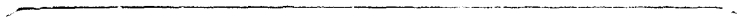
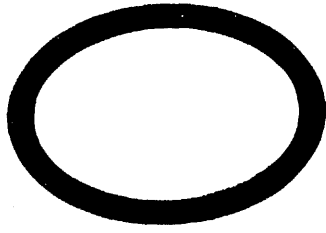




GIPPSLAND

BASIN.

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**ESSO EXPLORATION AND PRODUCTION
AUSTRALIA INC.**

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OIL and GAS DIVISION

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Esso Australia Ltd
Gippsland Basin
Geochemical Analyses

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Petroleum Geology Files

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1. Organic Analyses of five canned core samples from the Gippsland Shelf No. 1 Well, Australia, by Metter R.E. and Rohn R.E. BARRACOUTA - 1
2. Organic analyses of two canned samples from Esso Gippsland No. 3, Australia, by Metter R.E. COB-1
3. Organic analyses of samples from the Esso COB-1 Gippsland Shelf-3, and the Woodside Duck Bay-1 wells, Gippsland Basin, Australia, by Metter R.E.
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6. Canned cuttings gases from the Esso Bass-1, Bass-2 and Marlin B-1 wells, Australia - 2 by Metter R.E., Monaghan P.H., and Fry H.M., July 1967.
7. Canned cuttings hydrocarbon gases from the Barracouta A-1, Cod A-1 and Marlin A-1 wells, Australia, by Metter R.E. and Franklin L.J.
8. Comparison of oils from Marlin and Kingfish Fields, Australia, with various rock extracts from Marlin wells by Metter R.E., Fry H.M., Mercer J.N.
9. Source analysis of Sidewall cores from the Perch A-1 well Australia by Metter, Morgan, Fry and Coleman
10. Interim report on Geochemical Analyses of Gippsland Basin Oil. by Metter R.E., October, 1969
11. Geochemical Analyses of samples from Hapuku-1, Gippsland Basin, Australia by Metter R.E.
12. Geochemical analyses of cuttings from Bullseye-1 Gippsland Basin Australia by Metter R.E.
13. Oil from Oligocene "Greensand", Lakes Entrance. Koons C.B. Dec. 1970 letter
14. Gippsland Basin "Greensand" Source Analyses Koons C.B. Dec. 1970 letter

OIL and GAS DIVISION

ESSO PRODUCTION RESEARCH COMPANY

ORGANIC ANALYSES OF FIVE CANNED CORE SAMPLES
FROM THE GIPPSLAND SHELF NO. 1 WELL, AUSTRALIA

R. E. Metter
and
R. E. Rohn

August 1965

Summary

Five Tertiary cores from 2024 to 5679 feet in the Gippsland Shelf No. 1 Well have been examined for source potential. The organic matter and hydrocarbon contents of these samples are not suggestive of rocks with source potential. This conclusion is based on empirical data developed in other areas, including information from offshore Tertiary sediments of the U.S. Gulf Coast. Additional canned cores or cuttings from the area might help identify the source of the gas in the Gippsland reservoir.

Introduction

To obtain information on source potential, five canned core samples from the Gippsland Shelf No. 1 Well were analyzed for total organic matter, light gasoline (C₄-C₇) hydrocarbons, and intermediate (C₈-C₁₄) hydrocarbons. A rough measure of gas content (C₁-C₄) was also obtained as a by-product of the C₄-C₇ analysis. Sample descriptions, based on routine binocular examination, and analytical results are summarized in the accompanying table.

No geologic information was submitted with the samples; however, a rough understanding of the section drilled in the well was developed by gathering electric logs, seismic sections, production data, etc. from various Company and published sources. The core samples from 2024' and 2326', a marl and limestone, apparently come from the Gippsland Formation. The claystone core from 3351' apparently comes from the Lake Entrance Formation, which lies above the productive Latrobe Valley Coal Measures (top at 3458'). The sandstone core from 5261' seems to be from the basal part of the Latrobe Valley Coal Measures, more than a thousand feet below the productive interval (3458-3817'). The formation from which the claystone core at 5679' was taken is not known to us, but Mr. D. H. Jones, EPRCo paleontologist, has assigned it a Paleocene-Eocene age.

Interpretation

The organic matter and hydrocarbon contents of all the samples are quite low. Based on empirical correlations with the organic matter and hydrocarbon contents of samples from oil productive, gas productive and barren intervals in other parts of the world, these samples do not appear to represent oil- or gas-prone sections. However, most of our comparative information is from Paleozoic and Mesozoic sections. Present

studies of offshore Tertiary sediments from the U.S. Gulf Coast Basin indicate that oil and gas apparently may be sourced in sediments with total organic matter content in amounts as low as 0.6 to 1.0%.

The marl (2024') and limestone (2326') samples from the Gippsland formation contain only a trace of C₄-C₇ compounds and little C₁-C₄ gases. These values are not typical of samples from productive sections in the U.S. Gulf Coast or other areas. The total organic matter and C₈-C₁₄ content of the marl from 2024' are in the range of some apparent upper Tertiary sources in the U.S. Gulf Coast. The total organic matter content of the limestone from 2326' is lower than we have encountered in apparent source rocks. Based on all the analyses, these two samples are not typical of productive sections we have studied elsewhere.

The claystone (3351') sample is from the Lake Entrance Formation, a unit that geologically could be suspected as a possible source of the gas in the reservoir - because it overlies the producing unit. This sample has the lowest total organic content of the five submitted. The percent organic matter is lower than encountered in productive sections studied from the U.S. Gulf Coast or elsewhere, and, while C₄-C₇ and C₈-C₁₄ amounts are similar to those found in samples from offshore productive sections in the U.S. Gulf Coast, we would, therefore, not classify this as representative of an oil- or gas-prone section.

The core from 5261' is a sandstone, a possible reservoir. We have not found that analyses of reservoir rocks are helpful in indicating source potential.

The claystone core from 5679' is lean in organic matter and has only a trace of C₈-C₁₄ hydrocarbons. It does not have an organic composition typical of significant hydrocarbon source intervals in other areas.

These remarks regarding source potential are based on only five samples. These cannot be considered to represent all the possible source sediments encountered in the 8693 feet penetrated by the well. For example, the only sample from the coal measures, a possible source, is of reservoir lithology. Our conclusions regarding source potential are based on empirical correlations with data we have developed in studies of other areas. Factors involving lateral or vertical migration and other geologic variables cannot be considered from the information on hand. Additional source potential studies of cased cores or cuttings from this and nearby wells might help identify the source beds of the gas that has been discovered in this well.

Sample Description of Analytical Results

EPRCo No.	Approximate Depth (feet)	Formation	Age	Lithology	% Total Organic Matter	ppm Gas (C ₁ -C ₄) ³	ppm Light Gasoline (C ₄ -C ₇)	ppm Intermediate Hydrocarbon (C ₈ -C ₁₄)
48651	2024	Gippsland ¹	Tertiary?	Marl, light olive gray, trace of skeletal (foraminiferal) debris, sl. silty	0.63	0.11	trace	78
48652	2326	Gippsland ¹	Tertiary?	Limestone, lt. olive gray, micritic to skeletal (foraminiferal), argillaceous, sl. glauconitic.	0.29	0.16	trace	63
48653	3351	Lakes Entrance ¹	Tertiary?	Claystone, med. light gray, thin microscopic fragments of pyritized plant(?) remains.	0.27	0.33	2.3	56
48654	5261	Latrobe Valley Coal Measures ¹	Tertiary?	Sandstone, med. light gray, med. grained subangular quartz, poorly sorted, porous, sl. micaceous.	0.31	0.79	4.3	50
48655	5679		Paleocene ² Eocene	Claystone, light gray, trace of small flat black fragments (organic?).	0.34	0.69	1.1	trace

- 1 - From notes on electric log.
- 2 - From EPRCo paleo study, D. H. Jones 8-6-65.
- 3 - By-product of C₄-7 run.

ORGANIC ANALYSES OF TWO CANNED SAMPLES
FROM ESSO GIPPSLAND SHELF NO. 3, AUSTRALIA

By

R. E. Metter
December, 1965

SUMMARY

Two samples from the Esso Gippsland Shelf #3 well were analysed to assess source potential. The sample from the Lakes Entrance formation has organic characteristics similar to sources of oil and gas. The organic characteristics of the coal from the Latrobe Valley formation suggest that it could be the source of gas reservoided in the EGS-1 gas field.

INTRODUCTION

Esso Exploration Australia requested "source potential analyses" of two canned samples from their Esso Gippsland Shelf #3 well in Mr. John H. Hamlin's letter EX-1026 of November 2, 1965. Charges for this work will be billed via our charge number.

One sample was from the Lakes Entrance formation; the other sample was from the Latrobe Valley formation, which reservoirs the gas in the EGS-1 gas field.

PROCEDURES

The total organic matter, light gasoline (C₄-C₇) hydrocarbon content, and intermediate C₈-C₁₄) hydrocarbon content of both samples were measured. In addition a cuttings gas determination was made on the coal sample from the Latrobe Valley formation. Sample descriptions and the results of analyses are given in Table 1.

DISCUSSION

These analyses must be interpreted empirically to estimate source potential. The results are compared to similar analyses of rocks from other areas where we believe there are distinct patterns of hydrocarbon production (i.e., gas-prone, oil-prone or nonproductive). The results must also be interpreted in terms of the local geologic framework,

including possible times of migration, availability of traps, and available migration paths. This latter interpretation can best be made by those most familiar with the geology of the area.

Lakes Entrance Formation

A sample from this formation in the EGS-1 well studied earlier had been low (0.27%) in organic matter. The sample from this well (EGS-3), although still low, contained considerably more (0.53%) organic matter. A comparison of the analyses of the two samples is shown in Table II. The light gasoline content of each is about the same, but the total organic matter and C₈-C₁₄ hydrocarbon content is considerably higher in the sample from well No. 3. The sample from the #3 well is as rich in organic content and hydrocarbons as some samples that have been thought to be source rocks of petroleum in other areas. The amounts of hydrocarbons suggest that the organic matter is "oily" in nature and capable of generating liquid hydrocarbons as well as gas. Two samples do not adequately characterize a formation, and it is possible that shales of the Lakes Entrance formation show a greater range of organic content than is encompassed by these two samples.

Our interpretation of organic analyses are somewhat problematical in dealing with younger Tertiary strata, especially the upper Miocene and Pliocene section. We have had limited experience with samples of this age range and it is possible that organic matter in these rocks may still be undergoing notable chemical changes. If the Lakes Entrance samples are as young as upper Miocene, this should be taken into account in interpreting our results.

Latrobe Valley Formation

The coal cuttings from the Latrobe Valley formation contains considerably more wet gas than we have seen in most coal samples we have analyzed but it is common to get relatively high values of liquid hydrocarbons in an analysis of coal. The C₈-C₁₄ hydrocarbon content, when expressed as percent of total organic matter is only about 0.6%, which is considerably less than the relative amount (2.5%) of C₈-C₁₄ hydrocarbon contained in the Lakes Entrance shale sample. We believe that coal probably absorbs considerable amounts of liquid hydrocarbons and tends not to release them in significant quantities to reservoir strata.

The letter requesting this work specifically requested an opinion about possible sources of hydrocarbons in your area. It is quite possible that the Latrobe Valley formation is the source of the gas in the EGS-1 gas field. It is also possible that these beds have contributed hydrocarbons to the reservoir strata at Lakes Entrance Town Field, but the Latrobe Valley formation is probably much more gas-prone.

TABLE I

ESSO GIPPSLAND SHELF NO. 3
SAMPLE DESCRIPTIONS AND ANALYTICAL RESULTS

A. Total Organic Matter and Liquid Hydrocarbons

<u>EPRCo No.</u>	<u>Esso Ex. No.</u>	<u>Type of Sample</u>	<u>Sample Depth</u>	<u>Formation</u>	<u>Lithology of Analyzed Sample</u>	<u>% Total Organic Matter</u>	<u>ppm C₄-C₇ Hydrocarbons</u>	<u>ppm C₈-C₁₄ Hydrocarbons</u>
50937-A	AUST-156	Core	5613	Lakes Entrance	Claystone, med. olive gray, calcareous	0.53	2.5	134
50937-B	AUST-157	Cuttings	7150-70	Latrobe Valley	Coal, black to grayish black	84(±10)	295	4170

B. Cuttings Gas Analysis - Sample 50937-B (Coal)

(Gas units are in parts per million of the air space in the Waring blender used to agitate the cuttings)

<u>Methane</u>	<u>Ethane</u>	<u>Propane</u>	<u>Isobutane</u>	<u>n-Butane</u>	<u>Total Wet Gas</u>	<u>% Wet in Total Gas</u>
4467	1135	238	38	12	1422	24
					5889	

TABLE II

<u>EPRCo No.</u>	<u>Well</u>	<u>Depth</u>	<u>% T.O.M.</u>	<u>ppm C₄-C₇</u>	<u>ppm C₈-C₁₄</u>	<u>C₈-C₁₄ as % of T.O.M.</u>	<u>C₄-C₇ as % of T.O.M.</u>
48653	EGS-1	3351	0.27	2.3	56	2.1	0.85
50937-A	EGS-3	5613	0.53	2.5	134	2.5	0.47

ORGANIC ANALYSES OF SAMPLES FROM THE
ESSO GIPPSLAND SHELF-3 AND THE WOODSIDE
DUCK BAY-1 WELLS, GIPPSLAND BASIN, AUSTRALIA

by

R. E. Metter

SUMMARY

A claystone core sample from the Lower Cretaceous Strzelecki Group in the Woodside Duck Bay No. 1 well has an organic character typical of rocks believed to be sources of oil and associated gas in other areas of the world. We do not know how to interpret the source potential of coals such as the sample of the Latrobe Valley formation from the Esso Gippsland Shelf No. 3, but it is certain that considerable amounts of methane are released during coalification.

Geochemistry and Basin Geology Division
February, 1966

INTRODUCTION

Two samples were received for "hydrocarbon source analysis," which was authorized in an Esso Exploration Australia, Inc., letter of December 29, 1965, from the office of John H. Hamlin.

One of the samples was a coal fragment collected from the shale shaker of Esso Gippsland Shelf No. 3, presumably coming from approximately 7100 feet and definitely from the Eocene Latrobe Valley formation. The other sample was a claystone from the 2831-2851' interval of the Lower Cretaceous Strzelecki Group in the Woodside Duck Bay No. 1 well about 18 miles southwest of the Lakes Entrance pool.

PROCEDURE

Both samples were analyzed for total organic matter and yield of C₈-C₁₄ hydrocarbons produced by our standard thermal extraction technique. This technique releases free hydrocarbons in the sample plus a variable amount of "cracked" product. In spite of the problem of cracking, the procedure gives useful data for pre-Miocene shales. We are not yet certain how to interpret the results of this procedure in the case of very young rocks or of coals.

DISCUSSION OF RESULTS

Sample descriptions and analytical data are given in Table I. Our interpretations of the data are given below.

Our interpretations of source potential are purely empirical; that is, they are based on comparisons with analyses of samples from other parts of the world, from both productive and nonproductive sections. Furthermore, one sample seldom characterizes a formation. We have observed both vertical and lateral variations in the organic character of a single shale formation. The two samples analyzed in this job should not necessarily be considered to be representative of the complete section from which they came.

Lower Cretaceous Strzelecki Claystone

This sample has an organic composition similar to that of claystones in other areas that are believed to be source formations of oil and associated gas. The C₈-C₁₄ hydrocarbons are equivalent to approximately 2.2% of the total organic matter, which suggests an oil-prone source character.

Latrobe Valley Coal

We do not know how to interpret the source potential of coals. There is no question but that during coalification large amounts of gases are given off. However, we have little information on liquid hydrocarbons that might be released to reservoir zones, and there is the strong possibility that hydrocarbon liquids would tend to be adsorbed by the coal, rather than released.

Our analysis shows the Latrobe Valley coal sample is relatively free of impurities such as clay or silt. Although a large amount of C₈-C₁₄ hydrocarbon was produced during our analysis, it only represents approximately half a percent of the total organic matter. This ratio of C₈-C₁₄ hydrocarbons to organic matter in the case of shales would be interpreted to represent a gas-prone section. We are currently investigating the problem of how to interpret such data for coals as a part of our long-range research program, but at present we cannot give a dependable opinion on the possibility of coals being the origin of commercial oil pools.

TABLE I

Sample Description and Analytical Results

<u>EPRCo No.</u>	<u>Well</u>	<u>Approx. Depth</u>	<u>Age</u>	<u>Unit</u>	<u>Lithology</u>	<u>% Total Organic Matter</u>	<u>ppm C₈-C₁₄ Hydrocarbons</u>
51403	Duck Bay No. 1	2840	L. Cretaceous	Strzelecki Gp.	Claystone, med. gray, unctuous, brittle	0.96	210
51404	E.G.S. No. 3	7100	Eocene	Latrobe Valley	Coal, black	96.0	4700



ESSO PRODUCTION RESEARCH COMPANY

ORGANIC ANALYSES OF FOUR CANNED CORE SAMPLES FROM
THE-ESSO-GIPPSLAND SHELF NO. 4 WELL, AUSTRALIA
P.O. BOX 1

(Esso Exploration Australia Job Number 1)

R. E. Metter
H. M. Fry

Geochemistry & Basin Geology Division

March 31, 1966

INTRODUCTION

Hydrocarbon source potential analyses of four canned core samples from the Esso Gippsland Shelf-4 well were requested by Esso Exploration Australia in John H. Hamlin's February 4, 1966 letter by J. D. Langston. This service work was the first to be requested under the new Esso Exploration Australia job order numbering system. Charges for this work (Esso Exploration Australia Job No. 1) will be billed via our service charge number.

The samples, canned at the well site, came from Cores No. 12 and 14, which were cut from the intervals 7237-7267 ft and 7480-7509 ft, respectively. Esso Australia estimated their age to be Paleocene or Upper Cretaceous. Siltstones from these cores were reported to have bled a small amount of gas at the well site, and another sandstone core "from 7473-7499 ft, immediately above Core 14, bled a considerable amount of gas and contained a small oil show." Esso Australia wished to know if the samples sent for analysis contained organic matter capable of generating both gas and heavier hydrocarbons.

One of the four samples (AUST-167) is a coal. Another (AUST-164) includes both claystone and coal, which were analyzed separately. Sample AUST-165 is a siltstone and AUST-166 is a claystone.

PROCEDURE

Content of light gasoline-range hydrocarbons (C₄-C₇) in parts per million was determined for all samples. The two claystones and the siltstone were also analyzed for yield of intermediate hydrocarbons (C₈-C₁₄) and percent total organic matter. These latter analyses were not judged to be warranted for the two coal samples. Sample descriptions and analytical results are given in the table at the end of the report.

BASIS OF INTERPRETATION

Interpretations of source potential are empirical. That is, the organic compositions of new samples are merely compared to those of similar samples from other areas in the world where hydrocarbon distribution patterns are fairly well established. These other "type" areas have been categorized as being productive of "oil with associated gas," or of "dry gas" or as being relatively lean or poor in hydrocarbon accumulations.

The interpretations are complicated by sample limitations. Any single given core may not be representative of a stratigraphic unit. Any formation that has been a source of commercial hydrocarbons may have a considerable range of values of total organic and hydrocarbon content, both laterally and vertically.

Also, we may be able to show similarities between organic compositions of rocks from new and "type" areas, but we still cannot demonstrate whether or not the formations have actually given up hydrocarbons to reservoir beds.

DISCUSSION OF RESULTS

Core 14 appears more oil-prone than Core 12, but both are judged to be possible sources of hydrocarbons. The coals from each core contain far more gasoline-range hydrocarbons than average for coals, but we are not yet sure how to interpret organic data on coals. However, coals are believed to represent potential gas sources. Following are more specific comments.

Core 12

AUST-164: The claystone contains abundant total organic matter plus a high content of gasolines, but the ratios of liquid hydrocarbons to total organic matter are fairly low. Therefore, this core is interpreted to be a potential source of wet gas and distillate. The high amount of gasoline in the coal and the fact that the coalification process generates large amounts of methane support this interpretation.

AUST-165: The analyses of this sample resemble those of AUST-164 and the interpretation is the same. The slightly higher ratio of C₈-C₁₄ to total organic matter may be due to the fact that this sample is more porous and permeable and might be regarded as part reservoir.

Core 14

AUST-166: The C₈-C₁₄ content is high enough to suggest an oil-prone source potential, although the gasoline content is not particularly high. This sample is interpreted to have potential as a possible source of oil and gas.

AUST-167: Coals are assumed to be possible sources of gas. This coal sample has an unusually high content of gasolines. This supports the interpretation the section cut by Core 14 may be a possible source of liquids as well as gaseous hydrocarbons.

SAMPLE DESCRIPTIONS AND ANALYTICAL RESULTS

(All samples were identified as Paleocene-Upper Cretaceous by Esso Exploration Australia)

Esso Ex. Sample No.	EPRCo No.	Depth (feet)	Core No.	Lithology of Analyzed Core Chip	GSA Color Code	% Total Organic Matter	Ppm Light Gasolines (C ₄ -C ₇)	ppm Intermediate Hydrocarbons (C ₈ -C ₁₄)	C ₄ -C ₇ as % of T.O.M.	C ₈ -C ₁₄ as % of T.O.M.
AUST-164-A	51578-A	7248	12	Claystone, dark gray to brownish gray, silty, hard, brittle, strong, prominent slickensides, abundant microscopic coaly fragments and pyritized plant remains.	N3;5YR-3/1, 5YR-4/1	9.88	286	440	0.29	0.45
AUST-165	51578-B	7265	12	Siltstone, med. dark gray, abundant small lenses and stringers of fine-grained light gray sand, argillaceous, abundant carbonized plant fragments - some pyritized.	N4;N7	2.56	75	202	0.30	0.79
AUST-166	51578-C	7491	14	Claystone, medium gray, silty, scattered small darker areas (fossil debris?)	N5	0.84	15	120	0.18	1.43
AUST-164-B	51578-A	7248	12	Coal, black	N1		1857			
AUST-167	51578-D	7506	14	Coal, black	N1		3003			

ESSO PRODUCTION RESEARCH COMPANY

ORGANIC ANALYSIS OF CORE SAMPLE FROM ESSO GIPPSLAND SHELF NO. 4

R. E. Metter

Geochemistry and Basin Geology Division

May 1966

INTRODUCTION

A core sample from the Esso Gippsland Shelf No. 4 well was submitted by Esso Exploration Australia, Inc. for hydrocarbon source analysis. This service work was authorized in an April 14, 1966 letter from John H. Hamlin by J. D. Langston.

The sample was taken from Core No. 15, which came from 8434-8464 feet and is probably from the Upper Cretaceous section. Esso Exploration Australia reported a gross gas volume of 591 feet logged within this section at the 7049-7640 ft interval. Also, a production test of the gas zone through perforations at 7514-7574 and 7406-7466 feet flowed at a maximum rate of 11.55 MMCFGD, plus condensate at the rate of 36.4 bbl/MMCFG. Determining the source of this gas is of considerable interest. The sample submitted, of course, is from nearly a thousand feet deeper than the gas test cited above.

PROCEDURE

The sample was a silty sandstone with fine laminae and thin intervals of dark gray, micaceous carbonaceous claystone. The thickest bed of claystone (approximately a third of an inch thick) was separated from the sandstone and analyzed. Percent total organic matter and yield of intermediate hydrocarbons (hydrocarbons with 8 to 14 carbon atoms per molecule) were determined.

DISCUSSION

The analysis and sample description are as follows:

<u>EPRCo</u> <u>Sample</u> <u>Number</u>	<u>Lithology of</u> <u>Analyzed Material</u>	<u>% Total</u> <u>Organic</u> <u>Matter</u>	<u>ppm</u> <u>C₈-C₁₄</u> <u>Hydrocarbons</u>	<u>Hydrocarbons</u> <u>as %</u> <u>of T.O.M.</u>
52230	Claystone, grayish black, finely micaceous	38.2	2841	0.74

This sample is quite rich in organic content, and it yielded considerable amounts of hydrocarbon liquids. By criteria that we have used in other areas we would interpret the material to have good hydrocarbon source potential for oil and gas, with a tendency toward being gas-prone.

There is a serious problem in regard to quantity of rock material represented by this analysis. If only a few thin stringers and laminae are present there might not be enough source material available to make a commercial accumulation. However, the gross lithology appears to be typical of a tidal flat environment, which could provide widespread thicker beds of organic-rich claystones such as the one analyzed.

ESSO PRODUCTION RESEARCH COMPANY

CANNED CUTTINGS GASES FROM THE
ESSO BASS-1, BASS-2 AND MARLIN B-1 WELLS, AUSTRALIA

(Esso Exploration Australia Job No. 14)

R. E. Metter
P. H. Monaghan
H. M. Fry

Basin Geology Division

July 1967

CANNED CUTTINGS GASES FROM THE
ESSO BASS-1, BASS-2 AND MARLIN B-1 WELLS, AUSTRALIA

by

R. E. Metter
P. H. Monaghan
H. M. Fry

SUMMARY

Canned cuttings from the Oligocene section of the Marlin B-1 well in the Gippsland Basin gave up large amounts of hydrocarbon gas, including large amounts of C₂-C₄ "wet" gas. We interpret this to indicate the subsurface generation of both liquid and gaseous hydrocarbons in large amounts, which suggests that the pre-Oligocene is the main source of the oil and gas in Marlin field. Specific zones in the Miocene below 3000 feet have also generated dry gas, but lack of permeable beds in this section may have prevented significant accumulation of hydrocarbons from the Miocene.

Canned cuttings from the Esso Bass-1 and Bass-2 wells in the Bass Basin gave up considerably less "wet" gas than the Marlin well. The Bass-1 samples yielded fairly large amounts of gas, mainly methane, throughout the section. We interpret this to indicate that the section at Bass-1 had the potential to be a source of gas, with only minor liquids. The Bass-2 total cuttings gas yields were low throughout the section, with only modest amounts given up by the Eocene and Paleocene samples. However, the Bass-2 Eocene and Paleocene cuttings gas is quite "wet" with much of the gas containing over 50% C₂-C₄. This suggests that the Eocene-Paleocene section here had the potential to generate liquid as well as gaseous hydrocarbons, though in much smaller quantities than the corresponding section in the Gippsland Basin.

An attempt to evaluate the CO₂ potential of the sections by analyzing the free CO₂ in the cuttings gas was not successful, apparently because the high pH of the cuttings mixture caused the CO₂ to remain dissolved in the mixture.

INTRODUCTION

Canned cuttings samples from the Esso Bass-1 and Bass-2 wells in the Bass Basin and the EGS-5 (Marlin B-1) well in the Gippsland Basin (Fig. 1) were analyzed for their hydrocarbon gas content as a means for interpreting the hydrocarbon source potential of the sedimentary sections in these areas. This service work, which is reported here, was charged to Esso Standard Oil (Australia) Ltd.

In addition to analyzing the hydrocarbon gases an attempt was made to determine the source potential for CO₂ gas in these sections by analyzing the cuttings gas for CO₂ content. This part of the work, which is also reported here, was charged to research, and was regarded as a pilot study. It was our first attempt to evaluate CO₂ potential in this manner.

Canned cuttings were also received from wells EGS-1, EGS-3 and EGS-4 in the Gippsland Basin, and these are still being analyzed. It was requested that the analyses for the Bass Basin wells be given priority, and therefore these samples were run first. Data on the Marlin B-1 well from the Marlin oil and gas field in the Gippsland Basin was included because it provides a basis of comparison for the Bass wells. Both oil and gas have obviously been generated by the section near Marlin.

ANALYTICAL PROCEDURE

In our standard cuttings gas analysis, which was used in this project, we analyze the hydrocarbon gas that is in the air space above the cuttings in the sample can. We also later analyze the gas released after violent agitation of the cuttings with distilled water in a Waring blender. Both analyses are made by gas chromatography. Results are reported as parts per million by volume of cuttings. CO₂ gas content in the air space of the sample cans was also determined by gas chromatography.

DATA PRESENTATION

Tables

Results of the hydrocarbon gas analysis are given in Tables I, II and III for the Bass-1, Bass-2 and Marlin B-1 wells, respectively. In each table data on the "can only" gas and the "blender only" gas and total gas data for "blender and can combined" are listed.

In each category the amounts of methane, ethane, propane, isobutane and normal butane are given separately as parts per million, volume of gas per volume of cuttings. The total (C₁-C₄) hydrocarbon gas and the percent "wet" gas (C₂-C₄) in each category are also listed.

Results of the CO₂ pilot study analyses are given in Tables IV and V for wells EGS-5 and Bass-2, respectively. The pH of the cuttings and distilled water mixture in the blender and the amounts of CO₂ gas released by agitation in the blender are listed.

Figures

Figure 1 shows graphically for each well the amounts of total (C_1-C_4) and "wet" (C_2-C_4) hydrocarbon gas released from the cuttings after agitation in the blender. The strip logs are aligned on a sea level datum.

Figs. 2,3 and 4 show graphically for Bass-1, Bass-2 and EGS-5, respectively, the combined amounts of gases from the can and blender. The percent (C_2-C_4) in the total hydrocarbon gas and logs of the total mud gas determined by a hot wire detector at the well site are also plotted on separate strips. The mud gas curves were replotted from composite completion logs provided by Esso Exploration Australia, Inc.

Figs. 5 and 6 show the percent compositions of the (C_2-C_4) fractions of the gas from the top of sample cans and the gas released in the blender, respectively. The graphs of each well are aligned on a sea level datum. Iso-butane and normal butane are combined in this presentation, with total butane being given.

DISCUSSION AND INTERPRETATION OF DATA

Hydrocarbon Gas Data

Blender Gas - The blender gas data summarized in Figure 1 show a distinct difference between the Bass wells and the Marlin well, but they also show a difference between the Bass-1 and Bass-2 data. The pre-Oligocene samples from the Marlin well in general yielded considerably more total hydrocarbon gas and "wet" gas (C_2-C_4) than samples from comparable units in the Bass wells. Also, the Bass-1 samples in general yielded considerably more total gas than the Bass-2 samples. The pre-Oligocene samples from Bass-2 gave up predominantly "wet" gas while the Bass-1 samples yielded mostly methane.

The blender gas data from the pre-Oligocene of the Marlin well strongly suggest a section that has generated both liquid and gaseous hydrocarbons in considerable quantities. Three samples in the Miocene section produced moderate amounts of methane, but no significant "wet" gas. In western Canada, canned cuttings from sand-shale sections have been found to be associated with oil, "wet" gas or distillate production (if pools are present at all) where the (C_2-C_4) "wet" gas exceeds about 50% of the total hydrocarbon gas. By this criterion, the Marlin pre-Oligocene section would be interpreted to be productive of both hydrocarbon liquids and "wet" gas. The Miocene would be interpreted to have a few zones that have generated modest amounts of dry gas.

The oil and gas shows reported by Esso Exploration Australia support this interpretation. The cuttings gas data strongly suggest that the hydrocarbon liquids and gases in Marlin field came from the pre-Oligocene section. There appears to be a lack of permeable beds in the Miocene section that would have allowed the collection and accumulation of significant pools of Miocene gas.

In contrast, the Bass-1 data suggest fairly large amounts of dry gas may have been generated by the pre-Oligocene section, with less abundant generation of "wet" gas and liquids. The Bass-2 data suggest a section that has generated "wet" gas and hydrocarbon liquids, though not in large amounts.

Blender Plus Can Gas - Figs. 2-4 show a picture of gas compositions and yields comparable to that of Fig. 1. The Marlin B-1 pre-Oligocene samples gave up large amounts of total gas and "wet" gas, the Bass-1 pre-Oligocene samples yielded large amounts of mostly methane gas, and the Bass-2 samples gave up very modest amounts of "wet" gas.

Rules of thumb have not yet been established for interpreting the significant percentages of (C₂-C₄) in the total gas of the blender and can combined. However, the data are consistent with the conclusions drawn from the blender gas data alone. That is, the pre-Oligocene section at Marlin appears to have generated most of the hydrocarbons in Marlin field, but a few Oligo-Miocene zones have possible generated significant amounts of methane. The Bass-2 section has yields of gas that suggest generation of both liquid and gaseous hydrocarbons, but only in small amounts. The Bass-1 section appears to have generated fairly significant amounts of methane, but considerably smaller amounts of "wet" gas and liquids.

Composition Of Wet Gas - Figs. 5 and 6 show a difference in the composition of the (C₂-C₄) gas between the Marlin well and the Bass wells. In both the "can" gas and the "blender" gas from the pre-Oligocene section the Marlin well shows relatively low amounts of butane and relatively high amounts of ethane as compared to the Bass wells. We have no experience in interpreting such data and can only observe that this difference exists. It will be of interest to see if this difference between the Bass and Gippsland Basin sections persists in samples from other wells that are scheduled for analysis.

Carbon Dioxide Data

In analyzing the canned cuttings gas for CO₂ we found free carbon dioxide in only a few cans for the EGS-5 well, and none was found in any of the samples from the Esso Bass-2 well. However, we do not believe that these results depict the original CO₂ content of the rocks.

Upon failing to find CO₂ in some of the initial samples (which were chosen from stratigraphic intervals where CO₂ had been reported on test) we started measuring the pH of the cuttings and water mixtures in the blender. We found that the mixtures were basic, with pH's ranging even higher than 11 for some samples (Tables IV, V). No CO₂ was detected in the gas phase in any sample where the pH was greater than 8.5.

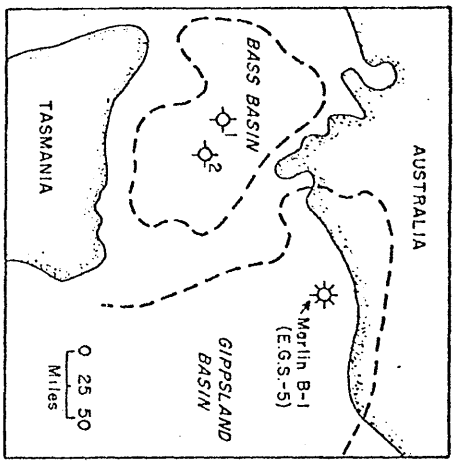
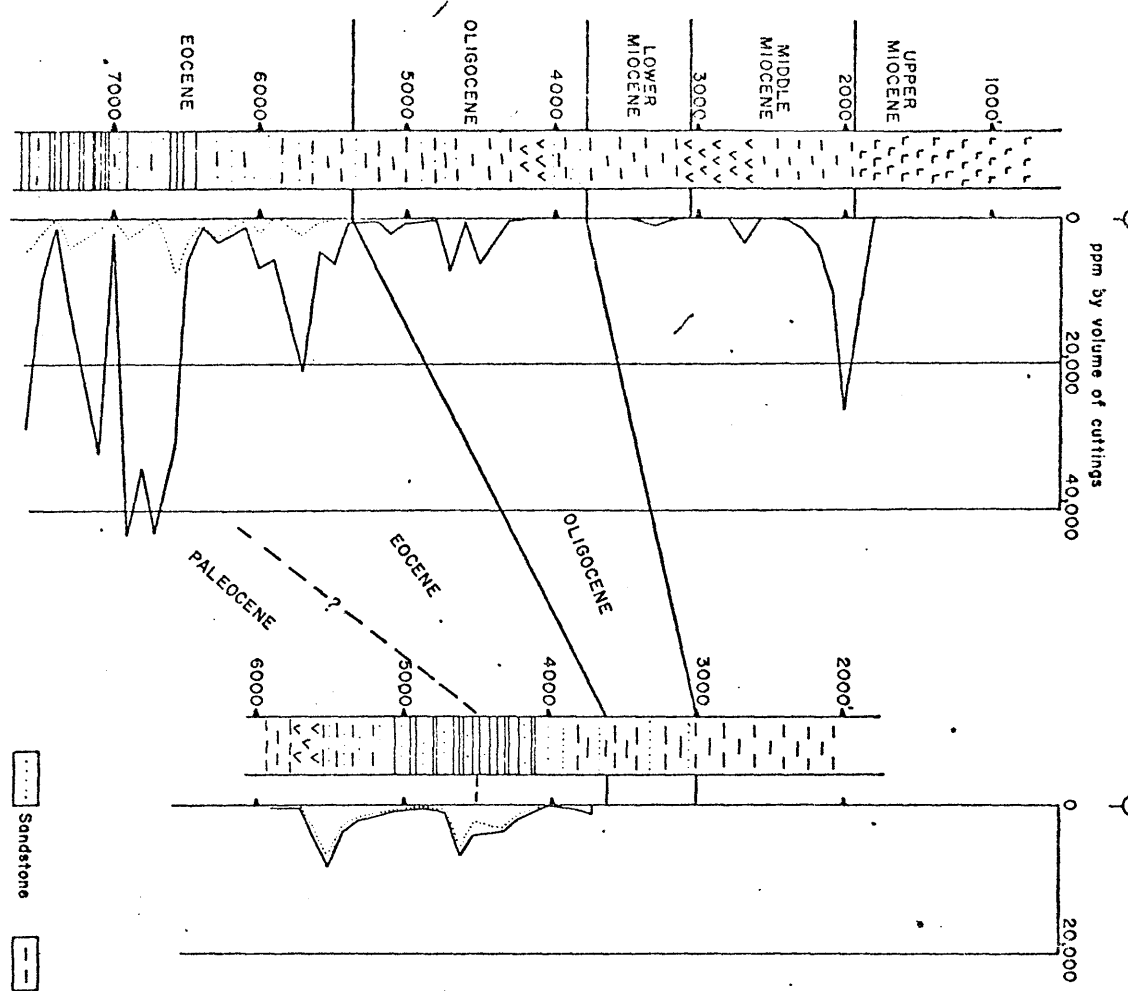
CO₂ will dissolve in a basic solution, and thus any CO₂ from the original rock could be dissolved in the cuttings and drilling mud mixture. The high pH of the samples is probably due to the drilling mud included with the cuttings when they were canned.

Although methods might be devised to determine the CO₂ dissolved in the cuttings mixture, they would be expensive and time consuming and it was decided to abandon the attempt at this time.

ESSO BASS-1

ESSO BASS-2

ESSO MARLIN B-1
(E.G.S.-5)



- | | | | | | |
|--|--------------|--|-------|--|-----------------|
| | Sandstone | | Marl | | Gas Production |
| | Calcareenite | | Shale | | Oil Show |
| | Volcanics | | Coal | | Hydrocarbon Cut |
| | | | | | Fluorescence |

Lithology, tops and shows are from completion logs by Esso Exploration Australia Inc.

R. E. Matter June, 1967

1000' Drilling Depth

Total Hydrocarbon Gas (C₁-C₄)

"Wet" gas (C₂-C₄)

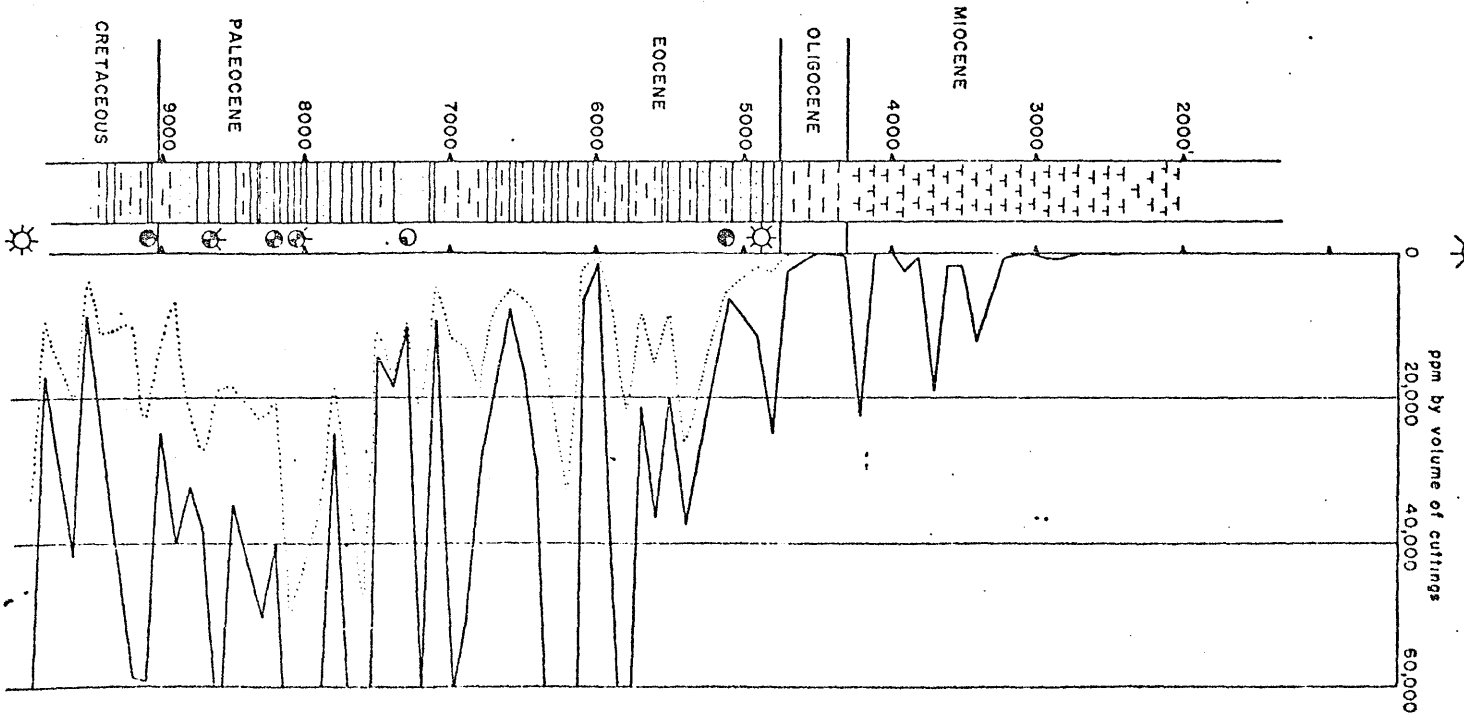
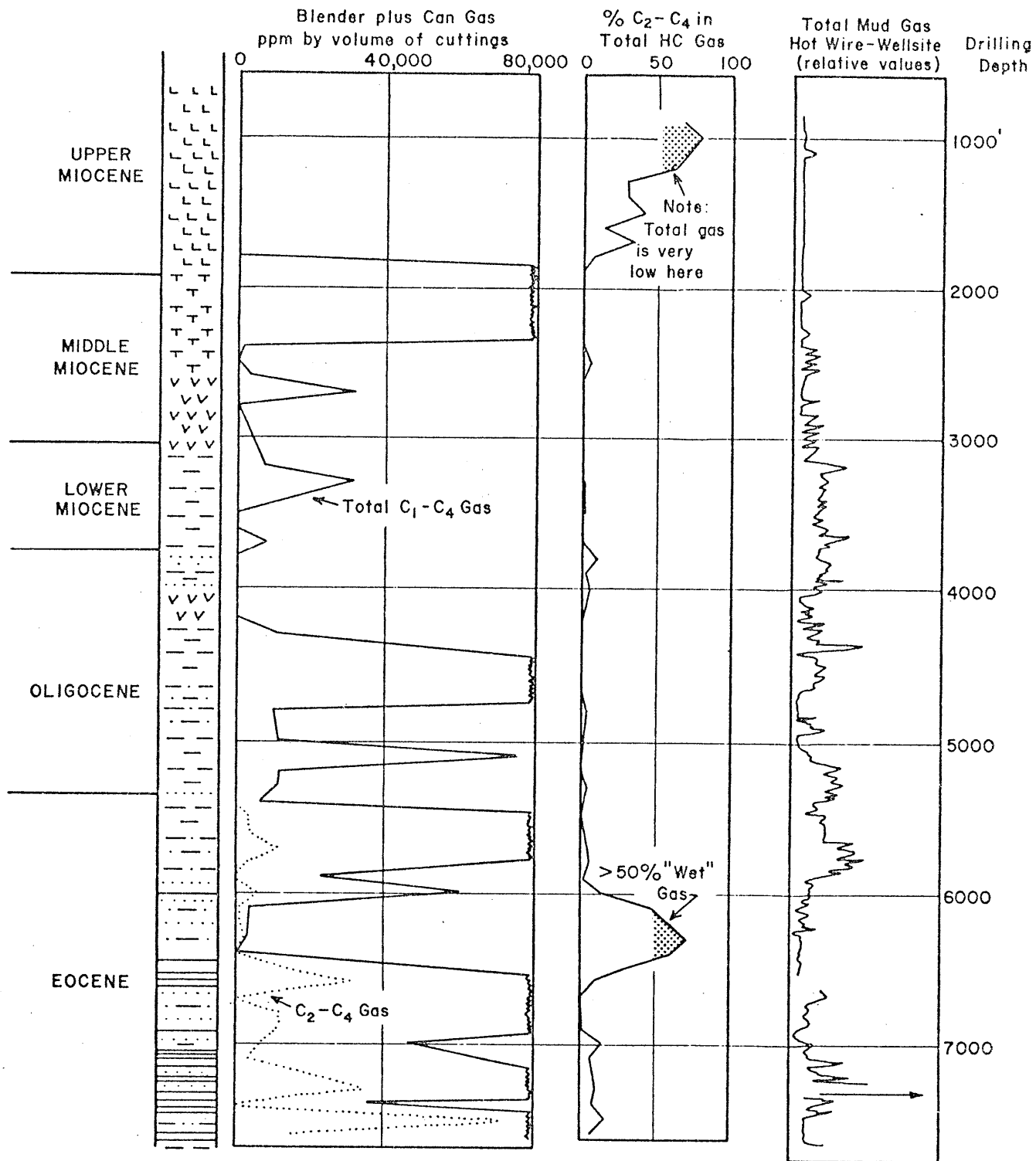
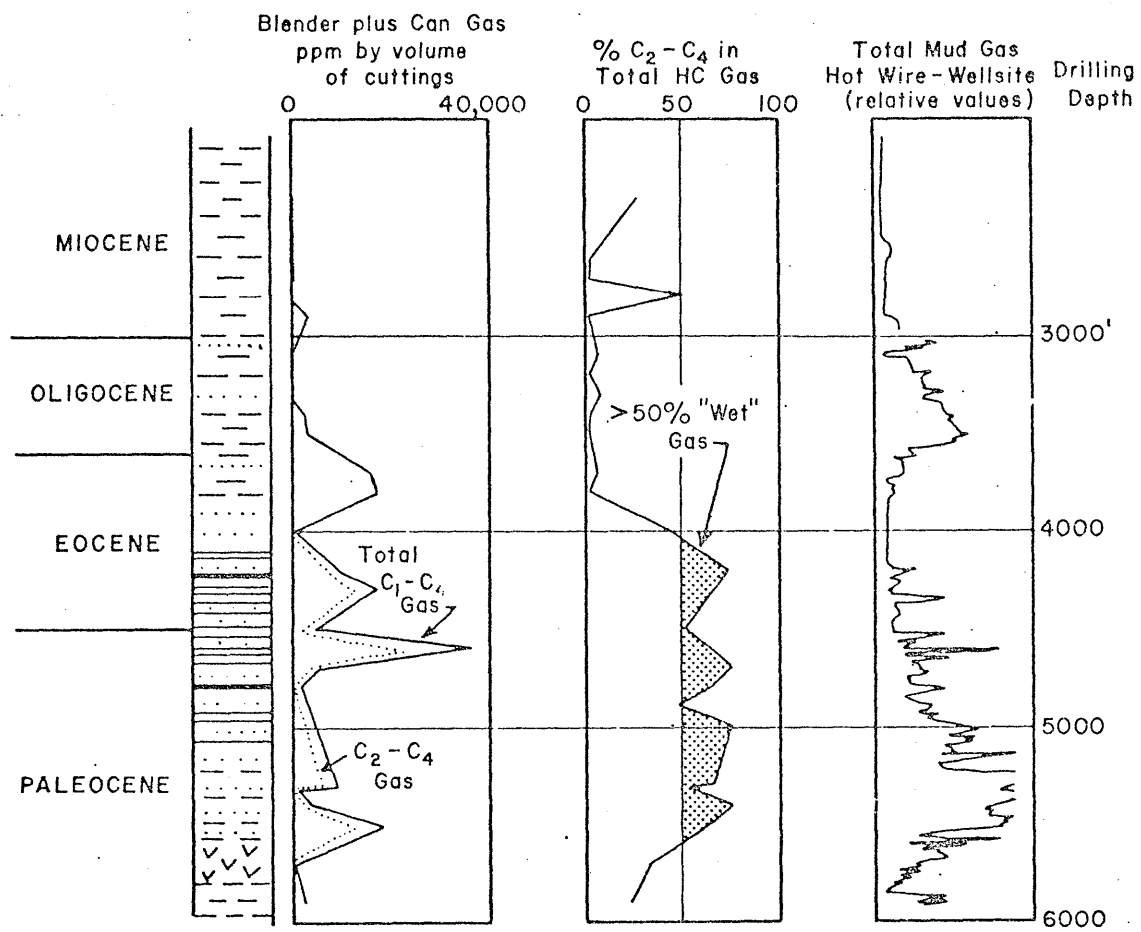


FIG. 1. HYDROCARBON GAS IN CANNED CUTTINGS, BASS BASIN vs. GIPPSLAND BASIN, AND MARLIN B-1 (E.G.S.-5). (Gas released from cuttings in blender)



Note: See Fig. 1 for explanation of symbols.

FIG. 2 - HYDROCARBON GAS FROM ESSO BASS-1.



Note: See Fig. 1 for explanation of symbols.

FIG. 3 - HYDROCARBON GAS FROM ESSO BASS - 2.

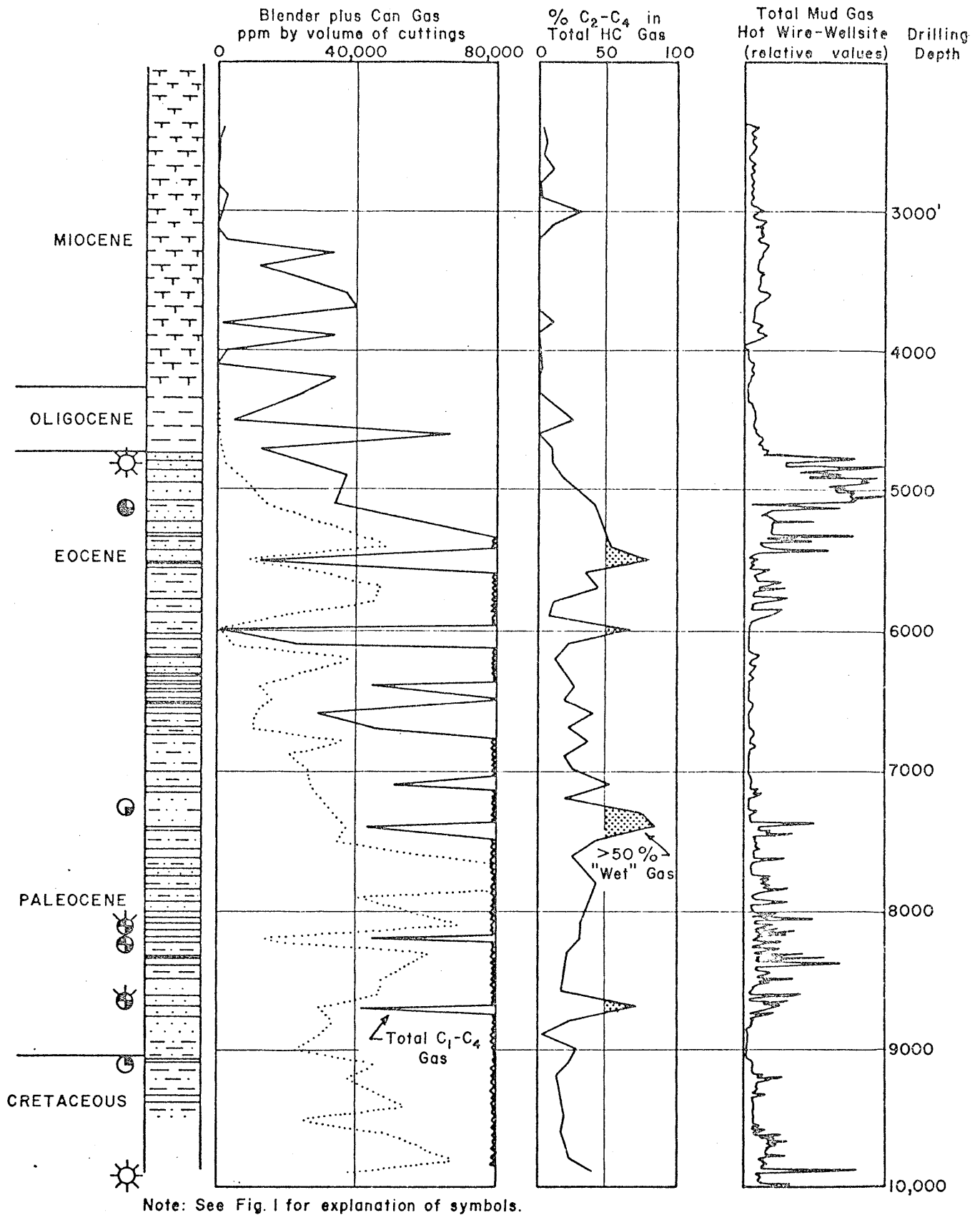


FIG. 4 - HYDROCARBON GAS FROM ESSO MARLIN B-1 (E.G.S.-5).

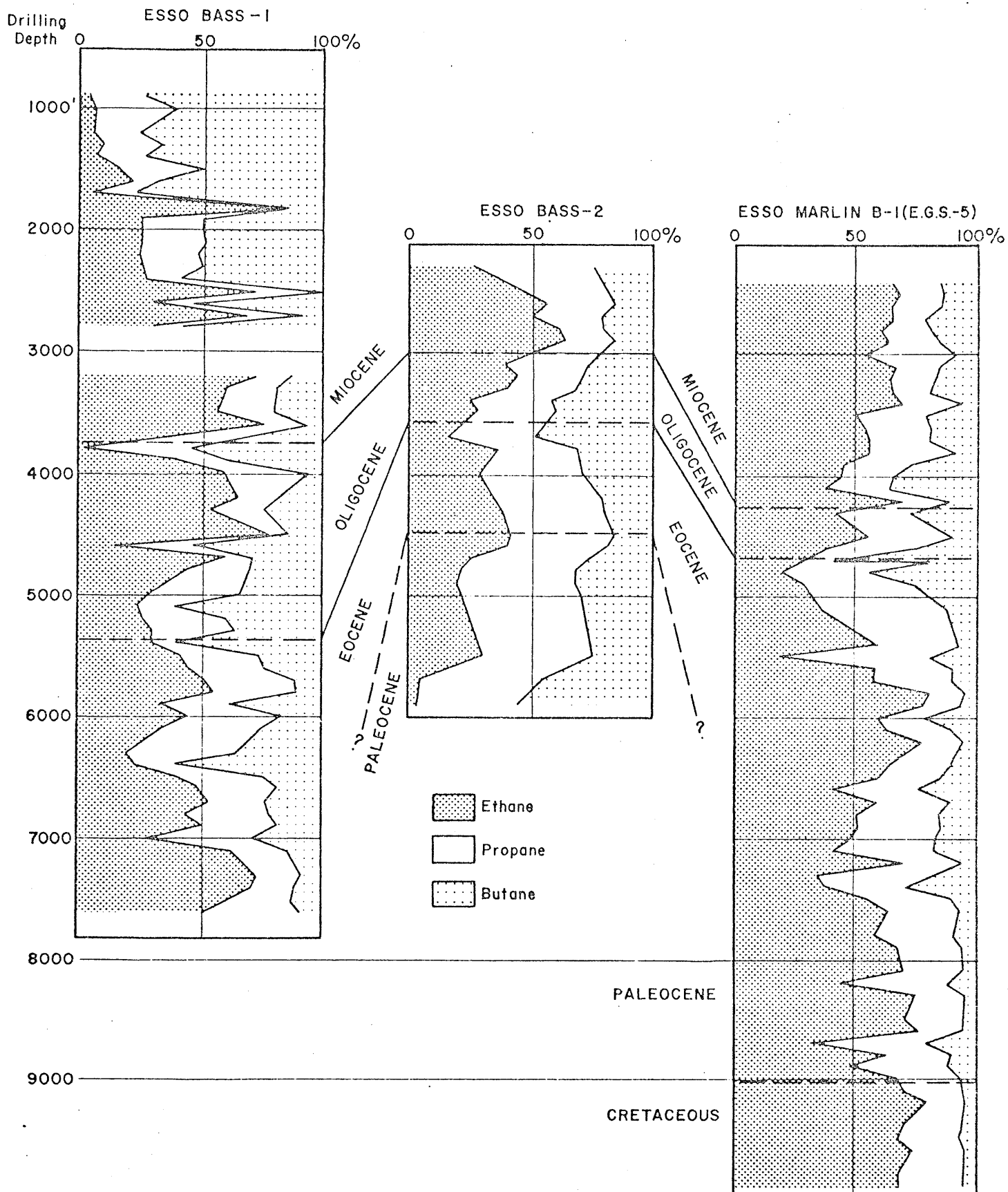


FIG. 5 - COMPOSITION OF C₂-C₄ GAS IN TOP OF CANS.

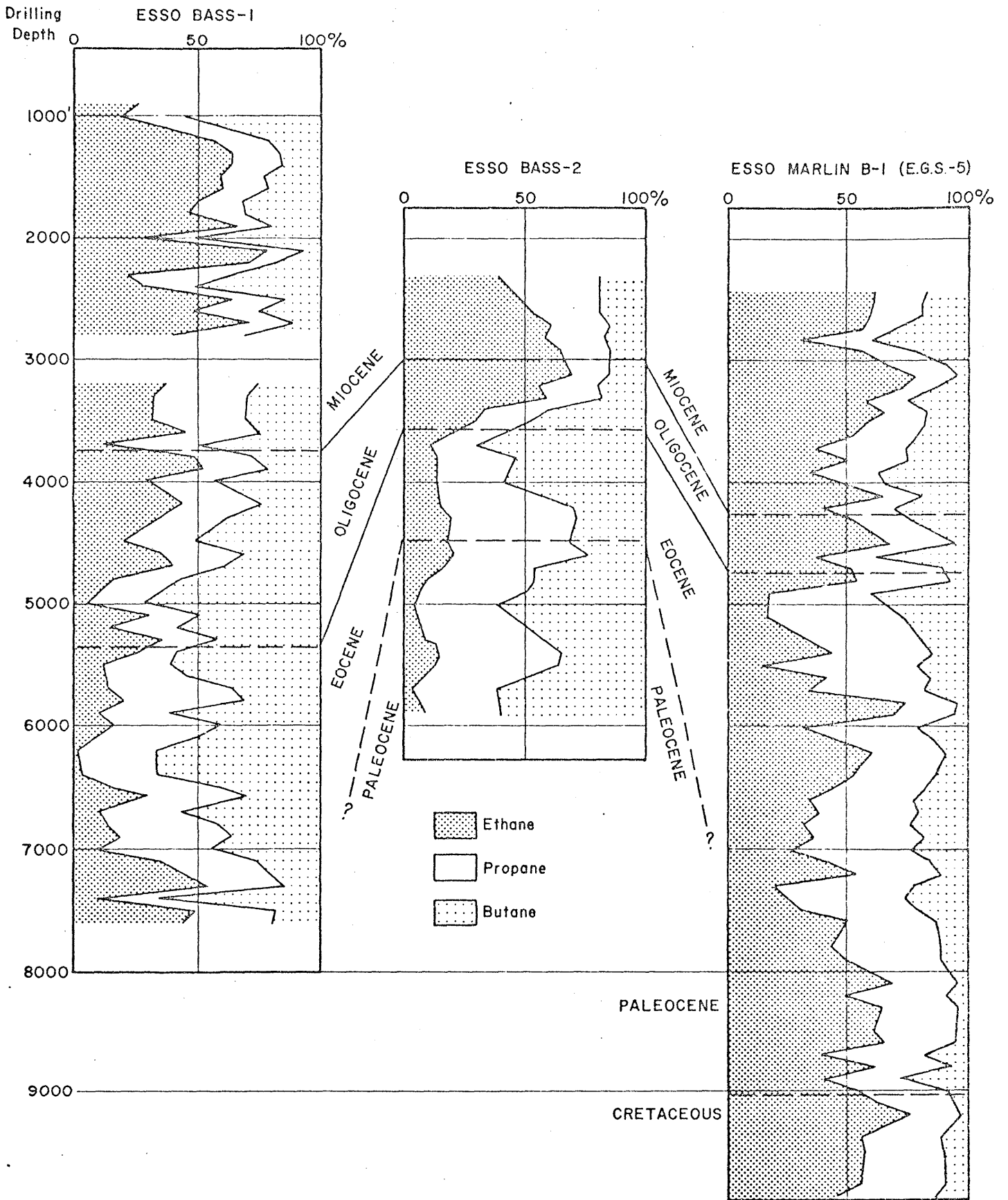


FIG. 6 - COMPOSITION OF C₂ - C₄ GAS RELEASED IN BLENDER.

TABLE II-C ESSO BASS-2

C₁-C₄ HYDROCARBON ANALYSES - CUTTINGS AND AIR SPACE

SAMPLE NUMBER	R	DEPTH	GAS CONCENTRATION (VOLUME GAS PER MILLION VOLUMES CUTTINGS)							GAS COMPOSITION (PERCENT)											NOTES
			MEthane	ETHANE	PROPANE	ISO. BUTANE (iC ₄)	NORMAL BUTANE (nC ₄)	WET	TOTAL	TOTAL GAS					WET GAS						
			(C ₁)	(C ₂)	(C ₃)	(iC ₄)	(nC ₄)	(C ₂ -C ₄)	(C ₁ -C ₄)	C ₂ -C ₄	C ₁	C ₂	C ₃	iC ₄	nC ₄	C ₂	C ₃	iC ₄	nC ₄		
537110	7	200	447.64	14.75	18.35	1.59	5.25	35.48	124.12	28.5852	72.11	12.1	1.4		37.44	4.15					
537110	7	200	447.64	14.75	18.35	1.59	5.25	35.48	124.12	28.5852	72.11	12.1	1.4		37.44	4.15					
537110	7	270	522.57	6.25	6.34	1.52	1.64	15.85	539.35	2.9387	97.2	1.0	0.0		53.77	7.15					
537110	7	300	111.57	2.27	2.57	1.52	1.55	13.42	124.99	10.7369	89.7	2.1	1.1		61.15	8.12					
537110	7	330	662.35	45.11	14.56	7.06	4.63	71.34	3753.59	1.9006	99.1	0.0	0.0		64.20	10.5					
537110	7	360	813.82	11.86	2.47	5.39	2.46	28.89	442.20	6.5310	93.5	2.1	1.1		40.23	15.5					
537110	7	390	883.35	5.66	2.91	1.55	1.36	11.33	395.26	2.8665	98.1	1.1	0.0		49.26	13.12					
537110	7	420	130.29	4.15	4.85	3.02	2.25	18.25	203.45	8.7551	92.4	2.1	1.1		44.27	17.12					
537111	7	450	318.82	21.72	27.23	23.84	11.57	83.76	3182.32	2.6248	97.1	1.1	1.0		26.33	29.15					
537111	7	480	638.30	27.45	33.17	26.73	12.73	97.13	3435.43	2.8273	97.1	1.1	1.0		28.31	29.13					
537111	7	510	1583.27	11.73	23.57	25.94	13.53	74.87	1129.14	6.6366	94.1	2.1	2.1		16.22	33.15					
537111	7	540	1310.25	12.70	33.44	32.59	13.90	97.63	1727.58	0.5994	100.0	0.0	0.0		13.46	33.15					
537111	7	570	13636.87	57.09	92.10	75.90	21.84	296.93	13721.73	2.0911	97.1	1.1	1.0		34.52	26.5					
537111	7	600	125.74	69.43	102.02	65.45	16.79	253.86	573.60	43.7992	56.12	18.11	3.3		27.40	26.7					
537111	7	630	2372.9	2259.45	3235.61	1333.99	290.77	7192.85	9578.85	75.1640	25.24	34.14	3.3		31.46	19.4					
537111	7	660	3547.93	4708.67	5317.49	2255.55	495.02	12026.13	17857.06	67.3089	33.22	30.12	3.3		33.45	18.4					
537111	7	690	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000	0.0	0.0	0.0		0.0	0.0		*BC*			
537111	7	720	2190.89	412.25	1117.32	532.81	150.36	2247.31	4665.80	50.5491	49.3	25.12	4.4		15.49	29.5					
537111	7	750	1360.25	1252.89	1754.55	3533.21	497.25	23298.94	36786.19	63.3361	37.22	29.10	3.3		35.46	15.4					
537111	7	780	1777.89	1225.45	1854.97	517.52	269.58	6362.95	5440.64	74.6778	25.19	34.17	5.5		25.45	23.7					
537111	7	810	127.72	213.65	505.16	222.12	108.52	1115.60	1717.39	64.9643	35.12	29.17	6.6		19.45	25.1					
537111	7	840	1537.97	351.11	837.63	455.36	186.87	1752.77	3718.53	47.8945	52.5	23.12	5.5		17.47	25.18					
537111	7	870	1091.87	615.73	1499.54	625.40	253.17	3120.21	4273.21	74.7085	25.14	35.14	6.6		19.47	25.1					
537111	7	900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000	0.0	0.0	0.0		0.0	0.0		*BC*			
537111	7	930	327.87	1346.70	2864.31	1297.85	607.28	6094.73	9179.45	66.4529	34.15	31.14	7.7		22.47	21.15					
537111	7	960	75.91	131.62	354.42	140.67	119.44	791.75	1467.66	53.9464	46.3	25.12	8.8		17.46	23.14					
537111	7	990	273.22	464.67	1401.52	623.93	361.55	2836.12	3899.94	74.4400	26.12	37.16	9.9		16.55	23.13					
537111	7	1020	363.21	2506.46	5931.97	2444.32	1335.76	12071.71	18771.72	64.4138	36.13	31.13	7.7		21.48	27.11					
537111	7	1050	327.02	62.26	55.88	60.30	38.18	160.76	428.38	32.9170	68.1	11.12	5.5		4.35	37.24					
537111	7	1080	1129.59	33.40	237.41	225.08	113.42	615.31	2744.81	22.4172	78.1	9.8	4.4		5.39	37.14					
537111	7	1110	3612.87	1357.69	4118.25	1640.52	282.49	7970.94	11710.94	67.4663	33.16	35.14	2.2		24.51	21.4					

B = CUTTINGS NOT ANALYZED *C* = AIR SPACE GAS NOT RUN *BC* = NO ANALYSES RUN

2
TABLE III-B ESSO MARLIN B-1 (E.G.S.-5)

C₁-C₄ HYDROCARBON ANALYSES - CUTTINGS ONLY

Table with columns: SAMPLE NUMBER, R, DEPTH, GAS CONCENTRATION (VOLUME GAS PER MILLION VOLUMES CUTTINGS), GAS COMPOSITION (PERCENT), NOTES. The gas concentration columns are Methane (C1), Ethane (C2), Propane (C3), Iso-Butane (iC4), Normal Butane (nC4), Wet (C2-C4), and Total (C1-C4). The gas composition columns are Total Gas (C2-C4, C1, C2, C3, iC4, nC4) and Wet Gas (C2, C3, iC4, nC4).

B = CUTTINGS NOT ANALYZED

C = AIR SPACE GAS NOT RUN

BC = NO ANALYSES RUN

TABLE IV

CO₂ Analysis Of Canned Cuttings Gas From Esso Marlin B-1 Well (EGS-5)

E.P.R. No.	Depth	pH*	Volume CO ₂ Per Volume of Cuttings (X10 ⁻⁴)	E.P.R. No.	Depth	pH*	Volume CO ₂ Per Volume of Cuttings (X10 ⁻⁴)
53700-A	2400	8.8	n.d.**	53703-A	6800	10.6	n.d.
B	2500	8.5	"	B	6900	9.2	"
C	2600	8.3	"	C	7000	9.2	trace
D	2700	9.7	"	D	7100	9.3	n.d.
E	2800	9.7	"	E	7200	9.9	"
F	2900	8.8	"	F	7300	9.6	"
G	3000	8.3	"	G	7400	11.2	"
H	3100	8.2	"	H	7500	10.3	"
I	3200	8.1	34.45	I	7600	not run	"
J	3300	8.3	n.d.	J	7800	9.5	"
K	3400	not run	7.91	K	7900	9.5	"
L	3500	8.6	n.d.	L	8000	-	can leaked
M	3600	8.4	35.1	M	8100	9.9	n.d.
N	3700	8.4	0.98	N	8200	8.0	"
53701-A	3800	8.2	9.68	53704-A	8300	9.4	"
B	3900	8.5	trace	B	8400	-	can leaked
C	4000	8.2	"	C	8500	7.5	2304
D	4100	8.2	"	D	8600	9.3	n.d.
E	4200	9.0	1.80	E	8700	9.3	"
F	4300	8.0	7.62	F	8800	10.6	"
G	4500	not run	n.d.	G	8900	9.8	"
H	4600	8.2	415.6	H	9000	10.7	"
I	4700	8.5	1761.7	I	9100	8.0	130.8
J	4800	7.9	10.92	J	9200	7.1	2618
K	4900	8.9	n.d.	K	9400	9.1	1.91
L	5100	8.5	660.0	L	9500	8.9	n.d.
M	5200	-	can leaked	M	9600	11.3	"
N	5400	8.7	trace	N	9800	10.5	"
53702-A	5500	7.8	27.30	53705-A	9900	9.9	"
B	5600	11.7	n.d.				
C	5600	9.7	"				
D	5700	11.0	"				
E	5800	8.3	21.19				
F	5900	8.3	85.15				
G	6000	8.6	n.d.				
H	6100	9.9	"				
I	6200	7.9	154.2				
J	6300	-	can leaked				
K	6400	9.6	n.d.				
L	6500	9.1	"				
M	6600	8.7	trace				
N	6700	8.9	n.d.				

*The pH was taken on the cuttings after mixing in blender with distilled water.

**n.d. = not detected

TABLE V

CO₂ Analysis Of Canned Cuttings Gas From Esso Bass-2 Well

<u>E.P.R.</u> <u>No.</u>	<u>Depth</u>	<u>pH*</u>	<u>CO₂ Volume</u> <u>Per Volume of</u> <u>Cuttings (X10⁻⁴)</u>
53711-A	2300	11.5	not detected
B	2600	11.3	"
C	2700	11.0	"
D	2800	10.7	"
E	2900	10.1	"
F	3100	10.6	"
G	3200	9.2	"
H	3300	9.4	"
I	3400	10.2	"
J	3500	10.2	"
K	3700	9.4	"
L	3700	9.2	"
M	3800	9.5	"
N	4000	10.8	"
53712-A	4200	10.4	"
B	4300	9.7	"
C	4400	-	-
D	4500	11.1	not detected
E	4600	10.0	"
F	4700	10.1	"
G	4800	9.8	"
H	4900	8.5	"
I	5000	9.5	"
J	5100	-	-
K	5300	9.5	not detected
L	5310	9.6	"
M	5400	9.8	"
N	5500	9.0	"
53713-A	5700	8.7	"
B	5900	9.0	"
C	7700	8.7	"

* Run on blender mixture of cuttings and distilled water.

CANNED CUTTINGS HYDROCARBON GASES FROM THE
BARRACOUTA A-1, COD A-1 AND MARLIN A-1 WELLS, AUSTRALIA

(Esso Exploration Australia Job No. 14)

by

R. E. Metter
L. J. Franklin
September, 1967

SUMMARY

Total hydrocarbon gas (C₁-C₄) and "wet" gas (C₂-C₄) released from canned cuttings samples suggest that the Latrobe Valley Formation in the Gippsland Basin has good hydrocarbon source potential, particularly in the Marlin area. The Latrobe Valley sections at Barracouta and Marlin both appear to have been able to generate liquid as well as gaseous hydrocarbons, and the section at Marlin is interpreted to have been especially productive of hydrocarbon liquids.

The Oligocene Lakes Entrance Formation does not appear to have good source potential in these areas. The basal Miocene portion of the Gippsland Formation at the Cod structure appears to be a potential source of dry gas, but probably only in rather modest quantities.

Regional patterns in the composition of the "wet" gas are present and may be related to generation of liquid hydrocarbons. This pattern in the Barracouta section is comparable to that in the section at the Bass-2 well in the Bass Basin.

INTRODUCTION

Canned cuttings samples from the following three wells in the Gippsland Basin have been analyzed for their hydrocarbon gas yields:

BARRACOUTA A-1 (E.G.S.-1)
COD A-1 (E.G.S.-3)
MARLIN A-1 (E.G.S.-4)

The purpose was to provide data that would indicate the hydrocarbon source potential of the stratigraphic sections involved.

This service work, which is summarized in this report, was authorized in a November 1, 1966 letter from John H. Hamlin by J.H. Hafenbrack, file 6244.

As a part of this same service project similar analyses were previously run on canned cuttings samples from three other wells in the Bass and Gippsland Basins, and these earlier results were transmitted in our service report of July 1967. These were the Bass-1, Bass-2, and Marlin B-1 (E.G.S.-5) wells. In this earlier study, it was noted that the pre-Oligocene samples from the Marlin B-1 well gave up large amounts of both methane and C₂-C₄ hydrocarbon gas, suggesting that the pre-Oligocene strata are the source of the oil and gas in the Marlin field. The composition of the C₂-C₄ "wet" gas from the pre-Oligocene samples showed relatively high amounts of ethane and low amounts of butane for the Marlin well as compared to the Bass-1 and Bass-2 wells.

Of the three wells involved in the present study, the Barracouta well produced gas from the top of the Latrobe Valley Formation, the Cod well was a dry hole, and the Marlin well produced both gas and oil from the top of the Latrobe Valley Formation (Fig. 1). The Latrobe Valley Formation is reported to be an Eocene-Paleocene deltaic complex of nonmarine strata with many coal beds. There is considerable interest in the possibility that such a coal-bearing sequence might generate commercial amounts of liquid as well as gaseous hydrocarbons. It was hoped that source potential studies might help either to confirm or to disprove this possibility. The present data strongly suggest that the Latrobe Valley Formation has been the source of the oil as well as the gas at Marlin Field.

ANALYTICAL PROCEDURE

In our standard cuttings gas analysis two different operations are involved. The hydrocarbon gas in the sample can air space above the cuttings is first analyzed. Then the hydrocarbon gas released from the cuttings after violent agitation with distilled water in a Waring blender is run. Both analyses are made by gas chromatography.

DATA PRESENTATION

Tables

Results of the hydrocarbon gas analyses are given in Tables I, II, and III for the Barracouta, Cod, and Marlin wells, respectively. In each Table the results are given separately for the gas from the air space in the can, for the gas released from the cuttings in the blender, and for the combined results from both air space and cuttings.

In each category the amounts of methane, ethane, propane, isobutane and normal butane are given separately as parts per million, volume of gas per volume of cuttings. The total hydrocarbon gas (C₁-C₄) and the percent "wet" gas (C₂-C₄) are listed as well as the normalized compositions of the (C₂-C₄) fractions.

Figures

Figure 1 shows graphically for each well the amounts of total (C_1-C_4) and "wet" (C_2-C_4) hydrocarbon gas released from the cuttings after agitation in the blender. The strip logs are aligned on a sea level datum. This figure is directly comparable to Fig. 1 in the report on the Bass-1, Bass-2 and Marlin B-1 wells.

Figure 2 shows the compositions of the C_2-C_4 fractions of the gases released in the blender. Only the Oligocene and pre-Oligocene data are shown because the younger samples gave up only small amounts of wet gas and the compositional data are not as reliable as for the older samples. These plots are aligned on the top of the Oligocene as a datum.

DISCUSSION AND INTERPRETATION OF DATA

Latrobe Valley Formation

Figure 1 shows that the Marlin A-1 samples from the Latrobe Valley Formation released considerably greater amounts of total gas and C_2-C_4 gas than the samples from the same formation in the other two wells. Several individual samples in both the Barracouta and the Cod wells released rather high amounts of total gas, but on the average the samples from these two wells gave up distinctly smaller amounts than the Marlin samples. This suggests that the Latrobe Valley Formation has a higher hydrocarbon source potential in the Marlin area than in the Cod and Barracouta areas.

The "wetness," or relative amounts of C_2-C_4 gas in the total gas are comparable in the Barracouta and Marlin Latrobe Valley samples, but the gas from the Cod samples is distinctly less "wet". This suggests that the Marlin and Barracouta sections are more likely to contain significant amounts of hydrocarbon liquids than the Cod section.

The gross amount of C_2-C_4 gas released by the Marlin section is far greater than that released by the Barracouta section. This suggests that the total amount of hydrocarbon liquids generated at Marlin is also notably greater than at Barracouta.

In summary, the Latrobe Valley Formation appears to have good hydrocarbon source potential, with the section at Marlin showing the greatest thicknesses of beds with good potential. The sections at Barracouta and Marlin appear to have potential for generating liquid as well as gaseous hydrocarbons, and the Marlin section in particular is interpreted to have generated large amounts of liquid hydrocarbons.

Lakes Entrance Formation

The samples from the Oligocene Lakes Entrance Formation did not give up much gas and from this data are interpreted to have relatively poor source potential.

Gippsland Formation

Samples from the Miocene Gippsland Formation gave up modest amounts of methane from the lower part of the section at Cod, but relatively insignificant amounts at Barracouta and Marlin. This suggests that any appropriate reservoirs associated with the Lower Miocene in the Cod area might contain accumulations of dry gas if any hydrocarbons are reservoired at all.

Wet Gas Compositions

Figure 2 shows that the C₂-C₄ gas from the Marlin and Cod samples contains relatively less butane and more ethane than the "wet" gas from the Barracouta samples. Possibly the Marlin "wet" gas contains slightly less relative amounts of ethane than the C₂-C₄ gas from Cod.

The pattern at Barracouta is comparable to the wet gas pattern in the Bass-2 well, shown in the earlier report, and included as Fig. 3 in this report. The pattern from Marlin A-1 is comparable to that from the Marlin B-1 well (Figs. 2 and 3). Thus, there is a regional consistency in the composition of the "wet" gas fractions produced from cuttings samples.

We do not know the significance of the wet gas compositional data, but it is of interest to see that regional relationships are prevailing. Possibly they may prove to relate to the generation of liquid hydrocarbons.

Basin Geology Division
September 1967

BARRACOUTA A-1
(E.G.S.-1)

COD A-1
(E.G.S.-3)

MARLIN A-1
(E.G.S.-4)

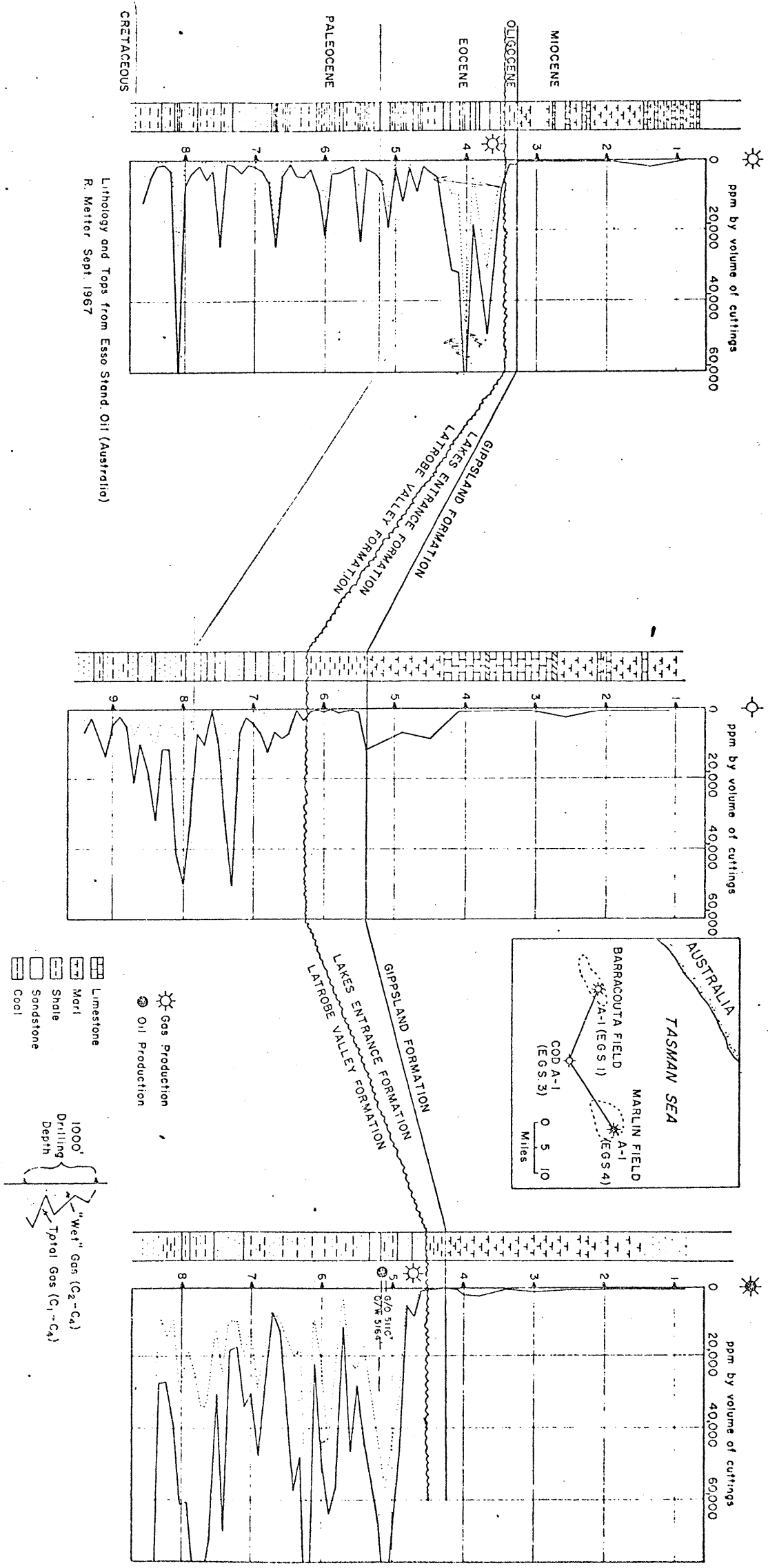


FIG. 1 - HYDROCARBON GAS IN CANNED CUTTINGS. (Gas released from cuttings in blender)

Lithology and Tops from Esso Stand, Oil (Australia)
R. Meitner Sept. 1967

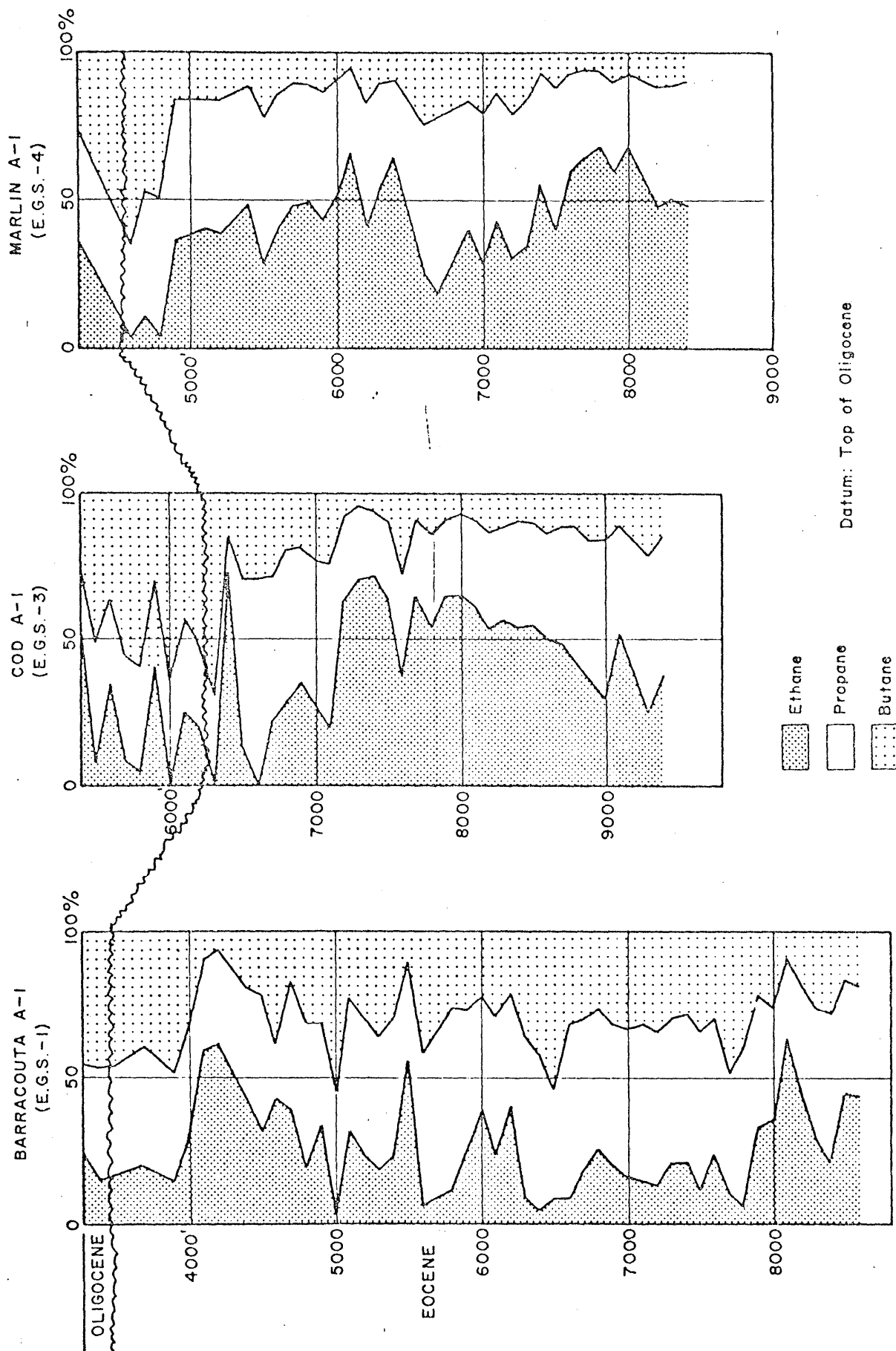


FIG. 2 - COMPOSITION OF C₂-C₄ GAS FROM BLENDER.

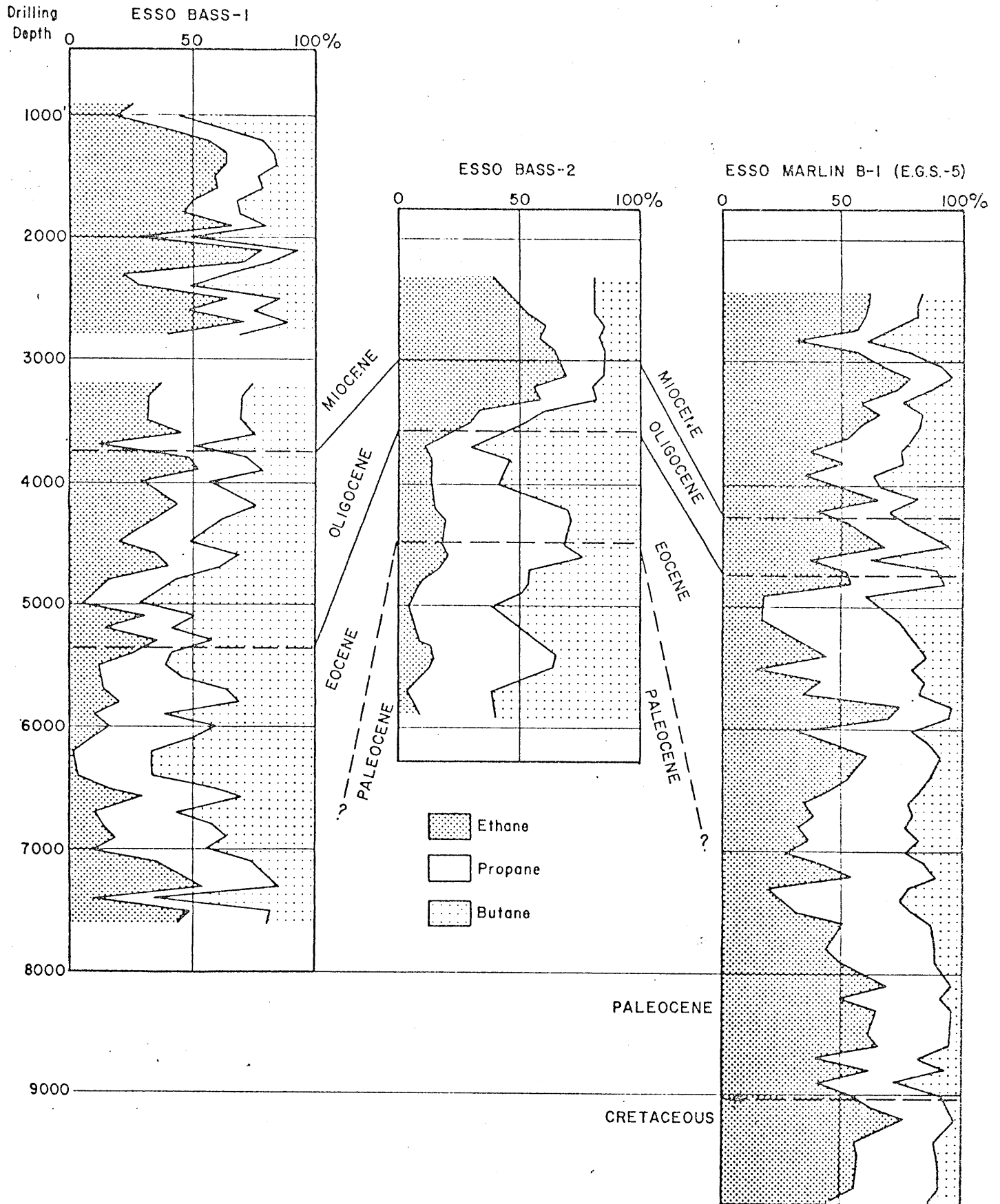


FIG. 3 - COMPOSITION OF $C_2 - C_4$ GAS RELEASED IN BLENDER.

COMPARISON OF OILS FROM MARLIN AND KINGFISH
FIELDS, AUSTRALIA, WITH VARIOUS ROCK EXTRACTS FROM MARLIN WELLS

by

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October, 1967

SUMMARY

Analyses were run on three crude oils and on hydrocarbon extracts from six core and thirteen cuttings samples. Various parameters were determined on both the light gasoline (C_4-C_7) and heavy hydrocarbon ($C_{15}+$) fractions. The crude oil samples came from the Marlin A-1 (E.G.S.-4) and Marlin C-1 wells and from the Kingfish A-1 well. The core and cuttings samples came from the Marlin A-1 (E.G.S.-4) and Marlin B-1 (E.G.S.-5) wells. The Marlin and Kingfish reservoirs are both at the top of the Latrobe Valley Formation, of Eocene-Paleocene age. The deeply eroded top of the Latrobe Valley section is overlain by the Oligocene Lakes Entrance Formation.

The three oil samples are distinctly different, even though the two Marlin samples came from the same pool. However, there are also definite similarities among the three oils that suggest they are related genetically, at least in part.

Examination of different fractions of the oils and rock extracts suggests that the oil accumulations at Marlin and Kingfish have received hydrocarbons from both the Latrobe Valley and Lakes Entrance Formations. The high relief on the buried erosion surface at the top of the Latrobe Valley Formation in this area would permit such mixing to occur.

No samples were available from the thick Lakes Entrance Formation section in the buried valley east of Marlin. This particular section might have a better source potential than we have previously noted for the Lakes Entrance section and might well have been a source of some of the Marlin and Kingfish hydrocarbons.

INTRODUCTION

At the request of Esso Exploration (Australia) a group of crude oils and rock extracts from the Gippsland Basin have been analyzed in an attempt to characterize the oils and identify the intervals that sourced them. This report is a summary of the status of our work on this subject.

The study includes data on 3 crude oil, 6 core and 13 cuttings samples. The lithologic samples are listed in Table I. Two of the oil samples came from different wells in the Marlin field: Marlin A-1 (E.G.S.-4) and Marlin C-1. Their locations are shown on the map of Fig. 1 and the cross section of Fig. 2. The third oil sample came from roughly 20 miles to the south from the Kingfish A-1 well (Fig. 1). All three of the oil samples were obtained from the Production Engineering Service Laboratory at EPRCo where they had been analyzed for P.V.T. data.

The lithologic samples all came from two wells in the Marlin Field: Marlin A-1 (E.G.S.-4) and Marlin B-1 (E.G.S.-5). These sample locations are also shown in Figs. 1 and 2. All six of the core samples came from the Marlin A-1 well.

The Marlin and Kingfish fields are both reservoirized in sands at the top of the Latrobe Valley Formation, which is a complex of deltaic sediments ranging in age from Eocene to Cretaceous. Marlin is mainly a gas field, with a 70-foot oil leg that may or may not be continuous throughout the field area. Kingfish is an oil field with no gas cap and a gas-oil ratio of only 137. In the Marlin area there are numerous coal beds in the Latrobe Valley Formation, but it is reported that there are no coals at Kingfish.

The top of the Latrobe Valley Formation in this area is an eroded surface with considerable topography (Figs. 1, 2). It is overlain by calcareous mudstones or marls of the Oligocene Lakes Entrance Formation. Thus, the Oligocene strata act as a seal for the Marlin reservoir, and possibly also as a source for some of the hydrocarbons. Previous geochemical studies in this area indicate that the Latrobe Valley Formation appears to have a good source potential for both gas and oil whereas the Lakes Entrance Formation appears to have only a poor to fair source potential. However, the Lakes Entrance unit has not been tested in some of its thicker sections, such as in the deep buried valley just east of Marlin field (Figs. 1, 2).

The oil samples from the Marlin field were of considerable interest in that the sample from the C-1 well was reported by EPR Engineering Service Laboratory (personal communication) to have a pour point of about 59° F and wax content of 15 percent, in contrast to the sample from the A-1 well which had a pour point of approximately 5° F and wax content of 2.7 percent. However, their A.P.I. gravities were reported to be about the same, namely 51.8° for C-1 and 50.9° for A-1 (at 75° F). The gravity of the Kingfish oil was reported as 48° to 49° A.P.I. at 60° F.

It was hoped that organic geochemical analyses might indicate whether the Marlin and Kingfish oils have come from similar or different source intervals and whether any particular parts of the stratigraphic section appear to have been the sources.

PROCEDURE

Oil Samples

The light gasoline fractions of the oils were analyzed by gas chromatography for amounts of different specific compounds in the C₄-C₇ range. Results are given in Table II. The data are also summarized in Table II by various ratios of compounds or groups of compounds that have previously been found to be useful for correlating crude oils.

The heavy, C₁₅+ fractions of the oils were analyzed by mass spectrometry for stable carbon isotope (C¹³/C¹²) values and by high mass spectrometry for relative amounts of various molecular groups of compounds. Gross chemical compositions of the heavy fractions were also determined by liquid chromatography. Data on the heavy fractions of the oils are given in Table III.

Lithologic Samples

Light gasoline analyses were made of extracts from 16 of the lithologic samples. Molecular compositions and ratios of compounds of comparable molecular weights are more significant than total amounts of gasolines for these samples because these volatile compounds are lost fairly readily as the rocks dry out. Where possible the extractions were made before the samples dried. Results are tabulated in Table IV.

The heavy fractions (C₁₅+ compounds) were analyzed by essentially the same procedures as used on the heavy fractions of the crude oils so that both carbon isotope and molecular data were obtained (Table III).

DISCUSSION OF RESULTS AND INTERPRETATIONS

Crude Oils

General Relationships. If it were known only that the three oil samples were from the same general area it would probably be assumed on the basis of this study that they came from three different but possibly related pools. There are several notable differences between the two Marlin samples, which was not a complete surprise in view of their differences in pour point and wax content. However, the two Marlin samples are more like each other than like the Kingfish sample. Further, all three samples have some similarities that suggest the oils might not be completely unrelated. For example, all three have essentially the same carbon isotope value for the heavy saturate fraction.

The Marlin oils and the Kingfish oil are discussed separately below.

Marlin Oil Samples. The light gasoline fractions of the two samples are similar in composition (Fig. 3; Table II) and the ratios A_1/D_2 , C_1/D_2 , and C_1/C_2 are nearly the same. The gasolines should be similar because there is a large gas cap common to the oils in these two wells, and gasoline compounds at equilibrium conditions will freely migrate between the oil column and the gas cap. Within the gas they will be quite mobile, and should readily attain a uniform distribution throughout the gas cap. Therefore, any oil in contact with the gas should contain gasoline fractions with similar compositions.

The carbon isotope values of the heavy saturate compounds are essentially the same (-27.3 and -27.4). In other studies this variable has been found very useful in helping define families of related oils.

Other geochemical parameters of the heavy $C_{15}+$ fractions of the oils that are commonly used in correlating oils are not the same for these two oils (Fig. 4). The mass spectrometer patterns for 4-ring naphthenes in the range of sterane compounds (Fig. 4C) are quite different. The patterns of naphthenes and of heavy aromatic compounds are also different for the two oils (Figs. 4A; 4D), although the patterns do have gross similarities. The gross compositions of the heavy fractions of these oils are also different.

These compounds of the heavy fraction are much less mobile than the gasolines and many would not be detected in the gas cap fluids. It is conceivable that differences in these compounds could exist over long periods of time in a laterally continuous oil leg, particularly if permeability restrictions such as dipping shale breaks cut across the oil zone between wells A-1 and C-1. Seismic evidence suggests that such is the case (Fig. 2).

Compositional differences within a single pool such as appears to exist at Marlin might be due to post-accumulation reactions with ground waters of different compositions, differential secondary migrations of selected fractions of the oil, or contributions to the pool from multiple sources. The latter explanation is supported at Marlin by the notable amount of topography on the unconformity surface at the top of the Latrobe Valley Formation, which makes possible the mixing of fluids from many different zones (Figs. 1, 2).

Kingfish A-1 Sample. The gasoline fraction of the Kingfish oil is somewhat similar to the Marlin gasoline. The ratio A_1/D_2 is about the same for all three oils (Fig. 3;), but the C_1/C_2 ratio is larger for the Kingfish oil (3.6 vs. 2.8 and 2.6).

The heavy fraction of the Kingfish oil is also similar in some variables to the Marlin oils, but different in others. The carbon isotope values of the heavy saturate fraction are essentially the same for all three oils (Table III) but the values of the heavy aromatic fraction are different. The gross heavy molecular composition of the Kingfish oil is different from the

Marlin oils, but the relative compositions of the heavy hydrocarbons alone are fairly similar in the Kingfish and Marlin A-1 oils (Table III). However, the patterns of 4-ring naphthenes (Fig. 4-C), of heavy aromatic compounds (Fig. 4-D) and of naphthene compounds (Fig. 4-A) in the Kingfish oil are all different from those of the Marlin oils.

Conclusions, Oil Compositions. The Kingfish oil is similar to the Marlin oils in some of the gasoline ratios, in carbon isotope values of the heavy saturate fraction, and in the gross composition of hydrocarbons in the heavy fractions. The oils are different in some of the gasoline ratios, in carbon isotope values of the heavy aromatic fraction, and in distributions of molecular types within the heavy saturate and heavy aromatic groups of compounds. The mixture of similarities and differences might be due to entirely different source zones for the different accumulations, or to formation waters of different compositions reacting with the oils to produce variations in oil character. However, in view of the great amount of buried topographic relief on the reservoir formation in this area it appears more likely that various source horizons have contributed to each of the fields, and that compositional variations between oil wells are more likely to be a result of differential contributions of hydrocarbons from a variety of source beds.

Comparison of Rock Extracts and Oils

Approach. Most of the variables that were considered in comparing the three crude oils were also used to compare the oils with the various hydrocarbon extracts from the rocks. Our working hypothesis in these comparisons is that hydrocarbons now present in the source rocks should show certain compositional identities with the reservoired oils. In several areas, although not universally, we have found that reservoired oils actually do closely resemble hydrocarbon extracts from rocks that are judged on other geologic evidence to be the source beds.

There are certain variables that we have found cannot be directly compared. In the gasoline range we do not obtain values for the D_1/D_2 ratio from the rock extracts. In the heavy fraction we cannot compare gross compositional data because we have found that considerably more asphaltene and NSO material, and possibly more aromatic compounds, are present in the rocks than in the related reservoired oils. Thus, we have fewer variables to use in comparing extracts and oils than we used in comparing only the oils.

In the following discussion the various fractions of the oil sand extracts are considered separately.

Gasoline Fraction. Several of the rock extracts have gasoline patterns fairly similar to those of the two Marlin oils (Tables II, IV; Fig. 5). The rock samples that give the best match with the oils are:

<u>Sample No.</u>	<u>Well</u>	<u>Sample Depth</u>	<u>Unit</u>
51578-C	A-1	7491	Latrobe Valley Fm.
53434-C	A-1	8463	" " "
53704-E	B-1	8700	" " "

None give as good a match with Kingfish oil. The Kingfish oil is most like the Marlin B-1 Latrobe Valley sample from 8900 ft (No. 53704-G).

Heavy Saturate Fraction. Several different variables were used to compare the heavy saturate compounds in the oils and extracts. The carbon isotope values of this fraction of the three oils are -27.3, -27.4 and -27.5. Only one rock extract has a similar value, namely the cuttings sample 54007 from 4300-4500 ft in Marlin A-1 (Table III), from the Lakes Entrance Formation, with the value -27.4.

However, molecular data do not show the same relationships as the isotope values. For example, the distributions of naphthenic materials in the Marlin oils do not resemble those in the extract of sample 54007 from 4300-4500 ft in Marlin A-1. The Marlin oil naphthenic patterns are more like those from various parts of the Latrobe Valley Formation (Fig. 6). The Kingfish oil, however, does have a naphthenic pattern similar to that of sample 54007, so that both isotopic and some of the molecular data suggest that heavy saturate compounds at Kingfish came from the Lakes Entrance Formation.

All of the oils show a high percent of paraffins in the saturate fraction (Table III). Four of the extracts, 54006-A, 54006-B, 51578-C, and 53434-C show a fairly high percent paraffins in saturates, and all are from the Latrobe Valley Formation.

Distributions of mass spectrometric peaks of the 4-ring naphthenes for carbon numbers C₂₁-C₃₂ are shown for both oils and rock extracts in Fig. 7. The prominent peak at C₂₉ shown by the Marlin C-1 is present in several of the extracts from various depths in the Latrobe Valley Formation such as the samples 54006-A, 51578-A and 53434-C. The Marlin A-1 oil and the Kingfish oil do not have patterns like any of the rock extracts that were analyzed. The Kingfish pattern may be relatively featureless because of more advanced maturation due to greater depth of burial.

Heavy Aromatic Fraction. The carbon isotope values for the heavy aromatic fractions of the Marlin oils are -27.0 and -28.3. All of the core extracts except 53434-B from 5049-5066 ft in the A-1 well have isotope values in this

same range. Thus, both the Lakes Entrance sample and all but one of the Latrobe Valley samples have aromatic carbon isotope values similar to those of the Marlin oils. No rock extract matches the Kingfish oil in this variable.

In patterns of heavy aromatic molecular types (Table III) there are no really close matches of oils and extracts although most of the extracts show peaking for both chrysenes and dibenzothiophenes, such as is also exhibited by the Marlin oils.

Resume. The interpretations of possible crude oil - parent rock relationships that were noted in the preceding discussion are summarized below.

Hydrocarbon Fraction	Marlin A-1 Oil	Marlin C-1 Oil	Kingfish A-1 Oil
Gasolines	Latrobe Valley Fm.	Latrobe Valley Fm.	Latrobe Valley Fm.
Heavy Saturates	{ Lakes Entrance Fm. { Latrobe Valley Fm.	{ Lakes Entrance Fm. { Latrobe Valley Fm.	Lakes Entrance Fm.
Heavy Aromatics	{ Lakes Entrance Fm. { Latrobe Valley Fm.	{ Lakes Entrance Fm. { Latrobe Valley Fm.	No close match of of extracts and oils

Conclusions

1. The three oils have distinct differences, even though the Marlin samples came from the same pool.
2. There are significant similarities among the oils, particularly in isotope values of the heavy saturate fractions, in gasoline compositions and in gross heavy hydrocarbon compositions. These suggest that the oils may have at least some genetic relationships.
3. Examination of different fractions of the oils and of hydrocarbon extracts of rock samples from the section at Marlin field suggests that the oils at Marlin and Kingfish have received contributions from both the Latrobe Valley and the Lakes Entrance Formations. The gasolines could well have come mainly from the Latrobe Valley Formation, but it appears that some of the heavier compounds might have come from the Lakes Entrance Formation.
4. The relatively high relief on the buried erosion surface at the top of the Latrobe Valley Formation would permit a mixing of hydrocarbons from various horizons in the Latrobe Valley section as well as from various zones in the Lakes Entrance Formation.
5. We have not analyzed samples from the thick Lakes Entrance section in the buried valley east of Marlin field. This section may have a better

source potential than previous studies have indicated for the Oligocene in general, and could have contributed some of the hydrocarbons in the Marlin and Kingfish pools that seem to have similarities to the one Lakes Entrance extract that was analyzed.

TABLE I
LITHOLOGIC SAMPLES USED IN STUDY

EPR No.	Well	Depth (feet)	Sample Type	Lithology	GSA Color Code	Type of Analysis Run	
						Gasoline Isotope	Carbon High Mass Spectrometry
A. Gippsland Formation (Miocene)							
53700-I	Marlin B-1	3200	Cuttings	Shale, greenish gray, minor silt.	5GY-6/1	x	
53700-N	B-1	3700	Cuttings	Shale, olive gray, minor silt, moderately hard, microfoss.		x	
53701-E	B-1	4200	Cuttings	Shale, olive gray, minor silt, moderately hard, microfoss.		x	
B. Lakes Entrance Formation (Oligocene)							
54007	Marlin A-1	4300-4500	Cuttings	Marl, med. light gray to greenish gray.	N6; 5GY-6/1	x	x
C. Latrobe Valley Formation (Eocene-Paleocene)							
53434-A	Marlin A-1	4894	Core 6	Shale, light to medium dark gray laminar; irregular silt lenses; light laminae are micaceous.	5Y-6/1; N4; 5YR-8/1	x	x
53434-B	A-1	5049; 5070	Cores 7, 8	Shale, med. dark gray to dark brownish gray; abundant pyrite and small irregular silty lenses.	N4; 5YR-3/1	x	x
53701-N	B-1	5200	Cuttings	Claystone, sl. calcareous.	5Y-6/1	x	
54006-A	B-1	5200; 5400	Cuttings	Shale.		x	x
54006-B	B-1	5200; 5400	Cuttings	Coal.		x	x
53697-A	A-1	5300	Cuttings	Coal, with impurities of salt and sand.		x	x
53702-A	B-1	5500	Cuttings	Shale, lt. gray to olive gray, mod. hard, silty.		x	
53702-N	B-1	6600	Cuttings	Shale, med. gray to dark brownish gray, silty, micromicaceous.		x	
51578-A	A-1	7248	Core 12	Shale, dark gray, pyritic, coaly laminae, plant fragments, resinous luster, glassy sicken-sides.	N3	x	x
53703-G	B-1	7400	Cuttings	Shale, med. gray to dark brownish gray, moderately hard, minor silt.		x	
51578-C	A-1	7491	Core 14	Argillite, med. gray, heavy, trace of plant debris.	N5	x	x
51578-D	A-1	7506	Core 14	Coal.		x	
53434-C	A-1	8463	Core 15	Siltstone, dark gray, argillaceous, hard, strong, micaceous.	N4	x	x
53704-E	B-1	8700	Cuttings	Shale, dark olive gray, moderately hard, silty, carbonaceous, micromicaceous.		x	
53704-G	B-1	8900	Cuttings	Shale, dark brownish gray, hard, carbonaceous.		x	

TABLE II

LIGHT GASOLINE COMPOSITIONS OF CRUDE OILS
AND VALUES OF "SIGNIFICANT" RATIOS

	Marlin A-1 54035	Marlin C-1 54036	Kingfish A-1 54053
Isobutane	0.68	1.96	2.57
n-Butane	2.69	5.64	5.71
Isopentane	4.25	6.66	7.36
n-Pentane	6.01	7.75	8.50
2,2 Dimethylbutane	0.25	0.29	0.27
Cyclopentane	0.53	0.65	0.57
2,3 Dimethylbutane	0.59	0.72	0.75
2 Methylpentane	4.92	6.13	6.25
3 Methylpentane	2.81	3.10	3.08
n-Hexane	9.38	9.98	9.83
Methylcyclopentane	5.15	4.66	3.31
2,2 Dimethylpentane	0.00	0.11	0.00
2,4 Dimethylpentane	0.83	0.71	0.55
2,2,3 Trimethylbutane	0.00	0.00	0.00
Cyclohexane	5.87	5.03	6.60
3,3 Dimethylpentane	0.11	0.10	0.04
1,1 Dimethylcyclopentane	0.00	0.00	0.00
2 Methylhexane	3.45	3.43	2.92
2,3 Dimethylpentane	1.69	1.68	1.56
3 Methylhexane	3.26	3.19	3.01
1-C-3 Dimethylcyclopentane	1.57	1.49	1.25
1-T-3 Dimethylcyclopentane	1.56	1.43	1.48
1-T-2 Dimethylcyclopentane	1.83	2.00	1.82
3 Ethylpentane	0.00	0.00	0.00
2,2,4 Trimethylpentane	0.00	0.00	0.00
n-Heptane	11.75	11.08	9.84
1-C-2 Dimethylcyclopentane	0.45	0.38	0.22
Methylcyclohexane	20.52	17.63	19.68
Ethylcyclopentane	1.87	1.61	1.15
Benzene	0.98	0.38	0.00
Toluene	7.00	2.25	1.67
	100.00	100.04	99.99
% Light Gasolines in Total Oil	14.7	20.0	17.1
"Significant" Ratios			
C ₁ /C ₂	2.84	2.63	3.62
A /D ₂	6.49	6.60	6.54
D ₁ /D ₂	2.45	0.82	0.56
C ₁ /D ₂	9.20	8.21	9.72

TABLE III

MOLECULAR AND ISOTOPIC DATA ON HEAVY FRACTIONS OF OILS AND ROCK EXTRACTS

Sample Number Sample Depth (feet)	Oils		Marlin A-1		Marlin A-1		Marlin A-1		Marlin A-1		Marlin A-1		Marlin A-1		Marlin A-1		Marlin A-1		Marlin A-1	
	54035 5120	54036 5120	Kingfish A-1 54053 7585-93	53434-A 4894	53434-B 5049; 5066	54006-A 5200-5400	54006-B 5200-5400	54006-C 5200-5400	54006-D 5200-5400	54006-E 5200-5400	54006-F 5200-5400	54006-G 5200-5400	54006-H 5200-5400	54006-I 5200-5400	54006-J 5200-5400	54006-K 5200-5400	54006-L 5200-5400	54006-M 5200-5400	54006-N 5200-5400	54006-O 5200-5400
Gross Composition, %																				
Saturates	43.5	36.1	71.6	0.6	2.7	0.9	1.5	2.6	8.7	10.3	15.6									
Aromatics	10.7	28.4	14.5	7.2	5.7	3.9	11.5	12.5	15.1	8.0	14.1									
Eluted NSO's	8.8	18.9	2.4	92.2	91.6	95.2	87.0	84.9	76.2	81.7	70.3									
None-luted NSO's	33.9	-	8.1																	
Asphaltenes	3.1	16.6	3.4																	
	100.0	100.0	100.0																	
Hydrocarbon Composition, %																				
Paraffins	65.2	33.4	61.5	1.3	23.8	10.0	5.5	5.6	10.1	26.8	28.6									
Naphthenes	15.0	22.7	21.7	6.4	8.3	8.4	6.0	11.3	26.5	29.5	23.9									
Aromatics	19.8	44.1	16.8	92.2	67.8	81.5	88.4	83.0	63.3	43.7	47.4									
	100.0	100.2	100.0	99.9	99.9	99.9	99.9	99.9	99.9	100.0	99.9									
Carbon Isotope Values, ‰																				
Saturates	-27.3	-27.4	-27.5	-30.1(?)	-30.4	-29.6	-28.5	-28.6	-28.6	-29.5(?)	-29.7									
Aromatics	-27.0	-28.3	-25.6	-28.5	-29.1	-28.2	-27.7	-28.3	-27.2	-28.3	-27.8									
Heavy Aromatic Types, %																				
Benzenes	15.6	7.9	16.3	4.3	3.8	5.7	2.6	4.3	1.0	5.1	1.9									
Indanes	8.9	8.9	6.6	6.4	5.4	7.7	6.2	8.3	1.8	3.3	1.0									
Indenes (IND)	14.6	15.3	10.9	8.5	5.6	11.9	8.9	10.7	2.1	4.7	1.0									
Naphthalenes (NAP)	5.6	4.0	4.1	2.8	1.6	4.4	4.0	4.6	2.0	3.6	1.6									
Tetrahydrophenanthrenes (THPH)	13.6	10.8	14.5	7.0	7.1	8.5	10.5	14.4	8.3	9.3	6.2									
Dihydrophenanthrenes (DHPH)	19.3	16.6	26.5	11.6	13.6	12.0	13.4	24.1	14.6	12.1	12.0									
Phenanthrenes (PHEN)	3.2	8.6	16.6	21.1	33.2	13.3	17.0	11.9	55.9	30.5	37.7									
Pyrenes (PYR)	3.4	0.8	2.2	4.9	12.7	3.1	5.5	4.5	7.6	7.9	27.1									
Chrysenes (CHRY)	5.3	9.8	1.2	9.8	8.6	7.3	7.2	8.3	5.3	12.5	8.7									
Benzo[thiophenes] (BTH)	2.3	3.9	0.0	2.8	1.5	2.4	2.9	0.0	0.2	0.9	0.4									
Dibenzo[thiophenes] (DBTH)	8.2	13.2	1.3	10.3	2.6	17.8	16.8	8.9	1.2	3.9	0.0									
Thiophenophenanthrenes (TPPH)	0.0	0.2	0.0	10.3	4.5	5.0	3.1	6.0	0.0	5.0	3.4									
	100.0	100.0	100.0	99.8	100.2	100.1	100.1	100.0	100.0	99.9	100.1									
Saturates, %																				
Paraffins	81.3	59.7	73.9	20.2	7.4	53.7	47.9	32.8	27.4	47.8	54.4									
1-Ring Naphthenes	3.2	7.1	10.3	9.4	4.3	6.9	6.5	4.1	6.7	11.3	12.0									
2-Ring Naphthenes	2.9	2.4	4.8	7.9	6.4	3.1	3.1	4.7	10.1	7.5	5.2									
3-Ring Naphthenes	3.6	7.8	4.0	18.2	24.5	21.1	21.5	21.5	17.2	14.8	9.8									
4-Ring Naphthenes	3.1	5.7	3.3	12.0	14.2	5.3	7.7	10.2	11.5	6.4	5.1									
5-Ring Naphthenes	2.2	6.2	1.5	9.9	12.9	3.8	5.1	10.9	8.9	4.9	4.3									
6-Ring Naphthenes	3.5	11.2	2.1	23.5	30.3	8.2	8.4	15.7	18.1	7.3	8.3									
	99.9	100.1	100.1	100.1	100.0	100.1	100.0	100.0	100.1	100.0	100.0									

(*) Includes NSO's plus asphaltene

TABLE IV

GASOLINE RATIOS FOR ROCK EXTRACTS

EPR No.	Well	Depth	Sample Type	A/D ₂	C ₁ /C ₂	C ₁ /D ₂	Total C ₄ -C ₇ ppm
A. Gippsland Formation							
53700-I	B-1	3200	Cuttings	87.3	2.66	68.7	0.28
53700-N	B-1	3700	Cuttings	846	1.04	812	0.23
53701-E	B-1	4200	Cuttings	-	1.08	-	0.13
B. Latrobe Valley Formation							
53701-M	B-1	5200	Cuttings	5.6	1.65	13.17	2.4
*54006-B	B-1	5200; 5400	Cuttings	6.95	1.90	10.6	229
*53697-A	A-1	5300	Cuttings	5.68	0.97	16.38	25.8
53702-A	B-1	5500	Cuttings	64.4	2.95	64.0	0.54
53702-M	B-1	6600	Cuttings	6.04	1.07	11.11	35.0
*51578-A	A-1	7248	Core	6.94	1.17	17.21	70
53703-G	B-1	7400	Cuttings	18.94	4.83	82.3	3.1
51578-C	A-1	7491	Core	5.77	2.51	17.86	0.55
*51578-D	A-1	7506	Core	8.94	1.71	6.63	1,345
53434-C	A-1	8463	Core	5.68	2.60	18.11	312
53704-E	B-1	8700	Cuttings	4.61	2.32	8.76	50.2
53704-G	B-1	8900	Cuttings	10.75	3.13	11.67	70.4

* Coal

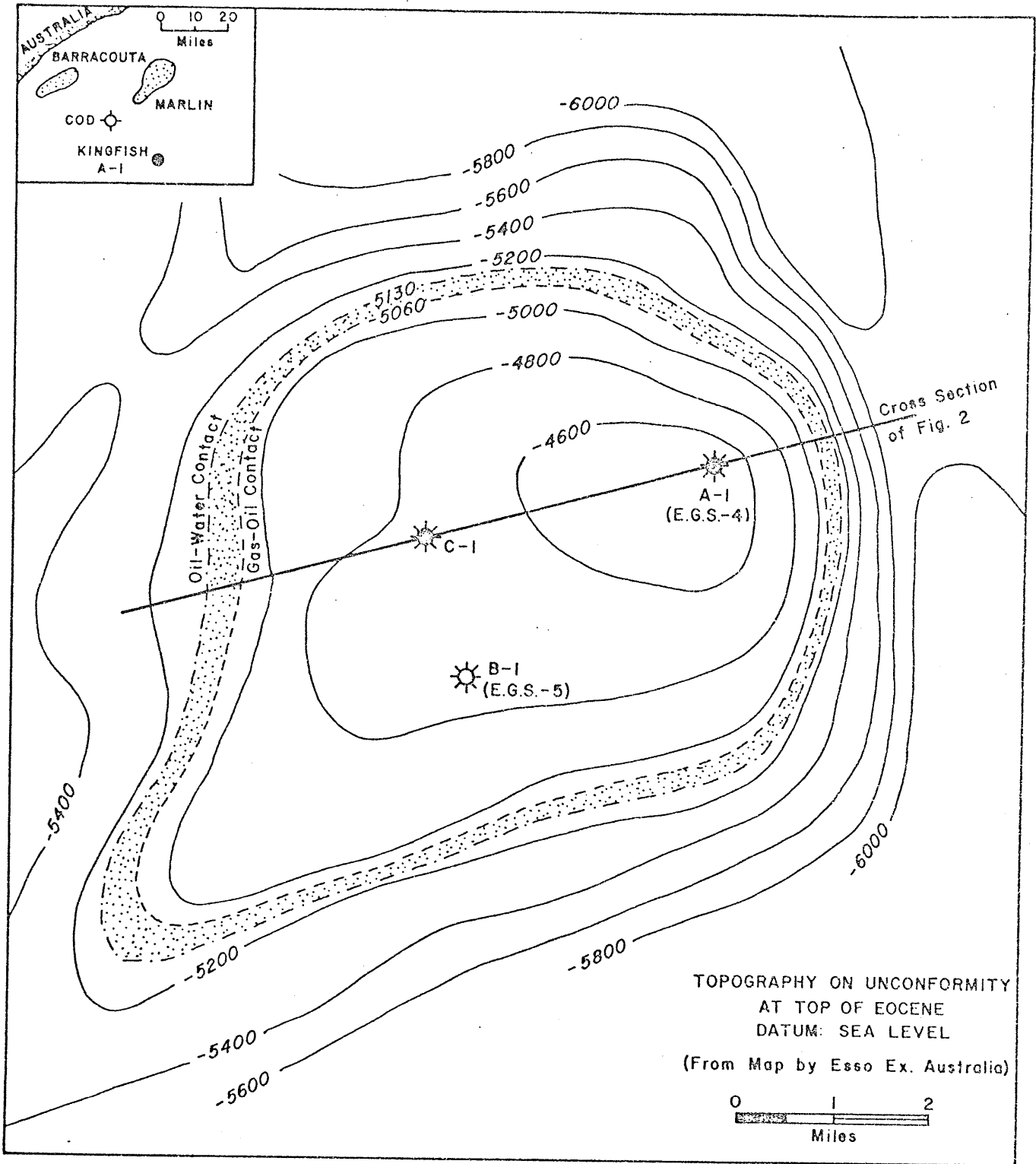


FIG. 1 - LOCATION MAP, MARLIN FIELD.

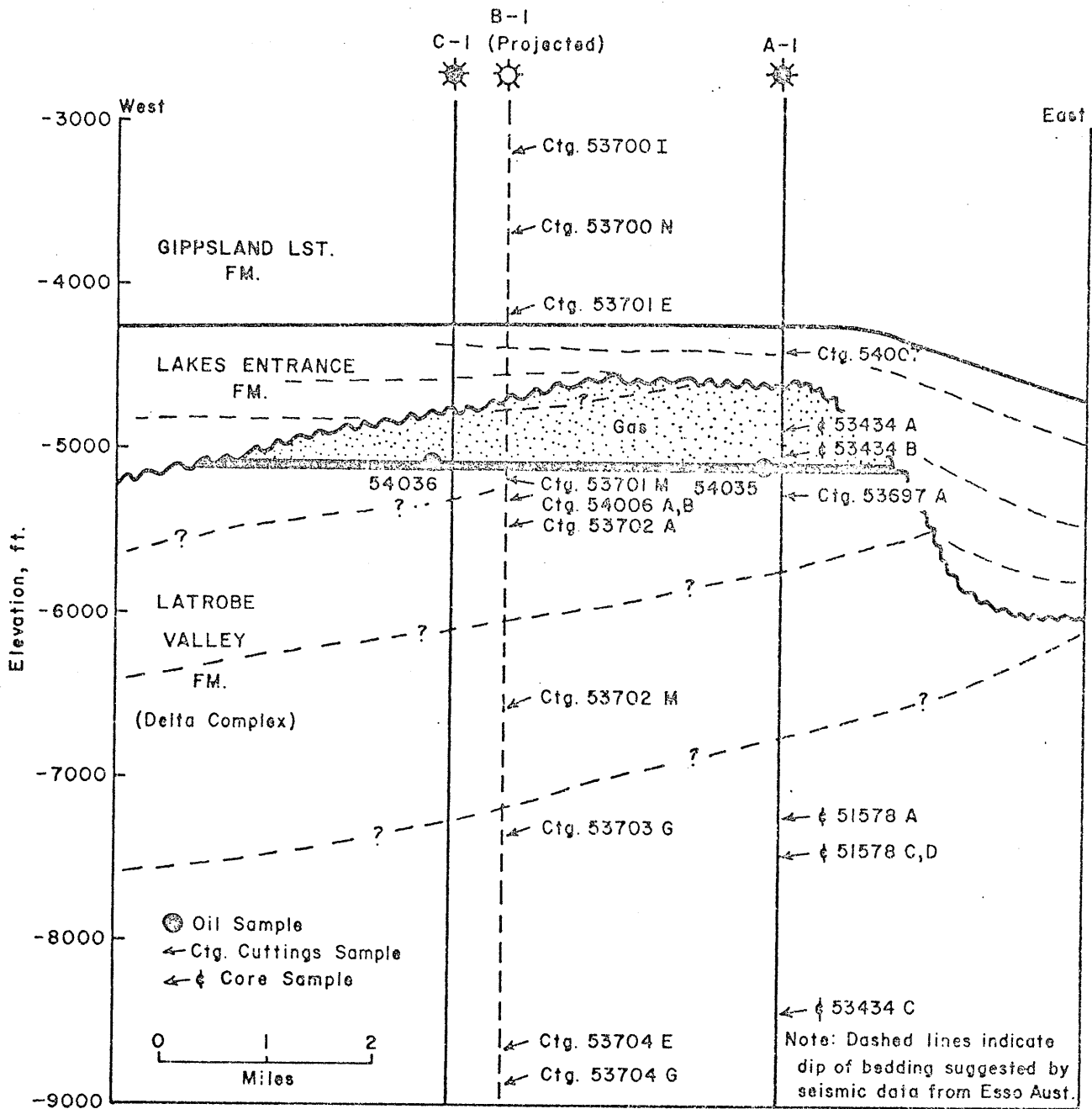


FIG. 2 - CROSS SECTION OF MARLIN FIELD SHOWING SAMPLE LOCATIONS (See Fig. 1).

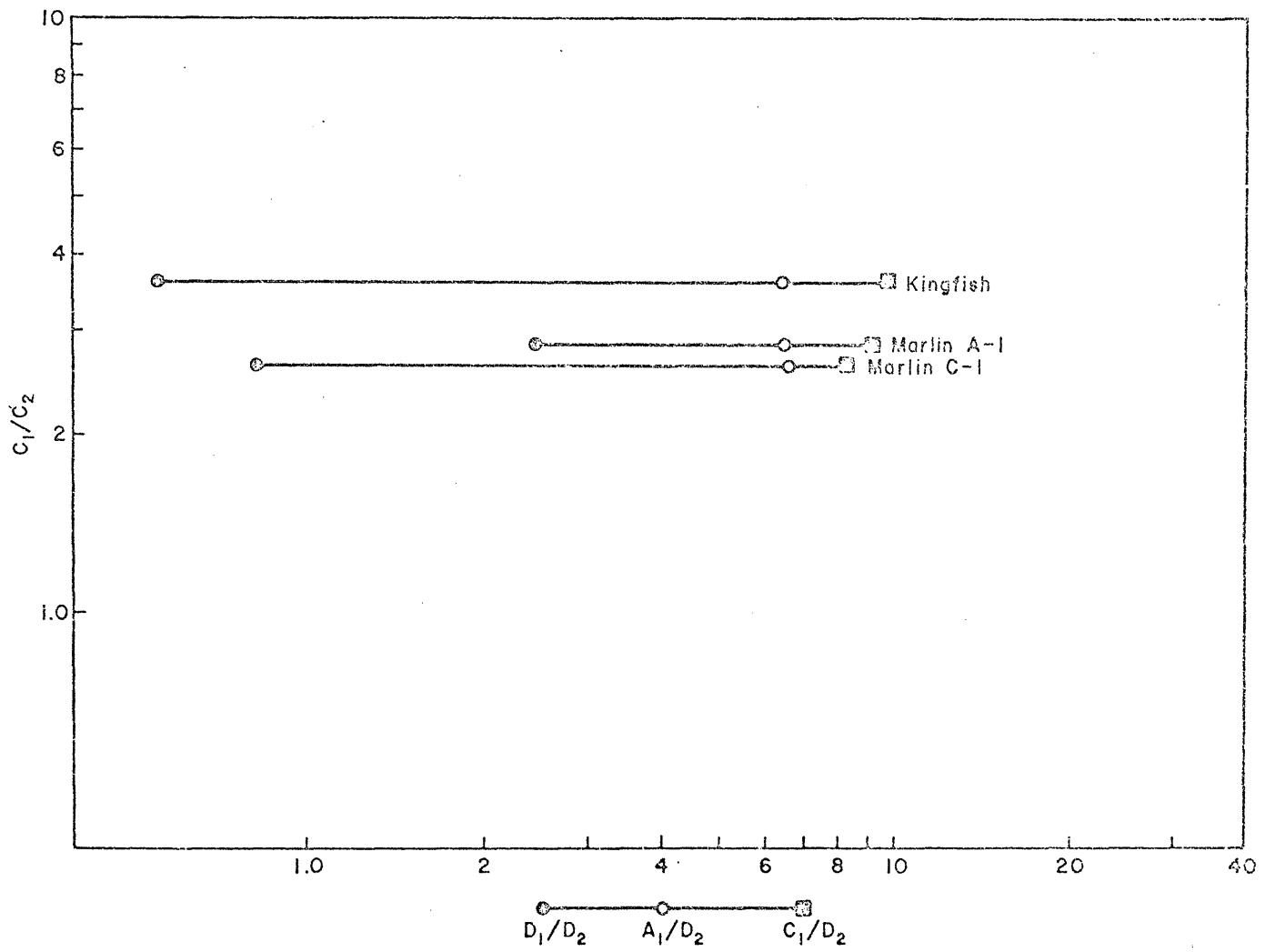


FIG. 3 - SIGNIFICANT RATIOS OF GASOLINE COMPOUNDS (See Table II).

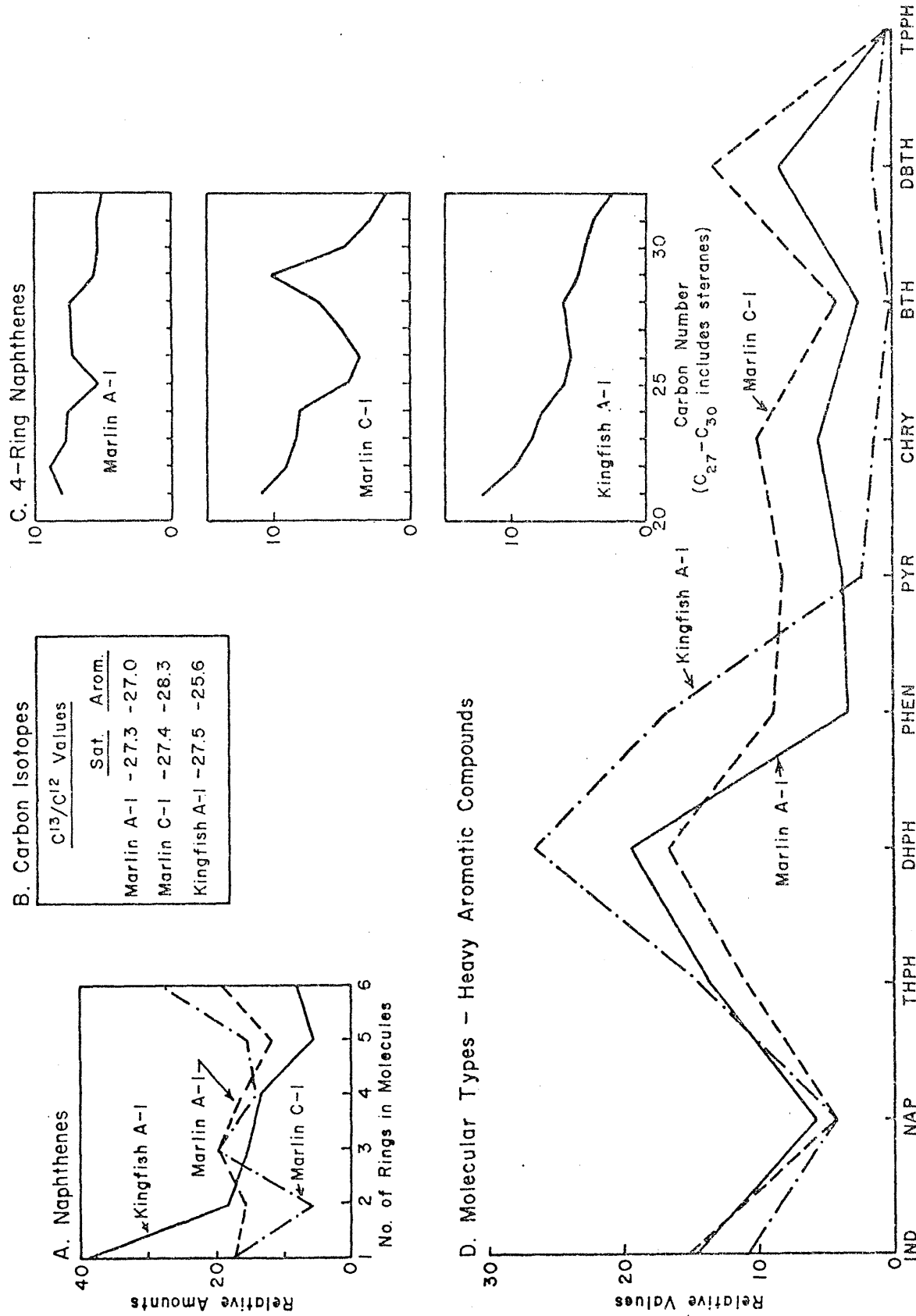
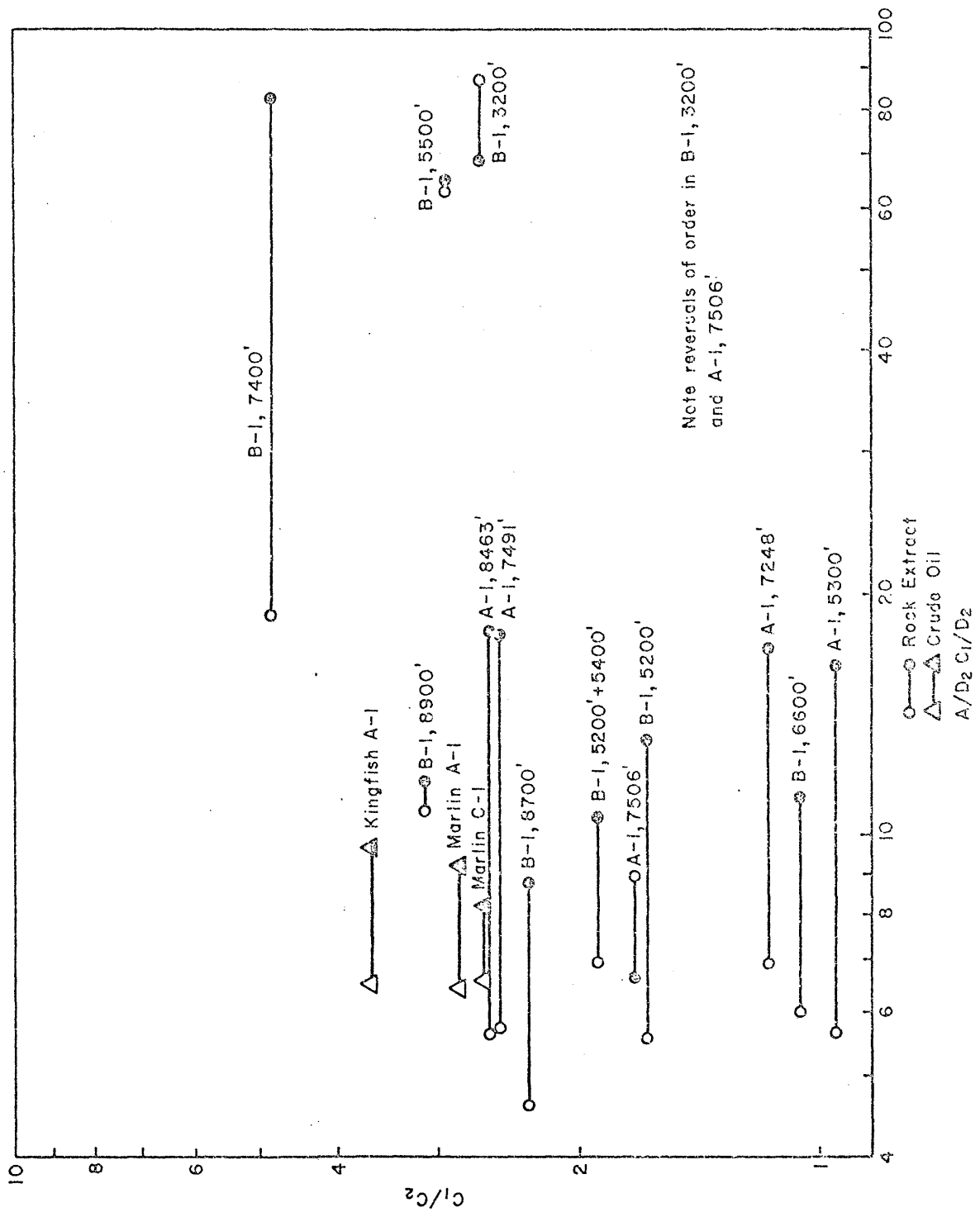


FIG. 4 - MOLECULAR AND ISOTOPIC VARIABLES - HEAVY FRACTIONS (C₁₅+) OF OILS.



Note reversals of order in B-1, 3200' and A-1, 7506'

FIG. 5 - SIGNIFICANT GASOLINE RATIOS, OILS vs. ROCK EXTRACTS (See Tables II, IV).

ROCK EXTRACTS

OILS

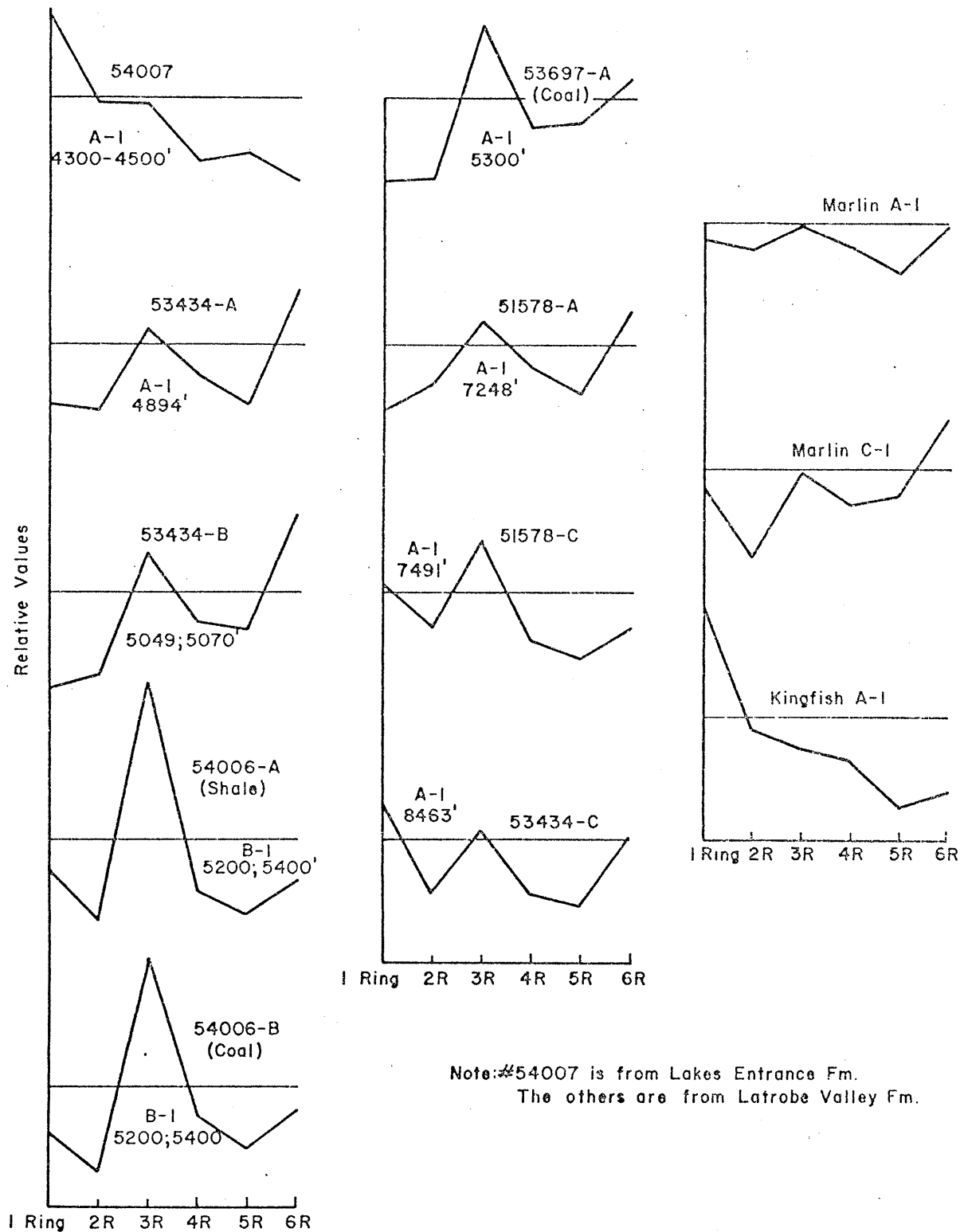


FIG. 6 - DISTRIBUTION OF NAPHTHENES, ROCK EXTRACTS FROM MARLIN A-I AND B-I vs. MARLIN AND KINGFISH OILS.

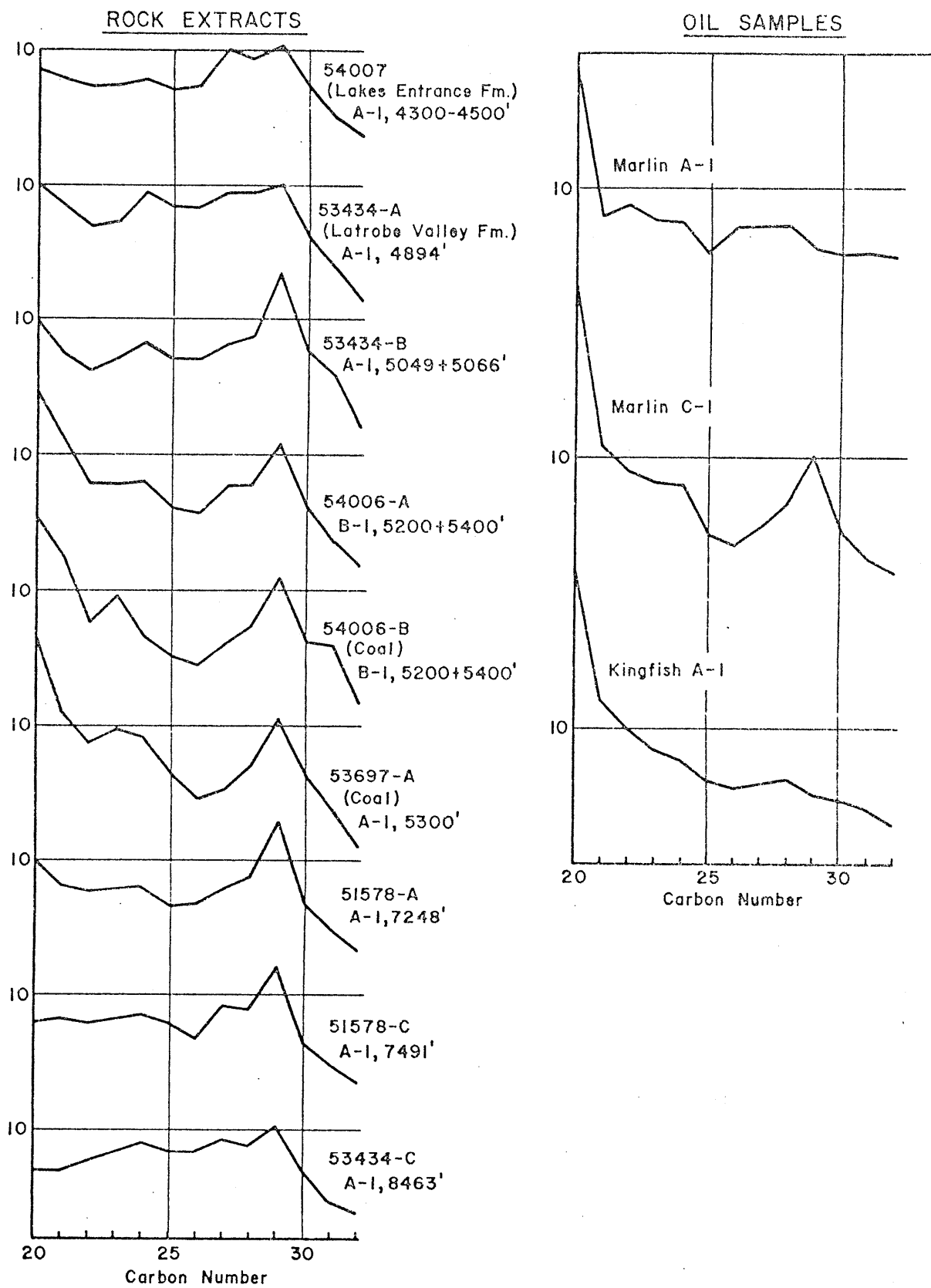


FIG. 7 - MASS SPECTROMETER PEAK DISTRIBUTIONS FOR 4-RING NAPHTENES (Steranes included in C₂₇-C₃₀ peaks).

SOURCE ANALYSIS OF SIDEWALL CORES
FROM THE PERCH A-1 WELL, AUSTRALIA

by

R. E. Metter
J. L. Morgan
H. M. Fry
T. D. Coleman
August, 1968.

SUMMARY

Source analyses were run on 23 sidewall cores, including 9 Miocene, 10 Lakes Entrance Formation, and 4 Latrobe samples. All were analyzed for total organic matter, light gasoline, and intermediate hydrocarbons, and three were also analyzed for heavy hydrocarbon yields. Four from each stratigraphic unit were examined for visual kerogen characteristics.

The Miocene samples are low in organic content and hydrocarbon yields, and their kerogen is only moderately altered; but four were rated as possibly poor to mediocre oil sources. The lower portion of the Lakes Entrance unit is interpreted to be an oil and associated gas source section on the basis of the chemical data from this study, and two of the four Latrobe samples are rated as oil sources. Kerogen in both of these units is only moderately altered.

INTRODUCTION

Sidewall core samples from 23 intervals in the Perch A-1 well were analyzed for their hydrocarbon source ratings.

At three of the intervals (2920, 3100, and 3630 feet) clusters of six sidewall cores were shot in order to obtain enough rock material for a heavy hydrocarbon (C₁₅+) analysis. At the other 20 intervals single cores were collected. Although these were too small for the heavy analysis, they were suitable for some of the tests that are used in assessing hydrocarbon source ratings.

The samples included 9 from the Miocene, 10 from the Lakes Entrance Formation, and 4 from the Latrobe Delta Complex. All were preserved in standard sidewall core bottles and were still moist and fresh appearing.

This service work was requested in the April 3, 1968 letter, Ref. 301.0 and 323.15, by J. H. Hafenbrack.

PROCEDURE

All 23 samples were analyzed for their total organic content and yields of light gasoline (C₄-C₇) and intermediate (C₈-C₁₄) hydrocarbon compounds. Twelve of the samples - four from each of the three stratigraphic intervals - were also analyzed for visual characteristics of their kerogen.

The three samples consisting of six sidewall cores each were analyzed for their heavy (C₁₅+) soluble organic matter and heavy hydrocarbons.

Sample descriptions and results of the visual kerogen analysis are compiled in Table I. Details of the C₁₅⁺ analysis are listed in Table II. Summaries of the various chemical analyses and interpretations of source ratings are included in Table III.

The heavy hydrocarbon yield from the 3690-ft. sample was sufficient to permit its use in the oil correlation study in the Gippsland Basin. Results of the further analysis of this extract will be included in a more general future report on crude oils from this area.

DISCUSSION AND INTERPRETATION OF RESULTS

Miocene Samples

These samples are all fairly low in organic content and in yields of intermediate (C₈-C₁₄) hydrocarbons. Four of the samples are rated as possible poor to mediocre oil sources (Table III), but none are considered to represent good sources.

The two heavy hydrocarbon analyses (samples at 2920 and 3100 feet) suggest possibly marginal oil sources, but the intermediate hydrocarbon (C₈-C₁₄) yields of these same two samples suggest poor sources. The sample from 3090 feet is the only one of the Miocene suite that yielded even moderate amounts of intermediate hydrocarbons (Table III).

Kerogen alteration (Table I) on our standard 1-5 scale is in the range 2-2+, suggesting that only a moderate amount of thermal diagenesis has occurred.

Lakes Entrance Samples

The lower portion of this interval is rated as a source section (Table III). Five of the bottom six samples, starting with the core from 3590 feet, are rated as sources of oil or oil with associated gas. These gave moderate to good yields of (C₈-C₁₄) hydrocarbons, and the sample from 3690 feet also gave a good yield of heavy hydrocarbons.

Gasoline (C₄-C₇) compounds first appear in fair amounts in the 3671-ft. sample (Table III). This appearance is believed to indicate the depth at which thermal maturation has progressed sufficiently to generate significant amounts of gasoline range compounds and at which medium to high API gravity oils might occur in the associated reservoirs. Interestingly, the kerogen alteration values (Table I) show no increase in this interval.

Latrobe Samples

The two samples from 3955 and 4462 feet are rated as oil sources. The other two are rated as poor sources (Table III). Alteration has been only moderate (2 on the kerogen alteration rating scale).

The two rated as oil sources have high organic content and gave fairly high yields of intermediate (C₈-C₁₄) hydrocarbons. Possibly these samples might be representative of strata that have generated considerable amounts of gas and distillate-range hydrocarbons.

TABLE I

Sample Descriptions and Visual Kerogen Characteristics

EPR No.	Depth, Feet	Lithology	GSA Color Code	Type of Kerogen		Color of Kerogen		Kerogen Preservation	Kerogen Alteration
				Predominant	Secondary	Predominant	Secondary		
<u>Miocene</u>									
54813-A	2530	Marl, white and v. lt. gray, very fossiliferous	N8, N9	amorphous	woody	orange	yellow	poor	2
B	2630	Marl, lt. olive to lt. yellowish gray, very fossiliferous	5Y6/1, 7/1	finely disseminated					
C	2730	Marl, med. to light gray, very fossiliferous	N2, N7						
D	2830	Marl, olive to light olive gray, fossil debris partially dissolved	5Y4/2, 6/1	woody	herbaceous	orange	l. brown	poor	2+
E	2920	Marl, lt. olive gray, tr. of fossils	5Y6/1						
F	2930	Marl, olive gray	5Y4/1	herbaceous	woody	orange	yellow	poor	2
G	3030	Marl, lt. olive gray, fragments of fossils	5Y6/1						
H	3090	Marl, lt. gray to lt. olive gray, fossiliferous	5Y6/1, N7	herbaceous	woody	orange	l. brown	poor	2+
I	3100	Marl, med. lt. gray	N6						
<u>Lakes Entrance</u>									
54814-A	3190	Marl, olive gray, trace of fossils	5Y4/1	woody	herbaceous	orange	l. brown	poor	2+
B	3290	Marl, lt. olive gray, trace of fossil material (shell and plant)	5Y6/1						
C	3390	Marl, olive to med. olive gray	5Y4/1, 5/1	woody	herbaceous	orange	yellow	poor	2
D	3490	Marl, lt. olive gray to med. lt. gray	5Y6/2, N5						
E	3590	Marl, med. lt. gray	N6	woody	coaly	orange	l. brown	v. poor	2+
F	3671	Very glauconitic clay, brownish to greenish black	5YR2/1, 5G2/1		herbaceous				
G	3690	Glauconitic clay, olive gray, sl. calcareous, trace of fossils	5Y4/1						
H	3700	Glauconitic clay, brownish to olive gray	5YR4/1, 5Y4/1						
I	3702	Glauconitic mudstone, olive gray, finely micaceous, trace of fossils	5Y4/1						
J	3706	Glauconitic mud, olive gray with quartz and mica silt and sand	5Y4/1	herbaceous	woody	orange	yellow	v. poor	2
<u>Latrebe</u>									
54815-A	3955	Claystone with thin discontinuous light gray silt laminae	5YR2/1, N2	herbaceous	woody	orange	yellow	v. poor	2
B	4133	Sand with clay matrix, coarse grained, poorly sorted	5Y4/1	amorphous	herbaceous	orange	yellow	v. poor	2
C	4325	Sand, clay and silt (trilling mud in part)	5Y6/1	herbaceous	woody	orange	yellow	v. poor	2
D	4462	Clay and silt	5Y6/1	herbaceous	woody	orange	yellow	v. poor	2

TABLE II
 Details of C₁₅+ Analysis

EPR No.	Unit	Depth, Feet	Soluble Organic Matter ppm	Normalized Composition				Sulfur in Extract, ppm	Total Hydrocarbons ppm
				Saturates	Aromatics	Eluted NSO	Non-eluted NSO		
54813-E	Miocene	2920	140	16.8	16.1	23.9	0.0	43.2	46
54813-I	Miocene	3100	185	11.5	16.9	21.3	6.9	43.4	53
54814-G	Lakes Entrance	3690	1196	5.9	9.9	11.5	6.4	66.2	189

TABLE III
Summary of Chemical Analyses and Interpreted Source Ratings

EPR No.	Depth, Feet	Total Organic Matter, %	C ₄ -C ₇ Hydrocarbons, ppm	C ₈ -C ₁₄ Hydrocarbons, ppm	C ₁₅ ⁺ Hydrocarbons, ppm	% Hydrocarbons in T.O.M.		Interpreted Source Rating
						C ₈ -C ₁₄	C ₁₅ ⁺	
<u>Miococene</u>								
54813-A	2530	0.26	*	trace				L
B	2630	0.30	*	trace				L
C	2730	0.52	trace	26		0.5		L
D	2830	0.39	trace	trace				L
E	2920	0.65	trace	14				L
F	2930	0.51	trace	40	46		.71	L-F
G	3030	0.52	*	15				L-F
H	3090	0.57	0.1	56				L
I	3100	0.49	*	20	53		1.1	L-F
<u>Lakes Entrance</u>								
54814-A	3190	0.55	trace	19			.35	L
B	3290	0.51	*	trace				L
C	3390	0.41	*	trace				L
D	3490	0.85	*	30				L
E	3590	2.00	*	1560			.35	L
F	3671	0.65	0.4	19			7.8	O
G	3690	1.56	1.6	68			.29	L
H	3700	1.38	1.3	59	189		.43	O,G
I	3702	1.68	7.4	122			.43	O,G
J	3706	2.00	2.7	214			.73	O
<u>Latrebe</u>								
54815-A	3955	6.15		397			1.1	O
B	4133	0.46	1.8	trace			.65	O
C	4325	0.34	0.2	14				L
D	4462	3.45	trace	278			.41	L
			0.6				.81	O

* - C₄-C₇ content too low for detailed analysis
L = Lean
O = Oil Source
G = Gas Source
F = Poor to Mediocre Source

INTERIM REPORT ON GEOCHEMICAL ANALYSES
OF GIPPSLAND BASIN OILS

by

R. E. Metter
October, 1969

SUMMARY AND CONCLUSIONS

Results of geochemical analyses of 23 crudes and condensates from the Gippsland Basin are summarised in Tables I-III. These data have previously been transmitted to Esso Australia, and they are tabulated here in order to provide a permanent record under a single cover.

Based on C₄-C₇ gasoline compounds the crudes from the Perch A-1 and Dolphin A-1 wells, together with condensate samples from the Barracouta A-2 and B-1 wells, form a distinct group of oils. Values for the ratio normal pentane/iso-pentane also suggest that these oils are different from the other oil samples. Heavy molecular data and carbon isotope values support this observation. That is, there appears to be a distinct group of oils in the Perch-Dolphin-Barracouta area that can be readily distinguished from the other oils in the basin.

The Perch-Dolphin-Barracouta grouping may not be a valid "oil family". These oils are depleted in benzene and toluene, which suggests that formation water movements or, alternatively, secondary migration of these oils through an aquifer, has occurred. This could have altered their compositional characteristics noted above.

INTRODUCTION

The purpose of this interim report is to provide a single compilation of data on the 23 Gippsland Basin oil samples that have been analysed to date by the Geochemistry Section at EPR. Results of various analyses and a few comments regarding possible correlations among the oils are included.

The 23 samples discussed in this report came from 14 different wells and include condensates as well as crude oils (Table 1). Some were obtained during production tests, but most came for F.I.T. samples.

The oils were received at various times and from different sources. Several samples were obtained from the Production Engineering Laboratory at EPR after they had been analysed for PVT properties. A single shipment of a suite of 14 oils was received from Esso Australia and described in the August 22, 1968 letter, File 301.0, by Dan C. Edwards. Dates of correspondence relating to these oils are listed in Table 1. Three oils—one each from the Dolphin A-1, Halibut A-1 and Marlin C-1 wells were obtained from the Production Engineering Laboratory after we learned through personal conversations that they had been sent for PVT analysis (Table 1). There was no formal correspondence regarding these latter three oils.

ANALYTICAL PROCEDURES

All of the oil samples were analysed for their molecular compositions in the light gasoline (C₄-C₇) range. The oils with significant fractions of heavy (C₁₅+) compounds were "topped" and their heavy fractions were separated by liquid chromatography into saturates, aromatics, "NSO's" (nitrogen, sulfur and oxygen-bearing compounds) and asphaltenes. The heavy saturate and aromatic fractions were analysed by mass spectrometry for molecular type distributions and for stable carbon isotope (C₁₃/C₁₂) values.

DISCUSSION OF RESULTS

The total suite of oil samples could only be correlated in the gasoline range. Most of the condensates contained insufficient heavy compounds for our routine analyses of heavy molecular types and of carbon isotope values. In making correlations it is preferable to be able to compare several variables in both the light and heavy hydrocarbon ranges. The different variables do not necessarily form the same groups of oils, and a weight of evidence based on several parameters is desirable in defining separate oil families.

The comments made below are mainly concerned with the gasoline data.

C₄-C₇ Data

The Perch, Dolphin, Barracouta A-2 and Barracouta B-1 oil samples are almost devoid of benzene and toluene (Table II). This strongly suggests

that these particular oils have been modified by formation waters, either by movement of the oils through the aquifers or by movement of formation waters past the oil accumulations. Benzene and toluene are the most soluble of the liquid hydrocarbons and would be the most readily removed by solution.

The same oils that have low concentrations of benzene and toluene also have low ratios of normal to iso-pentane (Table II). The reason for this is not clear, but differential solubility in water is not a likely cause. The iso-pentane is more soluble than the normal pentane. Water leaching, such as is suggested by low benzene and toluene concentrations, would be likely to produce higher rather than lower pentane ratios. The pentane ratios suggest the possibility that the Perch, Dolphin, and two Barracouta condensates may indeed represent a genetically distinct oil-family. We will investigate this further.

Carbon Isotope (C^{13}/C^{12}) Values

Isotope values are listed in Table III and no clear definition of distinct oil families is apparent.

Saturate fraction isotope values for the Gippsland oils show a smooth variation ranging from -26.6 to -28.3. The Perch and Dolphin oils have the least negative of the values, but there is no sharp break between these values and those for other oils.

The isotope values for the aromatic fractions are about the same for all oils except those from Marlin. All four of the Marlin samples have distinctly more negative values than others.

Heavy (C_{15+}) Molecular Data

Briefly, the data suggested that the Perch and Dolphin oils are similar and are relatively rich in isoprenoid compounds, and they are distinctive from the other oils that were analysed.

Possible groupings based on the heavier fractions will be investigated further and discussed in more detail after we complete the analysis of additional oil samples.

TABLE I

Gippsland Basin Oil and Condensate Samples Analyzed Through April, 1969

Well	Depth	EPR Sample No.	Remarks	Reservoir Unit	C ₁₅ + Fraction Analyzed (Table III)	C ₄ -C ₇ Analyzed
Barracouta A-2	{ 3516-3738 3757-3762 3768-3790 }	55311	Condensate	N. goniatus		X
Barracouta A-3	4616	55154	62° API, GOR = 50 cu ft/bbl, res temp 166°F	M. diversus		X
Barracouta B-1		55312	Test 1-C ₉ -q condensate	N. goniatus		X
Dolphin A-1	4027	55317	F.I.T.-7	N. goniatus	X	X
" "	?	54335	PVT sample	" "	X	X
Flounder A-1	8395	55318	F.I.T.-1	L. balmei	X	X
Halibut A-1	?	54233	PVT sample	L. balmei	X	X
Kingfish A-1	7585-7593	54053	48-49° API, GOR = 137 cu ft/bbl	M. diversus	X	X
Kingfish C-1	7600	55313	F.I.T.-2	M. diversus	X	X
Marlin A-1	4532-4552	55305	Zone 4; sep. pressure 660-700 psi; condensate	N. goniatus		X
	5069-5077	55306	Zone 3; " " 800-810 psi; condensate	M. diversus		X
	7406-7466	55307	Sep. pressure 980 psi	L. balmei	X	X
	7514-7574	55307	Sep. pressure 980 psi	L. balmei	X	X
	5122-5137	52191	51-53° API, GOR = 907 cu ft/bbl; Zone 2	M. diversus	X	X
	5120?	54035	51° API, res temp 180°F, pour point 5°F	M. diversus	X	X
Marlin B-1	5096-5107	55308	Sep. pressure 600-700	N. goniatus		X
Marlin C-1	5108-5131	55309	Zone 2; sep. pressure 430 psi; condensate	N. goniatus		X
	5030-5045	55310	Zone 1; " " 500 psi; condensate	M. diversus		X
	5120	54036	52° API, PVT sample, pour point 59°F	" "	X	X
Perch A-1	3740	55316	F.I.T.-2, main chamber	M. diversus	X	X
Snapper A-1	4568	55152-B	45° API, GOR = 810 cu ft/bbl, res temp 165°F, pour point 67°F	M. diversus	X	X
Tuna A-1	6409	55314	F.I.T.-6	L. balmei	X	X
	6494	55315	F.I.T.-1	" "	X	X
	6608	55153	40° API; GOR = 600 cu ft/bbl, res temp 201°F, pour point 74°F	L. Gracilicoccus	X	X

TABLE II

Light Gasoline Data (C₄-C₇ Hydrocarbons), Gippsland Basin Oils

Well	Depth	EPR Sample No.	% C ₄ -C ₇ in Total Sample	Percent of C ₄ -C ₇		$\frac{n C_5}{i C_5}$
				Benzene	Toluene	
Barracouta A-2	3516-3790	55311	22.6	.0	.03	.11
Barracouta A-3	?	55154	35.6	.0	.18	1.42
Barracouta B-1	?	55312	24.9	.0	.0	.03
Dolphin A-1	4027	55317	15.0	.0	.0	.31
" "	?	54335	14.9	.0	.0	.48
Flounder A-1	8395	55318	15.7	.76	5.51	1.12
Halibut A-1	?	54233	11.3	.02	2.09	1.04
Kingfish A-1	7585-7593	54053	17.1	.0	1.67	1.16
Kingfish C-1	7600	55313	17.5	.02	1.36	1.09
Marlin A-1	4532-4552	55305	21.7	.0	2.65	-
" "	5069-5077	55306	25.5	.08	3.20	-
" "	7406-7574	55307	18.3	.05	1.31	1.12
" "	5122-5137	52191	20.7	.97	3.55	1.27
" "	5120?	54035	14.7	.98	7.00	1.41
Marlin B-1	5096-5107	55308	48.0	.07	.50	2.17
Marlin C-1	5108-51	55309	67.3	.21	1.13	1.18
" "	5030-45	55310	29.4	.27	1.05	1.09
" "	5120	54036	20.0	.38	2.25	1.16
Perch A-1	3740	55316	10.2	.0	.0	.04
Snapper A-1	4568	55152-B	12.1	.08	.17	1.26
Tuna A-1	6409	55314	6.9	4.53	21.09	1.41
	6494	55315	8.5	4.62	18.88	1.32
	6608?	55153	7.7	4.95	23.62	1.56

TABLE III

Mass Spectrometric Analysis of Heavy (C₁₅+)₁ Fractions of Cippaland Basin Oils

Sample	Delphin A-1		Flounder A-1		Halibut A-1		Kingfish A-1		Kingfish G-1		Marlin A-1		Marlin C-1		Perch A-1		Snapper A-1		Tuna A-1				
	55317	54335	55318	54338	54233	54233	54033	55307	52191	54035	54036	55316	55315	55314	55315	55315	55315	55315	55315	55315			
Depth	4027	4000± ?	8395	?	7585-7593	7600	7406-7574	5122-5137	5120?	3120	3740	4568	6424	6409	6493	6494	6493	6494	6494	6493			
Reservoir Unit	N. gon.	N. gon.	L. balm.	L. balm.	L. balm.	M. div.	M. div.	M. div.	M. div.	M. div.	M. div.	M. div.	M. div.	M. div.	M. div.	M. div.	M. div.	M. div.	M. div.	L. balm.	L. balm.	L. balm.	U. Crat.
Gross Composition - %																							
Saturates	59.1	62.9	76.0	66.7	53.5	68.2	83.2	63.8	43.5	36.1	60.9	77.1	78.1	78.1	68.7	73.3							
Aromatics	29.1	23.6	9.7	22.9	10.8	17.7	5.1	6.2	10.7	28.4	30.2	14.7	11.4	11.4	11.6	12.6							
Eluted NSO's	6.0	7.8	3.4	4.8	1.8	3.3	1.6	6.6	8.8	4.7	4.8	4.8	3.2	3.2	3.9	2.9							
Noneluted NSO's	4.5	2.9	9.8	3.1	6.1	8.8	9.6	19.4	33.9	3.0	2.7	2.7	5.4	5.4	15.1	10.8							
Asphaltenes	1.2	2.9	1.1	2.5	2.5	1.9	0.5	3.6	3.1	16.6	1.1	0.6	1.9	1.9	9.8	0.3							
Hydrocarbon Composition - %																							
Paraffins	25.9	29.5	73.1	51.8	61.5	58.0	88.2	71.0	65.2	33.4	21.2	65.1	73.5	73.5	68.9	68.5							
Naphthenes	41.2	43.2	15.6	22.6	21.7	21.5	6.0	20.2	15.0	22.7	45.6	13.8	13.7	13.7	16.5	17.5							
Aromatics	33.0	27.1	11.4	25.5	16.8	20.7	5.8	8.8	19.8	44.1	33.1	16.1	12.6	14.5	14.5	14.7							
Carbon Isotope Values																							
Saturates	-26.6	-26.9	-27.9	-27.0	-27.5	-27.7	-27.2	-27.1	-27.3	-27.4	-26.7	-28.3	-27.1	-27.1	-27.3	-27.2							
Aromatics	-25.5	-25.4	-25.7	-26.0	-25.5	-25.5	-26.9	-28.1	-28.0	-28.3	-25.4	-25.5	-25.3	-25.1	-25.1	-25.2							
Heavy Aromatic Molecular Types - %																							
Benzenes (B)	16.1	15.8	13.9	16.9	16.3	10.5	11.8	1.5	15.6	7.9	20.4	19.3	9.3	9.3	8.9	17.3							
Indanes (IND)	9.7	7.8	7.6	8.7	6.6	6.4	20.9	1.2	8.9	8.9	12.3	7.6	2.9	2.9	5.3	5.8							
Indenes (INDE)	21.7	13.0	15.2	10.5	10.9	14.5	8.1	1.8	14.6	15.3	24.6	12.5	7.0	11.3	10.9	10.9							
Naphthalenes (N)	11.0	5.0	9.3	3.9	4.1	8.5	2.2	0.6	5.6	4.0	19.4	5.4	3.5	8.5	7.4	7.4							
Tetrahydrophenanthrenes (THP)	16.5	14.7	21.3	13.7	14.3	21.0	10.2	11.1	13.6	10.8	14.0	14.0	23.7	23.1	17.7	17.7							
Dihydrophenanthrenes (DHP)	18.9	23.4	26.6	23.8	26.5	31.9	16.3	23.5	19.3	16.6	14.9	23.7	17.3	32.2	27.0	27.0							
Phenanthrenes (PHEN)	0.0	6.4	17.0	6.4	16.6	4.3	7.8	28.0	3.2	8.6	0.0	11.6	20.5	8.0	14.7	14.7							
Pyrenes (PYR)	0.0	0.0	0.0	2.4	2.2	0.0	2.7	18.2	3.4	0.8	0.0	1.0	0.0	0.0	0.0	0.0							
Chrysenes (CHR)	0.0	4.1	0.0	1.7	1.2	0.0	3.2	7.8	5.3	9.8	0.0	1.0	3.4	0.0	0.0	0.0							
Benzothiofenenes (BT)	1.8	2.0	0.0	0.0	0.0	0.0	0.0	1.8	2.3	3.9	2.3	0.4	0.0	0.0	0.0	0.0							
Dibenzothiofenenes (DBT)	4.5	7.7	6.1	1.5	1.3	2.9	7.7	2.5	8.2	13.2	2.3	3.3	11.8	2.8	0.0	0.0							
Thiophenanthrenes (TPP)	0.0	0.0	0.0	0.0	0.0	0.0	9.1	2.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0							
Saturates - %																							
1-Ring Naphthenes	38.7	40.6	82.4	69.5	73.9	73.1	83.1	77.9	81.3	59.7	31.7	77.5	84.2	84.2	80.6	80.2							
2-Ring Naphthenes	26.5	18.3	5.1	8.9	10.3	4.8	1.2	5.5	3.2	7.1	23.2	7.6	4.4	5.4	5.1	5.1							
3-Ring Naphthenes	13.4	11.2	5.2	9.4	4.8	8.9	3.1	3.7	2.9	2.4	17.4	3.5	4.5	5.4	2.9	2.9							
4-Ring Naphthenes	9.8	11.3	4.2	3.4	4.0	7.0	3.6	4.7	3.6	7.8	3.3	3.5	3.5	4.7	2.6	2.6							
5-Ring Naphthenes	8.3	10.0	2.5	5.7	3.5	5.0	4.3	5.2	3.1	5.7	9.5	3.5	3.5	2.8	3.2	3.2							
6-Ring Naphthenes	3.1	5.1	0.6	2.6	1.5	1.2	3.2	2.4	2.2	6.1	2.7	1.7	0.8	0.7	1.9	1.9							
7-Ring Naphthenes	0.2	3.1	0.0	1.9	2.1	0.0	1.6	0.6	3.5	11.1	0.3	2.9	0.0	0.0	0.0	0.0							

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GEOCHEMICAL ANALYSES OF SAMPLES FROM HAPUKU-1
GIPPSLAND BASIN, AUSTRALIA

by

R. E. Metter
February, 1976

SUMMARY AND CONCLUSIONS

Canned cuttings from the interval 8500 ft - 11,974 ft were routinely analysed for hydrocarbon source characteristics. In addition, an oil sample from 9258 ft was analysed and compared to extracts of cuttings from three different depths in an attempt to delineate possible sources of the oil.

The analytical data suggest the following:

A. Source Patterns:

<u>Approximate Interval (ft)</u>	<u>Age (by Partridge)</u>	<u>Maturity</u>	<u>Source Richness</u>	<u>Indigenous Hydrocarbons Expected if Reservoired</u>
8,500- 9,182	Miocene	Immature	Poor	Lean
9,182- 9,400	Paleoc.-E.Olig.	Immature	Poor	Lean
9,400- 9,800	U. Cret.	Transitional	Poor	Lean
9,800-10,300?	U. Cret.	Transitional	Fair	Minor Gas & Liquids
10,300?-11,974	U. Cret	Mature	Good to Rich	Gas, Liquids

The data leading to these interpretations are listed in Tables I through VII and are summarised in Fig. 1.

B. Source of Hapuku Oil

1. The oil recovered in F.I.T.-6 (9258 ft) resembles oils previously analysed from Mackerel, Kingfish, Flounder, and some of the Cretaceous zones at Tuna. These oils were earlier interpreted to be sourced primarily from Cretaceous and Paleocene strata.

2. Gasolines in the Hapuku oil correlate with gasolines from 9600 ft, 10,000 ft, 11,200 ft, and possibly from other samples in the rich Cretaceous interval, and we assume their principal source is this rich Cretaceous.

3. The heavier compounds (C_{15+}) in the oil do not resemble the rock extracts that we analysed, and we have not chemically identified their source. However, the rich Cretaceous interval below 10,500 ft appears rich enough and mature enough to have been the source, despite the chemical differences. Perhaps the large quantities of gas and gasolines generated in this section have preferentially extracted certain compound types from the source beds and carried them along to the reservoir. This could explain the highly paraffinic nature of the oil and its lack of sulfur-bearing compounds.

Alternatively, the heavies might have originated in beds older than any of those touched by the well or from zones that were drilled but not analysed. In either case, we assume the principal source lies below 10,500 ft in the Hapuku-1 well.

PROCEDURES

1. Canned cuttings samples were analysed routinely for hydrocarbon source characteristics as follows:

Compositions and concentrations of hydrocarbon gases in the air spaces above the cuttings in the sample cans were determined by gas chromatography. Similar data were obtained on gases released from a standard mixture of cuttings and tap water after two minutes of agitation in a Waring blender. Combined results on the air space gas plus the cuttings gas were calculated for each sample. The data were plotted graphically to show vertical variations of total gas (C_1-C_4) and wet gas (C_2-C_4), and a graphical plot was also made of the percent wet gas in total gas (Fig. 1). Detailed results of these analyses are listed in Table I.

Chips of uniform lithologies were picked by hand from the heterogeneous mixtures of chips in 20 of the original canned samples. These are described in Table II. Our standard analytical procedures were used for determining C_4-C_7 light gasoline contents and total organic contents of the "picked" chips. These results are tabulated in Tables II and III and they are plotted graphically in Fig. 1. Visual kerogen characteristics of 17 of the "picked" samples were also determined (Table II and Fig. 1).

As is always the case when dealing with cuttings, cavings were probably "picked" in some instances when we selected uniform lithologies for analytical determinations. We tried to minimise

this. Lithologies are listed in Table II, and a geologist familiar with the section can possibly distinguished and eliminate those samples comprised of cavings.

2. Esso Australia submitted 25 kerogen slides prepared from sidewall cores and standard cores. These were routinely examined and the visual kerogen characteristics were described (Table IV).
3. Organic extracts were obtained from four cuttings samples by use of organic solvents. Three of the extracts were analysed by liquid chromatography, but the fourth was too small for analysis (Table V). The F.I.T. oil sample's heavy fraction was also analysed in the same way. Gas chromatograms were run on the heavy saturate fractions of the three extracts and the oil (Figs. 2 - 5).
4. The heavy saturate and the heavy aromatic fractions of the oil and the rock extracts were each analysed by mass spectrometry to give the carbon isotope values (per mil deviation from Peedee belemnite) and compositions of various molecular types of compounds (Table VI and Fig. 6).
5. The gasoline fraction of the oil was analysed by gas chromatography (Tables VII and III).

DISCUSSION

The profiles show in Fig. 1 strongly indicate that the Cretaceous section starting at about 10,500 ft is a rich, mature source of hydrocarbon gas and liquids. Some of this zone yielded gas that was predominantly methane, although shallower intervals produced samples that yielded gas that was up to 75 percent "wet". This reversal in percent C₂-C₄ starting at 10,500 ft might be an indication of a gas-prone interval, but the very high gasoline yields from these same samples indicate that condensate and oil have also been generated by this section. The high content of heavy (C₁₅+) hydrocarbons supports this latter interpretation.

Visual-kerogen prepared from the cuttings samples showed some minor differences from kerogen prepared from the sidewall cores. The alteration values were comparable (Table II vs Table IV) but the "cuttings kerogen" data suggest an "oilier" section than does the kerogen data from the cores. The kerogen profile in Fig. 1 includes only the cuttings data.

The composition of the oil is characterised by gasoline data (Tables III and VII), by heavy hydrocarbon data (Table VI and Fig. 2), and by carbon isotope data (Table VI). The rock extract compositions are also characterised by the same parameters (Tables III and VI, and Figs. 3-6). The gasolines in the oil resemble those in the cuttings from 9600 ft, from 10,000 ft, from 11,200 ft, and possibly from some of the other depths.

However, the heavy fractions of the oil do not match those of the three rock extracts that were analysed. Figs. 2-5 and Fig. 6 show these differences quite well.

The correlation data mentioned above suggest that the lighter compounds in the Hapuku oil came from the rich Cretaceous zone, but they do not identify the source beds of the heavy compounds. At least two possibilities are suggested:

1. The heavy compounds came from still deeper strata not reached by the well.
2. Migration of large amounts of gas and gasolines from the Cretaceous has fractionated the heavier hydrocarbons, preferentially extracting the more paraffinic and sulfur-free types. Thus, the migrated heaves would not necessarily resemble the heavies left behind.

In either case, the Hapuku oil had source strata similar to those which sourced oils in the nearby fields.

TABLE 1B

C₁-C₄ HYDROCARBON ANALYSES - CUTTINGS ONLY

SAMPLE NUMBER	DEPTH	GAS CONCENTRATION (VOLUME GAS PER MILLION VOLUMES CUTTINGS)								GAS COMPOSITION (PERCENT)									
		METHANE (C ₁)		ETHANE (C ₂)		PROPANE (C ₃)		ISO-BUTANE (iC ₄)		NORMAL BUTANE (nC ₄)		WET (C ₂ -C ₄)		TOTAL (C ₁ -C ₄)		TOTAL GAS			
		(C ₁)	(C ₂)	(C ₃)	(iC ₄)	(nC ₄)	(C ₂ -C ₄)	(C ₁ -C ₄)	C ₂ -C ₄	C ₁	C ₂	C ₃	iC ₄	nC ₄	C ₂	C ₃	iC ₄	nC ₄	
66321A	7	791.55	18.06	21.83	18.76	17.52	76.17	867.72	8.7781	91.	2.	3.	2.	2.	24.28	25.23.			
66321B	7	1364.46	34.98	36.83	26.42	23.89	122.12	1486.58	8.2148	92.	2.	2.	2.	2.	29.29	22.20.			
66321C	7	1147.91	45.00	51.54	44.44	39.82	180.80	1328.71	13.6072	87.	3.	4.	3.	3.	25.28	25.22.			
66321D	7	222.59	15.93	24.44	24.48	21.59	86.44	309.03	27.9713	72.	5.	8.	7.	7.	18.28	29.25.			
66321E	7	551.88	38.88	47.82	38.85	32.39	157.94	709.82	22.2506	78.	5.	7.	5.	5.	25.29	25.21.			
66321F	7	1063.81	115.56	121.22	59.05	56.82	355.65	1419.46	25.0553	75.	8.	9.	4.	4.	33.34	17.16.			
66321G	7	552.93	64.20	101.84	50.82	83.72	300.58	853.51	35.2169	64.	8.	12.	6.	10.	21.34	17.28.			
66321H	7	655.95	5.40	1.53	0.67	2.21	9.83	665.78	1.4764	99.	1.	0.	0.	0.	55.16	7.22.			
66321I	7	757.91	9.96	6.83	4.92	10.84	32.55	790.46	4.1178	96.	1.	0.	1.	1.	31.21	15.33.			
66321J	7	280.67	18.78	64.96	36.36	78.76	198.86	479.53	41.4697	58.	4.	14.	8.	16.	9.33	18.40.			
66321K	7	473.04	15.60	40.12	36.05	69.03	160.80	633.84	25.3691	75.	2.	2.	2.	3.	10.25	22.45.			
66321L	7	517.19	10.24	12.45	11.13	17.92	52.29	569.48	25.3691	91.	2.	2.	2.	3.	20.25	21.34.			
66321M	7	568.70	12.24	28.63	24.48	49.56	114.91	683.61	9.1820	83.	2.	4.	4.	7.	11.25	21.43.			
66321N	7	429.94	26.40	87.69	55.01	94.87	263.97	693.91	16.8092	61.	4.	13.	8.	14.	10.33	21.36.			
66321O	7	355.83	14.04	71.54	63.71	155.76	305.05	660.88	46.1581	53.	2.	11.	10.	24.	5.23	21.51.			
66321P	7	642.28	5.64	4.28	7.04	17.70	34.66	676.94	5.1200	94.	1.	1.	1.	3.	16.12	20.52.			
66321Q	7	781.04	29.82	60.13	473.04	1345.20	2449.19	3230.23	75.8209	24.	1.	19.	15.	41.	1.25	19.55.			
66321R	7	855.68	177.12	725.33	230.92	605.34	1738.71	2594.30	67.0161	33.	7.	28.	9.	23.	10.42	13.35.			
66321S	7	1639.87	624.00	1373.15	494.17	1213.51	3704.83	5344.70	69.3178	30.	12.	26.	9.	23.	17.37	13.33.			
66321T	7	55082.84	25535.98	11982.80	1396.60	2782.44	41699.72	96782.56	43.0860	58.	26.	12.	1.	3.	61.29	3.7.			
66321U	7	34605.40	17279.98	7859.37	951.59	1770.00	27760.93	62366.42	44.5126	44.	5.	12.	1.	3.	63.28	3.6.			
66321V	7	30148.40	15148.76	6210.00	629.37	1416.00	23404.14	53552.54	43.7031	55.	28.	12.	1.	3.	64.27	3.6.			
66321W	7	12114.96	7718.29	4162.18	400.76	1099.17	13441.49	26560.45	50.6072	49.	29.	16.	2.	4.	58.31	3.8.			
66321X	7	22916.14	13363.19	5901.94	578.09	1357.59	21200.84	44116.98	48.0560	53.	30.	13.	1.	3.	63.26	3.6.			
66321Y	7	68117.69	34060.77	14506.54	1774.67	3242.74	53584.50	121702.19	44.0292	56.	28.	12.	1.	3.	64.27	3.6.			
66321Z	7	42848.93	21384.78	9637.91	1006.99	2166.48	34700.01	77088.94	44.3643	44.	36.	13.	1.	3.	63.28	3.6.			
66322A	7	33512.24	27609.57	11943.06	1087.80	2619.60	43259.89	76772.13	56.3484	44.	36.	16.	1.	3.	63.28	3.6.			
66322B	7	26153.63	18492.77	9369.71	1343.74	2623.14	32019.35	58173.18	55.0414	45.	32.	16.	2.	5.	59.29	4.8.			
66322C	7	8514.72	8774.39	5911.92	758.35	1922.22	17366.87	254861.59	67.1012	33.	34.	23.	3.	7.	51.34	4.11.			
66322D	7	7926.04	8572.79	6488.20	899.76	2116.92	18077.66	26003.70	69.5198	30.	34.	23.	3.	7.	47.36	5.12.			
66322E	7	11416.01	11327.99	9538.56	1507.38	3518.76	25892.68	37308.69	69.4012	31.	30.	26.	3.	8.	43.37	6.14.			
66322F	7	11058.61	6451.19	3547.08	584.30	1265.55	11858.11	22616.72	51.7443	47.	28.	16.	4.	9.	54.30	5.11.			
66322G	7	23126.38	7094.79	3060.29	495.73	977.04	11617.84	34744.22	33.4382	67.	20.	9.	1.	3.	62.26	4.8.			
66322H	7	23462.77	10310.39	4769.28	630.92	1543.44	17254.02	40716.79	42.3757	57.	25.	12.	2.	4.	59.28	4.9.			

TABLE 1C
 C₁-C₄ HYDROCARBON ANALYSES - CUTTINGS AND AIR SPACE

SAMPLE NUMBER	DEPTH	GAS CONCENTRATION (VOLUME GAS PER MILLION VOLUMES CUTTINGS)					WET (C ₂ -C ₄)	TOTAL (C ₁ -C ₄)	GAS COMPOSITION (PERCENT)											
		METHANE (C ₁)		ETHANE (C ₂)		PROPANE (C ₃)			ISO-BUTANE (iC ₄)		NORMAL BUTANE (nC ₄)		TOTAL GAS				WET GAS			
		(C ₁)	(C ₂)	(C ₃)	(iC ₄)	(nC ₄)			C ₁	C ₂	C ₃	iC ₄	nC ₄	C ₂	C ₃	iC ₄	nC ₄	C ₂	C ₃	iC ₄
66321A	7	8600	1821.72	89.96	108.52	71.83	50.62	319.83	2141.55	14.0345	86.	4.	5.	3.	2.	28.34	22.16.			
66321B	7	8700	2399.46	80.47	192.98	54.41	38.41	266.27	2665.76	9.9885	91.	3.	3.	2.	1.	30.36	20.14.			
66321C	7	8800	2642.95	147.74	123.79	85.99	60.71	418.23	3061.18	13.6624	86.	5.	4.	3.	2.	34.30	21.15.			
66321D	7	8900	4408.70	466.17	451.03	279.27	166.69	1363.15	5771.65	23.6173	76.	8.	8.	5.	3.	35.33	20.12.			
66321E	7	9000	1403.65	190.20	177.56	114.86	73.86	556.57	1960.22	28.3932	71.	10.	9.	6.	4.	34.32	21.13.			
66321F	7	9100	2281.39	340.23	286.12	120.87	94.91	842.13	3123.52	26.9609	73.	11.	9.	4.	3.	41.34	14.11.			
66321G	7	9200	1867.35	406.92	404.69	171.29	215.20	1192.10	3065.45	39.0840	61.	13.	13.	6.	7.	34.34	14.18.			
66321H	7	9400	841.08	98.33	387.33	257.27	493.09	1236.02	2078.10	47.2728	41.	5.	19.	12.	24.	8.31	21.40.			
66321I	7	9500	941.38	80.54	277.82	196.37	301.59	824.00	1785.38	45.0316	52.	5.	15.	11.	17.	10.31	23.36.			
66321J	7	9600	291.14	22.52	77.82	43.13	95.04	238.51	529.65	45.0316	55.	4.	15.	8.	18.	19.33	16.43.			
66321K	7	9700	795.55	282.94	782.67	344.11	512.93	1922.65	2718.20	70.7325	29.	10.	29.	13.	19.	15.40	13.51.			
66321L	7	9800	638.10	70.16	149.04	83.23	100.18	402.61	1040.71	39.6860	61.	7.	14.	8.	10.	17.37	21.25.			
66321M	7	9900	680.09	78.11	295.01	179.79	247.78	800.69	1480.78	54.0721	46.	5.	20.	12.	17.	10.37	22.31.			
66321N	7	10000	647.57	165.87	453.67	236.95	287.90	1144.69	1791.26	63.9041	36.	9.	25.	13.	16.	14.40	21.25.			
66321O	7	10100	461.70	73.88	339.81	245.42	427.63	1086.74	1549.44	70.1376	30.	5.	22.	16.	28.	17.31	23.39.			
66321P	7	10200	657.33	77.88	27.07	35.44	76.39	146.78	804.11	18.2536	83.	1.	3.	4.	9.	5.18	24.53.			
66321Q	7	10300	781.75	30.03	602.87	474.60	1348.45	2465.05	3238.70	75.8313	24.	1.	19.	15.	42.	1.25	19.55.			
66321R	7	10400	2439.72	1516.97	2810.86	679.86	1807.70	7115.38	9555.10	74.4668	26.	16.	29.	10.	19.	33.31	10.28.			
66321S	7	10500	17861.02	4651.73	4376.03	13213.11	3573.51	13924.23	31785.25	43.8072	56.	15.	14.	4.	11.	21.40	14.25.			
66321T	7	10600	90946.75	38117.61	13213.11	1073.75	3078.70	56084.07	147080.81	38.1315	62.	28.	9.	1.	2.	68.24.	3.5.			
66322A	7	10700	187613.44	38173.29	13310.37	1553.05	2528.39	56165.06	243778.50	23.0394	77.	16.	5.	1.	1.	69.24.	3.5.			
66322B	7	10800	249171.56	41772.75	12524.88	1395.65	2242.00	57925.21	307096.75	18.8622	81.	14.	4.	0.	1.	72.22.	2.4.			
66322C	7	10900	67874.75	17361.04	7331.66	892.43	1625.25	27210.30	95085.06	28.6168	71.	18.	9.	1.	2.	64.27.	3.6.			
66322D	7	11000	160506.44	32669.84	10990.57	1209.40	2107.36	46677.03	207183.44	22.5293	77.	16.	5.	1.	1.	64.23.	3.5.			
66322E	7	11100	72237.75	35114.49	14797.79	1810.38	3283.51	46677.03	207183.44	43.1948	56.	28.	12.	1.	3.	64.27.	3.6.			
66322F	7	11200	136127.38	33442.62	12567.81	1366.47	2561.49	49938.57	189066.00	26.4133	73.	18.	7.	1.	1.	67.25.	3.5.			
66322G	7	11300	347470.38	78009.50	24404.46	2477.01	4354.20	109244.94	456715.38	23.9197	76.	17.	5.	1.	1.	72.22.	2.4.			
66322H	7	11400	150135.19	45589.91	16892.14	2151.62	3795.77	68433.31	215568.50	31.3998	68.	21.	8.	1.	2.	66.25.	3.6.			
66322I	7	11500	184800.75	53414.36	24839.98	3555.55	5705.59	87515.25	272316.06	32.1374	68.	20.	9.	1.	2.	61.29.	4.7.			
66322J	7	11600	11850.52	10420.25	7402.31	1022.01	2317.52	21162.08	33012.60	64.1030	36.	32.	22.	3.	7.	49.35.	5.11.			
66322K	7	11700	47457.13	21716.55	14234.50	2228.13	4474.25	42263.52	89720.63	47.1057	53.	24.	16.	2.	5.	50.34.	5.11.			
66322L	7	11800	58002.19	17971.18	8209.25	1425.13	2265.48	29971.02	87973.19	34.0682	66.	20.	9.	2.	3.	64.27.	5.7.			
66322M	7	11900	56834.80	12220.79	4964.69	1874.52	1435.76	19495.75	76330.50	25.5536	74.	16.	7.	1.	1.	64.25.	4.7.			
66322N	7	11974	165271.63	33251.55	12075.16	1880.21	3100.87	50307.64	215579.25	23.5360	77.	15.	6.	1.	1.	66.24.	4.6.			

TABLE II

DESCRIPTIONS OF "PICKED" CUTTINGS AND OF VISUAL KEROGEN CHARACTERISTICS, HAPUKU-1

(Kerogen by J. L. Morgan)

Depth	EPR No.	Gross Lithology of "Picked" Chips	GSA Color Code (dry)	Total Organic Matter (%)	Kerogen Alteration	Types of Kerogen (% of total on slide)				Remarks	
						Algal?	Herbaceous	Woody	Coaly		Other*
8,600	66321-A	Shale, lt. olive gray, calc.	5Y6/1	.10	2-	-	30	40	30	trace M	Range "1+" to "2"
8,800	66321-C	As above	5Y6/1	.10	2-	-	10	40	40	trace M	"
8,900	66321-D	As above, mod. calc.	5Y6/1	.21	2	-	10	40	40	trace M	Range "1+" to "2+"
9,100	66321-F	As above	5Y6/1	.07	2+	-	10	40	40	trace M	"
9,400	66321-H	Shale, med. gray to lt. olive gray; some calc.	N5-5Y6/1	.26	2+	20	trace	50	30	-	"
9,600	66321-J	Shale, lt. olive gray, variably calc.	5Y6/1	.35	2+	-	trace	50	40	-	"
9,800	66321-L	As above	5Y6/1	.27	2	-	20	40	40	-	Range "1+" to "2+"
9,900	66321-N	As above	5Y6/1	.92	2	-	trace	60	30	trace M	"
10,000	66321-O	As above	5Y6/1	.72	-	-	-	-	-	-	"
10,300	66321-Q	Mixture of 20% shale grains, 70% quartz grains, trace of coal	-	.76	2	10	30	30	30	-	"
10,500	66321-S	As above	-	.56	-	-	-	-	-	-	"
10,600	66321-T	Coal	N2	60.6	2+	40	-	40	20	-	"
10,800	66322-B	Mixture of grains of quartz, shale, sandstone, trace of coal	-	3.1	2+	40	-	30	20	10 A	"
11,000	66322-D	As above	-	3.5	2+	20	30	30	20	-	"
11,200	66322-F	Shale, olive gray, thin coaly laminae	5Y4/1	12.3	2+	10	10	50	trace	-	"
11,400	66322-H	Mixture 50% quartz plus grains of shale, siltstone and coal	-	9.7	2+	30	10	60	trace	-	"
11,600	66322-J	Shale, dark gray, some thin coaly laminae	N3	1.5	2+	20	20	50	trace	-	"
11,700	66322-L	Shale, as above, coaly debris more abundant	N3-N4	5.2	2+	20	20	50	10	-	"
11,900	66322-M	Mixture of med. lt. gray to v. lt. gray sandstone	N6-N8	1.5	-	-	-	-	-	-	"
11,974	66322-N	Shale, med. dk. gray, with argillaceous siltstone and sandstone	N4	4.8	2+	30	30	30	trace	-	"

* M - Microplankton
A - Amorphous

TABLE III

TOTAL ORGANIC MATTER AND LIGHT GASOLINE VALUES (C_4-C_7) FOR "PICKED" CUTTINGS
(Analyses by R. Dudley, N. Booher, H. M. Fry)

Depth (ft)	EPR No.	Unit	Total Organic Matter(%)	Total C_4-C_7 (ppm)	Correlation Ratios		
					C_1/C_2	A/D_2	C_1/D_2
8,600	66321-A	M.-L. Miocene	.10	3.1	2.20	8.91	11.98
8,800	66321-C	"	.10	1.7	.97	7.45	8.39
8,900	66321-D	"	.21	1.8	.76	7.48	8.30
9,100	66321-F	E. Miocene	.07	2.3	.79	9.20	9.33
9,400	66321-H	Late Cret.	.26	3.6	2.70	5.97	5.88
9,600	66321-J	"	.35	7.9	3.12	7.77	11.16
9,800	66321-L	"	.27	3.3	2.15	8.93	13.69
9,900	66321-N	"	.92	9.1	2.01	8.03	9.65
10,000	66321-O	"	.72	12.9	3.48	11.77	16.08
10,300	66321-Q	"	.76	35.5	3.93	4.80	11.03
10,500	66321-S	"	.56	14.1	3.75	7.21	18.54
10,600	66321-T	"	60.6	50.1	2.34	9.22	31.89
10,800	66322-B	"	3.1	588.	17.78	9.11	138.97
11,000	66322-D	"	3.5	247.	3.15	13.80	36.22
11,200	66322-F	"	12.3	967.	3.36	8.38	21.27
11,400	66322-H	"	9.7	1065.	4.48	42.86	97.25
11,600	66322-J	"	1.5	207.	4.76	13.79	36.27
11,700	66322-L	"	5.2	631.	4.86	16.99	47.87
11,900	66322-M	"	1.5	110.	2.80	11.33	22.96
11,974	66322-N	"	4.8	112.	2.65	11.86	26.49
9258	66573	Oil	F.I.T.-6	20.3% of total crude	3.40	8.45	13.06

TABLE III-A

Light Gasoline Compounds Determined by Gas Chromatography

1. Pentane
2. Hexane
3. Heptane
4. Iso-Pentane
5. 2-Methylpentane
6. 3-Methylpentane
7. 2,3-Dimethylbutane
8. 2,2-Dimethylbutane
9. 3-Methylhexane
10. 2-Methylhexane + 1,1-Dimethylcyclopentane
11. 2,3-Dimethylpentane
12. 2,4-Dimethylpentane
13. 2,2-Dimethylpentane
14. 2,2,3-Trimethylbutane
15. 2,2,4-Trimethylpentane
16. Cyclopentane
17. Methylcyclopentane
18. 1-c-3-Dimethylcyclopentane
19. 1-t-3-Dimethylcyclopentane
20. 1-c-2-Dimethylcyclopentane
21. 1-t-2-Dimethylcyclopentane + 3-Ethylpentane*
22. Cyclohexane + 3,3-Dimethylpentane*
23. Methylcyclohexane
24. Benzene
25. Toluene

TABLE IV

VISUAL KEROGEN CHARACTERISTICS FROM CORES

(Slides prepared by Esso Australia; described by J. L. Morgan)

Depth (ft)	Core No.	EPR No.	Kerogen Alteration	Types of Kerogen (% of Total)					
				Algal?	Algal	Amorphous	Herbaceous	Woody	Coaly
9,182	25	66312-A	2+	-	-	20	trace	50	20
9,209	22	66312-B	2+	-	30	20	-	40	10
9,221	20	66312-C	2+	-	20	-	-	60	20
9,236	18	66312-D	2+	-	40	10	-	40	10
9,250	1*	66313-A	2+	-	-	-	trace	50	40
9,265	1*	66313-B	2+	-	-	-	trace	50	40
9,329	3*	66313-C	2+	-	-	-	trace	50	50
9,346	3*	66313-D	2+	-	-	-	trace	50	40
9,700	10	66312-E	3-	-	-	-	-	40	60
9,750	9	66312-F	3-	-	-	-	-	50	50
9,875	7	66312-G	2+	10	-	-	10	40	40
10,022	3	66312-H	2+	30	-	-	10	30	30
10,068	1	66312-I	2+	-	-	-	trace	50	50
10,200	119	66312-J	2+	-	-	-	trace	50	40
10,385	116	66312-K	2-	-	-	-	10	50	40
10,450	115	66312-L	2+	-	-	-	10	50	40
10,643	112	66312-M	2-	-	-	-	20	60	20
10,766	110	66312-N	2+	-	-	-	trace	70	20
11,033	106	66312-O	2-	-	-	-	40	40	20
11,100	105	66312-P	2+	-	-	-	10	50	40
11,334	102	66312-Q	2-	-	-	-	10	60	30
11,400	101	66312-R	2+	-	-	-	trace	50	40
11,643	97	66312-S	2+	-	-	-	-	50	50
11,743	95	66312-T	2	-	-	-	trace	60	30
11,930	91	66312-U	2-	-	-	-	40	40	20

* - Standard Core; others were sidewall cores

TABLE V

HEAVY (C₁₅₊) SOLUBLE ORGANIC MATTER, HAPUKU-1 CANNED CUTTINGS
(Analysis by W. Byrd)

<u>Depth (ft)</u>	10,000	10,700	11,100	11,700
<u>EPR No.</u>	66321-N	66322-A	66322-E	66322-K
<u>Total Organic Matter (%)</u>	.45	8.45	20.35	3.50
<u>Soluble Organic Matter (ppm)</u>	101	2211	4658	921
<u>Composition of Soluble O.M. (%)</u>				
Saturates	*	5.3	13.9	14.5
Aromatics	*	20.9	23.7	25.7
NSO's	*	10.4	7.5	10.8
Noneluted NSO's	*	4.7	1.3	--
Asphaltenes	*	58.7	53.5	49.0
<u>Hydrocarbons</u>				
ppm of rock	*	580	1753	371
% of T.O.M.	*	.69	.86	1.06
<u>Lithology</u>	Lt. olive gray clay-stone and shale	Mixture of dk. gray shale, quartz grains, trace of coal	Like 10,700' sample	Like 10,700' sample, but >60% quartz
<u>Interpretation</u>	Poor Source	Rich Source gas and condensate	Rich Source gas and liquids	Good Source gas & liquids

* Too little S.O.M. for analysis

TABLE VI

MASS SPECTROMETRIC ANALYSES OF HEAVY (C₁₅₊) FRACTIONS
OF OIL AND THREE ROCK EXTRACT SAMPLES

(Analyses by J. N. Mercer, S. R. Tillotson, D. C. Wray)

<u>Sample</u>	Oil	Cttgs.	Cttgs.	Cttgs.
<u>Depth (ft)</u>	9258	10,700	11,100	11,700
<u>EPR No.</u>	66573	66322-A	66322-E	66322-K
<u>Unit</u>	L. balmei	U. Cret.	U. Cret.	U. Cret.
<u>Gross Composition-%</u>				
Saturates	68.8	5.3	13.9	14.5
Aromatics	14.6	20.9	23.7	25.7
Eluted NSO's	6.1	10.4	7.5	10.8
Noneluted NSO's	8.7	4.7	1.3	-
Asphaltenes	1.8	58.7	53.5	49.0
<u>Saturate Molecule Types-%</u>				
Paraffins	88.8	39.3	59.1	61.5
1-Ring Naphthenes	3.1	0.0	4.9	0.6
2- " "	3.4	8.4	2.6	5.2
3- " "	2.0	20.8	11.5	12.1
4- " "	1.6	13.8	8.9	9.3
5- " "	1.1	7.7	4.2	4.5
6- " "	0.0	10.0	8.8	6.9
<u>Aromatic Molecular Types-%</u>				
Benzenes (B)	10.8	2.8	3.1	2.9
Indanes (I)	5.1	5.2	5.4	4.6
Indenes (IE)	10.1	8.1	8.2	6.9
Naphthalenes (N)	6.1	3.2	5.5	3.1
Tetrahydrophenanthrenes (T)	13.2	15.0	13.9	11.8
Dihydrophenanthrenes (D)	29.7	19.4	18.9	18.4
Phenanthrenes (P)	14.5	23.0	14.0	17.5
Pyrenes (PY)	10.5	0.6	4.4	11.0
Chrysenes (C)	0.0	7.9	7.2	8.4
Benzothiophenes (BT)	0.0	1.9	3.0	1.7
Dibenzothiophenes (DB)	0.0	12.9	13.9	10.3
Thiophenophenanthrenes (TP)	0.0	0.0	2.6	3.4
<u>4-Ring Naphthenes</u>				
20 Carbon Atoms	13.5	22.7	16.7	13.8
21 " "	9.0	7.6	6.7	7.5
22 " "	8.1	6.1	5.6	6.2
23 " "	8.1	5.9	5.4	5.8
24 " "	8.1	5.5	5.1	5.8
25 " "	8.1	4.8	4.9	5.3
26 " "	7.2	4.5	4.9	5.1
27 " "	7.2	5.5	5.8	6.0
28 " "	7.2	7.5	8.5	8.7
29 " "	6.3	14.8	15.0	15.8
30 " "	6.3	6.2	8.7	8.2
31 " "	5.4	4.8	6.9	6.4
32 " "	5.4	4.0	5.8	5.5
<u>Carbon Isotope Values (‰ from PDB)</u>				
Saturates	-27.1	-28.5	-28.8	-28.5
Aromatics	-25.4	-27.5	-27.2	-27.2

TABLE VII

LIGHT GASOLINES IN F.I.T. - 6 OIL

66573 OFF. AUSTRALIA HAPUKU-1

	TOTAL PERCENT	NORM PERCENT		TOTAL PERCENT	NORM PERCENT
METHANE	0.0		HEX	1.356	6.68
ETHANE	0.110		33-DMP	0.0	0.0
PROPANE	0.350		11-DMCP	0.481	2.27
ISUTANE	0.422	2.08	2-MHEX	0.0	0.0
NEUTANE	1.070	5.27	23-DMP	0.275	1.35
IPENTANE	1.092	5.38	3-MHEX	0.454	2.23
NPENTANE	1.520	7.48	1C3-DMCP	0.231	1.14
22-DMR	0.039	0.19	1T3-DMCP	0.204	1.00
CPENTANE	0.141	0.70	1T2-DMCP	0.352	1.73
23-DMB	0.141	0.69	3-EPENT	0.0	0.0
2-MP	0.886	4.36	224-TMP	0.0	0.0
3-MP	0.498	2.45	NHEPTANE	1.095	9.82
NHEXANE	1.839	9.05	1C2-DMCP	0.056	0.28
MCP	0.902	4.44	MCH	4.090	20.14
22-DMP	0.0	0.0	ECP	0.069	0.34
24-DMP	0.074	0.37	BENZENE	0.170	0.84
223-TMB	0.0	0.0	TOLUENE	1.955	9.62

TOTALS

ALL COMP 20.674
GASOLINE 20.314

SIG COMP RATIOS

C1/C2 3.40
A /D2 8.45
D1/D2 4.68
C1/D2 13.06

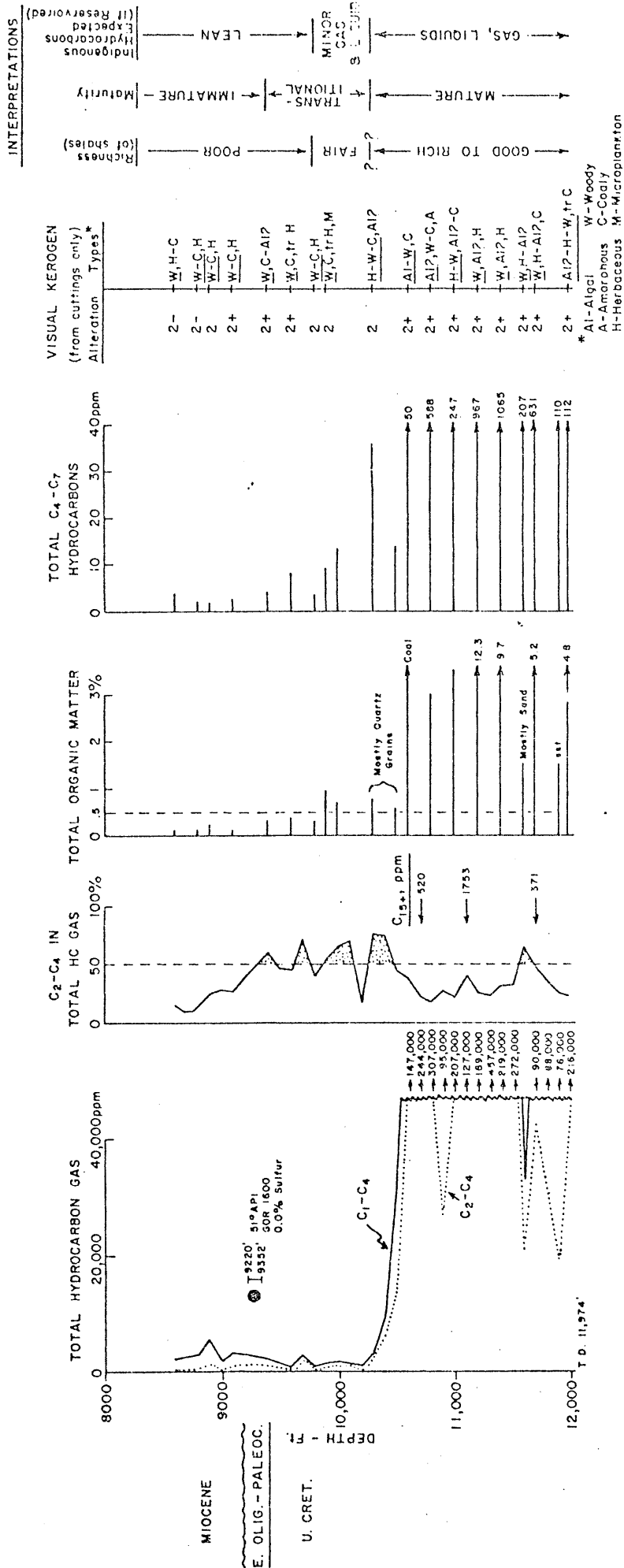


FIG. 1 - GEOCHEMICAL PROFILES, HAPUKU-1.

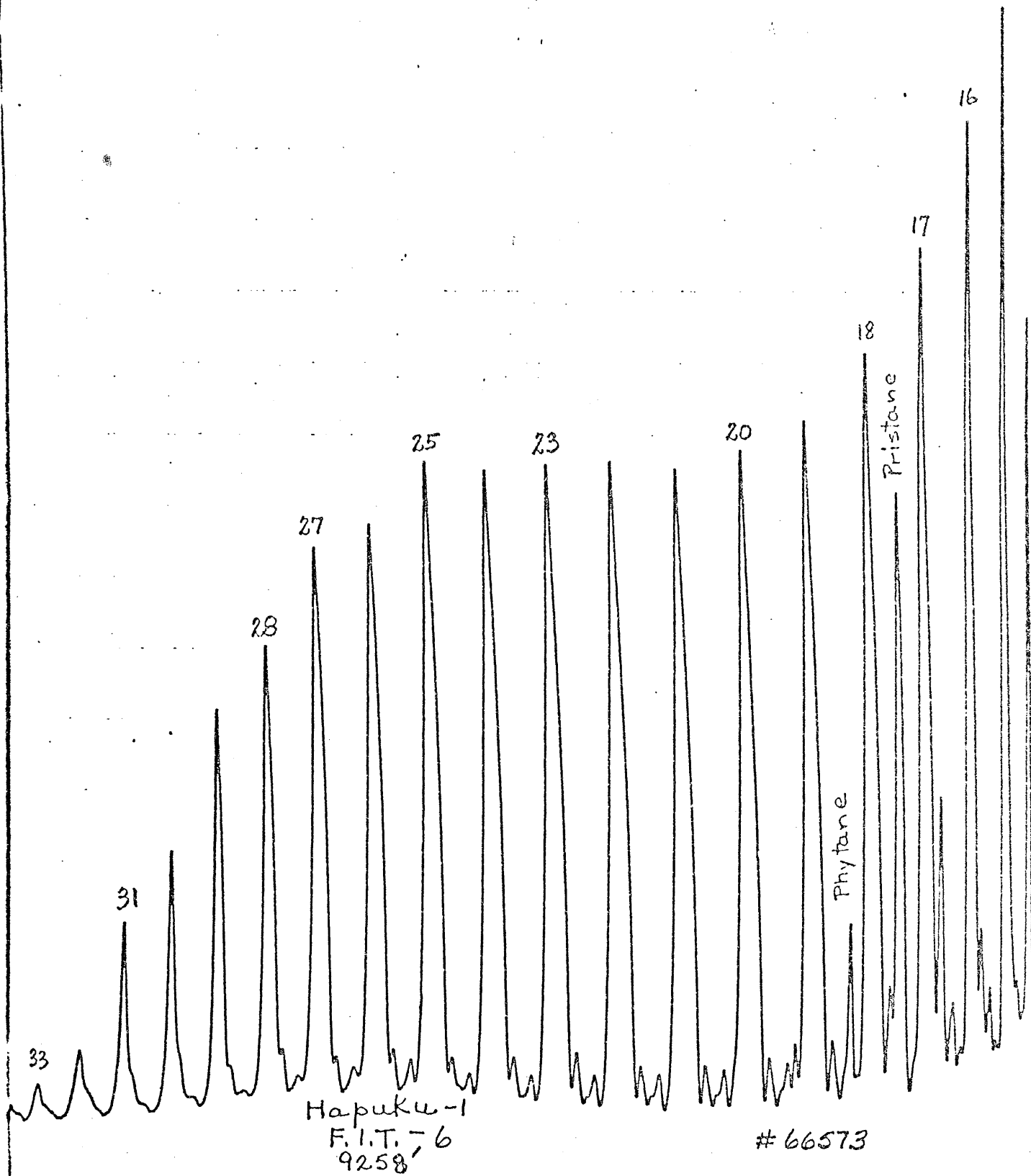


FIG. 2 - Gas Chromatogram of heavy saturates, oil sample.

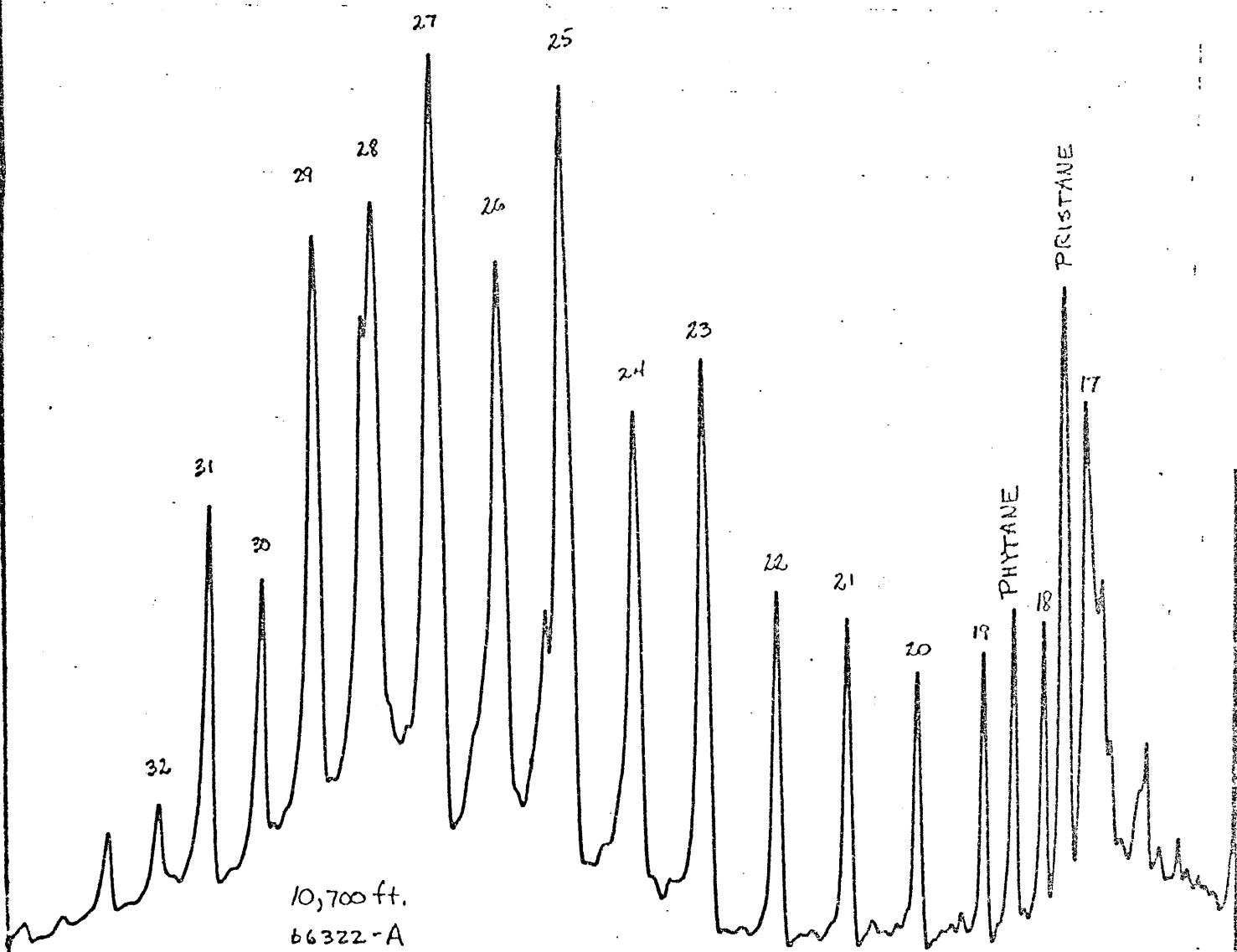


FIG. 3 - Gas chromatogram of heavy saturates, rock extract.

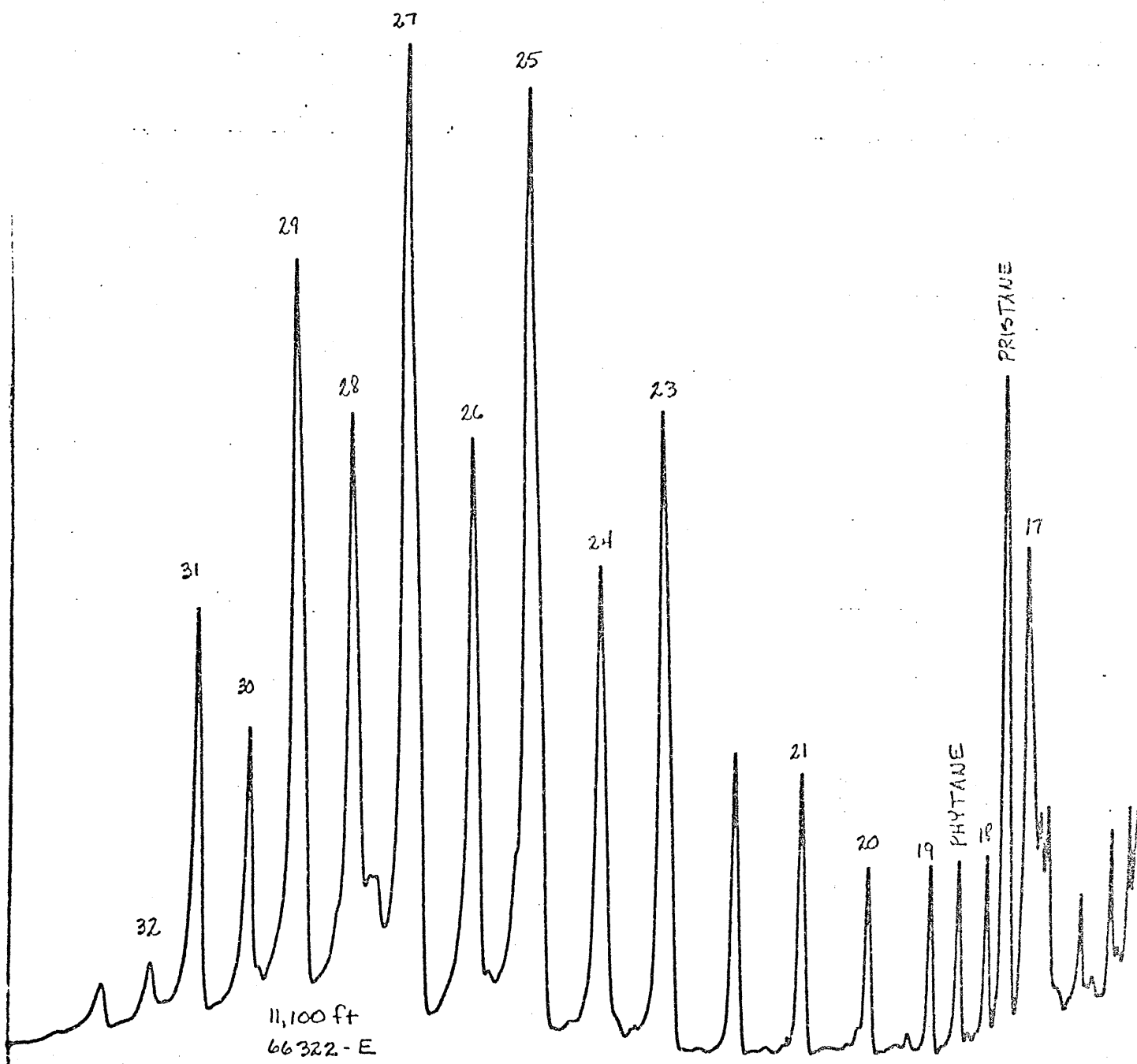


FIG. 4. - Gas Chromatogram of heavy saturates, rock extract.

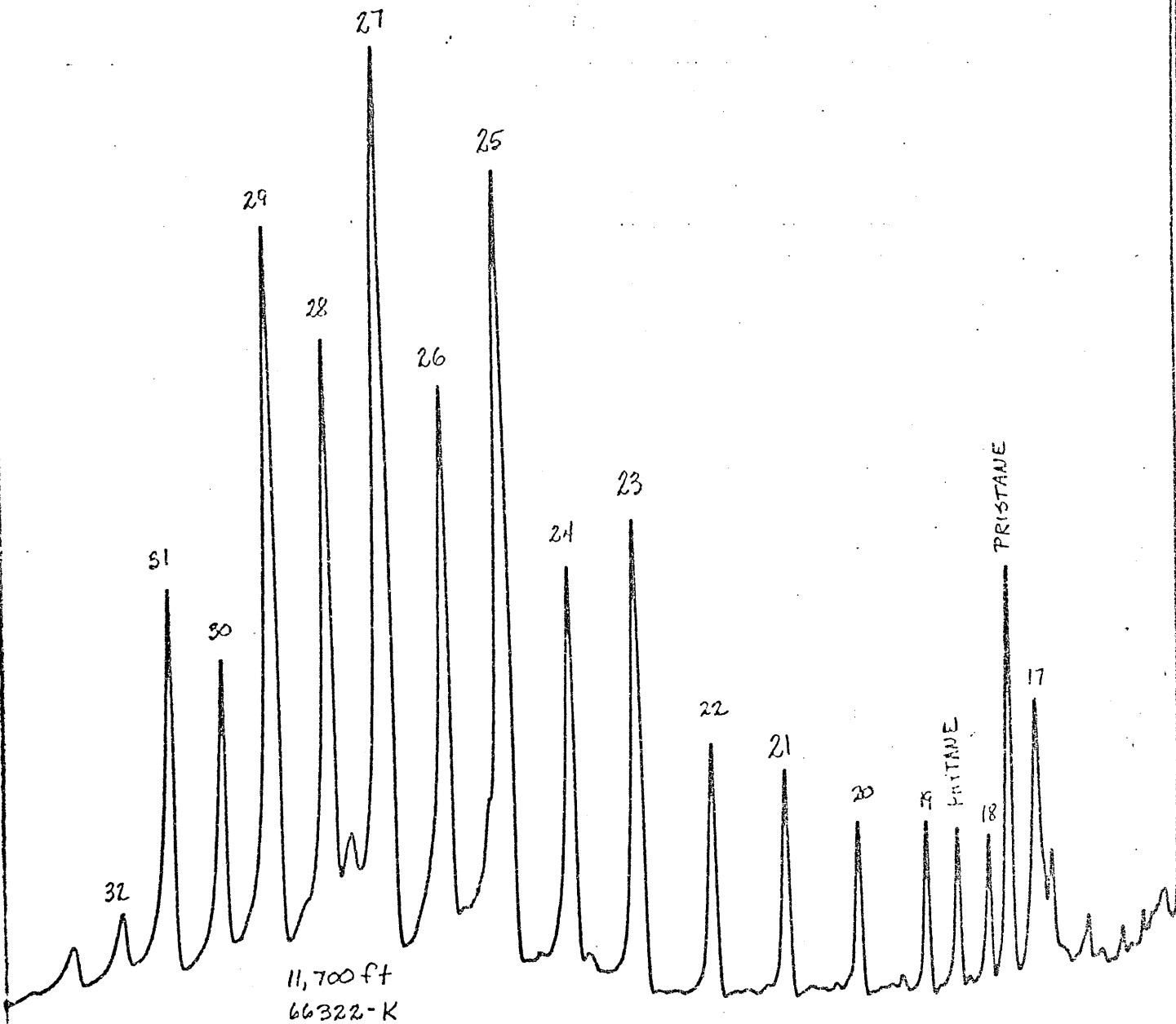


FIG. 5 - Gas Chromatogram of heavy saturates, rock extract.

GEOCHEMICAL ANALYSIS OF CUTTINGS
FROM BULLSEYE-1, GIPPSLAND BASIN, AUSTRALIA

by

R. E. Metter
June, 1976

INTRODUCTION

Three samples of dry cuttings from the interval 6800 ft to 6990 ft in the Bullseye-1 well were analysed for various hydrocarbon source characteristics. The data are to be used by Esso Australia in assessing the potential of the samples as a source for some Gippsland oils. The results are listed in Tables I - II and in Figs. 1 - 6.

The section from approximately 6720 ft to 7020 ft in this well is a shaly interval at the top of the N. asperus zone. Esso Australia suggested that the sampled interval represents a marine wedge that previously had not been studied in the Gippsland Basin.

PROCEDURES

The three samples were analysed for total organic matter and visual kerogen characteristics (Table I). The samples were then routinely extracted by a Soxhlet procedure at GeoChem Laboratories (Table II). The heavy (C₁₅₊) saturate and aromatic fractions of the extract were analysed separately by mass spectrometry for carbon isotope values and for molecular types (Table III). Gas chromatograms were run on the heavy saturate fractions (Figs. 1 - 3) and on the whole extracts (Figs. 4 - 6).

DISCUSSION

The analytical data are worrisome in that they strongly suggest contamination with diesel oil. The gas chromatograms (Figs. 1 - 3 and 4 - 6) show that the paraffinic and other saturate compounds peak at about C-18 and are about gone by C-23. Rock extracts generally show the presence of appreciable amounts of saturate compounds through the C-20's and beyond C-30.

The carbon isotope values of the three cuttings extracts are comparable to values for two oils from Marlin A-1 (5122' and 7406') and one from Bream-2 (8156'). (See Ref 1). These three oil samples have aromatic fractions with isotope values averaging about -27.0 whereas most of the oils from Gippsland Basin have aromatic fraction isotope values in the range -25 to -26.

One might argue from isotope data alone that the cuttings from Bullseye represent the source of the two Marlin oils cited above. However, the heavy molecular compositions and the saturate chromatographic patterns of the cuttings and the oils do not support the hypothesis.

The samples were washed thoroughly, but considerable amounts of mud still adhered to the chips that were analysed. If any oil was added to the mud at the wellsite it could have produced the chemical patterns we see. On the other hand, if no oil was present in the mud, these cuttings might indeed represent the source of the Marlin oil. This would be contrary to previous conclusions that the main source interval of Gippsland Basin oils has been the Cretaceous - Paleocene section.

RELATED REPORTS

Ref 1 "Comparison of Oils from Marlin and Kingfish Fields, Australia, with Various Rock Extracts from Marlin Wells" by R. E. Metter et al, October 1967.

TABLE I Sample Descriptions, Total Organic Matter, and Visual Kerogen

(Kerogen by J. L. Morgan)

Depth (ft)	EPR No.	Gross Lithology	GSA Color Code (dry)	Total Organic Matter (%)	Kerogen Alteration	Types of Kerogen (% of Total on Slide)				Remarks		
						Algal	Amorphous	Herbaceous	Woody		Coaly	Other*
6800-10	66782-A	Shale, lt. olive gray, calc.	5Y 6/1	.53	2	10	-	10	40	30	trace M, 10M	Range "1+" to "2+"
6840-50	66792-B	Shale, med. lt. gray, sl. calc. to med. calc.; plus drilling mud?	N6	.62	2	-	30	10	40	20	-	Range "1+" to "2+"
6980-90	66782-C	Shale, lt. olive gray, calc., plus drilling mud?	5Y 6/1	1.51	2	20	20	trace	40	10	trace N	Range "1+" to "2+"

*M-Microplankton, N-Nonfilamentous Algal

TABLE II Heavy (C₁₅₊) Soluble Organic Matter
(Analysis by Geochem)

Depth	Soluble* Organic Matter (ppm)	Composition of Soluble Organic Matter (%)			ppm of* rock	Hydrocarbons % of T.O.M.		
		Saturates**	Aromatics	Noneeluted NSO			Asphaltenes	
6800-10	404	26.2	13.1	11.6	12.1	36.6	159	3.0
6840-50	362	25.1	15.2	12.7	5.0	37.3	146	2.4
6980-90	551	22.7	19.4	15.1	7.6	35.0	232	1.5

**See Figs. 1 - 3 for gas chromatograms of heavy saturate fractions. Figs. 4 - 6 are chromatograms for the total heavy extracts.

*Note: GeoChem obtains larger extracts and hydrocarbon yields than EPR and Imperial. Bayliss regards 100 ppm hydrocarbons as the approximate minimum for oil source possibilities.

TABLE III Mass Spectrometric Data on Heavy (C₁₅⁺)
Fractions of Cuttings Extracts

(Analyses by S. R. Tillotson and D. C. Wray)

Depth (ft)	6800-10	6840-50	6980-90
EPR No.	66782-A	66782-B	66782-C
<u>Carbon Isotope Values (O/00 from PDB)</u>			
Saturates	-26.9	-27.3	-27.5
Aromatics	-26.6	-27.1	-27.1
<u>Saturate Molecular Types (%)</u>			
Paraffins	53.5	25.5	49.6
1-Ring Naphthenes	22.4	36.8	22.6
2- " "	8.9	12.1	9.9
3- " "	5.2	9.7	8.0
4- " "	3.4	6.1	4.3
5- " "	1.4	3.6	2.3
6- " "	5.1	6.2	3.3
<u>Heavy Aromatic Molecular Types (%)</u>			
Benzenes	12.6	11.6	13.6
Indanes	4.5	7.0	5.2
Indenes	8.9	13.9	11.6
Naphthalenes	6.3	7.3	10.4
Tetrahydrophenanthrenes	20.0	17.3	20.9
Dihydrophenanthrenes	22.9	17.7	22.8
Phenanthrenes	11.7	6.6	4.2
Pyrenes	0.0	0.0	0.0
Chrysenes	2.2	5.7	0.1
Benzothiophenes	0.5	0.9	0.1
Dibenzothiophenes	10.4	11.9	11.2
Thiophenophenanthrenes	0.0	0.0	0.0
<u>Four-Ring Naphthenes (Normalized)</u>			
C-20	16.2	17.7	18.5
C-21	11.9	13.0	10.7
C-22	11.0	11.3	9.8
C-23	10.7	11.6	8.8
C-24	8.9	9.7	7.8
C-25	7.6	8.0	6.8
C-26	6.1	6.4	6.3
C-27	7.0	6.1	6.3
C-28	5.8	5.0	5.9
C-29	5.5	4.2	5.9
C-30	4.0	3.1	4.9
C-31	2.8	2.1	4.4
C-32	2.4	1.9	3.9

SATURATES.
E-112-C01

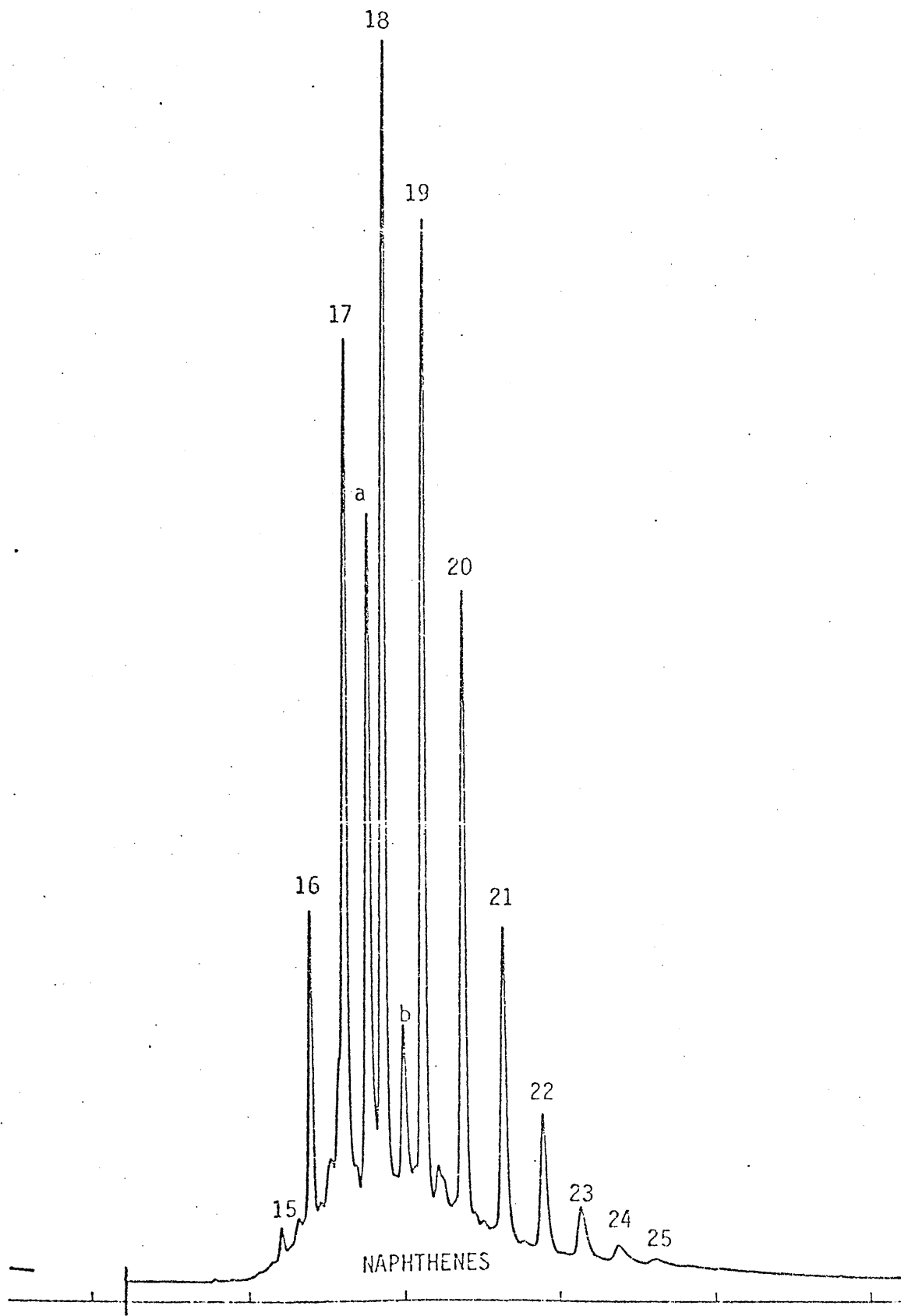


Fig. 1. Gas chromatogram of heavy saturate fraction, Bullseye-1 6800'-6810'

SATURATES.

E-112-002

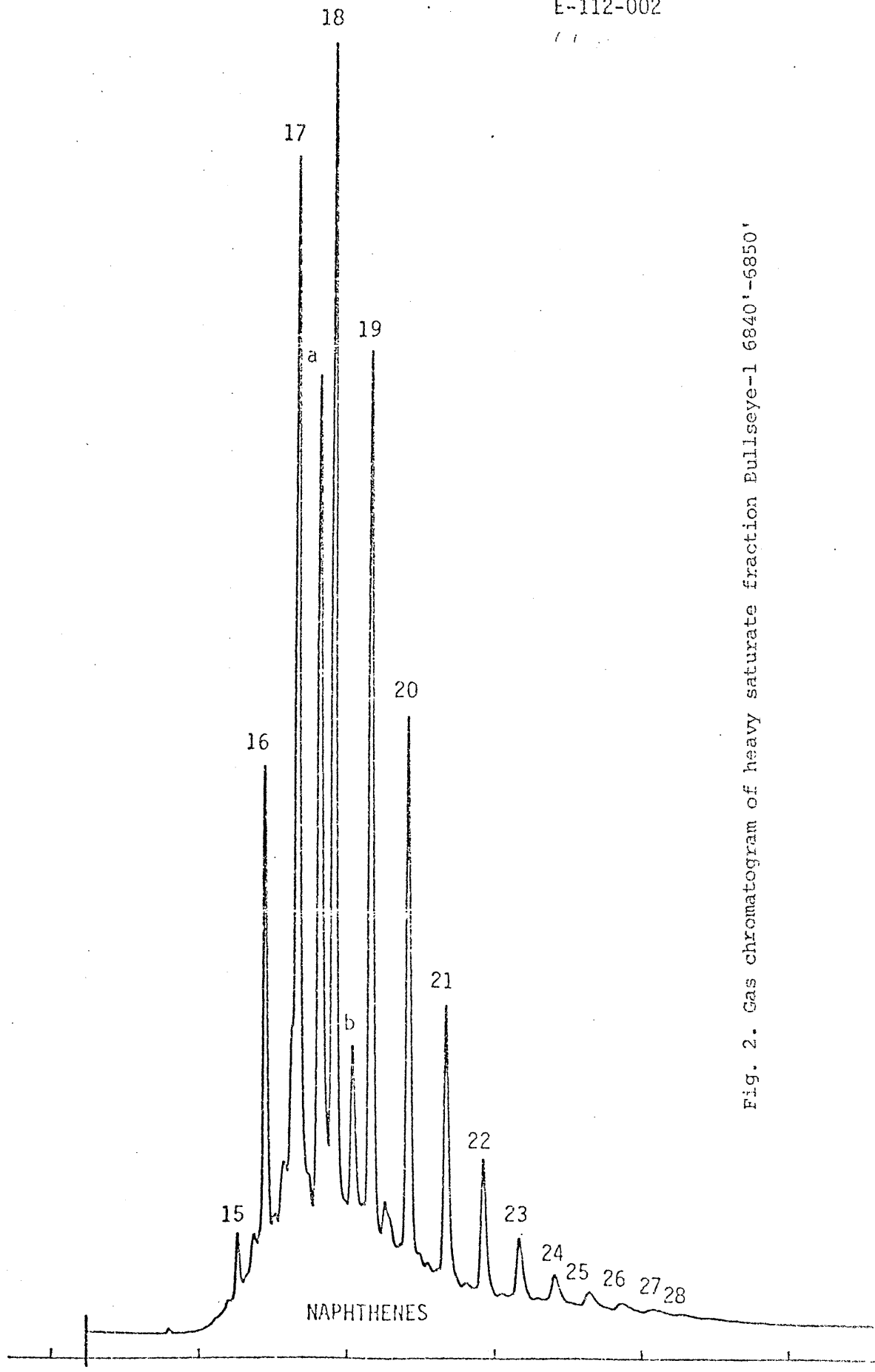


Fig. 2. Gas chromatogram of heavy saturate fraction Bullseye-1 6840'-6850'

SATURATES

E-112-003

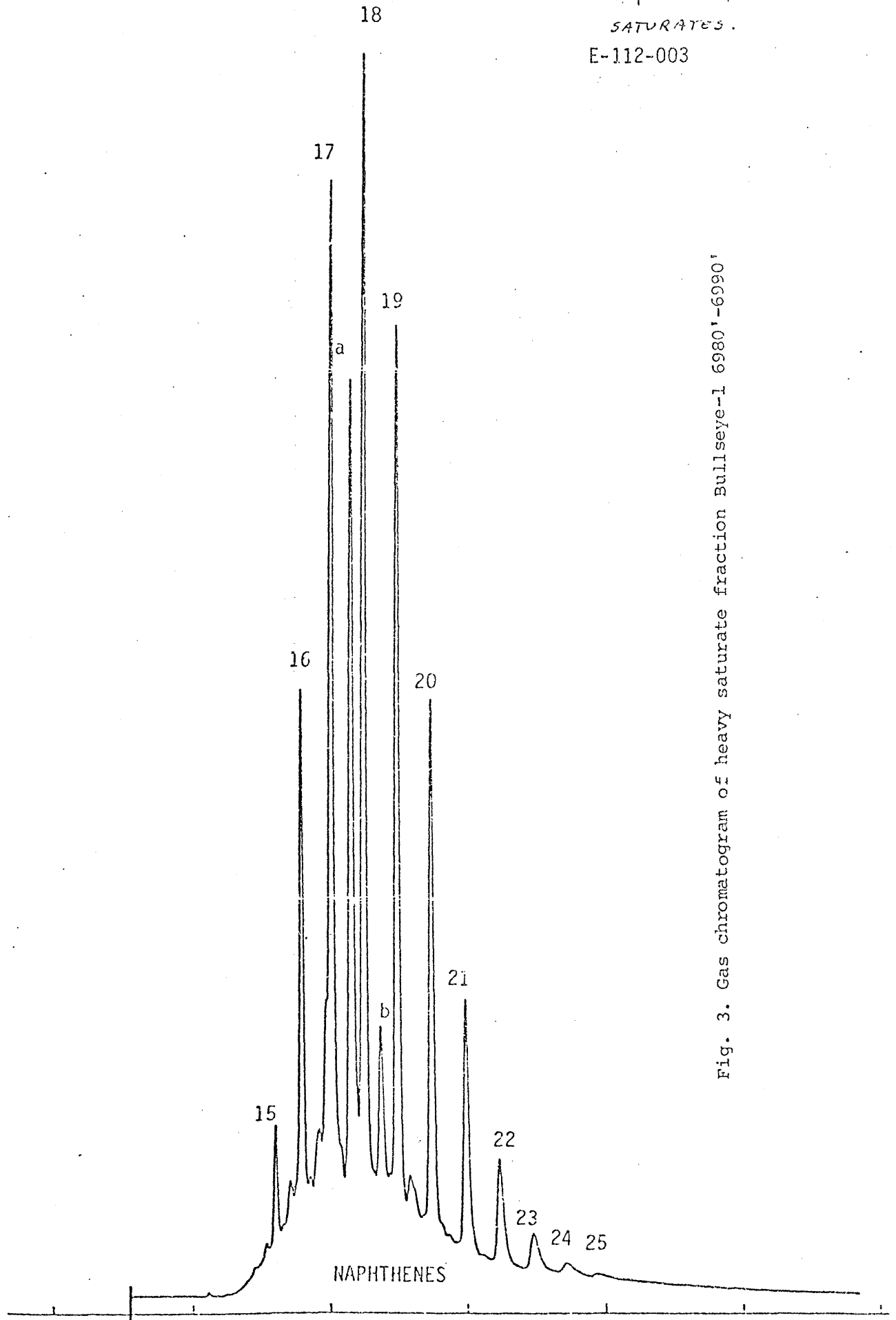


Fig. 3. Gas chromatogram of heavy saturate fraction Bullseye-1 6980'-6990'

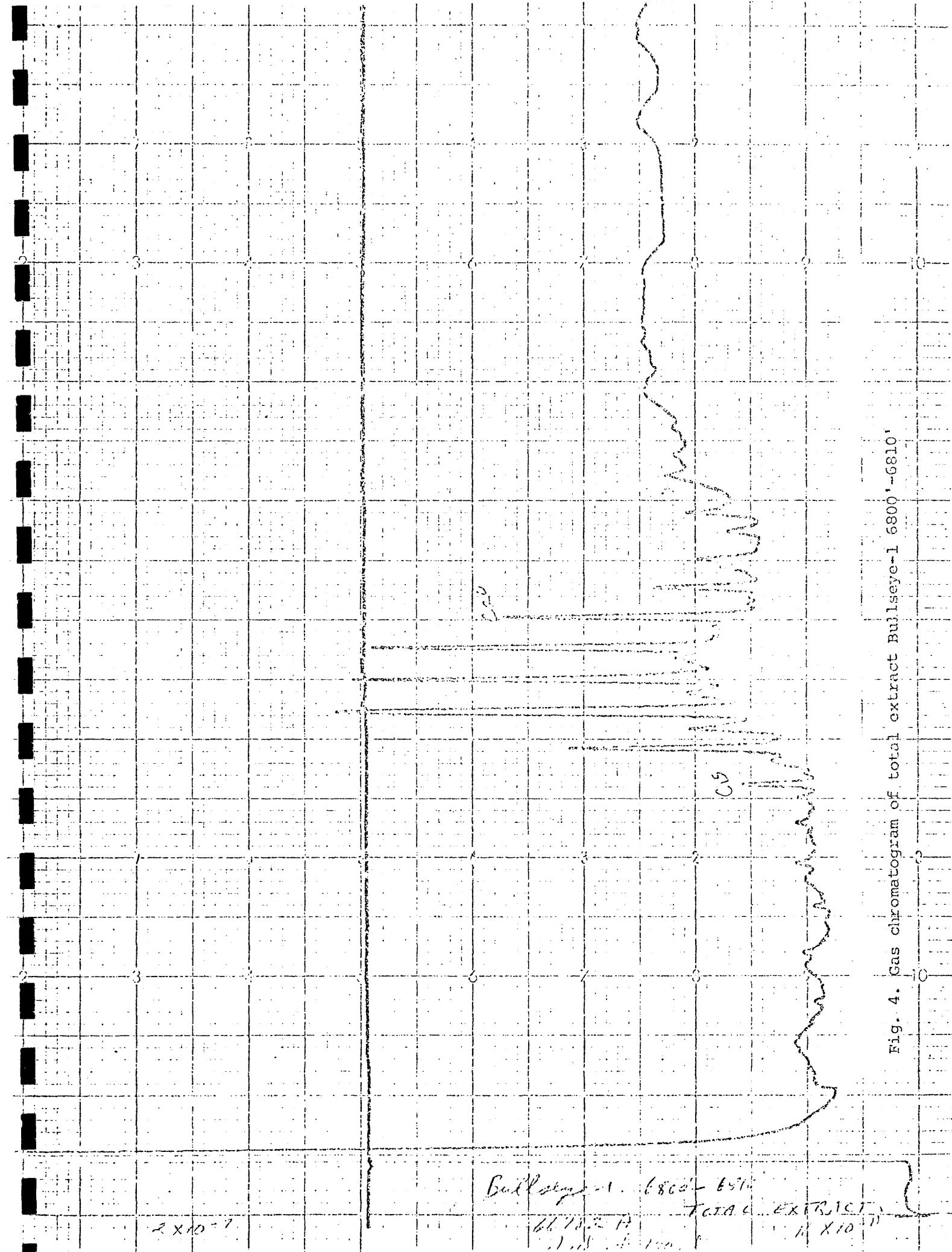


Fig. 4. Gas chromatogram of total extract Bullseye-1 6800'-6810'

2×10^{-7}

Bullseye-1 6800'-6810'
 TOTAL EXTRACT
 10×10^{-11}

C5

C6

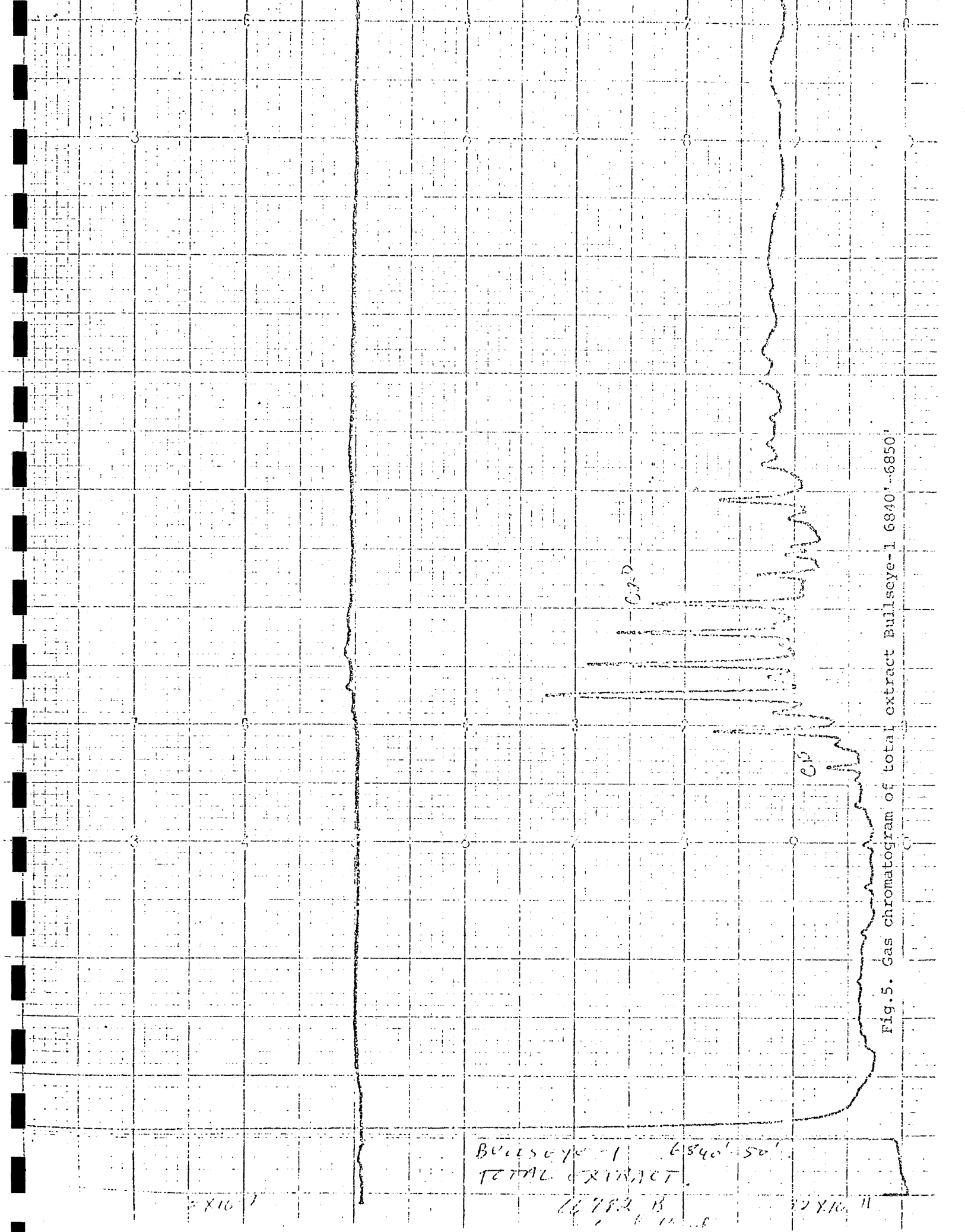


Fig. 5. Gas chromatogram of total extract Bullseye-1 6840' - 6850'

Bullseye-1 6840' - 50'
 TOTAL EXTRACT

76782 B

2 X 10⁷

2 X 10¹¹

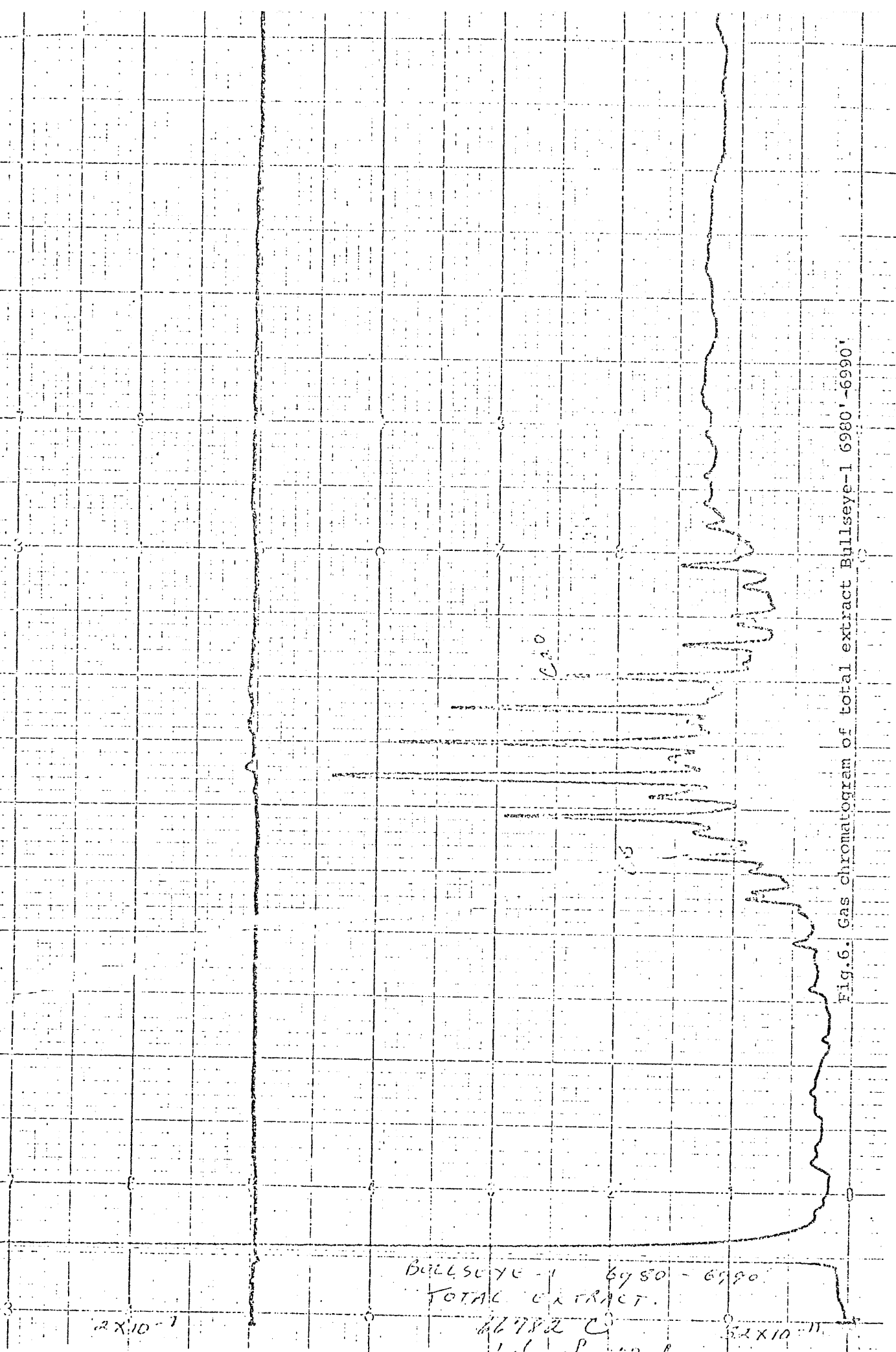


Fig. 6. Gas chromatogram of total extract Bullseye-1 6980'-6990'

BULLSEYE - 1 6980 - 6990
 TOTAL EXTRACT.
 6.20 6.35
 1.1 P 11.1
 2×10^{-11}

ESSO PRODUCTION RESEARCH COMPANY

POST OFFICE BOX 2180

HOUSTON, TEXAS 77001

December 18, 1970

ATOMIC GEOLOGY DIVISION
WARD McFARLAN, JR., MANAGER

AIR MAIL

Mr. C. R. Sitter
Esso Standard Oil (Australia) Ltd.
Fox 4047, G. P. O.
Sydney, N.S.W. 2001, Australia

Attention Mr. M. W. Leighton

Dear Sir:

Oil from Oligocene "Greensand," Lakes Entrance Area (9611)

We have completed our geochemical analysis of an oil sample that you submitted from the Oligocene "greensand" encountered at 1050-1094 feet in the Government Borehole No. 8, Parish of Colquhoun. The analysis of this oil was requested in your letter of November 6, 1970, by A. C. Pierce.

Four "greensand" core samples from the Gippsland Basin were also received for source rock analyses, and these results were sent to you in our letter of December 11.

The "greensand" oil appears to be an altered equivalent of the Strzelecki oil from the Flathead-1 well. It also resembles in some respects an oil sample from 4581 feet in the Tuna-1 well. The data upon which these conclusions are based are summarized in the attached Tables I and II and Figures 1-4. The "greensand" sample does not contain enough light gasolines for analysis, and therefore the data all pertain to the heavy (C₁₅+) fractions of the oils.

Some of the pertinent points that were considered in interpreting the data were as follows:

(1). The heavy aromatic fractions of all three oils are similar in their molecular compositions (Table I and Figure 1-C) and in their carbon isotope values (Table I).

(2). The patterns of mass spectrometric peak heights for the 4-ring naphthenes are similar in all three oils (Figure 1-B and Table II).

(3). The patterns of saturate molecular compositions are similar in all three oils if only the distributions for the 2-ring through 6-ring naphthenes are considered (Table I and Figure 1-A). However, the "greensand" oil is notably depleted in paraffins and 1-ring naphthenes with respect to the other two oils. We believe this depletion is a result of bacterial degradation and groundwater "flushing."

December 18, 1970

(4). The saturate fraction of the "greensand" oil has a carbon isotope value of -26.0. The values for the Flathead and Tuna samples are -27.1 and -27.3, respectively, which are significantly different from -26.0. We believe the less negative value is due to the low paraffin content of the "greensand" oil. Paraffins generally have more negative values than naphthenes, and the "greensand" saturate fraction contains only 1.2% paraffins (Table I; Figure 1-A).

(5). The heavy saturate fractions of the oils were analyzed by gas chromatography and copies of the chromatograms are included as Figures 2-4. The sharp peaks are mainly produced by paraffins, and these are mostly absent along the "greensand" curve (Figure 2). The "background" areas beneath the peaks are mainly produced by naphthenes. The naphthenic portions of the chromatograms in Figures 2 and 3 are quite similar in shape, suggesting a possible correlation between the Flathead and "greensand" oils, with the "greensand" oil being more altered. The Tuna oil (Figure 4) differs from the other two by this analysis.

We are still analyzing the heavy hydrocarbon extracts from the Tuna-1 and Cod-1 "greensand" core samples that were discussed in our December 11 letter on source characteristics. As soon as the analyses are completed, we will compare the rock extracts with the oils and send you the results.

If you have any questions regarding these data please let us know.

Yours truly,

E. McFarlan, Jr.

C. B. Koons

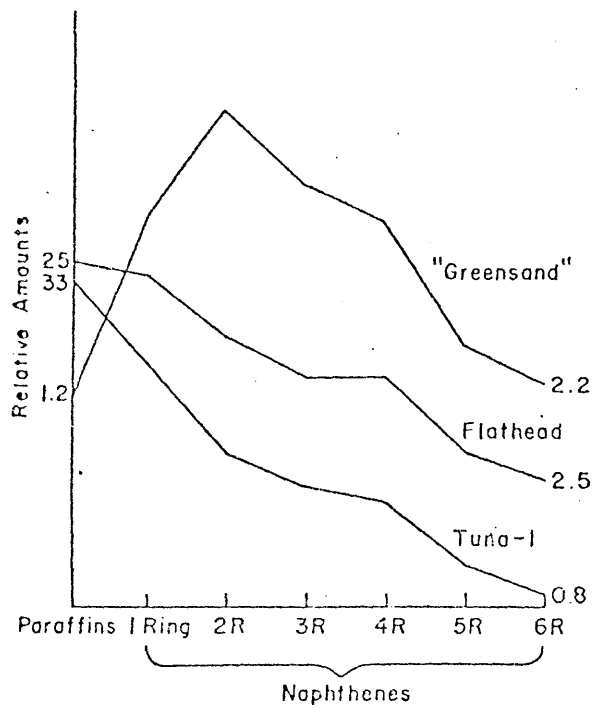
By C. B. Koons

R. E. Metter:et

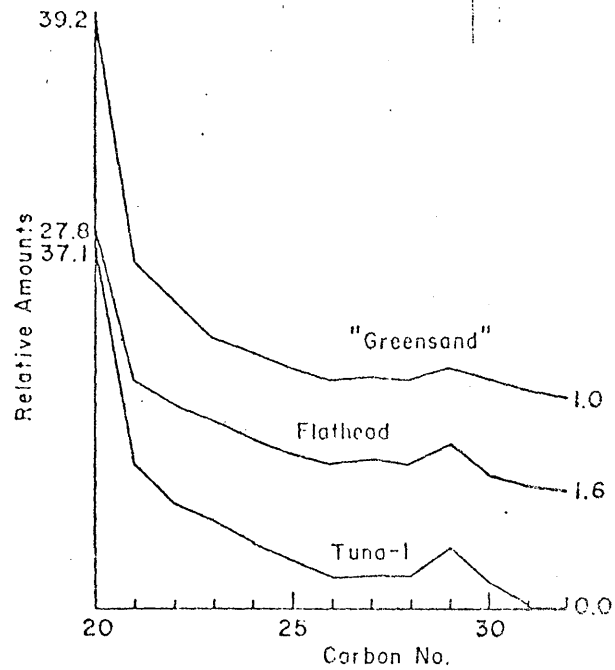
Attachments

c.c. Mr. W. R. Eckelmann (with attachments)

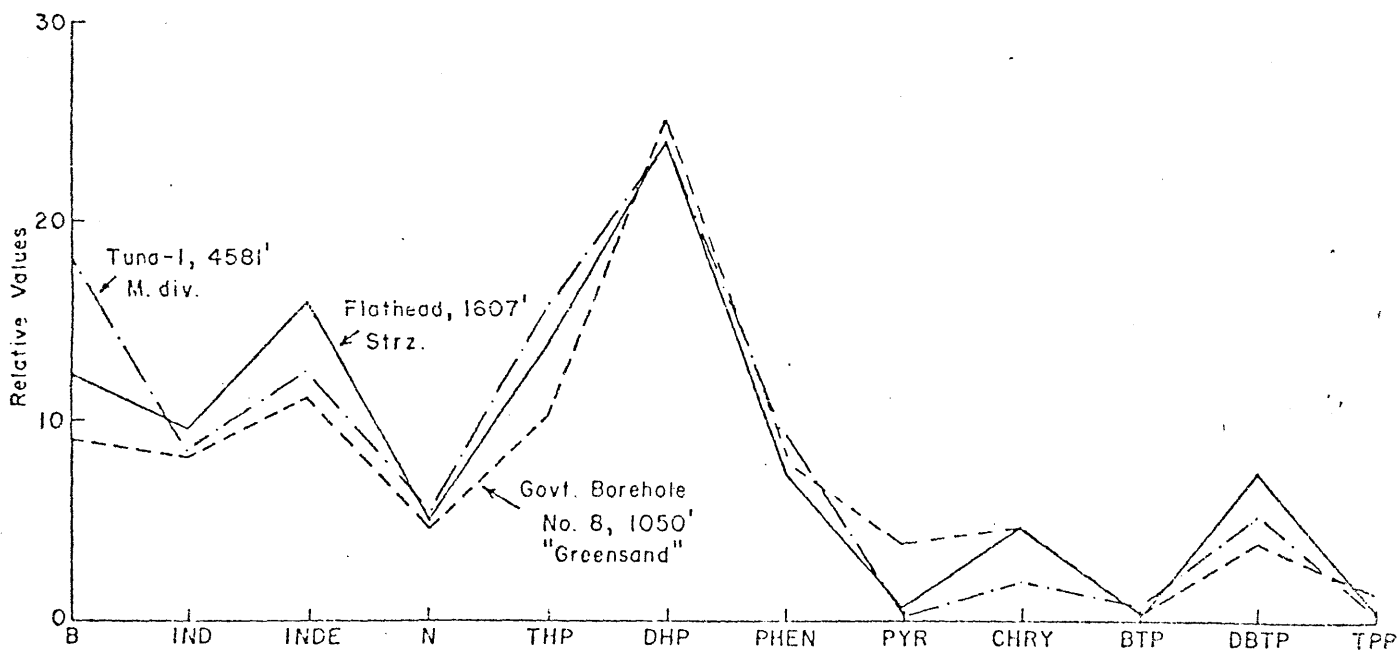
Mr. E. G. Baugh (without attachments)



A. SATURATE FRACTION.



B. 4-RING NAPHTHENES.



C. AROMATIC FRACTION (See Table I)

FIG. 1 - GEOCHEMICAL PATTERNS, HEAVY (C₁₅+) FRACTIONS OF OILS.

FIG. 2 - HEAVY SATURATE FRACTION,
OIL FROM GOVT. BOREHOLE NO. 8
"GREENSAND", 1050'

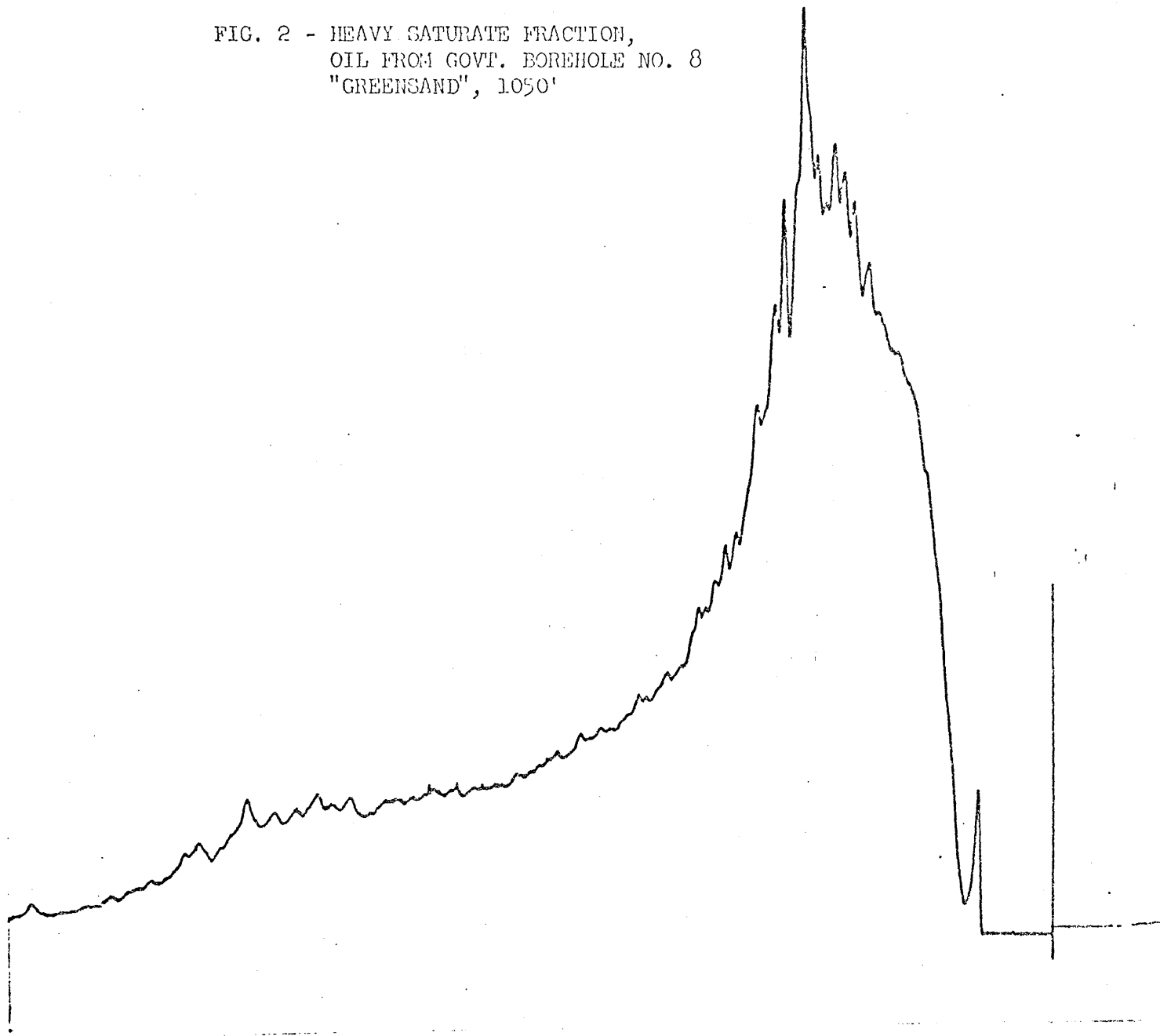


FIG. 3 - HEAVY SATURATE FRACTION,
OIL FROM FLATHEAD-1
STRZELECKI, 1607

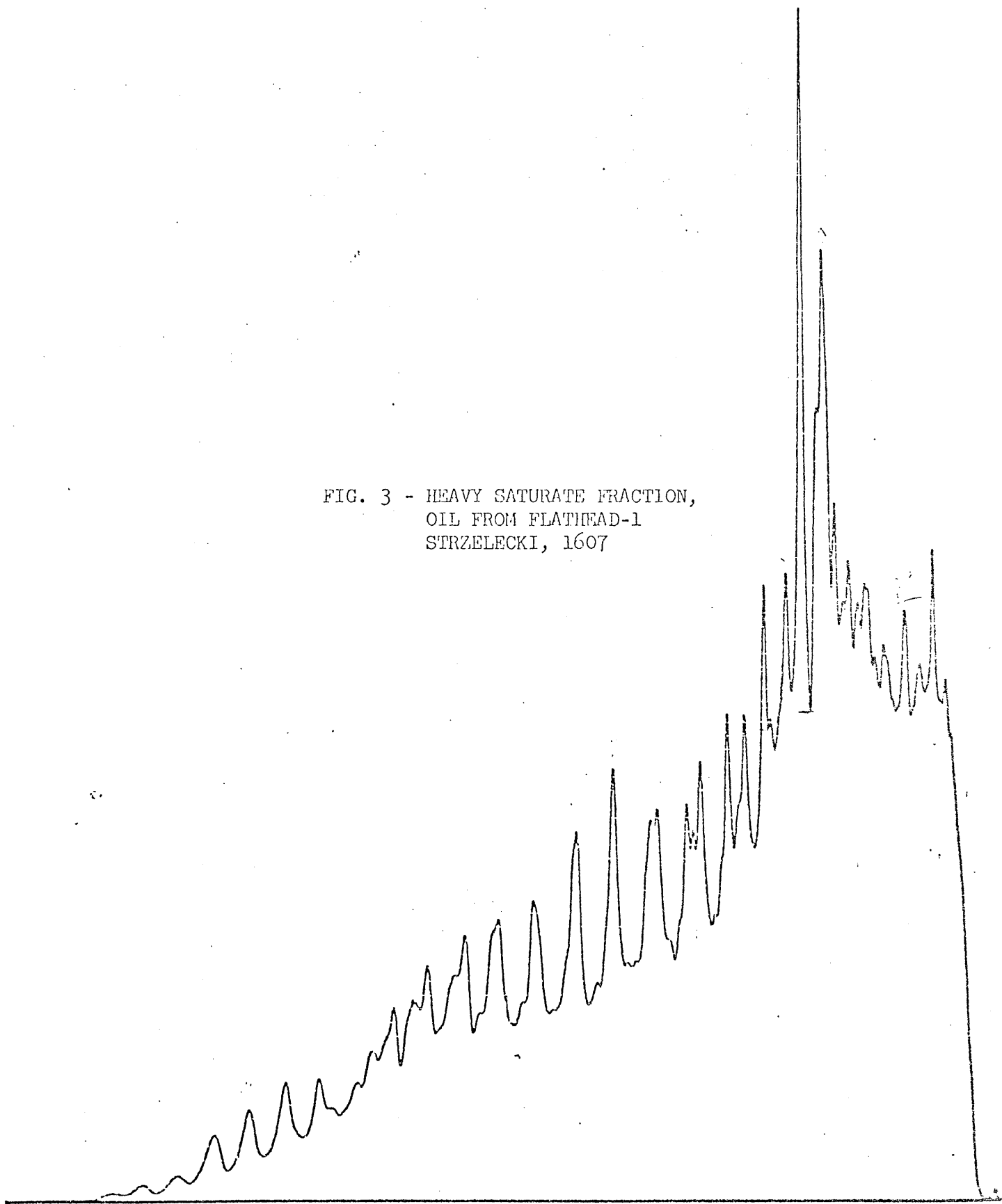
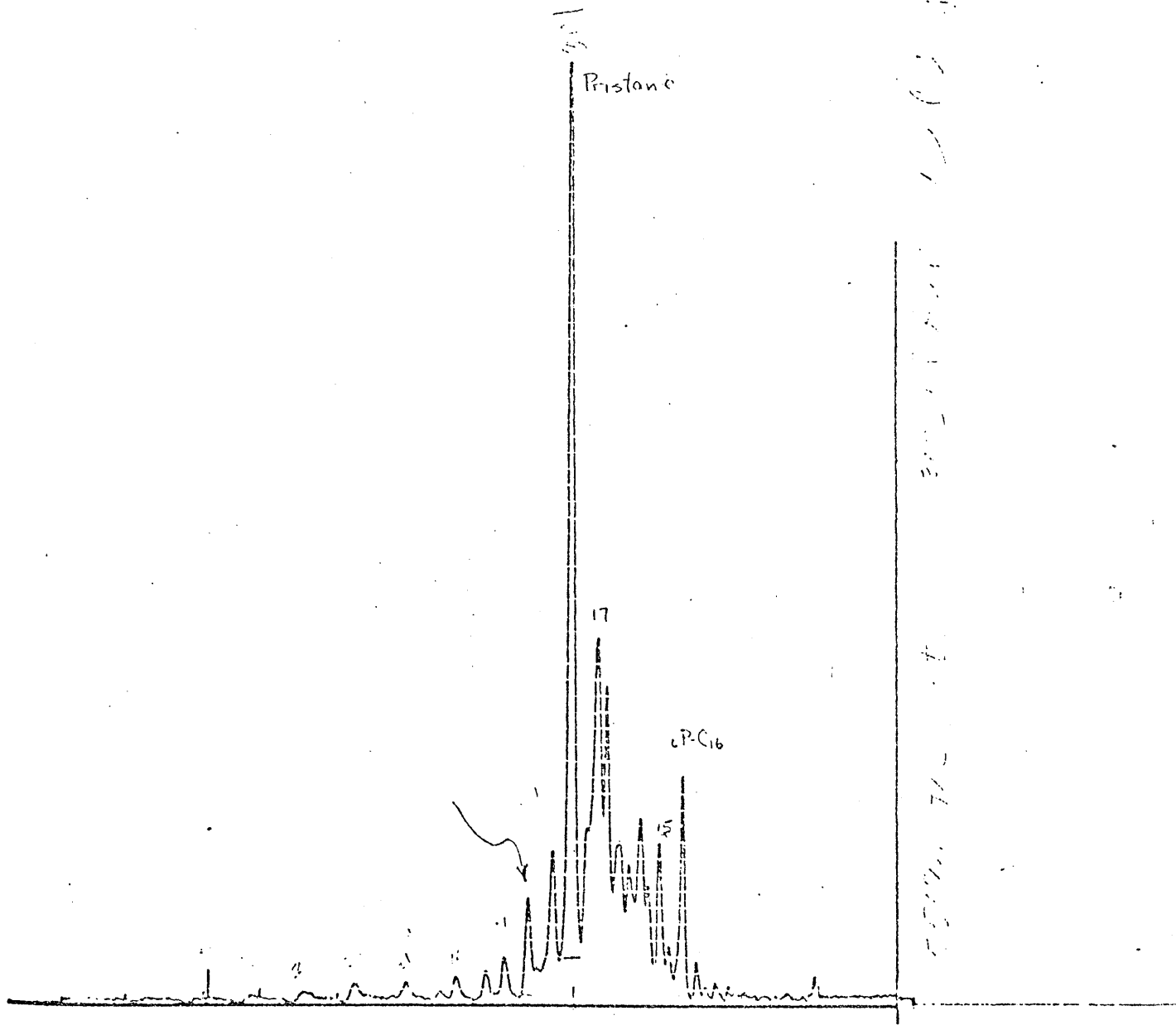


FIG. 4 - HEAVY SATURATE FRACTION,
OIL FROM TUNA-1
M. DIV., 4581'



30.0 min

TABLE I

MOLECULAR AND ISOTOPIC COMPOSITIONS OF HEAVY (C₁₅+) COMPOUNDS IN THREE GIPPSLAND BASIN OILS

<u>Well</u>	<u>Govt. Borehole No. 8</u>	<u>Flathead-1</u>	<u>Tuna-1</u>
<u>Depth (feet)</u>	1050-94'	1607-60'	4581'
<u>Reservoir</u>	"Greensand"	Strzelecki	M.Div.
<u>EPR Sample No.</u>	56566	55881	55674
<u>Gross Composition (%)</u>			
Saturates	32.1	49.4	39.7
Aromatics	38.4	34.8	31.5
Eluted NSO's	9.7	7.0	7.2
Noneluted NSO's	15.1	6.4	17.3
Asphaltenes	4.6	2.3	4.3
<u>Hydrocarbon Composition (%)</u>			
Paraffins	0.5	14.6	18.4
Naphthenes	45.0	44.0	37.3
Aromatics	54.5	41.3	44.2
<u>Carbon Isotope Values</u>			
Saturates	-26.0	-27.1	-27.3
Aromatics	-25.2	-25.5	-25.8
<u>Heavy Saturate Molecular Types (%)</u>			
Paraffins	1.2	25.0	33.0
1-Ring Naphthenes	19.6	23.7	24.6
2-Ring Naphthenes	29.8	17.1	15.5
3-Ring Naphthenes	22.5	13.2	12.0
4-Ring Naphthenes	18.6	13.1	10.3
5-Ring Naphthenes	6.0	5.3	3.8
6-Ring Naphthenes	2.2	2.5	0.8
<u>Heavy Aromatic Molecular Types (%)</u>			
Benzenes (B)	9.1	12.4	18.0
Indanes (IND)	8.3	9.5	8.5
Indenes (INDE)	21.2	16.0	12.4
Naphthalenes (N)	4.6	4.8	5.3
Tetrahydrophenanthrenes (THP)	10.1	14.0	15.9
Dihydrophenanthrenes (DHP)	25.2	23.9	23.9
Phenanthrenes (PHEN)	7.8	7.2	8.3
Pyrenes (PYR)	3.9	0.5	0.0
Chrysenes (CHRY)	4.6	4.6	1.9
Benzothiophenes (BTP)	0.0	0.0	0.8
Dibenzothiophenes (DBTP)	3.9	7.2	5.1
Thiophenophenanthrenes (TPP)	1.2	0.2	0.0

TABLE II

MASS SPECTROMETRIC DATA ON 4-RING NAPHTHENES
 IN THREE GIPPSLAND BASIN OILS
 (Relative peak heights normalized)

	<u>Well</u>	<u>Govt. Rorehold No. 8</u>	<u>Flathead-1</u>	<u>Tuna-1</u>
	<u>Depth (feet)</u>	1050-94'	1607-60'	4581'
	<u>EPR Sample No.</u>	56566	55881	55674
<u>Carbon No.</u>				
20		39.2	27.8	37.1
21		14.4	12.9	14.6
22		10.4	10.4	10.6
23		7.3	8.8	8.6
24		5.8	7.0	6.3
25		4.1	5.6	4.6
26		3.0	4.5	3.3
27		3.3	4.7	3.3
28		2.8	4.5	3.3
29		4.1	6.3	6.0
30		2.8	3.6	2.3
31		1.8	2.3	0.0
32		1.0	1.6	0.0

ESSO PRODUCTION RESEARCH COMPANY

Post Office Box 2188

HOUSTON, TEXAS 77001

December 11, 1970

STRATIGRAPHIC GEOLOGY DIVISION
EDWARD McFARLAN, JR., MANAGER

AIR MAIL

Mr. C. R. Sitter
Esso Standard Oil (Australia) Ltd.
Box 4047, G. P. O.
Sydney, N.S.W. 2001, Australia

Attention Mr. M. W. Leighton

Dear Sir:

Gippsland Basin "Greensand" Source Analyses (9611)

We have completed our hydrocarbon source analyses of the four Oligocene "greensand" samples described in your November 6, 1970 letter by C. N. Manhoff. The results are given in the attached Tables I-III and are summarized as follows:

<u>Well</u>	<u>Depth</u>	<u>Rating</u>	<u>Remarks</u>
Wahoo-1	1440'	Poor source	Immature; lean in organic content
Groper-1	3058'	Poor source	Lean in organic content
Tuna-1	4306'	Oil and gas source(?)	May include migrated hydrocarbons
Cod-1	6251'	Poor source	Adequate organic matter; low in hydrocarbons

The Wahoo sample had an immature kerogen alteration rating of 1+, contained a low 0.23 percent organic matter, and yielded heavy hydrocarbons in amounts too small to be analyzed.

The Groper sample was very lean both in organic matter and in hydrocarbons.

61312 1/5
The Tuna sample is tentatively rated as an oil and gas source on the basis of fair amounts of organic matter, 150 ppm heavy hydrocarbons, and detectable amounts of the full range of gasoline compounds. The gasoline ratio values are consistent with those of rocks from other areas that are considered to be sources of oil and gas. The question arises as to whether these are indigenous or migrated hydrocarbons. We will consider this problem further, and if we have any additional thoughts or evidence on the matter, we will let you know.

The Cod sample contained a fair content of organic matter, but the hydrocarbon content was too low for it to be rated as an oil source.

Mr. C. R. Sitter/Mr. M. W. Leighton

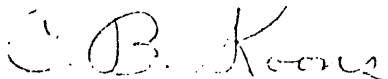
-2-

December 11, 1970

We are currently analyzing the oil from the "greensand" in the onshore Government Borehole No. 8 and will transmit the results as soon as they are available. This oil did not contain measurable amounts of gasoline compounds, so its characterization will be based on heavy compounds.

Very truly yours,

E. McFarlan, Jr.



By C. B. Koons

R. E. Metter/et

Attachments

c.c. Mr. W. R. Eckelmann (with enclosures)
Mr. E. G. Paugh (without enclosures)

TABLE I

SAMPLE DESCRIPTIONS AND VISUAL KEROGEN CHARACTERISTICS
(Kerogen Analysis by J. L. Morgan)

Well	Depth (feet)	EPR Sample No.	Lithology	Kerogen Alteration	Types of Kerogen*		
					Predominant	Secondary	Other
Wahoo-1	1,440	56567	Sandstone, lt. olive gray, med. to coarse grained, silty clay matrix, scattered rounded lithic granules	1+	-	C	Aln
Groper-1	3,058	56568	Sandstone, med. greenish gray, very glauconitic, med. grained, silty clay matrix	2	C	W	Aln, H
Tuna-1	4,306	56569	Sandstone, olive gray, fine grained, silty matrix, scattered coarse glauconitic grains	2	W	Aln	C
Cod-1	6,251	56570	Sandstone, med. brownish gray (salt and pepper), med. grained, thin silty matrix, scattered coarse glauconitic grains	2	W	Al	C

*Kerogen key

Al algal
Aln nonfilamentous algal
C coaly
H herbaceous
W woody

TABLE II

LEAD GASOLINE (C₄-C₇) ANALYSES
 (Analysis by V. C. Rodriguez)

Well	Depth (feet)	EPR Sample No.	Total Organic Matter	C ₄ -C ₇ Hydrocarbons (ppm)	Significant Ratios (see Table II-A)			nPent. iPent.
					C ₁ /C ₂	A/D ₂	C ₁ /D ₂	
Wahoo-1	1,440	56567	.23	.67*	-	-	-	12.7
Groper-1	3,058	56568	.07	.13*	-	-	-	11.3
Tuna-1	4,306	56569	1.02	.55	4.04	3.66	15.74	15.8
Cod-1	6,251	56570	.72	.45*	-	-	-	10.6
Borehole No. 8 Oil	1,050-94	56566	-	Trace	-	-	-	-

*No gasoline compounds heavier than 2,2 dimethylbutane were detected. Ratios could not be evaluated.

TABLE III

HEAVY (C₁₅⁺) ANALYSIS OF ORGANIC EXTRACTS
(Analysis by H. T. Conary)

<u>Well:</u>	<u>Wahoo-1</u>	<u>Groper-1</u>	<u>Tuna-1</u>	<u>Cod-1</u>
<u>Depth (feet):</u>	1,440	3,058	4,306	6,251
<u>Total Organic Matter (%)</u>	.23	.07	1.02	.72
<u>Soluble Organic Matter (ppm)</u>	-	-	496.	155.
<u>Composition of Soluble Organic Matter</u>				
Saturates	-	-	17.1	7.0
Aromatics	-	-	13.6	11.0
NSO's	-	-	20.0	28.4
Noneluted NSO's	-	-	7.5	-
Asphaltenes	-	-	41.8	53.6
<u>Heavy Hydrocarbons (ppm)</u>	-	-	152.	28.
<u>Hydrocarbons as % of T.O.M.</u>	-	-	1.50	.39
<u>Sulfur in Extract (%)</u>	-	-	22.	2.
<u>Source Rating</u>	Poor	Poor	Oil & Gas (?)	Poor