A	2335m	I;W-H;Am-Al		-	M-C	G	1+ to 2-
616-078A	2425m	I;W-Am**-H;Al	**as 060A	-	M	F-G	1+ to 2-
616-080A	2455m	I;W-H;Am-Al	significant H at 2-	-	M	G	1+ to 2-
616-082A	2485m	I;W-Am**-H-Al;-	**disseminated, grainy, poor quality	-	M	F	1+ to 2-
616-084A	2515m	-;Am**-H-I-W-Al;-	**as 082A	-	M	G	1+ to 2-
616-088B	2590m	-;H-W-I-Al;Am		-	M	G	1+ to 2-
616-092B	2650m	I-W;Am**-H-Al;-	**as 082A	-	F-M	P-F	1+ to 2-
616-096A	2711m	W-H**;I;Am	**includes material passing to Am	-	F-VC	F-G	1+ to 2-
616-096C	2711m	W;H-I;-		-	M-V/C	G	1+ to 2-/2-
616-102A	2801m	W;I;H		-	M-C	G	1+ to 2-
616-106A	2861m	W;H;I-Am		-	F-C	G	1+ to 2-/2-
616-112A	2951m	W;I-H**;Am	**includes material passing to Am	-	F-C	F-G	1+ to 2-/2-
616-114A	2981m	I-W;H**;Am	**includes marerial passing to Am	-	F-C	G	2-

Algal, Amorphous, Herbaceous, Inertinite, Resin, Wood

postscript = coarse, cuticle, cysts, degraded, fine, other,. structured, spore-pollen, thick-walled, unstructured

TABLE 5

VITRINITE REFLECTANCE DATA

DEPTH	SAMPLE TYPE	VITRINITE REFLECTANCE (Ro)
1690.8m	Swc	0.29
1832.2m	Swc	0.29
1882.5m	Swc	0.25
2008.4m	Swc	0.29
2012.2m	Swc	0.33
2205m	Swc	0.29
2305m	Swc	0.34
2320m	Swc	0.39
2342m	Swc	0.42
2356m	Swc	0.38
2421.7m	Swc	0.36
2440.4m	Swc	0.40
2455m	Swc	0.35
2663m	Swc	0.34
2700m	Swc	0.31
2746.6m	Swc	0.42
2923.7m	Swc	0.44
2961.2m	Swc	0.46
3061.5m	Swc	0.51
3095m	Swc	0.46

TABLE 6A
CONCENTRATION (PPM) OF EXTRACTED C_{15+} MATERIAL IN ROCK

GEOCHEM SAMPLE NUMBER	DEPTH	TOTAL EXTRACT	HYDROCARBONS			NON HYDROCARBONS			
			Paraffin - Naphthenes	Aromatics	TOTAL	Preciptd. Asphaltenes	Eluted NSO's	Non-eluted NSO's	Sulphur
616-059	2125	385	113	48	160	161	16	24	23
616-061A	2155	2303	1165	361	1526	541	63	110	63
616-067A	2245	1038	343	117	460	342	73	73	91
616-072A	2335	1811	830	276	1106	431	106	112	57
616-075	2380	830	219	171	389	263	89	66	22
616-083A	2500	1576	169	129	298	907	169	159	43
616-087	2575	1700	839	267	1106	279	141	117	57
616-096	2711	2576	699	492	1191	817	355	191	22
616-098	2741	3777	118	291	409	3155	151	53	9
616-106A	2861	20429	939	1920	2858	*	1222	175	61
616-114A	2981	11822	679	1573	2252	8575	799	120	76
616-121A	3086	1344	447	212	659	399	193	39	53

TABLE 6B

COMPOSITION (NORMALISED %) OF C_{15+} MATERIAL EXTRACTED FROM ROCK

GEOCHEM SAMPLE NUMBER	DEPTH	HYDROCARBONS		NON HYDROCARBONS			
		Paraffin – Naphthenes	Aromatics	Preciptd. Asphaltenes	Eluted NSO's	Non eluted NSO's	Sulphur
616-059	2125	29.30	12.35	41.92	4.20	6.18	6.04
616-061A	2155	50.61	15.66	23.49	2.74	4.76	2.74
616-067A	2245	33.06	11.29	32.93	6.99	6.99	8.74
616-072A	2335	45.83	15.22	23.83	5.83	6.17	3.13
616-075	2380	26.32	20.56	31.67	10.76	7.99	2.71
616-083A	2500	10.71	8.19	57.56	10.71	10.08	2.73
616-087	2575	49.33	15.73	16.39	8.31	6.90	3.34
616-096	2711	27.15	19.09	31.73	13.78	7.42	0.84
616-098	2741	3.12	7.71	83.55	4.00	1.39	0.23
616-106A	2861	4.59	9.40	78.87	5.98	0.85	0.30
616-114A	2981	5.75	13.30	72.54	6.76	1.01	0.65
616-121A	3086	33.26	15.80	29.73	14.35	2.91	3.95
616-125 +	2401	67.99	25.96	2.83	1.77	1.45	0.00
616-126 +	2526	71.57	22.80	3.54	0.76	1.33	0.00

+ CONDENSATE

TABLE 7
SIGNIFICANT RATIOS (%) OF C_{15+} FRACTIONS AND ORGANIC CARBON

GEOCHEM SAMPLE NUMBER	DEPTH	ORGANIC CARBON (wt. %)	HYDROCARBONS / TOTAL EXTRACT	HYDROCARBONS / ORG. CARBON	TOTAL EXTRACT / ORG. CARBON	P-NAPHTHENES / AROMATICS
616-059	2125	0.37	41.66	4.33	10.40	2.37
616-061A	2155	0.68	66.26	22.44	33.87	3.23
616-067A	2245	0.75	44.35	6.14	13.84	2.93
616-072A	2335	0.92	61.04	12.02	19.69	3.01
616-075	2380	0.88	46.87	4.42	9.44	1.28
616-083A	2500	0.95	18.91	3.14	16.59	1.31
616-087	2575	0.45	65.06	24.58	37.77	3.14
616-096	2711	8.79	46.24	1.36	2.93	1.42
616-098	2741	2.95	10.83	1.39	12.80	0.40
616-106A	2861	45.48	13.99	0.63	4.49	0.49
616-114A	2981	37.84	19.05	0.60	3.12	0.43
616-121A	3086	1.74	49.06	3.79	7.72	2.11
616-125 +	2401		93.95			2.62
616-126 +	2526		94.37			3.14

+ CONDENSATE

TABLE 8

MINI PYROLYSIS RESULTS

GEOCHEM SAMPLE NUMBER	DEPTH	WT. % ORGANIC CARBON (OC)	WT. PPM		RATIOS		Tmax (°C) Pyrolysate
			Thermal Bitumen (P1)	Pyrolysate (P2)	$\frac{P1}{P1+P2}$	$\frac{P2}{OC}$	
616-015B	1420	0.47	118	430	0.22	0.09	
616-016A	1450	0.35	18	1136	0.02	0.32	
616-017A	1480	0.61	54	742	0.07	0.12	
616-018A	1500	0.60	61	874	0.07	0.15	
616-019A	1515	0.86	67	742	0.08	0.09	
616-021A	1545	1.35	40	1582	0.02	0.12	
616-023A	1575	1.71	32	2070	0.02	0.12	
616-025A	1605	1.22	84	1328	0.06	0.11	
616-027A	1635	3.37	30	4301	0.01	0.13	
616-029A	1675	2.43	187	3930	0.05	0.16	
616-032A	1720	0.85	42	1419	0.03	0.17	
616-034A	1750	0.60	38	1005	0.04	0.17	
616-036A	1780	0.64	154	1798	0.08	0.28	
616-038A	1810	0.68	4	1293	0.00	0.19	
616-040A	1840	0.47	75	890	0.08	0.19	
616-042A	1870	0.47	217	694	0.24	0.15	
616-044A	1900	0.68	47	926	0.05	0.14	
616-046A	1930	0.64	148	1432	0.09	0.22	
616-048B	1960	0.60	122	987	0.11	0.16	
616-050B	1990	0.50	128	1027	0.11	0.21	
616-052B	2020	0.82	82	2222	0.04	0.27	
616-054A	2050	0.27	211	700	0.23	0.26	
616-056A	2080	0.63	35	1447	0.02	0.23	
616-058B	2110	0.44	8	567	0.01	0.13	
616-058A	2110	0.31	297	1141	0.21	0.37	
616-060A	2140	0.49	38	660	0.05	0.13	
616-062A	2170	0.55	51	599	0.08	0.11	
616-064A	2200	1.25	113	838	0.12	0.07	
616-066A	2230	1.00	184	778	0.19	0.08	
616-068A	2260	0.88	102	364	0.22	0.04	
616-070A	2305	1.06	52	555	0.09	0.05	
616-072A	2335	1.19	162	1515	0.10	0.13	
616-074A	2365	1.40	306	690	0.31	0.05	
616-076A	2395	0.91	46	542	0.08	0.06	
616-078A	2425	1.16	41	893	0.04	0.08	
616-080A	2455	1.00	103	828	0.11	0.08	
616-082A	2485	1.09	199	755	0.21	0.07	
616-084A	2515	2.14	595	4909	0.11	0.23	
616-086B	2560	1.30	209	910	0.19	0.07	
616-088A	2590	1.37	60	1519	0.04	0.11	
616-090B	2620	1.66	118	2663	0.04	0.16	
616-092B	2650	1.64	510	2424	0.17	0.15	
616-094B	2681	1.22	88	879	0.09	0.07	
616-094C	2681	40.40	1319	41361	0.03	0.10	
616-096A	2711	15.88	378	12605	0.03	0.08	
616-096C	2711	47.86	2101	43218	0.05	0.09	
616-098B	2741	8.56	700	8880	0.07	0.10	
616-100A	2771	46.18	1549	67008	0.02	0.15	
616-102A	2801	61.08	1445	71481	0.02	0.12	
616-104A	2831	32.30	573	25984	0.02	0.08	

Thermal Bitumen (Peak 1) evolved up to 340°C. Pyrolysate (Peak 2) evolved 340 – 550°C.

TABLE 8

MINI PYROLYSIS RESULTS

GEOCHEM SAMPLE NUMBER	DEPTH	WT. % ORGANIC CARBON (OC)	WT. PPM		RATIOS		Tmax (°C) Pyrolysate
			Thermal Bitumen (P1)	Pyrolysate (P2)	P1 / P1 + P2	HI P2 / OC	
616-106A	2861	45.66	1673	72847	0.02	0.16	
616-108A	2891	35.22	887	34432	0.03	0.10	
616-110A	2921	27.00	1270	22349	0.05	0.08	
616-110B	2921	1.65	130	1218	0.10	0.07	
616-112A	2951	59.74	2561	90947	0.03	0.15	
616-114A	2981	40.24	2772	64974	0.04	0.16	
616-116A	3011	11.41	213	10444	0.02	0.09	
616-118B	3041	1.31	120	1205	0.09	0.09	
616-118A	3041	13.30	434	18973	0.02	0.14	
616-120A	3071	11.24	59	10026	0.01	0.09	
616-122A	3107	1.62	69	4909	0.01	0.30	
616-124A	3137	3.12	162	4052	0.04	0.13	

Thermal Bitumen (Peak 1) evolved up to 340°C. Pyrolysate (Peak 2) evolved 340 – 550°C.

TABLE 9

EXTENDED PYROLYSIS RESULTS

GEOCHEM SAMPLE NUMBER	DEPTH	WT. % ORGANIC CARBON (OC)	WT. PPM		RATIOS		Tmax (°C) Pyrolysate
			Thermal Bitumen (P1)	Pyrolysate (P2)	P1 / P1 + P2	P2 / OC	
616-060A	2140	0.49	37	687	0.05	0.14	486
616-062A	2170	0.55	63	647	0.09	0.12	495
616-064A	2200	1.25	115	896	0.11	0.07	490
616-066A	2230	1.00	176	720	0.20	0.07	491
616-068A	2260	0.88	118	381	0.24	0.04	484
616-070A	2305	1.06	56	612	0.08	0.06	495
616-072A	2335	1.19	149	1479	0.09	0.12	494
616-078A	2425	1.16	45	889	0.05	0.08	487
616-080A	2455	1.00	121	946	0.11	0.09	485
616-082A	2485	1.09	247	831	0.23	0.08	496
616-084A	2515	2.14	656	5231	0.11	0.24	478
616-088B	2590	1.37	93	1872	0.05	0.14	493
616-092B	2650	1.64	740	2936	0.20	0.18	489
616-096A	2711	15.88	437	12842	0.03	0.08	488
616-096C	2711	47.86	2777	45162	0.06	0.09	482
616-102A	2801	61.08	2003	73356	0.03	0.12	496
616-106A	2861	45.66	1979	71630	0.03	0.16	494
616-112A	2951	59.74	2483	98632	0.02	0.17	493
616-114A	2981	40.24	2839	68234	0.04	0.17	488

Thermal Bitumen (Peak 1) evolved up to 340°C. Pyrolysate (Peak 2) evolved 340 – 550°C.

TABLE 10

COMPOSITION (NORMALISED %) OF C_{15+} PARAFFIN – NAPHTHENE HYDROCARBONS

GEOCHEM SAMPLE NUMBER	-059	-061A	-067A	-072A	-075	-083A	-087	-096	-098
DEPTH	2125m	2155m	2245m	2335m	2380m	2500m	2575m	2711m	2741m
SAMPLE TYPE									
nC_{15}	8.47	15.88	17.02	28.46	9.83	8.37	17.87	13.41	6.81
nC_{16}	13.05	17.83	24.47	21.72	14.36	21.48	19.11	15.46	8.06
nC_{17}	10.00	15.04	19.77	12.55	13.86	19.80	14.68	14.94	7.78
nC_{18}	12.03	12.53	14.10	9.74	13.18	14.09	12.47	14.12	7.71
nC_{19}	7.46	7.52	7.62	6.74	11.01	9.07	9.00	11.46	7.71
nC_{20}	6.78	5.01	3.89	4.68	9.05	5.86	6.09	8.80	5.07
nC_{21}	6.44	3.34	2.27	3.37	6.29	4.46	4.16	5.73	5.00
nC_{22}	6.10	3.06	1.62	2.25	4.72	3.21	3.05	3.68	3.68
nC_{23}	6.44	3.34	1.78	2.06	4.13	3.21	2.77	2.76	6.94
nC_{24}	5.93	3.62	1.62	1.69	3.15	3.07	2.22	1.84	4.17
nC_{25}	5.42	3.34	1.62	1.50	2.95	3.07	2.63	2.15	9.17
nC_{26}	4.41	2.51	1.46	1.50	2.46	1.81	1.94	1.23	4.10
nC_{27}	3.22	1.11	0.97	1.31	2.16	0.98	1.39	1.64	9.24
nC_{28}	1.69	1.11	0.49	0.94	1.18	0.42	0.69	0.82	3.47
nC_{29}	0.51	1.11	0.32	0.37	0.88	0.28	0.42	1.23	7.15
nC_{30}	0.51	0.84	0.16	0.19	0.29	0.14	0.42	0.20	1.46
nC_{31}	0.34	0.84	0.16	0.19	0.10	0.14	0.28	0.10	0.97
nC_{32}	0.34	0.56	0.16	0.19	0.10	0.14	0.28	0.10	0.83
nC_{33}	0.34	0.56	0.16	0.19	0.10	0.14	0.28	0.10	0.49
nC_{34}	0.34	0.56	0.16	0.19	0.10	0.14	0.14	0.10	0.14
nC_{35}	0.17	0.28	0.16	0.19	0.10	0.14	0.14	0.10	0.07
PARAFFIN	7.37	5.64	25.35	24.75	33.71	28.27	9.81	45.17	37.06
ISOPRENOID	0.86	0.80	3.66	2.41	4.28	3.79	1.17	6.06	4.53
NAPHTHENE	91.77	93.56	70.99	72.85	62.02	67.94	89.02	48.77	58.41
CPI INDEX A	1.06	0.93	1.03	1.05	1.08	1.11	1.10	1.21	1.88
CPI INDEX B	1.06	1.04	1.09	0.99	1.19	1.30	1.16	1.71	2.35
PRISTANE/PHYTANE	1.23	1.55	1.22	1.89	1.43	1.74	1.61	1.47	3.29
PRISTANE/nC_{17}	0.64	0.57	0.40	0.51	0.54	0.43	0.50	0.53	1.21

TABLE 10

COMPOSITION (NORMALISED %) OF C_{15+} PARAFFIN – NAPHTHENE HYDROCARBONS

GEOCHEM SAMPLE NUMBER	-106A	-114A	-121A	-125	-126
DEPTH	2861m	2981m	3086m	2401-5m	2526m
SAMPLE TYPE					
nC_{15}	4.97	3.55	6.27	15.15	19.42
nC_{16}	5.51	4.39	8.55	14.48	16.93
nC_{17}	5.78	5.02	6.84	11.98	12.47
nC_{18}	4.97	5.02	6.70	10.93	10.76
nC_{19}	5.38	5.54	4.99	9.68	8.40
nC_{20}	4.57	4.39	4.13	8.05	7.09
nC_{21}	4.70	4.39	4.13	6.62	5.64
nC_{22}	4.44	4.28	3.99	5.66	4.86
nC_{23}	7.66	6.17	9.40	4.60	3.94
nC_{24}	5.51	5.43	5.98	3.74	3.02
nC_{25}	11.02	11.49	12.39	3.07	2.36
nC_{26}	5.38	6.17	5.84	2.30	1.71
nC_{27}	11.29	11.81	10.11	1.63	1.31
nC_{28}	4.97	5.64	3.70	1.05	0.79
nC_{29}	9.14	10.14	2.71	0.67	0.52
nC_{30}	2.15	2.51	2.14	0.29	0.26
nC_{31}	1.61	1.57	0.71	0.10	0.26
nC_{32}	0.40	1.25	0.43	0.00	0.13
nC_{33}	0.27	0.84	0.43	0.00	0.13
nC_{34}	0.13	0.31	0.28	0.00	0.00
nC_{35}	0.13	0.10	0.28	0.00	0.00
PARAFFIN	36.78	41.45	10.92	65.64	68.10
ISOPRENOID	8.70	7.62	1.20	10.38	15.01
NAPHTHENE	54.52	50.93	87.88	23.98	16.89
CPI INDEX A	1.73	1.62	1.83	1.03	1.04
CPI INDEX B	2.20	2.01	1.80	0.00	1.16
PRSITANE/PHYTANE	6.33	6.65	4.13	1.95	1.02
PRISTANE/nC_{17}	3.53	3.19	1.29	0.87	0.89

TABLE 11

METHANE CARBON ISOTOPE RATIOS

GEOCHEM SAMPLE NO.	DEPTH	AIRSPACE METHANE	CUTTINGS METHANE
616-049	1975m	-	-37.4
616-055	2065m	-28.0	-
616-059	2125m	-45.7	-
616-067	2245m	-32.6	-
616-074	2365m	-38.0	-
616-125*	2401.5m	-37.6	-
616-126*	2526m	-42.6	-
616-098	2741m	-38.8	-
616-102	2801m	-32.3	-38.8
616-103	2816m	-51.0	-
616-107	2876m	-45.5	-37.0
616-112	2951m	-43.7	-
616-117	3026m	-44.0	-
616-121	3086m	-44.4	-33.5
616-124	3131m	-38.5	-

*gas/condensate

TABLE 12

C_{15+} HYDROCARBON CARBON ISOTOPE RATIOS

GEOCHEM SAMPLE NUMBER	DEPTH	PARAFFIN-NAPHTHENE ‰	AROMATICS ‰
616-096	2711m	-28.2	-27.3
616-106A	2861m	-31.5	-29.7
616-114A	2981m	-28.7	-28.2
616-125	CONDENSATE	-28.6	-26.6
616-126	CONDENSATE	-28.6	-26.8

BRIEF DESCRIPTION OF THE ANALYSES PERFORMED BY GEOCHEM

"Screen Analyses" are described in sections A, C and D, "Sample Preparation" in section B, "Follow-up Analyses" in sections E through K and "Correlation Studies" in section L. The analyses can be run on either core or cuttings material with the proviso that samples must be canned for the C_1-C_7 analysis and should be canned (or at least wet) for the C_4-C_7 analysis. The other analyses can be run on both canned and bagged samples.

A) C_1-C_7 LIGHT HYDROCARBON ANALYSIS

The abundance and composition of the C_1-C_7 hydrocarbons in sediments reflects their source richness, maturity and the character of the hydrocarbons they can yield. Most importantly, it is extremely sensitive to the presence of migrated hydrocarbons and is an excellent method for their detection. As it provides the information on most of the critical parameters and is also economical, this analysis is excellent for screening samples to decide which of them merit further analysis.

During the time which elapses betwwen the collection of the sample at the wellsite and its analysis in the laboratory, a fraction of the total gas passes from the rock to the air space at the top of the can. For this reason, both the air space and the cuttings are analysed.

The analysis involves the gas chromatographic separation of the individual C_1-C_4 gaseous hydrocarbons (methane, ethane, propane, isobutane and normal butane) and a partial resolution of the C_5-C_7 gasoline-range hydrocarbons (for their complete resolution see Section E). The ppm abundance of the five gases and of the total C_5-C_7 hydrocarbons are calculated from their electronically integrated peak areas (not from peak height) by comparison with a standard.

In the report, the following data are tabulated: the abundance and composition of the air space gas, of the cuttings gas and of the combined air space and cuttings gases. The combined results are also presented graphically.

B) SAMPLE WASHING AND HAND PICKING

All of the analyses described in subsequent sections are run on washed and hand picked samples.

Cuttings are washed to remove the drilling mud, care being taken not to remove soft clays and fine sand during the washing procedure. Using the C_1-C_7 hydrocarbon data profile of the well, or the organic carbon profile (if this analysis is used for screening), electric logs (if supplied) and the appearance of the cuttings under the binocular microscope, samples are selected to represent the lithological and geochemical zones penetrated by the well. These samples are then carefully hand picked and the lithology of the uncaved material is described. It is these samples which are submitted for further analysis.

Sample material remaining after analysis is retained for six months. Unless instructions are received to the contrary, Geochem Laboratories may then destroy the samples.

Our reports incorporate a gross lithological description of all the samples which have been analysed and litho percentage logs. As screen analyses are recommended at narrow intervals, a complete lithological profile is obtained.

C) ORGANIC CARBON ANALYSIS

The organic carbon content of a rock is a measure of its total organic richness. Combined with the visual kerogen, C_1-C_7, C_4-C_7, pyrolysis and C_{15+} analyses, the organic carbon content is used to evaluate the potential (not necessarily actual) hydrocarbon source richness of the sediment. This analysis is an integral part of a total evaluation and it can also be used as an economical screen analysis for dry samples (when the C_1-C_7 analysis cannot be used).

Hand picked samples are dried, crushed and then acidised to remove the inorganic calcium and magnesium carbonates. The actual analysis involves combustion in a Leco carbon analyser. Blanks, standards and duplicates are run routinely for purposes of quality control at no extra cost to the client.

The data are tabulated and presented diagramatically in our reports in a manner which facilitates comparison with the gross lithology (see Section B) of the samples.

D) MINI-PYROLYSIS

An ideal screen analysis which provides a definitive measure of potential source richness upon those samples whose organic carbon contents suggest fair or good source potential. This is described in detail in section K.

E) DETAILED C_4-C_7 HYDROCARBON ANALYSIS

The abundance and composition of the C_4-C_7 gasoline-range hydrocarbons in sediments reflects their source quality, level of thermal maturation and organic facies. In addition, the data also reveal the presence of migrated hydrocarbons and can be used for crude oil-parent source rock correlation studies.

This powerful analysis, performed upon hand picked lithologies, is employed as a follow-up to confirm the potential of samples which have been selected using the initial screen analysis. It is used in conjunction with the organic carbon, visual kerogen and C_{15+} analyses.

The individual normal paraffins, isoparaffins, naphthenes and aromatics with between four and seven carbon atoms in the molecule (but also including toluene) are resolved by capillary gas chromatography and their peak areas electronically integrated.

Normalised compositions, selected ratios and the ppm abundance of the total gasoline-range fraction are tabulated in the report and also presented graphically.

F) KEROGEN TYPE AND MATURATION

Kerogen is the insoluble organic matter in rocks. Visual examination of the kerogen gives a direct measure of thermal maturity and of the composition of the organic matter (organic facies) and indicates the source quality of the sediment - which is confirmed using the organic carbon, light hydrocarbon, pyrolysis and C_{15+} analyses.

The type of hydrocarbon (oil or gas) generated by a source rock is a function of the types and level of thermal maturation of the organic matter which are present. Both of these parameters are measured directly by this method.

Kerogen is separated from the inorganic rock matrix by acid digestion and flotation methods which avoid oxidation of the organic matter. It is then mounted on a glass slide and examined at high and low magnifications with a Leitz microscope. Chemical methods measure the total kerogen population but, with this technique, individual particles can be selected for examination and spurious material identified. This is particularly valuable in reworked, contaminated and turbodrilled sediments.

The following data are generated: the types of organic matter present and their relative abundances, an estimate of the proportion of reworked material, preservation state, the thermal maturity of the non-reworked organic matter using the spore colouration technique.

Our maturation scale has been developed to digitise small but recognisable changes in organic matter colouration resulting from increasing maturity and to place particular emphasis upon the immature to mature transition. In the absence of a universal colouration scale, the most significant points on our scale have been calibrated against equivalent vitrinite reflectance values. The following maturation stages are recognised at the low end of the scale:-

a) immature; thermal index less than 2- (0.45% Ro)
b) marginally mature; indices between 2- and 2. Minor hydrocarbon generation from amorphous and herbaceous (± algal) organic matter
c) mature; indices between 2 (0.53% Ro) and 2 to 2+ (0.72% Ro), significant generation from amorphous, algal and herbaceous organic matter but wood only marginally mature
d) oil window; indices of 2 to 2+ (0.72% Ro) through to 3 (1.2% Ro). Peak hydrocarbon generation.

The condensate zone starts at a thermal index of 3 whilst indices of 3+ (2.0% Ro) and higher indicate the eometamorphic dry gas stage.

A total of fourteen types of organic matter are sought based upon the major categories of algal, amorphous, herbaceous (spore, pollen, cuticle), wood, inertinite and resin. This detail is essential for a proper understanding of hydrocarbon source potential as the different sub-groups within each category have different properties.

Upon completion of the study, the kerogen slides are sent to the client.

G) VITRINITE REFLECTANCE

Vitrinite reflectance is an alternative/confirmatory method for evaluating thermal maturation which is used in conjection with the visual kerogen analysis. The reflectivity of vitrinite macerals increases in response to thermal alteration and is used to define maturation levels and, by projection, to predict maturity at depth or the thicknesses of section removed by erosion.

Measurements are made upon kerogen separations in conjunction with polished whole rock samples. In general, this analysis is performed upon the same samples as the visual kerogen analysis, thus facilitating a direct comparison of the two sets of results.

If possible, forty to fifty measurements are taken per sample - unless the sediments are organically lean, vitrinite is sparse or only a single uniform population is present. The data are plotted in a histogram which distinguishes the indigenous vitrinite from possible reworked or caved material. Averages are calculated for each population. Comments upon exinite fluorescence and upon the character of the phytoclasts are noted on the histograms. The reports contain the tabulated data, histograms and the reflectivities plotted against depth.

The vitrinite and visual kerogen techniques provide mutually complementary information upon maturity, organic matter type and diagenesis.

H) C_{15+} EXTRACTION, DEASPHALTENING AND CHROMATOGRAPHIC SEPARATION

Sections "A" and "E" dealt with analyses covering the light end of the hydrocarbon spectrum. This section is concerned with the solvent extractable organic material in the rock with more than fourteen carbon atoms in the molecule (i.e. the heavy end). The amount and composition of this extract indicates source richness and type, the level of thermal maturation and the possible presence of migrated hydrocarbons.

These results are integrated with those derived from the pyrolysis, visual kerogen, organic carbon and light hydrocarbon analyses.

The techniques involved in this analysis employ pure solvents and have been designed to give reproducible results. Hand picked samples are ground and then solvent extracted in a soxhlet apparatus, or by blending, with dichloromethane (the solvent system can be adapted to client's specifications). After asphaltene precipitation, the total extract is separated by column chromatography or high pressure liquid chromatography into the following fractions: paraffin-naphthene hydrocarbons, aromatic hydrocarbons, eluted NSO's (nitrogen-, sulphur-, and oxygen- containing non-hydrocarbons) and non-eluted NSO's. Note that the non-hydrocarbons are split into three fractions and not reported as a gross value. These fractions can be submitted for further analyses (carbon isotopes, gas chromatography, high mass spectroscopy) including correlation studies.

For convenience and thoroughness, the data are reported in three formats: the weights of the fractions, ppm abundances and normalised percentage compositions. The data are also presented diagramatically.

J) GC ANALYSIS OF C_{15+} PARAFFIN-NAPHTHENE HYDROCARBONS

The gas chromatographic configurations of the heavy C_{15+} paraffin-naphthene hydrocarbons reflect source type, the degree of thermal maturation and the presence and character of migrated hydrocarbons or contamination.

Not only is this analysis an integral part of any source rock study but it also provides a fingerprint for correlation purposes and helps to define the geochemical/palynological environmental character of the source rocks from which crude oils were derived.

The paraffin-naphthene hydrocarbons obtained by column chromatography are separated by high resolution capillary chromatography. Excellent resolution of the individual normal paraffins, isoprenoids and significant individual isoparaffins and naphthenes is achieved. Runs are normally terminated at nC_{35}. A powerful in-house microprocessor system is being introduced to correct for the change in response factor with chain length.

The normal paraffin carbon preference indices (C.P.I.) indicate if odd (values in excess of 1) or even (values less than 1) normal paraffins are dominant. Strong odd preferences ($\pm$ strong pristane peaks) are characteristic of immature land plant organic matter whilst even preferences ($\pm$ strong phytane peaks) suggest a reducing environment of deposition. With increasing maturity, values approach 1.0 and oils are typically close to 1.0. The indices are calculated using the following formulae:

$$C.P.I_A = \frac{\dfrac{C_{21} + C_{23} + C_{25} + C_{27}}{C_{20} + C_{22} + C_{24} + C_{26}} + \dfrac{C_{21} + C_{23} + C_{25} + C_{27}}{C_{22} + C_{24} + C_{26} + C_{28}}}{2}$$

$$C.P.I_B = \frac{\dfrac{C_{25} + C_{27} + C_{29} + C_{31}}{C_{24} + C_{26} + C_{28} + C_{30}} + \dfrac{C_{25} + C_{27} + C_{29} + C_{31}}{C_{26} + C_{28} + C_{30} + C_{32}}}{2}$$

Chromatograms are reproduced in the report for use as visual fingerprints and in addition, the following data are tabulated: normalised normal paraffin distributions; proportions of paraffins, isoprenoids and naphthenes in the total paraffin-naphthene fraction; C.P.I$_A$ and C.P.I$_B$; pristane to phytane ratio; pristane to nC_{17} ratio.

K) PYROLYSIS

The process of thermal maturation can be simulated in the laboratory by pyrolysis, which involves heating the sample under specified conditions and measuring the oil-like material which is freed/generated from the rock. With this analysis, the potential richness of immature sediments can be determined and, by coupling the pyrolysis unit to a gas chromatograph, the liberated material can be characterised. These results are correlated with those obtained from the organic carbon, kerogen and C_{15+} analyses.

Small amounts of powdered sample are heated in helium to release the thermal bitumen (up to 340°C) and pyrolysate (340-550°C). The thermal bitumen correlates with the solvent extractable material (see above) whilst the pyrolysate fraction does not exist in a "free" state but is generated from the kerogen, thus simulating maturation in the subsurface. Abundances (weight ppm of rock) are measured with a flame ionisation detector against a standard. Thermal bitumen includes source indigenous, contaminant and migrated hydrocarbons but the pyrolysate abundance is a measure of ultimate source richness. The capillary gas chromatogram of the pyrolysate is used to evaluate the character of the parent organic matter and whether it is oil or gas prone. Peak temperature(s) of pyrolysate evolution is recorded. Carbon dioxide can be measured if requested but is normally ignored as the separation of the organic and inorganic species has been found to be artificial and unreliable.

Pyrolysate yields provide a definitive measure of potential source richness which avoids the ambiguities of the organic carbon data and the problem of contamination. This analysis is also used to evaluate the quality and character of the organic matter and the degree to which it has realised its ultimate hydrocarbon potential. Geochem does not employ the pyrolysis technique to evaluate maturation, preferring the kerogen and vitrinite reflectance analyses which avoid the problem of reworking and hence, are more reliable.

Capillary chromatograms produced for the pyrolysate hydrocarbons range from C_1 (methane) out towards C_{35} but exhibit considerable variations. They are used to define whether a source rock will yield oil, condensate or gas. With this new technique, it is now possible to complete the evaluation of a source rock.

The data are tabulated and presented graphically. MINI-PYROLYSIS includes ppm thermal bitumen and ppm pyrolsate. PYROLYSIS also provides the above together with the temperature of peak pyrolysate evolution. The capillary chromatograms of the pyrolysate obtained by PYROLYSIS-GC are reproduced in the report. The Mini-Pyrolysis analysis is recommended as a screening technique.

L) CORRELATION STUDY ANALYSES

Oil to oil and oil to parent source rock correlation studies require high resolution analytical techniques. This requirement is satisfied by some of the analyses discussed above but others have been selected specifically for correlation work. Many of these analyses also provide information upon the character of the environment of deposition of the parent source rocks.

- detailed C_4-C_7 hydrocarbon (gasoline range) analysis. See Section E. Although these hydrocarbons can be affected by migrational/alteration processes, they commonly provide a very useful correlation parameter.
- capillary gas chromatography of the C_{15+} paraffin-naphthenes. See section J. The branched±normal paraffin distributions are used to "fingerprint" the samples.
- capillary chromatograms of whole oils and of the C_{8+} fraction of source rocks.
- capillary gas chromatography of C_{15+} aromatic hydrocarbons. Separate chromatograms of the hydrocarbons and of the sulphur-bearing species are reproduced.
- high pressure liquid chromatograms.
- mass spectrometric carbon isotope analyses of crude oil and rock extract fractions and of kerogen separations. A powerful tool for comparing hydrocarbons and correlating hydrocarbons to organic matter. With this technique the problem of source rock contamination can be avoided. The data are recorded on x-y or Galimov plots.
- mass fragmentograms (mass chromatograms) of fragment ions characteristic of selected hydrocarbon groups such as the steranes and terpanes. The fragmentograms provide a convenient and simple means of presenting detailed mass spectrometric data and are used as a sophisticated fingerprinting technique. This provides the ultimate resolution for correlating hydrocarbons and facilitates the examination of hydrocarbon classes.
- vanadium and nickel contents.

Suites of (rather than single) analyses are employed in correlation studies, the actual selection depending upon the complexity of the problem. See also section N.

M) <u>ANALYSES FOR SPECIAL CASES</u>

M-1) <u>ELEMENTAL KEROGEN ANALYSIS</u>

This analysis evaluates source quality, whether the sediments are oil or gas prone, the character of the organic matter and its level of thermal maturation. It is the chemical equivalent of the visual kerogen analysis. The pyrolysis analysis is generally preferred to this technique, both methods providing similar information.

M-2) <u>SULPHUR ANALYSIS</u>

The abundance of sulphur in source rocks and crude oils.

M-3) <u>CARBONATE CONTENT</u>

The mineral carbonate content of sediments is determined by acid treatment. These data are particularly useful when used in conjunction with organic carbon contents as a screening technique.

M-4) <u>NORMAL PARAFFIN ANALYSIS</u>

Following the removal of the branched paraffins and naphthenes from the total paraffin-naphthene fraction, a chromatogram of the normal paraffins is obtained. The resulting less complicated chromatogram facilitates the examination of normal paraffin distributions.

M-5) SOLID BITUMEN EVALUATION

Residual solid bitumen after crude oil is generated by three prime processes: the action of waters, gas deasphalting, thermal alteration. Thus it provides a means of determing the reservoir history of a crude and of evaluating whether adjacent traps will or will not be prospective for oil. In carbonate sections, where organic matter is sometimes sparse, this technique is also used to evaluate thermal maturation levels.

The analysis involves the determination of the solubility (in CS_2) of the solid bitumen and of the atomic hydrogen to carbon ratio of the insoluble fraction.

N) CRUDE OIL ANALYSIS

N-1) API GRAVITY

This can be performed upon large (hydrometer) and small (SG bottle, pycnometer) samples and even upon stains extracted from sediments (refractive index).

N-2) SULPHUR CONTENTS (ASTM E30-47)

N-3) POUR POINT (ASTM D97-66, IP15/67)

N-4) VISCOSITY (ASTM D445-72, IP71/75)

N-5) FRACTIONAL DISTILLATION

Graph of cumulative distillation yield against temperature. Five percent cuts taken for further analysis. Mass spectrometric studies of these fractions provide a detailed picture of the distribution of paraffins and of the various naphthene and aromatic groups within a crude, which is useful both for correlation and for refinery evaluation purposes.