March 16, 1998 Price: $29.00

Division of Geological & Geophysical Surveys

PUBLIC-DATA FILE 98-35

ORGANIC GEOCHEMISTRY OF CRETACEOUS, JURASSIC, AND TRIASSIC SHALES FROM THE NORTHWESTERN DELONG MOUNTAINS, WESTERN BROOKS RANGE, ALASKA, 1994-1997

by

Wallace G. Dow
DGSI, Inc.

March 1998

THIS REPORT HAS NOT BEEN REVIEWED FOR
TECHNICAL CONTENT (EXCEPT AS NOTED IN TEXT) OR FOR
CONFORMITY TO THE EDITORIAL STANDARDS OF DGGS.

Released by

STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
Division of Geological & Geophysical Surveys
794 University Avenue, Suite 200
Fairbanks, Alaska 99709-3645

TABLE OF CONTENTS

This report contains analytical data on the organic geochemistry of four suites of shale samples from the northwestern DeLong Mountains of the western Brooks Range, collected as part of a regional study of the hydrocarbon potential of the northwestern Arctic Slope. Individual reports here included are:

Dow, W.G., and Talukdar, S.C., 1995, Geochemical analysis of Brooks Range outcrop samples, Alaska, February 21, 1994, 40 pages: Previously released as Alaska Division of Geological and Geophysical Surveys Public-data file report 95-29.

Dow, Wallace G., 1997a, Geochemical analysis of twenty-eight outcrop samples, western Brooks Range, Alaska: Analytical report prepared for Alaska Division of Geological and Geophysical Surveys, January 3, 1997, 33 pages.

Dow, Wallace G., 1997b, Geochemical evaluation of twenty outcrop samples, northwestern Alaska: Interim report, prepared for Alaska Division of Geological and Geophysical Surveys, July 30, 1997, 26 pages.

Dow, Wallace G., 1997c, Geochemical evaluation of twenty outcrop samples, northwestern Alaska: Final report, prepared for Alaska Division of Geological and Geophysical Surveys, August 29, 1997. (Includes organic carbon and pyrolysis data, visual kerogen and vitrinite reflectance analysis, and whole extract gas chromatography on twnety samples, and biomarker analysis on four samples.)

.Summary Van Krevelyn diagram with significant geochemical samples plotted.

Summary table of geochemical data by DGSI, age data by Micropaleo Consultants , and stratigraphic assignments by C.G. Mull. Compiled by C.G. Mull.

Other reports in this series of reports on the hydrocarbon potential of the western Arctic Slope are:

Crowder, R. K., Adams, K.E., and Mull, C.G., 1994, Measured stratigraphic section of the Tingmerkpuk Sandstone (Neocomian), western Brooks Range, Alaska: Alaska Division of Geological and Geophysical Surveys Public-data file report 94-29, 5 p, 1 sheet.

Dow, W.G., and Talukdar, S.C., 1995, Geochemical analysis of outcrop samples, western DeLong Mountains, Brooks Range, Alaska: Alaska Division of Geological and Geophysical Surveys Public-data file report 95-29, 40 p.

Mickey, M.B., Haga, Hideyo, and Mull, C.G., 1995, Paleontologic data: Tingmerkpuk Sandstone and related units, northwestern DeLong Mountains, Brooks Range, Alaska: Alaska Div. of Geological and Geophysical Surveys Public-data file report 95-31, 42 p.

Mickey, M.B., Haga, Hideyo, Micropaleo Consultants, Inc. , 1996, Biostratigraphy report, 109 outcrop samples, western DeLong Mountains, field party, North Slope, Alaska, December 4, 1996, 121 pages: Alaska Div. of Geological and Geophysical Surveys Public-data file report 98-_____,

Mickey, M.B., Haga, Hideyo, Micropaleo Consultants, Inc. , 1997a, Biostratigraphy report of 16 outcrop samples from the Tingmerkpuk project area North Slope, Alaska July 11, 1995, 20 p: Alaska Div. of Geological and Geophysical Surveys Public-data file report PDF 98_____.

Mickey, M.B., Haga, Hideyo, Micropaleo Consultants, Inc. , 1997b, Biostratigraphic report of eleven outcrop samples from North Slope, Alaska, March 21, 1995, 12 p: Alaska Div. of Geological and Geophysical Surveys Public-data file report PDF 98_____.

Mickey, M.B., Haga, Hideyo, Micropaleo Consultants, Inc. , 1997, Biostratigraphy report, 74 outcrop samples, western DeLong Mountains, field party, North Slope, Alaska, December 4, 1996: 54 p: Alaska Div. of Geological and Geophysical Surveys Public-data file report PDF 98____

Mull, C.G., 1995, Preliminary evaluation of the hydrocarbon source rock potential of the Tingmerkpuk Sandstone (Neocomian) and related rocks, northwestern DeLong Mountains, Brooks Range, Alaska: Alaska Division of Geological and Geophysical Surveys Public-data file report PDF 95-30, 20 p.

Reifenstuhl, R.R., Wilson, M.D., and Mull, C.G., 1997, Petrography of the Tingmerkpuk Sandstone (Neocomian), northwestern Brooks Range, Alaska: A preliminary study, in Clough, J.G., (editor), Short Notes on Alaska Geology, 1997, Alaska Division of Geological and Geophysical Surveys Professional Report PR 118 (in press).

Wartes, M.A., and Reifenstuhl, R.R.,1997, Preliminary petrography and provenance of six Lower Cretaceous sandstones, northwestern Brooks Range, Alaska, in Clough, J.G., (editor), Short Notes on Alaska Geology, 1997, Alaska Division of Geological and Geophysical Surveys Professional Report PR 118 (in press).

Additional background information concerning this project has been presented by:

Crowder, R. K., Mull, Charles G. (Gil), and Adams. Karen E., 1995, Lowstand depositional systems related to Early Cretaceous rifting of the Arctic Alaska plate: A new stratigraphic play on Alaska's North Slope (abstract): 1995 Abstracts with Program, Pacific Section AAPG/SEPM meeting, San Francisco, May 3-5, 1995, p. 29.

Grow, J.A., Miller, J.J., Mull, C.G. and Bird, K.J., 1995, Seismic stratigraphy near the Tunalik well, North Slope, Alaska (abstract): 1995 Abstracts with Program, Pacific Section AAPG/SEPM meeting, San Francisco, May 3-5, 1995, p. 33.

Mowatt, T.C, Mull. C.G., Banet, A.C., Wilson, M.D., and Reeder, John, 1995, Petrography of Neocomian sandstones in western Brooks Range, and Tunalik, Burger, and Klondike wells, northwestern Arctic Slope-Chukchi Sea (abstract): 1995 Abstracts with Program, Pacific Section AAPG/SEPM meeting, San Francisco, May 3-5, 1995, p. 41.

Mull, C. G., Reifenstuhl, R.R., Harris, E.E,, and Crowder, R.K, 1995, Neocomian source and reservoir rocks in the western Brooks Range and Arctic Slope, Alaska (abstract): 1995 Abstracts with Programs, Pacific Section AAPG/SEPM meeting, San Francisco, May 3-5, 1995, p. 41.

Mull, C. G., Crowder, R.K, and Reifenstuhl, R.R., 1995, Exploration frontiers in Neocomian sandstones in northwest Alaska (abstract): 1995 Abstracts with Programs, Cordilleran Section, Geological Society of America meeting, Fairbanks, Alaska, May 24-26, 1995, p. 66.

Mull, C.G., 1997, Exploration Frontiers In Neocomian to Upper Jurassic sandstones, National Petroleum Reserve in Alaska (NPRA) (abstract): Alaska Geological Society newsletter, vol. 26, no. 10, May 1997

Wartes, Marwan A., 1997, Mesozoic stratigraphy at Surprise Creek: Preliminary evidence for anomalous Brookian tectonism and burial history, northwestern Brooks Range, Alaska (abstract): 1997 Abstracts with Programs, Geological Society of America annual meeting, Salt Lake City, can be viewed on World Wide Web atwww.geosociety.org/cgi-bin/config/doc.pl?beginqry.htm~7777777, search for Surprise Creek.

Additional reports in press include:

Elder, William P., 1998, Report on coquinoid limestone beds of the western Arctic Slope: Alaska Div. of Geological and Geophysical Surveys Public-data file report PDF 98-__, 9 p.

Elder, William P., 1997, Report on megafossils collected, 1996 Tingmerkpuk project: Alaska Div. of Geological and Geophysical Surveys Public-data file report PDF 98-__, 3 p.

Munley, Walt, Layer, Paul, and Mull, C.G., 1997, Ar-Ar age measurements on detrital white mica from Mt. Kelly Graywacke (Fortress Mountain Formation), Eagle Creek area., Alaska Division of Geological and Geophysical Surveys Public-data file report, PDF 98- __.

Murphy, John, 1997, Apatite fission-track data, 1994 and 1996 samples, Tingmerkpuk project: Alaska Division of Geological and Geophysical Surveys Public-data file report, PDF 98- ____.

2/21/94

GEOCHEMICAL ANALYSIS OF BROOKS RANGE OUTCROP SAMPLES ALASKA

For

State of Alaska
Department of Natural Resources
Division of Geology & Geophysical Surveys
794 University Avenue
Fairbanks, Alaska 99709

By

Wallace G. Dow
Suhas C. Talukdar
DGSI Project: 93/2826
February 21, 1994

5

DGSI
Total Quality Geochemistry

INTRODUCTION

Sixteen outcrop samples from the Brooks Range in Alaska were analyzed for TOC content and with Rock-Eval pyrolysis. Twelve of the samples were designated for kerogen microscopy and seven for solvent extraction and whole extract gas chromatography. No other analyses were authorized but biomarker (gc/ms) data on a few samples would have provided useful information.

KEROGEN DATA

Total organic carbon is variable but most samples are rated as good (1.0 - 2.0 wt.% TOC) in source quality. A few are organic lean and are non source rocks (less than 0.5 wt.% TOC) and one (93-MU-80-1) is very organic rich (4.63 wt.% TOC). Organic carbon contents can be reduced by outcrop weathering but this does not appear to be a major problem here. Some reduction due to maturity, however, has taken place.

Pyrolysis response is very low in nearly all of the samples, apparently due primarily to fairly high maturity. T_{max} values are high for most samples (449 to 483°C), indicating maturities between about 1.0 and 1.5 R_o. Lower T_{max} values (444 & 445°C) for samples 93-MU-80-1 and 1a suggest maturities between 0.7 and 0.8 R_o. Very low T_{max} values (426 and 296°C) for samples 93-MU-104 and 104-6 are invalid due to poor pyrolysis response. Sample 93-MU-80-1 differs from the others by having a much higher hydrogen index (367), indicative of moderately mature, type II, oil generating kerogen. It is possible that pyrolysis response has been reduced by outcrop weathering but this does not appear to be the case in these samples. Low oxygen indices also attest to lack of kerogen oxidation.

Kerogen microscopy on twelve samples reveal mixed marine and terrigenous organic matter with the marine component being the most abundant in most samples. Solid bitumen is very common and indicates that oil generation has taken place. Structured lipids are primarily liptodentrinite or minor terrigenous sporinite and cutinite. Thermal maturity based on good vitrinite populations ranges from 1.17 to 1.47 R_o for most samples and is supported by pyrolysis T_{max} data, 2+ to 3- TAI values, weak orange structured lipids fluorescence, and moderate to intense background fluorescence intensity. These samples appear to be nearly spent oil source rocks in the late stages of oil generation. The presence of appreciable amounts of terrigenous organic matter including some high rank, recycled material, probably has reduced the oil generation capability of most samples.

ORGANIC CARBON AND ROCK-EVAL PYROLYSIS DATA

BROOKS RANGE OUTCROPS

Project: DGSI/93/2826

SAMPLE IDENTIFICATION DGSI ID		TOC Wt%	S1 mg/g	S2 mg/g	S3 mg/g	Tmax degC	S1/ TOC	HI	OI	S2/ S3	PI
1 :	93-MU-101 -	1.30	0.31	0.41	0.34	479	24	32	26	1.21	0.43
2 :	93-MU-104 -	0.36	0.03	0.05	0.06	426	8	14	17	0.83	0.38
3 :	93-MU-104-6 -	0.14	0.01	0.00	0.02	296	7	0	14	0.00	1.00
4 :	93-MU-80 -	1.87	0.14	0.57	0.23	461	7	30	12	2.48	0.20
5 :	93-MU-80-1	4.63	2.14	17.00	0.34	445	46	367	7	50.00	0.11
6 :	93-MU-80-1a	0.92	0.34	0.86	0.09	444	37	93	10	9.56	0.28
7 :	93-MU-84	0.41	0.01	0.00	0.11	449	2	0	27	0.00	1.00
8 :	93-MU-87	1.81	0.23	0.55	0.52	483	13	30	29	1.06	0.29
9 :	93-MU-88-1	1.06	0.15	0.36	0.06	475	14	34	6	6.00	0.29
10 :	93-MU-93	1.69	0.26	0.76	0.26	469	15	45	15	2.92	0.25
11 :	93-RKC-22-12-B	0.18	0.01	0.01	0.03	477	6	6	17	0.33	0.50
12 :	93-RKC-22-138-B	1.27	0.08	0.41	0.13	453	6	32	0	0.00	0.16
13 :	93-RKC-22-153-B	1.19	0.04	0.26	0.03	465	3	22	3	8.67	0.13
14 :	93-RKC-22-36-B	1.84	0.08	0.56	0.04	468	4	30	2	14.00	0.13
15 :	93-RKC-22-43-B	1.50	0.07	0.31	0.13	476	5	21	9	2.38	0.18
16 :	93-RKC-22-72-B	1.32	0.05	0.41	0.08	455	4	31	0	0.00	0.11

Samples 93-MU-80, 80-1 and 80-1a contain similar type kerogen but appear to be lower in maturity than the others. Sample 93-MU-80 has a maturity of 0.92 R_o but the 0.74 & 0.77 R_o maturities of samples 93-MU-80-1 and 80-1a are questionable due to limited reflectance measurements. It is possible that the vitrinite in these two samples is weathered, lipid rich, or that some of the R_o values are on small fragments of solid bitumen. Other maturity indices such as pyrolysis T_{max}, kerogen fluorescence, and TAI support a maturity of about 0.9 to 1.0 R_o for these samples.

EXTRACT DATA

Seven outcrop samples were solvent extracted and analyzed with whole extract gas chromatography (gc). Six samples have low extract/TOC ratios (0.011 - 0.051) and probably contain indigenous bitumen. Sample 93-MU-80-1a has a high extract/TOC ratio (0.209), indicating that it contains migrated bitumen.

Samples 93-MU-80-1 and 93-MU-80-1a, from the Upper Triassic Sublik Formation at Surprise Creek, contain indigenous and migrated bitumen, respectively. Whole extract gas chromatograms are similar, indicating the same source and thermal maturity. Therefore, the migrated bitumen in sample 93-MU-80-1a was probably derived from adjacent, more organic-rich Sublik source rocks. The two extracts show quite similar C15+ n-alkane distributions (continuously decreasing with increasing carbon number) and isoprenoid distributions. The pristane/nC_{17} ratios (0.45 - 0.47) and phytane/nC_{18} ratios (0.19 - 0.21) (see Figure 2), high pristane/phytane ratios (2.6 - 2.7), CPI values > 1 (1.08 - 1.10) and minor C25+ n-alkanes indicate a mixed organic source with relatively minor terrigenous organic matter (probably deposited under oxic or suboxic conditions). A thermal maturity close to the peak oil generation stage is also indicated. Pristane/phytane ratios and pristane/nC_{17} ratios for these samples might have been increased due to surface weathering and, therefore may not reflect true depositional conditions. Kerogen microscopy data indicate a predominance of oil generating lipid kerogen and minor terrigenous organic matter in the mixed organic source facies. T_{max} data of 444 - 445°C are comparable with the maturity suggested from the pristane/nC_{17} versus phytane/nC_{18} plot. Measure R_o data (0.74 - 0.77%) are approximate and are somewhat lower.

Sample 93-MU-80 from the Neocomian Kingkak shale at Surprise Creek contains indigenous bitumen. A whole extract gas chromatogram suggests a mixed organic source (type II/III) with significant terrigenous organic matter deposited under mild to moderately oxic conditions and a peak oil generation stage thermal maturity. This is evidenced by the high pristane/phytane ratio of 2.0, the cross plot of pristane/nC_{17} (0.35) versus phytane/nC_{18} (0.23) in Figure 2, very significant C_{25+} n-alkanes, an odd carbon number predominance in the nC_{25} - nC_{35} range, and the high CPI of 1.33. Kerogen microscopy data show 65% lipid kerogen (unstructured lipids 50%, structured lipids 5%, solid bitumen 10%) and 35% humic kerogen (vitrinite 25%, inertinite 10%) and agree with the gc data. The thermal maturity shown by the pristane/nC_{17} versus phytane/nC_{18} plot (Figure 2) also agrees with the measured R_o of 0.92%. The T_{max} value of 461°C is unreliable because of the low and undefined S_2 peak.

Sample 93-RKC-22-153-B probably, from Kingkak shale (top Ting sandstone), and sample 93-RKC-22-36-B from Kingkak shale (both from Tingmerkpuk Mountain) have extract gas chromatograms that are characterized by mixed organic facies (type II/III) with significant terrigenous organic matter and by high thermal maturities. This is evidenced by high pristane/phytane ratios (2.0 and 5.1, respectively), the pristane/nC_{17} versus phytane/nC_{18} plot (Figure 2), and the CPI values (1.21 and 1.01, respectively). Kerogen microscopy data support the gc data by showing abundant humic kerogen (25 - 40%) relative to lipid-rich kerogen (60 - 75%). A high thermal maturity is also indicated from the measured R_o values of 1.43 - 1.57%. T_{max} values are unreliable because of low and undefined S_2 peaks.

Sample 93-MU-101, representing the Albian Torok Formation from Eagle Creek, contains indigenous extract. A whole extract gas chromatogram shows a mixed organic source (type III?) with primarily terrigenous organic matter deposited under sub-oxic depositional conditions and a high thermal maturity. This is shown by a high pristane/phytane ratio of 2.4, the pristane/nC_{17} (0.37) versus phytane/nC_{18} (0.18) plot (Figure 2) and the CPI >1 (1.12). Kerogen microscopy data show a high proportion of humic kerogen (45%) relative to lipid-rich kerogen (55%; unstructured 50% and structured 5%) and support the gc data. The high measured R_o of 1.47% also supports the high maturity indicated from pristane/nC_{17} versus phytane/nC_{18} plot (Figure 2).

Basal Brookian

Sample 93-MU-93, from an unknown formation in Tingmerkpuk Mountain, contains indigenous extract derived from a mixed organic source containing significant terrigenous organic matter (type II/III) and probably deposited under mildly reducing conditions. This is indicated by the pristane/phytane ratio of 1.3, the pristane/nC_{17} (0.73) versus phytane/nC_{18} (0.60) plot in Figure 2, the CPI >1 (1.06) and abundant C25+ n-alkanes. The pristane/nC_{17} versus phytane/nC_{18} plot and the bimodal n-alkane distribution suggest a relatively low thermal maturity (0.70% R_o). Kerogen microscopy data agree with the organic source facies suggested from the gc data. The measured R_o of 1.17 is significantly higher than that suggested from the pristane/nC_{17} versus phytane/nC_{18} plot (Figure 2). The T_{max} value is unreliable because of a low and undefined S_2 peak.

Considering all of the gc data, we conclude that the Brooks Range samples contain some mature, oil-prone source rocks that have generated and expelled crude oil. The organic-rich Sublik source rocks (e.g. sample 93-MU-80-1) contain type II, oil-prone kerogen and are the best quality oil source rocks. The Kingkak shales are mature to highly mature and contain low yield type II/III kerogen which probably has generated some waxy oil and gas. The Torok Formation contains highly mature, type III source rocks that generated mostly gas.

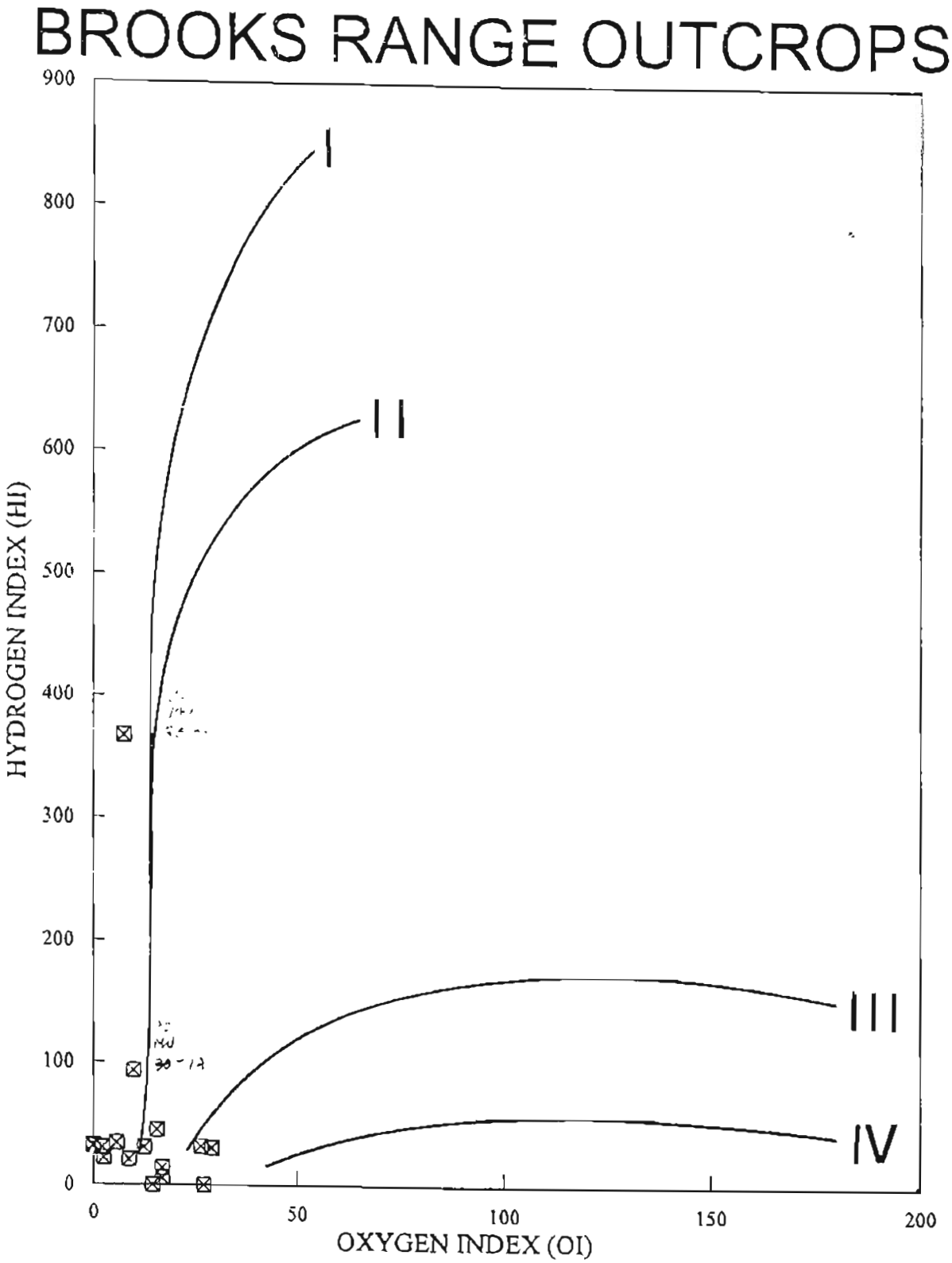


FIGURE 1 - Kerogen type determination from TOC and Rock-Eval pyrolysis data. Types I and II will generate oil, type III gas, and type IV little or no hydrocarbons.

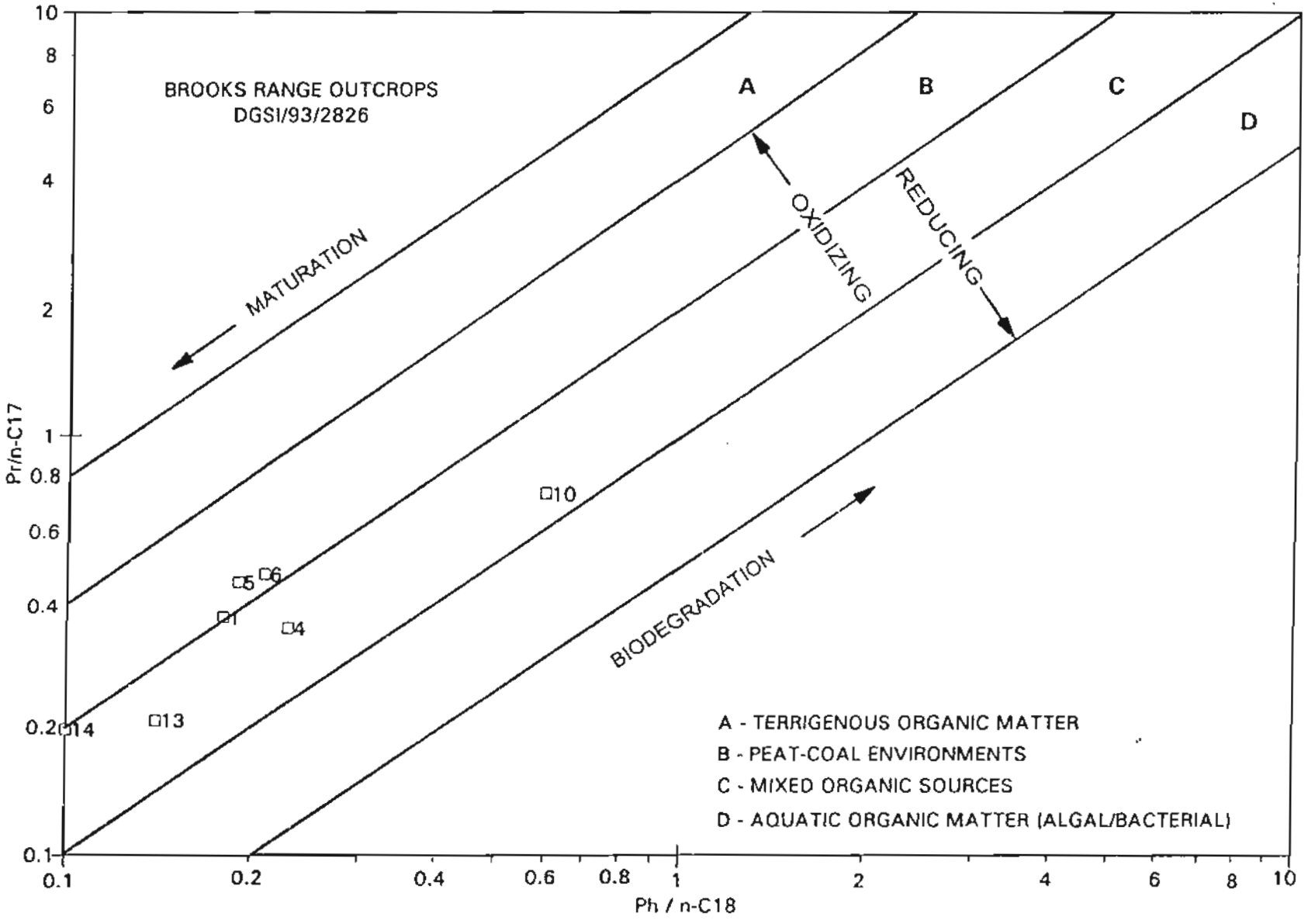


FIGURE 2 - Plot from chromatography data showing organic matter type, source rock depositional environment, and thermal maturity.

1993 Mull, Crowder Geochem Samples

17-Dec-93

Sample #	Formation	Discription	Location	Collector	Comments
93-Mu-101	K to	?	Eagle Creek	Mull	
93-Mu-104	Klk	?	Kukpowruk R	Mull	
93-Mu-104-6	Kjk	?	Kukpowruk R.	Mull	
93-Mu-80	Kjk?	?	Surprise Creek	Mull	
93-Mu-80-1	Trs	?	Surprise Creek	Mull	
93-Mu-80-1a	Tsr	Paper	Surprise Creek	Mull	
93-Mu-84	Kjk	?	Tingmerkpuk Mnt.	Mull	
93-Mu-87	?	?	Eagle Creek	Mull	
93-Mu-88-1	Kt		Tingmerkpuk R.	Mull	
93-Mu-93	?	?	Tingmerkpuk Mnt. SE	Mull	
93-RKC-22-12-B	Kingak Sh	Sh	Tingmerkpuk Mtn.	Crowder	
93-RKC-22-138-B	Ting SS	SS	Tingmerkpuk Mtn.	Crowder	
93-RKC-22-153B	Top Ting SS	Org SS	Tingmerkpuk Mtn.	Crowder	
93-RKC-22-36-B	Kjk		Tingmerkpuk Mtn.	Crowder	
93-RKC-22-43-B	Ting ?	?	Tingmerkpuk Mtn.	Crowder	
93-RKC-22-72-B	Ting SS	SS	Tingmerkpuk Mtn.	Crowder	

ORGANIC CARBON AND PYROLYSIS DATA

Total Organic Carbon (TOC) and Rock-Eval pyrolysis data provide basic geochemical information and are frequently used to select samples for more detailed studies, particularly kerogen microscopy, extract chromatography and biomarker analyses. Well data can be plotted to make geochemical logs. Unless otherwise specified by a client, DGSI uses LECO TOC then Rock-Eval II pyrolysis as the standard analytical sequence and Rock-Eval is recommended for samples with greater than 0.4% TOC. Samples for LECO TOC and Rock-Eval pyrolysis are ground to pass through a 60 mesh sieve to assure homogeneity.

LECO ORGANIC CARBON AND TOTAL SULFUR

Total Organic Carbon is best determined by direct combustion. Approximately 0.15 grams of sample are carefully weighed, treated with concentrated HCl to remove carbonates, and vacuum filtered on glass fiber paper. The residue and paper are placed in a ceramic crucible, dried, and combusted with pure oxygen in a LECO EC-12 or LECO CS-444 carbon analyzer at about 1,000°C. A laboratory standard is run every five samples. Total, insoluble, mineral plus organic sulfur can be determined by the CS-444 analyzer during the carbon analysis. Total carbonate can be determined from sample and acid residue weight differences or by LECO combustion TOC differences before and after acid digestion.

ROCK-EVAL II PYROLYSIS

Rock-Eval II pyrolysis is used to determine kerogen type, kerogen maturity and the amount of free hydrocarbons. About 0.1 grams of the same ground sample used for LECO TOC are carefully weighed in a pyrolysis crucible and then heated to 300°C to determine the amount of free hydrocarbons, S1, that is thermally distilled. Next, the amount of pyrolyzable hydrocarbons, S_2, is measured when the sample is heated in an inert environment which rises from 300° to 550°C at a heating rate of 25°C/minute. S_1 and S_2 are reported in mg HC/g sample. T_{max}, a maturity indicator, is the temperature of maximum S_2 generation. When S_2 values are less than 0.2 mg HC/g sample, the S_2 maximum typically has poor definition and thus, T_{max} cannot be reliably determined (Peters, 1986). Carbon dioxide generated during the S_2 pyrolysis, an indicator of kerogen oxidation, is collected up to a temperature of 390°C and reported as S_3 in units of mg CO_2/g sample. A laboratory standard is run every 10 samples. Hydrogen Index (HI = S_2*100/TOC) and Oxygen Index (OI = S_3*100/TOC) are used as kerogen type indicators when plotted on a van Krevelen type diagram.

ROCK-EVAL II PYROLYSIS PLUS TOC

Rock-Eval II Plus TOC is used to determine both Rock-Eval data (S_1, S_2, S_3, T_{max}) and TOC of a 0.1 gram ground sample. With this instrument, the pyrolysis stage (S_2) ramps to 600°C at which point the sample is switched to an oxidation oven where the sample is oxidized at 600°C for 5 minutes in air to measure the residual organic matter (S_4). A laboratory standard is run every 10 samples. S_1, S_2, S_3, and S_4 are summed appropriately to calculate TOC. True TOC will be greater than this calculated sum for samples with maturity greater than about 1.0% R_o because the Rock-Eval final temperature is inadequate for complete combustion (Peters, 1986). This instrument is preferred when there is insufficient sample to run TOC and pyrolysis separately, or when <u>all</u> samples in a study are to be analyzed for both TOC and Rock-Eval data without prior TOC screening.

ORGANIC CARBON AND ROCK-EVAL PYROLYSIS DATA

BROOKS RANGE OUTCROPS

Project: DGSI/93/2826

SAMPLE IDENTIFICATION DGSI ID		TOC Wt%	S1 mg/g	S2 mg/g	S3 mg/g	Tmax degC	S1/ TOC	HI	OI	S2/ S3	PI
1 :	93-MU-101 -	1.30	0.31	0.41	0.34	479	24	32	26	1.21	0.43
2 :	93-MU-104 -	0.36	0.03	0.05	0.06	426	8	14	17	0.83	0.38
3 :	93-MU-104-6 -	0.14	0.01	0.00	0.02	296	7	0	14	0.00	1.00
4 :	93-MU-80 -	1.87	0.14	0.57	0.23	481	7	30	12	2.48	0.20
5 :	93-MU-80-1	4.63	2.14	17.00	0.34	445	46	367	7	50.00	0.11
6 :	93-MU-80-1a	0.92	0.34	0.86	0.09	444	37	93	10	9.56	0.28
7 :	93-MU-84	0.41	0.01	0.00	0.11	449	2	0	27	0.00	1.00
8 :	93-MU-87	1.81	0.23	0.55	0.52	483	13	30	29	1.06	0.29
9 :	93-MU-88-1	1.06	0.15	0.36	0.06	475	14	34	6	6.00	0.29
10 :	93-MU-93	1.69	0.26	0.76	0.26	469	15	45	15	2.92	0.25
11 :	93-RKC-22-12-B	0.18	0.01	0.01	0.03	477	6	6	17	0.33	0.50
12 :	93-RKC-22-138-B	1.27	0.08	0.41	0.13	453	6	32	0	0.00	0.16
13 :	93-RKC-22-153-B	1.19	0.04	0.26	0.03	465	3	22	3	8.67	0.13
14 :	93-RKC-22-36-B	1.84	0.08	0.56	0.04	468	4	30	2	14.00	0.13
15 :	93-RKC-22-43-B	1.50	0.07	0.31	0.13	476	5	21	9	2.38	0.18
16 :	93-RKC-22-72-B	1.32	0.05	0.41	0.08	455	4	31	0	0.00	0.11

VISUAL KEROGEN ANALYSIS TECHNIQUES

Visual kerogen analysis employs a Zeiss Universal microscope system equipped with halogen, xenon, and tungsten light sources or a Jena Lumar microscope equipped with halogen and mercury light sources. Vitrinite reflectance and kerogen typing are performed on a polished epoxy plug of unfloated kerogen concentrate using reflected light from the halogen source. The digital indicator is calibrated using a glass standard with a reflectance of 1.02% in oil. This calibration is linearly accurate for reflectance values ranging from peat (R_o 0.20%) through anthracite (R_o 4.0%).

Reflectance values are recorded only on good quality vitrinite, including obvious contamination and recycled material. The relative abundance of normal, altered, lipid-rich, oxidized, and coked vitrinite is recorded. When good quality, normal vitrinite is absent, notations are made indicating how the maturity is affected by weathering, oxidation, bitumen saturation, or coking. When normal vitrinite is absent or sparse, other macerals may be substituted. Solid bitumen, for example is present in many samples. Although it often has a different reflectance than vitrinite, Jacob's calibration chart can be used to obtain an estimated vitrinite reflectance equivalent. Graptolites have about the same reflectance as vitrinite and can often be used to obtain maturity data in early Paleozoic rocks that have no vitrinite.

Unstructured lipid kerogen changes in texture and color during the maturation process. Typically, unstructured kerogen at low maturity is reddish brown and amorphous. Somewhere between R_o 0.50 to 0.65%, the kerogen takes on a massive texture and is gray in color. At higher maturity, generally above R_o 1.30%, unstructured kerogen is light gray and micrinized.

Kerogen typing and maturity assessments from the polished plug are enhanced by utilizing fluorescence from blue light excitation. The xenon or mercury lamp is used with an excitation filter at 495 nm coupled with a barrier filter of 520 nm. With the Jena microscope we also have the option of observing fluorescence under ultra violet excitation. The intensity of fluorescence in the epoxy mounting medium (background fluorescence) correlates well with the onset of oil generation and destruction. The identification of structured and unstructured liptinite is also enhanced with the use of fluorescence in those samples having a maturity less than R_o 1.3%. The relative abundance and type of pyrite is also recorded.

TAI is performed using tungsten or halogen light source that is transmitted through a glass slide made from the unfloated kerogen concentrate. Ideally, TAI color is based on sporinite of terrestrial origin. When sporinite is absent, TAI is estimated from the unstructured lipid material. Weathering, bitumen admixed with the unstructured material and micrinization can darken the kerogen and raise the TAI value. The character of the organic matter in transmitted light is correlated with observations made in reflected light for kerogen typing.

Kerogen typing and maturity assessments from the slide preparation are also reinforced by using different light sources. The slide is first observed in transmitted light to obtain TAI color and organic matter structure or type. The light is then switched to reflected halogen light to observe structure and amount of pyrite, and finally to reflected blue light excitation from the xenon or mercury source

for fluorescence. The fluorescence of structured and unstructured liptinite is not masked by the epoxy fluorescence as it is in the reflected light mode because the mounting medium is non-fluorescent. Remnant lipid structures (e.g. sporinite and alginite) within the unstructured kerogen can often be identified in blue light.

Maturity calculations are made from the vitrinite reflectance histograms. Decisions as to which reflectance measurements indicate the maturity of the sample are based not only on the histogram but on all of the kerogen descriptive elements as well. Because it is not done at the time of measurement, alternate maturity calculations can be made if kerogen data and geological information dictate.

In summary, vitrinite reflectance measurements are performed on a polished plug in reflected light, TAI is performed on a slide in transmitted light, and kerogen typing is estimated from both preparations using a combination of reflected, transmitted, and fluorescent light techniques. Fluorescence in blue light is used to enhance the identification of structured and unstructured lipid material, solid bitumens, and drilling mud contaminants. Fluorescence also correlates with the maturity and state of preservation of the sample. Maturity calculations from measured reflectance data are made from the histograms and are influenced by all of the kerogen data.

VISUAL KEROGEN ANALYSIS GLOSSARY

Several key definitions are included in this glossary in order to make our reports more self-explanatory. In our reports, we refer to organic substances as macerals. Macerals are akin to minerals in rock, in that they are organic constituents that have microscopically recognizable characteristics. However, macerals vary widely in their chemical and physical properties, and they are not crystalline.

1. UNSTRUCTURED KEROGEN, or sometimes called structureless organic matter (SOM) and bituminite; it is widely held that unstructured kerogen represents the bacterial breakdown of lipid material. It also includes fecal pellets, minute particles of algae, organic gels, and may contain a humic component. As described on the first page of this section, unstructured lipid kerogen changes character during maturation. The three principal stages are amorphous, massive, and micrinized. Amorphous kerogen is simply without any structure. Massive kerogen has taken on a cohesive structure, as the result of polymerization during the process of oil generation. At high maturity, unstructured kerogen becomes micrinized. Micrinite is characterized optically by an aggregation of very small (less than one micron) round bodies that make up the kerogen.

2. STRUCTURED LIPID KEROGEN consists of a group of macerals which have a recognized structure, and can be related to the original living tissue from which they were derived. There are many different types, and the types can be grouped follows:
    a. Alginite, derived from algae. It is sometimes very useful to distinguish the different algal types, for botryococcus and pediastrum are associated with lacustrine and non-marine source rocks, while algae such as tasmanites, gloecapsomorpha, and nostocopsis are typically marine. Acritarchs and dinoflaggelates are marine organisms which are also included in the algal category.

b. Cutinite, derived from plant cuticles, the remains of leaves.
c. Resinite, (including fluorinite) derived from plant resins, balsams, latexes, and waxes.
d. Sporinite, derived from spores and pollen from a wide variety of land plants.
e. Suberinite is derived from the corky tissue of land plants.
f. Liptodetrinite is that structured lipid material that is too small to be specifically identified. Usually, it is derived from alginite or sporinite.
g. Undifferentiated. At times, one can readily distinguish structured lipid material from the unstructured without being able to make a specific determination of the structured material.

The algae are an important part of many oil source rocks, both marine and lacustrine. Alginite has a very high hydrogen index in Rock-Eval pyrolysis. Resins, cuticles, and suberinite contribute to the waxy, non-marine oils that are found in Africa and the Far East. At vitrinite reflectance levels above R_o 1.2 - 1.4%, structured lipid kerogen changes structure and it becomes very difficult to distinguish them from vitrinite.

3. SOLID BITUMEN, also called migrabitumen and solid hydrocarbon. In 1992, the International Committee for Coal and Organic Petrology (ICCP) has decided to include solid bitumen in the Exsudatinite group. Solid bitumens are expelled hydrocarbon products which have particular morphology, reflectance and fluorescence properties which make it possible to identify them. They represent two classes of substances: one which is present at or near the place where it was generated, and second as a substance which is present in a reservoir rock and may have migrated a great distance from its point of origin. The solid bitumens have been given names, such as gilsonite, impsonite, grahamite, etc., but they represent generated heavy hydrocarbons which remain in place in the source rock or have migrated into a reservoir and mature along with the rock. Consequently, it is possible to use the reflectance of solid bitumens for maturation determinations when vitrinite is not present.

4. HUMIC TISSUE, that is organic material derived from the woody tissue of land plants. The most important of this group is:

a. Vitrinite is derived from woody tissue, which has been subjected to a minimum amount of oxidation. Normally, it is by far the most abundant maceral in humic coals, and because the rate of change of vitrinite reflectance is at a more even pace than it is for other macerals, it offers the best means of obtaining thermal maturity data in coals and other types of sedimentary rocks.

Because the measurement of vitrinite is so important, care is taken to distinguish normal (fresh, unaltered) vitrinite from other kinds of vitrinite. Rough vitrinite does not take a good polish and therefore may not yield good data. Oxidized vitrinite may have a reflectance higher or lower than fresh vitrinite; this is a problem often encountered in outcrop samples. Lipid-rich vitrinite, or saprovitrinite, has a lower reflectance than normal vitrinite, and will produce an abnormally low thermal maturity

value. Coked vitrinite is vitrinite that has structures found in vitrinite heated in a coke oven. Naturally coked vitrinite is the product of very rapid heating, such as that found adjacent to intrusions. Where it is possible to do so, vitrinite derived from an uphole portion of a well will be identified as caved vitrinite. Recycled vitrinite is the vitrinite of higher maturity which clearly can be separated from the indigenous first-cycle vitrinite population. Often, the recycled vitrinite merges in with the inert group.

b. Inertinite is made up of woody tissue that has been matured by a different pathway. Early intense oxidation, usually involving charring, fungal attack, biochemical gelification, creates the much more highly reflecting fusinite and semi-fusinite. Sometimes the division between vitrinite and fusinite is transitional. Sclerotinite, fungal remains having a distinct morphology are considered to be inert. An important consideration is that the inerts, as the name implies, are largely non- reactive, "dead carbon", and they have an extremely low hydrogen index in Rock-Eval pyrolysis.

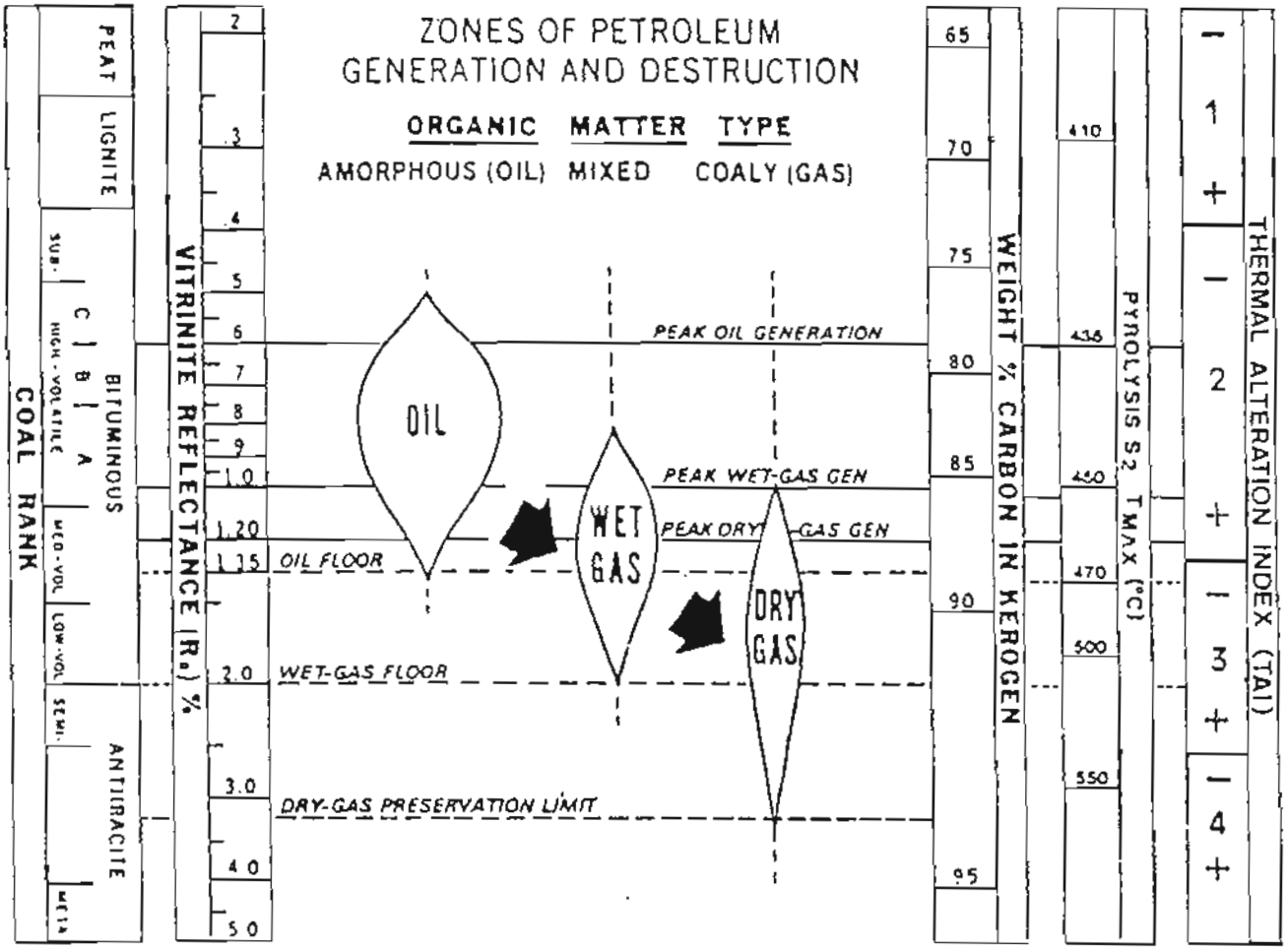
5. OTHER ORGANIC MATERIAL

a. In the table, we have put lipid-rich, caved and recycled vitrinite in this section so that we could show the percentages of these macerals; they are described above.

b. Exsudatinite. Oil and oily exudates fall in this group. Exsudatinite differs from the solid bitumens on the basis of mobility and solubility. We prefer to maintain this distinction although the ICCP has now included the solid bitumens in with the Exsudatinite group.

c. Graptolites are marine organisms that range from the Cambrian to the lower Mississippian; it has been found that they have a reflectance similar to that of vitrinite. Because vitrinite is lacking in early Paleozoic rocks, the proper identification and measurement of graptolites is important in these sediments.

6. PYRITE. Various forms of pyrite can be readily identified under the microscope. Euhedral is pyrite with a definite crystalline habit. Framboidal is pyrite in the form of grape-like clusters which are made up of euhedral to subhedral crystals. Framboidal pyrite is normally found in sediments with a marine influence; for example, coals with a marine shale roof rock usually contain framboidal pyrite. Massive pyrite is pyrite with no particular external form; often this is pyrite that forms rather late in the pore spaces of the sediment. Replacement/infilling is self-explanatory.



CORRELATION OF VARIOUS MATURATION INDICES AND ZONES OF PETROLEUM GENERATION AND DESTRUCTION.

BROOKS RANGE OUTCROPS

Project: DGSI/93/2826

DGSI

DATE: 2/17/94

DGSI NUMBER	ID OR DEPTH	SAMPLE TYPE	ORGANIC MATTER: LIPIDS UNSTRUCTURED: UNDIFFERENTIATED (%)	AMORPHOUS (%)	MASSIVE (%)	MICRINIZED (%)	LIPIDS STRUCTURED: TYPE / (%)	TYPE / (%)	TYPE / (%)	TYPE / (%)	SOLID BITUMEN (%)	HUMIC: INERTINITE (%)	VITRINITE (%)	OTHER: TYPE / (%)	TYPE / (%)	RELATIVE ABUNDANCE: PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE: NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI: REFLECTED LIPIDS UNSTR.: COLOR	INTENSITY	STRU.: COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED LIPIDS UNSTR.: TAI VALUE	FLUOR. COLOR	FLUOR. INTENSITY	STRU.: TAI VALUE	FLUOR. COLOR	FLUOR. INTENSITY	Ro: VITRINITE REFLECTANCE Maturity or Equivalent
1	93-MU-101	OC					U	LD																					3-				BL	0
		K	50				5	T			7	10	35			MA	-	+	NI	M				BL	0	BL	0	2	3	BL	0		O	1	1.47
Comments:	Gray - brown, grainy unstructured material.																																		
4	93-MU-80	OC					U	LD																				2	3	BL	0		BL	0	
		K	50				5	T			10	10	25			MA	M	+	+			T	T	BL	0	BL	0	3	2+	O	1		O	1	0.92
Comments:	Abundant VR ? Solid bitumen Ro 0.52, 0.55, 0.57, 0.78.																																		
5	93-MU-80-1	OC						LD								F										O		2	3	O	1		O		
		K				65	F	5			15	10	5				M	+	+			T		BL	0	OB	1	3	3+	BL	0		Y	1	70.74
Comments:	Wide range of solid bitumen Ro - 0.57 - 0.72 probably indigenous, 0.07 contam. , 1.77 - 2.65 ?																																		
6	93-MU-80-1a	OC					LD									F													3-						
		K	15			40	5				20	10	10			MA	M	+	+					DB	1	O	2	3	3+	BL	0		O	1	70.77
Comments:	Small, angular solid bitumen in micrinized unstructured material, Ro 0.51 - 0.55.																																		
8	93-MU-87	OC					U									MA																			
		K	60				5				5	10	20			F	-	+	+	-				BL	0			3	3-	BL	0				1.47
Comments:	Grainy unstructured material. Difficult to identify some vitrinite from bitumen.																																		

ANALYST

Castano
X O'Connor

MICROSCOPE

Jena
X Zeiss

SAMPLE TYPE/PREP		STRUCTURED LIPIDS		OTHER ORGANIC MATTER		PYRITE		ABUND.		FLUOR. INTENS.		VIT. REFLECT. EQUIVALENCE		FLUOR. COLOR		TAI COLOR VALUES	
CTG	Cuttings	AL	Alginite	E	Exudatinite	E	Euhedral	N	None	0	None	B	Bitumen	W	White	1-	Straw Yellow
CC	Conv. Core	SB	Suberinite	G	Graptolites	F	Framboid	T	Trace	1	Weak	G	Graptolites	G	Green	1	Pale Yellow
SWC	SideWallCore	C	Cutinite	VL	Lipid-Rich Vitrinite	MA	Massive	-	Small Amt.	2	Moderate	VL	Lipid-Rich Vitrinite	Y	Yellow	1+	Yellow
OC	Outcrop	LD	Liptodetrinite	VC	VitriniteContamination	RI	Replace-ment	M	Mod. Amt.	3	Strong	VC	Vitrinite Contam.	O	Orange	2-	Yellow-Orange
NI	No Inform.	U	Undiffer.	VR	Recycled Vitrinite			+	Large Amt.	4	Intense	VR	Recycled Vitrinite	R	Red	2	Golden
C	Coal	S	Sporinite					++	Abundant					B	Brown	2+	Amber
		R	Resinite											Bl.	Black	3-	Reddish Brown
K	Kerogen	O	Other													3	Medium Brown
WR	Whole Rock															3+	Dark Brown
														L	Light	4-	Brown-Black
														D	Dark	4	Black

VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

21

BROOKS RANGE OUTCROPS

Project: DGSI/93/2826

DGSI

DATE: 2/17/94

DGSI NUMBER	ID OR DEPTH	SAMPLE TYPE	ORGANIC MATTER: LIPIDS: UNSTRUCTURED: UNDIFFERENTIATED (%)	AMORPHOUS (%)	MASSIVE (%)	MICRINIZED (%)	STRUCTURED: TYPE / (%)	TYPE / (%)	TYPE / (%)	TYPE / (%)	SOLID BITUMEN (%)	HUMIC: INERTINITE (%)	VITRINITE (%)	OTHER: TYPE / (%)	TYPE / (%)	RELATIVE ABUNDANCE: PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE: NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI: REFLECTED: LIPIDS: UNSTR.: COLOR	INTENSITY	STRU.: COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED: LIPIDS: UNSTR.: TAI: VALUE	FLUOR.: COLOR	INTENSITY	STRU.: TAI: VALUE	FLUOR.: COLOR	INTENSITY	Ro: VITRINITE REFLECTANCE Maturity or Equivalent
9	93-MU-88-1	OC					U	LD																						3-						
		K	55				T	T			?	10	35			MA	M	M	M	M		T	T	BL	0			2	3	BL	0		O	1	1.19
Comments:	*Grainy unstructured material.*																																			
10	93-MU-93	OC					LD																	?												
		K	70				T				5	10	15			MA	+	+	M	M		-	T	OB	1			3	3-	BL	0		O	1	1.17
Comments:	*Same. Solid bitumen Ro 0.97 - 0.99.*																																			
12	93-RKC-22-138-B	OC					LD																													
		K	60				5				5	10	20			MA	M	+	+	-				OB	1			3	3-	BL	0		O	1	1.44
Comments:	*Grainy unstructured material.*																																			
13	93-RKC-22-153-B	OC					LD	C																												
		K	50				5	T			5	20	20			MA	-	M	+					OB	1			3	3-	BL	0		O	1	1.57
Comments:	*Same. Solid bitumen Ro 0.73, 0.75, 0.78, 1.09.*																																			
14	93-RKC-22-36-B	OC					LD	S	U					VL															2+				BL	0		
		K	60				T	T	5		10	10	15	?		MA	M	M	M	M	?	-		OB	1			4	3-	BL	0	2+	DO	1	1.43
Comments:	*Same. Solid bitumen Ro 0.81, 0.88, 0.99. Some VL ? Value at 0.78 looks like good vitrinite.*																																			

ANALYST

___ Castano
X O'Connor

MICROSCOPE

___ Jena
X Zeiss

SAMPLE TYPE/PREP	STRUCTURED LIPIDS	OTHER ORGANIC MATTER	PYRITE	ABUND.	FLUOR. INTENS.	VIT. REFLECT. EQUIVALENCE	FLUOR. COLOR	TAI COLOR VALUES
CTG Cuttings	AL Alginite	E Exudatinite	E Euhedral	N None	0 None	B Bitumen	W White	1- Straw Yellow
CC Conv. Core	SB Suberinite	G Graptolites	F Framboid	T Trace	1 Weak	G Graptolites	G Green	1 Pale Yellow
SWC SideWallCore	C Cutinite	VL Lipid-Rich Vitrinite	MA Massive	- Small Amt.	2 Moderate	VL Lipid-Rich Vitrinite	Y Yellow	1+ Yellow
OC Outcrop	LD Liptodetrinite	VC VitriniteContamination	RI Replace-infill	M Mod. Amt.	3 Strong	VC Vitrinite Contam.	O Orange	2- Yellow-Orange
NI No Inform.	U Undiffer.	VR Recycled Vitrinite		+ Large Amt.	4 Intense	VR Recycled Vitrinite	R Red	2 Golden
C Coal	S Sporinite			++ Abundant			B Brown	2+ Amber
	R Resinite						BL Black	3- Reddish Brown
K Kerogen	O Other							3 Medium Brown
WR Whole Rock								3+ Dark Brown
							L Light	4- Brown-Black
							D Dark	4 Black

VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

22

BROOKS RANGE OUTCROPS

Project: DGSI/93/2826

DGSI

DATE: 2/17/94

DGSI NUMBER	ID OR DEPTH	SAMPLE TYPE	ORGANIC MATTER: LIPIDS UNSTRUCTURED: UNDIFFERENTIATED (%)	AMORPHOUS (%)	MASSIVE (%)	MICRINIZED (%)	LIPIDS STRUCTURED: TYPE / (%)	TYPE / (%)	TYPE / (%)	TYPE / (%)	SOLID BITUMEN (%)	HUMIC: INERTINITE (%)	VITRINITE (%)	OTHER: TYPE / (%)	TYPE / (%)	RELATIVE ABUNDANCE: PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE: NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI: REFLECTED LIPIDS UNSTR.: COLOR	INTENSITY	STRU.: COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED LIPIDS UNSTR.: TAI VALUE	FLUOR. COLOR	FLUOR. INTENSITY	STRU.: TAI VALUE	FLUOR. COLOR	FLUOR. INTENSITY	Ro: VITRINITE REFLECTANCE Maturity or Equivalent
15	93-RKC-22-43-B	OC					U																						2+						
		K	70				5				5	10	10			MA	M	M	M	M			T	DB	1			4	3-	BL	0				1.43
Comments:			*Grainy unstructured material. Solid bitumen Ro 0.88, 1.05, 1.1, 1.8, 1.24.*																																
16	93-RKC-22-72-B	OC					LD	S																				3	2+					1	
		K	60				5	T			5	10	20			MA	M	M	M	M				DB	1			4	3-	BL	0	2+	O	2	1.46
Comments:			*Same. Solid bitumen Ro 0.66, 0.69, 0.70, 0.74, 0.94, 1.05.*																																
Comments:																																			
Comments:																																			
Comments:																																			

ANALYST

____ Castano
X O'Connor

MICROSCOPE

____ Jena
X Zeiss

SAMPLE TYPE/PREP	STRUCTURED LIPIDS	OTHER ORGANIC MATTER	PYRITE	ABUND.	FLUOR. INTENS.	VIT. REFLECT. EQUIVALENCE	FLUOR. COLOR	TAI COLOR VALUES
CTG Cuttings	AL Alginite	E Exsudatinite	E Euhedral	N None	0 None	B Bitumen	W White	1- Straw Yellow
CC Conv. Core	SB Suberinite	G Graptolites	F Framboid	T Trace	1 Weak	G Graptolites	G Green	1 Pale Yellow
SWC SideWallCore	C Cutinite	VL Lipid-Rich Vitrinite	MA Massive	- Small Amt.	2 Moderate	VL Lipid-Rich Vitrinite	Y Yellow	1+ Yellow
OC Outcrop	LD Liptodetrinite	VC VitriniteContamination	RI Replace-infill	M Med. Amt.	3 Strong	VC Vitrinite Contam.	O Orange	2- Yellow-Orange
NI No Inform.	U Undiffer.	VR Recycled Vitrinite		+ Large Amt.	4 Intense	VR Recycled Vitrinite	R Red	2 Golden
C Coal	S Sporinite			++ Abundant			B Brown	2+ Amber
	R Resinite						BL Black	3- Reddish Brown
K Kerogen	O Other							3 Medium Brown
WR Whole Rock								3+ Dark Brown
							L Light	4- Brown-Black
n.d. Not Determ.							D Dark	4 Black

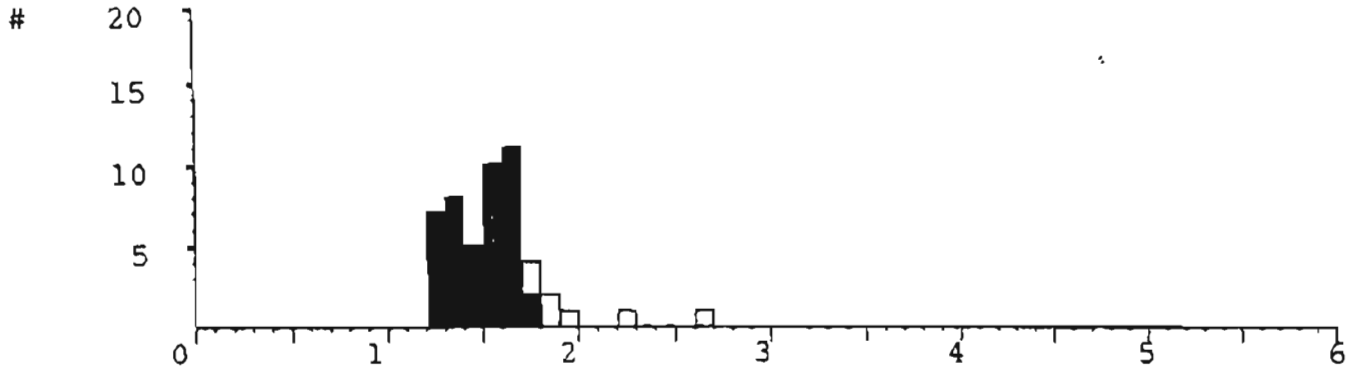
VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

23

BROOKS RANGE OUTCROPS

93-MU-101 OUTCROP KEROGEN

INTERPRETED MATURITY : 1.47 Ro Std. Dev. : 0.15 No. Readings : 43



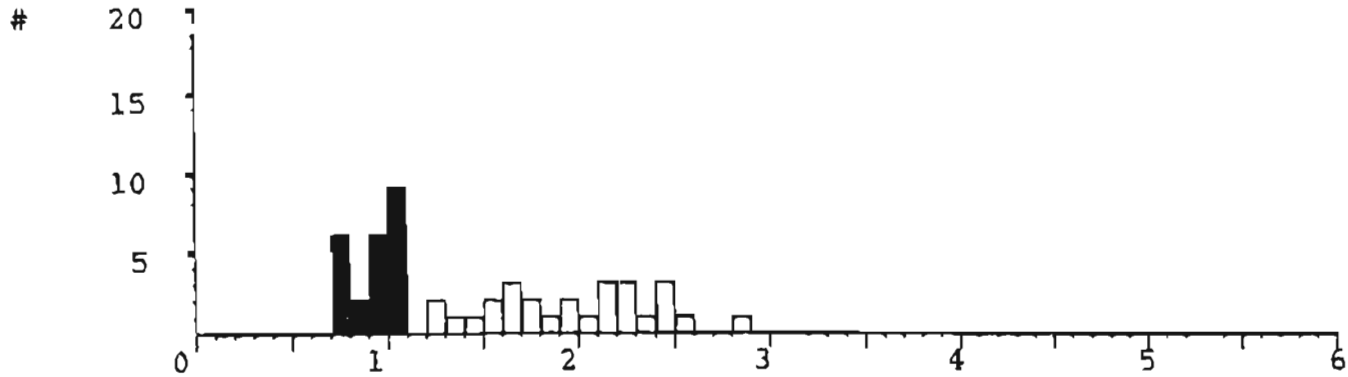
* = Maturity Values REFLECTANCE VALUES

*1.23	*1.35	*1.50	*1.60	*1.68
*1.23	*1.35	*1.51	*1.61	*1.71
*1.23	*1.35	*1.52	*1.61	*1.71
*1.26	*1.38	*1.53	*1.61	1.78
*1.27	*1.39	*1.54	*1.62	1.79
*1.27	*1.40	*1.54	*1.63	1.82
*1.28	*1.40	*1.55	*1.63	1.88
*1.31	*1.44	*1.55	*1.63	1.99
*1.32	*1.45	*1.56	*1.64	2.22
*1.33	*1.47	*1.56	*1.65	2.61

BROOKS RANGE OUTCROPS

93-MU-80 OUTCROP KEROGEN

INTERPRETED MATURITY : 0.92 Ro Std. Dev. : 0.13 No. Readings : 23



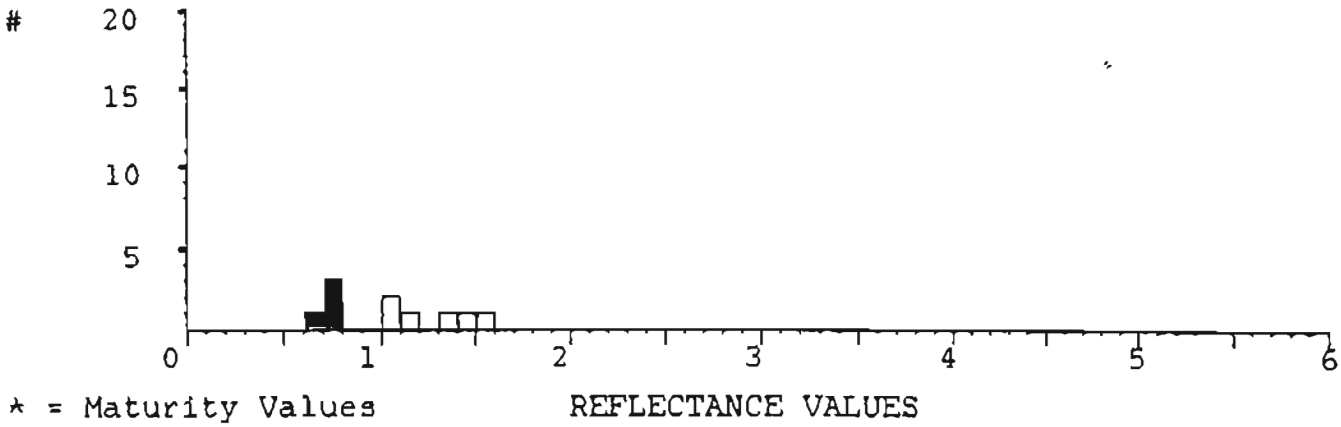
* = Maturity Values REFLECTANCE VALUES

*0.70	*0.92	*1.06	1.66	2.13
*0.74	*0.93	*1.09	1.66	2.20
*0.75	*0.94	*1.09	1.70	2.29
*0.75	*0.97	1.28	1.78	2.29
*0.76	*1.00	1.28	1.84	2.39
*0.77	*1.02	1.34	1.90	2.40
*0.83	*1.02	1.43	1.91	2.41
*0.87	*1.04	1.56	2.07	2.44
*0.90	*1.04	1.59	2.11	2.53
*0.90	*1.05	1.65	2.12	2.81

BROOKS RANGE OUTCROPS

93-MU-80-1 OUTCROP KEROGEN

INTERPRETED MATURITY : 0.74 Ro? Std. Dev. : 0.05 No. Readings : 4



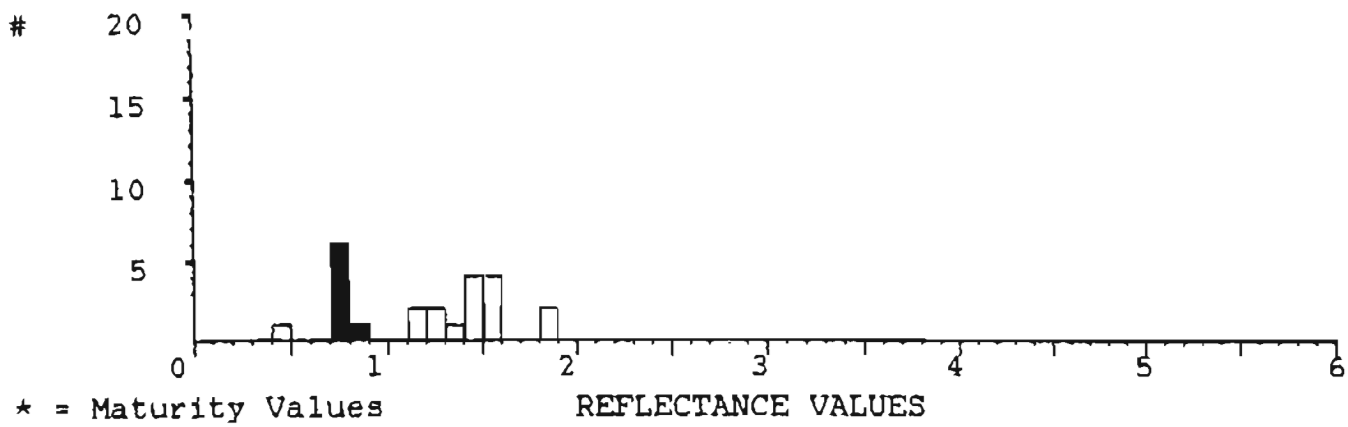
* = Maturity Values

*0.67
*0.74
*0.77
*0.77
1.01
1.09
1.11
1.39
1.49
1.58

BROOKS RANGE OUTCROPS

93-MU-80-1a OUTCROP KEROGEN

INTERPRETED MATURITY : 0.77 Ro? Std. Dev. : 0.05 No. Readings : 7



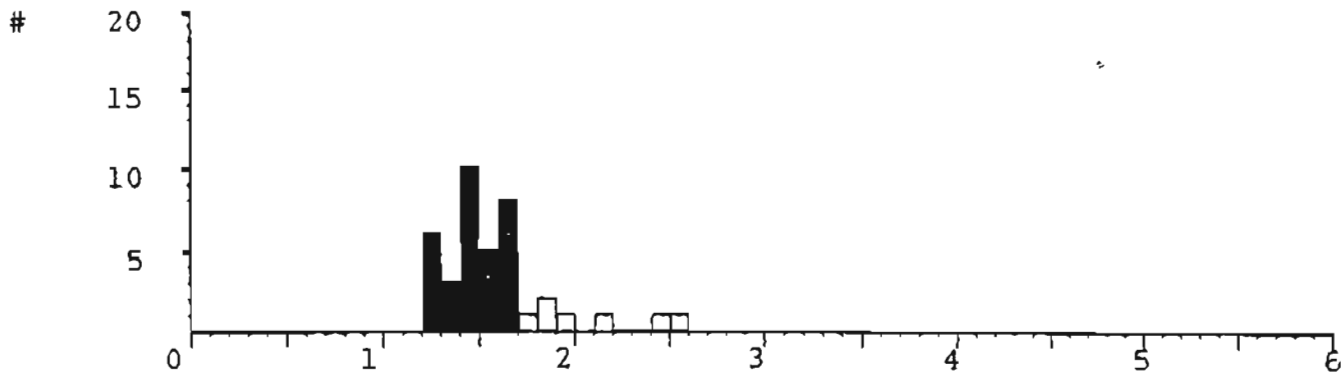
* = Maturity Values

0.46	1.21	1.55
*0.71	1.24	1.85
*0.73	1.32	1.89
*0.77	1.40	
*0.77	1.41	
*0.77	1.46	
*0.77	1.49	
*0.87	1.51	
1.11	1.52	
1.11	1.52	

BROOKS RANGE OUTCROPS

93-MU-87 OUTCROP KEROGEN

INTERPRETED MATURITY : 1.47 Ro Std. Dev. : 0.14 No. Readings : 32



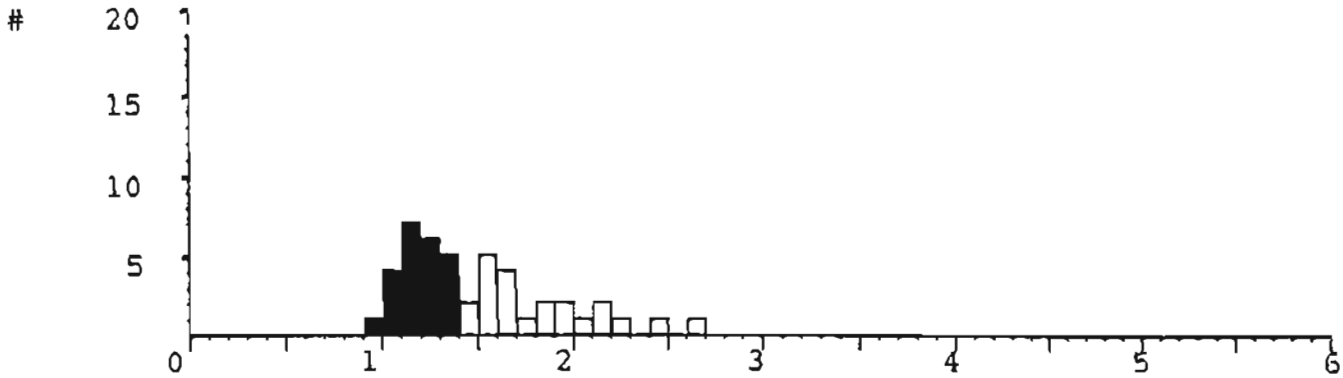
* = Maturity Values REFLECTANCE VALUES

*1.24	*1.42	*1.53	*1.68
*1.24	*1.42	*1.54	*1.68
*1.25	*1.43	*1.58	1.77
*1.25	*1.43	*1.59	1.82
*1.28	*1.43	*1.62	1.86
*1.28	*1.45	*1.63	1.99
*1.30	*1.46	*1.64	2.14
*1.35	*1.47	*1.64	2.41
*1.35	*1.47	*1.65	2.51
*1.41	*1.53	*1.65	

BROOKS RANGE OUTCROPS

93-MU-88-1 OUTCROP KEROGEN

INTERPRETED MATURITY : 1.19 Ro Std. Dev. : 0.12 No. Readings : 23



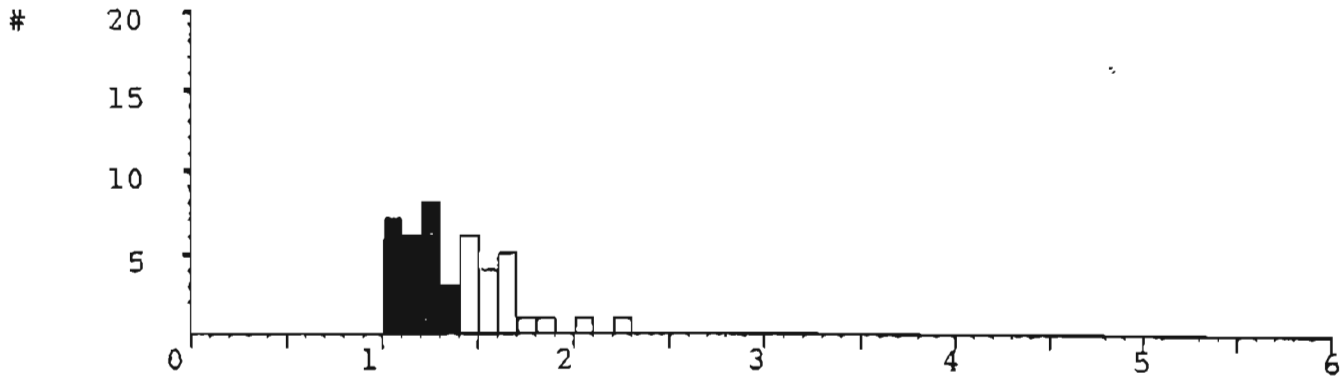
* = Maturity Values REFLECTANCE VALUES

*0.98	*1.17	*1.35	1.60	2.12
*1.01	*1.17	*1.36	1.62	2.19
*1.02	*1.22	*1.39	1.64	2.21
*1.04	*1.23	1.44	1.68	2.41
*1.08	*1.23	1.45	1.71	2.61
*1.11	*1.26	1.51	1.81	
*1.13	*1.27	1.51	1.87	
*1.14	*1.28	1.51	1.91	
*1.14	*1.30	1.55	1.94	
*1.15	*1.33	1.57	2.06	

BROOKS RANGE OUTCROPS

93-MU-93 OUTCROP KEROGEN

INTERPRETED MATURITY : 1.17 Ro Std. Dev. : 0.11 No. Readings : 24



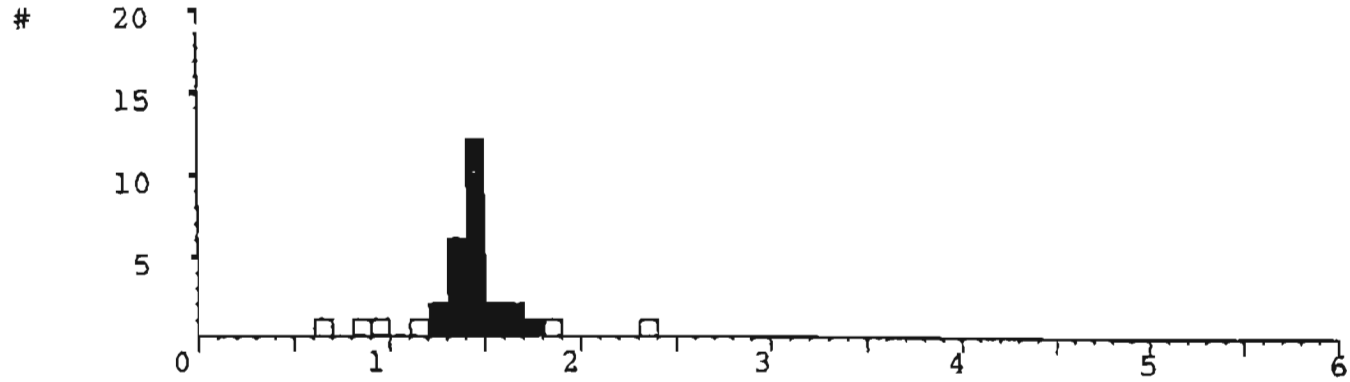
* = Maturity Values REFLECTANCE VALUES

*1.01	*1.11	*1.26	1.52	1.80
*1.02	*1.18	*1.34	1.52	2.09
*1.07	*1.19	*1.37	1.52	2.21
*1.08	*1.20	*1.38	1.57	
*1.08	*1.21	1.44	1.60	
*1.08	*1.23	1.44	1.62	
*1.08	*1.24	1.46	1.62	
*1.10	*1.24	1.46	1.65	
*1.11	*1.25	1.48	1.66	
*1.11	*1.26	1.49	1.74	

BROOKS RANGE OUTCROPS

93-RKC-22-138-B OUTCROP KEROGEN

INTERPRETED MATURITY : 1.44 Ro Std. Dev. : 0.12 No. Readings : 25



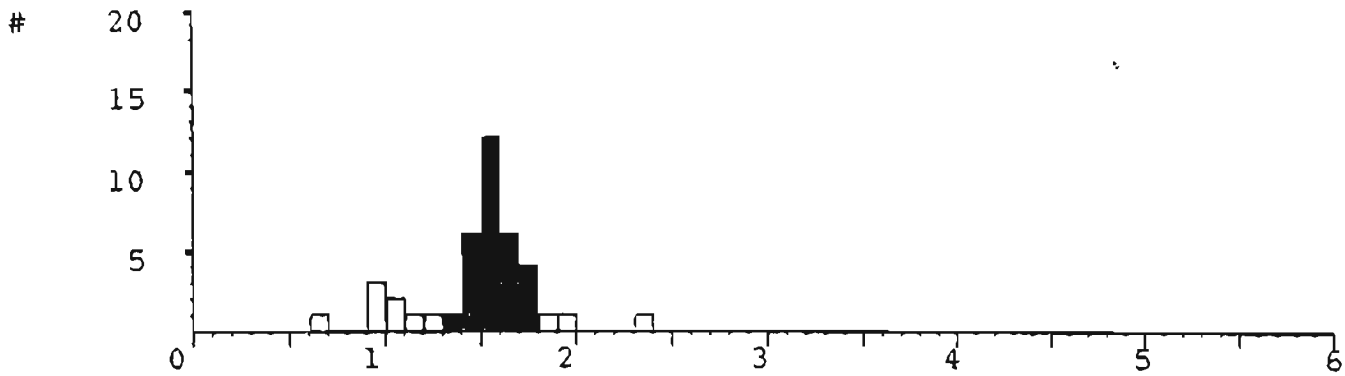
* = Maturity Values REFLECTANCE VALUES

0.64	*1.36	*1.46	2.38
0.87	*1.38	*1.46	
0.92	*1.41	*1.47	
1.12	*1.42	*1.48	
*1.21	*1.42	*1.55	
*1.23	*1.42	*1.57	
*1.32	*1.42	*1.60	
*1.33	*1.44	*1.66	
*1.33	*1.44	*1.70	
*1.36	*1.45	1.85	

BROOKS RANGE OUTCROPS

93-RKC-22-153-B OUTCROP KEROGEN

INTERPRETED MATURITY : 1.57 Ro Std. Dev. : 0.11 No. Readings : 29



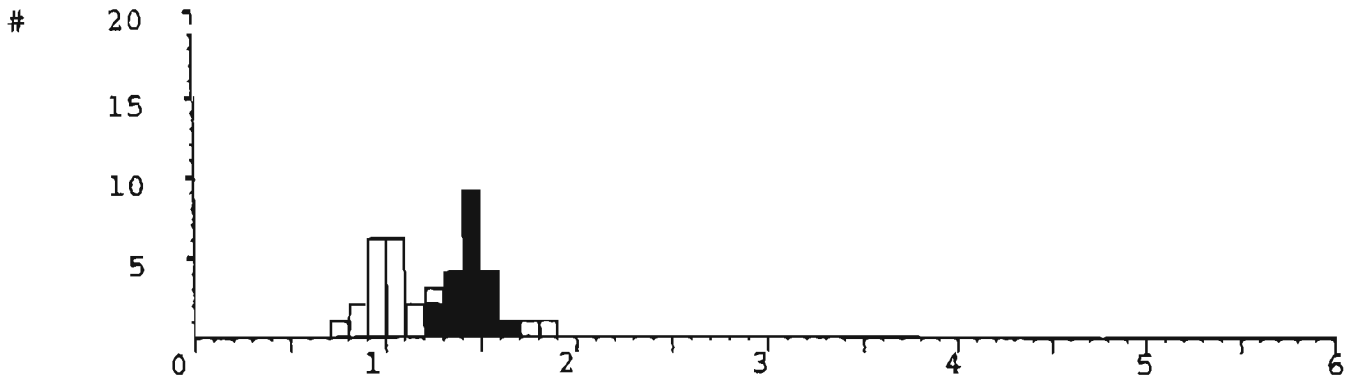
* = Maturity Values REFLECTANCE VALUES

0.63	*1.43	*1.54	*1.65
0.92	*1.44	*1.56	*1.65
0.96	*1.45	*1.56	*1.68
0.96	*1.47	*1.57	*1.72
1.04	*1.49	*1.58	*1.74
1.07	*1.50	*1.58	*1.76
1.16	*1.50	*1.59	*1.77
1.27	*1.51	*1.60	1.88
*1.37	*1.52	*1.61	1.99
*1.41	*1.52	*1.62	2.36

BROOKS RANGE OUTCROPS

93-RKC-22-36-B OUTCROP KEROGEN

INTERPRETED MATURITY : 1.43 Ro Std. Dev. : 0.09 No. Readings : 20



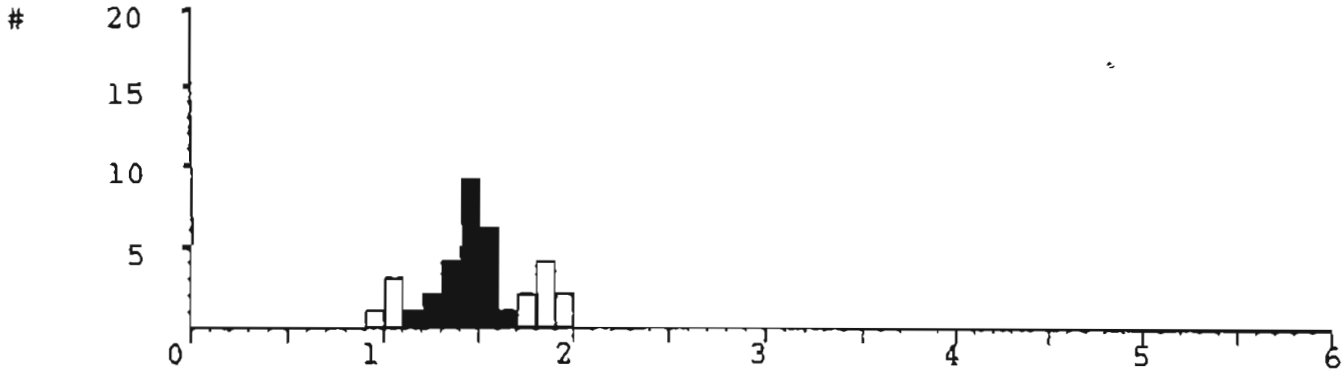
* = Maturity Values REFLECTANCE VALUES

0.78	1.01	*1.30	*1.44
0.80	1.03	*1.32	*1.45
0.88	1.04	*1.34	*1.48
0.93	1.06	*1.39	*1.50
0.93	1.07	*1.41	*1.52
0.95	1.16	*1.41	*1.52
0.96	1.17	*1.43	*1.52
0.96	1.21	*1.43	*1.62
0.99	*1.27	*1.43	1.74
1.01	*1.28	*1.44	1.88

BROOKS RANGE OUTCROPS

93-RKC-22-43-B OUTCROP KEROGEN

INTERPRETED MATURITY : 1.43 Ro Std. Dev. : 0.12 No. Readings : 23



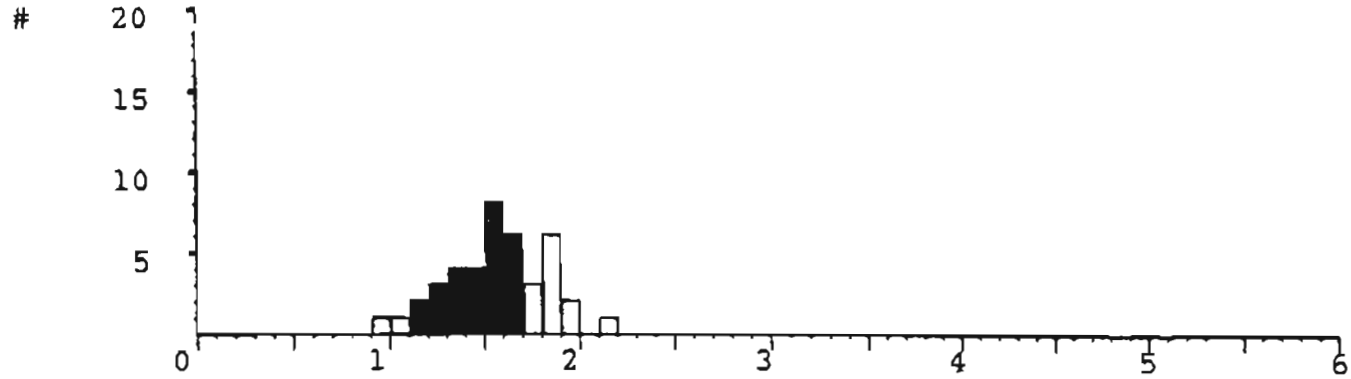
* = Maturity Values REFLECTANCE VALUES

0.93	*1.39	*1.51	1.85
1.02	*1.41	*1.51	1.85
1.05	*1.41	*1.53	1.88
1.07	*1.42	*1.54	1.92
*1.17	*1.43	*1.58	1.92
*1.24	*1.43	*1.59	
*1.25	*1.45	*1.66	
*1.31	*1.46	1.74	
*1.31	*1.47	1.78	
*1.37	*1.48	1.84	

BROOKS RANGE OUTCROPS

93-RKC-22-72-B OUTCROP KEROGEN

INTERPRETED MATURITY : 1.46 Ro Std. Dev. : 0.15 No. Readings : 27



* = Maturity Values REFLECTANCE VALUES

0.95	*1.39	*1.54	1.76	2.11
1.02	*1.43	*1.56	1.77	
*1.16	*1.45	*1.59	1.80	
*1.18	*1.47	*1.60	1.81	
*1.22	*1.49	*1.60	1.81	
*1.23	*1.50	*1.61	1.83	
*1.29	*1.51	*1.63	1.85	
*1.34	*1.52	*1.67	1.86	
*1.35	*1.52	*1.68	1.93	
*1.38	*1.53	1.72	1.97	

WHOLE EXTRACT GAS CHROMATOGRAPHY

About 50 grams of sample are crushed, passed through a 20 micron sieve, accurately weighed, and soxhlet extracted for 16 hours with dichloromethane. Other solvents can be substituted if desired. The solvent is evaporated and the residue weighed to obtain the weight percent of total organic extract. The advantage of whole extract chromatography over saturate chromatography is more of the lighter fraction (C_{10} - C_{15}) is preserved. A minor disadvantage is the nonsaturate compounds are retained and complicate the chromatograms in relatively immature extracts.

A sample of whole extract is injected directly into a Varian model 3400 gas chromatograph fitted with a Quadrex 50 meter fused silica capillary column. The GC is programmed from 40°C to 340°C at 10°C/minute with a 2 minute hold at 40°C and a 20 minute hold at 340°C. Analytical data are processed with a Nelson Analytical model 3000 chromatographic data system and IBM computer hardware. This software system facilitates data processing and graphic display as well as electronic data transmittal. All standard calculations are made including pristane/phytane ratio, carbon preference index, and other key parameters.

Whole extract gas chromatography provides information on organic facies and thermal maturity of source rocks and migrated petroleum. It serves as a basis for oil-rock correlations. It is recommended primarily to evaluate known or suspected source beds, oil shows, samples with anomalous pyrolysis S_1 values and to identify possible contamination products.

EXTRACT AND GAS CHROMATOGRAPHY

BROOKS RANGE OUTCROPS

DGSI/93/2826

EXTRACT AND GAS CHROMATOGRAPHY RATIOS

DGSI No.	Sample Identification	PPM	Ext./TOC	Pr/Ph	Pr/C17	Ph/C18	CPI	TOC
1	93-MU-101	662	0.051	2.4	0.37	0.18	1.12	1.30
4	93-MU-80	321	0.017	2.0	0.35	0.23	1.33	1.87
5	93-MU-80-1	1888	0.041	2.7	0.45	0.19	1.08	4.63
6	93-MU-80-1a	1925	0.209	2.6	0.47	0.21	1.10	0.92
10	93-MU-93	859	0.051	1.3	0.73	0.60	1.06	1.69

EXTRACT AND AREA DATA

DGSI No.	SAMPLE wt.	EXTRACT wt.	C17	Pr	C18	Ph	C28	C29	C30
1	61.6215	0.0408	101336	37594	87486	15436	11245	9846	6302
4	58.5042	0.0188	279586	98953	215968	48894	79957	84246	47087
5	67.6555	0.1277	82856	36886	70497	13693	9212	8506	6533
6	58.1916	0.1120	88571	41905	77582	16280	11861	11087	8296
10	66.1321	0.0568	71386	52099	66185	39627	43424	38866	25868

NORMALIZED ISOPRENOID PERCENT

DGSI No.	iC13	iC14	iC15	iC16	iC18	iC19	iC20
1	9.2	14.1	31.8	35.4	3.8	4.0	1.6
4	9.1	8.5	11.5	18.0	17.9	23.5	11.6
5	6.0	8.1	11.0	21.2	24.1	21.6	8.0
6	10.7	13.7	13.4	19.2	17.8	18.1	7.0
10	8.8	10.2	16.5	22.8	13.2	16.2	12.4

AREA DATA

DGSI No.	iC13	iC14	iC15	iC16	iC18	iC19	iC20
1	87843	134295	302501	336684	36052	37594	15436
4	38416	35883	48356	76014	75425	98953	48894
5	10176	13876	18805	36126	41062	36886	13693
6	24805	31870	31036	44571	41333	41905	16280
10	28135	32614	52810	73105	42431	52089	39627

EXTRACT AND GAS CHROMATOGRAPHY

BROOKS RANGE OUTCROPS

DGSI/93/2826

EXTRACT AND GAS CHROMATOGRAPHY RATIOS

DGSI No.	Sample Identification	PPM	Ext./TOC	Pr/Ph	Pr/C17	Ph/C18	CPI	TOC
13	93-RKC-22-153-B	152	0.013	2.0	0.21	0.14	1.21	1.19
14	93-RKC-22-36-B	199	0.011	5.1	0.20	0.08	1.01	1.84

EXTRACT AND AREA DATA

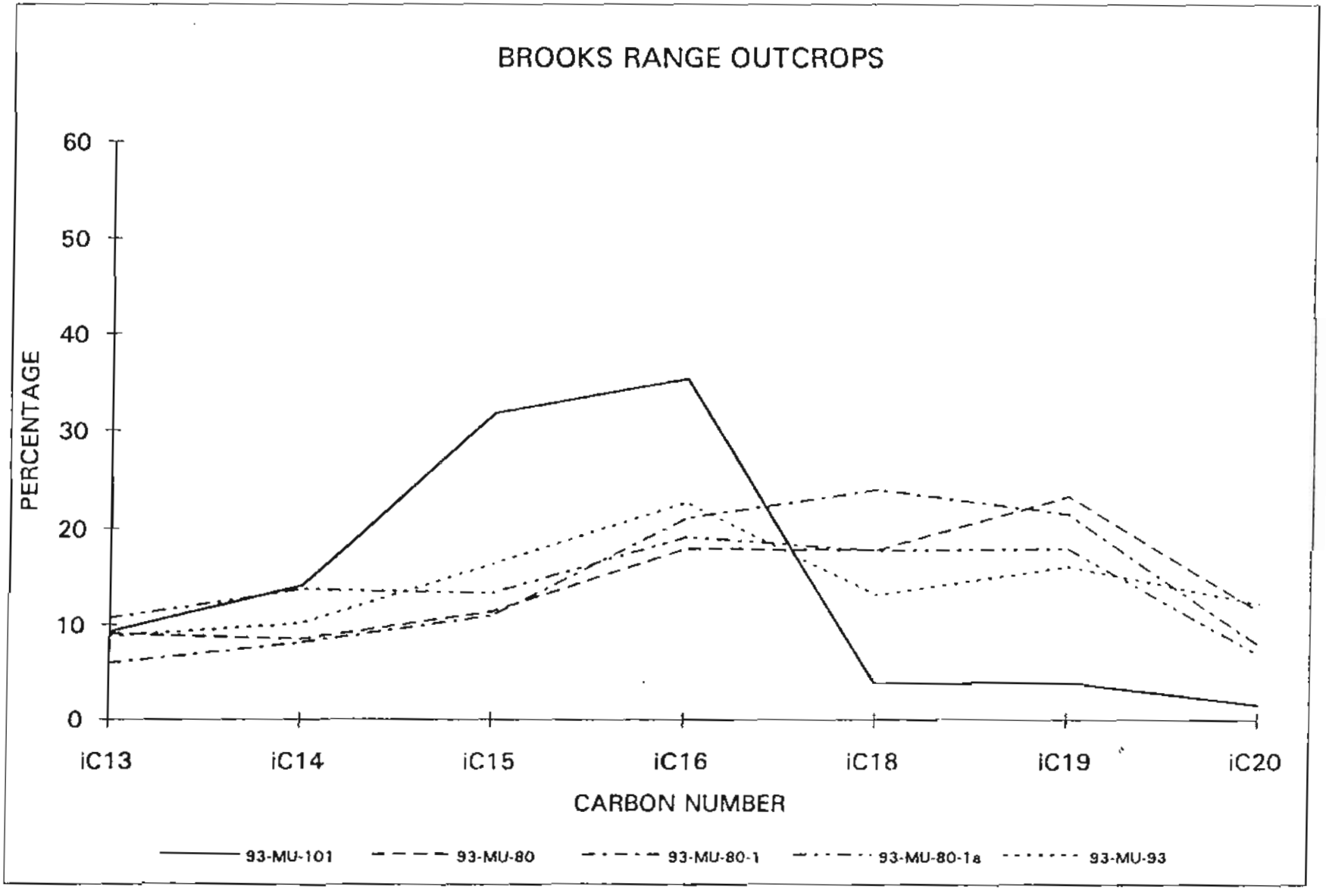
DGSI No.	SAMPLE wt.	EXTRACT wt.	C17	Pr	C18	Ph	C28	C29	C30
13	87.6166	0.0103	163494	33716	120061	16964	20140	20714	13972
14	72.4508	0.0144	294824	60312	144373	11878	26572	21177	15357

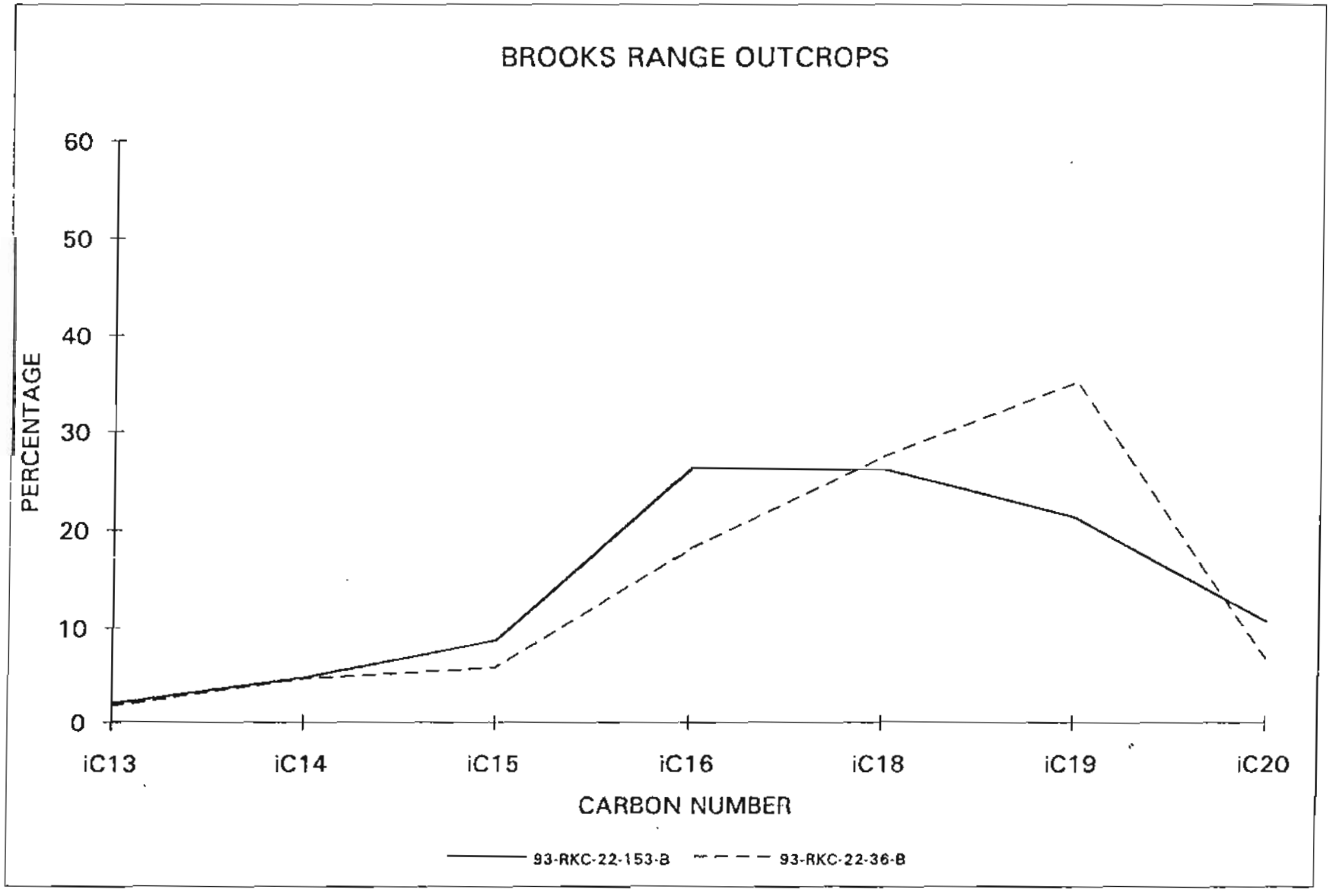
NORMALIZED ISOPRENOID PERCENT

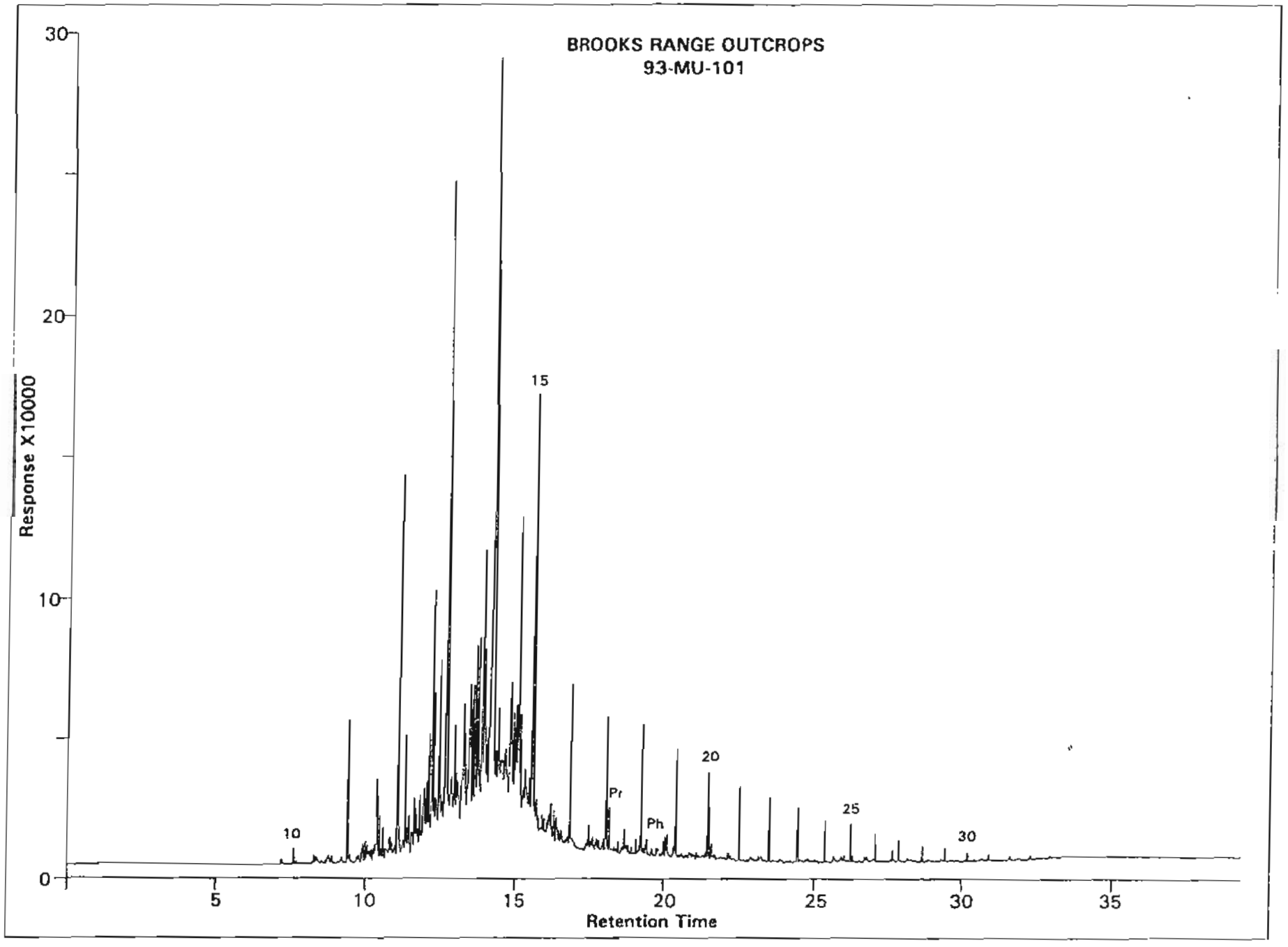
DGSI No.	iC13	iC14	iC15	iC16	iC18	iC19	iC20
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	1.8	4.6	5.8	18.2	27.5	35.2	6.9

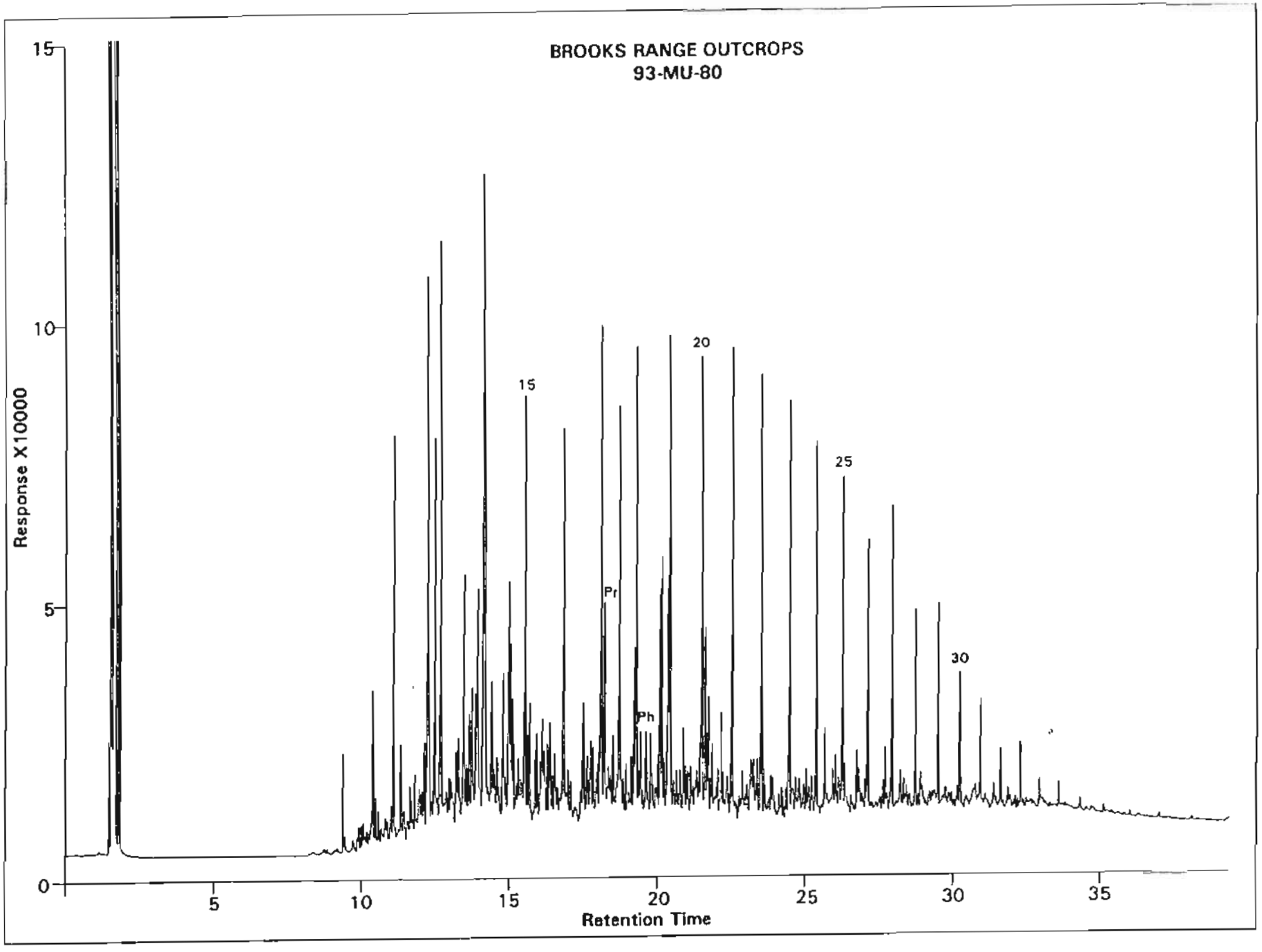
AREA DATA

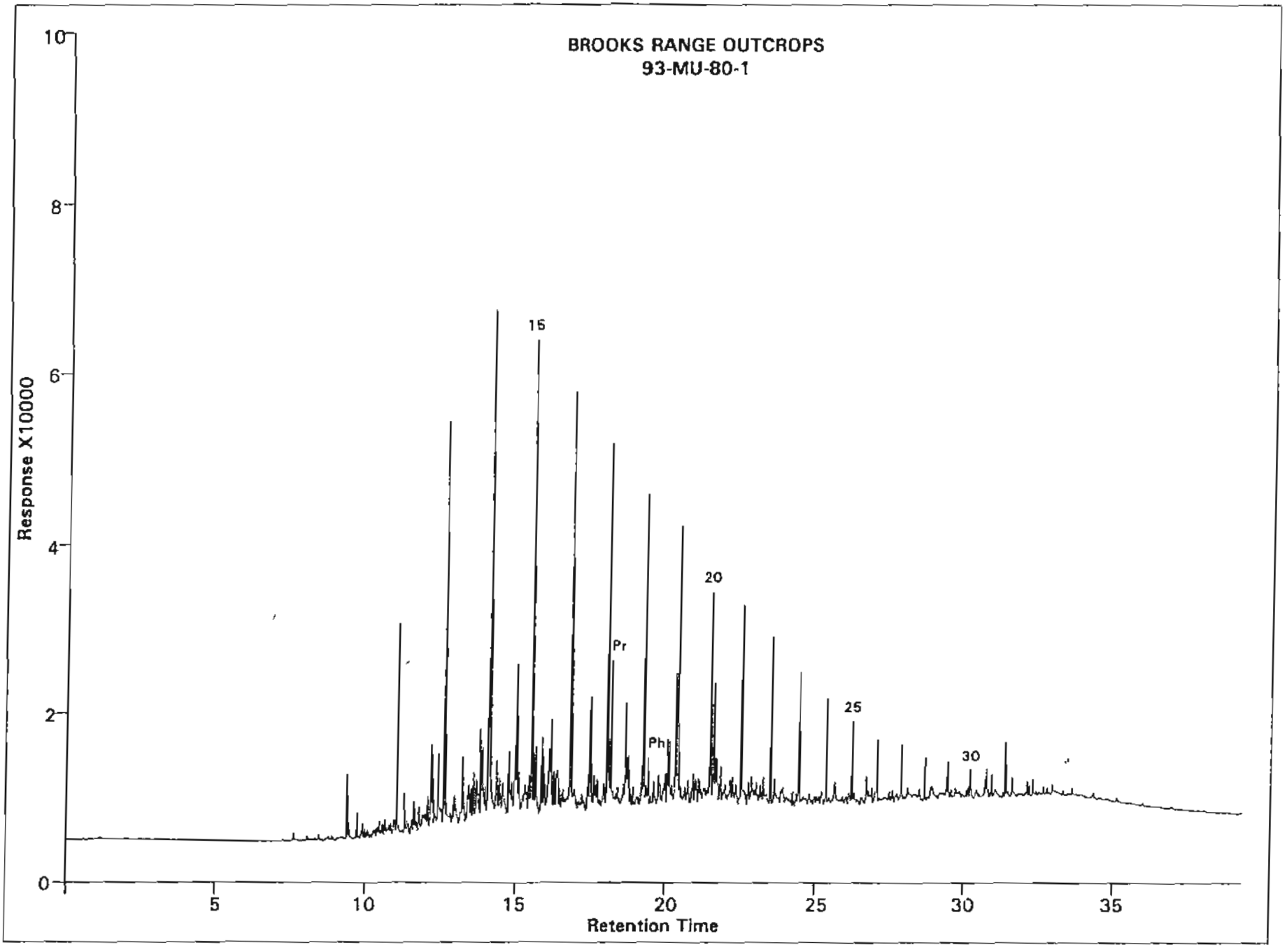
DGSI No.	iC13	iC14	iC15	iC16	iC18	iC19	iC20
13	3194	7468	13698	41410	41369	33716	16964
14	3001	7918	9975	31084	47048	60312	11878

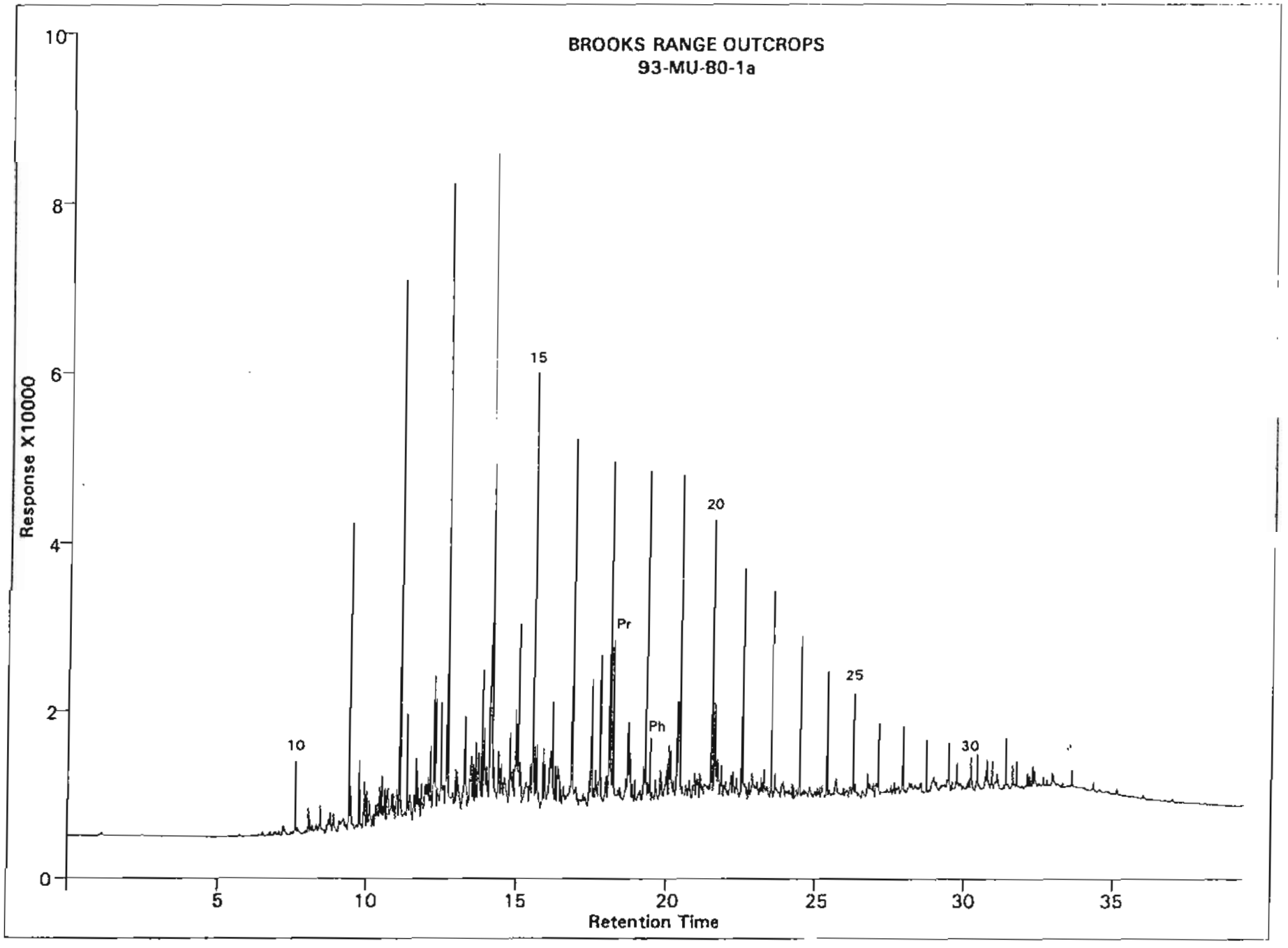

BROOKS RANGE OUTCROPS
PERCENTAGE
60
50
40
30
20
10
0
iC13
iC14
iC15
iC16
iC18
iC19
iC20
CARBON NUMBER
93-MU-101
93-MU-80
93-MU-80-1
93-MU-80-1a
93-MU-93

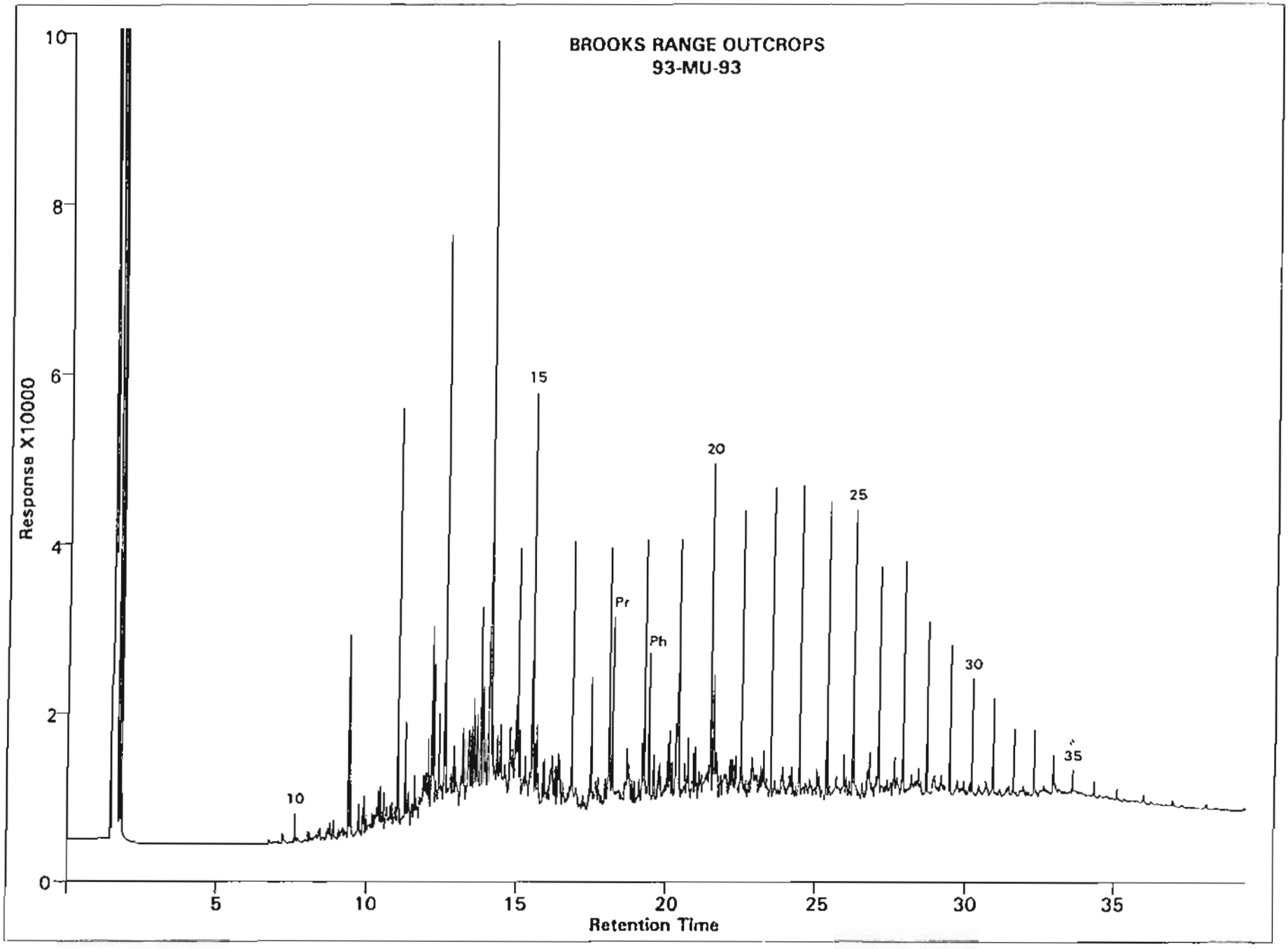

BROOKS RANGE OUTCROPS
PERCENTAGE
60
50
40
30
20
10
0
iC13
iC14
iC15
iC16
iC18
iC19
iC20
CARBON NUMBER
93-RKC-22-153-B
93-RKC-22-36-B

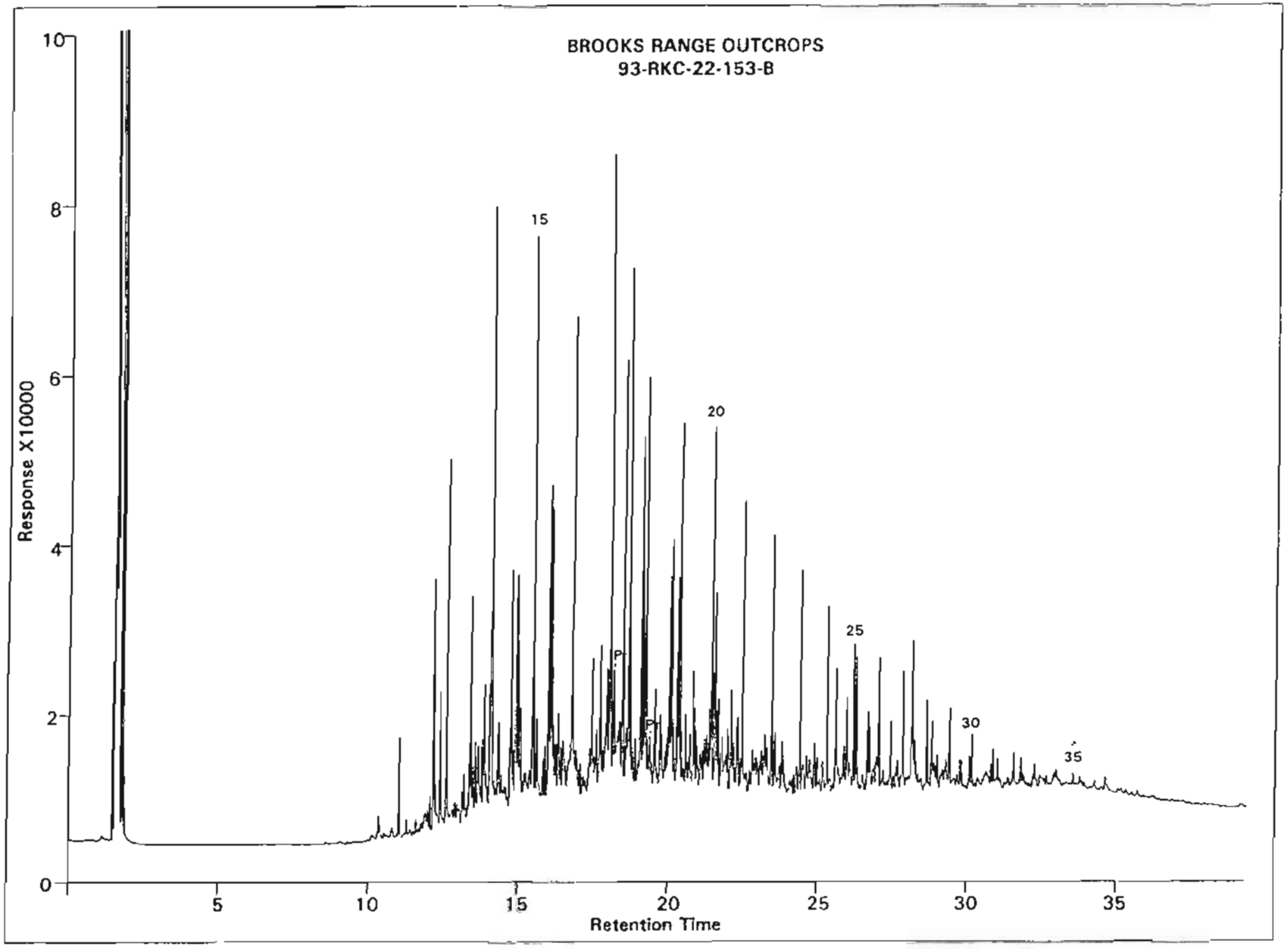

BROOKS RANGE OUTCROPS
93-MU-101
Response X10000
30
20
10
0
5
10
15
20
25
30
35
Retention Time
10
15
Pr
Ph
20
25
30


BROOKS RANGE OUTCROPS
93-MU-80
Response X10000
15
10
5
0
5
10
15
20
25
30
35
Retention Time
15
Pr
Ph
20
25
30

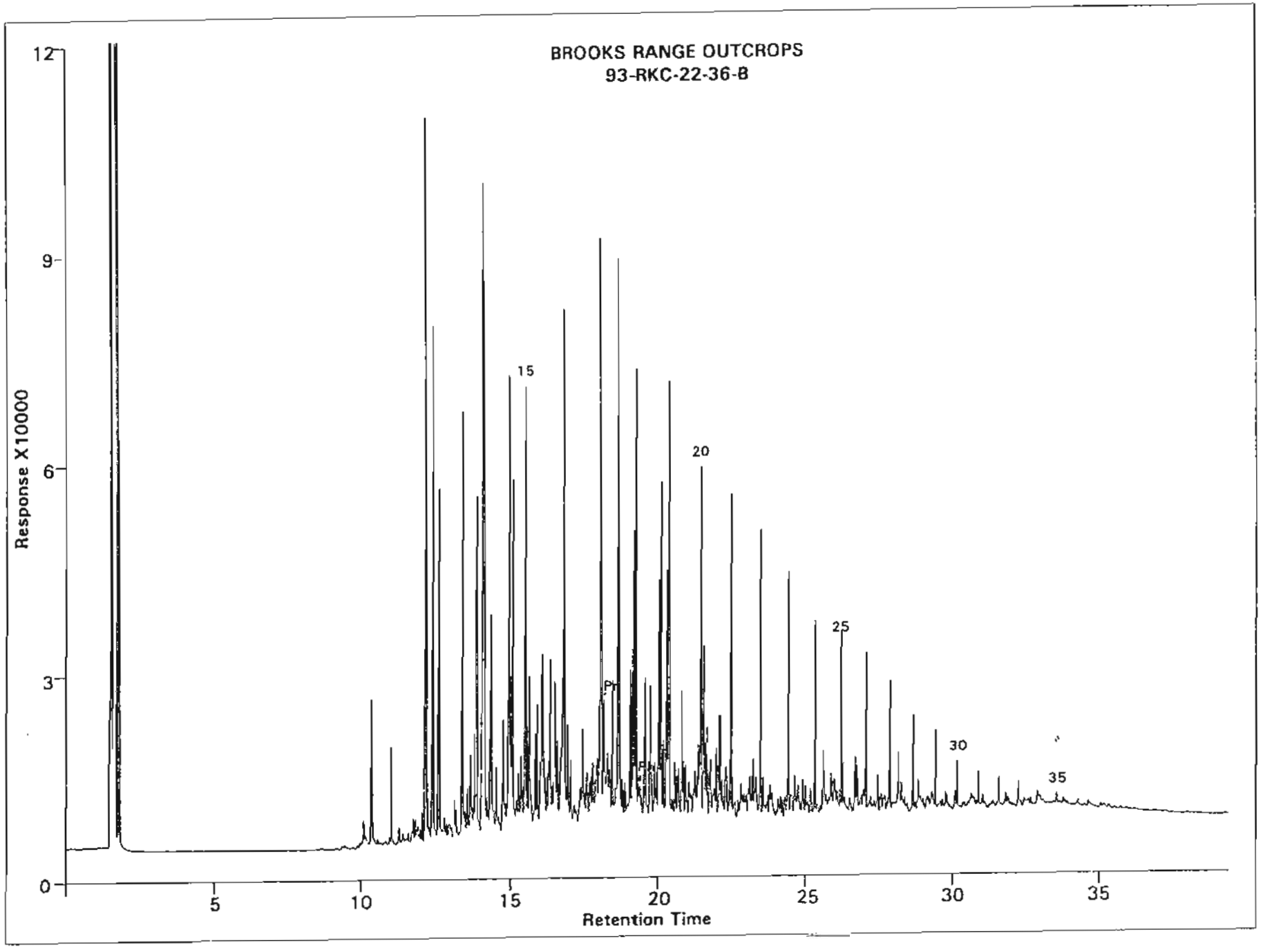

BROOKS RANGE OUTCROPS
93-MU-80-1
Response X10000
Retention Time
0
2
4
6
8
10
5
10
15
20
25
30
35
15
Pr
Ph
20
25
30


BROOKS RANGE OUTCROPS
93-MU-80-1a
Response X10000
Retention Time
10
15
20
25
30
Pr
Ph
0
2
4
6
8
10
5
10
15
20
25
30
35


BROOKS RANGE OUTCROPS
93-MU-93
Response X10000
Retention Time
10
15
20
25
30
35
Pr
Ph
0
2
4
6
8
10
5


BROOKS RANGE OUTCROPS
93-RKC-22-153-B
Response X10000
Retention Time
0
2
4
6
8
10
5
10
15
20
25
30
35
15
20
25
30
35
P
P

40


BROOKS RANGE OUTCROPS
93-RKC-22-36-B
Response X10000
12
9
6
3
0
15
20
25
30
35
Pr
Ph
5
10
15
20
25
30
35
Retention Time

GEOCHEMICAL ANALYSIS OF TWENTY-EIGHT OUTCROP SAMPLES WESTERN BROOKS RANGE, ALASKA

Prepared For:

State of Alaska - Dept. of Natural Resources
Division of Geological and Geophysical Surveys
794 University Avenue, Suite 200
Fairbanks, Alaska 99709-3645

Prepared By:

Wallace G. Dow
DGSI Project: 96/3631
January 3, 1997

42

DGSI
Total Quality Geochemistry

96 geochem to DGGI

	Sample #	Location	Collector	Formation	Age	Description	Analysis requested	Quadrangle	Lat.	Long.	Comments
1	96 Mu 33-5	Thetis Creek	Mull	KJk	Neocomian	Bk organic paper shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
2	96 Mu 33-7	Thetis Creek	Mull	KJk	[illegible]	Dk gr fissile gr clay shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
3	96 Ha 9	W of Surprise Ck.	Elder	Ktu	Albian	Shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong; D2			
4	96 Ha 11	W of Surprise Ck.	Elder	Ktu	Albian	Shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong D2			
5	96 Ha 14	W of Surprise Ck.	Elder	Ktu	Albian	Shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong D2			
6	96 Ha 15	W of Surprise Ck.	Elder	Ktu	Albian	Shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong D2			
7	96 Ha 18	W of Surprise Ck.	Elder	Ktu	Albian	Shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong D2			
8	96 Ha 45	NE of Thetis Ridge	Elder	Ktu	Albian	Sh, silty, nodular w/lig	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong C5			
9	96 Ha 49	NE of Thetis Ridge	Elder	Ktu	Albian	Sh, silty, nodular w/lig	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong C5			
10	94 Mu 65-A	Thetis Creek section	Mull	KJk	Neocomian	Bk sh, above top section	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
11	94 Mu 65-U1	Thetis Creek section	Elder	Kc/KJk	Neocomian	Gr shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
12	94 Mu 65-U3	Thetis Creek section	Elder	Kc/KJk	Neocomian	Gn gr shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
13	94 Mu 65-U8	Thetis Creek section	Elder	Kc/KJk	Neocomian	Maroon shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
14	94 Mu 65-U2J	Thetis Creek section	Elder	Kc/KJk	Neocomian	Gn sh, intbd w coquina	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
15	94 Mu 65-U19	Thetis Creek section	Elder	Kc/KJk	Neocomian	Gn gr coquina	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
16	94 Mu 65-U28	Thetis Creek section	Elder	Kc/KJk	Neocomian	Gray shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
17	96 Mu 28-3	Upper Ipewik sctn	Elder	Kc/KJk	Neocomian	Unit 33, dk gr sh intbd w Buchia coquina	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
18	96 Mu 28-4	Upper Ipewik sctn	Elder	Kc/KJk	Neocomian	Unit 52, dk gr shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
19	96 Mu 28-6	Upper Ipewik sctn	Elder	Kc/KJk	Neocomian	Unit 63, gn gr shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
20	96 MAW 6	Surprise Creek measured section	Wartes	Trc	U. Triassic		Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
							[illegible]				

22	96 MAW 9	Surprise Creek measured section	Wartes	Trc	U. Triassic		Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
23	96 MAW 11	Surprise Creek measured section	Wartes	Trc	U. Triassic		Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
24	96 MAW 16-B	Surprise Creek measured section	Wartes	KJk	Neocomian		Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
25	96 MAW 18-B	Surprise Creek measured section	Wartes	KJk	Neocomian		Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
26	96 MAW 20-E	Surprise Creek measured section	Wartes	KJk	Neocomian	Dk gr-bk shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
27	96 MAW 21-B	Surprise Creek measured section	Wartes	KJk	Neocomian	Gn gr shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
28	96 MAW 22-B	Surprise Creek measured section	Wartes	KJk	Neocomian	Dk gr-bk shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.			
Explanation of formation symbols: Ktc—Torok Formation, KJk—Kingak Shale, Kc/KJk—Coquinoid limestone/Kingak Shale											

ORGANIC CARBON AND PYROLYSIS DATA

Total Organic Carbon (TOC) and Rock-Eval pyrolysis data provide basic geochemical information and are frequently used to select samples for more detailed studies, particularly kerogen microscopy, extract chromatography and biomarker analyses. Well data can be plotted to make geochemical logs. Unless otherwise specified by a client, DGSI uses LECO TOC then Rock-Eval II pyrolysis as the standard analytical sequence and Rock-Eval is recommended for samples with greater than 0.4% TOC. Samples for LECO TOC and Rock-Eval pyrolysis are ground to pass through a 60 mesh sieve to assure homogeneity.

LECO ORGANIC CARBON AND TOTAL SULFUR

Total Organic Carbon is best determined by direct combustion. Approximately 0.15 grams of sample are carefully weighed, treated with concentrated HCl to remove carbonates, and vacuum filtered on glass fiber paper. The residue and paper are placed in a ceramic crucible, dried, and combusted with pure oxygen in a LECO EC-12 or LECO CS-444 carbon analyzer at about 1,000°C. A laboratory standard is run every five samples. Total, insoluble, mineral plus organic sulfur can be determined by the CS-444 analyzer during the carbon analysis. Total carbonate can be determined from sample and acid residue weight differences or by LECO combustion TOC differences before and after acid digestion.

ROCK-EVAL II PYROLYSIS

Rock-Eval II pyrolysis is used to determine kerogen type, kerogen maturity and the amount of free hydrocarbons. About 0.1 grams of the same ground sample used for LECO TOC are carefully weighed in a pyrolysis crucible and then heated to 300°C to determine the amount of free hydrocarbons, S_1, that is thermally distilled. Next, the amount of pyrolyzable hydrocarbons, S_2, is measured when the sample is heated in an inert environment which rises from 300° to 550°C at a heating rate of 25°C/minute. S_1 and S_2 are reported in mg HC/g sample. T_{max}, a maturity indicator, is the temperature of maximum S_2 generation. When S_2 values are less than 0.2 mg HC/g sample, the S_2 maximum typically has poor definition and thus, Tmax cannot be reliably determined (Peters, 1986). Carbon dioxide generated during the S_2 pyrolysis, an indicator of kerogen oxidation, is collected up to a temperature of 390°C and reported as S_3 in units of mg CO_2/g sample. A laboratory standard is run every 10 samples. Hydrogen Index (HI = S_2*100/TOC) and Oxygen Index (OI = S_3*100/TOC) are used as kerogen type indicators when plotted on a van Krevelen type diagram.

ORGANIC CARBON AND ROCK-EVAL PYROLYSIS DATA

BROOKS RANGE OUTCROPS

DGSI Project: 96/3631

SAMPLE IDENTIFICATION DGSI ID		ID	TOC Wt%	S1 mg/g	S2 mg/g	S3 mg/g	Tmax degC	S1/ TOC	HI	OI	S2/ S3	PI
1	:	96 Mu 33-5	18.65	0.77	52.11	0.84	435	4	279	5	62.04	0.01
2	:	96 Mu 33-7	3.12	0.09	4.09	0.43	439	3	131	14	9.51	0.02
3	:	96 Ha 9	0.86	0.03	0.28	0.31	451	3	33	36	0.90	0.10
4	:	96 Ha 11	1.09	0.08	0.37	0.37	463	7	34	34	1.00	0.18
5	:	96 Ha 14	1.12	0.06	0.40	0.78	478	5	36	70	0.51	0.13
6	:	96 Ha 15	0.99	0.11	0.34	0.27	472	11	34	27	1.26	0.24
7	:	96 Ha 18	1.16	0.10	0.45	0.40	470	9	39	34	1.13	0.18
8	:	96 Ha 45	1.15	0.06	0.51	0.61	460	5	44	53	0.84	0.11
9	:	96 Ha 49	1.23	0.04	0.34	0.57	421	3	28	46	0.60	0.11
10	:	94 Mu 65-A	1.38	0.07	0.38	0.64	464	5	28	46	0.59	0.16
11	:	94 Mu 65-U1	0.16	0.01	0.00	0.24	N.A.	6	0	150	0.00	1.00
12	:	94 Mu 65-U3	0.23	0.02	0.00	0.18	N.A.	9	0	78	0.00	1.00
13	:	94 Mu 65-U8	0.10	0.02	0.02	0.10	276	20	20	100	0.20	0.50
14	:	94 Mu 65-U12J	0.14	0.01	0.00	0.14	N.A.	7	0	100	0.00	1.00
15	:	94 Mu 65-U19	0.06	0.00	0.00	0.17	N.A.	0	0	283	0.00	
16	:	94 Mu 65-U28	0.20	0.03	0.00	0.11	N.A.	15	0	55	0.00	1.00
17	:	96 Mu 28-3	0.12	0.00	0.00	0.22	N.A.	0	0	183	0.00	
18	:	96 Mu 28-4	0.11	0.01	0.00	0.11	N.A.	9	0	100	0.00	1.00
19	:	96 Mu 28-6	0.24	0.02	0.00	0.42	N.A.	8	0	175	0.00	1.00
20	:	96 MAW 6	0.57	0.09	0.33	0.19	443	16	58	33	1.74	0.21
21	:	96 MAW 7	2.88	0.84	7.31	0.21	444	29	254	7	34.81	0.10
22	:	96 MAW 9	1.76	0.37	3.75	0.23	442	21	213	13	16.30	0.09
23	:	96 MAW 11	2.40	0.32	5.97	0.46	439	13	249	19	12.98	0.05
24	:	96 MAW 16-B	1.51	0.10	0.92	0.34	446	7	61	23	2.71	0.10
25	:	96 MAW 18-B	0.47	0.02	0.05	0.65	454	4	11	138	0.08	0.29
26	:	96 MAW 20-E	0.18	0.01	0.01	0.25	351	6	6	139	0.04	0.50
27	:	96 MAW 21-B	0.21	0.01	0.00	0.19	N.A.	5	0	90	0.00	1.00
28	:	96 MAW 22-B	1.20	0.11	0.45	0.45	465	9	38	38	1.00	0.20

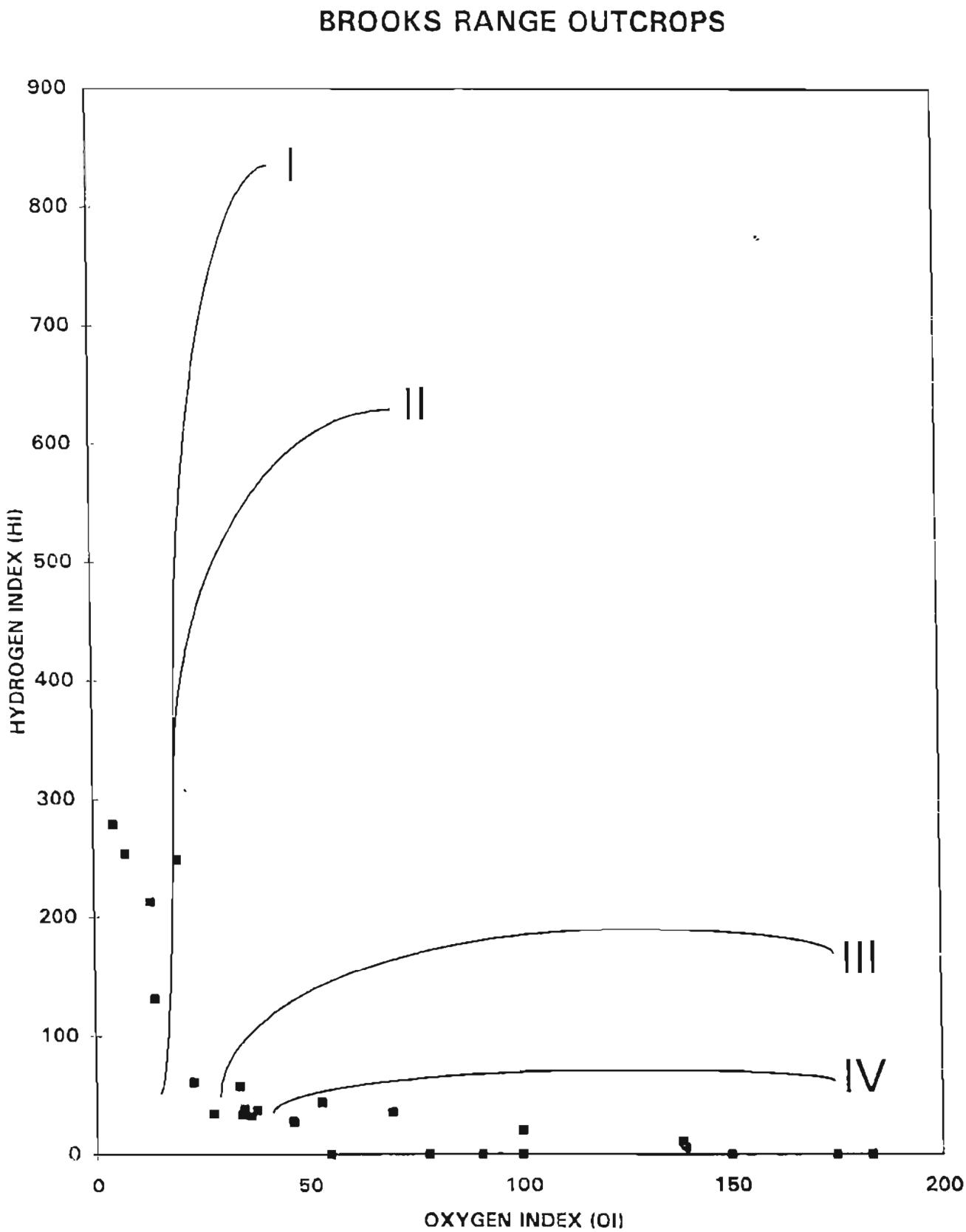


FIGURE 1 Kerogen type determination from TOC and Rock-Eval pyrolysis data. Types I and II will generate oil, type III gas, and type IV little or no hydrocarbons.

VISUAL KEROGEN ANALYSIS TECHNIQUES

Visual kerogen analysis employs a Zeiss Universal microscope system equipped with halogen, xenon, and tungsten light sources or a Jena Lumar microscope equipped with halogen and mercury light sources. Vitrinite reflectance and kerogen typing are performed on a polished epoxy plug of unfloated kerogen concentrate using reflected light from the halogen source. In certain situations, the whole rock is used for analysis. This approach is used for coals, where acid treatment is unnecessary ,in studies of solid bitumen and graptolites where preservation of rock structure is important, and in samples too small for acid treatment. The digital indicator is calibrated using a glass standard with a reflectance of 1.02% in oil. This calibration is linearly accurate for reflectance values ranging from peat (R_o 0.20%) through anthracite (R_o 4.0%).

Reflectance values are recorded only on good quality vitrinite, including obvious contamination and recycled material. The relative abundance of normal, altered, lipid-rich, oxidized, and coked vitrinite is recorded. When good quality, normal vitrinite is absent, notations are made indicating how the maturity is affected by weathering, oxidation, bitumen saturation, or coking. When normal vitrinite is absent or sparse, other macerals may be substituted. Solid bitumen, for example is present in many samples. Although solid bitumen has a different reflectance than vitrinite, Landis and Castaño's calibration chart can be used to obtain an estimated vitrinite reflectance equivalent. Graptolites have a slightly higher reflectance than vitrinite and can often be used to obtain maturity data in Paleozoic rocks that have no vitrinite.

Unstructured lipid kerogen changes in texture and color during the maturation process. Typically, unstructured kerogen at low maturity is reddish brown and amorphous. Somewhere between R_o 0.50 to 0.65%, the kerogen takes on a massive texture and is gray in color. At higher maturity, generally above R_o 1.30%, unstructured kerogen is light gray and micrinized.

Kerogen typing and maturity assessments from the polished plug are enhanced by utilizing fluorescence from blue light excitation. The xenon or mercury lamp is used with an excitation filter at 495 nm coupled with a barrier filter of 520 nm. With the Jena microscope we also have the option of observing fluorescence under ultraviolet excitation. The intensity of fluorescence in the epoxy mounting medium (background fluorescence) correlates well with the onset of oil generation and destruction. The identification of structured and unstructured liptinite is also enhanced with the use of fluorescence in those samples having a maturity less than R_o 1.3%. The relative abundance and type of pyrite is also recorded.

TAI is performed using tungsten or halogen light source that is transmitted through a glass slide made from the unfloated kerogen concentrate. Ideally, TAI color is based on sporinite of terrestrial origin. When sporinite is absent, TAI is estimated from the unstructured lipid material. Weathering, bitumen admixed with the unstructured material and micrinization can darken the kerogen and raise the TAI value. The character of the organic matter in transmitted light is correlated with observations made in reflected light for kerogen typing.

Kerogen typing and maturity assessments from the slide preparation are also reinforced by using different light sources. The slide is first observed in transmitted light to obtain TAI color and organic matter structure or type. The light is then switched to reflected halogen light to observe structure and amount of pyrite and finally to reflected blue light excitation from the xenon or mercury source for fluorescence. The fluorescence of structured and unstructured liptinite is not masked by the epoxy fluorescence as it is in the reflected light mode because the mounting medium is non-fluorescent. Remnant lipid structures (e.g. sporinite and alginite) within the unstructured kerogen can often be identified in blue light.

Maturity calculations are made from the vitrinite reflectance histograms. Decisions as to which reflectance measurements indicate the maturity of the sample are based not only on the histogram but on all of the kerogen descriptive elements as well. Because it is not done at the time of measurement, alternate maturity calculations can be made if kerogen data and geological information dictate.

In summary, vitrinite reflectance measurements are performed on a polished plug in reflected light, TAI is performed on a slide in transmitted light, and kerogen typing is estimated from both preparations using a combination of reflected, transmitted, and fluorescent light techniques. Fluorescence in blue light is used to enhance the identification of structured and unstructured lipid material, solid bitumens, and drilling mud contaminants. Fluorescence also correlates with the maturity and state of preservation of the sample. Maturity calculations from measured reflectance data are made from the histograms and are influenced by all of the kerogen data.

VISUAL KEROGEN ANALYSIS GLOSSARY

Several key definitions are included in this glossary in order to make our reports more self-explanatory. In our reports, we refer to organic substances as macerals. Macerals are akin to minerals in rock in that they are organic constituents that have microscopically recognizable characteristics. However, macerals vary widely in their chemical and physical properties and they are not crystalline.

1. UNSTRUCTURED KEROGEN is sometimes called structureless organic matter (SOM) or bituminite. It is widely held that unstructured kerogen represents the bacterial breakdown of lipid material. It also includes fecal pellets, minute particles of algae, organic gels, and may contain a humic component. As described on the first page of this section, unstructured lipid kerogen changes character during maturation. The three principal stages are amorphous, massive, and micrinized. Amorphous kerogen is simply without any structure. Massive kerogen has taken on a cohesive structure, as the result of polymerization during the process of oil generation. At high maturity, unstructured kerogen becomes micrinized. Micrinite is characterized optically by an aggregation of very small (less than one micron) round bodies that make up the kerogen.

2. STRUCTURED LIPID KEROGEN consists of a group of macerals which have a recognized structure, and can be related to the original living tissue from which they were derived. There are many different types, and the types can be group follows:

   a. Alginite, derived from algae. It is sometimes very useful to distinguish the different algal types, for botryococcus and pediastrum are associated with lacustrine and non-marine source rocks, while algae such as tasmanites, gloecapsomorpha, and nostocopsis are typically marine. Acritarchs and dinoflaggelates are marine organisms which are also included in the algal category.
   b. Cutinite, derived from plant cuticles, the remains of leaves.
   c. Resinite, (including fluorinite) derived from plant resins, balsams, latexes, and waxes.
   d. Sporinite, derived from spores and pollen from a wide variety of land plants.
   e. Suberinite is derived from the corky tissue of land plants.
   f. Liptodetrinite is that structured lipid material that is too small to be specifically identified. Usually, it is derived from alginite or sporinite.

   The algae are an important part of many oil source rocks, both marine and lacustrine. Alginite has a very high hydrogen index in Rock-Eval pyrolysis. Resins, cuticles, and suberinite contribute to the waxy, non-marine oils that are found in Africa and the Far East. At vitrinite reflectance levels above R_o 1.2 - 1.4%, structured lipid kerogen changes structure and it becomes very difficult to distinguish them from vitrinite.

3. SOLID BITUMEN also is called migrabitumen and solid hydrocarbon. In 1992, the International Committee for Coal and Organic Petrology (ICCP) decided to include solid bitumen in the Exsudatinite group. Solid bitumens are expelled hydrocarbon products which have particular morphology, reflectance and fluorescence properties which make it possible to identify them. They represent two classes of substances: one which is present at or near the place where it was generated, and second is a substance which is present in a reservoir rock and may have migrated a great distance from its point of origin. The solid bitumens have been given names, such as gilsonite, impsonite, grahamite, etc., but they represent generated heavy hydrocarbons which remain in place in the source rock or have migrated into a reservoir and mature along with the rock. Consequently, it is possible to use the reflectance of solid bitumens for maturation determinations when vitrinite is not present.

4. HUMIC TISSUE is organic material derived from the woody tissue of land plants. The most important of this group are vitrinite and inertinite:

   a. Vitrinite is derived from woody tissue which has been subjected to a minimum amount of oxidation. Normally it is by far the most abundant maceral in humic coals and because the rate of change of vitrinite reflectance is at a more even pace than it is for other macerals, it offers the best means of

obtaining thermal maturity data in coals and other types of sedimentary rocks.

Because the measurement of vitrinite is so important, care is taken to distinguish normal (fresh, unaltered) vitrinite from other kinds of vitrinite. Rough vitrinite does not take a good polish and therefore may not yield good data. Oxidized vitrinite may have a reflectance higher or lower than fresh vitrinite; this is a problem often encountered in outcrop samples. Lipid-rich vitrinite, or saprovitrinite, has a lower reflectance than normal vitrinite and will produce an abnormally low thermal maturity value. Coked vitrinite is vitrinite that has structures found in vitrinite heated in a coke oven. Naturally coked vitrinite is the product of very rapid heating, such as that found adjacent to intrusions. Where it is possible to do so, vitrinite derived from an uphole portion of a well will be identified as caved vitrinite. Recycled vitrinite is the vitrinite of higher maturity which clearly can be separated from the indigenous first-cycle vitrinite population. Often, the recycled vitrinite merges in with the inert group.

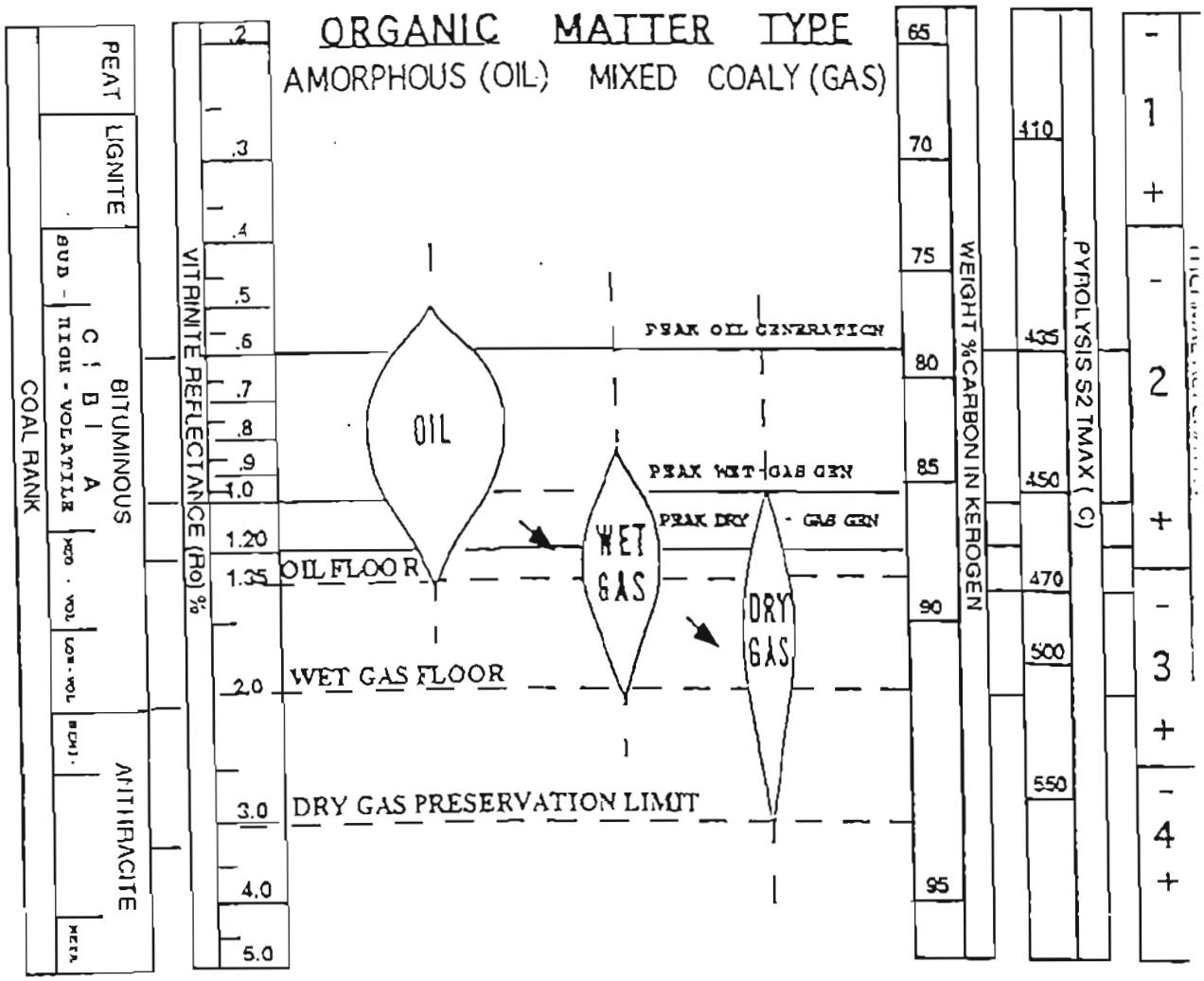
b. Inertinite is made up of woody tissue that has been matured by a different pathway. Early intense oxidation, usually involving charring, fungal attack or biochemical gelification, creates the much more highly reflecting fusinite and semi-fusinite. Sometimes the division between vitrinite and fusinite is transitional. Sclerotinite, fungal remains having a distinct morphology, are considered to be inert. An important consideration is that the inerts, as the name implies, are largely non- reactive "dead carbon" and they have an extremely low hydrogen index in Rock-Eval pyrolysis.

5. OTHER ORGANIC MATERIAL

a. Lipid-rich, caved and recycled vitrinite. These are put in this section so we can show the percentages of these macerals; they are described above.
b. Exsudatinite. Oil and oily exudates fall in this group. Exsudatinite differs from the solid bitumens on the basis of mobility and solubility. We prefer to maintain this distinction although the ICCP has now included the solid bitumens in with the Exsudatinite group.
c. Graptolites are marine organisms that range from the Cambrian to the lower Mississippian; it has been found that they have a reflectance slightly higher than vitrinite. Because vitrinite is lacking in early Paleozoic rocks, the proper identification and measurement of graptolites is important in these sediments.

6. PYRITE. Various forms of pyrite can be readily identified under the microscope. Euhedral is pyrite with a definite crystalline habit. Framboidal is pyrite in the form of grape-like clusters which are made up of euhedral to subhedral crystals. Framboidal pyrite is normally found in sediments with a marine influence; for example, coals with a marine shale roof rock usually contain framboidal pyrite. Massive pyrite is pyrite with no particular external form. Often this is pyrite that forms rather late in the pore spaces of the sediment. Replacement/infilling is self-explanatory.

ZONES OF PETROLEUM GENERATION AND DESTRUCTION



CORRELATION OF VARIOUS MATURATION INDICES AND ZON
OF PETROLEUM GENERATION AND DESTRUCTION.

DGSI PROJECT: 96/3631

State of Alaska, Brooks Range Outcrops

1	96 Mu 33-5	Organic matter consists primarily of bitumen-like material with slightly angular texture mixed with micrinized lipids. This material is difficult to differentiate from alginite and some lipid-rich vitrinite fragments. Some solid bitumen fragments are isolated from the micrinized groundmass and have granular texture. TAI values may be raised by the presence of bitumen-like material in the unstructured lipids. Bitumen may lower Tmax value.
2	96 Mu 33-7	Organic matter is primarily unstructured lipids with massive-micrinized texture and inclusions of small, stringy to angular solid bitumen fragments. Bitumen may slightly lower Tmax value, but TAI, Ro, background fluorescence, and general appearance of kerogen agree.
3	96 Ha 9	Dense groundmass of unstructured lipids with micrinized-massive texture and terrestrial fragments. Trace of high-rank recycled vitrinite. Tmax, TAI, Ro, and background fluorescence agree.
4	96 Ha 11	Organic matter is primarily terrestrial with some grainy unstructured material. Some high-rank VL and normal vitrinite are difficult to differentiate. Tmax, TAI, and Ro agree. Background fluorescence may be slightly high because of VL.
5	96 Ha 14	Similar to 96 Ha 11,but with slightly higher maturity.
6	96 Ha 15	Similar to 96 Ha 11. TAI on sporinite.
7	96 Ha 18	Organic matter consists of terrestrial fragments with a small amount of grainy, unstructured lipids. There are three populations of vitrinite and VL. Tmax indicates a maturity of about Ro 1.3 which agrees with the background fluorescence.
8	96 Ha 45	Organic matter is primarily terrestrial. Small fragments are difficult to identify. TAI, Tmax, Ro, and background fluorescence indicate a maturity slightly over 1.0.
9	96 Ha 49	Mixture of terrestrial fragments with some grainy, unstructured lipids. A trace of surface contamination may lower Tmax.
10	94 Mu 65-A	Organic matter is primarily terrestrial with some grainy, unstructured lipids. Fragments consist of VL, normal vitrinite, coking vitrinite, inertinite, and fluorescing liptodetrinite. Intense background fluorescence.
11	94 Mu 65-U1	Trace of organic matter. Ro is on very small, vitrinite-like fragments.
12	94 Mu 65-U3	Small amount of organic matter. Ro is on very small, vitrinite-like fragments. Some acritarchs, etc. visible in slide.

13	94 Mu 65-U8	Trace of organic matter. Ro is on very small, vitrinite-like fragments.
14	94 Mu 65-U12J	Small amount of organic matter.
15	94 Mu 65-U19	Organic matter is primarily unstructured lipids with massive texture. Small vitrinite fragments are severely oxidized.
16	94 Mu 65-U28	Trace of organic matter consisting primarily of very small terrestrial fragments.
17	96 Mu 28-3	Trace of very small organic fragments, primarily terrestrial.
18	96 Mu 28-4	Small amount of unstructured lipids and terrestrial fragments. Some vitrinite is coking. TAI of 3.
19	96 Mu 28-6	Organic matter is primarily terrestrial. Many small fragments are difficult to identify. TAI of 3+ agrees with Ro maturity.
20	96 MAW 6	Primarily terrestrial fragments with some low-rank contamination which may raise background fluorescence. TAI is 3 to 3+.
21	96 MAW 7	Unstructured lipids have micrinized texture and small, stringy, angular, solid bitumen inclusions. Some oil generation has occurred. Solid bitumen may slightly lower Tmax and raise TAI values. TAI is 3-.
22	96 MAW 9	Mixture of unstructured lipids and terrestrial fragments. Some vitrinite has dark oxidation rims and some Ro values may be lowered. Trace of solid bitumen which may lower Tmax and raise TAI values. TAI is 3- to 3.
23	96 MAW 11	Organic matter is primarily fine-grained, unstructured lipids with stringy, angular, solid bitumen inclusions. Some oil generation has occurred. Solid bitumen may slightly lower Tmax and raise TAI values. TAI is 3- to 3.
24	96 MAW 16-B	Unstructured lipids have a grainy texture. Small terrestrial fragments are difficult to identify. Trace of surface contamination. Surface contamination and traces of solid bitumen may slightly lower Tmax value. TAI is 2+ to 3-.
25	96 MAW 18-B	Moderate amount of organic matter consisting primarily of very small, difficult to identify terrestrial fragments. There is one large fragment of VL or solid bitumen -like material. TAI is 2+.
26	96 MAW 20-E	Small amount of organic matter consisting primarily of lipid-rich vitrinite. TAI agrees with Ro for a maturity slightly less than 1.0.
27	96 MAW 21-B	Trace of organic matter, not enough for analysis.
28	96 MAW 22-B	Mixture of terrestrial material with a wide range of Ro values. Many small fragments are difficult to identify. Micrinized lipids are mixed with mineral and TAI cannot be determined. Background fluorescence agrees with lower population of vitrinite and VL.

BROOKS RANGE OUTCROPS

DGSI Project: 96/3631

DGSI

DGSI NUMBER	DATE: 12/29/96 ID OR DEPTH	PREPARATION/ SAMPLE TYPE	ORGANIC MATTER (%) LIPIDS UNSTRUCTURED UNDIFFERENTIATE	AMORPHOUS	MASSIVE	MICRINIZED	STRUCTURED TYPE	TYPE	TYPE	TYPE	SOLID BITUMEN	HUMIC INERTINITE	VITRINITE	OTHER TYPE	TYPE	RELATIVE ABUNDANCE PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI REFLECTED LIPIDS UNSTR. COLOR	INTENSITY	STRU. COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED LIPIDS UNSTR. TAI VALUE	FLUOR. COLOR	FLUOR. INTENSITY	STRU. TAI VALUE	FLUOR. COLOR	FLUOR. INTENSITY	Ro VITRINITE REFLECTANCE OR EQUIVALENCY
1	96 Mu 33-5	K/OC				30	AL ?				760	5		VL 5		F	-	+	N		+			DB	1			3	3-	BL	0				B1 03 ?0 96
Comments:	Some granular bitumen fragments, but most of bitumen-like material is mixed with micrinized lipids and is difficult to differentiate from alginite and VL.																																		
2	96 Mu 33-7	K/OC			75						20	5	T			MA	-	+	+	-				DB	1			4	2+	BL	0				B?0.99 -
Comments:	Massive-micrinized lipids with small, stringy to angular solid bitumen fragments																																		
3	96 Ha 9	K/OC				65					T	10	5	VL 20		E	+	+	-	M	+		T	BL	0			3	3-	BL	0				- 1.04
Comments:	Dense groundmass of micrinized-massive lipids with terrestrial fragments																																		
4	96 Ha 11	K/OC	15									15	30	VL 40		MA	M	+	+	-	M		T	DB	1			3 4	2+ 3	BL	0				- 1.29
Comments:	Difficult to differentiate normal vitrinite and high-rank VL.																																		
5	96 Ha 14	K/OC	20				U T	S T				20	50	VL 10		MA	-	+	+	-	M		T	BL	0	BL	0	3	2+ 3	BL	0	2+ 3	BL	0	- 1.33
Comments:	Similar to 96 Ha 11, but with slightly higher maturity.																																		

ANALYST	SAMPLE TYPE/PREP	STRUCTURED LIPIDS	OTHER ORGANIC MATTER	PYRITE	ABUND.	FLUOR. INTENS.	VIT. REFLECT. EQUIVALENCE	FLUOR. COLOR	TAI COLOR VALUES
Castano	CTG Cuttings	AL Alginite	E Exsudatinite	E Euhedral	N None	0 None	B Bitumen	W White	1- Straw Yellow
X O'Connor	CC Conv. Core	SB Suberinite	G Graptolites	F Framboid	T Trace	1 Weak	G Graptolites	G Green	1 Pale Yellow
	SWC SideWallCore	C Cutinite	VL Lipid-Rich Vitrinite	MA Massive	- Small Amt	2 Moderate	VL Lipid-Rich Vitrinite	Y Yellow	1+ Yellow
	OC Outcrop	LD Liptodetrinite	VC VitriniteContamination	RI Replace-infill	M Mod. Amt	3 Strong	VC Vitrinite Contam.	O Orange	2- Yellow-Orange
	NI No Inform	U Undiffer	VR Recycled Vitrinite		+ Large Amt	4 Intense	VR Recycled Vitrinite	R Red	2 Golden
MICROSCOPE	C Coal	S Sporinite			++ Abundant			B Brown	2+ Amber
		R Resinite						BL Black	3- Reddish Brown
Jena	K Kerogen	O Other							3 Medium Brown
X Zeiss	WR Whole Rock								3+ Dark Brown
								L Light	4- Brown-Black
	n.d. Not Determined							D Dark	4 Black
									4+ Black-Opaque

VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

BROOKS RANGE OUTCROPS

DGSI Project: 96/3631

DGSI NUMBER	DATE: 12/29/96 ID OR DEPTH	PREPARATION/ SAMPLE TYPE	ORGANIC MATTER (%) LIPIDS UNSTRUCTURED UNDIFFERENTIATE	AMORPHOUS	MASSIVE	MICRINIZED	STRUCTURED TYPE	TYPE	TYPE	TYPE	SOLID BITUMEN	HUMIC INERTINITE	VITRINITE	OTHER TYPE	TYPE	RELATIVE ABUNDANCE PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI REFLECTED LIPIDS UNSTR. COLOR	INTENSITY	STRU. COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED LIPIDS UNSTR. TAI VALUE	FLUOR. COLOR	INTENSITY	STRU. TAI VALUE	FLUOR. COLOR	INTENSITY	Ro VITRINITE REFLECTANCE OR EQUIVALENCY
6	96 Ha 15	K/OC	20				U S	S T	LD T			20	40	VL 15		MA	M	+	M	-	M		T	DB BL	1 0	BL	0	4	n.d.			3-	BL O	0 1	- 1.19
Comments:	Brown, grainy unstructured lipids. Difficult to differentiate some vitrinite and VL.																																			
7	96 Ha 18	K/OC	10				LD T					20	35	VL 35		MA	M	+	M	-	M			n.d.		OB	2	3	n.d				O	1 2	- ?1.42
Comments:	Mixture of terrestrial material - three populations of VL and vitrinite.																																			
8	96 Ha 45	K/OC	20				LD T					20	30	VL 30		MA	M	+	M	-	M	T	-	DB BL	1 0			4	3-	BL	0		O	1	- 1.20
Comments:	Small terrestrial fragments.																																			
9	96 Ha 49	K/OC	15				LD S	S T				20	30	VL 30		MA	M	+	M	-	M		-	DB BL	1 0	DO	1	4	n.d.			2+	O	1 2	- ?1.18
Comments:	Mix of terrestrial fragments. Trace of surface contamination																																			
10	94 Mu 65-A	K/OC	15				LD S					20	30	VL 30		MA	M	+	M	T	M		-	DB	1	O	1 3	4	3- 2+	BL	0		O	1 2	- 1.14
Comments:	Mixture of terrestrial fragments.																																			

ANALYST

Castano
X O'Connor

MICROSCOPE

Jena
X Zeiss

SAMPLE TYPE/PREP		STRUCTURED LIPIDS		OTHER ORGANIC MATTER		PYRITE		ABUND.		FLUOR. INTENS.		VIT. REFLECT. EQUIVALENCE		FLUOR. COLOR		TAI COLOR VALUES	
CTG	Cuttings	AL	Alginite	E	Exsudatinite	E	Euhedral	N	None	0	None	B	Bitumen	W	White	1-	Straw Yellow
CC	Conv. Core	SB	Suberinite	G	Graptolites	F	Framboid	T	Trace	1	Weak	G	Graptolites	G	Green	1	Pale Yellow
SWC	SideWallCore	C	Cutinite	VL	Lipid-Rich Vitrinite	MA	Massive	-	Small Amt.	2	Moderate	VL	Lipid-Rich Vitrinite	Y	Yellow	1+	Yellow
OC	Outcrop	LD	Liptodetrinite	VC	VitriniteContamination	RI	Replace-infill	M	Mod. Amt.	3	Strong	VC	Vitrinite Contam.	O	Orange	2-	Yellow-Orange
NI	No Inform.	U	Undiffer	VR	Recycled Vitrinite			+	Large Amt	4	Intense	VR	Recycled Vitrinite	R	Red	2	Golden
C	Coal	S	Sporinite					++	Abundant					B	Brown	2+	Amber
		R	Resinite											BL	Black	3-	Reddish Brown
K	Kerogen	O	Other													3	Medium Brown
WR	Whole Rock															3+	Dark Brown
														L	Light	4-	Brown-Black
n.d.	Not Determined													D	Dark	4	Black
																4+	Black-Opaque

VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

BROOKS RANGE OUTCROPS

DGSI Project: 96/3631

DGSI NUMBER	DATE: 12/29/96 ID OR DEPTH	PREPARATION/ SAMPLE TYPE	ORGANIC MATTER (%) LIPIDS UNSTRUCTURED UNDIFFERENTIATE	AMORPHOUS	MASSIVE	MICRINIZED	STRUCTURED TYPE	TYPE	TYPE	TYPE	SOLID BITUMEN	HUMIC INERTINITE	VITRINITE	OTHER TYPE	TYPE	RELATIVE ABUNDANCE PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI REFLECTED LIPIDS UNSTR. COLOR	INTENSITY	STRU. COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED LIPIDS UNSTR TAI VALUE	FLUOR COLOR	FLUOR INTENSITY	STRU. TAI VALUE	FLUOR. COLOR	FLUOR. INTENSITY	Ro VITRINITE REFLECTANCE OR EQUIVALENCY
11	94 Mu 65-U1	K/OC	T									T	T	VL T		MA	-	T	M	M	M			n.d.				1	3	BL	0				- -
Comments:	Trace of organic matter. Ro on very small fragments																																		
12	94 Mu 65-U3	K/OC	T				AL T					T	T			MA	-	-	+					n.d.				1	3+	BL	0				- 71.72
Comments:	Small amount of organic matter. Ro on very small fragments.																																		
13	94 Mu 65-U8	K/OC	T									T	T	VL T		MA	-	T	M	T	M			n.d.				1	n d.						- -
Comments:	Trace of organic matter.																																		
14	94 Mu 65-U12J	K/OC		T								T	T			MA	-	-	+					n.d				1	2+ 3	BL	0				- -
Comments:	Small amount of organic matter.																																		
15	94 Mu 65-U19	K/OC			90							5	5	VL T		MA	-	M	N	+	-	+		BL	0			2	2+	BL	0				- -
Comments:	Massive unstructured lipids. Oxidized vitrinite.																																		

DGSI

ANALYST

Castano
X O'Connor

MICROSCOPE

Jena
X Zeiss

SAMPLE TYPE/PREP		STRUCTURED LIPIDS		OTHER ORGANIC MATTER		PYRITE		ABUND.		FLUOR. INTENS.		VIT. REFLECT. EQUIVALENCE		FLUOR. COLOR		TAI COLOR VALUES	
CTG	Cuttings	AL	Alginite	E	Exsudatinite	E	Euhedral	N	None	0	None	B	Bitumen	W	White	1-	Straw Yellow
CC	Conv Core	SB	Suberinite	G	Graptolites	F	Framboid	T	Trace	1	Weak	G	Graptolites	G	Green	1	Pale Yellow
SWC	SideWallCore	C	Cutinite	VL	Lipid-Rich Vitrinite	MA	Massive	-	Small Amt	2	Moderate	VL	Lipid-Rich Vitrinite	Y	Yellow	1+	Yellow
OC	Outcrop	LD	Liptodetrinite	VC	VitriniteContamination	RI	Replace-infill	M	Mod Amt	3	Strong	VC	Vitrinite Contam.	O	Orange	2-	Yellow-Orange
NI	No Inform	U	Undiffer.	VR	Recycled Vitrinite			+	Large Amt	4	Intense	VR	Recycled Vitrinite	R	Red	2	Golden
C	Coal	S	Sporinite					++	Abundant					B	Brown	2+	Amber
		R	Resinite											BL	Black	3-	Reddish Brown
K	Kerogen	O	Other													3	Medium Brown
WR	Whole Rock															3+	Dark Brown
														L	Light	4-	Brown-Black
n.d.	Not Determined													D	Dark	4	Black
																4+	Black-Opaque

VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

BROOKS RANGE OUTCROPS

DGSI Project: 96/3631

DGSI NUMBER	DATE: 12/29/96 ID OR DEPTH	PREPARATION/ SAMPLE TYPE	ORGANIC MATTER (%) LIPIDS UNSTRUCTURED UNDIFFERENTIATE	AMORPHOUS	MASSIVE	MICRINIZED	STRUCTURED TYPE	TYPE	TYPE	TYPE	SOLID BITUMEN	HUMIC INERTINITE	VITRINITE	OTHER TYPE	TYPE	RELATIVE ABUNDANCE PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI REFLECTED LIPIDS UNSTR. COLOR	INTENSITY	STRU COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED LIPIDS UNSTR. TAI VALUE	FLUOR. COLOR	INTENSITY	STRU. TAI VALUE	FLUOR COLOR	INTENSITY	Ro VITRINITE REFLECTANCE OR EQUIVALENCY
16	94 Mu 65-U28	K/OC	T									T	T	VL T		MA	T	T	N	M	M			BL	0			1	n d						- -
Comments:	*Trace of organic matter, primarily terrestrial fragments*																																			
17	96 Mu 28-3	K/OC	T									T	T			MA	-	T	M	M				n d				0	n d.						- ?1.82
Comments:	*Trace of very small organic fragmnts, primarily terrestrial.*																																			
18	96 Mu 28-4	K/OC	T									T	T			MA	T	-	M	M			M	n d				0	3	BL	0				- -
Comments:	*Small amount of unstructured and terrestrial material Some coking*																																			
19	96 Mu 28-6	K/OC	30									20	50			MA	M	M	+		?			BL	0			1	3+	BL	0				- 1.87
Comments:	*Many small terrestrial fragments are difficult to identify.*																																			
20	96 MAW 6	K/OC	20									20	60	VL T		MA RI	M	M	+	-	T		T	BL	0			3	3 3+	BL	0				- 1.36
Comments:	*Some low-rank contamination*																																			

ANALYST	SAMPLE TYPE/PREP	STRUCTURED LIPIDS	OTHER ORGANIC MATTER	PYRITE	ABUND.	FLUOR. INTENS.	VIT. REFLECT. EQUIVALENCE	FLUOR. COLOR	TAI COLOR VALUES
Castano	CTG Cuttings	AL Alginite	E Exsudatinite	E Euhedral	N None	0 None	B Bitumen	W White	1- Straw Yellow
X O'Connor	CC Conv. Core	SB Suberinite	G Graptolites	F Framboid	T Trace	1 Weak	G Graptolites	G Green	1 Pale Yellow
	SWC SideWallCore	C Cutinite	VL Lipid-Rich Vitrinite	MA Massive	- Small Amt	2 Moderate	VL Lipid-Rich Vitrinite	Y Yellow	1+ Yellow
	OC Outcrop	LD Liptodetrinite	VC VitriniteContamination	RI Replace-infill	M Mod. Amt.	3 Strong	VC Vitrinite Contam.	O Orange	2- Yellow-Orange
	NI No Inform	U Undiffer.	VR Recycled Vitrinite		+ Large Amt	4 Intense	VR Recycled Vitrinite	R Red	2 Golden
	C Coal	S Sporinite			++ Abundant			B Brown	2+ Amber
MICROSCOPE		R Resinite						BL Black	3- Reddish Brown
		O Other							3 Medium Brown
Jena	K Kerogen								3+ Dark Brown
X Zeiss	WR Whole Rock							L Light	4- Brown-Black
	n.d. Not Determined							D Dark	4 Black
									4+ Black-Opaque

VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

BROOKS RANGE OUTCROPS

DGSI Project: 96/3631

DGSI NUMBER	DATE: 12/29/96 ID OR DEPTH	PREPARATION/ SAMPLE TYPE	ORGANIC MATTER (%) LIPIDS UNSTRUCTURED: UNDIFFERENTIATED	AMORPHOUS	MASSIVE	MICRINIZED	STRUCTURED: TYPE	TYPE	TYPE	TYPE	SOLID BITUMEN	HUMIC: INERTINITE	VITRINITE	OTHER: TYPE	TYPE	RELATIVE ABUNDANCE: PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE: NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI REFLECTED LIPIDS: COLOR	INTENSITY	COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED LIPIDS UNSTR TAI: VALUE	FLUOR.: COLOR	FLUOR.: INTENSITY	STRU. TAI: VALUE	FLUOR: COLOR	FLUOR: INTENSITY	Ro: VITRINITE REFLECTANCE OR EQUIVALENCY
21	96 MAW 7	K/OC				50	LD 5				20	15	10	VL T		F	M	+	M	M	T	T		DB	1			4	3-	BL	0		O Y	2	- 1.36
Comments: Small, stringy, angular solid bitumen fragments in micrinized lipids.																																			
22	96 MAW 9	K/OC				60	LD T				T	20	20			F MA	M	M	M			M		DB	1			4	3- 3	BL	0		O Y	2	- 1.38
Comments: Some vitrinite has dark oxidation rims - some Ro values may be lowered																																			
23	96 MAW 11	K/OC				65	LD T				20	10	5			MA	M	+	M	M				B	1	O	2	3	3- 3	BL	0				- ?1.16
Comments: Fine-grained, micrinized lipids with stringy, angular solid bitumen inclusions.																																			
24	96 MAW 16-B	K/OC	50				LD 10				5	20	15	VL T		F	M	M	M	M	.		T	B	1			4	2+ 3-	BL	0		O	1	- 1.20
Comments: Grainy unstructured lipids Small terrestrial fragments are difficult to identify. Trace surface contamination.																																			
25	96 MAW 18-B	K/OC	10				LD T				T	? 60	? 30			MA	+	M	M	-	M			n d				3	2+	BL	0		Y O	1	- ?1.01
Comments: Most terrestrial fragments are very small and difficult to identify. One large fragment VL or bitumen-like material.																																			

ANALYST

Castano
X O'Connor

MICROSCOPE

Jena
X Zeiss

SAMPLE TYPE/PREP		STRUCTURED LIPIDS		OTHER ORGANIC MATTER		PYRITE		ABUND.		FLUOR. INTENS.		VIT. REFLECT. EQUIVALENCE		FLUOR. COLOR		TAI COLOR VALUES	
CTG	Cuttings	AL	Alginite	E	Exsudatinite	E	Euhedral	N	None	0	None	B	Bitumen	W	White	1-	Straw Yellow
CC	Conv. Core	SB	Suberinite	G	Graptolites	F	Framboid	T	Trace	1	Weak	G	Graptolites	G	Green	1	Pale Yellow
SWC	SideWallCore	C	Cutinite	VL	Lipid-Rich Vitrinite	MA	Massive	-	Small Amt	2	Moderate	VL	Lipid-Rich Vitrinite	Y	Yellow	1+	Yellow
OC	Outcrop	LD	Liptodetrinite	VC	VitriniteContamination	RI	Replace-infill	M	Mod Amt	3	Strong	VC	Vitrinite Contam.	O	Orange	2-	Yellow-Orange
NI	No Inform.	U	Undiffer	VR	Recycled Vitrinite			+	Large Amt	4	Intense	VR	Recycled Vitrinite	R	Red	2	Golden
C	Coal	S	Sporinite					++	Abundant					B	Brown	2+	Amber
		R	Resinite											BL	Black	3-	Reddish Brown
K	Kerogen	O	Other													3	Medium Brown
WR	Whole Rock															3+	Dark Brown
														L	Light	4-	Brown-Black
n d.	Not Determined													D	Dark	4	Black
																4+	Black-Opaque

VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

BROOKS RANGE OUTCROPS

DGSI Project: 96/3631

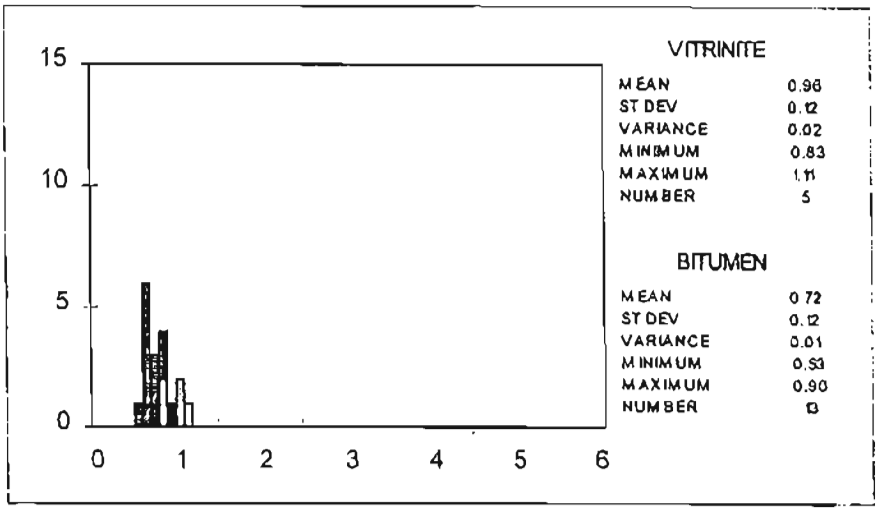
DGSI NUMBER	DATE: 12/29/96 ID OR DEPTH	PREPARATION/ SAMPLE TYPE	ORGANIC MATTER (%) LIPIDS UNSTRUCTURED UNDIFFERENTIATE	AMORPHOUS	MASSIVE	MICRINIZED	STRUCTURED TYPE	TYPE	TYPE	TYPE	SOLID BITUMEN	HUMIC INERTINITE	VITRINITE	OTHER TYPE	TYPE	RELATIVE ABUNDANCE PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI REFLECTED LIPIDS UNSTR. COLOR	INTENSITY	STRU. COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED LIPIDS UNSTR TAI VALUE	FLUOR. COLOR	FLUOR. INTENSITY	STRU. TAI VALUE	FLUOR. COLOR	FLUOR. INTENSITY	Ro VITRINITE REFLECTANCE OR EQUIVALENCY
26	96 MAW 20-E	K/OC	20									10	20	VL 50		MA	M	-	-	M	M	T		BL	0			1	2+	BL	0				- 0.94
Comments: *Small amount of organic matter.*																																			
27	96 MAW 21-B	K/OC	T									T	T			MA	-	T	+					BL	0			0 1	n.d.						- -
Comments: *Trace of organic matter.*																																			
28	96 MAW 22-B	K/OC				10	LD T	U 5				20	30	VL 35		MA	M	+	M	M	M	T	T	BL	0	BL OB	0 1	3	n.d.				0	2	- 0.81
Comments: *Mixture of terrestrial fragments ranging from VL to slightly coked vitrinite. Many small fragments*																																			
Comments:																																			
Comments:																																			

ANALYST	SAMPLE TYPE/PREP	STRUCTURED LIPIDS	OTHER ORGANIC MATTER	PYRITE	ABUND.	FLUOR. INTENS.	VIT. REFLECT. EQUIVALENCE	FLUOR. COLOR	TAI COLOR VALUES
Castano	CTG Cuttings	AL Alginite	E Exsudatinite	E Euhedral	N None	0 None	B Bitumen	W White	1- Straw Yellow
X O'Connor	CC Conv. Core	SB Suberinite	G Graptolites	F Framboid	T Trace	1 Weak	G Graptolites	G Green	1 Pale Yellow
	SWC SideWallCore	C Cutinite	VL Lipid-Rich Vitrinite	MA Massive	- Small Amt	2 Moderate	VL Lipid-Rich Vitrinite	Y Yellow	1+ Yellow
	OC Outcrop	LD Liptodetrinite	VC VitriniteContamination	RI Replace-infill	M Mod. Amt.	3 Strong	VC Vitrinite Contam.	O Orange	2- Yellow-Orange
	NI No Inform.	U Undiffer.	VR Recycled Vitrinite		+ Large Amt.	4 Intense	VR Recycled Vitrinite	R Red	2 Golden
	C Coal	S Sporinite			++ Abundant			B Brown	2+ Amber
MICROSCOPE		R Resinite						BL Black	3- Reddish Brown
	K Kerogen	O Other							3 Medium Brown
Jena	WR Whole Rock								3+ Dark Brown
X Zeiss								L Light	4- Brown-Black
	n.d. Not Determined							D Dark	4 Black
									4+ Black-Opaque

VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

VITRINITE REFLECTANCE — BROOKS RANGE OUTCROPS

DGSI Project 96/3631 — Sample No. 1
OTHER ID: 96 Mu 33-5



B 0.53 B 0.67 L 0.83 L 1.00
B 0.62 B 0.68 L 0.84 L 1.03
B 0.63 B 0.74 B 0.88 L 1.11
B 0.64 B 0.77 B 0.89
B 0.67 B 0.78 B 0.90

TYPE	K/OC	
	TOC	18.65
	TMAX	435
	HI	279
	V Ro	?0.96
	B Ro	0.72
	VRE	1.03

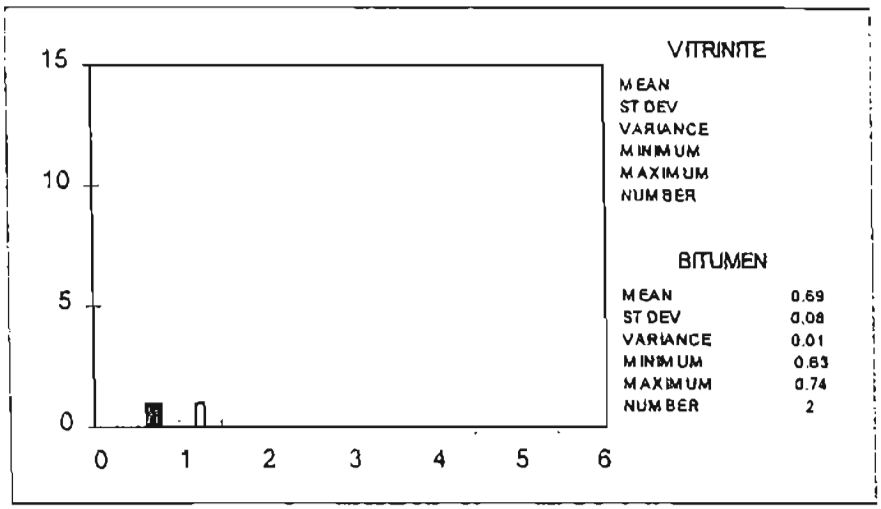
Visual Kerogen Summary

Unstructured Lipids	30
Structured Lipids	-
Solid Bitumen	?60
Inertinite	5
Vitrinite	-
Other	5
TOTAL	40

Background Fluorescence	Strong
TAI Unstructured	3-
TAI Structured	

COMMENTS:
Lipid-rich vitrinite

DGSI Project 96/3631 — Sample No. 2
OTHER ID: 96 Mu 33-7



B 0.63
B 0.74
v 1.29

TYPE	K/OC	
	TOC	3.12
	TMAX	439
	HI	131
	V Ro	-
	B Ro	?0.69
	VRE	?0.99

Visual Kerogen Summary

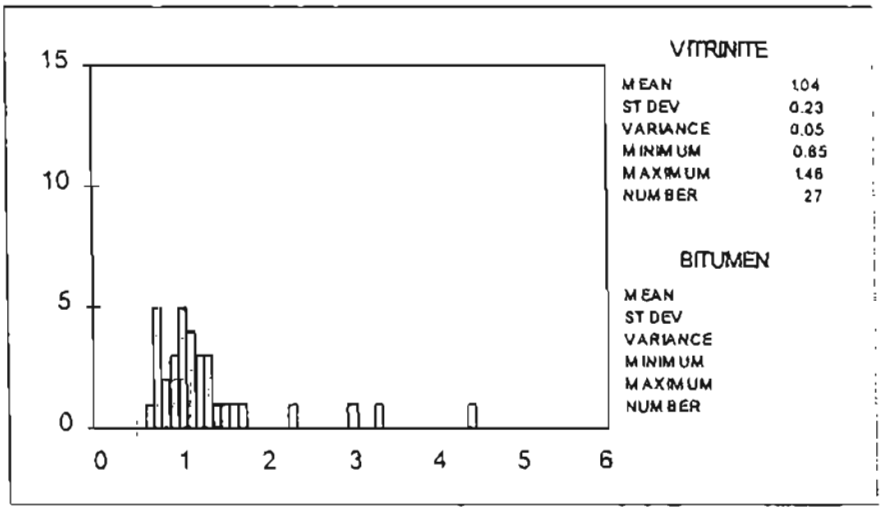
Unstructured Lipids	75
Structured Lipids	-
Solid Bitumen	20
Inertinite	5
Vitrinite	T
Other	0
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	2+
TAI Structured	

COMMENTS:

VITRINITE REFLECTANCE — BROOKS RANGE OUTCROPS

DGSI Project 96/3631 — Sample No. 3
OTHER ID: 96 Ha 9



VITRINITE	
MEAN	1.04
ST DEV	0.23
VARIANCE	0.05
MINIMUM	0.65
MAXIMUM	1.46
NUMBER	27

BITUMEN	
MEAN	
ST DEV	
VARIANCE	
MINIMUM	
MAXIMUM	
NUMBER	

L 0.65	L 0.79	L 0.95	V 1.08	L 1.20	L 1.39	v 2.36
L 0.71	V 0.82	L 1.01	L 1.13	V 1.23	L 1.46	v 3.03
L 0.73	L 0.87	L 1.01	L 1.15	V 1.26	v 1.54	v 3.33
L 0.74	L 0.91	V 1.01	V 1.17	V 1.34	I 1.65	v 4.42
L 0.78	L 0.95	V 1.06	V 1.19	L 1.39	I 1.79	

TYPE	K/OC	
	TOC	0.86
	TMAX	451
	HI	33
	V Ro	1.04
	B Ro	-
	VRE	-

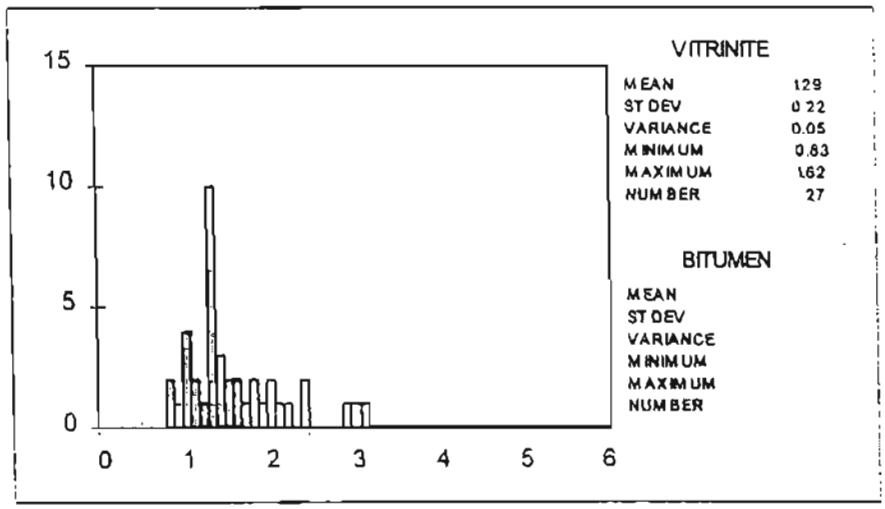
Visual Kerogen Summary

Unstructured Lipids	65
Structured Lipids	-
Solid Bitumen	T
Inertinite	10
Vitrinite	5
Other	20
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	3-
TAI Structured	

COMMENTS:

DGSI Project 96/3631 — Sample No. 4
OTHER ID: 96 Ha 11



VITRINITE	
MEAN	1.29
ST DEV	0.22
VARIANCE	0.05
MINIMUM	0.83
MAXIMUM	1.62
NUMBER	27

BITUMEN	
MEAN	
ST DEV	
VARIANCE	
MINIMUM	
MAXIMUM	
NUMBER	

L 0.83	V 1.05	L 1.32	L 1.38	L 1.47	V 1.60	I 1.95	v 2.44
V 0.87	V 1.07	V 1.33	V 1.38	V 1.47	V 1.62	v 2.07	v 2.46
V 0.99	L 1.11	V 1.35	V 1.38	V 1.49	I 1.78	v 2.08	v 2.94
V 1.00	L 1.18	V 1.36	V 1.39	V 1.53	v 1.87	v 2.11	v 3.06
V 1.05	V 1.29	V 1.37	V 1.39	V 1.56	v 1.89	v 2.29	v 3.19

TYPE	K/OC	
	TOC	1.09
	TMAX	463
	HI	34
	V Ro	1.29
	B Ro	-
	VRE	-

Visual Kerogen Summary

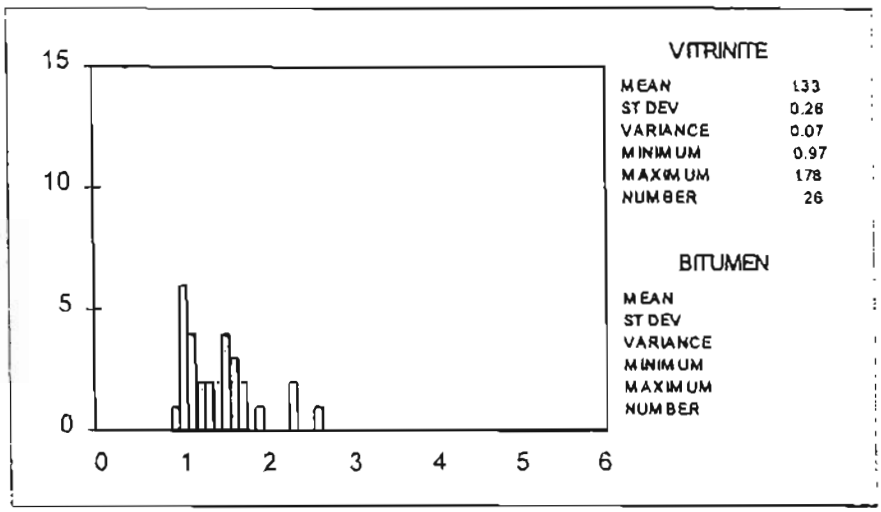
Unstructured Lipids	15
Structured Lipids	-
Solid Bitumen	-
Inertinite	15
Vitrinite	30
Other	40
TOTAL	100

Background Fluorescence	Strong,Intense
TAI Unstructured	2+,3
TAI Structured	

COMMENTS:
Some recycled vitrinite

VITRINITE REFLECTANCE BROOKS RANGE OUTCROPS

DGSI Project 96/3631 Sample No. 5
OTHER ID: 96 Ha 14



VITRINITE	
MEAN	1.33
ST DEV	0.26
VARIANCE	0.07
MINIMUM	0.97
MAXIMUM	1.78
NUMBER	26

BITUMEN	
MEAN	
ST DEV	
VARIANCE	
MINIMUM	
MAXIMUM	
NUMBER	

L 0.97 V 1.05 V 1.19 L 1.40 V 1.59 V 1.78
L 1.00 L 1.08 V 1.23 L 1.46 V 1.67 v 1.94
V 1.03 L 1.13 L 1.28 V 1.51 V 1.68 v 2.36
V 1.03 V 1.14 V 1.34 V 1.54 V 1.68 v 2.38
V 1.04 L 1.17 V 1.35 L 1.57 V 1.75 v 2.60

TYPE	K/OC	
	TOC	1.12
	TMAX	478
	HI	36
	V Ro	1.33
	B Ro	-
	VRE	-

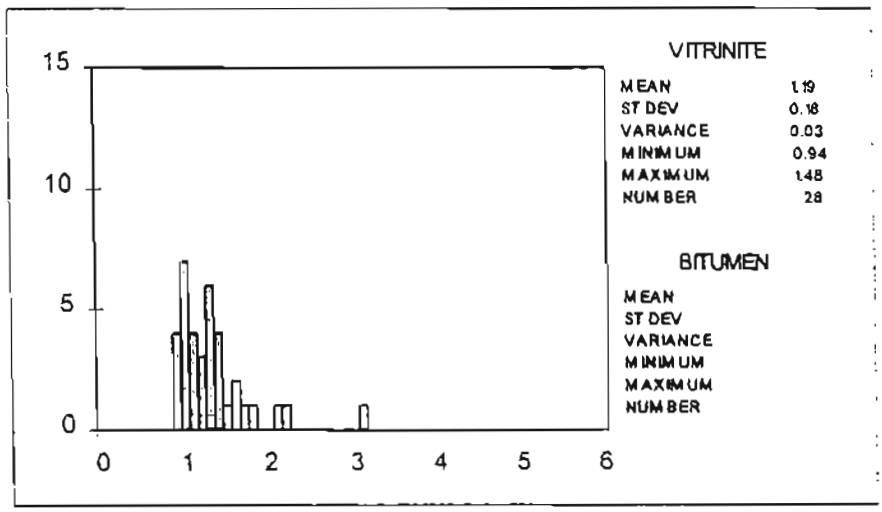
Visual Kerogen Summary

Unstructured Lipids	20
Structured Lipids	-
Solid Bitumen	-
Inertinite	20
Vitrinite	50
Other	10
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	2+,3
TAI Structured	2+,3

COMMENTS:

DGSI Project 96/3631 Sample No. 6
OTHER ID: 96 Ha 15



VITRINITE	
MEAN	1.19
ST DEV	0.18
VARIANCE	0.03
MINIMUM	0.94
MAXIMUM	1.48
NUMBER	28

BITUMEN	
MEAN	
ST DEV	
VARIANCE	
MINIMUM	
MAXIMUM	
NUMBER	

L 0.94 L 1.01 L 1.07 L 1.23 V 1.34 V 1.45 v 1.66 v 3.19
L 0.94 L 1.01 V 1.13 V 1.28 V 1.34 V 1.47 v 1.74
L 0.95 V 1.02 L 1.14 V 1.28 V 1.35 V 1.48 v 1.86
V 0.99 V 1.02 V 1.16 V 1.32 V 1.38 I 1.57 v 2.14
L 1.00 L 1.07 V 1.19 L 1.34 V 1.40 v 1.62 v 2.23

TYPE	K/OC	
	TOC	0.99
	TMAX	472
	HI	34
	V Ro	1.19
	B Ro	-
	VRE	-

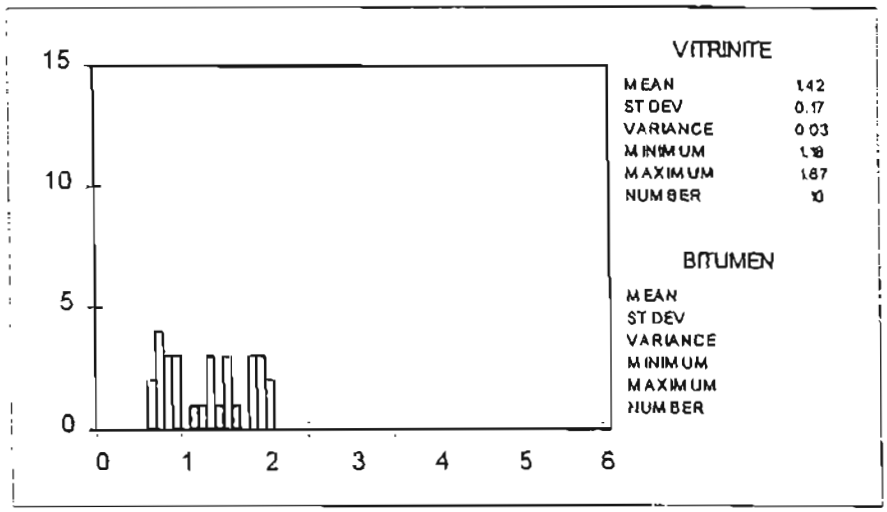
Visual Kerogen Summary

Unstructured Lipids	20
Structured Lipids	5
Solid Bitumen	-
Inertinite	20
Vitrinite	40
Other	15
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	n.d.
TAI Structured	3-

COMMENTS:

DGSI Project 96/3631 Sample No. 7
OTHER ID: 96 Ha 18



I 0.62	v 0.74	v 0.90	V 1.32	V 1.59	v 1.92
I 0.64	I 0.81	I 0.99	V 1.36	V 1.67	v 1.95
I 0.72	I 0.82	V 1.18	V 1.42	v 1.81	v 1.97
I 0.74	I 0.83	V 1.22	V 1.50	v 1.85	v 2.00
I 0.74	v 0.90	L 1.32	V 1.58	v 1.88	v 2.05

TYPE	K/OC	
	TOC	1.16
	TMAX	470
	HI	39
	V Ro	?1.42
	B Ro	.
	VRE	-

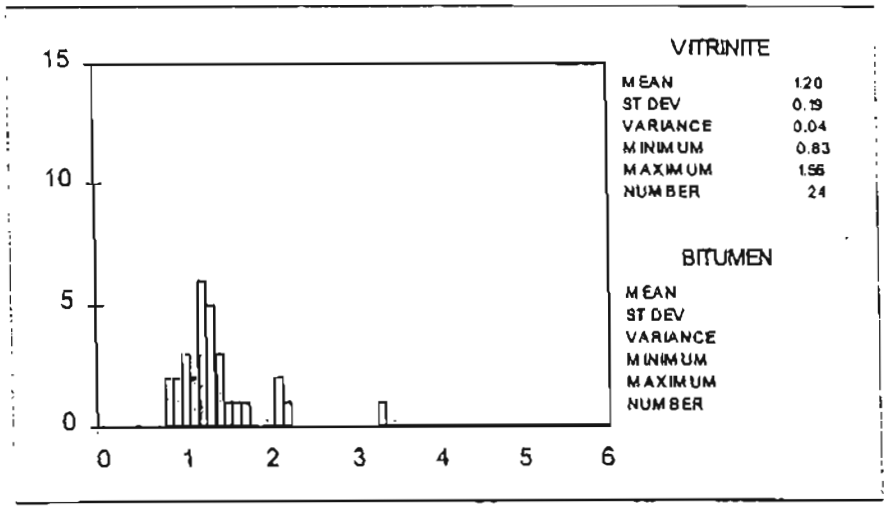
Visual Kerogen Summary

Unstructured Lipids	10
Structured Lipids	-
Solid Bitumen	-
Inertinite	20
Vitrinite	35
Other	35
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:
Lipid-rich vitrinite & recycled vitrinite

DGSI Project 96/3631 Sample No. 8
OTHER ID: 96 Ha 45



L 0.83	L 1.03	L 1.22	V 1.32	V 1.41	I 1.73
V 0.84	V 1.07	V 1.23	V 1.32	V 1.42	v 2.15
V 0.91	L 1.15	V 1.23	L 1.33	V 1.42	Z 2.15
L 0.97	V 1.18	V 1.25	V 1.33	V 1.56	Z 2.20
L 1.03	V 1.20	V 1.28	V 1.33	v 1.66	v 3.36

TYPE	K/OC	
	TOC	1.15
	TMAX	460
	HI	44
	V Ro	1.20
	B Ro	-
	VRE	-

Visual Kerogen Summary

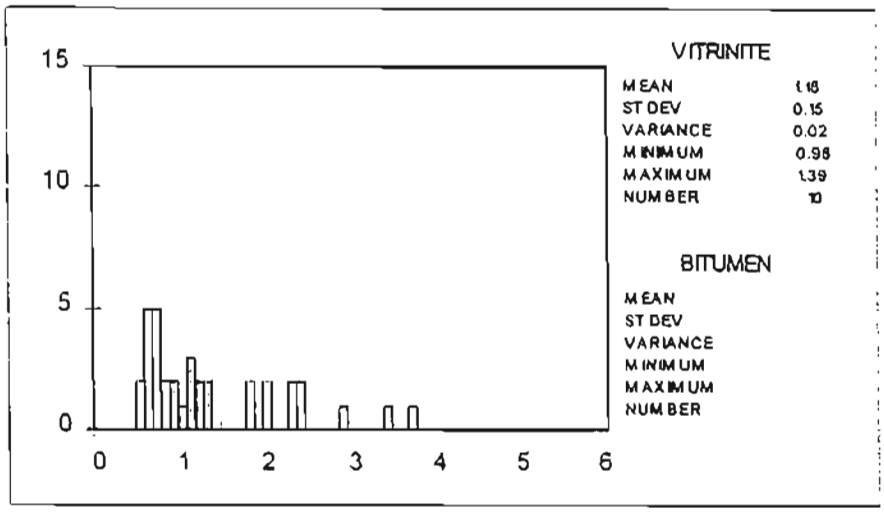
Unstructured Lipids	20
Structured Lipids	-
Solid Bitumen	-
Inertinite	20
Vitrinite	30
Other	30
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	3-
TAI Structured	

COMMENTS:

VITRINITE REFLECTANCE — BROOKS RANGE OUTCROPS

DGSI Project 96/3631 — Sample No. 9
OTHER ID: 96 Ha 49



VITRINITE	
MEAN	1.18
ST DEV	0.15
VARIANCE	0.02
MINIMUM	0.98
MAXIMUM	1.39
NUMBER	10

BITUMEN	
MEAN	
ST DEV	
VARIANCE	
MINIMUM	
MAXIMUM	
NUMBER	

v 0.56	v 0.67	I 0.75	V 0.98	V 1.24	v 1.81	Z 2.45
I 0.57	v 0.68	I 0.77	V 1.01	V 1.29	v 2.00	v 2.48
I 0.65	v 0.70	I 0.80	V 1.16	V 1.38	v 2.05	v 2.93
v 0.65	v 0.70	v 0.80	V 1.19	V 1.39	v 2.30	v 3.45
I 0.67	I 0.72	V 0.98	V 1.19	v 1.81	v 2.33	Z 3.79

TYPE	K/OC	
	TOC	1.23
	TMAX	421
	HI	28
	V Ro	?1.18
	B Ro	-
	VRE	-

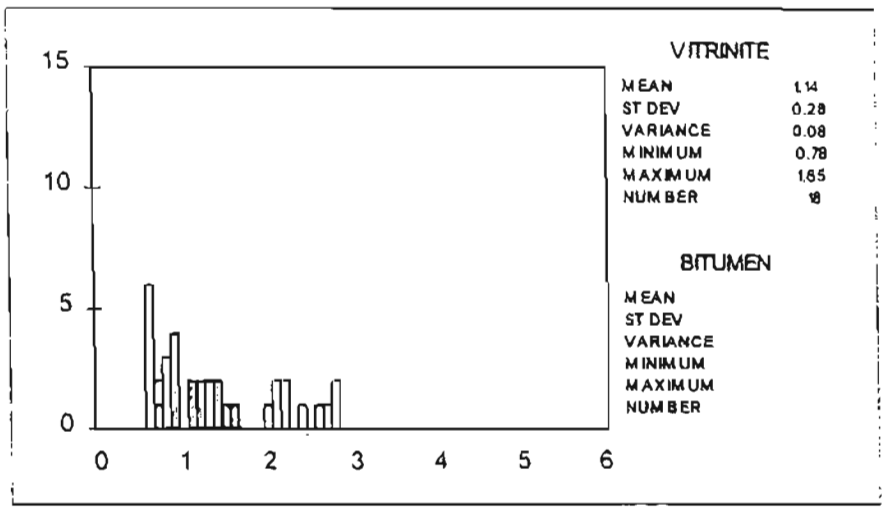
Visual Kerogen Summary

Unstructured Lipids	15
Structured Lipids	5
Solid Bitumen	-
Inertinite	20
Vitrinite	30
Other	30
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	n.d.
TAI Structured	2+

COMMENTS:
Lipid-rich & recycled vitrinite

DGSI Project 96/3631 — Sample No. 10
OTHER ID: 94 Mu 65-A



VITRINITE	
MEAN	1.14
ST DEV	0.28
VARIANCE	0.08
MINIMUM	0.78
MAXIMUM	1.65
NUMBER	18

BITUMEN	
MEAN	
ST DEV	
VARIANCE	
MINIMUM	
MAXIMUM	
NUMBER	

I 0.61	v 0.69	L 0.82	V 1.15	V 1.37	v 2.09	v 2.43
v 0.65	v 0.72	V 0.91	V 1.16	V 1.44	Z 2.11	Z 2.84
I 0.68	V 0.78	V 0.96	V 1.23	V 1.45	v 2.17	v 2.74
I 0.68	L 0.80	V 0.98	V 1.24	V 1.55	Z 2.22	v 2.88
I 0.69	V 0.81	L 0.99	V 1.30	V 1.65	v 2.24	Z 2.89

TYPE	K/OC	
	TOC	1.38
	TMAX	464
	HI	28
	V Ro	1.14
	B Ro	-
	VRE	-

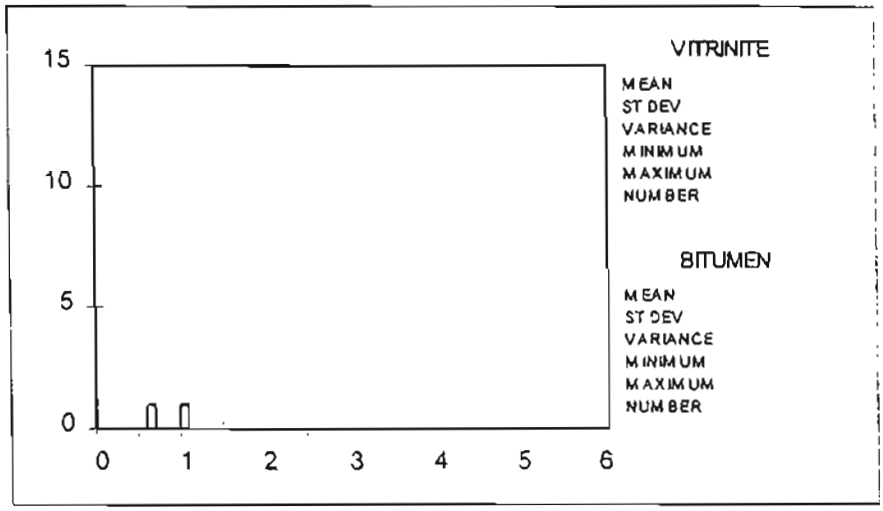
Visual Kerogen Summary

Unstructured Lipids	15
Structured Lipids	5
Solid Bitumen	-
Inertinite	20
Vitrinite	30
Other	30
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	3-,2+
TAI Structured	

COMMENTS:
Some lipid-rich vitrinite & recycled vitrinite

DGSI Project 96/3631 Sample No. 11
OTHER ID94 Mu 65-U1



I 0.67
v 1.06

TYPE	K/OC	
	TOC	0.16
	TMAX	N.A.
	HI	0
	V Ro	-
	B Ro	-
	VRE	-

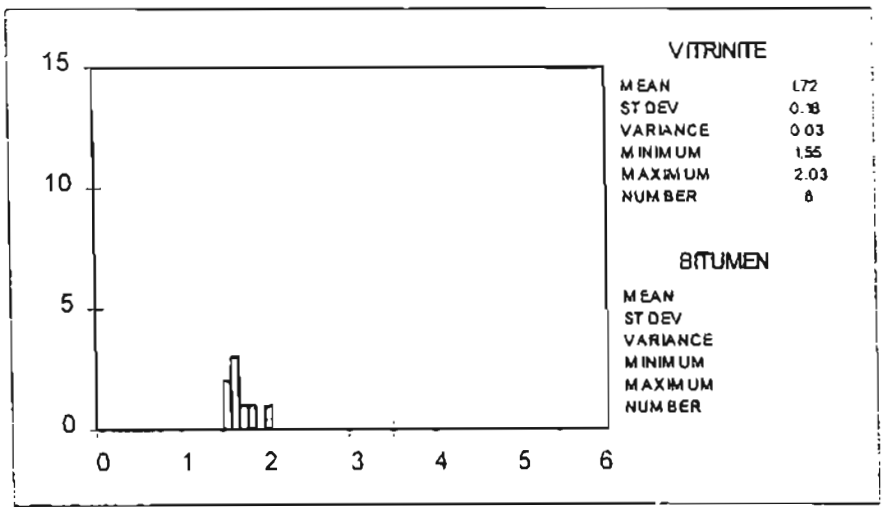
Visual Kerogen Summary

Unstructured Lipids	-
Structured Lipids	-
Solid Bitumen	-
Inertinite	T
Vitrinite	T
Other	0
TOTAL	0

Background Fluorescence	Weak
TAI Unstructured	3
TAI Structured	

COMMENTS:

DGSI Project 96/3631 Sample No. 12
OTHER ID94 Mu 65-U3



V 1.55 V 1.71
V 1.56 V 1.87
V 1.66 V 2.03
V 1.68
V 1.68

TYPE	K/OC	
	TOC	0.23
	TMAX	N.A.
	HI	0
	V Ro	?1.72
	B Ro	-
	VRE	-

Visual Kerogen Summary

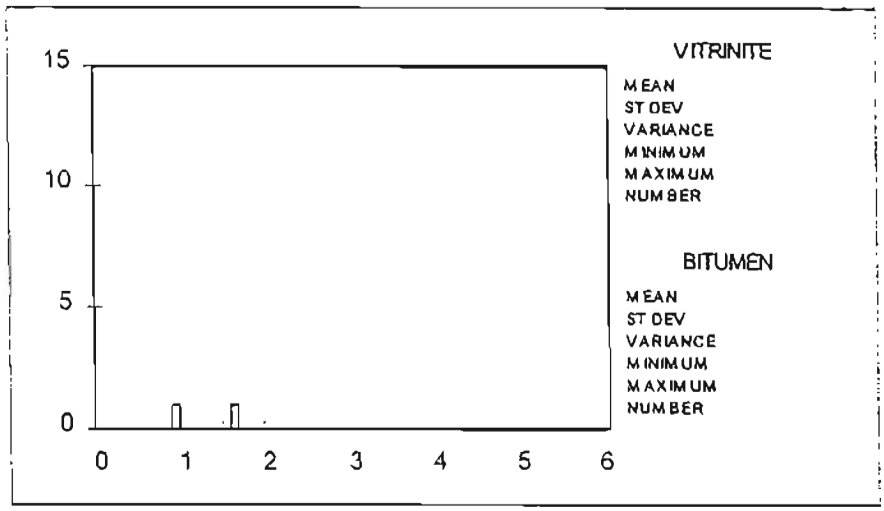
Unstructured Lipids	-
Structured Lipids	-
Solid Bitumen	-
Inertinite	T
Vitrinite	T
Other	0
TOTAL	0

Background Fluorescence	Weak
TAI Unstructured	3+
TAI Structured	

COMMENTS:

VITRINITE REFLECTANCE — BROOKS RANGE OUTCROPS

DGSI Project 96/3631 — Sample No. 13
OTHER ID 94 Mu 65-U8



I 0.90
v 1.67

TYPE	K/OC	
	TOC	0.10
	TMAX	276
	HI	20
	V Ro	-
	B Ro	-
	VRE	-

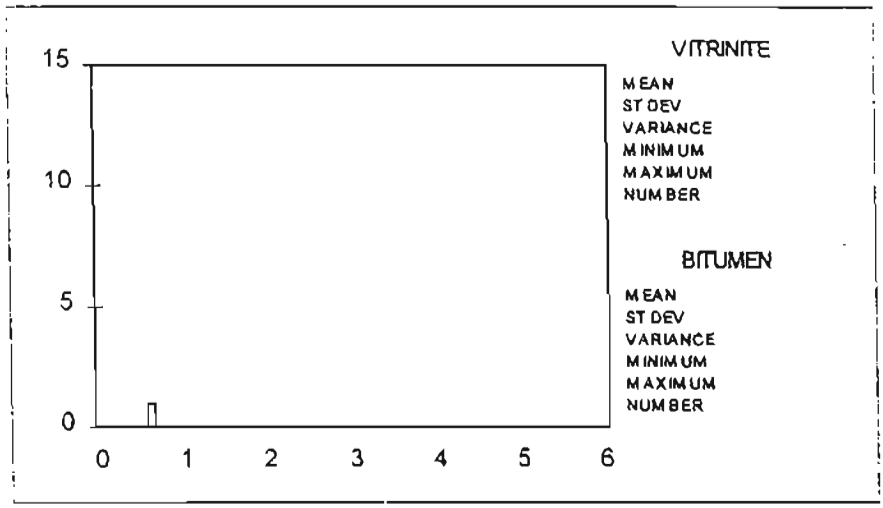
Visual Kerogen Summary

Unstructured Lipids	-
Structured Lipids	-
Solid Bitumen	-
Inertinite	T
Vitrinite	T
Other	0
TOTAL	0

Background Fluorescence	Weak
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 96/3631 — Sample No. 14
OTHER ID 94 Mu 65-U12J



v 0.66

TYPE	K/OC	
	TOC	0.14
	TMAX	N.A.
	HI	0
	V Ro	-
	B Ro	-
	VRE	-

Visual Kerogen Summary

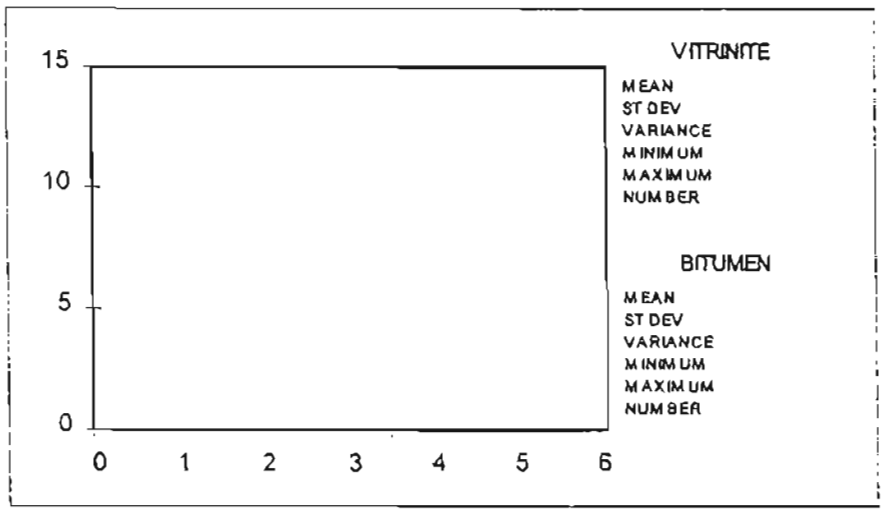
Unstructured Lipids	-
Structured Lipids	-
Solid Bitumen	-
Inertinite	T
Vitrinite	T
Other	0
TOTAL	0

Background Fluorescence	Weak
TAI Unstructured	2+,3
TAI Structured	

COMMENTS:

VITRINITE REFLECTANCE BROOKS RANGE OUTCROPS

DGSI Project 96/3631 Sample No. 15
OTHER ID94 Mu 65-U19



TYPE	K/OC	
	TOC	0.06
	TMAX	N.A.
	HI	0
	V Ro	-
	B Ro	-
	VRE	-

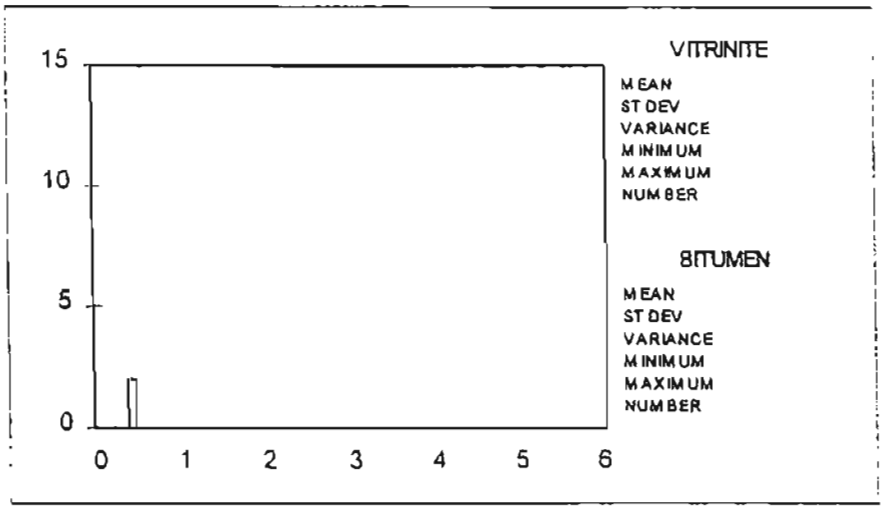
Visual Kerogen Summary

Unstructured Lipids	90
Structured Lipids	-
Solid Bitumen	-
Inertinite	5
Vitrinite	5
Other	0
TOTAL	100

Background Fluorescence	Moderate
TAI Unstructured	2+
TAI Structured	

COMMENTS:

DGSI Project 96/3631 Sample No. 16
OTHER ID94 Mu 65-U28



10.48
10.46

TYPE	K/OC	
	TOC	0.20
	TMAX	N.A.
	HI	0
	V Ro	-
	B Ro	-
	VRE	-

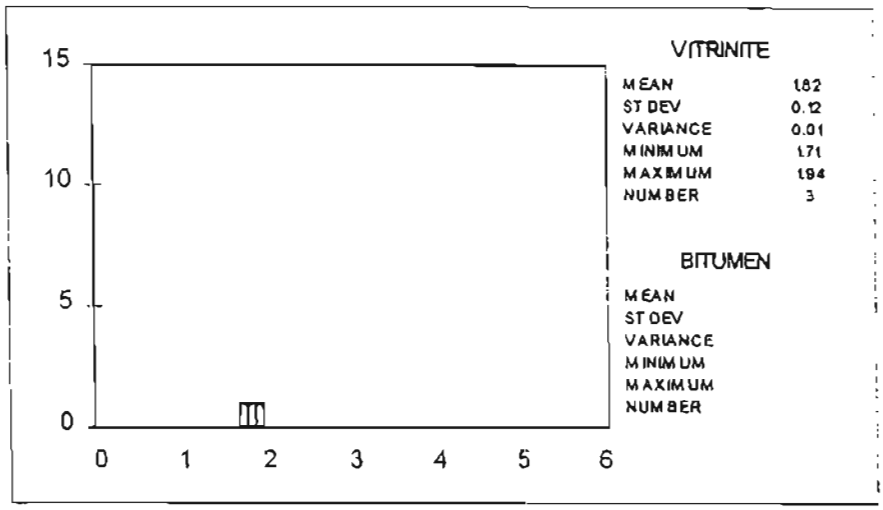
Visual Kerogen Summary

Unstructured Lipids	-
Structured Lipids	-
Solid Bitumen	-
Inertinite	T
Vitrinite	T
Other	0
TOTAL	0

Background Fluorescence	Weak
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 96/3631 Sample No. 17
OTHER ID: 96 Mu 28-3



V 1.71
V 1.81
V 1.94

TYPE	K/OC	
	TOC	0.12
	TMAX	N.A.
	HI	0
	V Ro	?1.82
	B Ro	-
	VRE	-

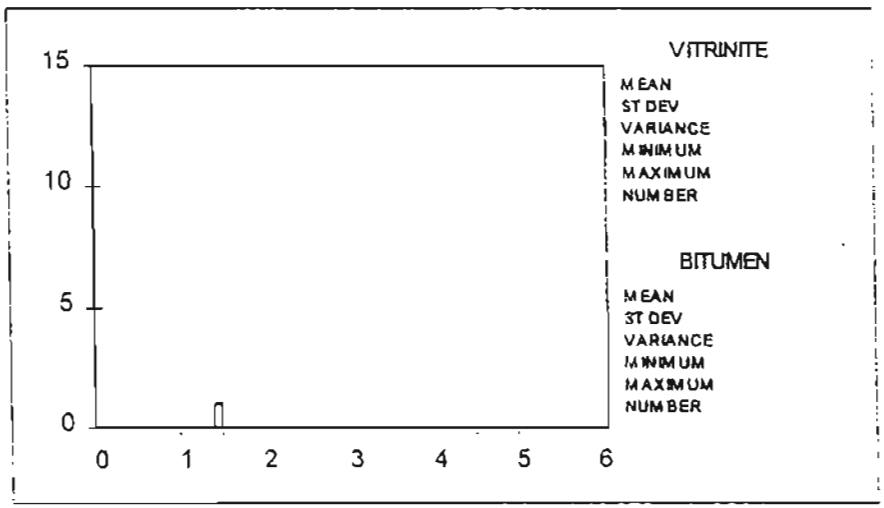
Visual Kerogen Summary

Unstructured Lipids	-
Structured Lipids	-
Solid Bitumen	-
Inertinite	T
Vitrinite	T
Other	0
TOTAL	0

Background Fluorescence	None
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 96/3631 Sample No. 18
OTHER ID: 96 Mu 28-4



v 1.47

TYPE	K/OC	
	TOC	0.11
	TMAX	N.A.
	HI	0
	V Ro	-
	B Ro	-
	VRE	-

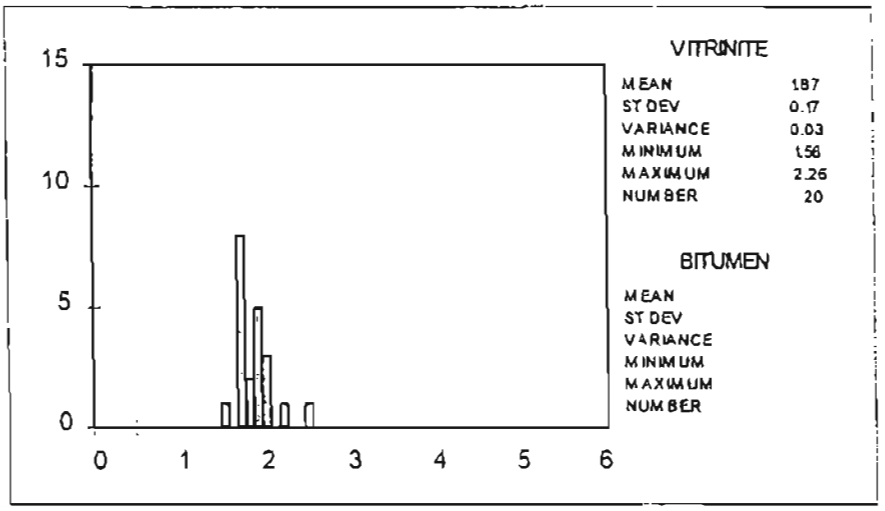
Visual Kerogen Summary

Unstructured Lipids	-
Structured Lipids	-
Solid Bitumen	-
Inertinite	T
Vitrinite	T
Other	0
TOTAL	0

Background Fluorescence	None
TAI Unstructured	3
TAI Structured	

COMMENTS:

DGSI Project 96/3631 Sample No. 19
OTHER ID: 96 Mu 28-6



V 1.56 V 1.75 V 1.88 V 1.99 v 2.51
V 1.70 V 1.78 V 1.92 V 2.02
V 1.70 V 1.77 V 1.94 V 2.05
V 1.73 V 1.77 V 1.95 V 2.07
V 1.75 V 1.81 V 1.98 V 2.26

TYPE	K/OC	
	TOC	0.24
	TMAX	N.A.
	HI	0
	V Ro	1.87
	B Ro	-
	VRE	-

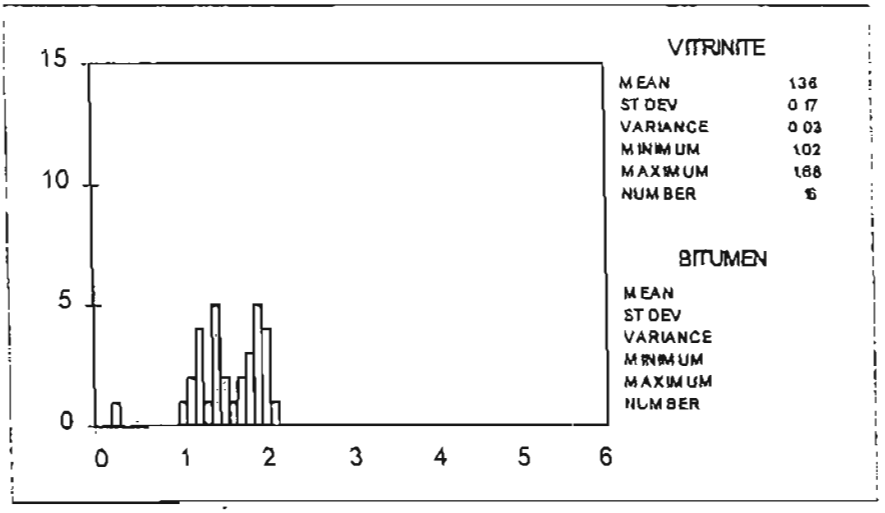
Visual Kerogen Summary

Unstructured Lipids	30
Structured Lipids	-
Solid Bitumen	-
Inertinite	20
Vitrinite	50
Other	0
TOTAL	100

Background Fluorescence	Weak
TAI Unstructured	3+
TAI Structured	

COMMENTS:

DGSI Project 96/3631 Sample No. 20
OTHER ID: 96 MAW 6



o 0.22 L 1.22 V 1.41 V 1.58 v 1.86 v 1.95 v 2.03
L 1.02 V 1.28 V 1.42 V 1.68 v 1.89 v 1.96 v 2.13
V 1.19 L 1.29 V 1.42 v 1.78 v 1.92 v 2.00
V 1.19 V 1.37 V 1.49 v 1.79 v 1.92 v 2.00
V 1.20 V 1.41 V 1.53 v 1.84 v 1.95 v 2.01

TYPE	K/OC	
	TOC	0.57
	TMAX	443
	HI	58
	V Ro	1.36
	B Ro	-
	VRE	-

Visual Kerogen Summary

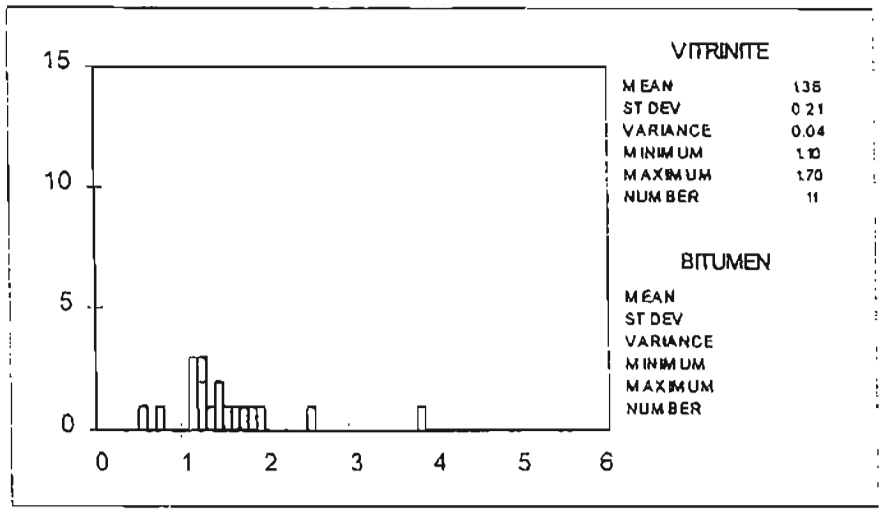
Unstructured Lipids	20
Structured Lipids	-
Solid Bitumen	-
Inertinite	20
Vitrinite	60
Other	0
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	3,3+
TAI Structured	

COMMENTS:
Some recycled vitrinite

VITRINITE REFLECTANCE BROOKS RANGE OUTCROPS

DGSI Project 96/3631 Sample No. 21
OTHER ID: 96 MAW 7



VITRINITE	
MEAN	1.36
ST DEV	0.21
VARIANCE	0.04
MINIMUM	1.10
MAXIMUM	1.70
NUMBER	11

BITUMEN	
MEAN	
ST DEV	
VARIANCE	
MINIMUM	
MAXIMUM	
NUMBER	

b 0.58 V 1.22 V 1.42 v 1.90
b 0.71 b 1.23 V 1.57 v 2.55
V 1.10 L 1.23 V 1.64 v 3.82
V 1.13 V 1.32 V 1.70
V 1.17 V 1.41 v 1.83

TYPE	K/OC	
	TOC	2.88
	TMAX	444
	HI	254
	V Ro	1.36
	B Ro	-
	VRE	-

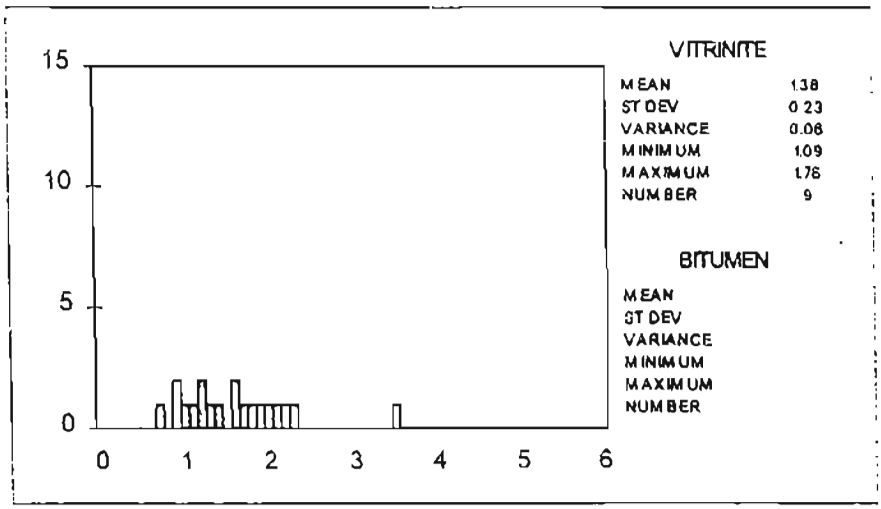
Visual Kerogen Summary

Unstructured Lipids	50
Structured Lipids	5
Solid Bitumen	20
Inertinite	15
Vitrinite	10
Other	0
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	3-
TAI Structured	

COMMENTS:

DGSI Project 96/3631 Sample No. 22
OTHER ID: 96 MAW 9



VITRINITE	
MEAN	1.38
ST DEV	0.23
VARIANCE	0.06
MINIMUM	1.09
MAXIMUM	1.76
NUMBER	9

BITUMEN	
MEAN	
ST DEV	
VARIANCE	
MINIMUM	
MAXIMUM	
NUMBER	

b 0.71 V 1.21 V 1.61 v 2.11
b 0.91 V 1.21 V 1.76 v 2.21
b 0.98 V 1.34 v 1.86 v 2.35
V 1.09 V 1.41 v 1.94 v 3.56
V 1.16 V 1.60 v 2.02

TYPE	K/OC	
	TOC	1.76
	TMAX	442
	HI	213
	V Ro	1.38
	B Ro	-
	VRE	-

Visual Kerogen Summary

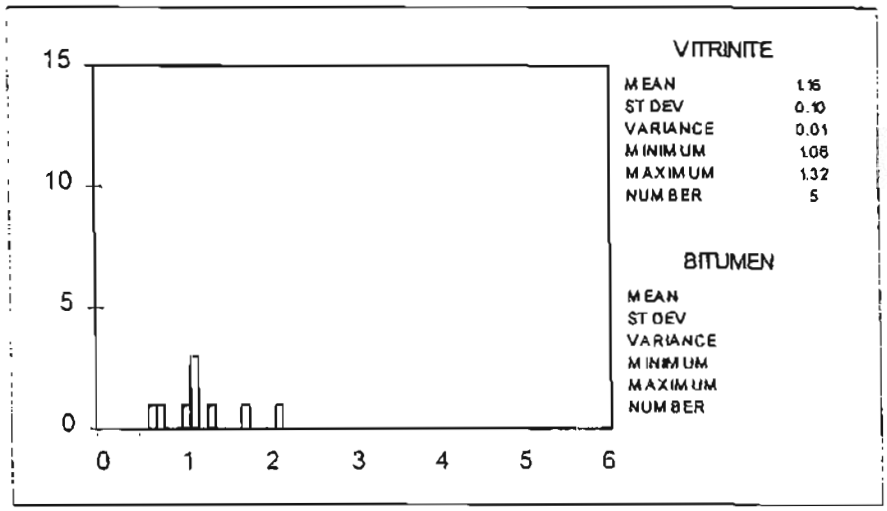
Unstructured Lipids	60
Structured Lipids	-
Solid Bitumen	T
Inertinite	20
Vitrinite	20
Other	0
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	3-,3
TAI Structured	

COMMENTS:
Some recycled vitrinite

DGSI Project 96/3631 Sample No. 23
OTHER ID: 96 MAW 11

TYPE	K/OC	
	TOC	2.40
	TMAX	439
	HI	249
	V Ro	?1.16
	B Ro	-
	VRE	-



VITRINITE	
MEAN	1.16
ST DEV	0.10
VARIANCE	0.01
MINIMUM	1.06
MAXIMUM	1.32
NUMBER	5

BITUMEN	
MEAN	
ST DEV	
VARIANCE	
MINIMUM	
MAXIMUM	
NUMBER	

b 0.69 V 1.15
b 0.74 V 1.32
V 1.06 v 1.76
V 1.12 v 2.11
V 1.14

Visual Kerogen Summary

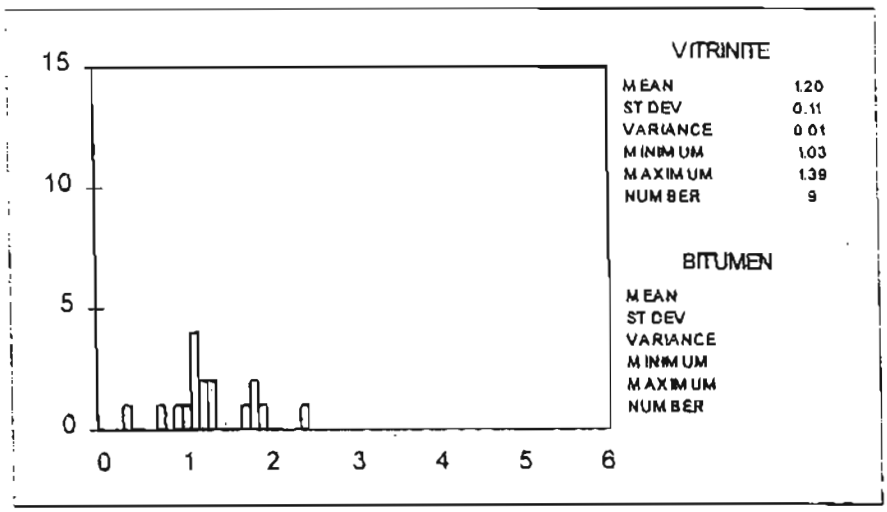
Unstructured Lipids	65
Structured Lipids	-
Solid Bitumen	20
Inertinite	10
Vitrinite	5
Other	0
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	3-,3
TAI Structured	

COMMENTS:

DGSI Project 96/3631 Sample No. 24
OTHER ID96 MAW 16-B

TYPE	K/OC	
	TOC	1.51
	TMAX	446
	HI	61
	V Ro	1.20
	B Ro	-
	VRE	-



VITRINITE	
MEAN	1.20
ST DEV	0.11
VARIANCE	0.01
MINIMUM	1.03
MAXIMUM	1.39
NUMBER	9

BITUMEN	
MEAN	
ST DEV	
VARIANCE	
MINIMUM	
MAXIMUM	
NUMBER	

o 0.30 V 1.13 V 1.31 v 1.98
b 0.76 V 1.16 V 1.39 v 2.48
b 0.91 V 1.18 v 1.78
V 1.03 L 1.20 v 1.87
V 1.11 L 1.27 v 1.89

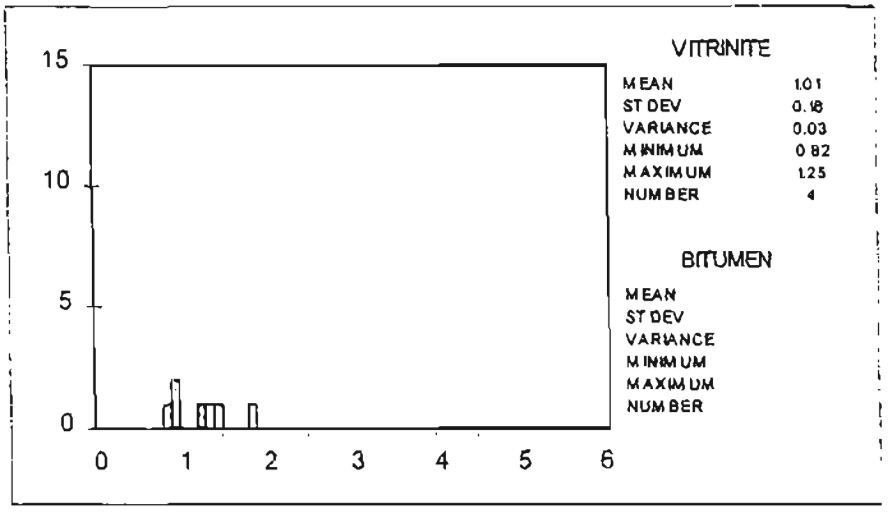
Visual Kerogen Summary

Unstructured Lipids	50
Structured Lipids	10
Solid Bitumen	5
Inertinite	20
Vitrinite	15
Other	0
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	2+,3-
TAI Structured	

COMMENTS:

DGSI Project 96/3631 Sample No. 25
OTHER ID96 MAW 18-B



VITRINITE	
MEAN	1.01
ST DEV	0.18
VARIANCE	0.03
MINIMUM	0.82
MAXIMUM	1.25
NUMBER	4

BITUMEN	
MEAN	
ST DEV	
VARIANCE	
MINIMUM	
MAXIMUM	
NUMBER	

L 0.82 v 1.49
V 0.99 v 1.89
V 0.99
V 1.25
v 1.39

TYPE	K/OC	
	TOC	0.47
	TMAX	454
	HI	11
	V Ro	?1.01
	B Ro	-
	VRE	-

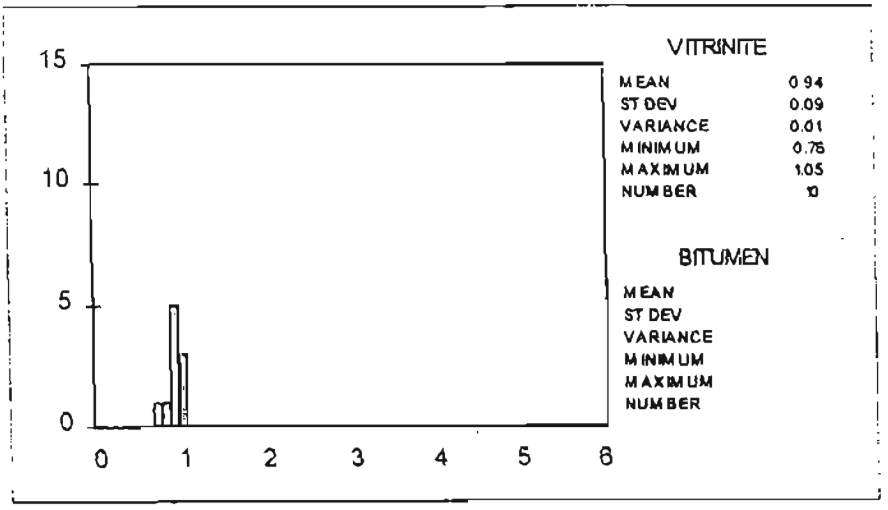
Visual Kerogen Summary

Unstructured Lipids	10
Structured Lipids	-
Solid Bitumen	T
Inertinite	60
Vitrinite	30
Other	0
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	2+
TAI Structured	

COMMENTS:

DGSI Project 96/3631 Sample No. 26
OTHER ID96 MAW 20-E



VITRINITE	
MEAN	0.94
ST DEV	0.09
VARIANCE	0.01
MINIMUM	0.76
MAXIMUM	1.05
NUMBER	10

BITUMEN	
MEAN	
ST DEV	
VARIANCE	
MINIMUM	
MAXIMUM	
NUMBER	

L 0.76 L 0.97
V 0.81 V 0.99
L 0.90 V 1.00
V 0.96 V 1.02
L 0.97 V 1.05

TYPE	K/OC	
	TOC	0.18
	TMAX	351
	HI	6
	V Ro	0.94
	B Ro	-
	VRE	-

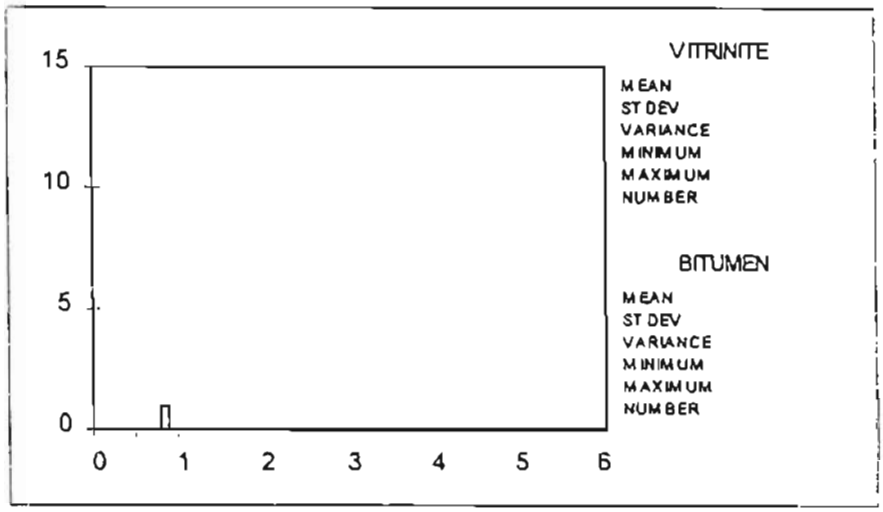
Visual Kerogen Summary

Unstructured Lipids	20
Structured Lipids	-
Solid Bitumen	-
Inertinite	10
Vitrinite	20
Other	50
TOTAL	100

Background Fluorescence	Weak
TAI Unstructured	2+
TAI Structured	

COMMENTS:

DGSI Project 96/3631 Sample No. 27
OTHER ID96 MAW 21-B



v 0.81

TYPE	K/OC	
	TOC	0.21
	TMAX	N.A.
	HI	0
	V Ro	-
	B Ro	-
	VRE	-

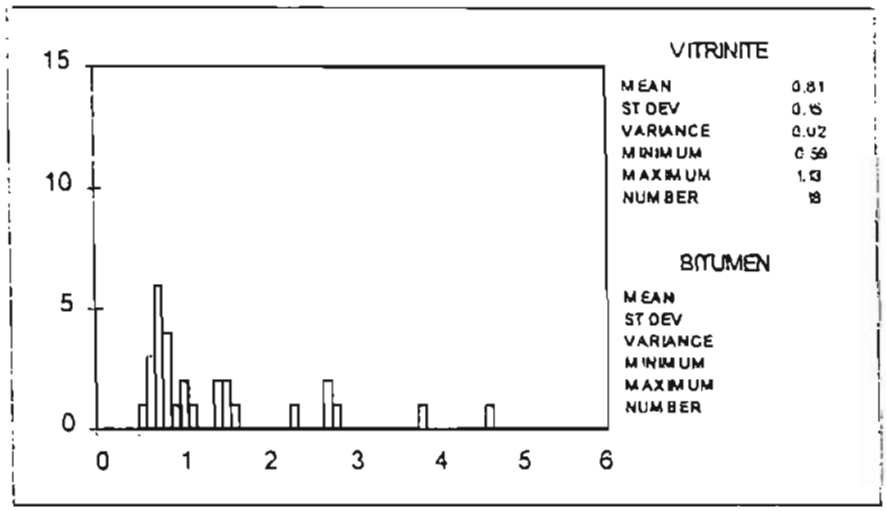
Visual Kerogen Summary

Unstructured Lipids	-
Structured Lipids	-
Solid Bitumen	-
Inertinite	T
Vitrinite	T
Other	0
TOTAL	0

Background Fluorescence	None,Weak
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 96/3631 Sample No. 28
OTHER ID96 MAW 22-B



L 0.59	L 0.70	V 0.83	L 1.00	v 1.51	v 2.77
L 0.62	L 0.73	L 0.86	L 1.02	v 1.55	v 2.83
L 0.65	V 0.74	L 0.87	V 1.13	v 1.60	v 3.86
L 0.69	V 0.75	L 0.88	I 1.41	v 2.38	v 4.67
L 0.70	L 0.77	L 0.99	I 1.42	v 2.75	

TYPE	K/OC	
	TOC	1.20
	TMAX	465
	HI	38
	V Ro	0.81
	B Ro	-
	VRE	-

Visual Kerogen Summary

Unstructured Lipids	10
Structured Lipids	5
Solid Bitumen	-
Inertinite	20
Vitrinite	30
Other	35
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:
Ro on lipid-rich vitrinite

GEOCHEMICAL EVALUATION OF OUTCROP SAMPLES NORTHWESTERN ALASKA

Interim Report

Prepared For:

State of Alaska
Dept. of Natural Resources
Division of Geological and Geophysical Surveys
794 University Avenue, Suite 200
Fairbanks, Alaska 99709

Prepared By:

Wallace G. Dow
DGSI Project: 97/3805
July 30, 1997

75

DGSI
Total Quality Geochemistry
DGSI • 8701 NEW TRAILS DRIVE • THE WOODLANDS, TX 77381
(281) 363-2176 • FAX (281) 292-3528 • EMAIL: dgsilab@onramp.net • www.dgsilab.com

Gill Mull
State of Alaska/DNR
DGGS
3700 Airport Way
Fairbanks, AK 99709-4699

July 30, 1997

Dear Gill:

Enclosed is our report on the twenty Alaska outcrops that you sent. This report includes the Total Organic Carbon, Rock Eval Pyrolysis and Kerogen Microscopy. We have also enclosed our invoice for the work performed thus far.

We have reviewed the data for both outcrop projects and we recommend that seven samples be analyzed by soxhlet extraction/gas chromatography. From the first project (96/3631) we recommend 96Mu33-5, 96MAW7, 96MAW9 and 96MAW11. From the second project (97/3805) we recommend 94Mu72-1, 96Mu35-2 and 96Mu46. After these are finished we will recommend that several be analyzed for biomarkers.

Please call or write if you have any questions about the work.

Sincerely,

John Allen
Lab Manager

JRA/el
Enclosure

DGSI
Total Quality Geochemistry
DGSI • 8701 NEW TRAILS DRIVE • THE WOODLANDS, TX 77381
(281) 363-2176 • FAX (281) 292-3528 • EMAIL: dgsilab@onramp.net • www.dgsilab.com

		GEOCHEM SAMPLES TO DGSI, 2nd SHIPMENT, DECEMBER								
	Sample #	Location	Box #	Collector	Formation	Age	Description	Analysis requested	Quadrangle	Discussion
1	96 Mu 6	NW of Poko Mtn	18	Mull	Torok	Aptian/Albian?	Clay shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
2	96 Mu 12	Kukpowruk River	18	Mull	Torok	Aptian/Albian?	Silty mudstone	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
3	96 Mu 14	S Driftwood anticline	18	Mull	Torok	Aptian/Albian?	Silty mudstone	Ro, TAI, kerogen type, Rock Eval, and TOC	Misheguk Mtn	
4	96 Mu 18	Tupikchak syncline	18	Mull	Nanushuk	Albian	Carb. shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
5	96 Mu 30-2	Plimegua trib.	33	Mull	Kingak	Jurassic	Sheared bk sh & bentonit	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
6	96 Mu 33-1	Thetis Creek	33	Mull	Kingak	Jurassic	Dk gr sh w bentonite	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
7	94 Mu 72-1	Ipewik River	33	Mull	Kingak	Jurassic	Dk gr organic shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
8	96 Mu 35-2	Thetis Ridge	33	Mull	Kingak	Jurassic	Organic shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
9	96 Mu 35-4	Thetis Ridge	33	Mull	Torok	Aptian/Albian?	Silty mudstone	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
10	96 Mu 46	Tingmerkpuk River	33	Mull	Torok	Jurassic	Organic shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
11	96 Mu 52-1	Horseshoe Bend	68	Mull	Kingak	Jurassic	Bk organic paper shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
12	96 Mu 57-4	Kukpowruk River	68	Mull	Kingak	Cret./Jurassic	Dk gr to bk shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
13	96 Ha 26	Spike/Ilgluruk Ck.	27	Harris	Lower Brookian	Probable Aptian	Ss, siltst, sh	Ro, TAI, kerogen type, Rock Eval, and TOC	Misheguk C5	
14	96 Ha 37	Plimegua tributary	27	Harris	Kingak	J. Jur to L. Cret	Bk shale w concretions	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong C4	
15	96 Ha 56	Upper Plimegua R.	43	Harris	Lower Brookian	Probable Aptian	Ss, siltst, sh	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong C4	
16	96 Ha 66	Spike Creek	43	Harris	Lower Brookian	Probable Aptian	Ss, siltst, sh	Ro, TAI, kerogen type, Rock Eval, and TOC	Misheguk Mtn. C5	
17	96 TM 29-B	Ilgluruk Creek	31	Moore	Lower Brookian	Aptian/Albian?	Claystone	Ro, TAI, kerogen type, Rock Eval, and TOC	Misheguk C5	
18	96 TM 56-A	Ilgluruk Creek	68	Moore	Lower Brookian	Aptian/Albian?	shale	Ro, TAI, kerogen type, Rock Eval, and TOC	Misheguk C5	
19	94 Mu43-1	Tingmerkpuk River measured section		Mickey/ Elder	Lower Brookian	Aptian/Albian?	Unit 7	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
20	94 Mu43-10	Tingmerkpuk River measured section			Lower Brookian	Aptian/Albian?	Unit 26-15.5 m.	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	

ORGANIC CARBON AND PYROLYSIS DATA

Total Organic Carbon (TOC) and Rock-Eval pyrolysis data provide basic geochemical information and are frequently used to select samples for more detailed studies, particularly kerogen microscopy, extract chromatography and biomarker analyses. Well data can be plotted to make geochemical logs. Unless otherwise specified by a client, DGSI uses LECO TOC then Rock-Eval II pyrolysis as the standard analytical sequence and Rock-Eval is recommended for samples with greater than 0.4% TOC. Samples for LECO TOC and Rock-Eval pyrolysis are ground to pass through a 60 mesh sieve to assure homogeneity.

LECO ORGANIC CARBON AND TOTAL SULFUR

Total Organic Carbon is best determined by direct combustion. Approximately 0.15 grams of sample are carefully weighed, treated with concentrated HCl to remove carbonates, and vacuum filtered on glass fiber paper. The residue and paper are placed in a ceramic crucible, dried, and combusted with pure oxygen in a LECO EC-12 or LECO CS-444 carbon analyzer at about 1,000°C. A laboratory standard is run every five samples. Total, insoluble, mineral plus organic sulfur can be determined by the CS-444 analyzer during the carbon analysis. Total carbonate can be determined from sample and acid residue weight differences or by LECO combustion TOC differences before and after acid digestion.

ROCK-EVAL II PYROLYSIS

Rock-Eval II pyrolysis is used to determine kerogen type, kerogen maturity and the amount of free hydrocarbons. About 0.1 grams of the same ground sample used for LECO TOC are carefully weighed in a pyrolysis crucible and then heated to 300°C to determine the amount of free hydrocarbons, S_1, that is thermally distilled. Next, the amount of pyrolyzable hydrocarbons, S_2, is measured when the sample is heated in an inert environment which rises from 300° to 550°C at a heating rate of 25°C/minute. S_1 and S_2 are reported in mg HC/g sample. T_{max}, a maturity indicator, is the temperature of maximum S_2 generation. When S_2 values are less than 0.2 mg HC/g sample, the S_2 maximum typically has poor definition and thus, Tmax cannot be reliably determined (Peters, 1986). Carbon dioxide generated during the S_2 pyrolysis, an indicator of kerogen oxidation, is collected up to a temperature of 390°C and reported as S_3 in units of mg CO_2/g sample. A laboratory standard is run every 10 samples. Hydrogen Index (HI = S_2*100/TOC) and Oxygen Index (OI = S_3*100/TOC) are used as kerogen type indicators when plotted on a van Krevelen type diagram.

ORGANIC CARBON AND ROCK-EVAL PYROLYSIS DATA

ALASKA OUTCROPS

DGSI Project: 97/3805

SAMPLE IDENTIFICATION DGSI ID		ID	TOC Wt%	S1 mg/g	S2 mg/g	S3 mg/g	Tmax degC	S1/ TOC	HI	OI	S2/ S3	PI
1	:	96 Mu 5	1.78	0.10	0.44	0.78	467	6	25	44	0.56	0.19
2	:	96 Mu 12	1.12	0.09	0.43	0.63	471	8	38	56	0.68	0.17
3	:	96 Mu 14	0.88	0.25	0.47	0.27	459	28	53	31	1.74	0.35
4	:	96 Mu 18	1.38	0.05	0.58	0.80	448	4	41	58	0.70	0.08
5	:	96 Mu 30-2	1.12	0.04	0.39	0.28	446	4	35	25	1.39	0.09
6	:	96 Mu 33-1	4.22	0.09	7.48	0.14	438	2	177	3	53.43	0.01
7	:	94 Mu 72-1	22.34	3.72	142.99	1.46	431	17	640	7	97.94	0.03
8	:	96 Mu 35-2	12.86	0.75	60.09	1.48	434	6	467	12	40.60	0.01
9	:	96 Mu 35-4	0.96	0.05	0.43	0.39	440	5	45	41	1.10	0.10
10	:	96 Mu 46	9.84	0 40	26.69	0.73	438	4	271	7	36.56	0.01
11	:	96 Mu 52-1	3.80	0.10	11.14	0.32	434	3	293	8	34.81	0.01
12	:	96 Mu 57-4	2.94	0.11	5.23	0.39	437	4	178	13	13.41	0.02
13	:	96 Ha 25	1.07	0.06	0.26	0.37	496	6	24	35	0.70	0.19
14	:	96 Ha 37	2.92	0.10	0.86	0.56	497	3	29	19	1.54	0.10
15	:	96 Ha 58	0.90	0.02	0.24	0.32	499	2	27	36	0.75	0.08
16	:	96 Ha 66	1.25	0.10	0.52	0.59	473	8	42	47	0.88	0.16
17	:	96 TM 29-B	1.12	0.06	0.34	0.43	499	5	30	38	0.79	0.15
18	:	96 TM 56-A	0.45	0.05	0.07	0.39	498	11	16	87	0.18	0.42
19	:	94 Mu 43-1	0.43	0.01	0.07	0.22	504	2	16	51	0.32	0.13
20	:	94 Mu 43-16	1.80	0.08	0.70	0.62	469	4	39	34	1.13	0.10

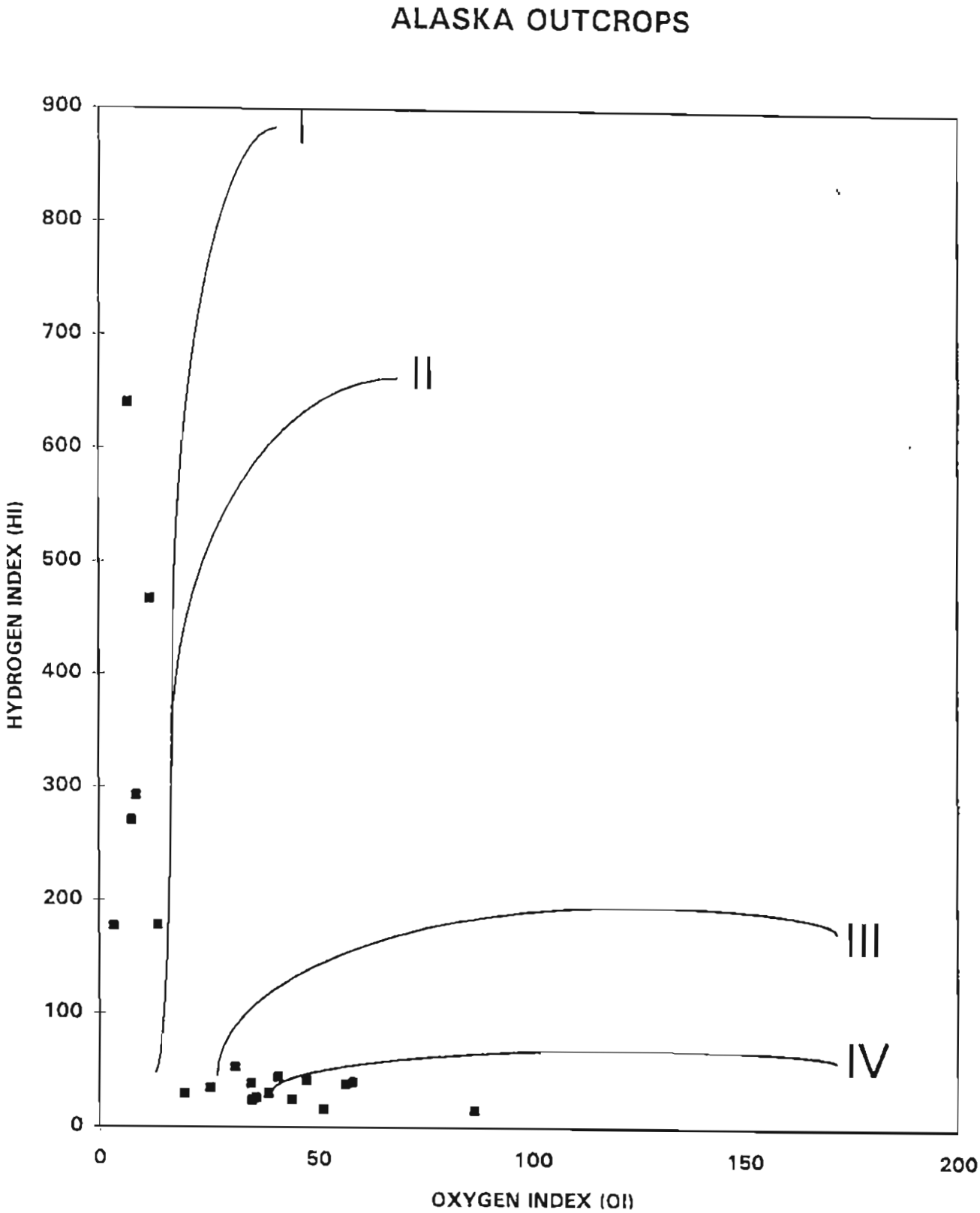


FIGURE 1 Kerogen type determination from TOC and Rock-Eval pyrolysis data. Types I and II will generate oil, type III gas, and type IV little or no hydrocarbons.

VISUAL KEROGEN ANALYSIS TECHNIQUES

Visual kerogen analysis employs a Zeiss Universal microscope system equipped with halogen, xenon, and tungsten light sources or a Jena Lumar microscope equipped with halogen and mercury light sources. Vitrinite reflectance and kerogen typing are performed on a polished epoxy plug of unfloated kerogen concentrate using reflected light from the halogen source. In certain situations, the whole rock is used for analysis. This approach is used for coals, where acid treatment is unnecessary in studies of solid bitumen and graptolites where preservation of rock structure is important, and in samples too small for acid treatment. The digital indicator is calibrated using a glass standard with a reflectance of 1.02% in oil. This calibration is linearly accurate for reflectance values ranging from peat (R_o 0.20%) through anthracite (R_o 4.0%).

Reflectance values are recorded only on good quality vitrinite, including obvious contamination and recycled material. The relative abundance of normal, altered, lipid-rich, oxidized, and coked vitrinite is recorded. When good quality, normal vitrinite is absent, notations are made indicating how the maturity is affected by weathering, oxidation, bitumen saturation, or coking. When normal vitrinite is absent or sparse, other macerals may be substituted. Solid bitumen, for example is present in many samples. Although solid bitumen has a different reflectance than vitrinite, Landis and Castaño's calibration chart is used to obtain an estimated vitrinite reflectance equivalent. Graptolites have a slightly higher reflectance than vitrinite and can often be used to obtain maturity data in Upper Cambrian-Silurian rocks that have no vitrinite.

Unstructured lipid kerogen changes in texture and color during the maturation process. Typically, unstructured kerogen at low maturity is reddish brown and amorphous. Somewhere between R_o 0.50 to 0.65%, the kerogen takes on a massive texture and is gray in color. At higher maturity, generally above R_o 1.30%, unstructured kerogen is light gray and micrinized.

Kerogen typing and maturity assessments from the polished plug are enhanced by utilizing fluorescence from blue light excitation. The xenon or mercury lamp is used with an excitation filter at 495 nm coupled with a barrier filter of 520 nm. With the Jena microscope we also have the option of observing fluorescence under ultraviolet excitation. The intensity of fluorescence in the epoxy mounting medium (background fluorescence) correlates well with the onset of oil generation and destruction. The identification of structured and unstructured liptinite is also enhanced with the use of fluorescence in those samples having a maturity less than R_o 1.3%. The relative abundance and type of pyrite is also recorded.

Thermal alteration index (TAI) is performed using tungsten or halogen light source that is transmitted through a glass slide made from the unfloated kerogen concentrate. Ideally, TAI color is based on sporinite of terrestrial origin. When sporinite is absent, TAI is estimated from the unstructured lipid material. Weathering, bitumen admixed with the unstructured material and micrinization can darken the kerogen and raise the TAI value. The character of the organic matter in transmitted light is correlated with observations made in reflected light for kerogen typing.

Kerogen typing and maturity assessments from the slide preparation are also reinforced by using different light sources. The slide is first observed in transmitted light to obtain TAI color and organic matter structure or type. The light is then switched to reflected halogen light to observe structure and amount of pyrite and finally to reflected blue light excitation from the xenon or mercury source for fluorescence. The fluorescence of structured and unstructured liptinite is not masked by the epoxy fluorescence as it is in the reflected light mode because the mounting medium is non-fluorescent. Lipid structures (e.g. sporinite and alginite) within the unstructured kerogen can often be identified in blue light.

Maturity calculations are made from the vitrinite reflectance histograms. Decisions as to which reflectance measurements indicate the maturity of the sample are based not only on the histogram but on all of the kerogen descriptive elements as well. Because it is not done at the time of measurement, alternate maturity calculations can be made if kerogen data and geological information dictate.

DGSI's vitrinite reflectance histograms contain much useful information. All reflectance measurements are graphically displayed and the individual readings are listed below the histogram in numeric order. In the reflectance table, each reading is coded with a letter corresponding to the measured maceral. Capital letters are used to designate reflectance values that are used in calculating the mean reflectance while reflectance values falling outside the selected range are shown with a lower case letter code. Reflectance readings lying inside the selected range are marked with a pattern on the histogram diagram and readings falling outside the selected range are left open. Each maceral has a different pattern. Codes currently in use include: Solid bitumen (B), Granular solid bitumen (X), Coked solid bitumen (Y), Graptolites (G), Inertinite (I), Other 1 (O), Other 2 (W), Vitrinite (V), Lipid-rich vitrinite (L), and Coked Vitrinite (Z). The use of two 'other' categories allows us the flexibility of measuring unusual materials that do not fall into one of the other classes or contamination from mud additives or caving. Specific information regarding 'other' material is shown in the Comments section at the lower right corner of the Figure and in the Comments section of the VKA data sheet.

Statistics for selected macerals are listed adjacent to the histogram and the mean reflectance values are also listed below the TOC and Rock-Eval data at the upper right corner of the Figure. The <u>measured</u> reflectance values for solid bitumen and graptolites are recalculated in order to obtain a <u>vitrinite reflectance equivalent (VRE).</u> Therefore, for these two macerals we show both the measured reflectance and the VRE. For example, VRE-B signifies vitrinite reflectance equivalent for solid bitumen and VRE-G is the vitrinite reflectance equivalent for graptolites.

In summary, vitrinite reflectance measurements are performed on a polished plug in reflected light, TAI is performed on a slide in transmitted light, and kerogen typing is estimated from both preparations using a combination of reflected, transmitted, and fluorescent light techniques. Fluorescence in blue light is used to enhance the identification of structured and unstructured lipid material, solid bitumens, and drilling mud contaminants. Fluorescence also correlates with the maturity and state of preservation of the sample. Maturity calculations from measured reflectance data are made from the histograms and are influenced by all of the kerogen data.

VISUAL KEROGEN ANALYSIS GLOSSARY

Several key definitions are included in this glossary in order to make our reports more self-explanatory. In our reports, we refer to organic substances as macerals. Macerals are akin to minerals in rock in that they are organic constituents that have microscopically recognizable characteristics. However, macerals vary widely in their chemical and physical properties and they are not crystalline.

1. UNSTRUCTURED KEROGEN is sometimes called structureless organic matter (SOM) or bituminite. It is widely held that unstructured kerogen represents the bacterial breakdown of lipid material. It also includes fecal pellets, minute particles of algae, organic gels, and may contain a humic component. As described on the first page of this section, unstructured lipid kerogen changes character during maturation. The three principal stages are amorphous, massive, and micrinized. Amorphous kerogen is simply without any structure. Massive kerogen has taken on a cohesive structure, as the result of polymerization during the process of oil generation. At high maturity, unstructured kerogen becomes micrinized. Micrinite is characterized optically by an aggregation of very small (less than one micron) round bodies that make up the kerogen.

2. STRUCTURED LIPID KEROGEN consists of a group of macerals which have a recognized structure, and can be related to the original living tissue from which they were derived. There are many different types, and the types can be group follows:

   a. Alginite, derived from algae. It is sometimes very useful to distinguish the different algal types, for botryococcus and pediastrum are associated with lacustrine and non-marine source rocks, while algae such as tasmanites, gloecapsomorpha, and nostocopsis are typically marine. Acritarchs and dinoflaggelates are marine organisms which are also included in the algal category.
   b. Cutinite, derived from plant cuticles, the remains of leaves.
   c. Resinite, (including fluorinite) derived from plant resins, balsams, latexes, and waxes.
   d. Sporinite, derived from spores and pollen from a wide variety of land plants.
   e. Suberinite is derived from the corky tissue of land plants.
   f. Liptodetrinite is that structured lipid material that is too small to be specifically identified. Usually, it is derived from alginite or sporinite.

   The algae are an important part of many oil source rocks, both marine and lacustrine. Alginite has a very high hydrogen index in Rock-Eval pyrolysis. Resins, cuticles, and suberinite contribute to the waxy, non-marine oils that are found in Africa and the Far East. At vitrinite reflectance levels above R_o 1.2 - 1.4%, structured lipid kerogen changes structure and it becomes very difficult to distinguish them from vitrinite.

3. SOLID BITUMEN also is called migrabitumen and solid hydrocarbon. In 1992, the International Committee for Coal and Organic Petrology (ICCP) decided to include solid bitumen in the Exsudatinite group. Solid bitumens are expelled hydrocarbon products which have particular morphology, reflectance and fluorescence properties which make it possible to identify them. They represent two classes of substances: one which is present at or near the place where it was generated, and second is a substance which is present in a reservoir rock and may have migrated a great distance from its point of origin. The solid bitumens have been given names, such as gilsonite, impsonite, grahamite, etc., but they represent generated heavy hydrocarbons which remain in place in the source rock or have migrated into a reservoir and mature along with the rock. Consequently, it is possible to use the reflectance of solid bitumens for maturation determinations when vitrinite is not present.

4. HUMIC TISSUE is organic material derived from the woody tissue of land plants. The most important of this group are vitrinite and inertinite:

   a. Vitrinite is derived from woody tissue which has been subjected to a minimum amount of oxidation. Normally it is by far the most abundant maceral in humic coals and because the rate of change of vitrinite reflectance is at a more even pace than it is for other macerals, it offers the best means of obtaining thermal maturity data in coals and other types of sedimentary rocks.

Because the measurement of vitrinite is so important, care is taken to distinguish normal (fresh, unaltered) vitrinite from other kinds of vitrinite. Rough vitrinite does not take a good polish and therefore may not yield good data. Oxidized vitrinite may have a reflectance higher or lower than fresh vitrinite; this is a problem often encountered in outcrop samples. Lipid-rich vitrinite, or saprovitrinite, has a lower reflectance than normal vitrinite and will produce an abnormally low thermal maturity value. Coked vitrinite is vitrinite that has structures found in vitrinite heated in a coke oven. Naturally coked vitrinite is the product of very rapid heating, such as that found adjacent to intrusions. Where it is possible to do so, vitrinite derived from an uphole portion of a well will be identified as caved vitrinite. Recycled vitrinite is the vitrinite of higher maturity which clearly can be separated from the indigenous first-cycle vitrinite population. Often, the recycled vitrinite merges in with the inert group.

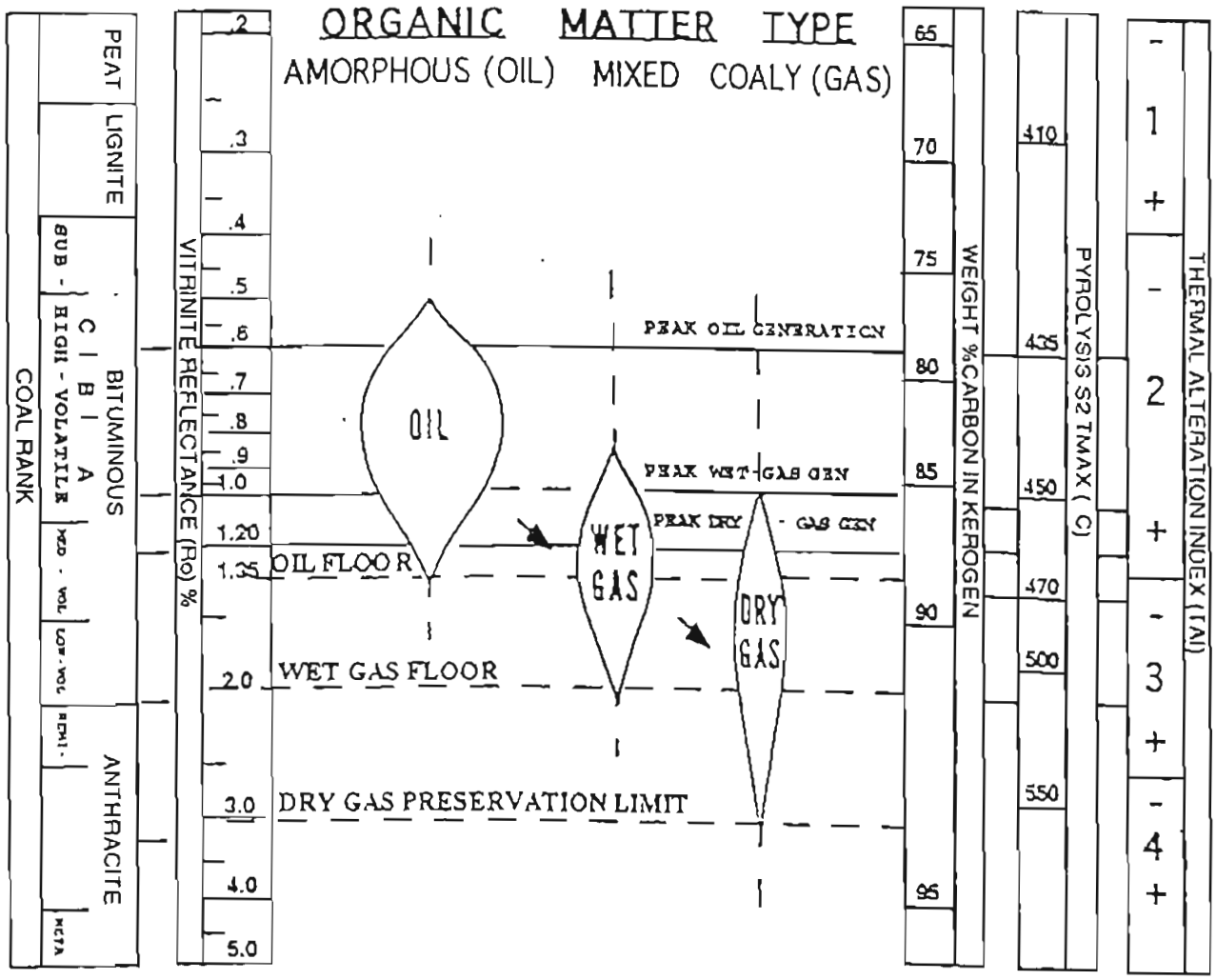
   b. Inertinite is made up of woody tissue that has been matured by a different pathway. Early intense oxidation, usually involving charring, fungal attack or biochemical gelification, creates the much more highly reflecting fusinite and semi-fusinite. Sometimes the division between vitrinite and fusinite is transitional. Sclerotinite, fungal remains having a distinct morphology, are considered to be inert. An important consideration is that the inerts, as the name implies, are largely non- reactive "dead carbon" and they have an extremely low hydrogen index in Rock-Eval pyrolysis.

5. OTHER ORGANIC MATERIAL

a. Lipid-rich, caved and recycled vitrinite. These are put in this section so we can show the percentages of these macerals; they are described above.
b. Exsudatinite. Oil and oily exudates fall in this group. Exsudatinite differs from the solid bitumens on the basis of mobility and solubility. We prefer to maintain this distinction although the ICCP has now included the solid bitumens in with the Exsudatinite group.
c. Graptolites are marine organisms that range from the Cambrian to the lower Mississippian; it has been found that they have a reflectance slightly higher than vitrinite. Because vitrinite is lacking in early Paleozoic rocks, the proper identification and measurement of graptolites is important in these sediments.

6. PYRITE. Various forms of pyrite can be readily identified under the microscope. Euhedral is pyrite with a definite crystalline habit. Framboidal is pyrite in the form of grape-like clusters which are made up of euhedral to subhedral crystals. Framboidal pyrite is normally found in sediments with a marine influence; for example, coals with a marine shale roof rock usually contain framboidal pyrite. Massive pyrite is pyrite with no particular external form. Often this is pyrite that forms rather late in the pore spaces of the sediment. Replacement/infilling is self-explanatory.

ZONES OF PETROLEUM GENERATION AND DESTRUCTION



CORRELATION OF VARIOUS MATURATION INDICES AND ZONES OF PETROLEUM GENERATION AND DESTRUCTION.

ALASKA OUTCROPS

DGSI Project: 97/3805

DGSI

DGSI NUMBER	DATE: 7/3/97 IDENTIFICATION	PREPARATION/ SAMPLE TYPE	ORGANIC MATTER (%) LIPIDS UNSTRUCTURED UNDIFFERENTIATE	AMORPHOUS	MASSIVE	MICRINIZED	STRUCTURED TYPE	TYPE	TYPE	TYPE	SOLID BITUMEN	HUMIC INERTINITE	VITRINITE	OTHER TYPE	TYPE	RELATIVE ABUNDANCE PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI REFLECTED LIPIDS UNSTR. COLOR	INTENSITY	STRU. COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED LIPIDS UNSTR. TAI VALUE	FLUOR. COLOR	INTENSITY	STRU TAI VALUE	FLUOR COLOR	INTENSITY	Ro VITRINITE REFLECTANCE OR EQUIVALENCY
1	96 Mu 5	K/OC	10				LD T					15	15	VL 60		MA F	-	M	M	-	+		T	n d		DO	1	3	n d				O	1	- V 0 90
Comments:	*Mixture of small terrestrial fragments with some desmocollinite. Trace graphite.*																																			
2	96 Mu 12	K/OC	5									10	80	VL 5		MA	M	M	+	-	-		T	n.d.				3	n d.						- V 1.04
Comments:	*Mixture of small terrestrial fragments. Trace graphite.*																																			
3	96 Mu 14	K/OC	15									15	65	VL 5		MA	M	M	+	-	-		T	n.d.		DO	1	4	n d.				O	1	- V 0.89
Comments:	*Similar to 96 Mu 12.*																																			
4	96 Mu 18	K/OC	10				LD 5					15	65	VL 5		MA	M	T	+	-	-			LR		O	1	4	n.d.				O Y	2 3	- V 0.65
Comments:	*Terrestrial fragments as in 96 Mu 12 and 14, but slightly larger.*																																			
5	96 Mu 30-2	K/OC	5				LD 5					10	70	VL 10		MA	M	M	+	-	-		T	n d.		O	1 3	3	n.d.				O	2	- V 0.74
Comments:	*Mixture of terrestrial fragments. Trace graphite.*																																			

ANALYST

X O'Connor

MICROSCOPE

X Zeiss

SAMPLE TYPE/PREP		STRUCTURED LIPIDS		OTHER ORGANIC MATTER		PYRITE		ABUND.		FLUOR. INTENS.		VIT. REFLECT. EQUIVALENCE		FLUOR. COLOR		TAI COLOR VALUES	
CTG	Cuttings	AL	Alginite	E	Exsudatinite	E	Euhedral	N	None	0	None	B	Bitumen	W	White	1-	Straw Yellow
CC	Conv. Core	SB	Suberinite	G	Graptolites	F	Framboid	T	Trace	1	Weak	G	Graptolites	G	Green	1	Pale Yellow
SWC	SideWallCore	C	Cutinite	VL	Lipid-Rich Vitrinite	MA	Massive	-	Small Amt.	2	Moderate	VL	Lipid-Rich Vitrinite	Y	Yellow	1+	Yellow
OC	Outcrop	LD	Liptodetrinite	VC	VitrinteContamination	RI	Replace-infill	M	Mod. Amt.	3	Strong	VC	Vitrinite Contam.	O	Orange	2-	Yellow-Orange
NI	No Inform.	U	Undiffer	VR	Recycled Vitrinite			+	Large Amt.	4	Intense	VR	Recycled Vitrinite	R	Red	2	Golden
C	Coal	S	Sporinite					++	Abundant					B	Brown	2+	Amber
		R	Resinite											BL	Black	3-	Reddish Brown
K	Kerogen	O	Other													3	Medium Brown
WR	Whole Rock															3+	Dark Brown
														L	Light	4-	Brown-Black
n.d.	Not Determined													D	Dark	4	Black
																4+	Black-Opaque

VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

ALASKA OUTCROPS

DGSI Project: 97/3805

DGSI

DGSI NUMBER	DATE: 7/3/97 IDENTIFICATION	PREPARATION/ SAMPLE TYPE	ORGANIC MATTER (%) LIPIDS UNSTRUCTURED UNDIFFERENTIATE	AMORPHOUS	MASSIVE	MICRINIZED	STRUCTURED TYPE	TYPE	TYPE	TYPE	SOLID BITUMEN	HUMIC INERTINITE	VITRINITE	OTHER TYPE	TYPE	RELATIVE ABUNDANCE PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI REFLECTED LIPIDS UNSTR. COLOR	INTENSITY	STRU. COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED LIPIDS UNSTR. TAI VALUE	FLUOR. COLOR	FLUOR. INTENSITY	STRU. TAI VALUE	FLUOR. COLOR	FLUOR. INTENSITY	Ro VITRINITE REFLECTANCE OR EQUIVALENCY
6	96 Mu 33-1	K/OC	75				LD 10				5	5	5			MA	-	M	+	-				DB	1			4	2+	BL	0		O	1 2	- V ?0 77
Comments:	Very small, angular fragments of solid bitumen in grainy lipids. Difficult to differentiate vit. from non-angular solid bit in kerogen sample																																		
7	94 Mu 72-1	K/OC			50		AL 40				? 10	T		VL T		MA	-	+	N	-	+			B	1	Y	2	2	2+ 3-	OB	2		Y	2 4	- V ?0 69
Comments:	Groundmass of massive lipids with alginite and solid bitumen fragments - difficult to differentiate in reflected light																																		
8	96 Mu 35-2	K/OC				70	AL 20				? 10	T	T	VL T		MA	-	+	M	-	M			DB	1	O	2	2	3-	DOB	1		O	2	- V ?0.75
Comments:	Unstructured lipids appear to be micrinized Alginite and granular bitumen as in 96 Mu 75-1. Remnant algal structure identified in slide.																																		
9	96 Mu 35-4	K/OC	25				LD T	S T				10	35	VL 30		MA F	M	M	M	-	M		T	DB	1	O	2	3	3	BL	0	2+	O	2 3	- V 0.61
Comments:	Unstructured lipids have grainy texture. Trace graphite.																																		
10	96 Mu 46	K/OC				30	AL 10				55	T	T	VL 5		F MA	M	+	-	-	+			BL	0	BL	0	1 2	3+	BL	0				- V 70.98
Comments:	Angular solid bitumen dissolves when analyzed for fluorescence. Some angular material may be alginite. Bitumen raises TAI value																																		

ANALYST	SAMPLE TYPE/PREP	STRUCTURED LIPIDS	OTHER ORGANIC MATTER	PYRITE	ABUND.	FLUOR. INTENS.	VIT. REFLECT. EQUIVALENCE	FLUOR. COLOR	TAI COLOR VALUES
X O'Connor	CTG Cuttings	AL Alginite	E Exsudatinite	E Euhedral	N None	0 None	B Bitumen	W White	1- Straw Yellow
	CC Conv. Core	SB Suberinite	G Graptolites	F Framboid	T Trace	1 Weak	G Graptolites	G Green	1 Pale Yellow
	SWC SideWallCore	C Cutinite	VL Lipid-Rich Vitrinite	MA Massive	- Small Amt	2 Moderate	VL Lipid-Rich Vitrinite	Y Yellow	1+ Yellow
	OC Outcrop	LD Liptodetrinite	VC VitriniteContamination	RI Replace-infill	M Mod. Amt.	3 Strong	VC Vitrinite Contam.	O Orange	2- Yellow-Orange
	NI No Inform.	U Undiffer.	VR Recycled Vitrinite		+ Large Amt.	4 Intense	VR Recycled Vitrinite	R Red	2 Golden
	C Coal	S Sporinite			++ Abundant			B Brown	2+ Amber
MICROSCOPE		R Resinite						BL Black	3- Reddish Brown
	K Kerogen	O Other							3 Medium Brown
	WR Whole Rock								3+ Dark Brown
X Zeiss								L Light	4- Brown-Black
	n.d. Not Determined							D Dark	4 Black
									4+ Black-Opaque

VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

ALASKA OUTCROPS

DGSI Project: 97/3805

DGSI NUMBER	DATE: 7/3/97 IDENTIFICATION	PREPARATION/ SAMPLE TYPE	ORGANIC MATTER (%) LIPIDS UNSTRUCTURED: UNDIFFERENTIATE	AMORPHOUS	MASSIVE	MICRINIZED	STRUCTURED TYPE	TYPE	TYPE	TYPE	SOLID BITUMEN	HUMIC INERTINITE	VITRINITE	OTHER TYPE	TYPE	RELATIVE ABUNDANCE PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI REFLECTED LIPIDS UNSTR. COLOR	INTENSITY	STRU. COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED LIPIDS UNSTR. TAI VALUE	FLUOR. COLOR	FLUOR. INTENSITY	STRU. TAI VALUE	FLUOR. COLOR	FLUOR. INTENSITY	Ro VITRINITE REFLECTANCE OR EQUIVALENCY
11	96 Mu 52-1	K/OC			55		AL 10				? 30	T	T	VL 5		MA	-	+	-	M	+			DB	1	O	2	2 3	3-	DOB	1		O	1 2	- V ?0.68
Comments:	Mixture of angular solid bitumen and remnant algal structure ? - difficult to identify. Unstr. lipids have massive-micrnized texture.																																		
12	96 Mu 57-4	K/OC	70				AL 10				? 10	5		VL 5		MA F	-	+	N	M	+			DB	1	O	1	3	2+ 3-	BL DOB	0 1		O	1	- V ?1.08
Comments:	Grainy lipids with angular alginite and solid bitumen? - difficult to identify.																																		
13	96 Ha 25	K/OC	30				U S					20	45			MA	M	+	+	-	?			BL	0	BL	0	3	n.d.						- V 1.65
Comments:	Small terrestrial fragments - difficult to separate vitrinite from inertinite. Grainy lipids.																																		
14	96 Ha 37	K/OC				80	U T	S T			5	5	10			F MA	M	+	M	M	?		M	BL	0	BL	0	2 3	3- 3+	BL	0	3+	BL	0	- V 1.81
Comments:	Slight anisotrophy may lower some Ro values.																																		
15	96 Ha 58	K/OC	10				U T					15	75			MA E	M	+	+					n.d		BL	0	2 3	n.d.						- V 1.67
Comments:	Small terrestrial fragments.																																		

ANALYST	SAMPLE TYPE/PREP	STRUCTURED LIPIDS	OTHER ORGANIC MATTER	PYRITE	ABUND.	FLUOR. INTENS.	VIT. REFLECT. EQUIVALENCE	FLUOR. COLOR	TAI COLOR VALUES
X O'Connor	CTG Cuttings	AL Alginite	E Exsudatinite	E Euhedral	N None	0 None	B Bitumen	W White	1- Straw Yellow
	CC Conv Core	SB Suberinite	G Graptolites	F Framboid	T Trace	1 Weak	G Graptolites	G Green	1 Pale Yellow
	SWC SideWallCore	C Cutinite	VL Lipid-Rich Vitrinite	MA Massive	- Small Amt	2 Moderate	VL Lipid-Rich Vitrinite	Y Yellow	1+ Yellow
	OC Outcrop	LD Liptodetrinite	VC VitrinteContamination	RI Replace-infill	M Mod. Amt.	3 Strong	VC Vitrinite Contam.	O Orange	2- Yellow-Orange
	NI No Inform	U Undiffer.	VR Recycled Vitrinite		+ Large Amt.	4 Intense	VR Recycled Vitrinite	R Red	2 Golden
MICROSCOPE	C Coal	S Sporinite			++ Abundant			B Brown	2+ Amber
		R Resinite						BL Black	3- Reddish Brown
	K Kerogen	O Other							3 Medium Brown
	WR Whole Rock								3+ Dark Brown
X Zeiss	n.d. Not Determined							L Light	4- Brown-Black
								D Dark	4 Black
									4+ Black-Opaque

VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

ALASKA OUTCROPS

DGSI Project: 97/3805

DGSI

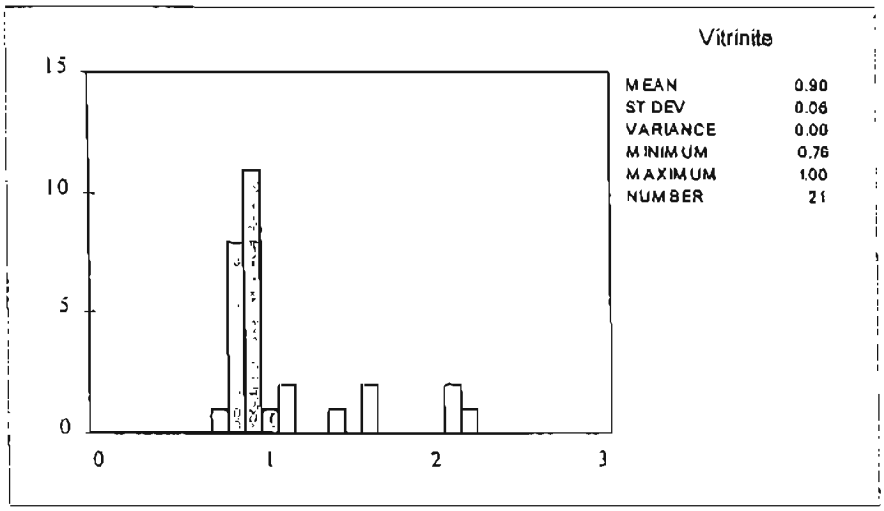
DGSI NUMBER	DATE: 7/3/97 / IDENTIFICATION	PREPARATION/ SAMPLE TYPE	ORGANIC MATTER (%) LIPIDS UNSTRUCTURED: UNDIFFERENTIATE	AMORPHOUS	MASSIVE	MICRINIZED	STRUCTURED: TYPE	TYPE	TYPE	TYPE	SOLID BITUMEN	HUMIC: INERTINITE	VITRINITE	OTHER: TYPE	TYPE	RELATIVE ABUNDANCE: PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE: NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI REFLECTED LIPIDS: UNSTR. COLOR	INTENSITY	STRU COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED LIPIDS: UNSTR. TAI VALUE	UNSTR. FLUOR. COLOR	UNSTR. FLUOR. INTENSITY	STRU. TAI VALUE	STRU. FLUOR. COLOR	STRU. FLUOR. INTENSITY	Ro: VITRINITE REFLECTANCE OR EQUIVALENCY
16	96 Ha 66	K/OC	30				U T					20	50	VL T		MA F	M	+	+	-	T		T	BL	0	BL	0	4	3-	BL	0				V ?1.20
Comments:	Small terrestrial fragments with grainy lipids.																																		
17	96 TM 29-B	K/OC	10				U T					15	70	VL 5		MA F	M	M	+	T	-			BL	0	BL	0	2	n.d						V 1.72
Comments:	Small terrestrial fragments with grainy lipids.																																		
18	96 TM 56-A	K/OC	20				U T					20	60	VL T		MA F	M	M	+	T	T	?		BL	0	BL	0	1	n.d						V 1.72
Comments:	Small terrestrial fragments.																																		
19	94 Mu 43-1	K/OC	50			10						20	20	VL T		MA	M	-	+	-	T			? B	1			3	3	BL	0				V 1.78
Comments:	Small amount of organic matter. Ro on small vitrinite-like fragments.																																		
20	94 Mu 43-16	K/OC	70				U T					10	20	VL T		MA F	M	M	+	-	T		T	BL	0	BL	0	4	3-3	BL	0				V 1.29
Comments:	Ro on small, vitrinite-like fragments. Fine-grained unstructured lipids mixed with mineral. Trace graphite.																																		

ANALYST	SAMPLE TYPE/PREP	STRUCTURED LIPIDS	OTHER ORGANIC MATTER	PYRITE	ABUND.	FLUOR. INTENS.	VIT. REFLECT. EQUIVALENCE	FLUOR. COLOR	TAI COLOR VALUES
X O'Connor	CTG Cuttings	AL Alginite	E Exsudatinite	E Euhedral	N None	0 None	B Bitumen	W White	1- Straw Yellow
	CC Conv. Core	SB Subalginite	G Graptolites	F Framboid	T Trace	1 Weak	G Graptolites	G Green	1 Pale Yellow
	SWC SideWallCore	C Cutinite	VL Lipid-Rich Vitrinite	MA Massive	- Small Amt	2 Moderate	VL Lipid-Rich Vitrinite	Y Yellow	1+ Yellow
MICROSCOPE	OC Outcrop	LD Liptodetrinite	VC VitriniteContamination	RI Replace-infill	M Mod. Amt	3 Strong	VC Vitrinite Contam.	O Orange	2- Yellow-Orange
	NI No Inform.	U Undiffer	VR Recycled Vitrinite		+ Large Amt	4 Intense	VR Recycled Vitrinite	R Red	2 Golden
	C Coal	S Sporinite			++ Abundant			B Brown	2+ Amber
		R Resinite						BL Black	3- Reddish Brown
	K Kerogen	O Other							3 Medium Brown
	WR Whole Rock								3+ Dark Brown
X Zeiss								L Light	4- Brown-Black
	n.d. Not Determined							D Dark	4 Black
									4+ Black-Opaque

VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

DGSI Project 97/3805 Sample No. 1
OTHER ID: 96 Mu 5

TYPE	K/OC	
	TOC	1.78
	TMAX	467
	HI	25
	V Ro	0.90



L 0.76	L 0.87	L 0.91	L 0.94	V 1.00	v 1.61
L 0.82	L 0.87	L 0.91	L 0.94	v 1.10	v 2.10
V 0.84	L 0.88	V 0.91	L 0.95	I 1.19	v 2.19
L 0.85	L 0.89	L 0.93	L 0.95	I 1.48	v 2.23
L 0.86	L 0.91	L 0.94	L 0.96	v 1.60	

Visual Kerogen Summary

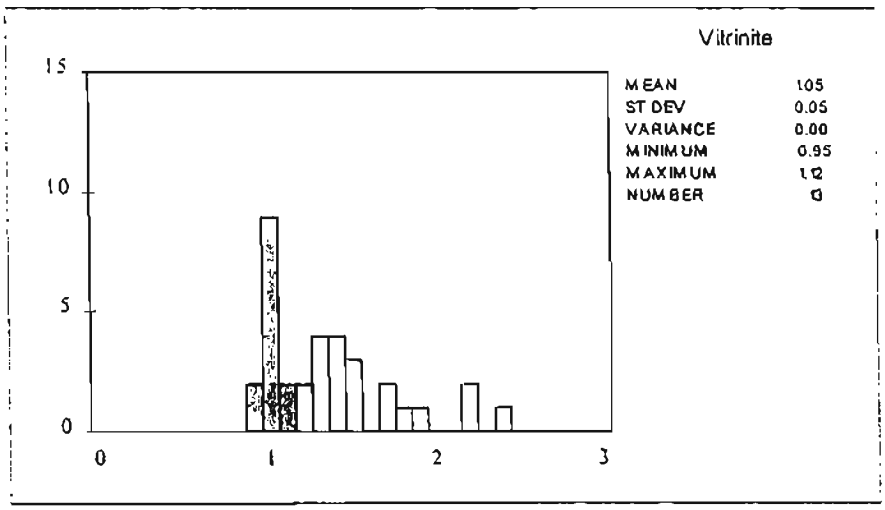
Unstructured Lipids	10
Structured Lipids	-
Solid Bitumen	-
Inertinite	15
Vitrinite	15
Other	60
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 2
OTHER ID: 96 Mu 12

TYPE	K/OC	
	TOC	1.12
	TMAX	471
	HI	38
	V Ro	1.04



V 0.95	L 1.05	V 1.09	v 1.30	v 1.40	v 1.59	v 2.22
L 0.97	V 1.05	V 1.10	v 1.31	v 1.46	v 1.74	I 2.28
L 1.00	V 1.07	V 1.12	v 1.31	v 1.48	v 1.78	v 2.48
L 1.01	V 1.07	I 1.21	v 1.33	v 1.51	v 1.88	
V 1.03	V 1.07	v 1.22	v 1.40	v 1.59	v 1.99	

Visual Kerogen Summary

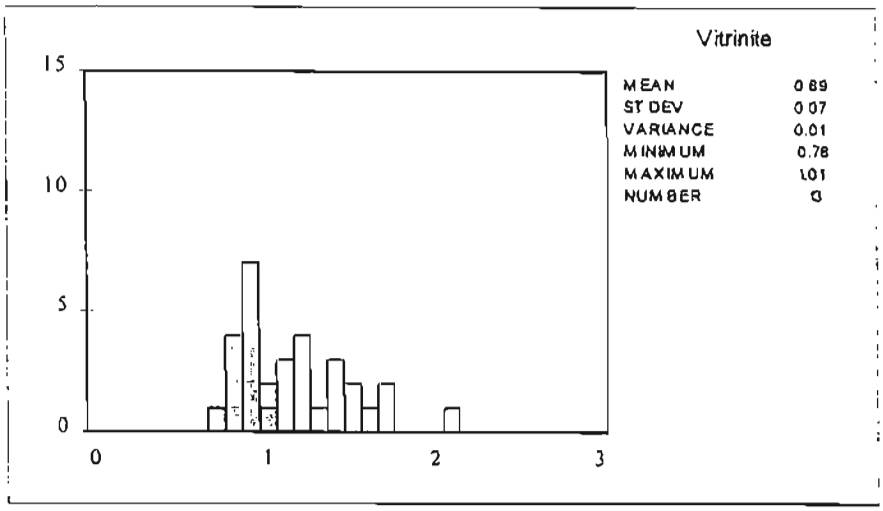
Unstructured Lipids	5
Structured Lipids	-
Solid Bitumen	-
Inertinite	10
Vitrinite	80
Other	5
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 3
OTHER ID: 96 Mu 14

TYPE	K/OC	
	TOC	0.88
	TMAX	459
	HI	53
	V Ro	0.89



L 0.78 L 0.90 V 0.95 v 1.15 v 1.28 v 1.54 v 2.12
L 0.81 L 0.91 L 0.98 v 1.17 v 1.31 v 1.58
V 0.82 V 0.91 V 1.01 v 1.20 v 1.41 v 1.63
L 0.83 V 0.92 v 1.08 v 1.24 v 1.42 v 1.71
V 0.87 L 0.93 v 1.11 v 1.27 v 1.49 v 1.75

Visual Kerogen Summary

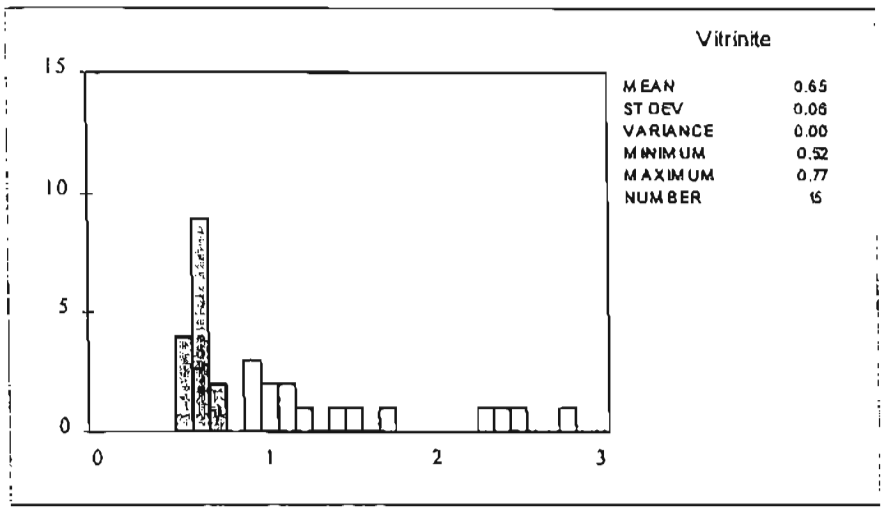
Unstructured Lipids	15
Structured Lipids	-
Solid Bitumen	-
Inertinite	15
Vitrinite	65
Other	5
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 4
OTHER ID: 96 Mu 18

TYPE	K/OC	
	TOC	1.38
	TMAX	448
	HI	41
	V Ro	0.65



V 0.52 V 0.63 V 0.67 v 0.94 v 1.12 v 1.79
L 0.59 L 0.64 V 0.69 v 0.97 v 1.15 v 2.39
V 0.59 L 0.66 V 0.69 v 0.99 v 1.26 v 2.41
V 0.59 V 0.66 V 0.74 v 1.05 v 1.47 v 2.56
L 0.60 L 0.67 V 0.77 v 1.09 v 1.52 v 2.89

Visual Kerogen Summary

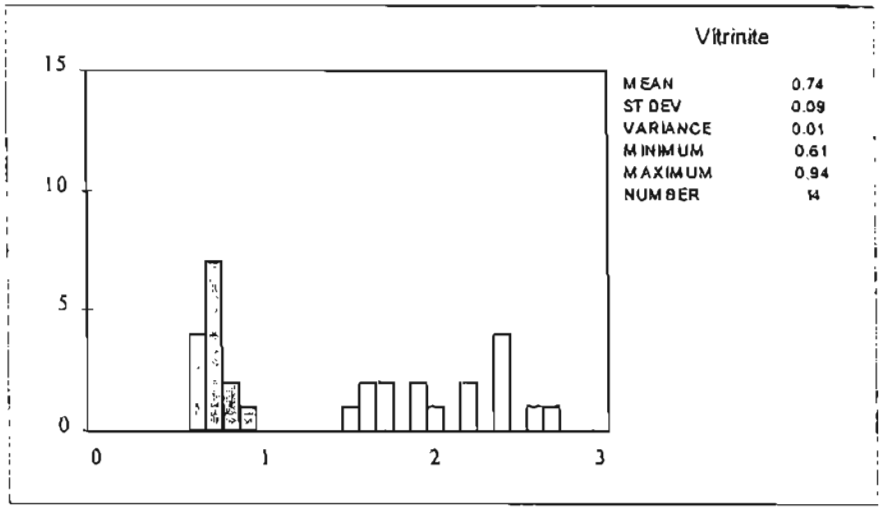
Unstructured Lipids	10
Structured Lipids	5
Solid Bitumen	-
Inertinite	15
Vitrinite	65
Other	5
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 5
OTHER ID: 96 Mu 30-2

TYPE	K/OC	
	TOC	1.12
	TMAX	446
	HI	35
	V Ro	0.74



L 0.61 V 0.72 V 0.79 v 1.61 v 1.91 v 2.46
V 0.61 L 0.74 V 0.80 v 1.67 v 2.00 v 2.47
L 0.62 V 0.75 V 0.83 v 1.72 v 2.20 v 2.48
V 0.66 L 0.78 V 0.94 v 1.74 v 2.21 v 2.69
V 0.70 L 0.79 v 1.53 v 1.91 12.46 v 2.73

Visual Kerogen Summary

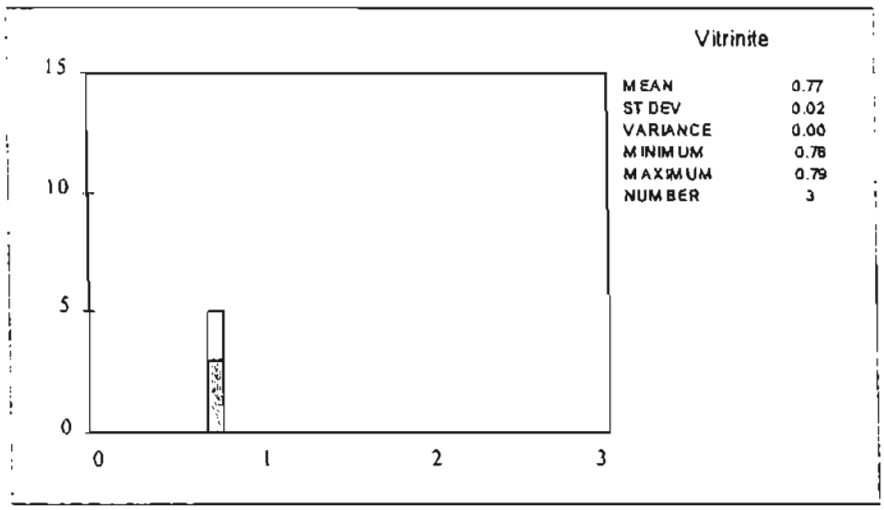
Unstructured Lipids	5
Structured Lipids	5
Solid Bitumen	-
Inertinite	10
Vitrinite	70
Other	10
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 6
OTHER ID: 96 Mu 33-1

TYPE	K/OC	
	TOC	4.22
	TMAX	438
	HI	177
	V Ro	?0.77



b 0.74
b 0.76
V 0.76
V 0.76
V 0.79

Visual Kerogen Summary

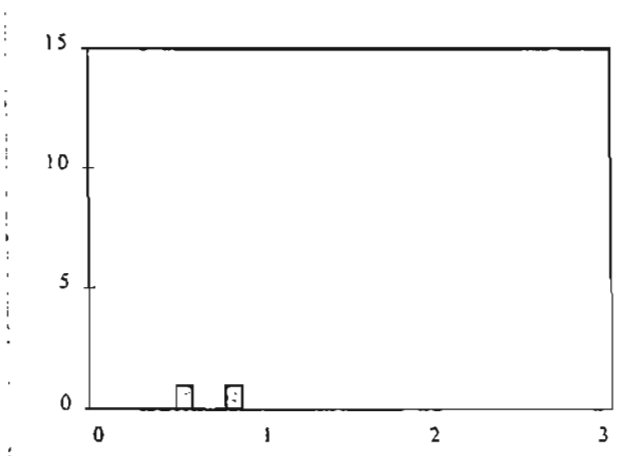
Unstructured Lipids	75
Structured Lipids	10
Solid Bitumen	5
Inertinite	5
Vitrinite	5
Other	0
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	2+
TAI Structured	

COMMENTS:

VITRINITE REFLECTANCE ALASKA OUTCROPS

DGSI Project 97/3805 Sample No. 7
OTHER ID: 94 Mu 72-1



MEAN	0.69
ST DEV	0.23
VARIANCE	0.05
MINIMUM	0.53
MAXIMUM	0.85
NUMBER	2

L 0.53
L 0.85

TYPE	K/OC	
	TOC	22.34
	TMAX	431
	HI	640
	V Ro	?0.69

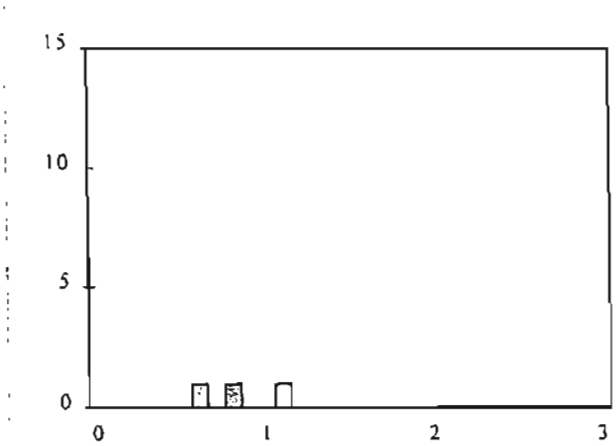
Visual Kerogen Summary

Unstructured Lipids	50
Structured Lipids	40
Solid Bitumen	10
Inertinite	T
Vitrinite	-
Other	0
TOTAL	100

Background Fluorescence	Moderate
TAI Unstructured	2+,3-
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 8
OTHER ID: 96 Mu 35-2



MEAN	0.75
ST DEV	0.16
VARIANCE	0.03
MINIMUM	0.63
MAXIMUM	0.88
NUMBER	2

L 0.63
V 0.88
v 1.19

TYPE	K/OC	
	TOC	12.86
	TMAX	434
	HI	467
	V Ro	?0.75

Visual Kerogen Summary

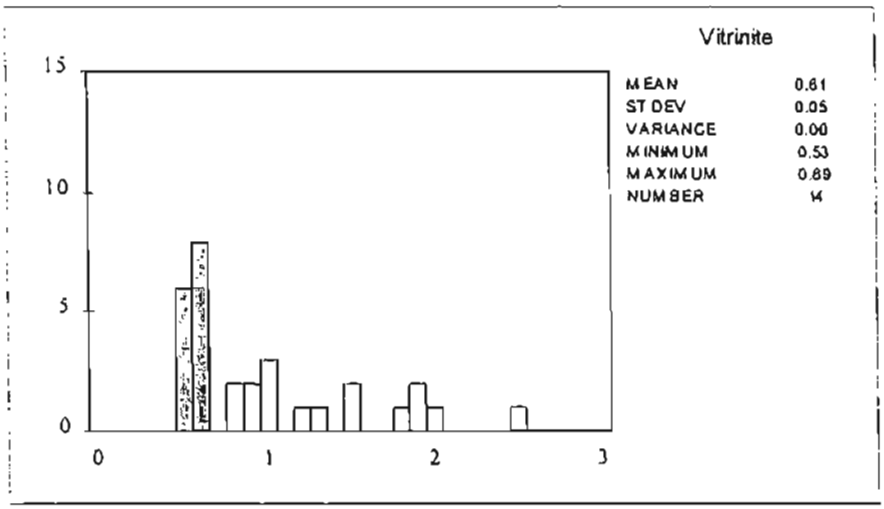
Unstructured Lipids	70
Structured Lipids	20
Solid Bitumen	10
Inertinite	T
Vitrinite	T
Other	0
TOTAL	100

Background Fluorescence	Moderate
TAI Unstructured	3-
TAI Structured	

COMMENTS:

VITRINITE REFLECTANCE ALASKA OUTCROPS

DGSI Project 97/3805 Sample No. 9
OTHER ID: 96 Mu 35-4



L 0.53 L 0.59 L 0.66 v 0.85 v 1.03 v 1.80
L 0.54 V 0.62 V 0.66 I 0.99 I 1.25 v 1.96
L 0.56 V 0.64 V 0.67 v 0.99 v 1.37 v 1.98
V 0.58 L 0.64 L 0.69 I 1.00 v 1.50 v 2.09
V 0.58 V 0.65 I 0.85 I 1.01 v 1.59 v 2.59

TYPE	K/OC	
	TOC	0.96
	TMAX	440
	HI	45
	V Ro	0.61

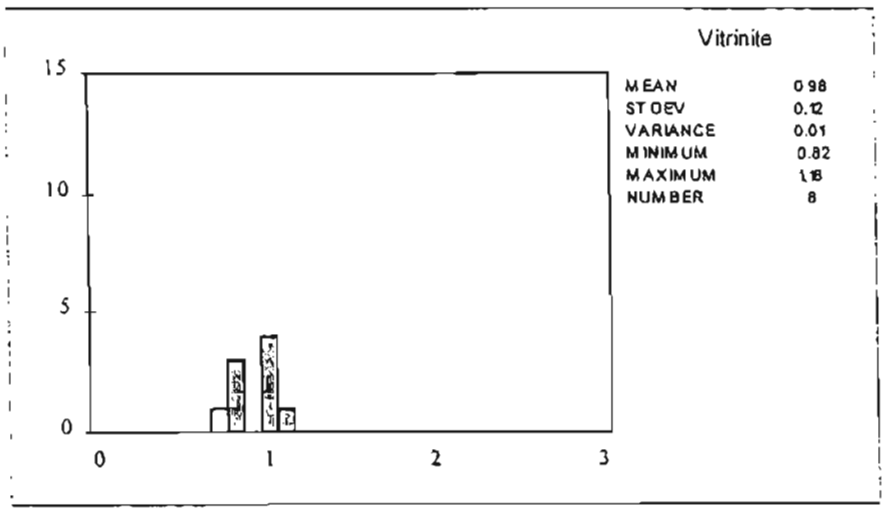
Visual Kerogen Summary

Unstructured Lipids	25
Structured Lipids	-
Solid Bitumen	-
Inertinite	10
Vitrinite	35
Other	30
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	3
TAI Structured	2+

COMMENTS:

DGSI Project 97/3805 Sample No. 10
OTHER ID: 96 Mu 46



b 0.79 L 1.04
V 0.82 L 1.04
L 0.87 L 1.05
L 0.87 V 1.16
L 1.01

TYPE	K/OC	
	TOC	9.84
	TMAX	438
	HI	271
	V Ro	70.98

Visual Kerogen Summary

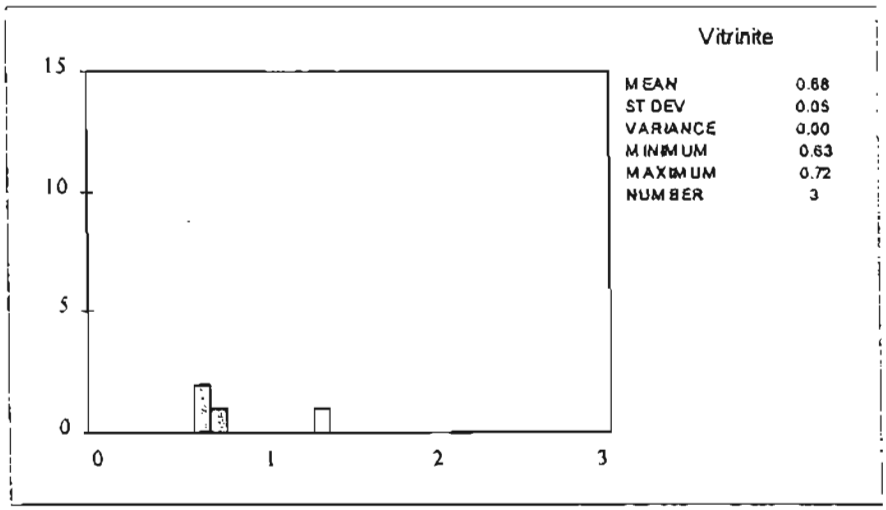
Unstructured Lipids	30
Structured Lipids	10
Solid Bitumen	55
Inertinite	T
Vitrinite	T
Other	5
TOTAL	100

Background Fluorescence	Weak,Mod
TAI Unstructured	3+
TAI Structured	

COMMENTS:

VITRINITE REFLECTANCE ALASKA OUTCROPS

DGSI Project 97/3805 Sample No. 11
OTHER ID: 96 Mu 52-1



L 0.63
L 0.68
V 0.72
I 1.39

TYPE	K/OC	
	TOC	3.80
	TMAX	434
	HI	293
	V Ro	?0.68

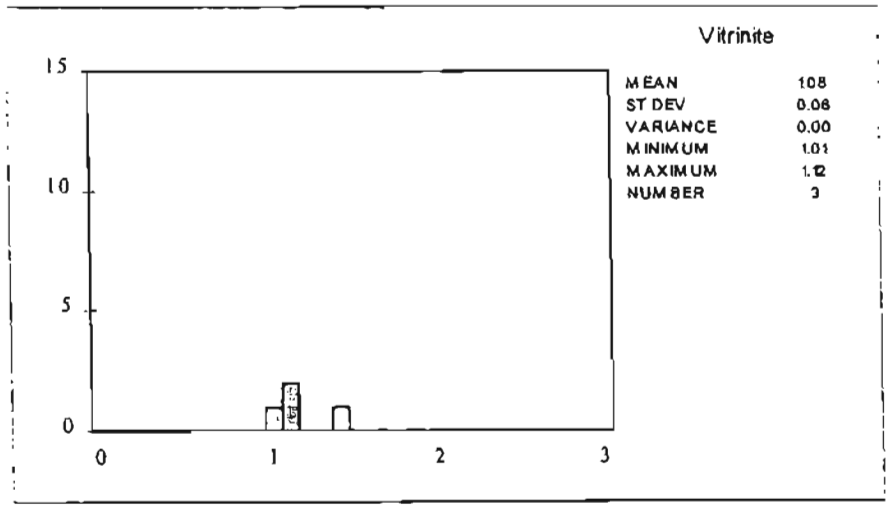
Visual Kerogen Summary

Unstructured Lipids	55
Structured Lipids	10
Solid Bitumen	30
Inertinite	T
Vitrinite	T
Other	5
TOTAL	100

Background Fluorescence	Mod.Strong
TAI Unstructured	3-
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 12
OTHER ID: 96 Mu 57-4



L 1.01
L 1.10
L 1.12
I 1.48

TYPE	K/OC	
	TOC	2.94
	TMAX	437
	HI	178
	V Ro	?1.08

Visual Kerogen Summary

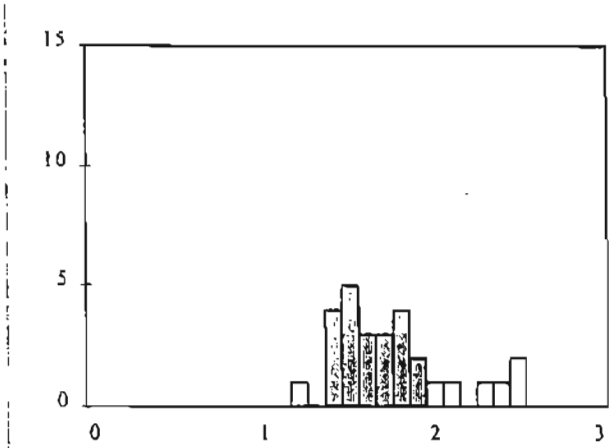
Unstructured Lipids	70
Structured Lipids	10
Solid Bitumen	10
Inertinite	5
Vitrinite	-
Other	5
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	2+,3-
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 13
OTHER ID: 96 Ha 25

TYPE	K/OC	
	TOC	1.07
	TMAX	496
	HI	24
	V Ro	1.65



MEAN	1.65
ST DEV	0.17
VARIANCE	0.03
MINIMUM	1.42
MAXIMUM	1.92
NUMBER	21

v 1.26 V 1.51 V 1.61 V 1.79 V 1.92 v 2.40
V 1.42 V 1.51 V 1.67 V 1.80 V 1.92 v 2.52
V 1.43 V 1.51 V 1.69 V 1.83 v 2.05 v 2.55
V 1.43 V 1.51 V 1.70 V 1.85 v 2.18
V 1.45 V 1.58 V 1.72 V 1.88 v 2.33

Visual Kerogen Summary

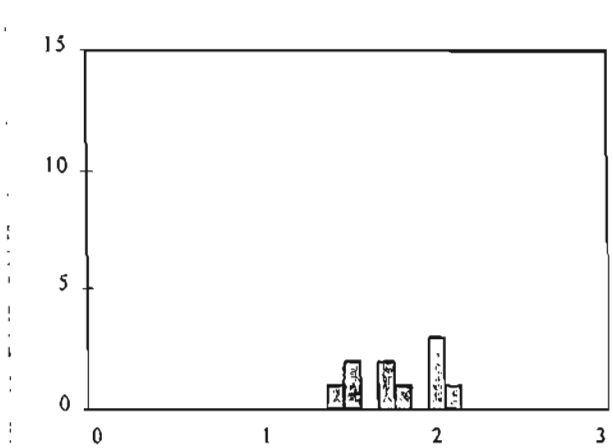
Unstructured Lipids	30
Structured Lipids	5
Solid Bitumen	-
Inertinite	20
Vitrinite	45
Other	0
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 14
OTHER ID: 96 Ha 37

TYPE	K/OC	
	TOC	2.92
	TMAX	497
	HI	29
	V Ro	1.81



MEAN	1.81
ST DEV	0.24
VARIANCE	0.06
MINIMUM	1.48
MAXIMUM	2.13
NUMBER	10

V 1.48 V 1.87
V 1.50 V 2.00
V 1.54 V 2.02
V 1.72 V 2.04
V 1.76 V 2.13

Visual Kerogen Summary

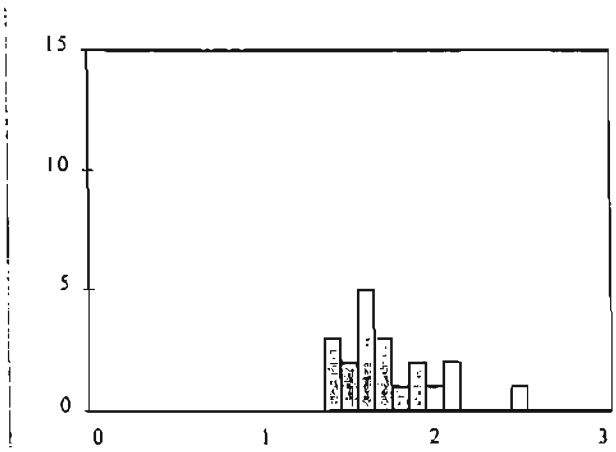
Unstructured Lipids	80
Structured Lipids	-
Solid Bitumen	5
Inertinite	5
Vitrinite	10
Other	0
TOTAL	100

Background Fluorescence	Mod.Strong
TAI Unstructured	3-,3+
TAI Structured	3+

COMMENTS:

DGSI Project 97/3805 Sample No. 15
OTHER ID: 96 Ha 58

TYPE	K/OC	
	TOC	0.90
	TMAX	499
	HI	27
	V Ro	1.67



Vitrinite	
MEAN	1.67
ST DEV	0.16
VARIANCE	0.03
MINIMUM	1.40
MAXIMUM	1.96
NUMBER	15

V 1.40 V 1.61 V 1.72 V 1.96
V 1.45 V 1.65 V 1.74 v 2.04
V 1.48 V 1.65 V 1.77 v 2.13
V 1.55 V 1.67 V 1.86 v 2.14
V 1.57 V 1.69 V 1.95 v 2.51

Visual Kerogen Summary

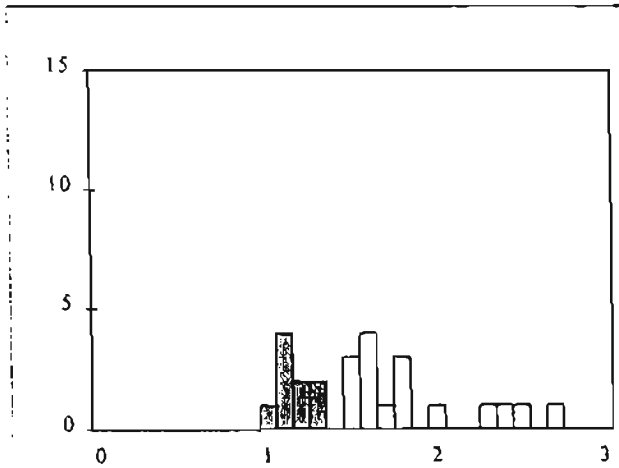
Unstructured Lipids	10
Structured Lipids	-
Solid Bitumen	-
Inertinite	15
Vitrinite	75
Other	0
TOTAL	100

Background Fluorescence	Mod.Strong
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 16
OTHER ID: 96 Ha 66

TYPE	K/OC	
	TOC	1.25
	TMAX	473
	HI	42
	V Ro	?1.20



Vitrinite	
MEAN	1.20
ST DEV	0.09
VARIANCE	0.01
MINIMUM	1.08
MAXIMUM	1.34
NUMBER	9

L 1.08 V 1.22 v 1.51 v 1.89 v 2.02
V 1.11 V 1.24 v 1.58 v 1.73 v 2.34
V 1.14 V 1.31 v 1.81 v 1.83 v 2.40
V 1.16 V 1.34 v 1.82 v 1.84 v 2.52
V 1.18 v 1.51 v 1.86 v 1.88 v 2.75

Visual Kerogen Summary

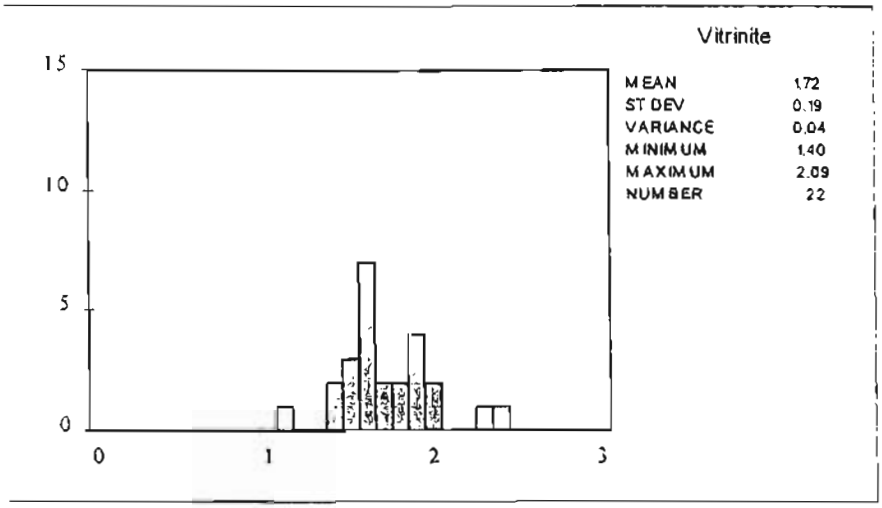
Unstructured Lipids	30
Structured Lipids	-
Solid Bitumen	-
Inertinite	20
Vitrinite	50
Other	0
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	3-
TAI Structured	

COMMENTS:

VITRINITE REFLECTANCE ALASKA OUTCROPS

DGSI Project 97/3805 Sample No. 17
OTHER ID: 96 TM 29-B



I 1.19	V 1.58	V 1.63	V 1.85	V 1.94
L 1.40	V 1.60	V 1.64	V 1.89	V 2.01
V 1.46	V 1.61	V 1.67	V 1.91	V 2.09
L 1.50	V 1.61	V 1.71	V 1.92	v 2.36
V 1.56	V 1.63	V 1.76	V 1.93	v 2.42

TYPE	K/OC	
	TOC	1.12
	TMAX	499
	HI	30
	V Ro	1.72

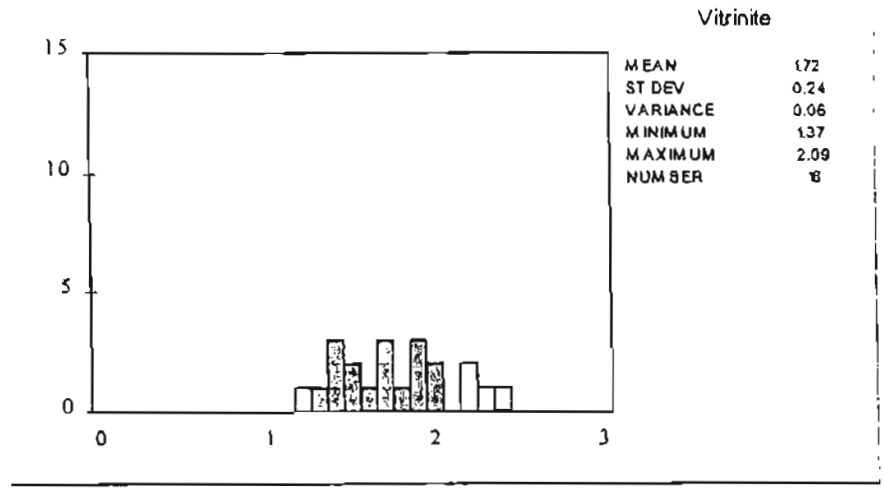
Visual Kerogen Summary

Unstructured Lipids	10
Structured Lipids	-
Solid Bitumen	-
Inertinite	15
Vitrinite	70
Other	5
TOTAL	100

Background Fluorescence	Moderate
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 18
OTHER ID: 96 TM 56-A



I 1.21	V 1.55	V 1.78	V 2.02	v 2.47
V 1.37	V 1.58	V 1.84	V 2.09	
V 1.42	V 1.65	V 1.96	v 2.22	
V 1.43	L 1.72	V 1.98	v 2.28	
V 1.44	V 1.72	V 1.99	v 2.38	

TYPE	K/OC	
	TOC	
	TMAX	
	HI	
	V Ro	1.72

Visual Kerogen Summary

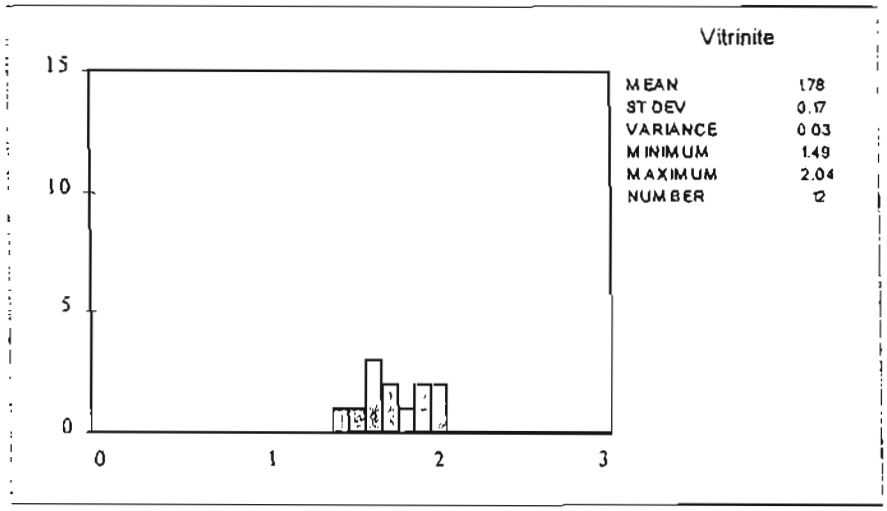
Unstructured Lipids	20
Structured Lipids	-
Solid Bitumen	-
Inertinite	20
Vitrinite	60
Other	0
TOTAL	100

Background Fluorescence	Weak
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

VITRINITE REFLECTANCE ALASKA OUTCROPS

DGSI Project 97/3805 Sample No. 19
OTHER ID: 94 Mu 43-1



V 1.49 V 1.75 V 2.01
V 1.58 V 1.79 V 2.04
V 1.66 V 1.86
V 1.68 V 1.90
V 1.69 V 1.93

TYPE	
K/OC	
TOC	
TMAX	
HI	
V Ro	1.78

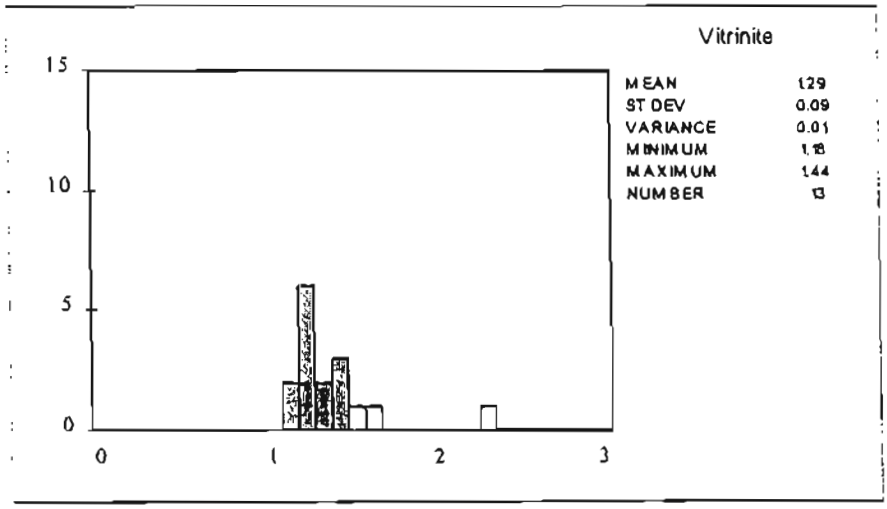
Visual Kerogen Summary

Unstructured Lipids	60
Structured Lipids	-
Solid Bitumen	-
Inertinite	20
Vitrinite	20
Other	0
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	3
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 20
OTHER ID:94 Mu 43-16



V 1.18 V 1.24 L 1.41 v 2.31
V 1.18 V 1.25 V 1.41
V 1.21 V 1.26 V 1.44
V 1.23 V 1.32 v 1.55
V 1.24 V 1.39 v 1.62

TYPE	
K/OC	
TOC	
TMAX	
HI	
V Ro	1.29

Visual Kerogen Summary

Unstructured Lipids	70
Structured Lipids	-
Solid Bitumen	-
Inertinite	10
Vitrinite	20
Other	0
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	3-,3
TAI Structured	

COMMENTS:

GEOCHEMICAL EVALUATION OF OUTCROP SAMPLES NORTHWESTERN ALASKA

Prepared For:

State of Alaska
Dept. of Natural Resources
Division of Geological and Geophysical Surveys
794 University Avenue, Suite 200
Fairbanks, Alaska 99709

Prepared By:

Wallace G. Dow
DGSI Project: 97/3805
August 29, 1997

101

DGSI
Total Quality Geochemistry
DGSI • 8701 NEW TRAILS DRIVE • THE WOODLANDS, TX 77381
(281) 363-2176 • FAX (281) 292-3528 • EMAIL: dgsilab@onramp.net • www.dgsilab.com

		GEOCHEM SAMPLES TO DGSI, 2nd SHIPMENT, DECEMBER								
	Sample #	Location	Box #	Collector	Formation	Age	Description	Analysis requested	Quadrangle	Discussion
1	96 Mu 6	NW of Poko Mtn	18	Mull	Torok	Aptian/Albian?	Clay shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
2	96 Mu 12	Kukpowruk River	18	Mull	Torok	Aptian/Albian?	Silty mudstone	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
3	96 Mu 14	S Driftwood anticline	18	Mull	Torok	Aptian/Albian?	Silty mudstone	Ro, TAI, kerogen type, Rock Eval, and TOC	Misheguk Mtn	
4	96 Mu 18	Tupikchak syncline	18	Mull	Nanushuk	Albian	Carb. shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
5	96 Mu 30-2	Pitmegea vlb.	33	Mull	Kingak	Jurassic	Sheared bk sh & bentonit	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
6	96 Mu 33-1	Thetis Creek	33	Mull	Kingak	Jurassic	Dk gr sh w bentonite	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
7	94 Mu 72-1	Ipewik River	33	Mull	Kingak	Jurassic	Dk gr organic shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
8	96 Mu 35-2	Thetis Ridge	33	Mull	Kingak	Jurassic	Organic shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
9	96 Mu 35-4	Thetis Ridge	33	Mull	Torok	Aptian/Albian?	Silty mudstone	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
10	96 Mu 46	Tingmerkpuk River	33	Mull	Torok	Jurassic	Organic shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
11	96 Mu 52-1	Horseshoe Bend	68	Mull	Kingak	Jurassic	Bk organic paper shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
12	96 Mu 57-4	Kukpowruk River	68	Mull	Kingak	Cret./Jurassic	Dk gr to bk shale	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
13	96 Ha 25	Spike/Iligluruk Ck.	27	Harris	Lower Brooklan	Probable Aptian	Ss, sltst, sh	Ro, TAI, kerogen type, Rock Eval, and TOC	Misheguk C5	
14	96 Ha 37	Pitmegea tributary	27	Harris	Kingak	U. Jur to L. Cret	Bk shale w concretions	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong C4	
15	96 Ha 58	Upper Pitmegea R.	43	Harris	Lower Brooklan	Probable Aptian	Ss, sltst, sh	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong C4	
16	96 Ha 65	Spike Creek	43	Harris	Lower Brooklan	Probable Aptian	Ss, sltst, sh	Ro, TAI, kerogen type, Rock Eval, and TOC	Misheguk Mtn. C5	
17	95 TM 29-B	Iligluruk Creek	31	Moore	Lower Brooklan	Aptian/Albian?	Claystone	Ro, TAI, kerogen type, Rock Eval, and TOC	Misheguk C5	
18	96 TM 56-A	Iligluruk Creek	68	Moore	Lower Brooklan	Aptian/Albian?	shale	Ro, TAI, kerogen type, Rock Eval, and TOC	Misheguk C5	
19	94 Mu43-1	Tingmerkpuk River measured section		Mickey/ Elder	Lower Brooklan	Aptian/Albian?	Unit 7	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	
20	94 Mu43-10	Tingmerkpuk River measured section			Lower Brooklan	Aptian/Albian?	Unit 26-15.5 m.	Ro, TAI, kerogen type, Rock Eval, and TOC	DeLong Mtns.	

102

ALASKA OUTCROPS

DGSI Project: 97/3805

DGSI

DGSI NUMBER	DATE: 7/3/97 IDENTIFICATION	PREPARATION/ SAMPLE TYPE	ORGANIC MATTER (%) LIPIDS UNSTRUCTURED UNDIFFERENTIATE	AMORPHOUS	MASSIVE	MICRINIZED	STRUCTURED TYPE	TYPE	TYPE	TYPE	SOLID BITUMEN	HUMIC INERTINITE	VITRINITE	OTHER TYPE	TYPE	RELATIVE ABUNDANCE PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI REFLECTED LIPIDS COLOR	INTENSITY	STRU COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED LIPIDS UNSTR. TAI VALUE	FLUOR. COLOR	INTENSITY	STRU TAI VALUE	FLUOR. COLOR	INTENSITY	Ro VITRINITE REFLECTANCE OR EQUIVALENCY
1	96 Mu 5	K/OC	10				LD T					15	15	VL 60		MA F	-	M	M	-	+		T	n.d.		DO	1	3	n.d				O	1	- V 0.90
Comments:	*Mixture of small terrestrial fragments with some desmocollinite Trace graphite.*																																			
2	96 Mu 12	K/OC	5									10	80	VL 5		MA	M	M	+	-	-		T	n.d.				3	n.d						- V 1.04
Comments:	*Mixture of small terrestrial fragments. Trace graphite.*																																			
3	96 Mu 14	K/OC	15									15	65	VL 5		MA	M	M	+	-	-		T	n.d		DO	1	4	n.d.				O	1	- V 0.89
Comments:	*Similar to 96 Mu 12.*																																			
4	96 Mu 18	K/OC	10				LD 5					15	65	VL 5		MA	M	T	+	-	-			LR		O	1	4	n.d.				O Y	2 3	- V 0.65
Comments:	*Terrestrial fragments as in 96 Mu 12 and 14, but slightly larger.*																																			
5	96 Mu 30-2	K/OC	5				LD 5					10	70	VL 10		MA	M	M	+	-	-		T	n.d.		O	1 3	3	n.d				O	2	- V 0.74
Comments:	*Mixture of terrestrial fragments. Trace graphite.*																																			

ANALYST

X O'Connor

MICROSCOPE

X Zeiss

SAMPLE TYPE/PREP		STRUCTURED LIPIDS		OTHER ORGANIC MATTER		PYRITE		ABUND.		FLUOR. INTENS.		VIT. REFLECT. EQUIVALENCE		FLUOR. COLOR		TAI COLOR VALUES	
CTG	Cuttings	AL	Alginite	E	Exsudatinite	E	Euhedral	N	None	0	None	B	Bitumen	W	White	1-	Straw Yellow
CC	Conv. Core	SB	Sobernite	G	Graptolites	F	Framboid	T	Trace	1	Weak	G	Graptolites	G	Green	1	Pale Yellow
SWC	SideWallCore	C	Cutinite	VL	Lipid-Rich Vitrinite	MA	Massive	-	Small Amt	2	Moderate	VL	Lipid-Rich Vitrinite	Y	Yellow	1+	Yellow
OC	Outcrop	LD	Liptodetrinite	VC	VitrinicContamination	RL	Replace-infill	M	Mod. Amt.	3	Strong	VC	Vitrinite Contam.	O	Orange	2-	Yellow-Orange
NI	No Inform.	U	Undiffer.	VR	Recycled Vitrinite			+	Large Amt	4	Intense	VR	Recycled Vitrinite	R	Red	2	Golden
C	Coal	S	Sporinite					++	Abundant					B	Brown	2+	Amber
		R	Resinite											BL	Black	3-	Reddish Brown
K	Kerogen	O	Other													3	Medium Brown
WR	Whole Rock															3+	Dark Brown
														L	Light	4-	Brown-Black
n.d.	Not Determined													D	Dark	4	Black
																4+	Black-Opaque

VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

ALASKA OUTCROPS

DGSI Project: 97/3805

DGSI NUMBER	DATE: 7/3/97 / IDENTIFICATION	PREPARATION/ SAMPLE TYPE	ORGANIC MATTER (%) LIPIDS UNSTRUCTURED: UNDIFFERENTIATE	AMORPHOUS	MASSIVE	MICRINIZED	STRUCTURED: TYPE	TYPE	TYPE	TYPE	SOLID BITUMEN	HUMIC: INERTINITE	VITRINITE	OTHER: TYPE	TYPE	RELATIVE ABUNDANCE: PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE: NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI REFLECTED LIPIDS: UNSTR. COLOR	INTENSITY	STRU. COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED LIPIDS: UNSTR TAI	UNSTR FLUOR COLOR	UNSTR FLUOR INTENSITY	STRU TAI VALUE	STRU FLUOR COLOR	STRU FLUOR INTENSITY	Ro: VITRINITE REFLECTANCE OR EQUIVALENCY
6	96 Mu 33-1	K/OC	75				LD 10				5	5	5			MA	-	M	+	-				DB	1			4	2+	BL	0		O	1 2	- V ?0 77
Comments: Very small, angular fragments of solid bitumen in grainy lipids. Difficult to differentiate vit from non-angular solid bit in kerogen sample																																			
7	94 Mu 72-1	K/OC			50		AL 40				? 10	T		VL T		MA	-	+	N	-	+			B	1	Y	2	2	2+ 3-	OB	2		Y	2 4	- V ?0 69
Comments: Groundmass of massive lipids with alginite and solid bitumen fragments - difficult to differentiate in reflected light																																			
8	96 Mu 35-2	K/OC				70	AL 20				? 10	T	T	VL T		MA	-	+	M	-	M			DB	1	O	2	2	3-	DOB	1		O	2	- V ?0 75
Comments: Unstructured lipids appear to be micrinized. Alginite and granular bitumen as in 96 Mu 75-1. Remnant algal structure identified in slide																																			
9	96 Mu 35-4	K/OC	25				LD T	S T				10	35	VL 30		MA F	M	M	M	-	M		T	DB	1	O	2	3	3	BL	0	2+	O	2 3	- V 0.61
Comments: Unstructured lipids have grainy texture. Trace graphite																																			
10	96 Mu 46	K/OC				30	AL 10				55	T	T	VL 5		F MA	M	+	-	-	+			BL	0	BL	0	1 2	3+	BL	0				- V ?0 98
Comments: Angular solid bitumen dissolves when analyzed for fluorescence. Some angular material may be alginite. Bitumen raises TAI value.																																			

ANALYST	SAMPLE TYPE/PREP	STRUCTURED LIPIDS	OTHER ORGANIC MATTER	PYRITE	ABUND.	FLUOR. INTENS.	VIT. REFLECT. EQUIVALENCE	FLUOR. COLOR	TAI COLOR VALUES
X O'Connor	CTG Cuttings	AL Alginite	E Exsudatinite	E Euhedral	N None	0 None	B Bitumen	W White	1- Straw Yellow
	CC Conv. Core	SB Suberinite	G Graptolites	F Framboid	T Trace	1 Weak	G Graptolites	G Green	1 Pale Yellow
	SWC SideWallCore	C Cutinite	VL Lipid-Rich Vitrinite	MA Massive	- Small Amt	2 Moderate	VL Lipid-Rich Vitrinite	Y Yellow	1+ Yellow
	OC Outcrop	LD Liptodetrinite	VC VitriniteContamination	RI Replace-infill	M Mod Amt.	3 Strong	VC Vitrinite Contam.	O Orange	2- Yellow-Orange
	NI No Inform	U Undiffer.	VR Recycled Vitrinite		+ Large Amt	4 Intense	VR Recycled Vitrinite	R Red	2 Golden
	C Coal	S Sporinite			++ Abundant			B Brown	2+ Amber
MICROSCOPE		R Resinite						BL Black	3- Reddish Brown
		O Other							3 Medium Brown
	K Kerogen								3+ Dark Brown
X Zeiss	WR Whole Rock							L Light	4- Brown-Black
	n.d. Not Determined							D Dark	4 Black
									4+ Black-Opaque

VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

ALASKA OUTCROPS

DGSI Project: 97/3805

DGSI

DGSI NUMBER	DATE: 7/3/97 / IDENTIFICATION	PREPARATION/ SAMPLE TYPE	ORGANIC MATTER (%) LIPIDS UNSTRUCTURED: UNDIFFERENTIATE	AMORPHOUS	MASSIVE	MICRINIZED	STRUCTURED: TYPE	TYPE	TYPE	TYPE	SOLID BITUMEN	HUMIC: INERTINITE	VITRINITE	OTHER: TYPE	TYPE	RELATIVE ABUNDANCE: PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE: NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI REFLECTED LIPIDS: COLOR	INTENSITY	COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED LIPIDS UNSTR TAI: VALUE	UNSTR FLUOR.: COLOR	INTENSITY	STRU TAI: VALUE	STRU FLUOR.: COLOR	INTENSITY	Ro: VITRINITE REFLECTANCE OR EQUIVALENCY
11	96 Mu 52-1	K/OC			55		AL 10				7 30	T	T	VL 5		MA	-	+	-	M	+			DB	1	O	2	2 3	3-	DOB	1		O	1 2	- V ?0.68
Comments:	Mixture of angular solid bitumen and remnant algal structure ? - difficult to identify. Unstr lipids have massive-micrinized texture																																			
12	96 Mu 57-4	K/OC	70				AL 10				7 10	5		VL 5		MA F	-	+	N	M	+			DB	1	O	1	3	2+ 3-	BL DOB	0 1		O	1	- V ?1.08
Comments:	Grainy lipids with angular alginite and solid bitumen? - difficult to identify.																																			
13	96 Ha 25	K/OC	30				U 5					20	45			MA	M	+	+	-	?			BL	0	BL	0	3	n.d.						- V 1.65
Comments:	Small terrestrial fragments - difficult to separate vitrinite from inertinite. Grainy lipids.																																			
14	96 Ha 37	K/OC				80	U T	S T			5	5	10			F MA	M	+	M	M	?		M	BL	0	BL	0	2 3	3- 3+	BL	0	3+	BL	0	- V 1.81
Comments:	Slight anisotrophy may lower some Ro values																																			
15	96 Ha 58	K/OC	10				U T					15	75			MA E	M	+	+					n.d.		BL	0	2 3	n.d.						- V 1.67
Comments:	Small terrestrial fragments.																																			

ANALYST	SAMPLE TYPE/PREP	STRUCTURED LIPIDS	OTHER ORGANIC MATTER	PYRITE	ABUND.	FLUOR. INTENS.	VIT. REFLECT. EQUIVALENCE	FLUOR. COLOR	TAI COLOR VALUES
	CTG Cuttings	AL Alginite	E Exsudatinite	E Euhedral	N None	0 None	B Bitumen	W White	1- Straw Yellow
	CC Conv Core	SB Suberinite	G Graptolites	F Framboid	T Trace	1 Weak	G Graptolites	G Green	1 Pale Yellow
X O'Connor	SWC SideWallCore	C Cutinite	VL Lipid-Rich Vitrinite	MA Massive	- Small Amt	2 Moderate	VL Lipid-Rich Vitrinite	Y Yellow	1+ Yellow
	OC Outcrop	LD Liptodetrinite	VC VitriniteContamination	RI Replacement	M Mod Amt.	3 Strong	VC Vitrinite Contam.	O Orange	2- Yellow-Orange
	NI No Inform.	U Undiffer	VR Recycled Vitrinite		+ Large Amt.	4 Intense	VR Recycled Vitrinite	R Red	2 Golden
	C Coal	S Sporinite			++ Abundant			B Brown	2+ Amber
MICROSCOPE		R Resinite						Bl. Black	3- Reddish Brown
		O Other							3 Medium Brown
	K Kerogen								3+ Dark Brown
	WR Whole Rock							L Light	4- Brown-Black
X Zeiss	n.d. Not Determined							D Dark	4 Black
									4+ Black-Opaque

VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

ALASKA OUTCROPS

DGSI Project: 97/3805

DGSI

DGSI NUMBER	DATE: 7/3/97 IDENTIFICATION	PREPARATION/ SAMPLE TYPE	ORGANIC MATTER (%) LIPIDS UNSTRUCTURED: UNDIFFERENTIATE	AMORPHOUS	MASSIVE	MICRINIZED	STRUCTURED: TYPE	TYPE	TYPE	TYPE	SOLID BITUMEN	HUMIC: INERTINITE	VITRINITE	OTHER: TYPE	TYPE	RELATIVE ABUNDANCE: PYRITE TYPE	PYRITE	TOTAL ORGANIC MATTER	VITRINITE: NORMAL	ROUGH	LIPID-RICH	OXIDIZED	COKED	FLUORESCENCE / TAI REFLECTED LIPIDS UNSTR.: COLOR	INTENSITY	STRU.: COLOR	INTENSITY	BACKGROUND INTENSITY	TRANSMITTED LIPIDS UNSTR: TAI VALUE	FLUOR. COLOR	FLUOR. INTENSITY	STRU: TAI VALUE	FLUOR. COLOR	FLUOR. INTENSITY	Ro: VITRINITE REFLECTANCE OR EQUIVALENCY
16	96 Ha 66	K/OC	30				U T					20	50	VL T		MA F	M	+	+	-	T		T	BL	0	BL	0	4	3-	BL	0				- V ?1 20
Comments: Small terrestrial fragments with grainy lipids.																																				
17	96 TM 29-B	K/OC	10				U T					15	70	VL 5		MA F	M	M	+	T	-			BL	0	BL	0	2	n.d.						- V 1.72
Comments: Small terrestrial fragments with grainy lipids.																																				
18	96 TM 56-A	K/OC	20				U T					20	50	VL T		MA F	M	M	+	T	T	?		BL	0	BL	0	1	n.d.						- V 1.72
Comments: Small terrestrial fragments.																																				
19	94 Mu 43-1	K/OC	50			10						20	20	VL T		MA	M	-	+	-	T			? B	1			3	3	BL	0				- V 1.78
Comments: Small amount of organic matter. Ro on small vitrinite-like fragments																																				
20	94 Mu 43-16	K/OC	70				U T					10	20	VL T		MA F	M	M	+	-	T		T	BL	0	BL	0	4	3- 3	BL	0				- V 1.29
Comments: Ro on small, vitrinite-like fragments. Fine-grained unstructured lipids mixed with mineral. Trace graphite.																																				

ANALYST

X O'Connor

MICROSCOPE

X Zeiss

SAMPLE TYPE/PREP		STRUCTURED LIPIDS		OTHER ORGANIC MATTER		PYRITE		ABUND.		FLUOR. INTENS.		VIT. REFLECT. EQUIVALENCE		FLUOR. COLOR		TAI COLOR VALUES	
CTG	Cuttings	AL	Alginite	E	Exudatinite	E	Euhedral	N	None	0	None	B	Bitumen	W	White	1-	Straw Yellow
CC	Conv. Core	SB	Suberinite	G	Graptolites	F	Framboid	T	Trace	1	Weak	G	Graptolites	G	Green	1	Pale Yellow
SWC	SideWallCore	C	Cutinite	VL	Lipid-Rich Vitrinite	MA	Massive	-	Small Amt	2	Moderate	VL	Lipid-Rich Vitrinite	Y	Yellow	1+	Yellow
OC	Outcrop	LD	Liptodetrinite	VC	VitriniteContamination	RI	Replace-infill	M	Mod. Amt.	3	Strong	VC	Vitrinite Contam	O	Orange	2-	Yellow-Orange
NI	No Inform.	U	Undiffer	VR	Recycled Vitrinite			+	Large Amt.	4	Intense	VR	Recycled Vitrinite	R	Red	2	Golden
C	Coal	S	Sporinite					++	Abundant					B	Brown	2+	Amber
		R	Resinite											BL	Black	3-	Reddish Brown
K	Kerogen	O	Other													3	Medium Brown
WR	Whole Rock															3+	Dark Brown
														L	Light	4-	Brown-Black
n.d.	Not Determined													D	Dark	4	Black
																4+	Black-Opaque

VISUAL KEROGEN ANALYSIS
Total Quality Geochemistry

DGSI

EXTRACT SUMMARY SHEET

Alaska Outcrops
Other ID: 96 Mu 33-5 DGSI Project: 96/3631

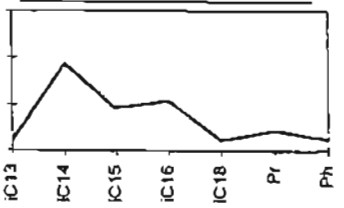
DGSI Project: 97/3959
Sample No. 1

BULK PROPERTIES

API Gravity	N.A.
% S	N.A.
ppm V	N.A.
ppm Ni	N.A.

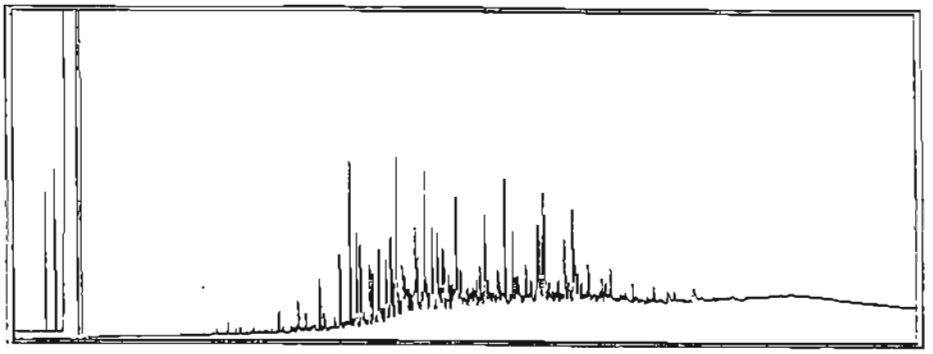
%C15 + Comp		$\delta^{13}C$
Sat	30.80	N.A.
Arom	N.A.	N.A.
NSO	N.A.	
Asph	N.A.	
Sat/Arom	N.A.	

Isoprenoid Distribution

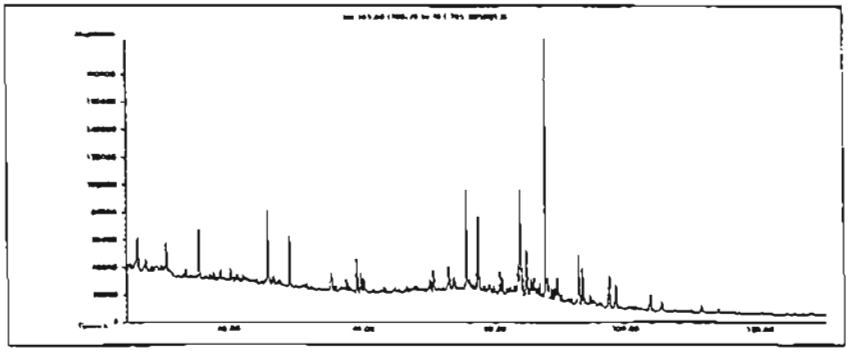


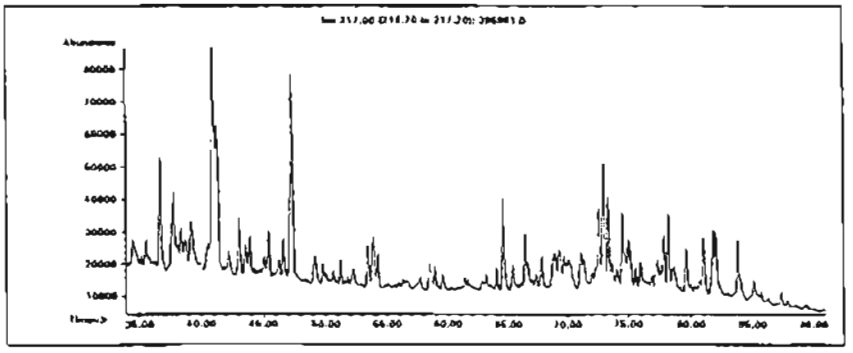
WHOLE EXTRACT GC

Pr/Ph	1.88
OEP	N.A.
Pr/nC17	0.28
Ph/nC18	0.25



SATURATE BIOMARKERS





Terpane Ratios

C_{24} Tetracyclic/C_{26} Tricyclics	0.88
C_{19} + C_{20} Tricyclics/C_{23} Tricyclic	1.27
Ts/Tm	1.20
C_{28} Hopane/C_{30} Hopane	0.00
C_{29} Norhopane/C_{30} Hopane	0.41
C_{30} Oleanane/C_{30} Hopane	0.00
Gammacerane/C_{30} Hopane	0.00
Tricyclics (%)	27.52
C_{35}/C_{34} Extended Hopanes	0.42
C_{25} Tricyclics/C_{26} Tricyclics	0.73

Sterane Ratios

Diasteranes (%)	25.03
20S C_{29} Steranes (%)	53.29
αββ C_{29} Steranes (%)	49.64
Hopanes/Steranes	0.94
C_{21} Sterane (%)	17.42
C_{22} Sterane (%)	20.89
C_{27} Sterane (%)	24.37
C_{28} Sterane (%)	15.38
C_{29} Sterane (%)	19.03
C_{30} Sterane (%)	2.91

DGSI

EXTRACT SUMMARY SHEET

Alaska Outcrops
Other ID: 94 Mu 72-1 DGSI Project: 97\3805

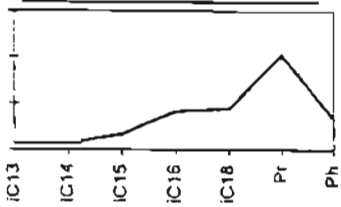
DGSI Project: 97/3959
Sample No. 7

BULK PROPERTIES

API Gravity	N.A.
% S	N.A.
ppm V	N.A.
ppm Ni	N.A.

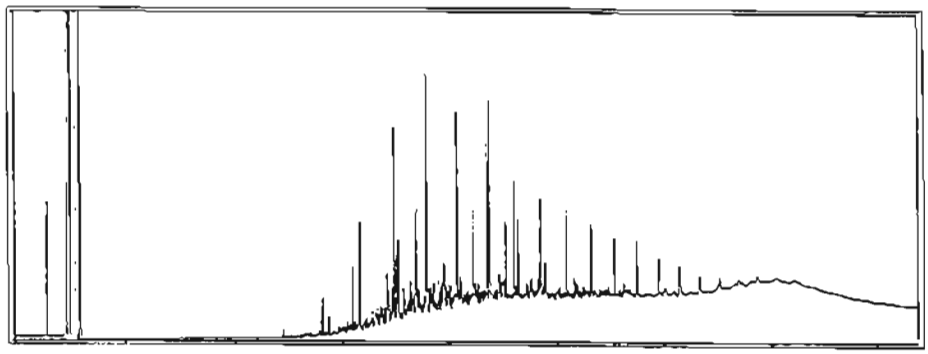
%C15 + Comp		$\delta^{13}C$
Sat	47.00	N.A.
Arom	N.A.	N.A.
NSO	N.A.	
Asph	N.A.	
Sat/Arom	N.A.	

Isoprenoid Distribution

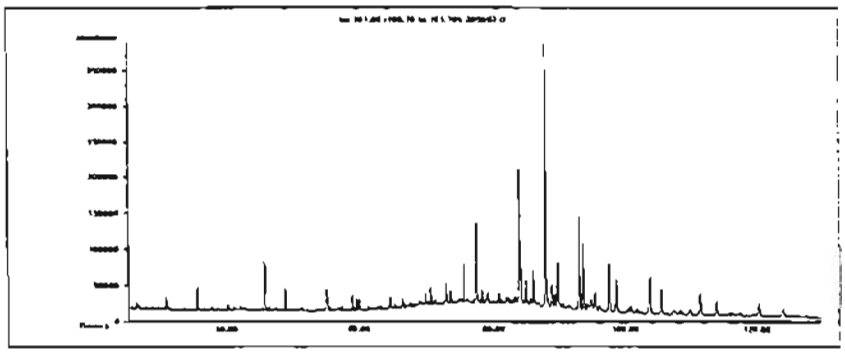


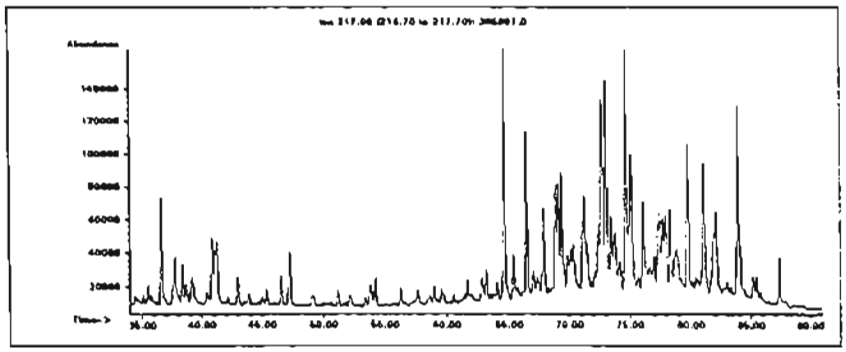
WHOLE EXTRACT GC

Pr/Ph	3.04
OEP	N.A.
Pr/nC17	1.45
Ph/nC18	0.77



SATURATE BIOMARKERS





Terpane Ratios

C_{24} Tetracyclic/C_{26} Tricyclics	0.58
C_{19} + C_{20} Tricyclics/C_{23} Tricyclic	0.41
Ts/Tm	0.41
C_{28} Hopane/C_{30} Hopane	0.00
C_{29} Norhopane/C_{30} Hopane	0.53
C_{30} Oleanane/C_{30} Hopane	0.00
Gammacerane/C_{30} Hopane	0.00
Tricyclics (%)	18.54
C_{35}/C_{34} Extended Hopanes	0.64
C_{25} Tricyclics/C_{26} Tricyclics	1.51

Sterane Ratios

Diasteranes (%)	44.05
20S C_{29} Steranes (%)	49.53
αββ C_{29} Steranes (%)	32.96
Hopanes/Steranes	0.73
C_{21} Sterane (%)	4.37
C_{22} Sterane (%)	4.60
C_{27} Sterane (%)	35.15
C_{28} Sterane (%)	24.72
C_{29} Sterane (%)	27.33
C_{30} Sterane (%)	3.84

DGSI

EXTRACT SUMMARY SHEET

Alaska Outcrops
Other ID: 96 MAW 7

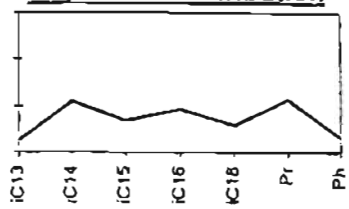
DGSI Project: 97/3959
Sample No. 21

BULK PROPERTIES

API Gravity	N.A.
% S	N.A.
ppm V	N.A.
ppm Ni	N.A.

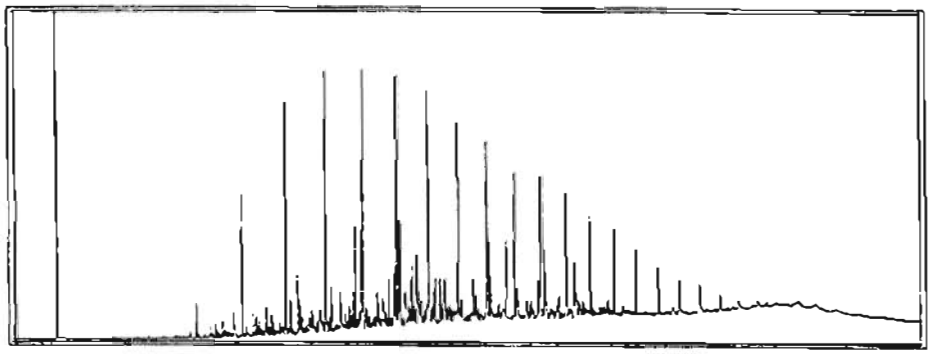
%C15 + Comp		$\delta^{13}C$
Sat	45.30	N.A.
Arom	N.A.	N.A.
NSO	N.A.	
Asph	N.A.	
Sat/Arom	N.A.	

Isoprenoid Distribution

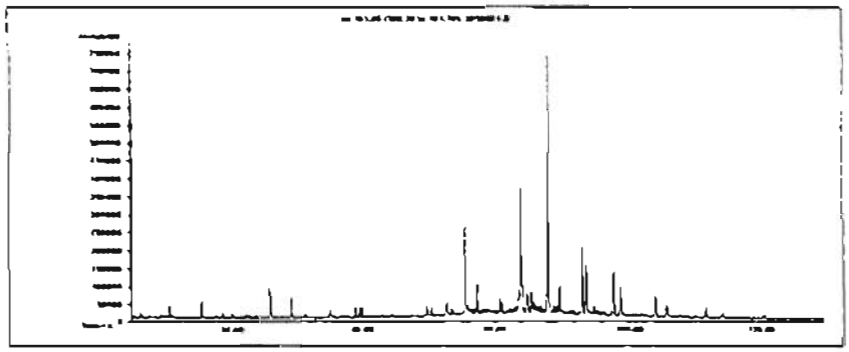


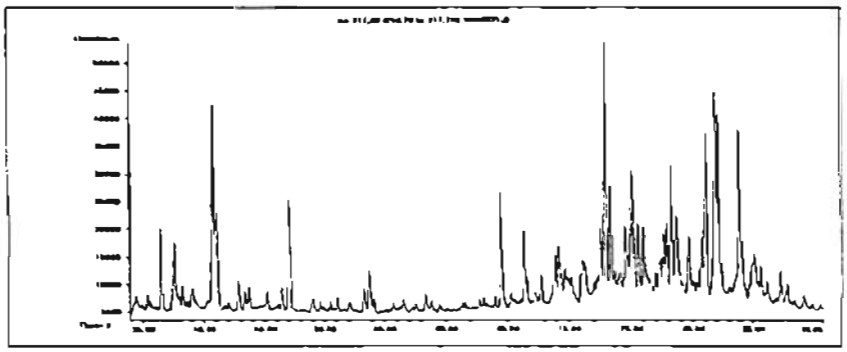
WHOLE EXTRACT GC

Pr/Ph	3.49
OEP	N.A.
Pr/nC17	0.54
Ph/nC18	0.20



SATURATE BIOMARKERS





Terpane Ratios

C_{24} Tetracyclic/C_{26} Tricyclics	0.55
C_{19} + C_{20} Tricyclics/C_{23} Tricyclic	0.60
Ts/Tm	2.80
C_{28} Hopane/C_{30} Hopane	0.00
C_{29} Norhopane/C_{30} Hopane	0.43
C_{30} Oleanane/C_{30} Hopane	0.00
Gammacerane/C_{30} Hopane	0.00
Tricyclics (%)	13.97
C_{35}/C_{34} Extended Hopanes	0.42
C_{25} Tricyclics/C_{26} Tricyclics	0.67

Sterane Ratios

Diasteranes (%)	28.92
20S C_{29} Steranes (%)	53.70
αββ C_{29} Steranes (%)	52.80
Hopanes/Steranes	4.93
C_{21} Sterane (%)	8.74
C_{22} Sterane (%)	9.55
C_{27} Sterane (%)	20.23
C_{28} Sterane (%)	16.17
C_{29} Sterane (%)	39.68
C_{30} Sterane (%)	5.64

DGSI

EXTRACT SUMMARY SHEET

Alaska Outcrops
Other ID: 96 MAW 11

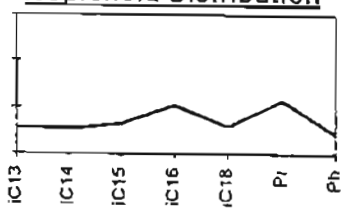
DGSI Project: 97/3959
Sample No. 23

BULK PROPERTIES

API Gravity	N.A.
% S	N.A.
ppm V	N.A.
ppm Ni	N.A.

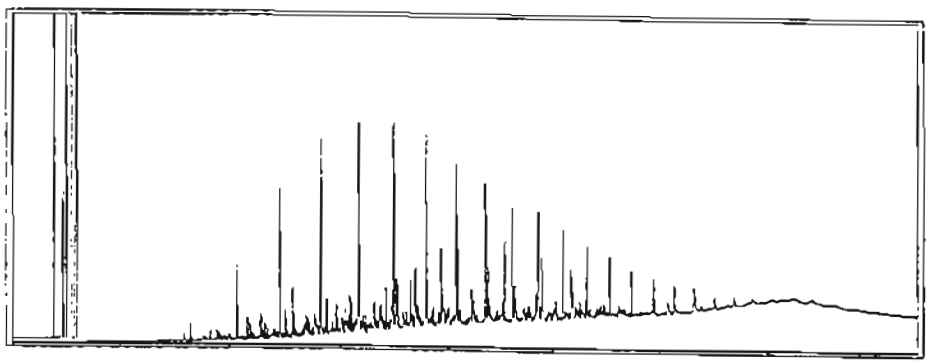
%C15 + Comp		$\delta^{13}C$
Sat	30.60	N.A.
Arom	N.A.	N.A.
NSO	N.A.	
Asph	N.A.	
Sat/Arom	N.A.	

Isoprenoid Distribution

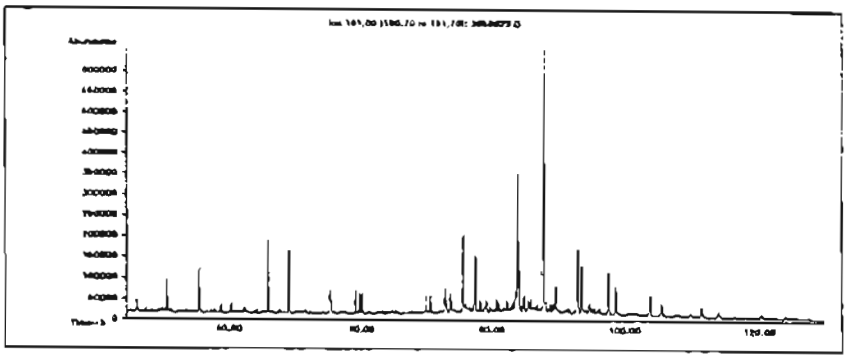


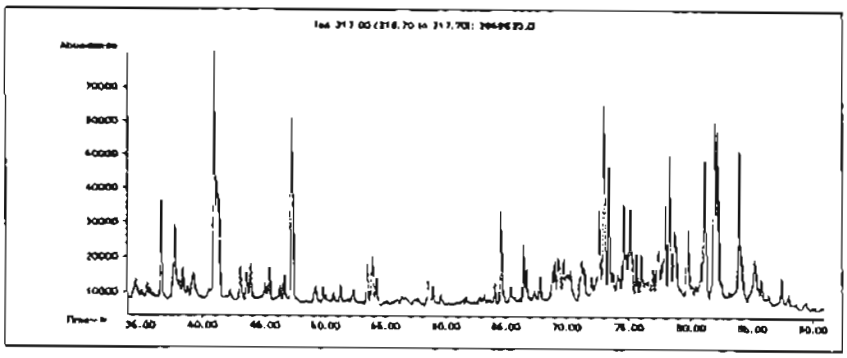
WHOLE EXTRACT GC

Pr/Ph	2.64
OEP	N.A.
Pr/nC17	0.56
Ph/nC18	0.27



SATURATE BIOMARKERS





Terpane Ratios

C_{24} Tetracyclic/C_{26} Tricyclics	0.57
C_{19} + C_{20} Tricyclics/C_{23} Tricyclic	0.70
Ts/Tm	1.25
C_{28} Hopane/C_{30} Hopane	0.00
C_{29} Norhopane/C_{30} Hopane	0.48
C_{30} Oleanane/C_{30} Hopane	0.00
Gammacerane/C_{30} Hopane	0.00
Tricyclics (%)	27.97
C_{35}/C_{34} Extended Hopanes	0.53
C_{23} Tricyclics/C_{26} Tricyclics	1.07

Sterane Ratios

Diasteranes (%)	21.92
20S C_{29} Steranes (%)	51.80
αββ C_{29} Steranes (%)	53.40
Hopanes/Steranes	2.73
C_{21} Sterane (%)	11.82
C_{22} Sterane (%)	13.52
C_{27} Sterane (%)	19.96
C_{28} Sterane (%)	16.98
C_{29} Sterane (%)	32.57
C_{30} Sterane (%)	5.16

ORGANIC CARBON AND PYROLYSIS DATA

Total Organic Carbon (TOC) and Rock-Eval pyrolysis data provide basic geochemical information and are frequently used to select samples for more detailed studies, particularly kerogen microscopy, extract chromatography and biomarker analyses. Well data can be plotted to make geochemical logs. Unless otherwise specified by a client, DGSI uses LECO TOC then Rock-Eval II pyrolysis as the standard analytical sequence and Rock-Eval is recommended for samples with greater than 0.4% TOC. Samples for LECO TOC and Rock-Eval pyrolysis are ground to pass through a 60 mesh sieve to assure homogeneity.

LECO ORGANIC CARBON AND TOTAL SULFUR

Total Organic Carbon is best determined by direct combustion. Approximately 0.15 grams of sample are carefully weighed, treated with concentrated HCl to remove carbonates, and vacuum filtered on glass fiber paper. The residue and paper are placed in a ceramic crucible, dried, and combusted with pure oxygen in a LECO EC-12 or LECO CS-444 carbon analyzer at about 1,000°C. A laboratory standard is run every five samples. Total, insoluble, mineral plus organic sulfur can be determined by the CS-444 analyzer during the carbon analysis. Total carbonate can be determined from sample and acid residue weight differences or by LECO combustion TOC differences before and after acid digestion.

ROCK-EVAL II PYROLYSIS

Rock-Eval II pyrolysis is used to determine kerogen type, kerogen maturity and the amount of free hydrocarbons. About 0.1 grams of the same ground sample used for LECO TOC are carefully weighed in a pyrolysis crucible and then heated to 300°C to determine the amount of free hydrocarbons, S_1, that is thermally distilled. Next, the amount of pyrolyzable hydrocarbons, S_2, is measured when the sample is heated in an inert environment which rises from 300° to 550°C at a heating rate of 25°C/minute. S_1 and S_2 are reported in mg HC/g sample. T_{max}, a maturity indicator, is the temperature of maximum S_2 generation. When S_2 values are less than 0.2 mg HC/g sample, the S_2 maximum typically has poor definition and thus, Tmax cannot be reliably determined (Peters, 1986). Carbon dioxide generated during the S_2 pyrolysis, an indicator of kerogen oxidation, is collected up to a temperature of 390°C and reported as S_3 in units of mg CO_2/g sample. A laboratory standard is run every 10 samples. Hydrogen Index (HI = S_2*100/TOC) and Oxygen Index (OI = S_3*100/TOC) are used as kerogen type indicators when plotted on a van Krevelen type diagram.

VISUAL KEROGEN ANALYSIS TECHNIQUES

Visual kerogen analysis employs a Zeiss Universal microscope system equipped with halogen, xenon, and tungsten light sources or a Jena Lumar microscope equipped with halogen and mercury light sources. Vitrinite reflectance and kerogen typing are performed on a polished epoxy plug of unfloated kerogen concentrate using reflected light from the halogen source. In certain situations, the whole rock is used for analysis. This approach is used for coals, where acid treatment is unnecessary in studies of solid bitumen and graptolites where preservation of rock structure is important, and in samples too small for acid treatment. The digital indicator is calibrated using a glass standard with a reflectance of 1.02% in oil. This calibration is linearly accurate for reflectance values ranging from peat (R_o 0.20%) through anthracite (R_o 4.0%).

Reflectance values are recorded only on good quality vitrinite, including obvious contamination and recycled material. The relative abundance of normal, altered, lipid-rich, oxidized, and coked vitrinite is recorded. When good quality, normal vitrinite is absent, notations are made indicating how the maturity is affected by weathering, oxidation, bitumen saturation, or coking. When normal vitrinite is absent or sparse, other macerals may be substituted. Solid bitumen, for example is present in many samples. Although solid bitumen has a different reflectance than vitrinite, Landis and Castaño's calibration chart is used to obtain an estimated vitrinite reflectance equivalent. Graptolites have a slightly higher reflectance than vitrinite and can often be used to obtain maturity data in Upper Cambrian-Silurian rocks that have no vitrinite.

Unstructured lipid kerogen changes in texture and color during the maturation process. Typically, unstructured kerogen at low maturity is reddish brown and amorphous. Somewhere between R_o 0.50 to 0.65%, the kerogen takes on a massive texture and is gray in color. At higher maturity, generally above R_o 1.30%, unstructured kerogen is light gray and micrinized.

Kerogen typing and maturity assessments from the polished plug are enhanced by utilizing fluorescence from blue light excitation. The xenon or mercury lamp is used with an excitation filter at 495 nm coupled with a barrier filter of 520 nm. With the Jena microscope we also have the option of observing fluorescence under ultraviolet excitation. The intensity of fluorescence in the epoxy mounting medium (background fluorescence) correlates well with the onset of oil generation and destruction. The identification of structured and unstructured liptinite is also enhanced with the use of fluorescence in those samples having a maturity less than R_o 1.3%. The relative abundance and type of pyrite is also recorded.

Thermal alteration index (TAI) is performed using tungsten or halogen light source that is transmitted through a glass slide made from the unfloated kerogen concentrate. Ideally, TAI color is based on sporinite of terrestrial origin. When sporinite is absent, TAI is estimated from the unstructured lipid material. Weathering, bitumen admixed with the unstructured material and micrinization can darken the kerogen and raise the TAI value. The character of the organic matter in transmitted light is correlated with observations made in reflected light for kerogen typing.

Kerogen typing and maturity assessments from the slide preparation are also reinforced by using different light sources. The slide is first observed in transmitted light to obtain TAI color and organic matter structure or type. The light is then switched to reflected halogen light to observe structure and amount of pyrite and finally to reflected blue light excitation from the xenon or mercury source for fluorescence. The fluorescence of structured and unstructured liptinite is not masked by the epoxy fluorescence as it is in the reflected light mode because the mounting medium is non-fluorescent. Lipid structures (e.g. sporinite and alginite) within the unstructured kerogen can often be identified in blue light.

Maturity calculations are made from the vitrinite reflectance histograms. Decisions as to which reflectance measurements indicate the maturity of the sample are based not only on the histogram but on all of the kerogen descriptive elements as well. Because it is not done at the time of measurement, alternate maturity calculations can be made if kerogen data and geological information dictate.

DGSI's vitrinite reflectance histograms contain much useful information. All reflectance measurements are graphically displayed and the individual readings are listed below the histogram in numeric order. In the reflectance table, each reading is coded with a letter corresponding to the measured maceral. Capital letters are used to designate reflectance values that are used in calculating the mean reflectance while reflectance values falling outside the selected range are shown with a lower case letter code. Reflectance readings lying inside the selected range are marked with a pattern on the histogram diagram and readings falling outside the selected range are left open. Each maceral has a different pattern. Codes currently in use include: Solid bitumen (B), Granular solid bitumen (X), Coked solid bitumen (Y), Graptolites (G), Inertinite (I), Other 1 (O), Other 2 (W), Vitrinite (V), Lipid-rich vitrinite (L), and Coked Vitrinite (Z). The use of two 'other' categories allows us the flexibility of measuring unusual materials that do not fall into one of the other classes or contamination from mud additives or caving. Specific information regarding 'other' material is shown in the Comments section at the lower right corner of the Figure and in the Comments section of the VKA data sheet.

Statistics for selected macerals are listed adjacent to the histogram and the mean reflectance values are also listed below the TOC and Rock-Eval data at the upper right corner of the Figure. The <u>measured</u> reflectance values for solid bitumen and graptolites are recalculated in order to obtain a <u>vitrinite reflectance equivalent (VRE).</u> Therefore, for these two macerals we show both the measured reflectance and the VRE. For example, VRE-B signifies vitrinite reflectance equivalent for solid bitumen and VRE-G is the vitrinite reflectance equivalent for graptolites.

In summary, vitrinite reflectance measurements are performed on a polished plug in reflected light, TAI is performed on a slide in transmitted light, and kerogen typing is estimated from both preparations using a combination of reflected, transmitted, and fluorescent light techniques. Fluorescence in blue light is used to enhance the identification of structured and unstructured lipid material, solid bitumens, and drilling mud contaminants. Fluorescence also correlates with the maturity and state of preservation of the sample. Maturity calculations from measured reflectance data are made from the histograms and are influenced by all of the kerogen data.

VISUAL KEROGEN ANALYSIS GLOSSARY

Several key definitions are included in this glossary in order to make our reports more self-explanatory. In our reports, we refer to organic substances as macerals. Macerals are akin to minerals in rock in that they are organic constituents that have microscopically recognizable characteristics. However, macerals vary widely in their chemical and physical properties and they are not crystalline.

1. UNSTRUCTURED KEROGEN is sometimes called structureless organic matter (SOM) or bituminite. It is widely held that unstructured kerogen represents the bacterial breakdown of lipid material. It also includes fecal pellets, minute particles of algae, organic gels, and may contain a humic component. As described on the first page of this section, unstructured lipid kerogen changes character during maturation. The three principal stages are amorphous, massive, and micrinized. Amorphous kerogen is simply without any structure. Massive kerogen has taken on a cohesive structure, as the result of polymerization during the process of oil generation. At high maturity, unstructured kerogen becomes micrinized. Micrinite is characterized optically by an aggregation of very small (less than one micron) round bodies that make up the kerogen.

2. STRUCTURED LIPID KEROGEN consists of a group of macerals which have a recognized structure, and can be related to the original living tissue from which they were derived. There are many different types, and the types can be group follows:

   a. Alginite, derived from algae. It is sometimes very useful to distinguish the different algal types, for botryococcus and pediastrum are associated with lacustrine and non-marine source rocks, while algae such as tasmanites, gloecapsomorpha, and nostocopsis are typically marine. Acritarchs and dinoflaggelates are marine organisms which are also included in the algal category.
   b. Cutinite, derived from plant cuticles, the remains of leaves.
   c. Resinite, (including fluorinite) derived from plant resins, balsams, latexes, and waxes.
   d. Sporinite, derived from spores and pollen from a wide variety of land plants.
   e. Suberinite is derived from the corky tissue of land plants.
   f. Liptodetrinite is that structured lipid material that is too small to be specifically identified. Usually, it is derived from alginite or sporinite.

   The algae are an important part of many oil source rocks, both marine and lacustrine. Alginite has a very high hydrogen index in Rock-Eval pyrolysis. Resins, cuticles, and suberinite contribute to the waxy, non-marine oils that are found in Africa and the Far East. At vitrinite reflectance levels above R_o 1.2 - 1.4%, structured lipid kerogen changes structure and it becomes very difficult to distinguish them from vitrinite.

3. SOLID BITUMEN also is called migrabitumen and solid hydrocarbon. In 1992, the International Committee for Coal and Organic Petrology (ICCP) decided to include solid bitumen in the Exsudatinite group. Solid bitumens are expelled hydrocarbon products which have particular morphology, reflectance and fluorescence properties which make it possible to identify them. They represent two classes of substances: one which is present at or near the place where it was generated, and second is a substance which is present in a reservoir rock and may have migrated a great distance from its point of origin. The solid bitumens have been given names, such as gilsonite, impsonite, grahamite, etc., but they represent generated heavy hydrocarbons which remain in place in the source rock or have migrated into a reservoir and mature along with the rock. Consequently, it is possible to use the reflectance of solid bitumens for maturation determinations when vitrinite is not present.

4. HUMIC TISSUE is organic material derived from the woody tissue of land plants. The most important of this group are vitrinite and inertinite:

   a. Vitrinite is derived from woody tissue which has been subjected to a minimum amount of oxidation. Normally it is by far the most abundant maceral in humic coals and because the rate of change of vitrinite reflectance is at a more even pace than it is for other macerals, it offers the best means of obtaining thermal maturity data in coals and other types of sedimentary rocks.

Because the measurement of vitrinite is so important, care is taken to distinguish normal (fresh, unaltered) vitrinite from other kinds of vitrinite. Rough vitrinite does not take a good polish and therefore may not yield good data. Oxidized vitrinite may have a reflectance higher or lower than fresh vitrinite; this is a problem often encountered in outcrop samples. Lipid-rich vitrinite, or saprovitrinite, has a lower reflectance than normal vitrinite and will produce an abnormally low thermal maturity value. Coked vitrinite is vitrinite that has structures found in vitrinite heated in a coke oven. Naturally coked vitrinite is the product of very rapid heating, such as that found adjacent to intrusions. Where it is possible to do so, vitrinite derived from an uphole portion of a well will be identified as caved vitrinite. Recycled vitrinite is the vitrinite of higher maturity which clearly can be separated from the indigenous first-cycle vitrinite population. Often, the recycled vitrinite merges in with the inert group.

   b. Inertinite is made up of woody tissue that has been matured by a different pathway. Early intense oxidation, usually involving charring, fungal attack or biochemical gelification, creates the much more highly reflecting fusinite and semi-fusinite. Sometimes the division between vitrinite and fusinite is transitional. Sclerotinite, fungal remains having a distinct morphology, are considered to be inert. An important consideration is that the inerts, as the name implies, are largely non- reactive "dead carbon" and they have an extremely low hydrogen index in Rock-Eval pyrolysis.

5. OTHER ORGANIC MATERIAL

a. Lipid-rich, caved and recycled vitrinite. These are put in this section so we can show the percentages of these macerals; they are described above.
b. Exsudatinite. Oil and oily exudates fall in this group. Exsudatinite differs from the solid bitumens on the basis of mobility and solubility. We prefer to maintain this distinction although the ICCP has now included the solid bitumens in with the Exsudatinite group.
c. Graptolites are marine organisms that range from the Cambrian to the lower Mississippian; it has been found that they have a reflectance slightly higher than vitrinite. Because vitrinite is lacking in early Paleozoic rocks, the proper identification and measurement of graptolites is important in these sediments.

6. PYRITE. Various forms of pyrite can be readily identified under the microscope. Euhedral is pyrite with a definite crystalline habit. Framboidal is pyrite in the form of grape-like clusters which are made up of euhedral to subhedral crystals. Framboidal pyrite is normally found in sediments with a marine influence; for example, coals with a marine shale roof rock usually contain framboidal pyrite. Massive pyrite is pyrite with no particular external form. Often this is pyrite that forms rather late in the pore spaces of the sediment. Replacement/infilling is self-explanatory.

ORGANIC CARBON AND ROCK-EVAL PYROLYSIS DATA

ALASKA OUTCROPS

DGSI Project: 97/3805

SAMPLE IDENTIFICATION DGSI ID		ID	TOC Wt%	S1 mg/g	S2 mg/g	S3 mg/g	Tmax degC	S1/ TOC	HI	OI	S2/ S3	PI
1	:	96 Mu 5	1.78	0.10	0.44	0.78	467	6	25	44	0.56	0.19
2	:	96 Mu 12	1 12	0.09	0.43	0.63	471	8	38	56	0.68	0.17
3	:	96 Mu 14	0.88	0.25	0.47	0.27	459	28	53	31	1.74	0.35
4	:	96 Mu 18	1.38	0.05	0.56	0.80	448	4	41	58	0.70	0.08
5	:	96 Mu 30-2	1 12	0 04	0.39	0 28	446	4	35	25	1.39	0.09
6	:	96 Mu 33-1	4 22	0.09	7 48	0.14	438	2	177	3	53.43	0.01
7	:	94 Mu 72-1	22.34	3.72	142.99	1.46	431	17	640	7	97.94	0.03
8	:	96 Mu 35-2	12.86	0.75	60.09	1.48	434	5	467	12	40.60	0.01
9	:	96 Mu 35-4	0.96	0 05	0.43	0.39	440	5	45	41	1.10	0.10
10	:	96 Mu 46	9.84	0.40	26.69	0.73	438	4	271	7	36.56	0.01
11	:	96 Mu 52-1	3.80	0.10	11.14	0.32	434	3	293	8	34.81	0.01
12	:	96 Mu 57-4	2.94	0.11	5.23	0.39	437	4	178	13	13.41	0.02
13	:	96 Ha 25	1.07	0.06	0.26	0.37	496	6	24	35	0.70	0.19
14	:	96 Ha 37	2.92	0.10	0.86	0.56	497	3	29	19	1.54	0.10
15	:	96 Ha 58	0.90	0.02	0.24	0.32	499	2	27	36	0.75	0.08
16	:	96 Ha 66	1 25	0.10	0.52	0.59	473	8	42	47	0.88	0.16
17	:	96 TM 29-B	1.12	0.06	0.34	0.43	499	5	30	38	0.79	0.15
18	:	96 TM 56-A	0 45	0.05	0.07	0.39	498	11	16	87	0.18	0.42
19	:	94 Mu 43-1	0.43	0 01	0.07	0.22	504	2	16	51	0.32	0.13
20	:	94 Mu 43-16	1.80	0 08	0.70	0.62	469	4	39	34	1.13	0.10

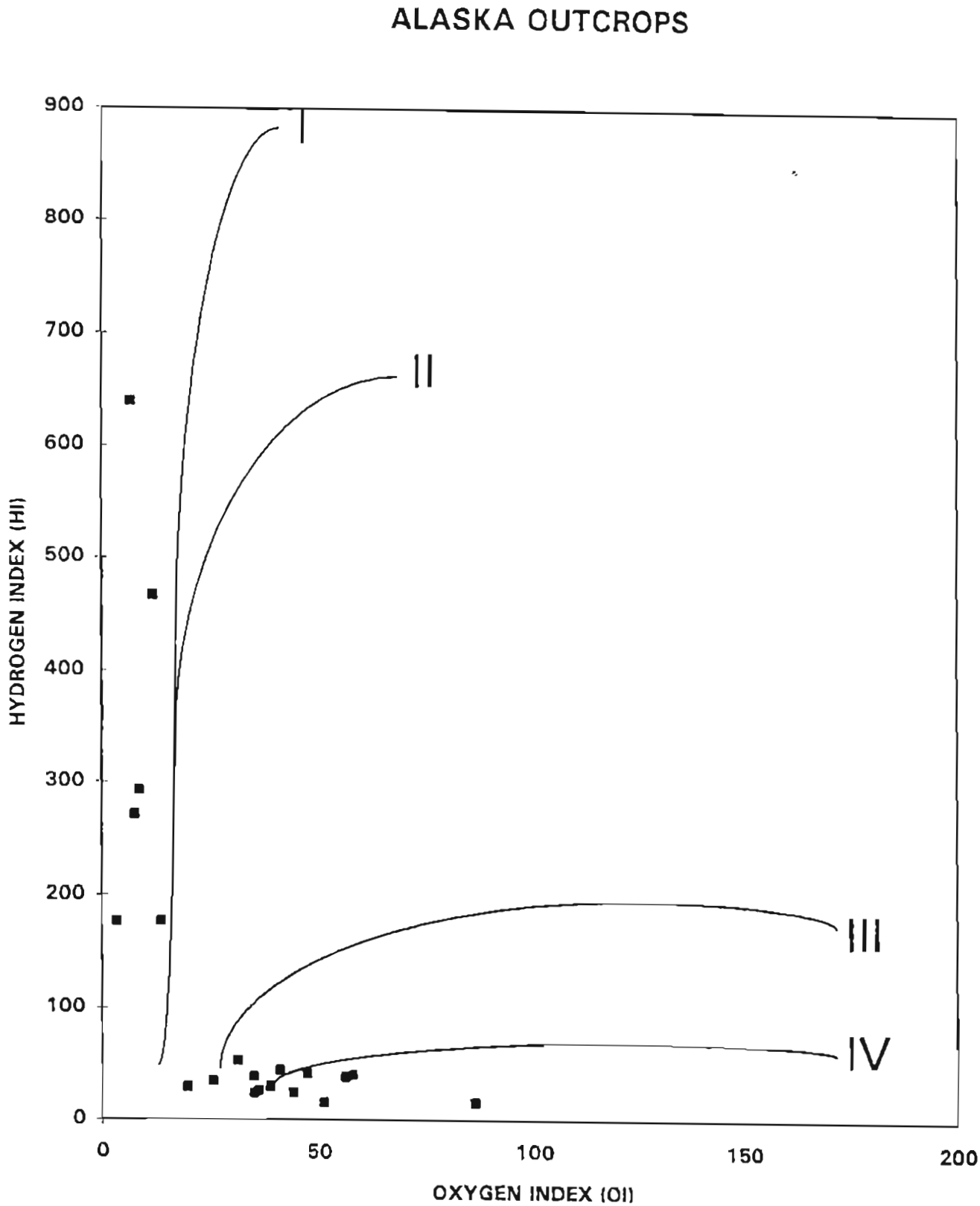
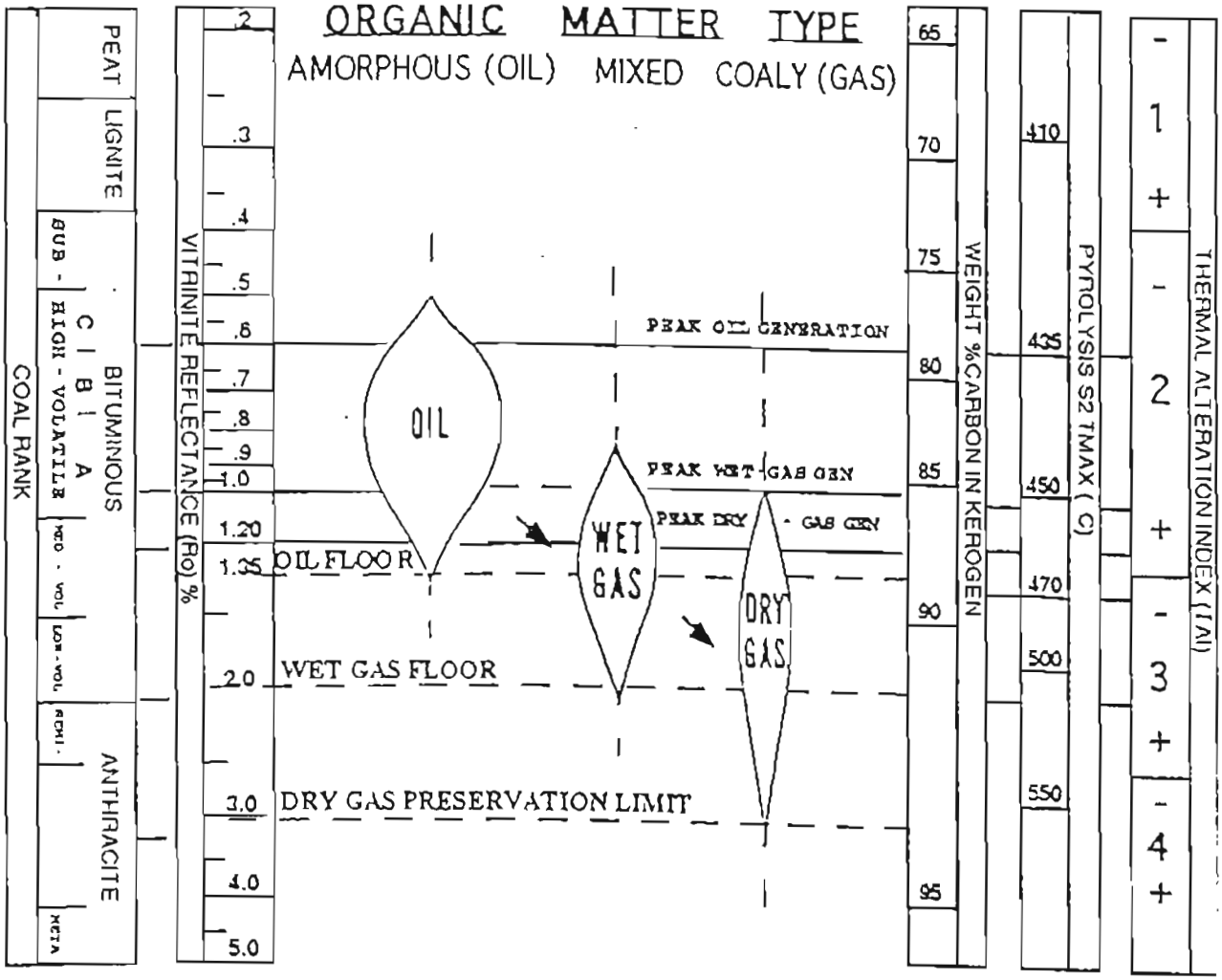


FIGURE 1 Kerogen type determination from TOC and Rock-Eval pyrolysis data. Types I and II will generate oil, type III gas, and type IV little or no hydrocarbons.

ZONES OF PETROLEUM GENERATION AND DESTRUCTION

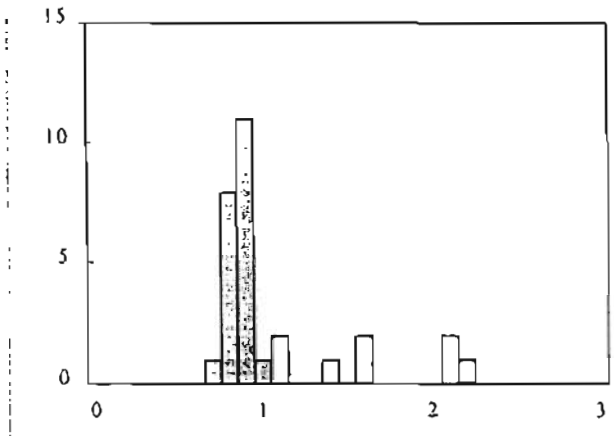


CORRELATION OF VARIOUS MATURATION INDICES AND ZONES OF PETROLEUM GENERATION AND DESTRUCTION.

VITRINITE REFLECTANCE — ALASKA OUTCROPS

DGSI Project 97/3805 — Sample No. 1
OTHER ID: 96 Mu 5

TYPE	K/OC	
	TOC	1.78
	TMAX	467
	HI	25
	V Ro	0.90



MEAN	0.90
ST DEV	0.06
VARIANCE	0.00
MINIMUM	0.76
MAXIMUM	1.00
NUMBER	21

Visual Kerogen Summary

Unstructured Lipids	10
Structured Lipids	-
Solid Bitumen	-
Inertinite	15
Vitrinite	15
Other	60
TOTAL	100

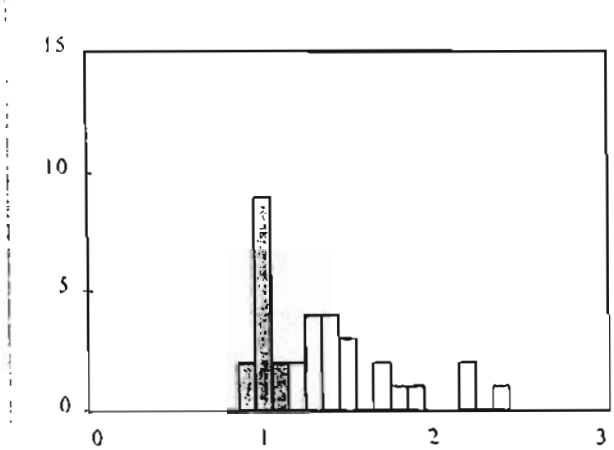
L 0.76	L 0.87	L 0.91	L 0.94	V 1.00	v 1.61
L 0.82	L 0.87	L 0.91	L 0.94	v 1.10	v 2.10
V 0.84	L 0.88	V 0.91	L 0.95	I 1.19	v 2.19
L 0.85	L 0.89	L 0.93	L 0.95	I 1.48	v 2.23
L 0.86	L 0.91	L 0.94	L 0.96	v 1.60	

Background Fluorescence	Strong
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 97/3805 — Sample No. 2
OTHER ID: 96 Mu 12

TYPE	K/OC	
	TOC	1.12
	TMAX	471
	HI	38
	V Ro	1.04



MEAN	1.05
ST DEV	0.05
VARIANCE	0.00
MINIMUM	0.95
MAXIMUM	1.12
NUMBER	13

Visual Kerogen Summary

Unstructured Lipids	5
Structured Lipids	-
Solid Bitumen	-
Inertinite	10
Vitrinite	80
Other	5
TOTAL	100

V 0.95	L 1.05	V 1.09	v 1.30	v 1.40	v 1.59	v 2.22
L 0.97	V 1.05	V 1.10	v 1.31	v 1.46	v 1.74	I 2.28
L 1.00	V 1.07	V 1.12	v 1.31	v 1.48	v 1.78	v 2.48
L 1.01	V 1.07	I 1.21	v 1.33	v 1.51	v 1.88	
V 1.03	V 1.07	v 1.22	v 1.40	v 1.59	v 1.99	

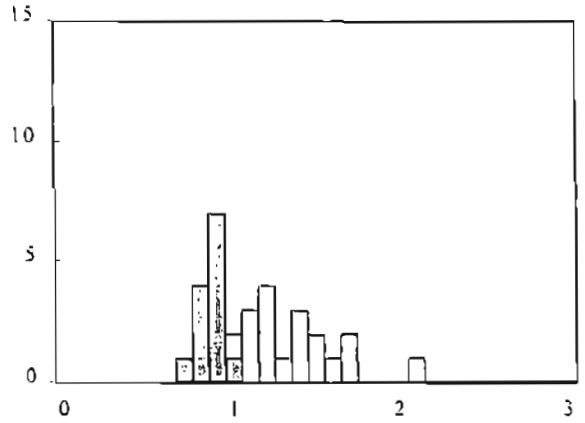
Background Fluorescence	Strong
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

VITRINITE REFLECTANCE ALASKA OUTCROPS

DGSI Project 97/3805 Sample No. 3
OTHER ID: 96 Mu 14

TYPE	K/OC	
	TOC	0.88
	TMAX	459
	HI	53
	V Ro	0.89



MEAN	0.89
ST DEV	0.07
VARIANCE	0.01
MINIMUM	0.78
MAXIMUM	1.01
NUMBER	8

L 0.78	L 0.90	V 0.95	v 1.15	v 1.28	v 1.54	v 2.12
L 0.81	L 0.91	L 0.98	v 1.17	v 1.31	v 1.58	
V 0.82	V 0.91	V 1.01	v 1.20	v 1.41	v 1.63	
L 0.83	V 0.92	v 1.08	v 1.24	v 1.42	v 1.71	
V 0.87	L 0.93	v 1.11	v 1.27	v 1.49	v 1.75	

Visual Kerogen Summary

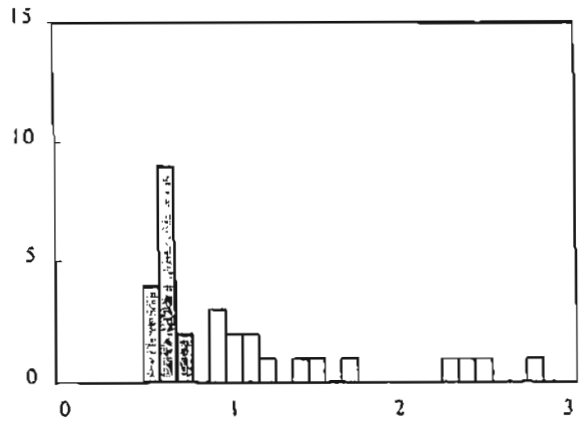
Unstructured Lipids	15
Structured Lipids	-
Solid Bitumen	-
Inertinite	15
Vitrinite	65
Other	5
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 4
OTHER ID: 96 Mu 18

TYPE	K/OC	
	TOC	1.38
	TMAX	448
	HI	41
	V Ro	0.85



MEAN	0.65
ST DEV	0.06
VARIANCE	0.00
MINIMUM	0.52
MAXIMUM	0.77
NUMBER	15

V 0.52	V 0.63	V 0.67	v 0.94	v 1.12	v 1.79
L 0.59	L 0.64	V 0.69	v 0.97	v 1.15	v 2.39
V 0.59	L 0.66	V 0.69	v 0.99	v 1.26	v 2.41
V 0.59	V 0.66	V 0.74	v 1.05	v 1.47	v 2.56
L 0.60	L 0.67	V 0.77	v 1.09	v 1.52	v 2.89

Visual Kerogen Summary

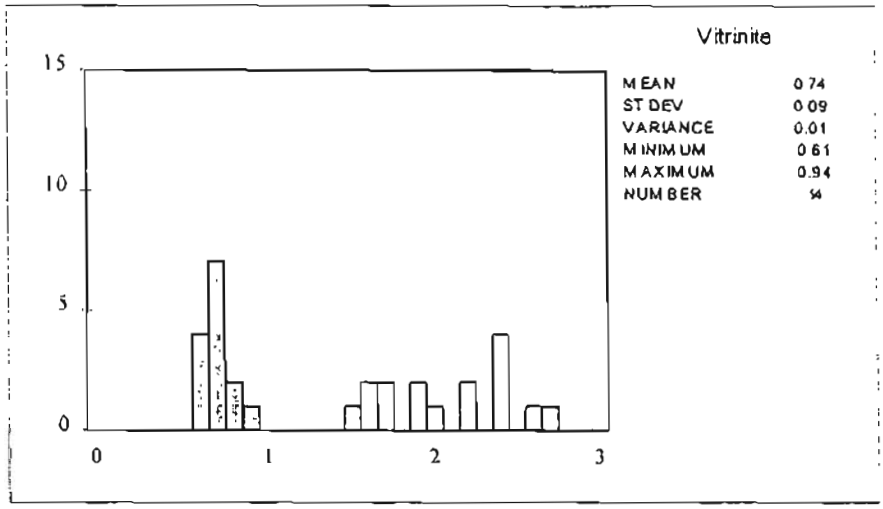
Unstructured Lipids	10
Structured Lipids	5
Solid Bitumen	-
Inertinite	15
Vitrinite	65
Other	5
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 5
OTHER ID: 96 Mu 30-2

TYPE	K/OC	
	TOC	1.12
	TMAX	446
	HI	35
	V Ro	0.74



Vitrinite	
MEAN	0.74
ST DEV	0.09
VARIANCE	0.01
MINIMUM	0.61
MAXIMUM	0.94
NUMBER	54

L 0.61	V 0.72	V 0.79	v 1.61	v 1.91	v 2.46
V 0.61	L 0.74	V 0.80	v 1.67	v 2.00	v 2.47
L 0.62	V 0.75	V 0.83	v 1.72	v 2.20	v 2.48
V 0.68	L 0.78	V 0.94	v 1.74	v 2.21	v 2.69
V 0.70	L 0.79	v 1.53	v 1.91	I 2.46	v 2.73

Visual Kerogen Summary

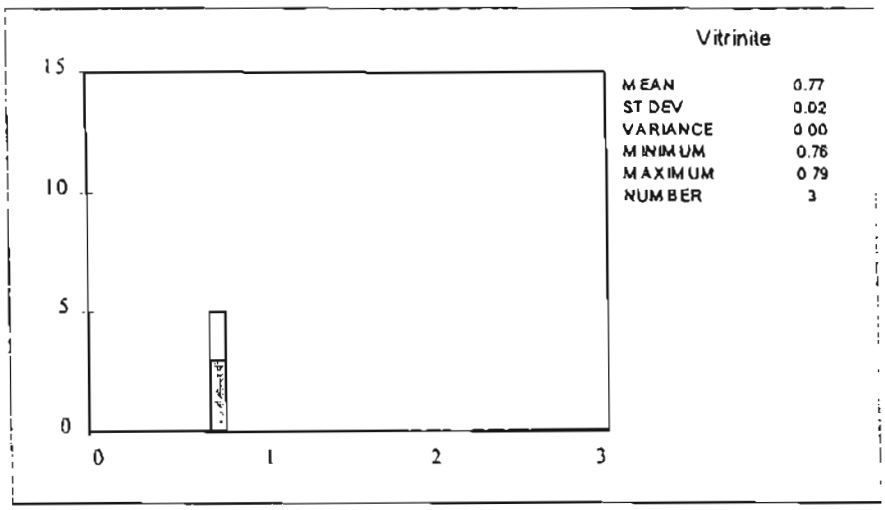
Unstructured Lipids	5
Structured Lipids	5
Solid Bitumen	-
Inertinite	10
Vitrinite	70
Other	10
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 6
OTHER ID: 96 Mu 33-1

TYPE	K/OC	
	TOC	4.22
	TMAX	438
	HI	177
	V Ro	?0.77



Vitrinite	
MEAN	0.77
ST DEV	0.02
VARIANCE	0.00
MINIMUM	0.76
MAXIMUM	0.79
NUMBER	3

b 0.74
b 0.76
V 0.76
V 0.76
V 0.79

Visual Kerogen Summary

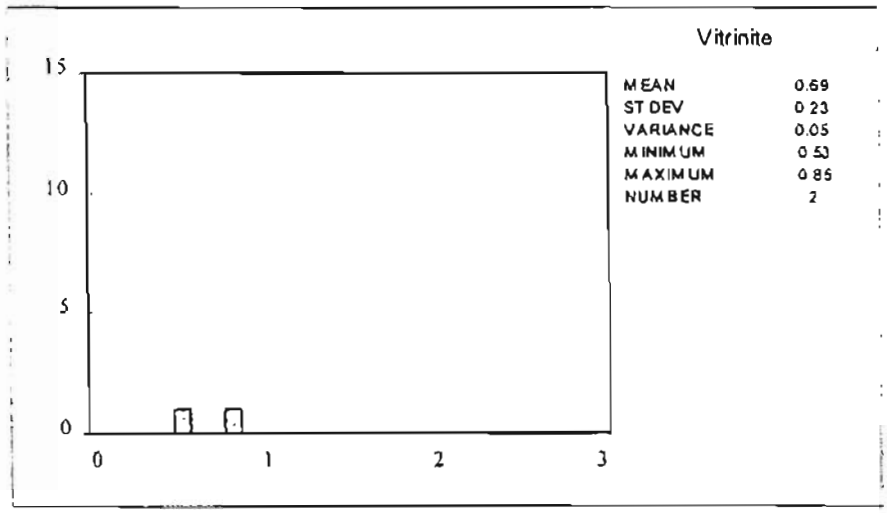
Unstructured Lipids	75
Structured Lipids	10
Solid Bitumen	5
Inertinite	5
Vitrinite	5
Other	0
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	2+
TAI Structured	

COMMENTS:

VITRINITE REFLECTANCE ALASKA OUTCROPS

DGSI Project 97/3805 Sample No. 7
OTHER ID: 94 Mu 72-1



MEAN	0.69
ST DEV	0.23
VARIANCE	0.05
MINIMUM	0.53
MAXIMUM	0.85
NUMBER	2

L 0.53
L 0.85

TYPE	K/OC	
	TOC	22.34
	TMAX	431
	HI	640
	V Ro	?0.69

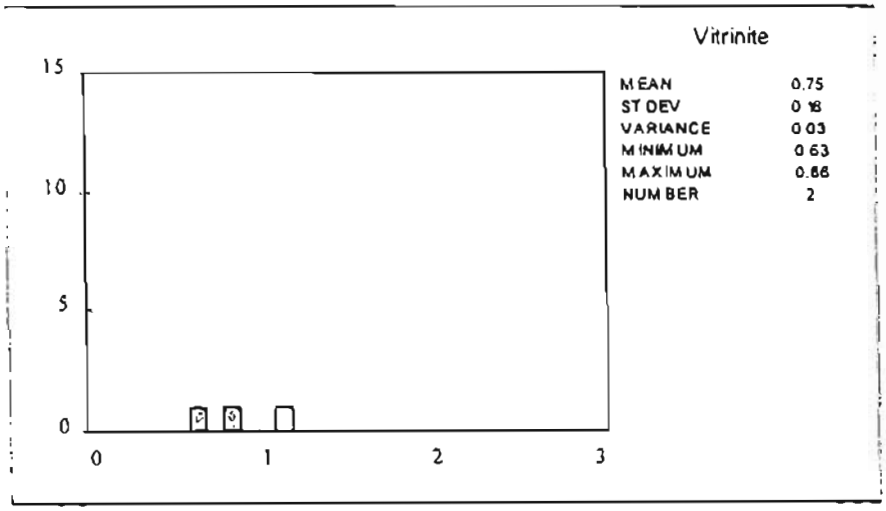
Visual Kerogen Summary

Unstructured Lipids	50
Structured Lipids	40
Solid Bitumen	10
Inertinite	T
Vitrinite	-
Other	0
TOTAL	100

Background Fluorescence	Moderate
TAI Unstructured	2+,3-
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 8
OTHER ID: 96 Mu 35-2



MEAN	0.75
ST DEV	0.18
VARIANCE	0.03
MINIMUM	0.63
MAXIMUM	0.86
NUMBER	2

L 0.63
V 0.86
v 1.19

TYPE	K/OC	
	TOC	12.86
	TMAX	434
	HI	467
	V Ro	?0.75

Visual Kerogen Summary

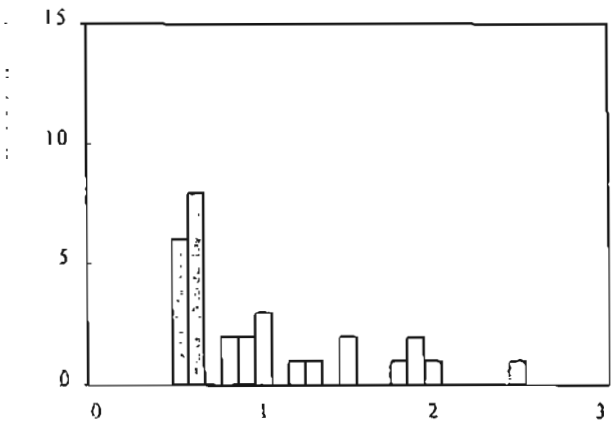
Unstructured Lipids	70
Structured Lipids	20
Solid Bitumen	10
Inertinite	T
Vitrinite	T
Other	0
TOTAL	100

Background Fluorescence	Moderate
TAI Unstructured	3-
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No 9
OTHER ID: 96 Mu 35-4

TYPE	K/OC
TOC	0.96
TMAX	440
HI	45
V Ro	0.61



MEAN	0.61
ST DEV	0.05
VARIANCE	0.00
MINIMUM	0.53
MAXIMUM	0.69
NUMBER	14

L 0.53 L 0.59 L 0.66 v 0.85 v 1.03 v 1.80
L 0.54 V 0.62 V 0.66 I 0.99 I 1.25 v 1.96
L 0.56 V 0.64 V 0.67 v 0.99 v 1.37 v 1.96
V 0.56 L 0.64 L 0.69 I 1.00 v 1.50 v 2.09
V 0.58 V 0.65 I 0.85 I 1.01 v 1.59 v 2.59

Visual Kerogen Summary

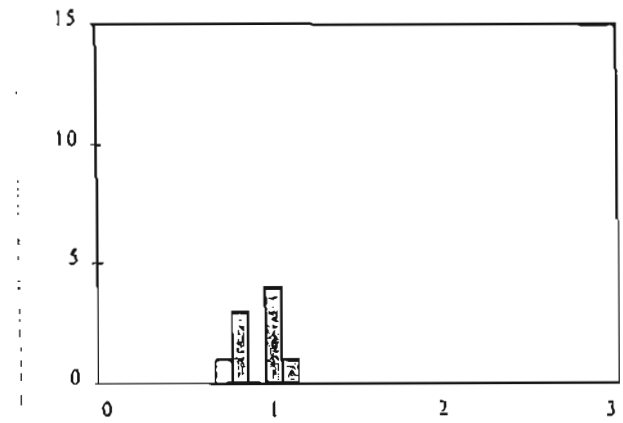
Unstructured Lipids	25
Structured Lipids	-
Solid Bitumen	-
Inertinite	10
Vitrinite	35
Other	30
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	3
TAI Structured	2+

COMMENTS:

DGSI Project 97/3805 Sample No. 10
OTHER ID: 96 Mu 46

TYPE	K/OC
TOC	9.84
TMAX	438
HI	271
V Ro	?0.98



MEAN	0.98
ST DEV	0.12
VARIANCE	0.01
MINIMUM	0.82
MAXIMUM	1.16
NUMBER	8

b 0.79 L 1.04
V 0.82 L 1.04
L 0.87 L 1.05
L 0.87 V 1.16
L 1.01

Visual Kerogen Summary

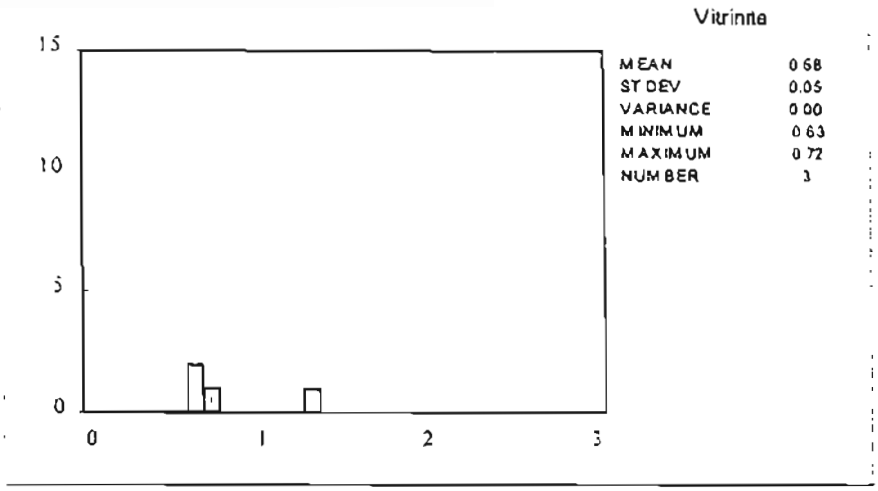
Unstructured Lipids	30
Structured Lipids	10
Solid Bitumen	55
Inertinite	T
Vitrinite	T
Other	5
TOTAL	100

Background Fluorescence	Weak,Mod
TAI Unstructured	3+
TAI Structured	

COMMENTS:

VITRINITE REFLECTANCE ALASKA OUTCROPS

DGSI Project 97/3805 Sample No 11
OTHER ID: 96 Mu 52-1



L 0.63
L 0.68
V 0.72
I 1.39

TYPE	K/OC	
	TOC	3.80
	TMAX	434
	HI	293
	V Ro	?0.68

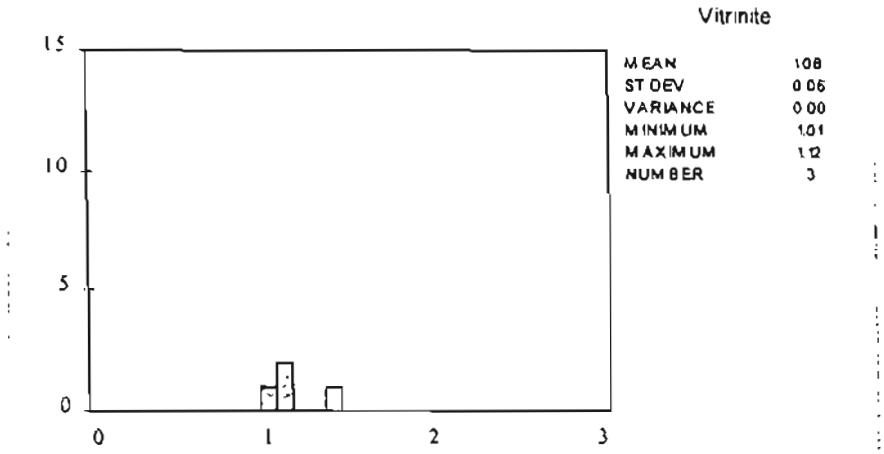
Visual Kerogen Summary

Unstructured Lipids	55
Structured Lipids	10
Solid Bitumen	30
Inertinite	T
Vitrinite	T
Other	5
TOTAL	100

Background Fluorescence	Mod.Strong
TAI Unstructured	3-
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 12
OTHER ID: 96 Mu 57-4



L 1.01
L 1.10
L 1.12
I 1.48

TYPE	K/OC	
	TOC	2.94
	TMAX	437
	HI	178
	V Ro	?1.08

Visual Kerogen Summary

Unstructured Lipids	70
Structured Lipids	10
Solid Bitumen	10
Inertinite	5
Vitrinite	-
Other	5
TOTAL	100

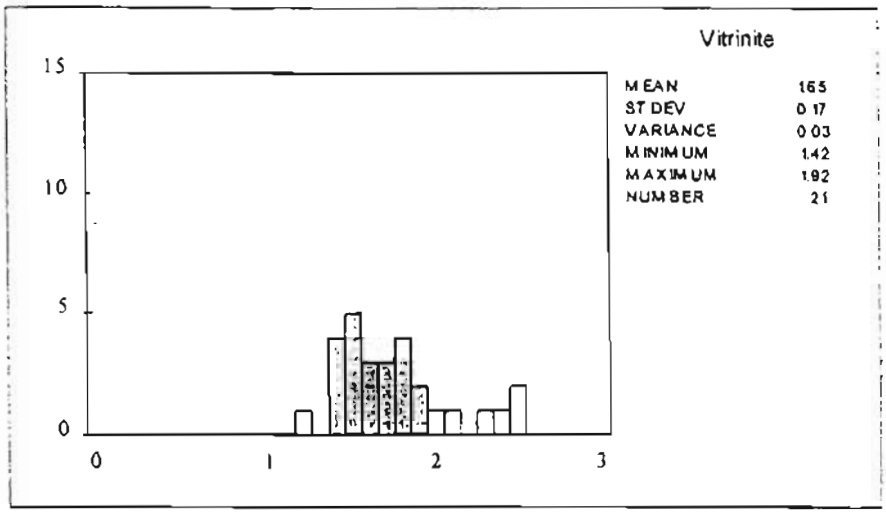
Background Fluorescence	Strong
TAI Unstructured	2+,3-
TAI Structured	

COMMENTS:

VITRINITE REFLECTANCE — ALASKA OUTCROPS

DGSI Project 97/3805 — Sample No. 15
OTHER ID: 96 Ha 25

TYPE	K/OC	
	TOC	1.07
	TMAX	496
	HI	24
	V Ro	1.65



v 1.28 V 1.51 V 1.61 V 1.79 V 1.92 v 2.40
V 1.42 V 1.51 V 1.67 V 1.80 V 1.92 v 2.52
V 1.43 V 1.51 V 1.69 V 1.83 v 2.05 v 2.55
V 1.43 V 1.51 V 1.70 V 1.85 v 2.16
V 1.45 V 1.58 V 1.72 V 1.88 v 2.33

Visual Kerogen Summary

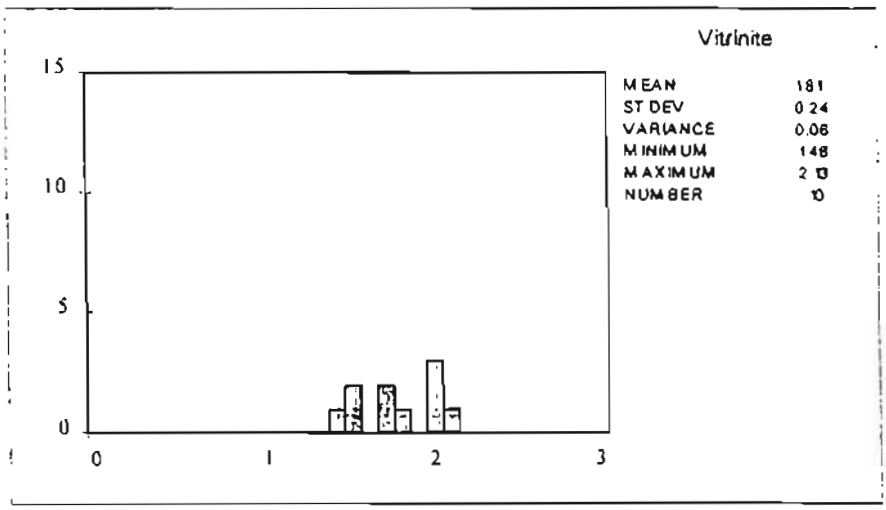
Unstructured Lipids	30
Structured Lipids	5
Solid Bitumen	-
Inertinite	20
Vitrinite	45
Other	0
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 97/3805 — Sample No. 14
OTHER ID: 96 Ha 37

TYPE	K/OC	
	TOC	2.92
	TMAX	497
	HI	29
	V Ro	1.81



V 1.48 V 1.87
V 1.50 V 2.00
V 1.54 V 2.02
V 1.72 V 2.04
V 1.76 V 2.13

Visual Kerogen Summary

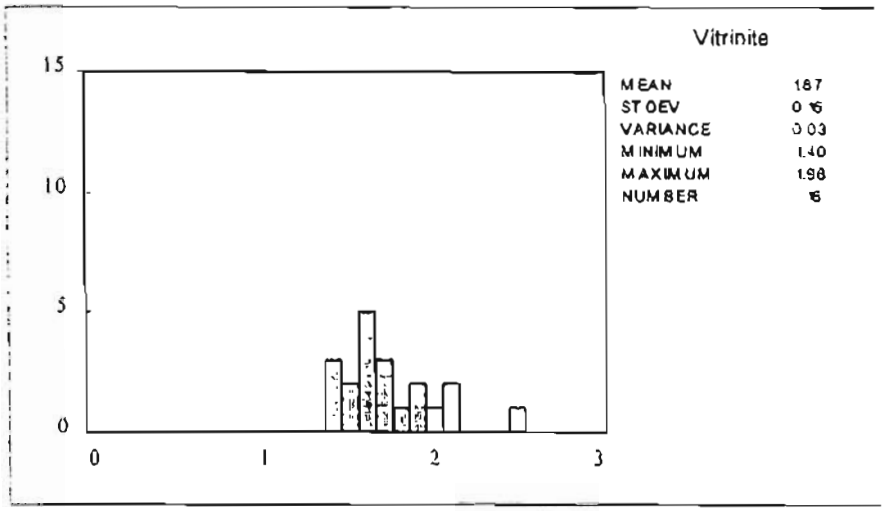
Unstructured Lipids	80
Structured Lipids	-
Solid Bitumen	5
Inertinite	5
Vitrinite	10
Other	0
TOTAL	100

Background Fluorescence	Mod.Strong
TAI Unstructured	3-,3+
TAI Structured	3+

COMMENTS:

VITRINITE REFLECTANCE ALASKA OUTCROPS

DGSI Project 97/3805 Sample No. 15
OTHER ID: 96 Ha 58



MEAN	1.67
ST DEV	0.16
VARIANCE	0.03
MINIMUM	1.40
MAXIMUM	1.98
NUMBER	15

V 1.40 V 1.61 V 1.72 V 1.96
V 1.45 V 1.65 V 1.74 v 2.04
V 1.48 V 1.65 V 1.77 v 2.13
V 1.55 V 1.67 V 1.86 v 2.14
V 1.57 V 1.69 V 1.95 v 2.51

TYPE	K/OC	
	TOC	0.90
	TMAX	499
	HI	27
	V Ro	1.67

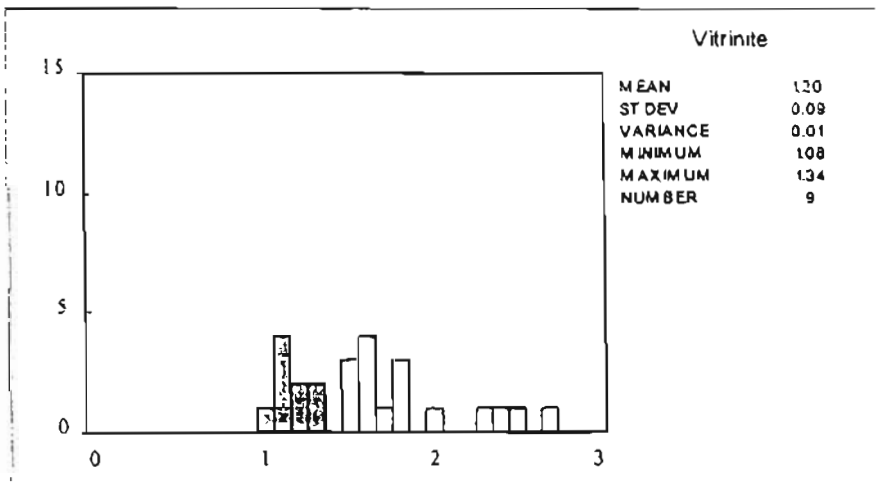
Visual Kerogen Summary

Unstructured Lipids	10
Structured Lipids	-
Solid Bitumen	-
Inertinite	15
Vitrinite	75
Other	0
TOTAL	100

Background Fluorescence	Mod.Strong
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 16
OTHER ID: 96 Ha 66



MEAN	1.20
ST DEV	0.09
VARIANCE	0.01
MINIMUM	1.08
MAXIMUM	1.34
NUMBER	9

L 1.08 V 1.22 v 1.51 v 1.69 v 2.02
V 1.11 V 1.24 v 1.58 v 1.73 v 2.34
V 1.14 V 1.31 v 1.61 v 1.83 v 2.40
V 1.16 V 1.34 v 1.62 v 1.84 v 2.52
V 1.18 v 1.51 v 1.66 v 1.88 v 2.75

TYPE	K/OC	
	TOC	1.25
	TMAX	473
	HI	42
	V Ro	?1.20

Visual Kerogen Summary

Unstructured Lipids	30
Structured Lipids	-
Solid Bitumen	-
Inertinite	20
Vitrinite	50
Other	0
TOTAL	100

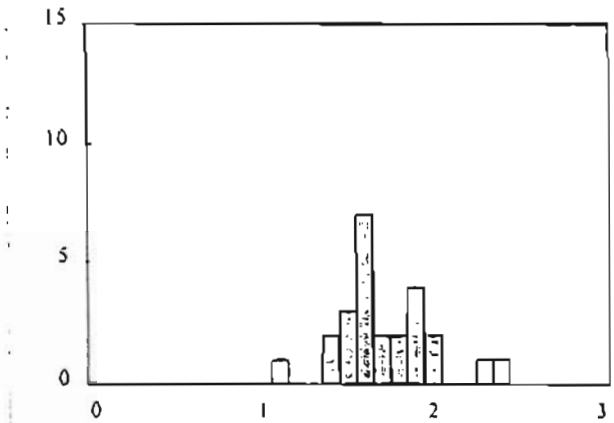
Background Fluorescence	Intense
TAI Unstructured	3-
TAI Structured	

COMMENTS:

VITRINITE REFLECTANCE

ALASKA OUTCROPS

DGSI Project 97/3805 Sample No. 17
OTHER ID: 96 TM 29-B



MEAN	1.72
ST DEV	0.19
VARIANCE	0.04
MINIMUM	1.40
MAXIMUM	2.09
NUMBER	22

I 1.19 V 1.58 V 1.63 V 1.85 V 1.94
L 1.40 V 1.60 V 1.64 V 1.89 V 2.01
V 1.46 V 1.61 V 1.67 V 1.91 V 2.09
L 1.50 V 1.61 V 1.71 V 1.92 v 2.36
V 1.56 V 1.63 V 1.76 V 1.93 v 2.42

TYPE	K/OC	
	TOC	1.12
	TMAX	499
	HI	30
	V Ro	1.72

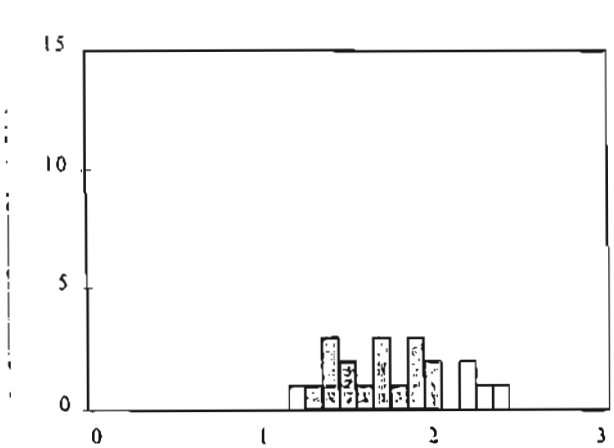
Visual Kerogen Summary

Unstructured Lipids	10
Structured Lipids	-
Solid Bitumen	-
Inertinite	15
Vitrinite	70
Other	5
TOTAL	100

Background Fluorescence	Moderate
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No. 18
OTHER ID: 96 TM 56-A



MEAN	1.72
ST DEV	0.24
VARIANCE	0.08
MINIMUM	1.37
MAXIMUM	2.09
NUMBER	16

I 1.21 V 1.55 V 1.78 V 2.02 v 2.47
V 1.37 V 1.58 V 1.84 V 2.09
V 1.42 V 1.65 V 1.96 v 2.22
V 1.43 L 1.72 V 1.96 v 2.26
V 1.44 V 1.72 V 1.99 v 2.38

TYPE	K/OC	
	TOC	
	TMAX	
	HI	
	V Ro	1.72

Visual Kerogen Summary

Unstructured Lipids	20
Structured Lipids	-
Solid Bitumen	-
Inertinite	20
Vitrinite	60
Other	0
TOTAL	100

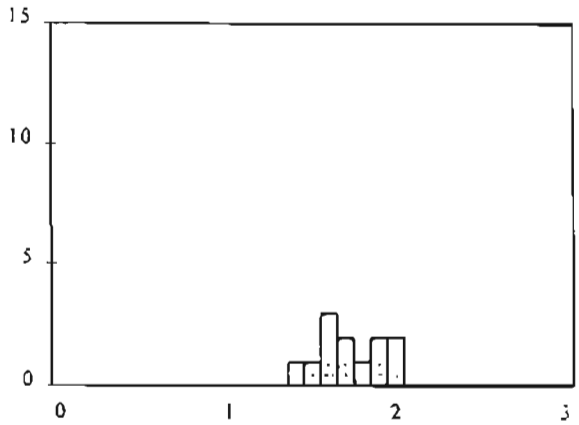
Background Fluorescence	Weak
TAI Unstructured	n.d.
TAI Structured	

COMMENTS:

VITRINITE REFLECTANCE

ALASKA OUTCROPS

DGSI Project 97/3805 Sample No. 19
OTHER ID: 94 Mu 43-1



MEAN	1.78
ST DEV	0.17
VARIANCE	0.03
MINIMUM	1.49
MAXIMUM	2.04
NUMBER	12

V 1.49 V 1.75 V 2.01
V 1.56 V 1.79 V 2.04
V 1.66 V 1.86
V 1.68 V 1.90
V 1.69 V 1.93

TYPE	
K/OC	
TOC	
TMAX	
HI	
V Ro	1.78

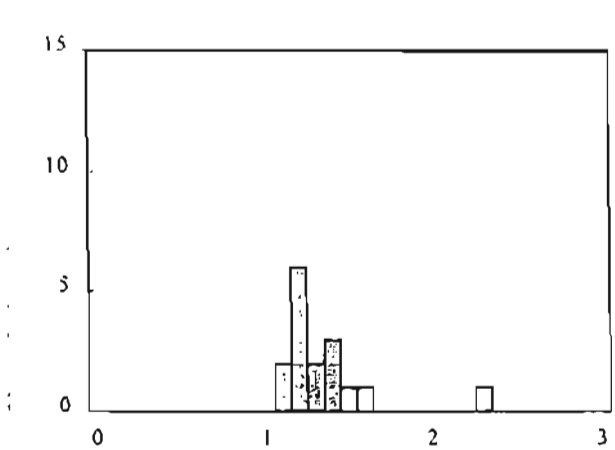
Visual Kerogen Summary

Unstructured Lipids	60
Structured Lipids	-
Solid Bitumen	-
Inertinite	20
Vitrinite	20
Other	0
TOTAL	100

Background Fluorescence	Strong
TAI Unstructured	3
TAI Structured	

COMMENTS:

DGSI Project 97/3805 Sample No 20
OTHER ID:94 Mu 43-16



MEAN	1.29
ST DEV	0.09
VARIANCE	0.01
MINIMUM	1.18
MAXIMUM	1.44
NUMBER	13

V 1.18 V 1.24 L 1.41 v 2.31
V 1.18 V 1.25 V 1.41
V 1.21 V 1.26 V 1.44
V 1.23 V 1.32 v 1.55
V 1.24 V 1.39 v 1.62

TYPE	
K/OC	
TOC	
TMAX	
HI	
V Ro	1.29

Visual Kerogen Summary

Unstructured Lipids	70
Structured Lipids	-
Solid Bitumen	-
Inertinite	10
Vitrinite	20
Other	0
TOTAL	100

Background Fluorescence	Intense
TAI Unstructured	3-,3
TAI Structured	

COMMENTS:

WHOLE EXTRACT GAS CHROMATOGRAPHY

About 50 grams of sample are crushed, passed through a 20 micron sieve, accurately weighed, and soxhlet extracted for 16 hours with dichloromethane. Other solvents can be substituted if desired. The solvent is evaporated and the residue weighed to obtain the weight percent of total organic extract. The advantage of whole extract chromatography over saturate chromatography is more of the lighter fraction (C_{10} - C_{15}) is preserved. A minor disadvantage is the nonsaturate compounds are retained and complicate the chromatograms in relatively immature extracts.

A sample of whole extract is injected directly into a Varian model 3400 gas chromatograph fitted with a Quadrex 50 meter fused silica capillary column. The GC is programmed from 40°C to 340°C at 10°C/minute with a 2 minute hold at 40°C and a 20 minute hold at 340°C. Analytical data are processed with a Nelson Analytical model 3000 chromatographic data system and IBM computer hardware. This software system facilitates data processing and graphic display as well as electronic data transmittal. All standard calculations are made including pristane/phytane ratio, carbon preference index, and other key parameters.

Whole extract gas chromatography provides information on organic facies and thermal maturity of source rocks and migrated petroleum. It serves as a basis for oil-rock correlations. It is recommended primarily to evaluate known or suspected source beds, oil shows, samples with anomalous pyrolysis S_1 values and to identify possible contamination products.

WHOLE EXTRACT GAS CHROMATOGRAPHY

Alaska Outcrops

DGSI Project: 97/3959

Sample Identification DGSI ID		TOC Wt%	PPM	GAS CHROMATOGRAPHY RATIOS Ext./TOC	Pr/Ph	Pr/C17	Ph/C18	OEP
DGSI Project: 96/3631								
1	: 96 Mu 33-5	18.65	3900	0.021	1.9	0.28	0.25	N.A.
21	: 96 MAW 7	2.88	1630	0.057	3.5	0.54	0.20	N.A.
22	: 96 MAW 9	1.76	914	0.052	2.6	0.64	0.30	1.12
23	: 96 MAW 11	2.40	2829	0.118	2.6	0.56	0.27	N.A.
DGSI Project: 97\3805								
7	: 94 Mu 72-1	22.34	7216	0.032	3.0	1.45	0.77	N.A.
8	: 96 Mu 35-2	12.86	2486	0.019	2.7	0.64	0.30	N.A.
10	: 96 Mu 46	9.84	2043	0.021	2.8	0.49	0.24	N.A.

DGSI ID		Sample Weight	Extract Weight	AREA DATA C17	Pr	C18	Ph	C28	C29	C30
1	:	30.6144	0.1194	148592	41261	86362	21990	n.d.	n.d.	n.d.
21	:	71.5364	0.1166	314488	169575	237871	48529	47319	41328	n.d.
22	:	40.2630	0.0368	364957	231961	298173	88749	65671	63701	48045
23	:	59.5685	0.1685	148629	82703	116337	31298	25227	n.d.	n.d.
7	:	19.4701	0.1255	202661	294653	125487	96893	n.d.	n.d.	n.d.
8	:	30.7342	0.0764	238617	151861	191252	57302	n.d.	n.d.	n.d.
10	:	43.5065	0.0889	128716	63508	96432	22832	n.d.	n.d.	n.d.

NORMALIZED ISOPRENOID PERCENT

Alaska Outcrops

DGSI Project: 97/3959

DGSI ID	iC13	iC14	iC15	iC16	iC18	iC19	iC20
1	4.5	37.7	18.4	21.6	4.3	8.8	4.7
21	4.9	21.8	13.5	18.5	11.7	23.0	6.6
22	8.4	7.4	7.6	19.9	7.0	35.9	13.7
23	11.4	10.5	13.1	20.9	12.0	23.3	8.8
7	2.5	2.4	6.5	16.5	17.8	40.9	13.4
8	N.A.	N.A.	7.9	27.0	19.4	33 2	12.5
10	N.A.	23.3	4.8	20.8	11 8	28.9	10.4

AREA DATA

DGSI ID	iC13	iC14	iC15	iC16	iC18	iC19	iC20
1	21169	176457	86012	101185	20176	41261	21990
21	35933	160461	99800	136104	86386	169575	48529
22	54140	47921	49102	128758	45255	231961	88749
23	40502	37167	46307	74002	42498	82703	31298
7	17810	17290	47212	118635	128599	294653	96893
8	n.d.	n.d.	36291	123598	88882	151861	57302
10	n.d.	51141	10441	45694	25978	63508	22832

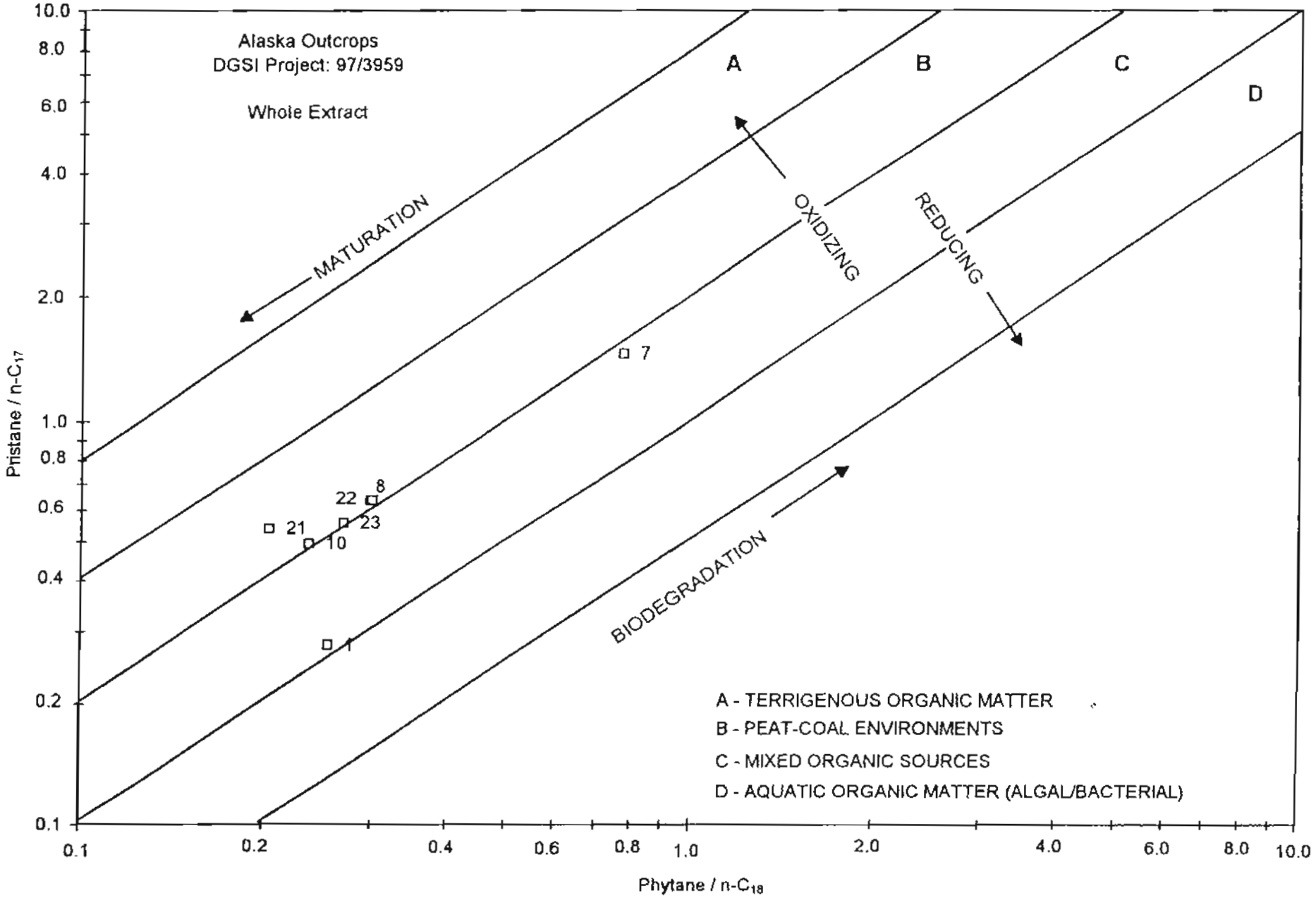
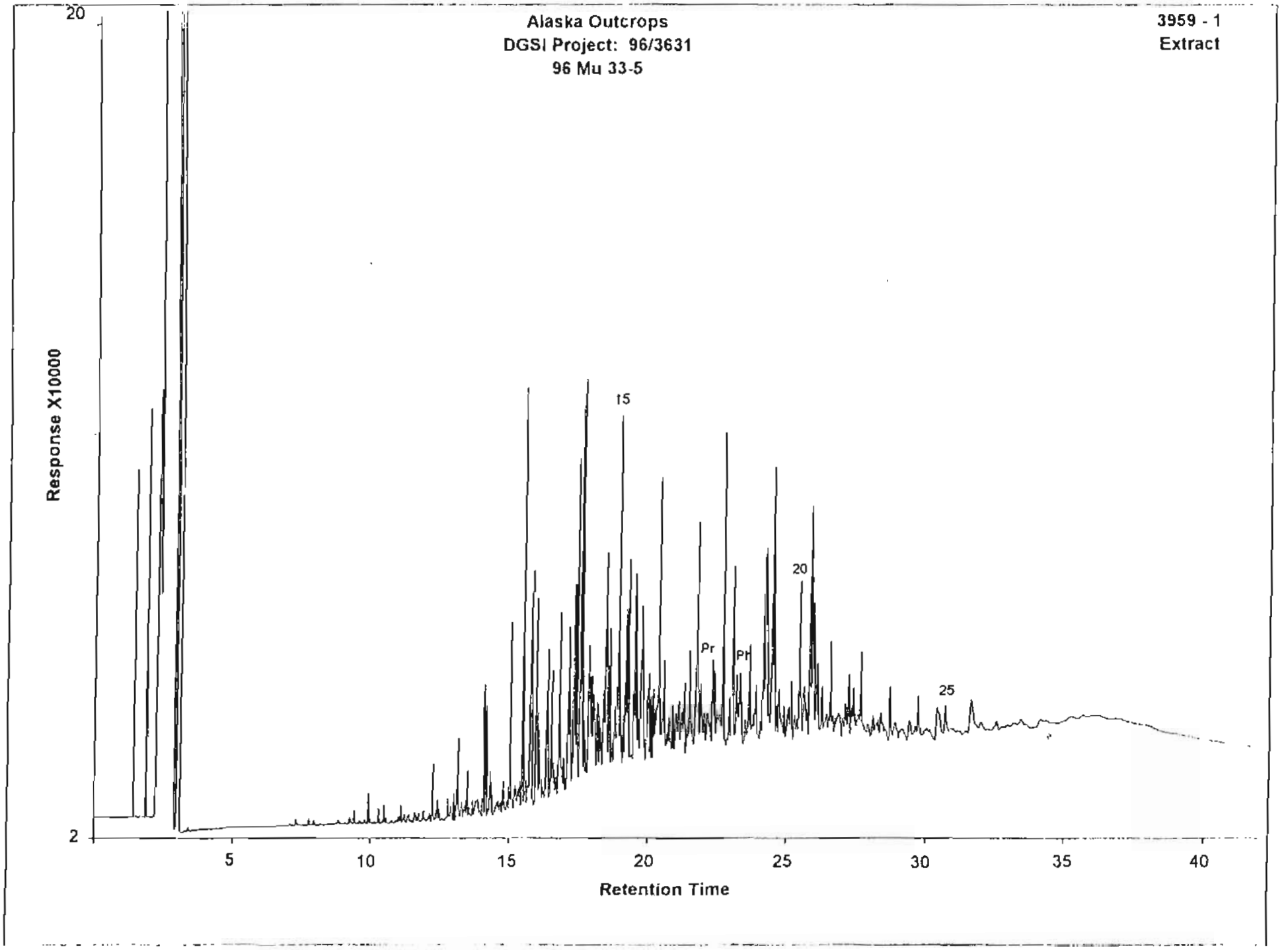
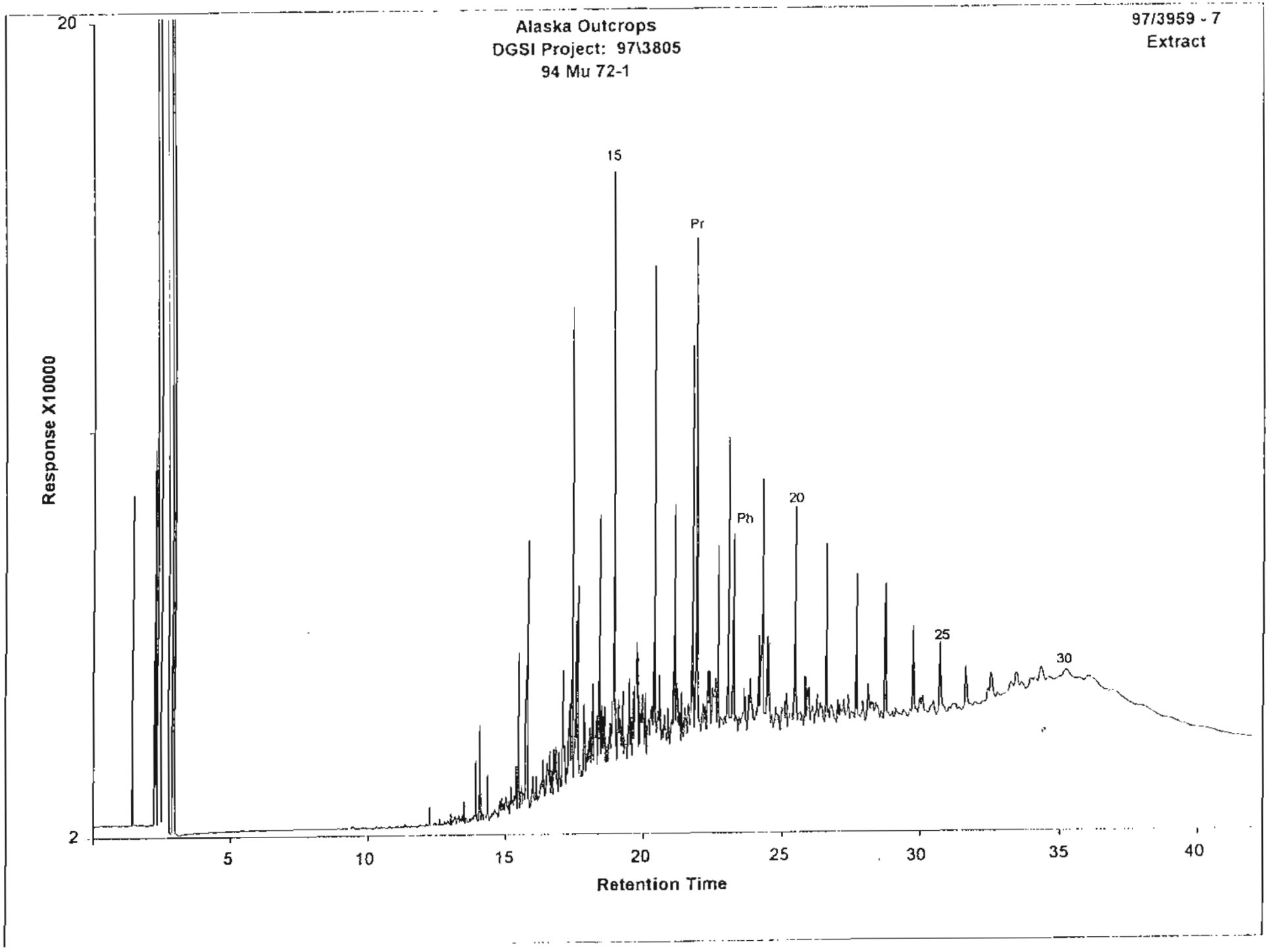
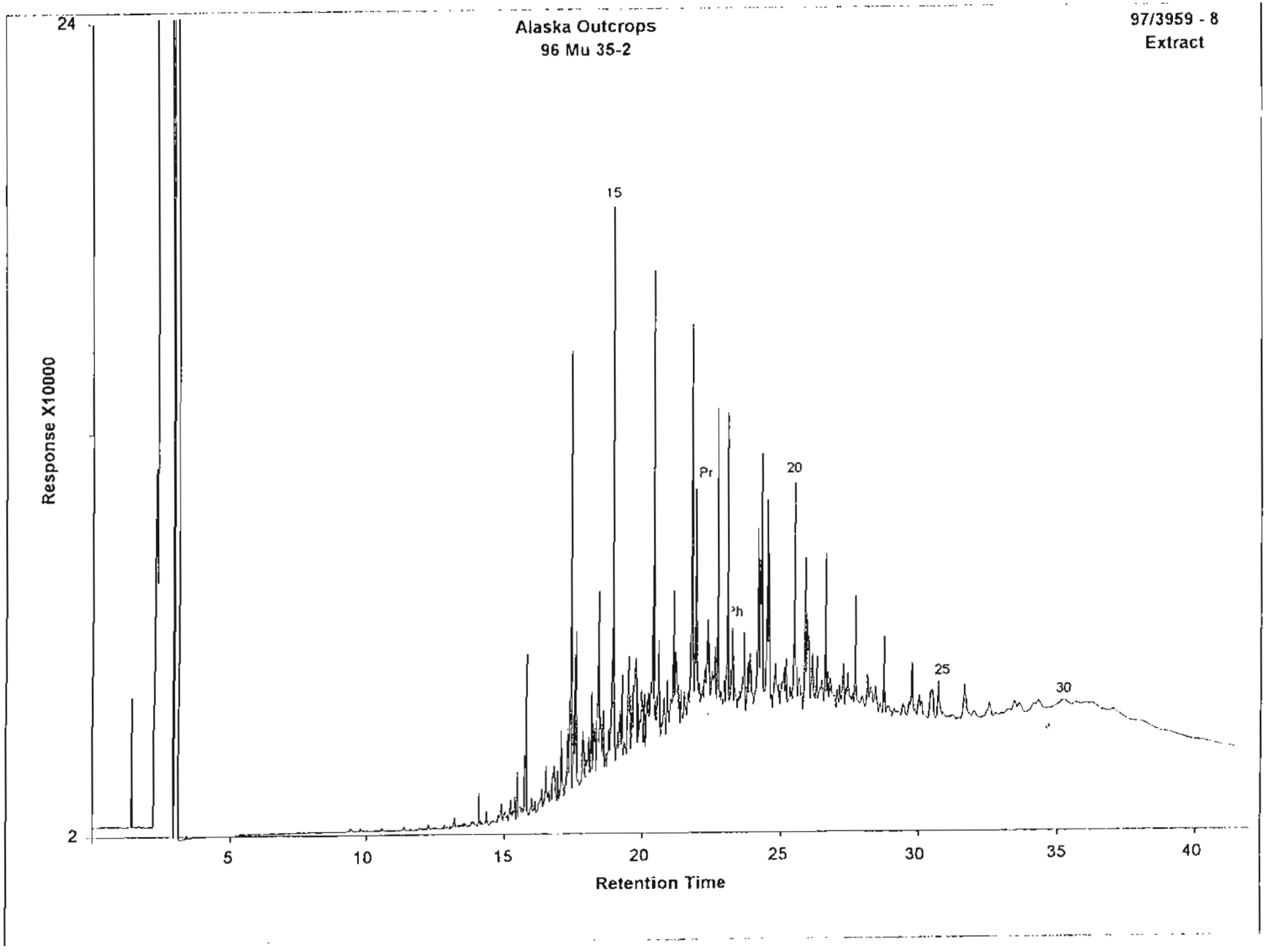
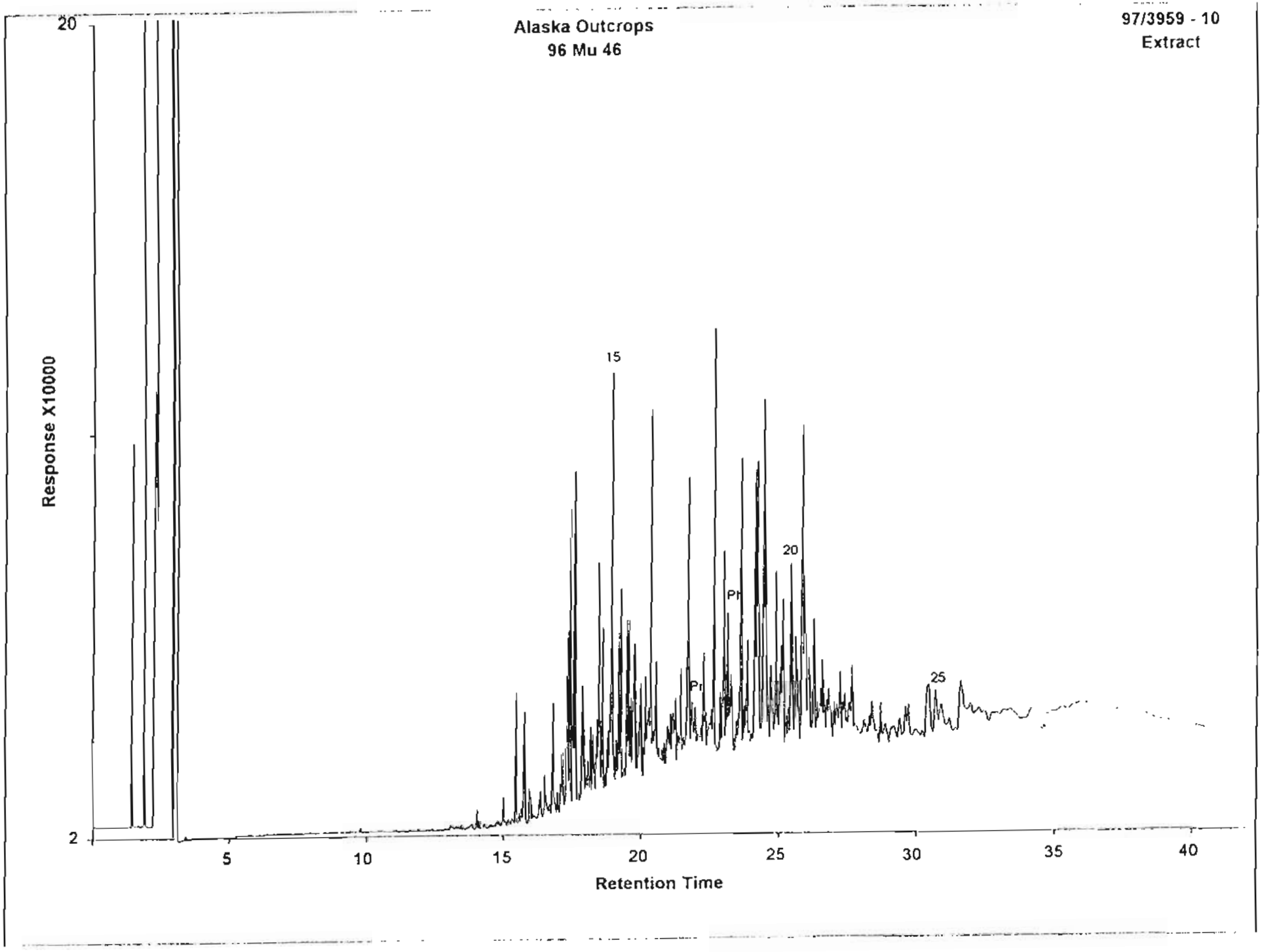


FIGURE 2 - Plot from chromatography data showing organic matter type.

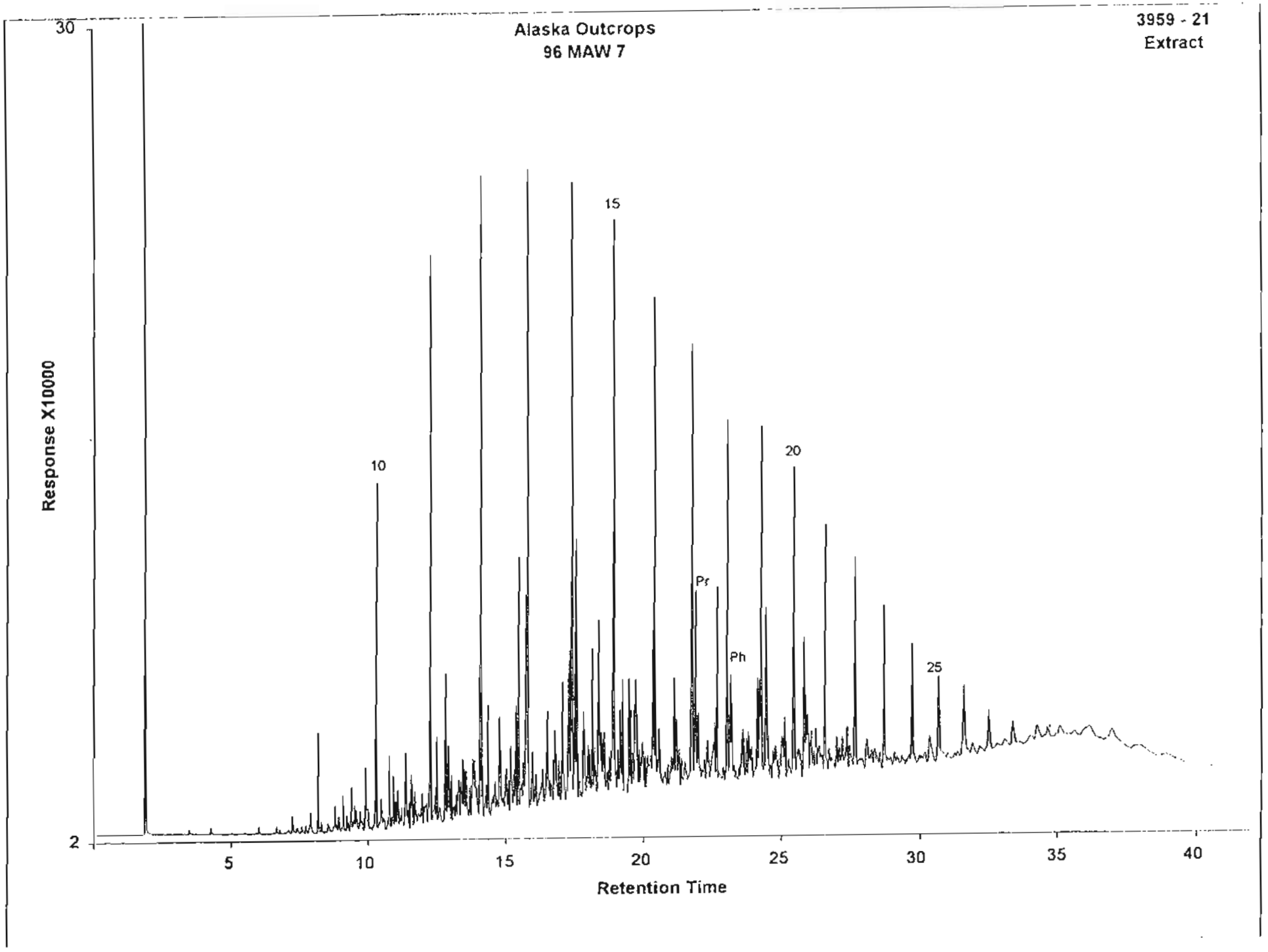

Alaska Outcrops
DGSI Project: 96/3631
96 Mu 33-5
3959 - 1
Extract
Response X10000
20
2
15
Pr
Ph
20
25
5
10
15
20
25
30
35
40
Retention Time


Alaska Outcrops
DGSI Project: 97\3805
94 Mu 72-1
97/3959 - 7
Extract
15
Pr
Ph
20
25
30
Response X10000
20
2
5
10
15
20
25
30
35
40
Retention Time

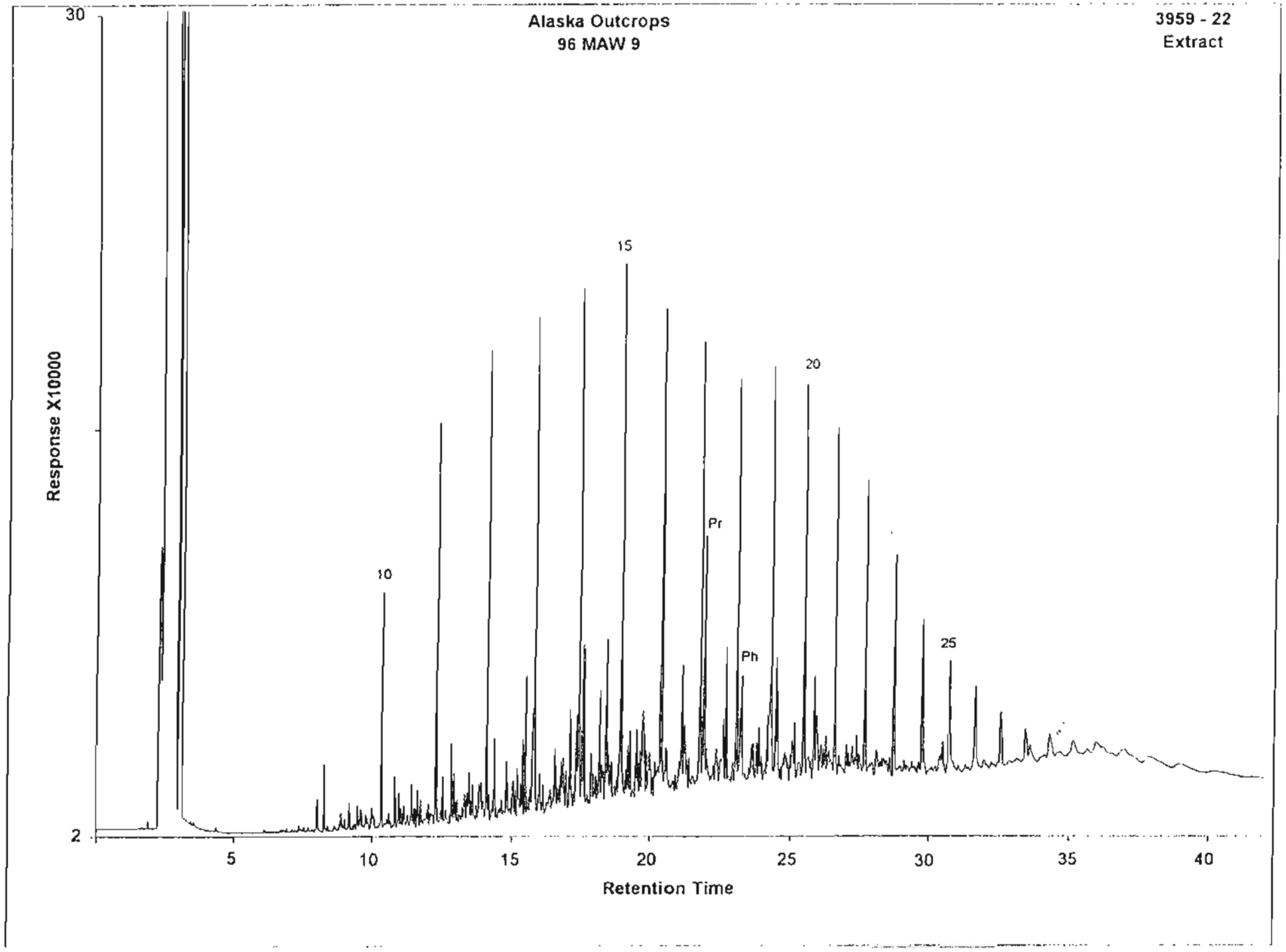

Alaska Outcrops
96 Mu 35-2
97/3959 - 8
Extract
24
2
Response X10000
15
Pr
Ph
20
25
30
5
10
15
20
25
30
35
40
Retention Time


Alaska Outcrops
96 Mu 46
97/3959 - 10
Extract
Response X10000
20
2
15
20
25
Pr
Ph
5
10
15
20
25
30
35
40
Retention Time

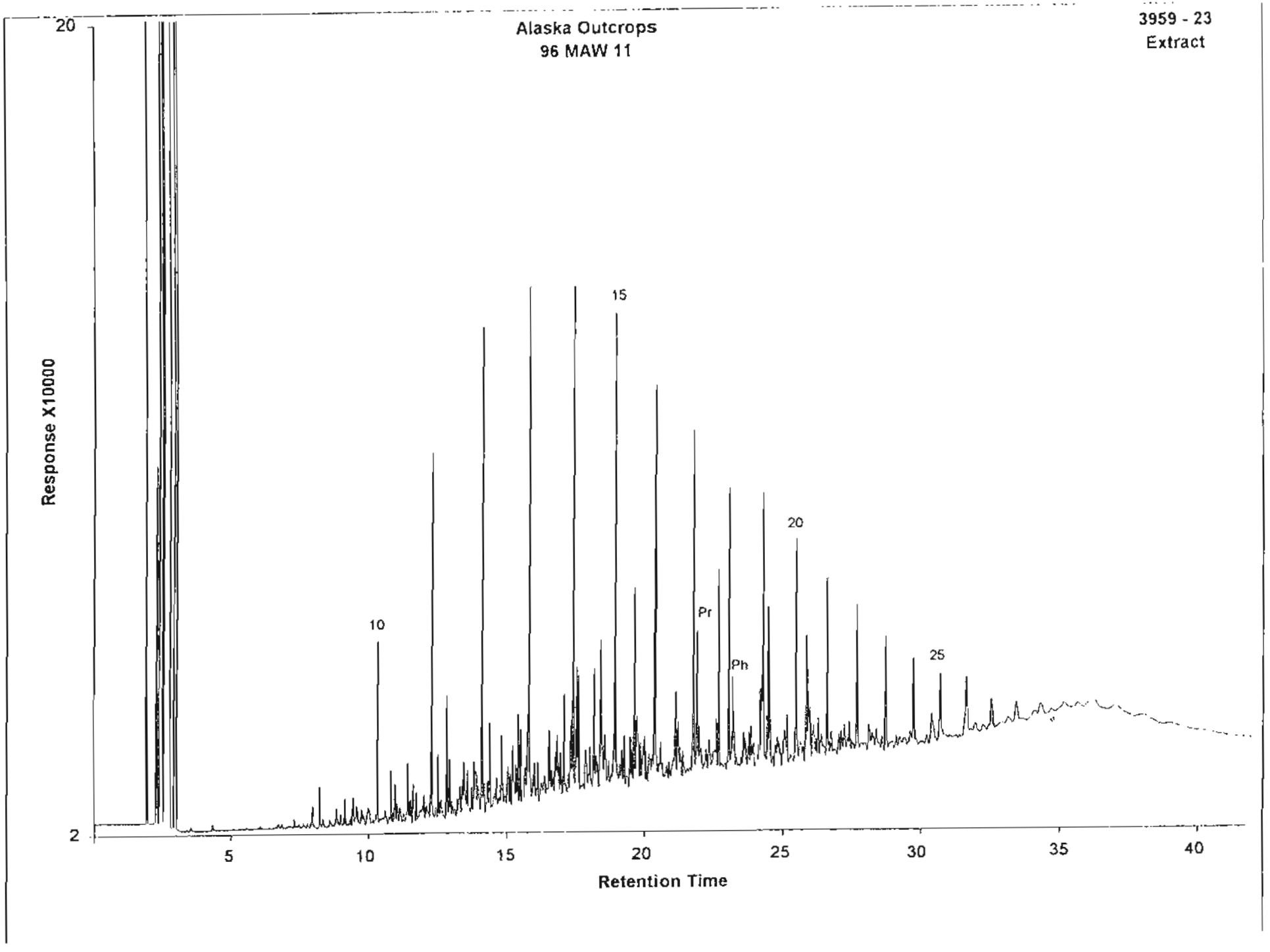
137


Alaska Outcrops
96 MAW 7
3959 - 21
Extract
Response X10000
30
2
10
15
20
25
Pr
Ph
5
10
15
20
25
30
35
40
Retention Time

281


Alaska Outcrops
96 MAW 9
3959 - 22
Extract
Response X10000
30
2
10
15
Pr
Ph
20
25
5
10
15
20
25
30
35
40
Retention Time

139


Alaska Outcrops
96 MAW 11
3959 - 23
Extract
Response X10000
20
2
10
15
20
25
Pr
Ph
5
10
15
20
25
30
35
40
Retention Time

140

GC/MS (BIOMARKER) ANALYSIS

Computerized gas chromatography/mass spectrometry (GC/MS) of saturate and aromatic fractions is used to evaluate various geochemical characteristics of oils and rock extracts, including organic facies, thermal maturity level and degree of alteration. The saturate and aromatic fractions are isolated by liquid chromatography from whole oils or rock extracts and injected into a HP5890 gas chromatograph fitted with a Quadrex 50M fuzed silica capillary column coupled to a HP5971A Mass Selective Detector (MSD). The analysis targets two important hydrocarbon classes: *triterpane and sterane biomarkers* and *2- and 3-ring aromatic hydrocarbons*.

Triterpane and sterane biomarkers are biologically-derived naphthenic hydrocarbons found in most oils and rock extracts. These biological precursors are incorporated either directly or with some alteration into petroleum, imparting a fingerprint to a rock-extract or oil. By careful comparison of these fingerprints as well as the relative concentration and ratios of specific compounds, geochemical information regarding correlation, maturity, migration, and biodegradation can be obtained.

In describing the specific compounds, chemical conventions are used to delineate specific structural differences. Alpha "α" or beta "β" designations refer to the orientation of carbon-hydrogen bonds in the ring system: "α" refers to orientation above the plane of the ring, whereas "β" is below the plane. The S and R designations are chemical conventions for designating molecular chiral centers in the hydrocarbon chains: R designates clockwise and S the counter-clockwise orientation in these sequencing rules. Normally the isomers are reported in elution order, first 20S then 20R.

The Selected Ion Monitoring (SIM) feature of the GC/MS data acquisition system permits specific ions to be monitored. Ions with mass/charge (m/z) 191 allow characterization of specific triterpenoid compounds, while ions with m/z 217 are diagnostic for steranes. Steranes with different chemical structures can be identified using different ions. Thus, m/z 218 is characteristic of steranes with abb stereochemistry and diasteranes exhibit a pronounced m/z 259 fragment. In addition, molecular ions characteristic of individual triterpane and sterane compounds (m/z 370, 372, 384, 386, 398, 400, 412, 414 and 426) are acquired. These molecular ions are not provided as part of the routine analytical report, but are available to confirm peak identifications and to identify unknown compounds. In addition to saturated steranes, monoaromatic and triaromatic steranes are identified in the aromatic fractions by the ions m/z 253 and 231, respectively.

Two- and three-ring aromatic hydrocarbons are useful as indicators of thermal maturity as well as organic facies. Three classes of aromatics are monitored: Dimethyl and trimethylnaphthalenes are detected using ions with m/z 156 and 170, phenanthrenes are measured by monitoring ions with m/z 178, 192 and 206, and dibenzothiophenes are identified by the m/z 184, 198 and 202 ions.

BIOMARKER EXPLANATIONS

Parameter	Definition	Interpretive Guidelines
Sterane Carbon Number (%)	Relative abundance of C_{21}, C_{22}, C_{27}, C_{28}, C_{29} and C_{30} steranes expressed as percent.	Sterane carbon number distributions are used to infer source characteristics. An enrichment in C_{27} steranes is indicative of algal inputs, while higher plant organic matter is enriched in C_{29} steranes. C_{30} (24-propyl) steranes are found exclusively in marine depositional environments, while an enrichment in C_{21} and C_{22} steranes is common in carbonate settings.
Hopane Carbon Number (%)	Relative abundance of C_{27}, C_{28}, C_{29}, C_{30} and C_{31} - C_{35} hopanes expressed as percent.	Hopane carbon number distributions can be used to infer source characteristics. Enrichment in C_{28} hopanes is primarily due to the presence of bisnorhopane, a marker of highly reducing depositional conditions. Enrichment in C_{31} - C_{35} hopanes is characteristic of some marine and carbonate depositional environments.
Sterane Isomer Distribution (%)	Relative abundance of diasterane, $\alpha\alpha\alpha$, $\alpha\beta\beta$ steranes (C_{27} through C_{30}) and short-chain (C_{21} and C_{22}) steranes expressed as percent.	Sterane isomer distributions vary with both maturity and source type. Carbonate systems exhibit a low proportion of diasteranes, while siliciclastic environments are enriched in diasteranes. Carbonates can also be enriched in short-chain and $\alpha\beta\beta$ steranes. Maturity results in an increase in diasteranes and $\alpha\beta\beta$ steranes.
Triterpane Distribution (%)	Relative abundance of tricyclic terpanes, hopanes and other triterpanes expressed as percent.	Triterpane distributions are both maturity and source related. Enrichment in tricyclic terpanes is common in lacustrine systems, but can also result from high maturity. Triterpanes like gammacerane and oleanane are source-diagnostic.
Extended Hopane Distribution (%)	Relative abundance of C_{31} through C_{35} extended hopanes expressed as percent.	Enhanced abundance of extended hopanes, in particular the C_{35} isomers, are found in sulfur-rich oils and in carbonates and calcareous mudstones. Their abundance decreases with increasing maturation level.
C_{19} + C_{20} Tricyclics/C_{23} Tricyclic		C_{19} and C_{20} tricyclics are associated with higher plant material found in deltaic systems.
C_{24} Tetracyclic/C_{26} Tricyclics		The C_{24} tetracyclic terpane can be enriched in carbonate environments.
C_{23} Tricyclic/C_{24} Tricyclic		Can vary for different oil families.
C_{25} Tricyclics/C_{26} Tricyclics		Can be diagnostic for lacustrine systems.
C_{28} Bisnorhopane/C_{30} Hopane		Bisnorhopane is associated with highly reducing conditions.
C_{29} 25-Norhopane/C_{30} Hopane		Norhopanes are markers of biodegradation, but also result from highly reducing conditions.
C_{29} Norhopane/C_{30} Hopane		C_{29} Norhopane rivals or exceeds the C_{30} compound in some carbonates.
C_{30} Diahopane/ C_{30} Hopane		Diahopane can be enriched in siliciclastic samples; it also increases with increasing thermal maturity.

BIOMARKER EXPLANATIONS

Parameter	Definition	Interpretive Guidelines
C_{30} Oleanane/C_{30} Hopane		Oleanane is a marker of angiosperm plant input that is associated with deltaic, predominantly Tertiary, settings.
C_{30} 30-Norhomohopane/C_{30} Hopane		A series of norhomohopanes are found in carbonates and calcareous mudstones.
Gammacerane/C_{30} Hopane		Gammacerane is a marker of hypersalinity and is also enriched in some freshwater lacustrine settings.
Extended Hopanes (%)	Sum of C_{31} through C_{35} extended hopanes, expressed as percent of total triterpanes.	Marine conditions are typified by an abundance of extended hopanes.
C_{35}/C_{34} Extended Hopanes	Sum of C_{35} extended hopane isomers (22S and 22R) divided by the sum of C_{34} extended hopane isomers (22S and 22R).	Carbonate samples can exhibit C_{35}/C_{34} hopane values greater than 1.0
Tricyclic Terpanes/Hopanes	Sum of all tricyclic terpanes (C_{19} through C_{35}) divided by the sum of all hopanes (C_{27} through C_{35}).	An enrichment in tricyclic terpanes is associated with lacustrine samples, but can also be an indicator of high maturity
Hopanes/Steranes	Sum of C_{27} through C_{35} hopanes (m/z 191) divided by the sum of all steranes (m/z 217).	The hopane/sterane ratio is used to infer source characteristics. Marine environments exhibit low values, while deltaic and lacustrine environments are characterized by elevated values. Hypersaline and some marine carbonate environments can also exhibit elevated hopane/sterane ratios.
Biomarker Isomerization Ratios (%)	A series of biomarker parameters that are maturity dependent: % 20S C_{29} Steranes, % $\alpha\beta\beta$ C_{29} Steranes, % 22S C_{31} Hopane, % 22S C_{32} Hopane, and % C_{30} Moretane.	With increasing thermal maturation level, sterane and hopane biomarkers are transformed from an unstable "biological" configuration to a more stable "geological" configuation. These ratios quantify the progression of the transformation. All increase with increasing maturity with the exception of the % C_{30} Moretane parameter, which decreases.
Ts/Tm		The Ts/Tm ratio increases with increasing maturation level. This ratio also exhibits some facies dependence.
C_{29} Neohopane (29Ts)/C_{29} Norhopane		This ratio behaves similarly to the Ts/Tm ratio.
Diasteranes (%)	Sum of all diasteranes (C_{27} through C_{29}) expreessed as percent of total steranes	The relative proportion of diasteranes will increase with increasing maturation level. This parameter is also source-dependent.
Short-chain steranes (%)	Sum of all C_{21} and C_{22} steranes expressed as percent of total steranes.	The relative abundance of short-chain steranes will increase with increasing maturation level. Short-chain steranes are also enriched in some carbonate environments.

REFERENCES

Anders, D. E. and Magoon. L. B., 1986, Oil-source correlation study in northeastern Alaska, Adv. in Org. Geochemistry 1985, Org. Geochem. Vol 10, p. 407-415.

Connan, J., Bouroullec, J., Dessort, D. and Albrecht, P., 1986, The microbial input in carbonate-anhydrite facies of a sabkha paleoenvironment from Guatemala: A molecular approach, Adv. in Org. Geochemistry 1985, Org. Geochem. Vol. 10, p. 29-50.

Mackenzie, A. S. and Maxwell, J. R. (1981), Assessment of thermal maturation in sedimentary rocks by molecular measurements. In: Orgtanic Maturation Studies and Fossil Fuel Exploration. Brooks, J. (ed.) Academic Press, London, p. 239-254.

Mackenzie, A. S., Patience, R. L., Maxwell, J. R., Vandenbroucke, M. and Durand, B., 1980, Molecular parameters of maturation in the Toarcian shales, Paris basin, France; I, changes in the configuration of acyclic isoprenoid alkanes, steranes and triterpanes, Geochim. et. Cosmochimica Acta, Vol. 44, p. 1709-1722.

McKirdy, D. M., Aldridge, A. K., and Ypma, P. J. M., 1983, A geochemical comparison of some crude oils from pre-Ordovician carbonate rocks, In Adv. in Org. Geochemistry 1981, edited by Bjorøy, M. et al., p. 99-107, Wiley, Chichester.

Mello, M. R., Gaglianone, P. C., Brassell, S. C. and Maxwell, J. R., 1988, Geochemical and biological marker assessment of depositional environments using Brazilian offshore oils, Marine and Petroleum Geology, Vol. 5, p. 205-223.

Moldowan, J. M., Seifert, W. K. and Gallegos, E. J., 1985, Relationship between petroleum composition and depositional environment of petroleum source rocks, Bull. A.A.P.G., Vol. 69, p.1255-1268.

Palacas, J. G., Monopolis, D., Nicolaou, C. A. and Anders, D. E., 1986, Geochemical correlation of surface and subsurface oils, western Greece, Adv.in Org. Geochemistry 1985, Org. Geochem. Vol. 10, p. 417-423.

Peters, K. E., Moldowan, J. M., Schoell, M. and Hempkins, W. B., 1986, Petroleum isotopic and biomarker composition related to source rock organic matter and depositional environment, Adv. in Org. Geochemistry 1985, Org. Geochem. Vol. 10, p. 17-27.

Peters, K. E., Moldowan, J. M., and Sundararaman, P., 1990, Effects of hydrous pyrolysis on biomarker thermal maturity parameters: Monterey phosphatic and siliceous members, Org. Geochem., Vol. 15, p. 249-265.

Peters, K. E. and Moldowan, J. M., 1991, Effects of source, thermal maturity, and biodegradation of the distribution and isomerization of homohopanes in petroleum, Org. Geochem., Vol. 17, p. 47-61.

Seifert, W. K. and Moldowan, J. M., 1978, Applications of steranes, terpanes, and monoaromatics to the maturation, migration and source of crude oils, Geochimica et. Cosmochimica Acta, V. 42, p. 77-95.

Seifert, W. K. and Moldowan, J. M., 1981, Paleoreconstruction by biological markers, Geochimica et. Cosmochimica Acta, Vol. 45, p. 783-794.

Seifert, W. K., Carlson, R. M. K. and Moldowan, J. M., 1983, Geomimetic synthesis, structure assignment and geochemical correlation application of monoaromatized petroleum steroids, Adv. in Org. Geochemistry, 1981, p. 710-724.

GAS CHROMATOGRAPHY - MASS SPECTROMETRY

Interpretation of Saturate Biomarker Ratios

Alaska Outcrops
Other ID: 96 Mu 33-5 DGSI Project: 96/3631

DGSI Project: 97/3959
Sample No. 1

ORGANIC FACIES AND DEPOSITIONAL ENVIRONMENT

Ratio	Value	Interpretation
C_{19} + C_{20} Tricyclics / C_{23} Tricyclic	1.27	Not diagnostic
C_{24} Tetracyclic / C_{26} Tricyclics	0.88	Not diagnostic
C_{25} Tricyclics / C_{26} Tricyclics	0.73	Non-marine
C_{28} Bisnorhopane / C_{30} Hopane	0.00	Not diagnostic
C_{29} Norhopane / C_{30} Hopane	0.41	Not diagnostic
C_{30} Diahopane / C_{30} Hopane	0.20	Siliciclastic and/or terrigenous
C_{30} Oleanane / C_{30} Hopane	0.00	No significant angiosperm input
Gammacerane / C_{30} Hopane	0.00	Not lacustrine or hypersaline
% C_{31} - C_{35} Extended Hopanes	25.5	Marine maturity-influenced
C_{35}/C_{34} Extended Hopanes	0.42	Not diagnostic
Hopane/Sterane	0.94	Marine
% C_{27} Steranes	24.4	Mixed source
% C_{29} Steranes	19.0	Not higher plant dominated
Diasteranes	25.0	Mixed Source
Isosteranes (abb)	19.5	Not diagnostic
Short-chain steranes	38.3	Carbonate or hypersaline
Pristane/phytane	1.9	Marine

THERMAL MATURITY

Ts / Tm	1.20	Mature
% C30 Moretane	9.34	Greater than 0.5% Ro equivalent
22S / (22S+22R) C31 Hopane (%)	56.3	Greater than 0.5% Ro equivalent
% 20S/(20S + 20R)	53.3	Between 0.6% and 1.0% Ro equivalent
% abb/(abb + aaa)	49.6	Between 0.6% and 1.0% Ro equivalent
Odd Even Preference	N.A.	N.A.
Pristane/nC17	0.3	Paraffinic
Phytane/nC18	0.3	Paraffinic

Copyright ©, DGSI, 1997

GAS CHROMATOGRAPHY - MASS SPECTROMETRY

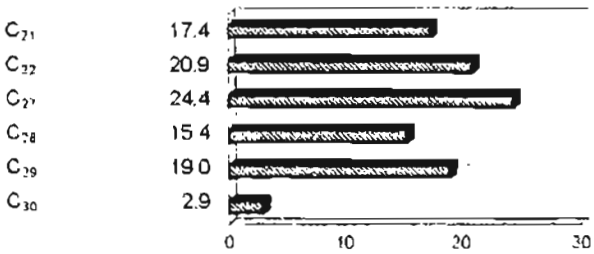
Triterpanes and Steranes

Alaska Outcrops
Other ID: 96 Mu 33-5 DGSI Project: 96/3631

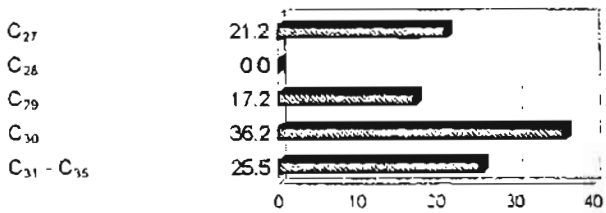
DGSI Project: 97/3959
Sample No. 1

ORGANIC FACIES AND DEPOSITIONAL ENVIRONMENT

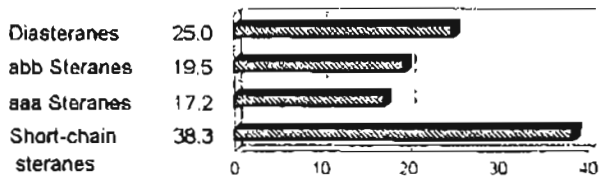
Sterane Carbon Number (%)



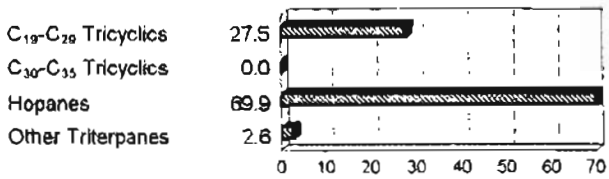
Hopane Carbon Number (%)



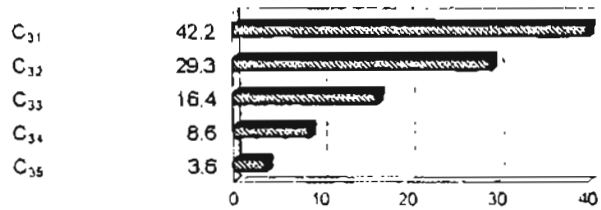
Sterane Isomer Distribution (%)



Triterpane Distribution (%)



Extended Hopane Distribution (%)



ORGANIC FACIES AND DEPOSITIONAL ENVIRONMENT RATIOS

C_{19} + C_{20} Tricyclics / C_{23} Tricyclic	1.27	C_{30} Oleanane / C_{30} Hopane	0.00
C_{24} Tetracyclic / C_{26} Tricyclics	0.88	C_{30} 30-Norhomohopane / C_{30} Hopane	0.05
C_{23} Tricyclic / C_{24} Tricyclic	1.61	Gammacerane / C_{30} Hopane	0.00
C_{25} Tricyclics / C_{26} Tricyclics	0.73	Extended Hopanes (%)	17.80
C_{28} Bisnorhopane / C_{30} Hopane	0.00	C_{35}/C_{34} Extended Hopanes	0.42
C_{29} 25-Norhopane / C_{30} Hopane	0.00	Tricyclic Terpanes / Hopanes	0.39
C_{29} Norhopane / C_{30} Hopane	0.41	Hopanes / Steranes	0.94
C_{30} Diahopane / C_{30} Hopane	0.20		

Copyright © DGSI, 1997

GAS CHROMATOGRAPHY - MASS SPECTROMETRY

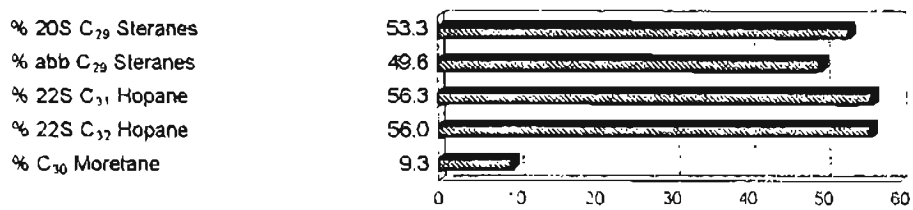
Triterpanes and Steranes

Alaska Outcrops
Other ID: 96 Mu 33-5 DGSI Project: 96/3631

DGSI Project: 97/3959
Sample No. 1

THERMAL MATURITY

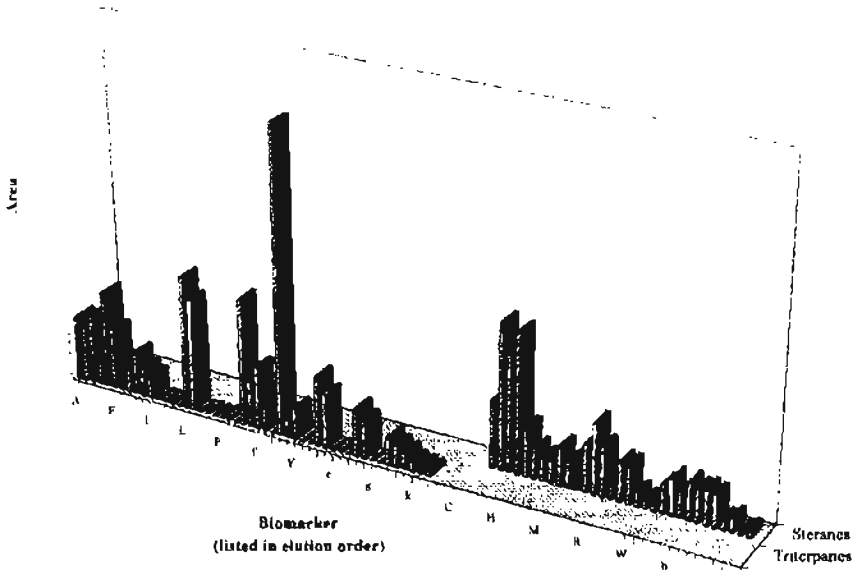
Biomarker Isomerization Ratios (%)



Maturity-Dependent Ratios

Ts / Tm	1.20
C_{29} Neohopane (29Ts) / C_{29} Norhopane	0.36
C_{30} Diahopane / C_{30} Hopane	0.20
% Diasteranes	25.0
Tricyclic Terpanes / Hopanes	0.39
% Short-chain steranes	38.3

TRITERPANE AND STERANE DISTRIBUTIONS



Copyright © DGSI 1997

TRITERPANE REPORT (m/z 191)

Alaska Outcrops

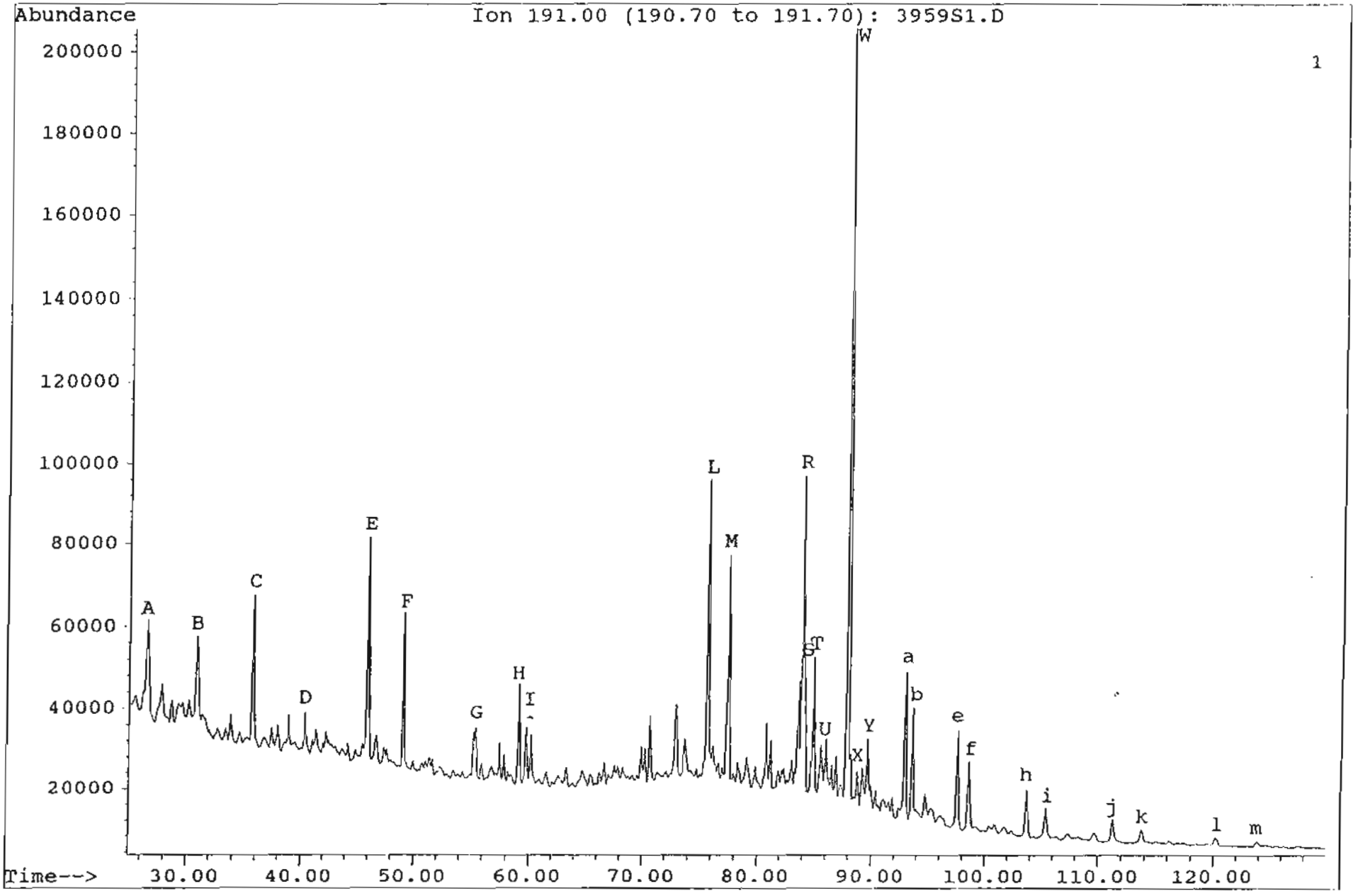
DGSI Project: 97/3959

Sample No. 1 | Other ID: 96 Mu 33-5 | DGSI Project: 96/3631

No.	ID	Triterpane Name	Ret Time	Area	Area%
1	A	C_{19} Tricyclic Terpane	26.603	4583088	3.87
2	B	C_{20} Tricyclic Terpane	30.883	4265201	3.60
3	C	C_{21} Tricyclic Terpane	35.711	4974153	4.20
4	D	C_{22} Tricyclic Terpane	40.373	1523887	1.29
5	E	C_{23} Tricyclic Terpane	45.903	6957085	5.87
6	F	C_{24} Tricyclic Terpane	49.020	4312008	3.64
7	G	C_{25} Tricyclic Terpane (22R)	55.159	966862	0.82
8	G	C_{25} Tricyclic Terpane (22S)	55.334	1553977	1.31
9	H	C_{24} Tetracyclic Terpane	59.074	3042459	2.57
10	I	C_{26} Tricyclic Terpane (22R)	59.704	1920065	1.62
11	I	C_{26} Tricyclic Terpane (22S)	60.116	1556929	1.31
12	J	C_{28} Tricyclic Terpane (22R)		0	0.00
13	J	C_{28} Tricyclic Terpane (22S)		0	0.00
14	K	C_{29} Tricyclic Terpane (22R)		0	0.00
15	K	C_{29} Tricyclic Terpane (22S)		0	0.00
16	L	C_{27} 18aH-Trisnorhopane (Ts)	75.612	9553323	8.06
17	M	C_{27} 17aH-Trisnorhopane (Tm)	77.442	7992063	6.74
18	N	C_{30} Tricyclic Terpane (22R)		0	0.00
19	N	C_{30} Tricyclic Terpane (22S)		0	0.00
20	O	C_{28} 17aH,18aH,21bH-28,30-Bisnorhopane		0	0.00
21	P	C_{31} Tricyclic Terpane (22R)		0	0.00
22	Q	C_{29} 17aH,21bH 25-Norhopane		0	0.00
23	P	C_{31} Tricyclic Terpane (22S)		0	0.00
24	R	C_{29} 17aH,21bH-Norhopane	83.890	9073213	7.66
25	S	C_{29} 18aH-Norneohopane (29Ts)	84.129	3274774	2.76
26	T	C_{30} 17aH Diahopane	84.930	4495821	3.79
27	U	C_{29} 17bH,21aH-Normoretane	85.991	1897742	1.60
28	V	C_{30} 18aH+18bH-Oleanane		0	0.00
29	W	C_{30} 17aH,21bH-Hopane	87.844	22000068	18.57
30	X	C_{30} 30-Nor-29-homo-17aH-hopane	88.138	1204753	1.02
31	Y	C_{30} 17bH,21aH-Moretane	89.643	2265298	1.91
32	Z	C_{33} Tricyclic Terpane (22R)		0	0.00
33	Z	C_{33} Tricyclic Terpane (22S)		0	0.00
34	a	C_{31} 17aH,21bH-Homohopane (22S)	92.956	5009010	4.23
35	b	C_{31} 17aH,21bH-Homohopane (22R)	93.574	3881315	3.28
36	c	C_{30} Gammacerane		0	0.00
37	d	C_{34} Tricyclic Terpane (22R)		0	0.00
38	d	C_{34} Tricyclic Terpane (22S)		0	0.00
39	e	C_{32} 17aH,21bH-Bishomohopane (22S)	97.536	3455943	2.92
40	f	C_{32} 17aH,21bH-Bishomohopane (22R)	98.577	2712525	2.29
41	g	C_{35} Tricyclic Terpane (22R)		0	0.00
42	g	C_{35} Tricyclic Terpane (22S)		0	0.00
43	h	C_{33} 17aH,21bH-Trishomohopane (22S)	103.675	1939825	1.64
44	i	C_{33} 17aH,21bH-Trishomohopane (22R)	105.361	1510983	1.28
45	j	C_{34} 17aH,21bH-Tetrahomohopane (22S)	111.248	1118494	0.94
46	k	C_{34} 17aH,21bH-Tetrahomohopane (22R)	113.736	691777	0.58
47	l	C_{35} 17aH,21bH-Pentahomohopane (22S)	120.228	471386	0.40
48	m	C_{35} 17aH,21bH-Pentahomohopane (22R)	123.897	296455	0.25

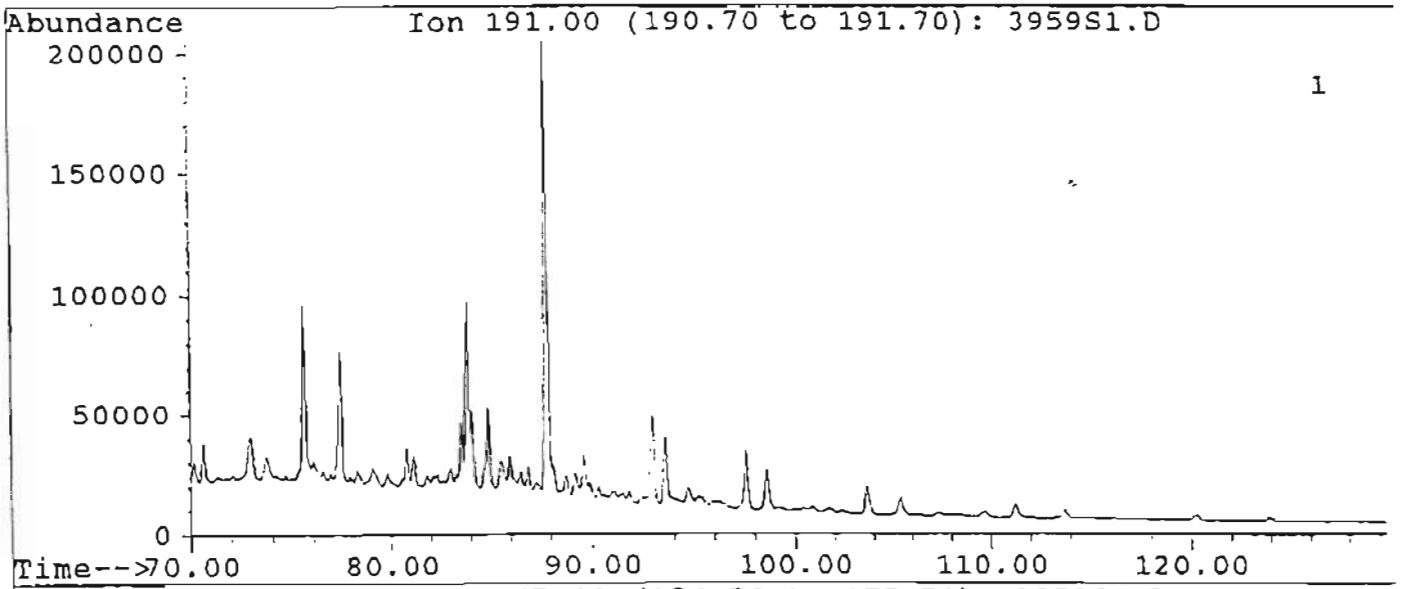
Copyright© DGSI, 1997

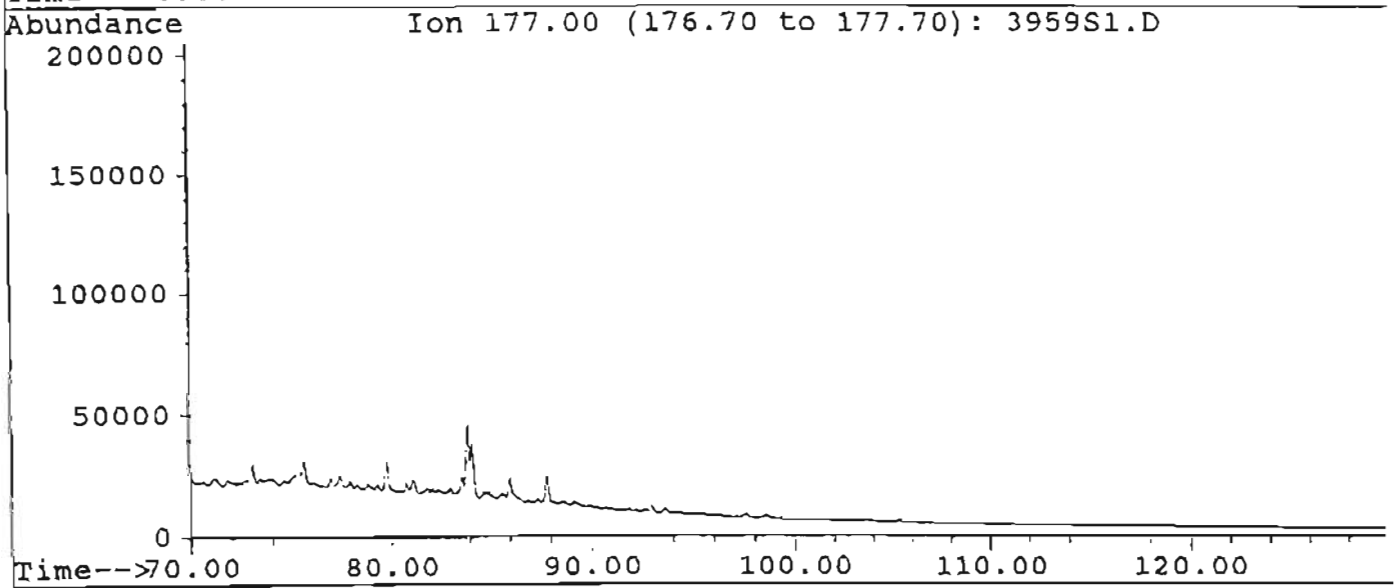
Alaska Outcrops
96 Mu 33-5
DGSI Project: 97/3959

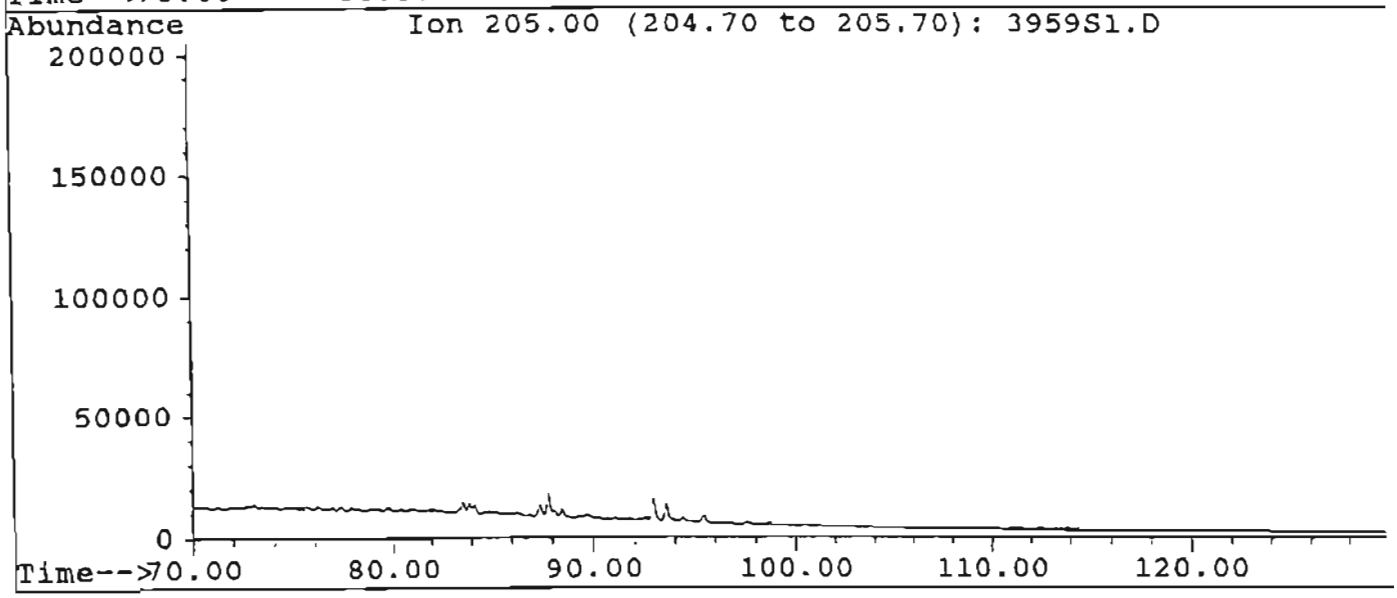


149

Alaska Outcrops
96 Mu 33-5
DGSI Project: 97/3959







STERANE REPORT (m/z 217)

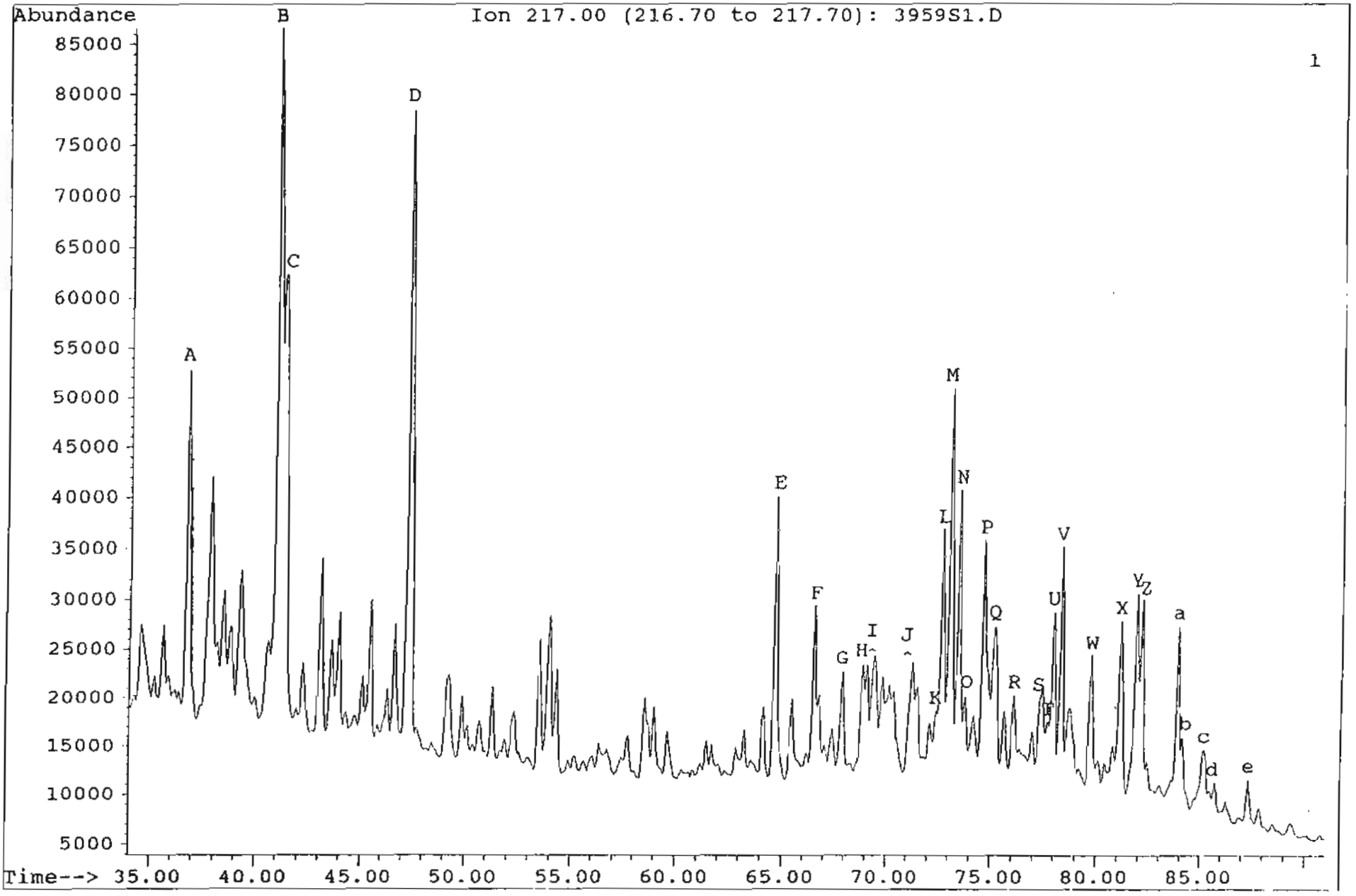
Alaska Outcrops

DGSI Project: 97/3959

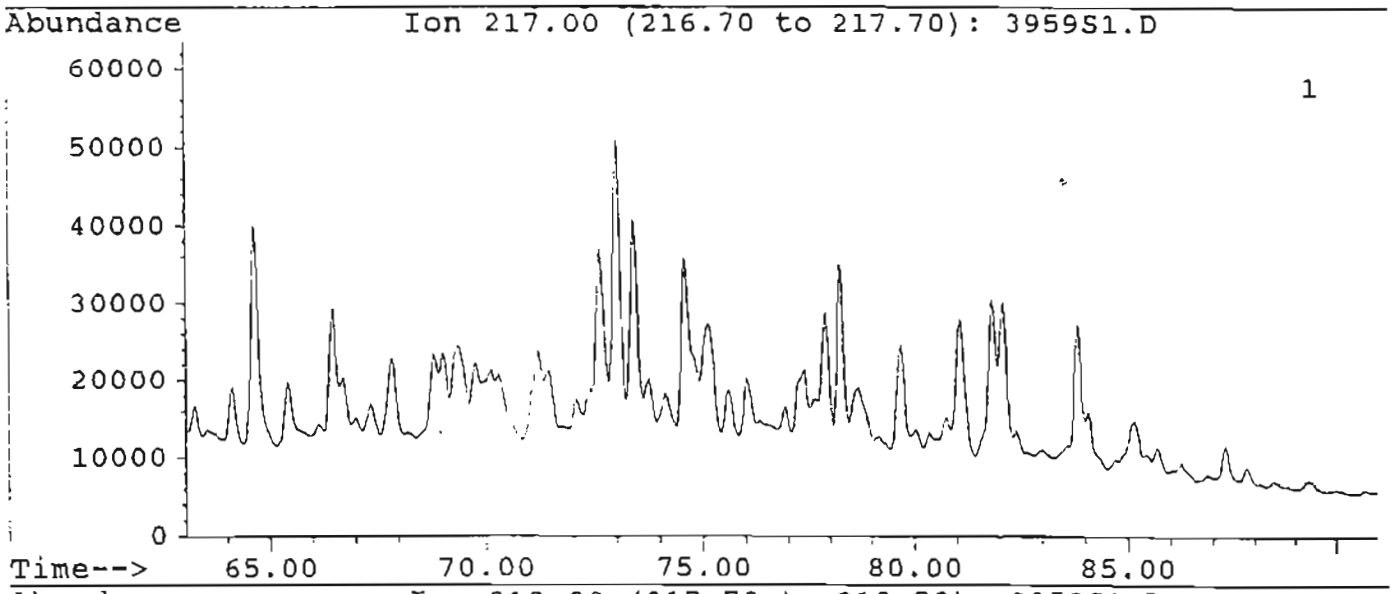
Sample No. 1 Other ID: 96 Mu 33-5 DGSI Project: 96/3831

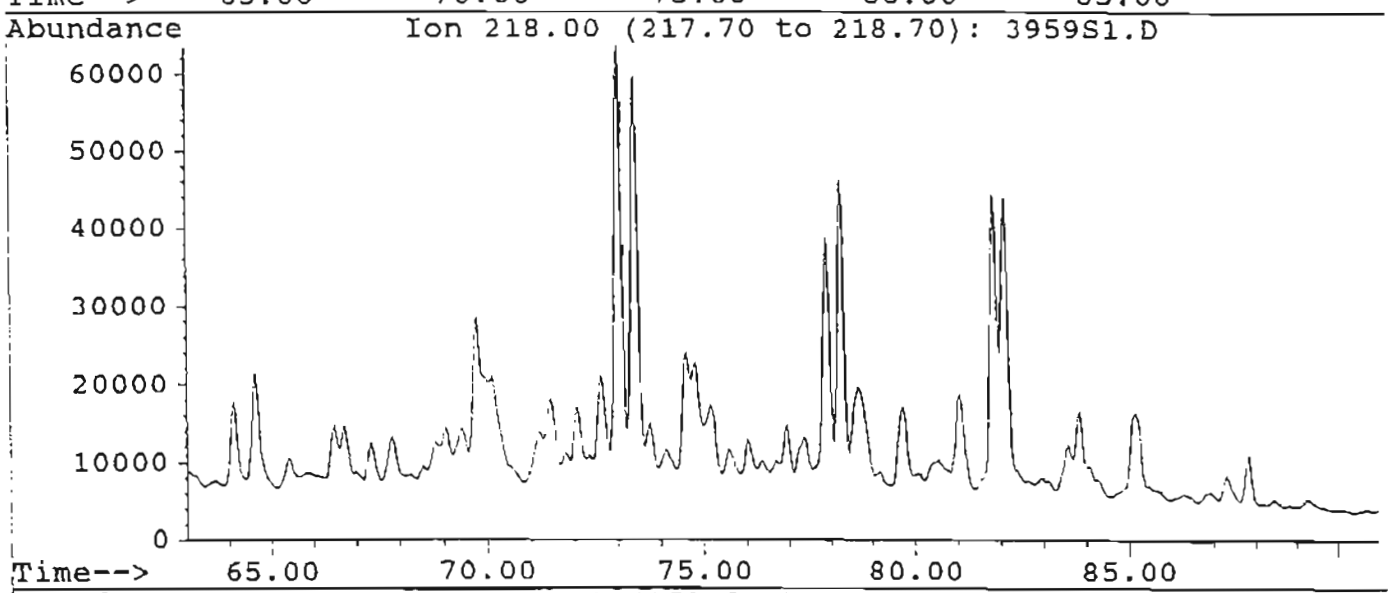
No.	ID	Sterane Name	Ret Time	Area	Area%
1	A	C_{21} diasterane	36.77	4889418	5.56
2	B	C_{21} abb sterane	41.02	10422499	11.86
3	C	C_{22} diasterane	41.30	8318043	9.47
4	D	C_{22} abb sterane	47.30	10042997	11.43
5	E	C_{27} ba diasterane (20S)	64.64	3530968	4.02
6	F	C_{27} ba diasterane (20R)	66.49	2177671	2.48
7	G	C_{27} ab diasterane (20S)	67.87	1654490	1.88
8	H	C_{27} ab diasterane (20R)	68.85	1541779	1.75
9	I	C_{28} ba diasterane (20S)	69.38	2813731	3.20
10	J	C_{28} ba diasterane (20R)	71.22	1881771	2.14
11	K	C_{28} ab diasterane (20S)	72.39	634326	0.72
12	L	C_{27} aaa sterane (20S)	72.63	3502275	3.99
13	M	C_{27} abb ster-(20R)+C_{29} ba dia-(20S)	73.02	5108992	5.81
14	N	C_{27} abb sterane (20S)	73.41	3610253	4.11
15	O	C_{28} ab diasterane (20R)	73.74	1026816	1.17
16	P	C_{27} aaa sterane (20R)	74.60	2843638	3.24
17	Q	C_{29} ba diasterane (20R)	75.14	2710888	3.08
18	R	C_{29} ab diasterane (20S)	76.05	955198	1.09
19	S	C_{28} aaa sterane (20S)	77.27	598964	0.68
20	T	C_{29} ab diasterane (20R)	77.66	515857	0.59
21	U	C_{28} abb sterane (20R)	77.92	2058514	2.34
22	V	C_{28} abb sterane (20S)	78.29	2631930	2.99
23	W	C_{28} aaa sterane (20R)	79.72	1869580	2.13
24	X	C_{29} aaa sterane (20S)	81.11	2679296	3.05
25	Y	C_{29} abb sterane (20R)	81.85	2427374	2.76
26	Z	C_{29} abb sterane (20S)	82.11	2527948	2.88
27	a	C_{29} aaa sterane (20R)	83.85	2348586	2.67
28	b	C_{30} aaa sterane (20S)	84.10	738417	0.84
29	c	C_{30} abb sterane (20R)	85.15	1052555	1.20
30	d	C_{30} abb sterane (20S)	85.43	253404	0.29
31	e	C_{30} aaa sterane (20R)	87.32	510260	0.58

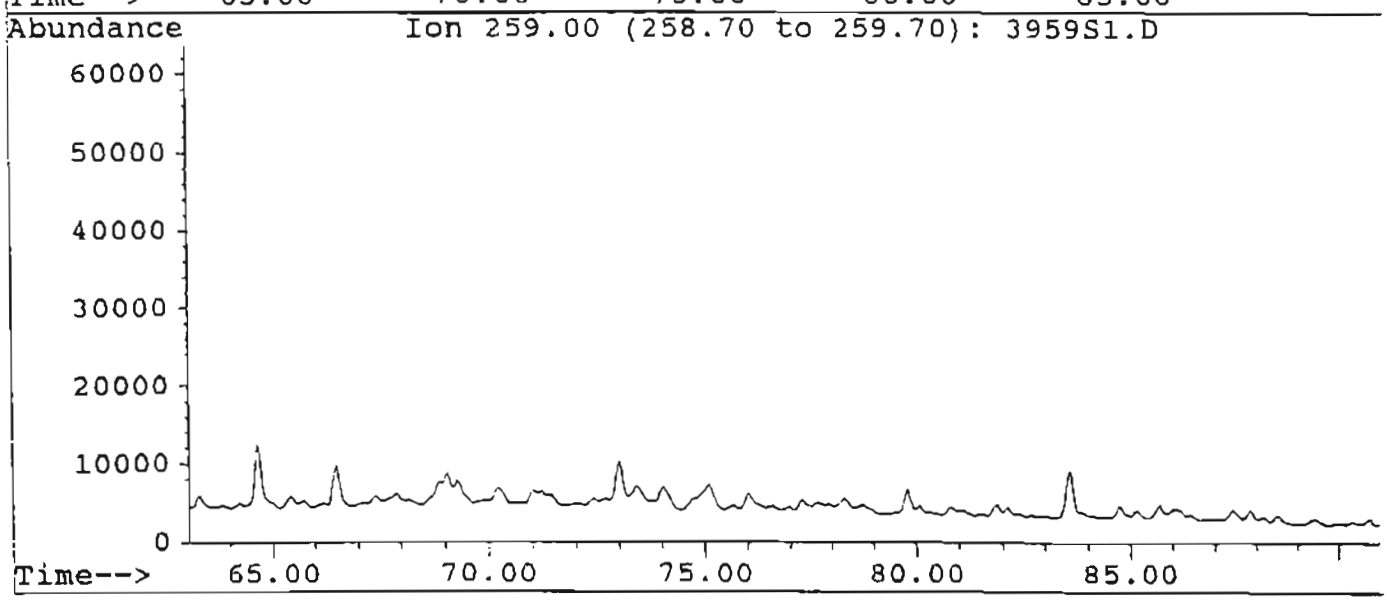
Alaska Outcrops
96 Mu 33-5
DGSI Project: 97/3959



Alaska Outcrops
96 Mu 33-5
DGSI Project: 97/3959







GAS CHROMATOGRAPHY - MASS SPECTROMETRY

Interpretation of Saturate Biomarker Ratios

Alaska Outcrops — DGSI Project: 97/3959

Other ID: 94 Mu 72-1 DGSI Project: 97\3805 — Sample No. 7

ORGANIC FACIES AND DEPOSITIONAL ENVIRONMENT

Ratio	Value	Interpretation
C_{19} + C_{20} Tricyclics / C_{23} Tricyclic	0.41	Not diagnostic
C_{24} Tetracyclic / C_{26} Tricyclics	0.58	Not diagnostic
C_{25} Tricyclics / C_{26} Tricyclics	1.51	Not diagnostic
C_{28} Bisnorhopane / C_{30} Hopane	0.00	Not diagnostic
C_{29} Norhopane / C_{30} Hopane	0.53	Not diagnostic
C_{30} Diahopane / C_{30} Hopane	0.09	Not diagnostic
C_{30} Oleanane / C_{30} Hopane	0.00	No significant angiosperm input
Gammacerane / C_{30} Hopane	0.00	Not lacustrine or hypersaline
% C_{31} - C_{35} Extended Hopanes	41.2	Marine
C_{35}/C_{34} Extended Hopanes	0.64	Not diagnostic
Hopane/Sterane	0.73	Marine
% C_{27} Steranes	35.1	Mixed source
% C_{29} Steranes	27.3	Not higher plant dominated
Diasteranes	44.0	Siliciclastic
Isosteranes (abb)	15.9	Not diagnostic
Short-chain steranes	9.0	Not diagnostic
Pristane/phytane	3.0	Marine terrigenous influence

THERMAL MATURITY

Ts / Tm	0.41	Low maturity
% C30 Moretane	15.38	Facies-influenced
22S / (22S+22R) C31 Hopane (%)	59.2	Greater than 0.5% Ro equivalent
% 20S/(20S + 20R)	49.5	Approx. 0.6% Ro equivalent
% abb/(abb + aaa)	33.0	Approx. 0.6% Ro equivalent
Odd Even Preference	N.A.	N.A.
Pristane/nC17	1.5	Low maturity or biodegraded
Phytane/nC18	0.8	Mature

Copyright ©, DGSI, 1997

GAS CHROMATOGRAPHY - MASS SPECTROMETRY

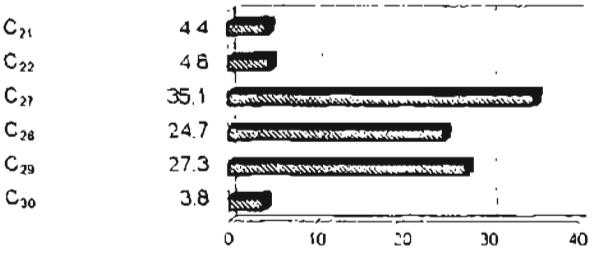
Triterpanes and Steranes

Alaska Outcrops
Other ID: 94 Mu 72-1 DGSI Project: 97\3805

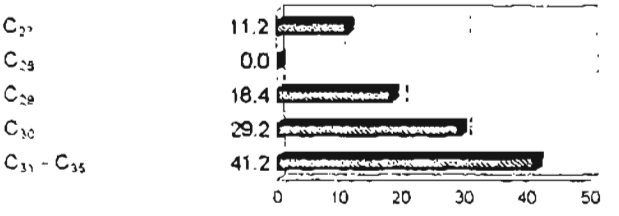
DGSI Project: 97/3959
Sample No. 7

ORGANIC FACIES AND DEPOSITIONAL ENVIRONMENT

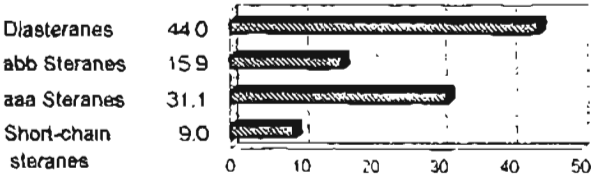
Sterane Carbon Number (%)



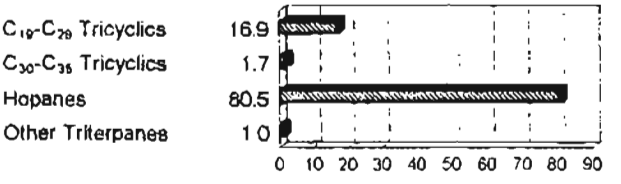
Hopane Carbon Number (%)



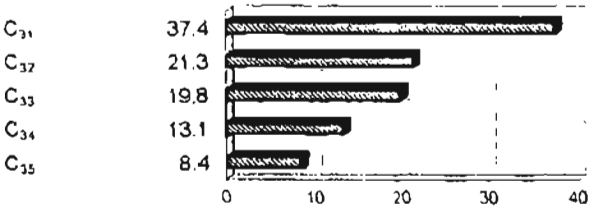
Sterane Isomer Distribution (%)



Triterpane Distribution (%)



Extended Hopane Distribution (%)



ORGANIC FACIES AND DEPOSITIONAL ENVIRONMENT RATIOS

C_{19} + C_{20} Tricyclics / C_{23} Tricyclic	0.41	C_{30} Oleanane / C_{30} Hopane	0.00
C_{24} Tetracyclic / C_{26} Tricyclics	0.58	C_{30} 30-Norhomohopane / C_{30} Hopane	0.03
C_{23} Tricyclic / C_{24} Tricyclic	2.13	Gammacerane / C_{30} Hopane	0.00
C_{25} Tricyclics / C_{26} Tricyclics	1.51	Extended Hopanes (%)	33.17
C_{28} Bisnorhopane / C_{30} Hopane	0.00	C_{35}/C_{34} Extended Hopanes	0.64
C_{29} 25-Norhopane / C_{30} Hopane	0.00	Tricyclic Terpanes / Hopanes	0.23
C_{29} Norhopane / C_{30} Hopane	0.53	Hopanes / Steranes	0.73
C_{30} Diahopane / C_{30} Hopane	0.09		

Copyright © DGSI, 1997

GAS CHROMATOGRAPHY - MASS SPECTROMETRY

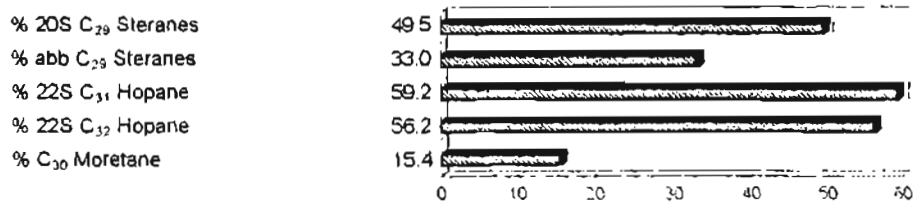
Triterpanes and Steranes

Alaska Outcrops
Other ID: 94 Mu 72-1 DGSI Project: 97\3805

DGSI Project: 97/3959
Sample No. 7

THERMAL MATURITY

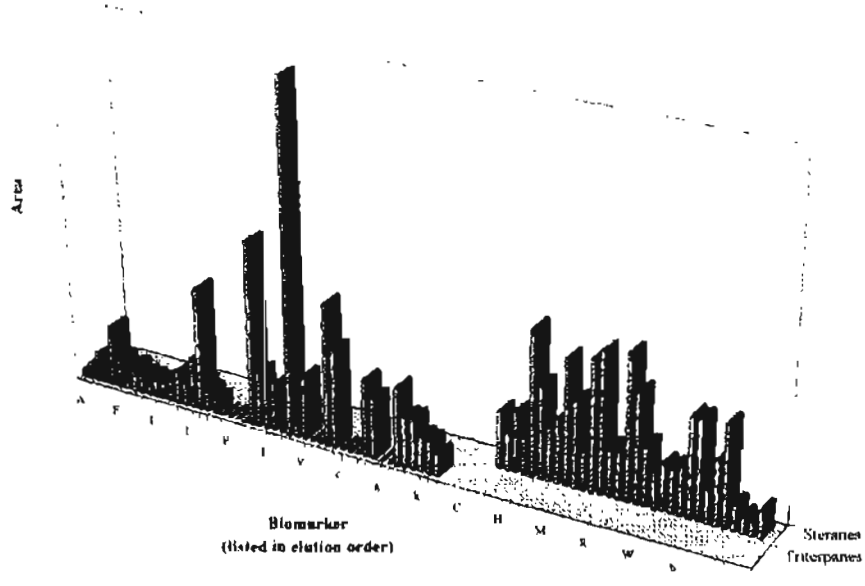
Biomarker Isomerization Ratios (%)



Maturity-Dependent Ratios

Ts / Tm	0.41
C_{29} Neohopane (29Ts) / C_{29} Norhopane	0.30
C_{30} Diahopane / C_{30} Hopane	0.09
% Diasteranes	44.0
Tricyclic Terpanes / Hopanes	0.23
% Short-chain steranes	9.0

TRITERPANE AND STERANE DISTRIBUTIONS



Copyright © DGSI, 1997

TRITERPANE REPORT (m/z 191)

Alaska Outcrops

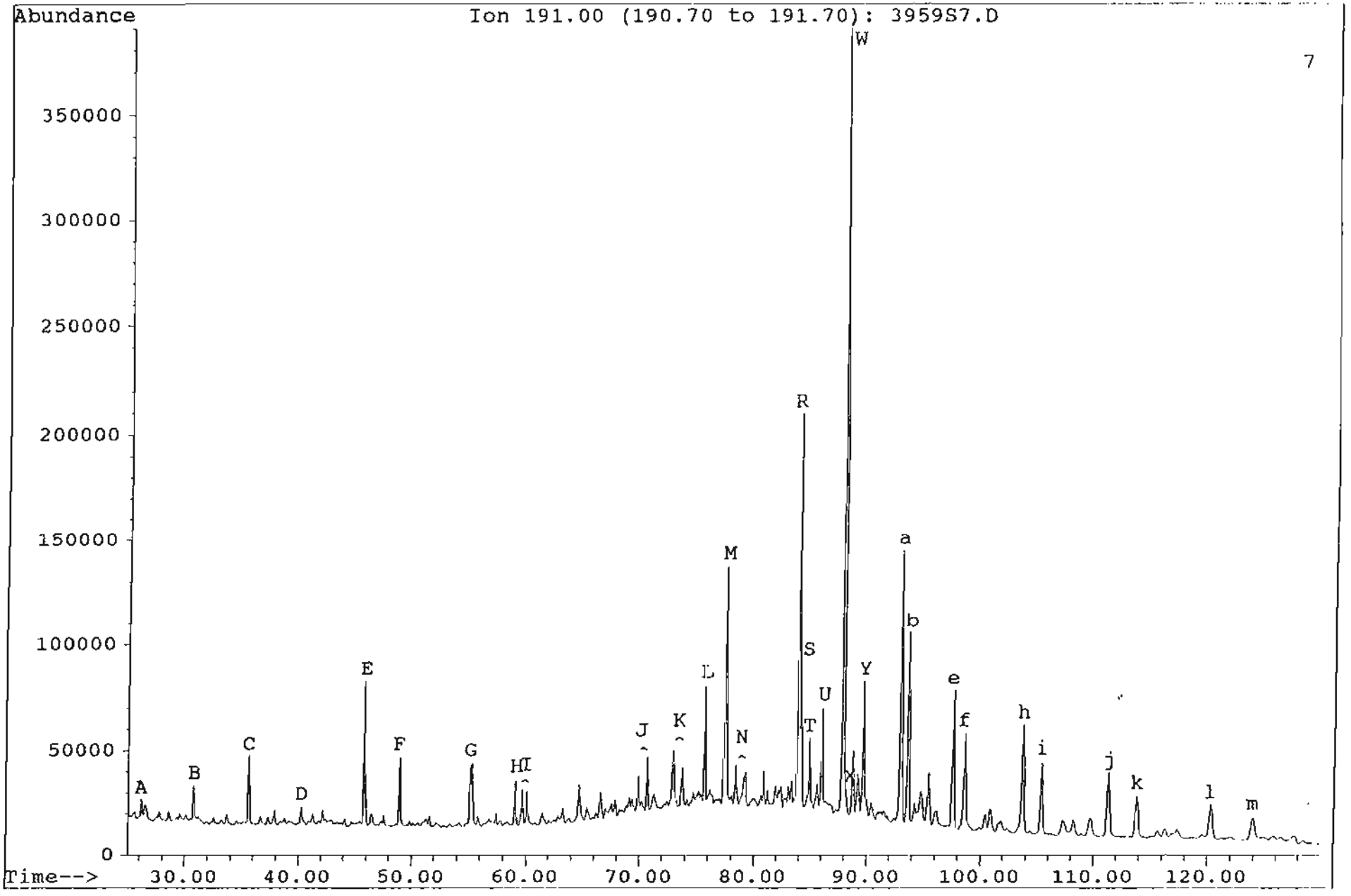
DGSI Project: 97/3959

Sample No. 7 | Other ID: 94 Mu 72-1 | DGSI Project: 97\3805

No.	ID	Triterpane Name	Ret Time	Area	Area%
1	A	C_{19} Tricyclic Terpane	26.185	937931	0.42
2	B	C_{20} Tricyclic Terpane	30.779	1923798	0.87
3	C	C_{21} Tricyclic Terpane	35.609	3375028	1.53
4	D	C_{22} Tricyclic Terpane	40.274	980038	0.44
5	E	C_{23} Tricyclic Terpane	45.821	6970681	3.15
6	F	C_{24} Tricyclic Terpane	48.942	3266229	1.48
7	G	C_{25} Tricyclic Terpane (22R)	55.113	2588581	1.17
8	G	C_{25} Tricyclic Terpane (22S)	55.290	2893670	1.31
9	H	C_{24} Tetracyclic Terpane	59.037	2102336	0.95
10	I	C_{26} Tricyclic Terpane (22R)	59.679	1916638	0.87
11	I	C_{26} Tricyclic Terpane (22S)	60.090	1710681	0.77
12	J	C_{28} Tricyclic Terpane (22R)	69.897	1978925	0.90
13	J	C_{28} Tricyclic Terpane (22S)	70.640	2520325	1.14
14	K	C_{29} Tricyclic Terpane (22R)	72.943	3797759	1.72
15	K	C_{29} Tricyclic Terpane (22S)	73.726	2418433	1.09
16	L	C_{27} 18aH-Trisnorhopane (Ts)	75.649	5783759	2.62
17	M	C_{27} 17aH-Trisnorhopane (Tm)	77.476	14228063	6.44
18	N	C_{30} Tricyclic Terpane (22R)	78.329	2219449	1.00
19	N	C_{30} Tricyclic Terpane (22S)	79.228	1482637	0.67
20	O	C_{28} 17aH,18aH,21bH-28,30-Bisnorhopane		0	0.00
21	P	C_{31} Tricyclic Terpane (22R)		0	0.00
22	Q	C_{29} 17aH,21bH 25-Norhopane		0	0.00
23	P	C_{31} Tricyclic Terpane (22S)		0	0.00
24	R	C_{29} 17aH,21bH-Norhopane	83.911	21130611	9.56
25	S	C_{29} 18aH-Norneohopane (29Ts)	84.158	6241413	2.82
26	T	C_{30} 17aH Diahopane	84.936	3427334	1.55
27	U	C_{29} 17bH,21aH-Normoretane	86.014	5304102	2.40
28	V	C_{30} 18aH+18bH-Oleanane		0	0.00
29	W	C_{30} 17aH,21bH-Hopane	87.892	39986202	18.09
30	X	C_{30} 30-Nor-29-homo-17aH-hopane	88.196	1227737	0.56
31	Y	C_{30} 17bH,21aH-Moretane	89.679	7268707	3.29
32	Z	C_{33} Tricyclic Terpane (22R)		0	0.00
33	Z	C_{33} Tricyclic Terpane (22S)		0	0.00
34	a	C_{31} 17aH,21bH-Homohopane (22S)	92.991	16255311	7.36
35	b	C_{31} 17aH,21bH-Homohopane (22R)	93.621	11179963	5.06
36	c	C_{30} Gammacerane		0	0.00
37	d	C_{34} Tricyclic Terpane (22R)		0	0.00
38	d	C_{34} Tricyclic Terpane (22S)		0	0.00
39	e	C_{32} 17aH,21bH-Bishomohopane (22S)	97.557	8768160	3.97
40	f	C_{32} 17aH,21bH-Bishomohopane (22R)	98.587	6841238	3.10
41	g	C_{35} Tricyclic Terpane (22R)		0	0.00
42	g	C_{35} Tricyclic Terpane (22S)		0	0.00
43	h	C_{33} 17aH,21bH-Trishomohopane (22S)	103.734	8830222	4.00
44	i	C_{33} 17aH,21bH-Trishomohopane (22R)	105.423	5678123	2.57
45	j	C_{34} 17aH,21bH-Tetrahomohopane (22S)	111.308	5703743	2.58
46	k	C_{34} 17aH,21bH-Tetrahomohopane (22R)	113.794	3927438	1.78
47	l	C_{35} 17aH,21bH-Pentahomohopane (22S)	120.329	3692460	1.67
48	m	C_{35} 17aH,21bH-Pentahomohopane (22R)	123.972	2429229	1.10

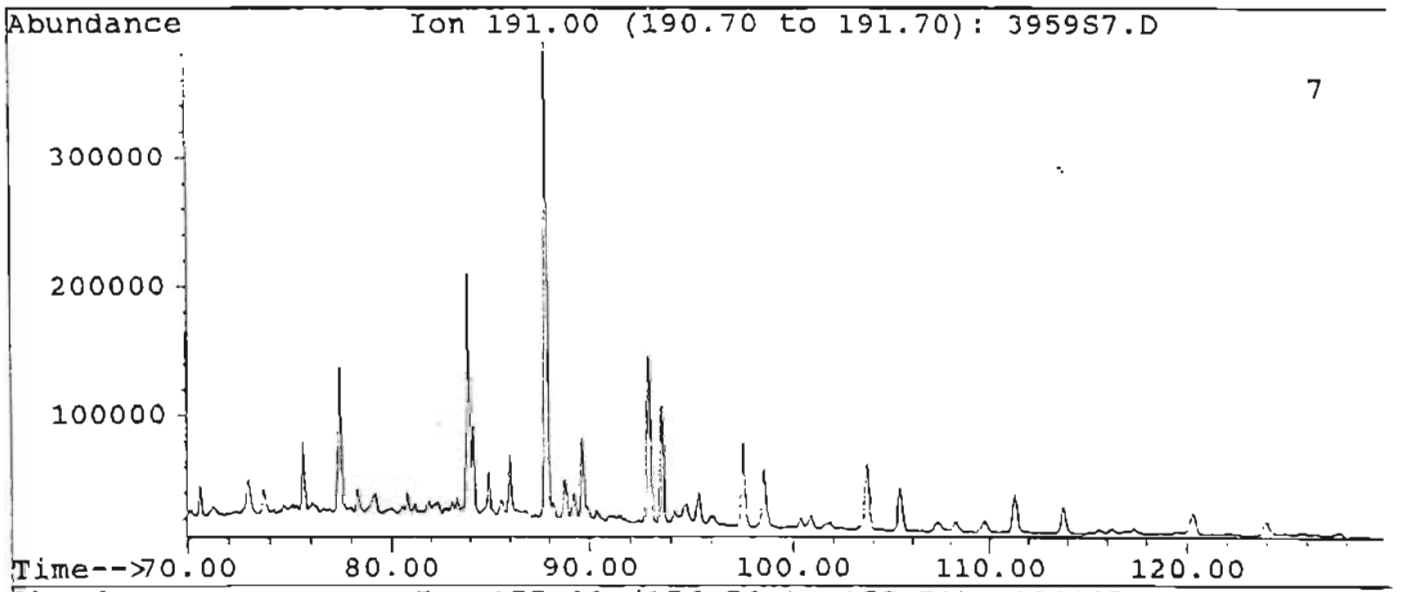
Copyright©, DGSI 1997

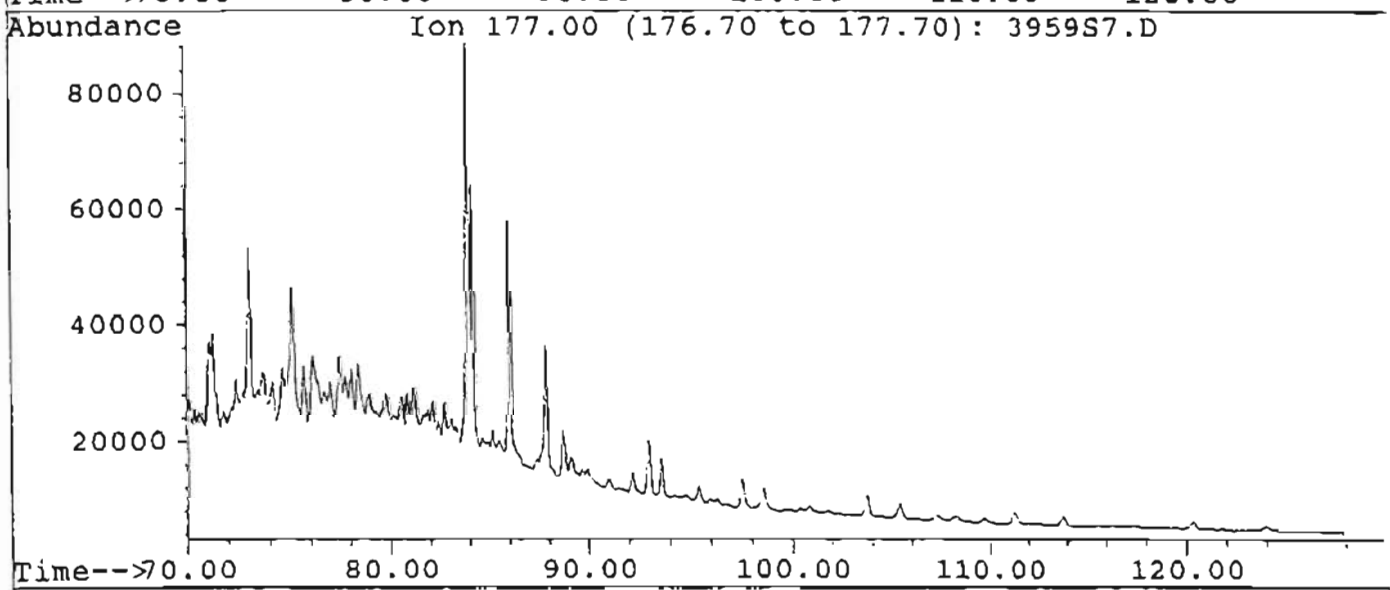
Alaska Outcrops
94 Mu 72-1
DGSI Project: 97/3959

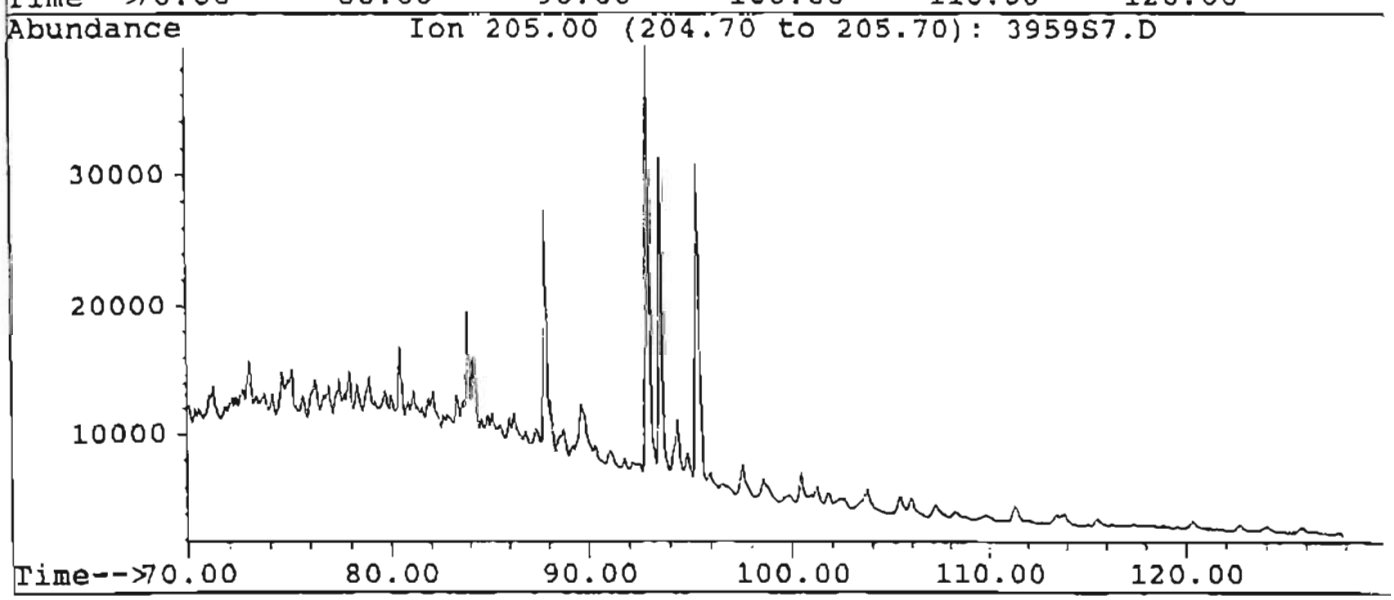


851

Alaska Outcrops
94 Mu 72-1
DGSI Project: 97/3959







STERANE REPORT (m/z 217)

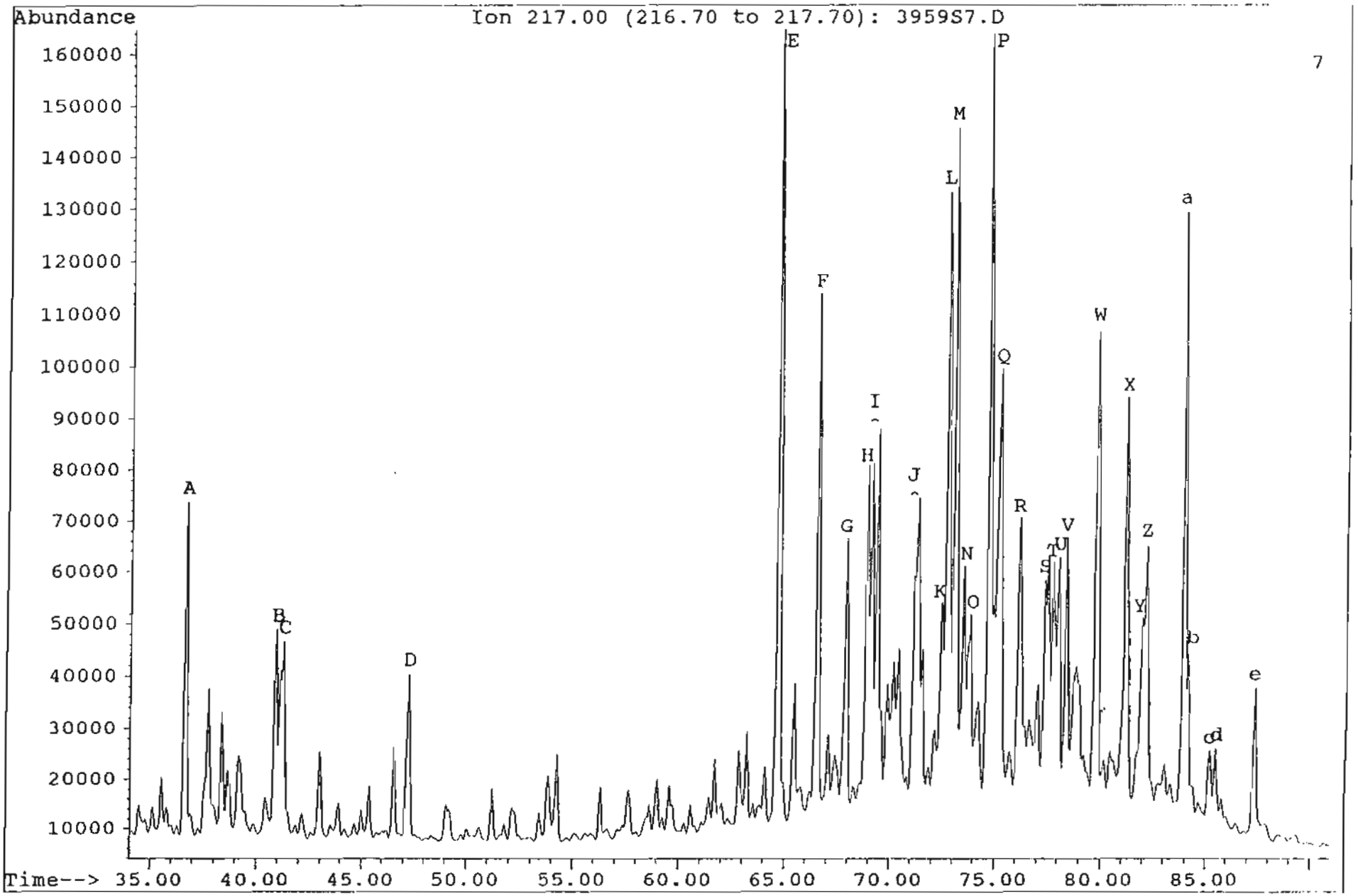
Alaska Outcrops

DGSI Project: 97/3959

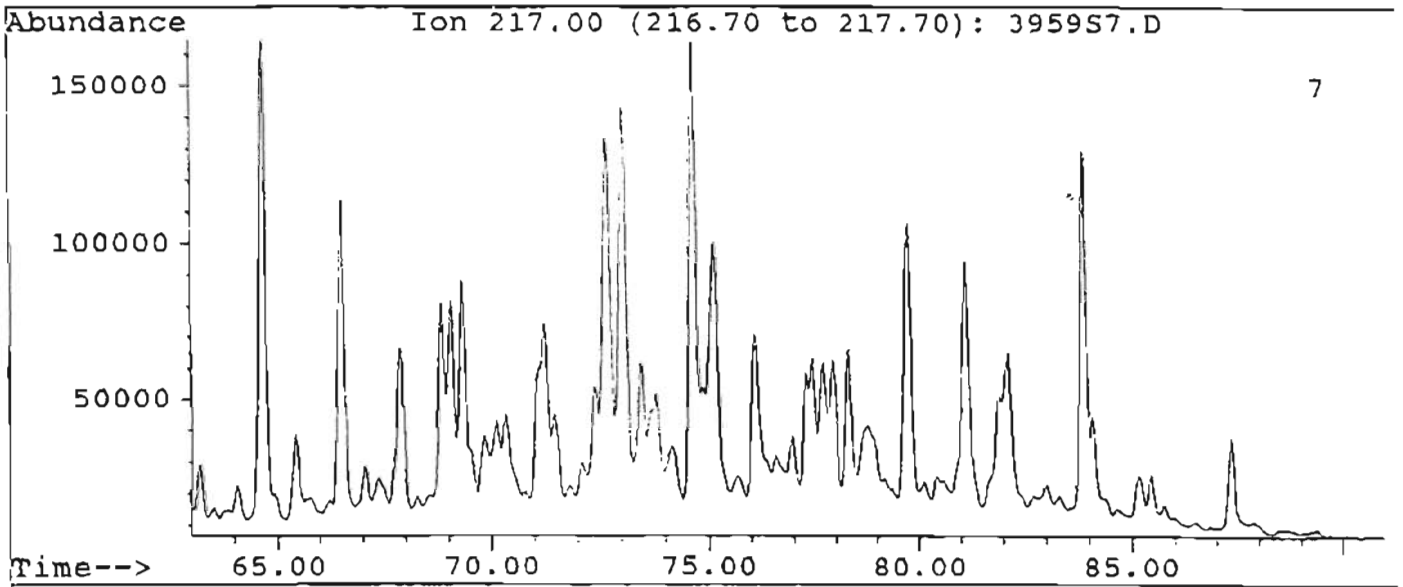
Sample No. 7 | Other ID: 94 Mu 72-1 | DGSI Project: 97\3805

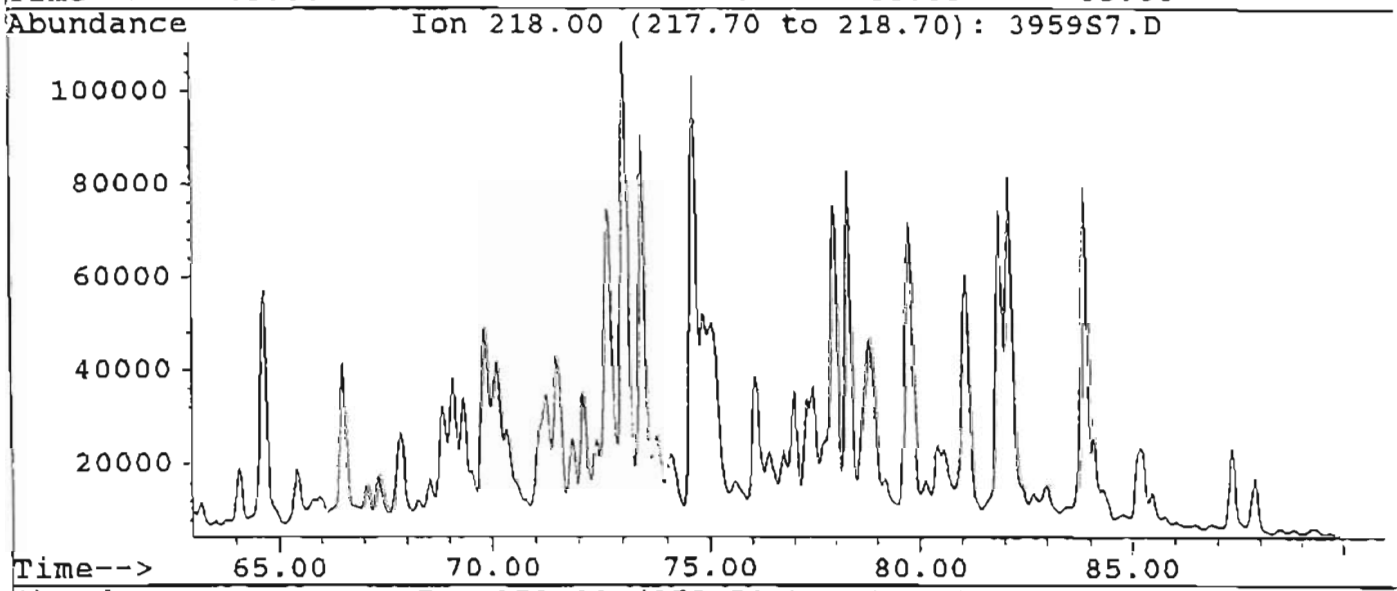
No.	ID	Sterane Name	Ret Time	Area	Area%
1	A	C_{21} diasterane	36.65	6441897	2.64
2	B	C_{21} abb sterane	40.88	4209022	1.73
3	C	C_{22} diasterane	41.23	6872494	2.82
4	D	C_{22} abb sterane	47.25	4340745	1.78
5	E	C_{27} ba diasterane (20S)	64.67	16675812	6.84
6	F	C_{27} ba diasterane (20R)	66.50	10461447	4.29
7	G	C_{27} ab diasterane (20S)	67.89	6176331	2.53
8	H	C_{27} ab diasterane (20R)	68.85	7306174	3.00
9	I	C_{28} ba diasterane (20S)	69.34	14303853	5.87
10	J	C_{28} ba diasterane (20R)	71.25	9787734	4.02
11	K	C_{28} ab diasterane (20S)	72.40	4567517	1.87
12	L	C_{27} aaa sterane (20S)	72.67	15004689	6.16
13	M	C_{27} abb ster-(20R)+C_{29} ba dia-(20S)	73.05	16082461	6.60
14	N	C_{27} abb sterane (20S)	73.45	5435465	2.23
15	O	C_{28} ab diasterane (20R)	73.78	5478461	2.25
16	P	C_{27} aaa sterane (20R)	74.65	16557223	6.79
17	Q	C_{29} ba diasterane (20R)	75.13	12480398	5.12
18	R	C_{29} ab diasterane (20S)	76.09	6831850	2.80
19	S	C_{28} aaa sterane (20S)	77.30	4123081	1.69
20	T	C_{29} ab diasterane (20R)	77.70	5246215	2.15
21	U	C_{28} abb sterane (20R)	77.95	5133101	2.11
22	V	C_{28} abb sterane (20S)	78.32	5498648	2.26
23	W	C_{28} aaa sterane (20R)	79.75	11351553	4.66
24	X	C_{29} aaa sterane (20S)	81.14	11292086	4.63
25	Y	C_{29} abb sterane (20R)	81.91	3823959	1.57
26	Z	C_{29} abb sterane (20S)	82.12	7384211	3.03
27	a	C_{29} aaa sterane (20R)	83.90	11506486	4.72
28	b	C_{30} aaa sterane (20S)	84.11	2884479	1.18
29	c	C_{30} abb sterane (20R)	85.17	1778822	0.73
30	d	C_{30} abb sterane (20S)	85.46	1581797	0.65
31	e	C_{30} aaa sterane (20R)	87.34	3106203	1.27

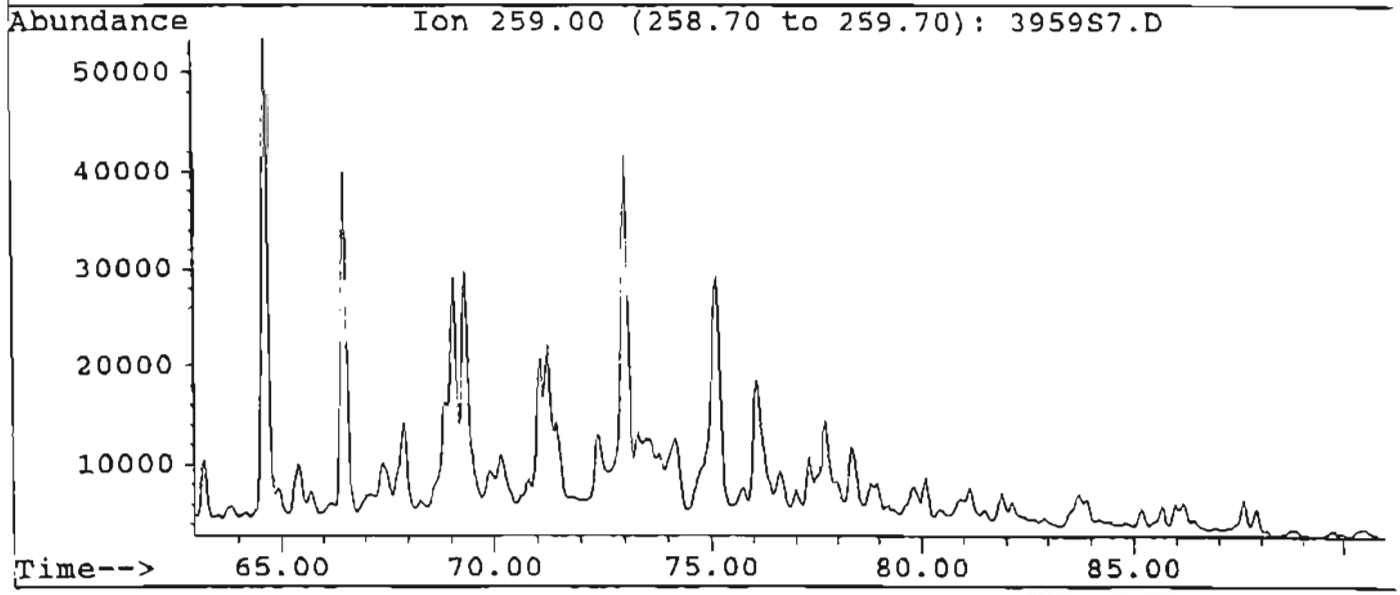
Alaska Outcrops
94 Mu 72-1
DGSI Project: 97/3959



Alaska Outcrops
94 Mu 72-1
DGSI Project: 97/3959







GAS CHROMATOGRAPHY - MASS SPECTROMETRY

Interpretation of Saturate Biomarker Ratios

Alaska Outcrops
Other ID: 96 MAW 7

DGSI Project: 97/3959
Sample No. 21

ORGANIC FACIES AND DEPOSITIONAL ENVIRONMENT

Ratio	Value	Interpretation
C_{19} + C_{20} Tricyclics / C_{23} Tricyclic	0.60	Terrigenous
C_{24} Tetracyclic / C_{26} Tricyclics	0.55	Not diagnostic
C_{25} Tricyclics / C_{26} Tricyclics	0.67	Non-marine
C_{28} Bisnorhopane / C_{30} Hopane	0.00	Not diagnostic
C_{29} Norhopane / C_{30} Hopane	0.43	Not diagnostic
C_{30} Diahopane / C_{30} Hopane	0.07	Not diagnostic
C_{30} Oleanane / C_{30} Hopane	0.00	No significant angiosperm input
Gammacerane / C_{30} Hopane	0.00	Not lacustrine or hypersaline
% C_{31} - C_{35} Extended Hopanes	33.0	Terrigenous
C_{35}/C_{34} Extended Hopanes	0.42	Not diagnostic
Hopane/Sterane	4.93	Terrigenous or non-marine
% C_{27} Steranes	20.2	Mixed source
% C_{29} Steranes	39.7	Terrigenous
Diasteranes	28.9	Mixed Source
Isosteranes (abb)	30.1	Maturity-influenced
Short-chain steranes	18.3	Maturity-influenced
Pristane/phytane	3.5	Terrigenous

THERMAL MATURITY

Ts / Tm	2.80	Elevated maturity
% C30 Moretane	8.69	Greater than 0.5% Ro equivalent
22S / (22S+22R) C31 Hopane (%)	57.9	Greater than 0.5% Ro equivalent
% 20S/(20S + 20R)	53.7	Between 0.6% and 1.0% Ro equivalent
% abb/(abb + aaa)	52.8	Between 0.6% and 1.0% Ro equivalent
Odd Even Preference	N.A.	N.A.
Pristane/nC17	0.5	Mature
Phytane/nC18	0.2	Paraffinic

Copyright ©, DGSI, 1997

GAS CHROMATOGRAPHY - MASS SPECTROMETRY

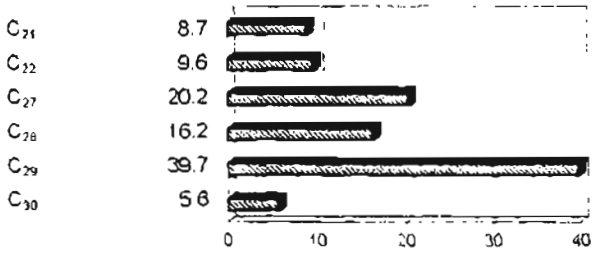
Triterpanes and Steranes

Alaska Outcrops
Other ID: 96 MAW 7

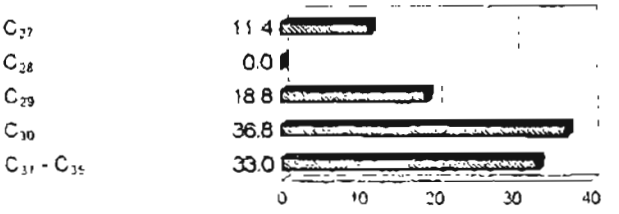
DGSI Project: 97/3959
Sample No. 21

ORGANIC FACIES AND DEPOSITIONAL ENVIRONMENT

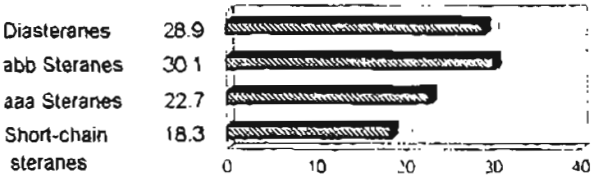
Sterane Carbon Number (%)



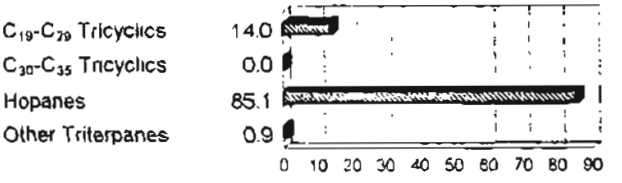
Hopane Carbon Number (%)



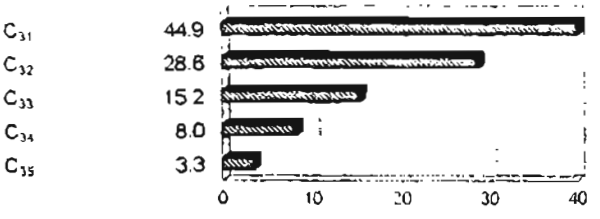
Sterane Isomer Distribution (%)



Triterpane Distribution (%)



Extended Hopane Distribution (%)



ORGANIC FACIES AND DEPOSITIONAL ENVIRONMENT RATIOS

C_{19} + C_{20} Tricyclics / C_{23} Tricyclic	0.60	C_{30} Oleanane / C_{30} Hopane	0.00
C_{24} Tetracyclic / C_{26} Tricyclics	0.55	C_{30} 30-Norhomohopane / C_{30} Hopane	0.04
C_{23} Tricyclic / C_{24} Tricyclic	1.48	Gammacerane / C_{30} Hopane	0.00
C_{25} Tricyclics / C_{26} Tricyclics	0.67	Extended Hopanes (%)	28.11
C_{28} Bisnorhopane / C_{30} Hopane	0.00	C_{35}/C_{34} Extended Hopanes	0.42
C_{29} 25-Norhopane / C_{30} Hopane	0.00	Tricyclic Terpanes / Hopanes	0.16
C_{29} Norhopane / C_{30} Hopane	0.43	Hopanes / Steranes	4.93
C_{30} Diahopane / C_{30} Hopane	0.07		

Copyright © DGSI, 1997

GAS CHROMATOGRAPHY - MASS SPECTROMETRY

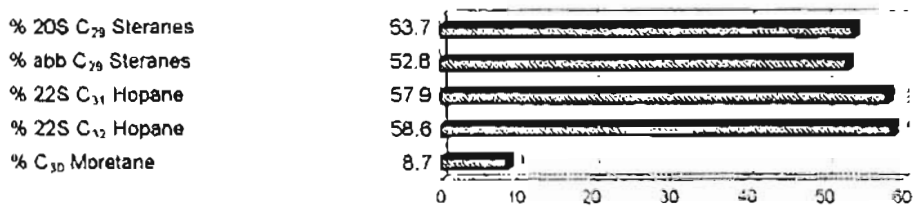
Triterpanes and Steranes

Alaska Outcrops
Other ID: 96 MAW 7

DGSI Project: 97/3959
Sample No. 21

THERMAL MATURITY

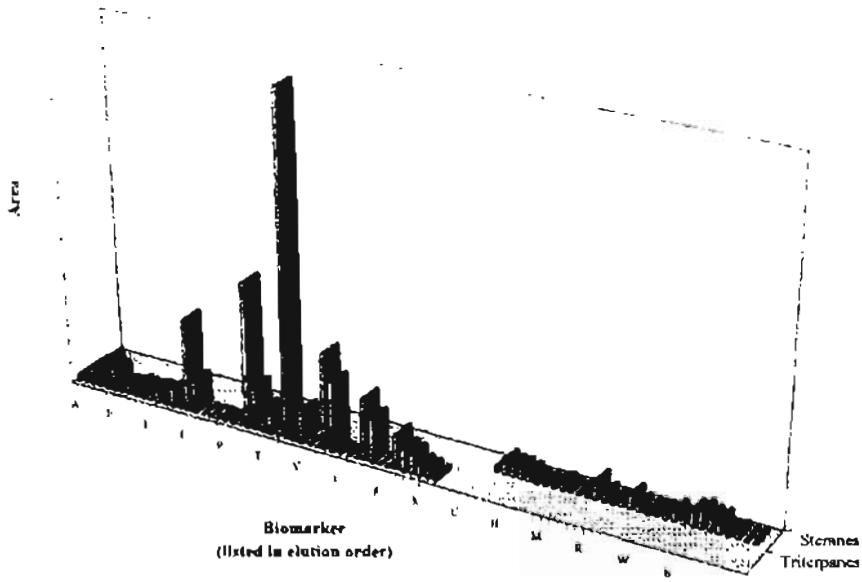
Biomarker Isomerization Ratios (%)



Maturity-Dependent Ratios

Ts / Tm	2.80
C_{29} Neohopane (29Ts) / C_{29} Norhopane	0.29
C_{30} Diahopane / C_{30} Hopane	0.07
% Diasteranes	28.9
Tricyclic Terpanes / Hopanes	0.16
% Short-chain steranes	18.3

TRITERPANE AND STERANE DISTRIBUTIONS



Copyright © DGSI 1997

TRITERPANE REPORT (m/z 191)

Alaska Outcrops

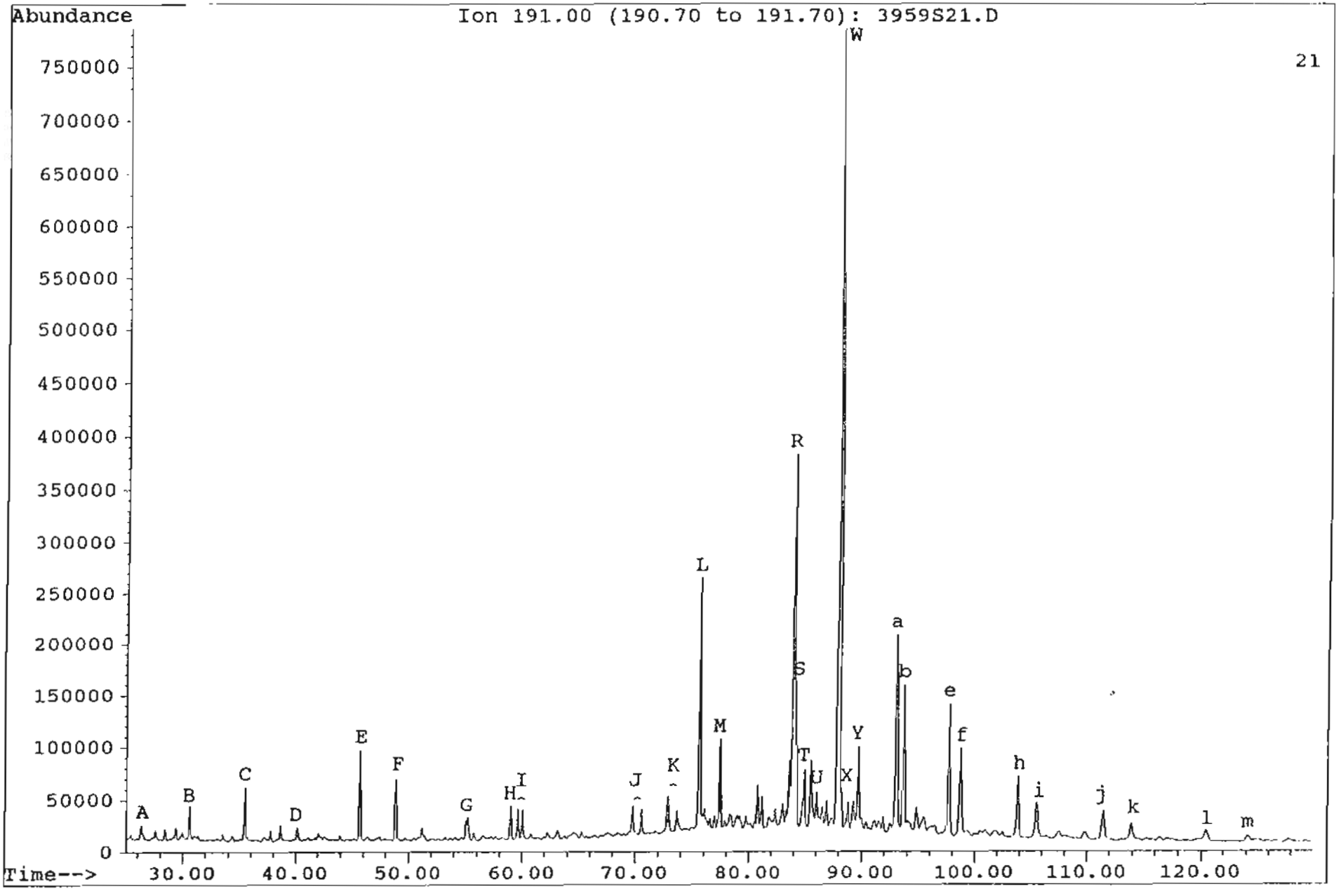
DGSI Project: 97/3959

Sample No. 21 | Other ID: 96 MAW 7 | DGSI Project: 97\3805

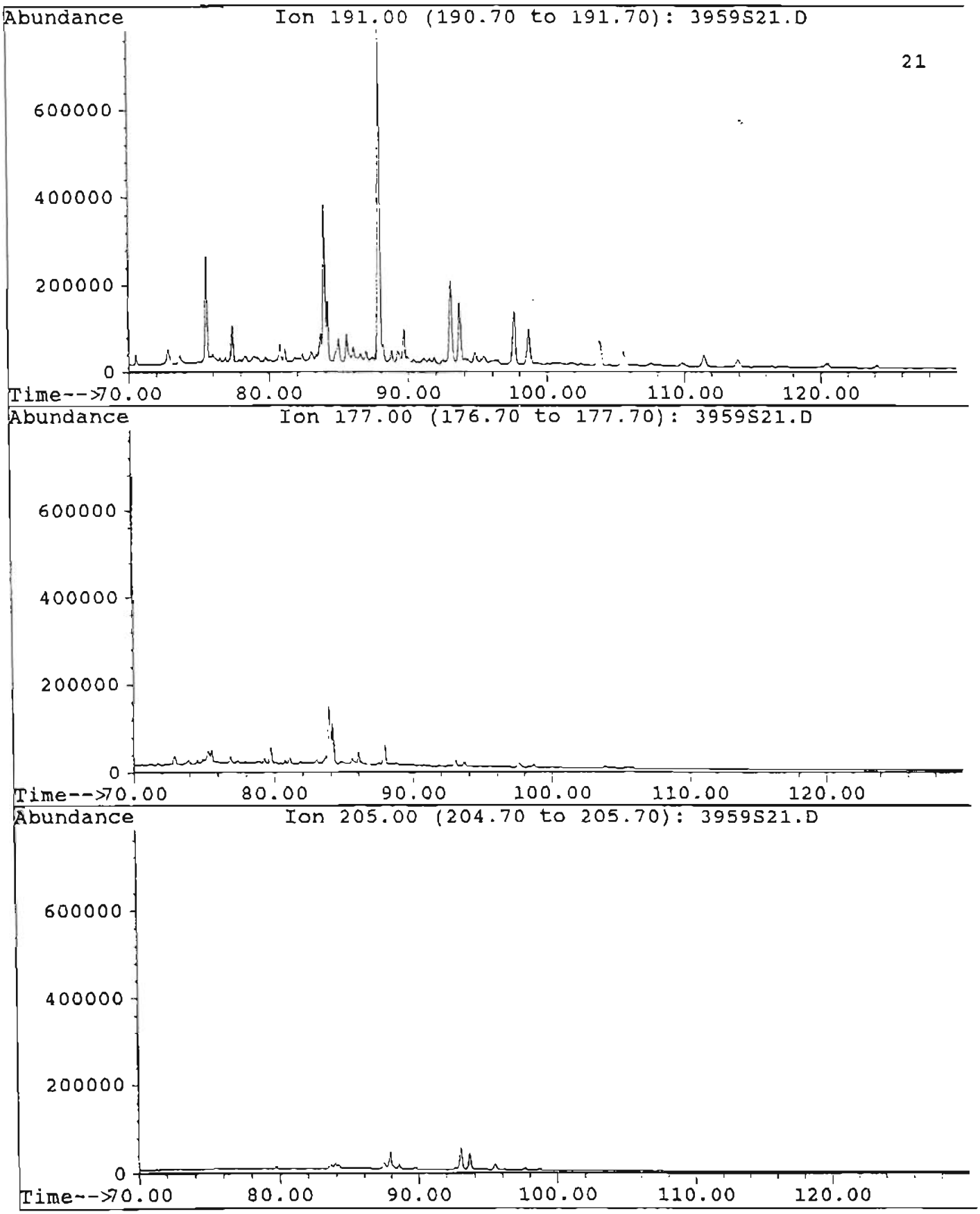
No.	ID	Triterpane Name	Ret Time	Area	Area%
1	A	C_{19} Tricyclic Terpane	28.327	1814004	0.48
2	B	C_{20} Tricyclic Terpane	30.613	3653888	0.97
3	C	C_{21} Tricyclic Terpane	35.435	5534919	1.48
4	D	C_{22} Tricyclic Terpane	40.129	1667472	0.44
5	E	C_{23} Tricyclic Terpane	45.694	9066730	2.42
6	F	C_{24} Tricyclic Terpane	48.831	6116342	1.63
7	G	C_{25} Tricyclic Terpane (22R)	55.020	1749491	0.47
8	G	C_{25} Tricyclic Terpane (22S)	55.195	2290731	0.61
9	H	C_{24} Tetracyclic Terpane	58.952	3318556	0.88
10	I	C_{26} Tricyclic Terpane (22R)	59.592	2996002	0.80
11	I	C_{26} Tricyclic Terpane (22S)	60.005	3046917	0.81
12	J	C_{28} Tricyclic Terpane (22R)	69.800	3279282	0.87
13	J	C_{28} Tricyclic Terpane (22S)	70.540	2545770	0.68
14	K	C_{29} Tricyclic Terpane (22R)	72.838	5556777	1.48
15	K	C_{29} Tricyclic Terpane (22S)	73.651	3078526	0.82
16	L	C_{27} 18aH-Trisnorhopane (Ts)	75.573	26910597	7.18
17	M	C_{27} 17aH-Trisnorhopane (Tm)	77.385	9608352	2.56
18	N	C_{30} Tricyclic Terpane (22R)		0	0.00
19	N	C_{30} Tricyclic Terpane (22S)		0	0.00
20	O	C_{28} 17aH,18aH,21bH-28,30-Bisnorhopane		0	0.00
21	P	C_{31} Tricyclic Terpane (22R)		0	0.00
22	Q	C_{29} 17aH,21bH 25-Norhopane		0	0.00
23	P	C_{31} Tricyclic Terpane (22S)		0	0.00
24	R	C_{29} 17aH,21bH-Norhopane	83.919	42296328	11.28
25	S	C_{29} 18aH-Nomeohopane (29Ts)	84.152	12371883	3.30
26	T	C_{30} 17aH Diahopane	84.923	6610041	1.76
27	U	C_{29} 17bH,21aH-Normoretane	85.996	5207441	1.39
28	V	C_{30} 18aH+18bH-Oleanane		0	0.00
29	W	C_{30} 17aH,21bH-Hopane	87.954	97925192	26.11
30	X	C_{30} 30-Nor-29-homo-17aH-hopane	88.184	3614811	0.96
31	Y	C_{30} 17bH,21aH-Moretane	89.686	9324981	2.49
32	Z	C_{33} Tricyclic Terpane (22R)		0	0.00
33	Z	C_{33} Tricyclic Terpane (22S)		0	0.00
34	a	C_{31} 17aH,21bH-Homohopane (22S)	93.044	27448983	7.32
35	b	C_{31} 17aH,21bH-Homohopane (22R)	93.675	19924261	5.31
36	c	C_{30} Gammacerane		0	0.00
37	d	C_{34} Tricyclic Terpane (22R)		0	0.00
38	d	C_{34} Tricyclic Terpane (22S)		0	0.00
39	e	C_{32} 17aH,21bH-Bishomohopane (22S)	97.640	17636255	4.70
40	f	C_{32} 17aH,21bH-Bishomohopane (22R)	98.671	12467748	3.32
41	g	C_{35} Tricyclic Terpane (22R)		0	0.00
42	g	C_{35} Tricyclic Terpane (22S)		0	0.00
43	h	C_{33} 17aH,21bH-Trishomohopane (22S)	103.818	9669896	2.58
44	i	C_{33} 17aH,21bH-Trishomohopane (22R)	105.510	6308734	1.68
45	j	C_{34} 17aH,21bH-Tetrahomohopane (22S)	111.412	5511308	1.47
46	k	C_{34} 17aH,21bH-Tetrahomohopane (22R)	113.933	2897810	0.77
47	l	C_{35} 17aH,21bH-Pentahomohopane (22S)	120.452	2348560	0.63
48	m	C_{35} 17aH,21bH-Pentahomohopane (22R)	124.158	1182014	0.32

Copyright©, DGSI, 1997

Alaska Outcrops
96 MAW 7
DGSI Project: 97/3959



Alaska Outcrops
96 MAW 7
DGSI Project: 97/3959



STERANE REPORT (m/z 217)

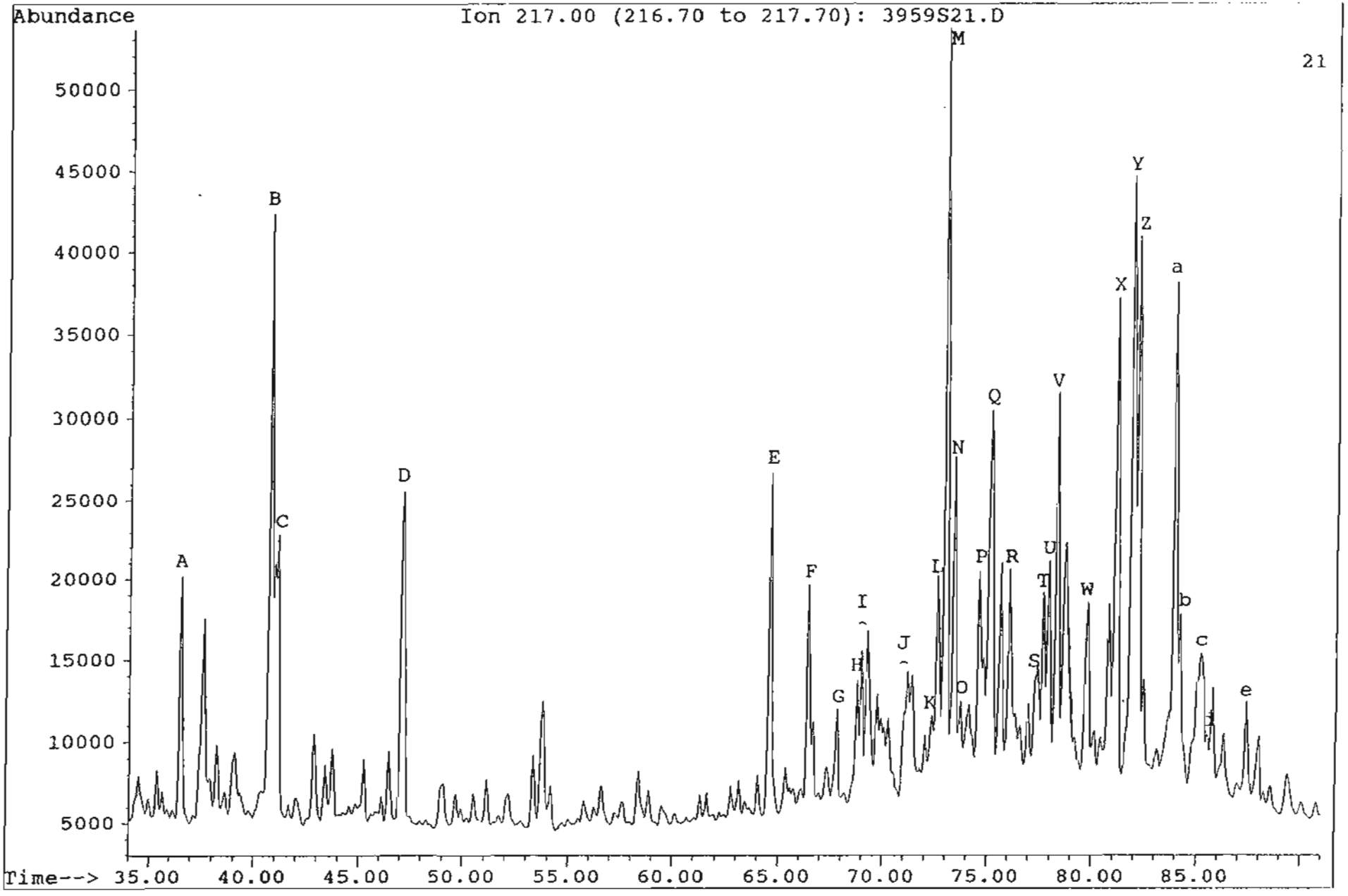
Alaska Outcrops

DGSI Project: 97/3959

Sample No. 21 | Other ID: 96 MAW 7 | DGSI Project: 97\3805

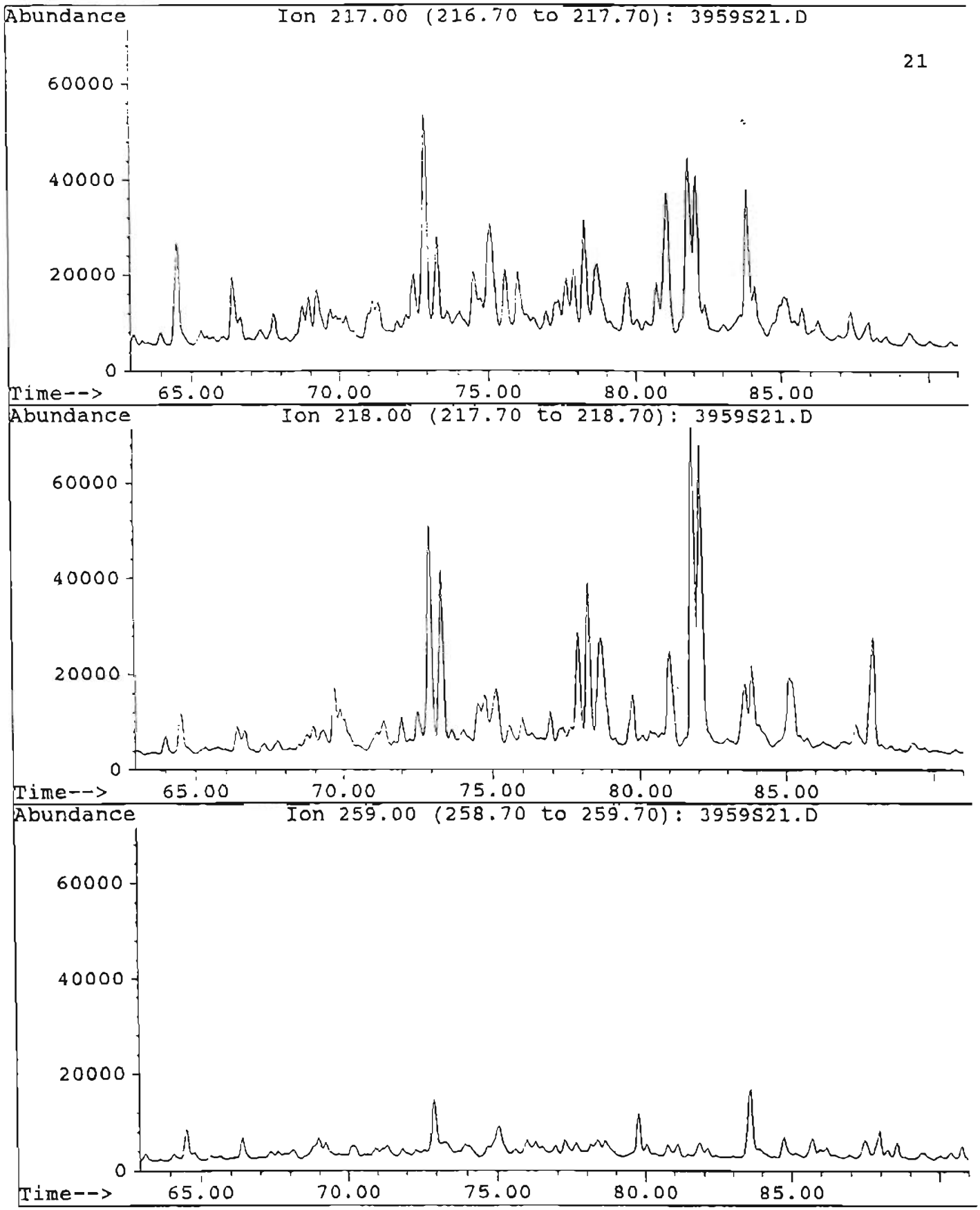
No.	ID	Sterane Name	Ret Time	Area	Area%
1	A	C_{21} diasterane	36.50	1655691	2.56
2	B	C_{21} abb sterane	40.73	3998621	6.18
3	C	C_{22} diasterane	41.09	3093965	4.78
4	D	C_{22} abb sterane	47.04	3086999	4.77
5	E	C_{27} ba diasterane (20S)	64.56	2348986	3.63
6	F	C_{27} ba diasterane (20R)	66.38	1358788	2.10
7	G	C_{27} ab diasterane (20S)	67.77	659741	1.02
8	H	C_{27} ab diasterane (20R)	68.74	901159	1.39
9	I	C_{28} ba diasterane (20S)	69.23	1972384	3.05
10	J	C_{28} ba diasterane (20R)	71.15	1246380	1.93
11	K	C_{28} ab diasterane (20S)	72.29	438684	0.68
12	L	C_{27} aaa sterane (20S)	72.55	1589264	2.46
13	M	C_{27} abb ster-(20R)+C_{29} ba dia-(20S)	72.94	5265616	8.14
14	N	C_{27} abb sterane (20S)	73.34	2111041	3.26
15	O	C_{28} ab diasterane (20R)	73.67	491144	0.76
16	P	C_{27} aaa sterane (20R)	74.55	1484590	2.29
17	Q	C_{29} ba diasterane (20R)	75.09	3780144	5.84
18	R	C_{29} ab diasterane (20S)	76.01	1646017	2.54
19	S	C_{28} aaa sterane (20S)	77.23	598303	0.92
20	T	C_{29} ab diasterane (20R)	77.62	1238142	1.91
21	U	C_{28} abb sterane (20R)	77.89	1460748	2.26
22	V	C_{28} abb sterane (20S)	78.25	2762470	4.27
23	W	C_{28} aaa sterane (20R)	79.74	1488882	2.30
24	X	C_{29} aaa sterane (20S)	81.10	4150418	6.41
25	Y	C_{29} abb sterane (20R)	81.83	4848373	7.49
26	Z	C_{29} abb sterane (20S)	82.10	3797536	5.87
27	a	C_{29} aaa sterane (20R)	83.86	3578870	5.53
28	b	C_{30} aaa sterane (20S)	84.13	989512	1.53
29	c	C_{30} abb sterane (20R)	85.12	1465167	2.26
30	d	C_{30} abb sterane (20S)	85.47	408876	0.83
31	e	C_{30} aaa sterane (20R)	87.36	783587	1.21

Alaska Outcrops
96 MAW 7
DGSI Project: 97/3959



170

Alaska Outcrops
96 MAW 7
DGSI Project: 97/3959



GAS CHROMATOGRAPHY - MASS SPECTROMETRY

Interpretation of Saturate Biomarker Ratios

Alaska Outcrops
Other ID: 96 MAW 11

DGSI Project: 97/3959
Sample No. 23

ORGANIC FACIES AND DEPOSITIONAL ENVIRONMENT

Ratio	Value	Interpretation
C_{19} + C_{20} Tricyclics / C_{23} Tricyclic	0.70	Not diagnostic
C_{24} Tetracyclic / C_{26} Tricyclics	0.57	Not diagnostic
C_{25} Tricyclics / C_{26} Tricyclics	1.07	Not diagnostic
C_{28} Bisnorhopane / C_{30} Hopane	0.00	Not diagnostic
C_{29} Norhopane / C_{30} Hopane	0.48	Not diagnostic
C_{30} Diahopane / C_{30} Hopane	0.10	Not diagnostic
C_{30} Oleanane / C_{30} Hopane	0.00	No significant angiosperm input
Gammacerane / C_{30} Hopane	0.00	Not lacustrine or hypersaline
% C_{31} - C_{35} Extended Hopanes	31.4	Marine maturity-influenced
C_{35}/C_{34} Extended Hopanes	0.53	Not diagnostic
Hopane/Sterane	2.73	Terrigenous or non-marine
% C_{27} Steranes	20.0	Mixed source
% C_{29} Steranes	32.6	Not higher plant dominated
Diasteranes	21.9	Mixed Source
Isosteranes (abb)	29.6	Not diagnostic
Short-chain steranes	25.3	Carbonate or hypersaline
Pristane/phytane	2.6	Terrigenous

THERMAL MATURITY

Ts / Tm	1.25	Mature
% C30 Moretane	9.65	Greater than 0.5% Ro equivalent
22S / (22S+22R) C31 Hopane (%)	57.8	Greater than 0.5% Ro equivalent
% 20S/(20S + 20R)	51.8	Between 0.6% and 1.0% Ro equivalent
% abb/(abb + aaa)	53.4	Between 0.6% and 1.0% Ro equivalent
Odd Even Preference	N.A.	N.A.
Pristane/nC17	0.6	Mature
Phytane/nC18	0.3	Paraffinic

Copyright ©, DGSI, 1997

GAS CHROMATOGRAPHY - MASS SPECTROMETRY

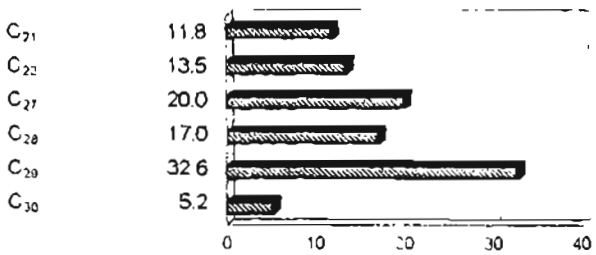
Triterpanes and Steranes

Alaska Outcrops
Other ID: 96 MAW 11

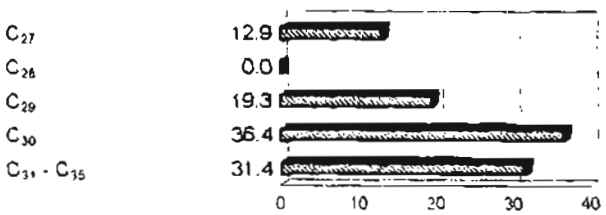
DGSI Project: 97/3959
Sample No. 23

ORGANIC FACIES AND DEPOSITIONAL ENVIRONMENT

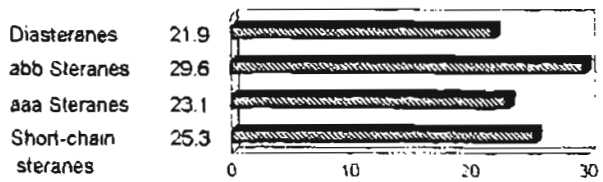
Sterane Carbon Number (%)



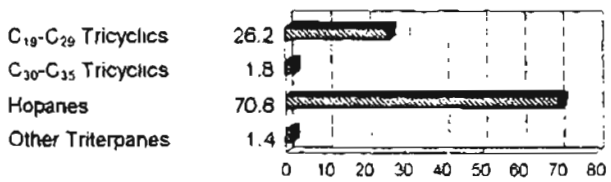
Hopane Carbon Number (%)



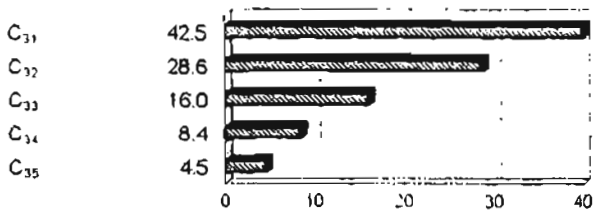
Sterane Isomer Distribution (%)



Triterpane Distribution (%)



Extended Hopane Distribution (%)



ORGANIC FACIES AND DEPOSITIONAL ENVIRONMENT RATIOS

C_{19} + C_{20} Tricyclics / C_{23} Tricyclic	0.70	C_{30} Oleanane / C_{30} Hopane	0.00
C_{24} Tetracyclic / C_{26} Tricyclics	0.57	C_{30} 30-Norhomohopane / C_{30} Hopane	0.04
C_{23} Tricyclic / C_{24} Tricyclic	1.18	Gammacerane / C_{30} Hopane	0.00
C_{25} Tricyclics / C_{26} Tricyclics	1.07	Extended Hopanes (%)	22.16
C_{28} Bisnorhopane / C_{30} Hopane	0.00	C_{35}/C_{34} Extended Hopanes	0.53
C_{29} 25-Norhopane / C_{30} Hopane	0.00	Tricyclic Terpanes / Hopanes	0.40
C_{29} Norhopane / C_{30} Hopane	0.48	Hopanes / Steranes	2.73
C_{30} Diahopane / C_{30} Hopane	0.10		

Copyright © DGSI, 1997

GAS CHROMATOGRAPHY - MASS SPECTROMETRY

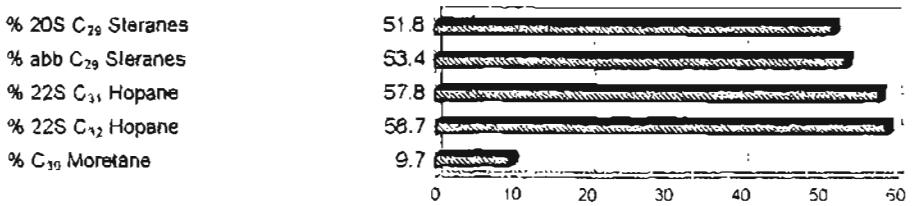
Triterpanes and Steranes

Alaska Outcrops
Other ID: 96 MAW 11

DGSI Project: 97/3959
Sample No. 23

THERMAL MATURITY

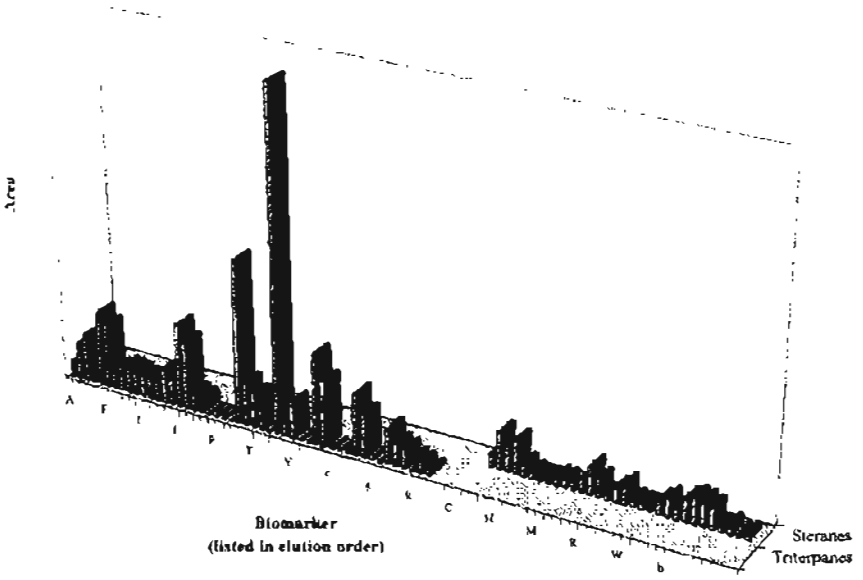
Biomarker Isomerization Ratios (%)



Maturity-Dependent Ratios

Ts / Tm	1.25
C_{29} Neohopane (29Ts) / C_{29} Norhopane	0.26
C_{30} Diahopane / C_{30} Hopane	0.10
% Diasteranes	21.9
Tricyclic Terpanes / Hopanes	0.40
% Short-chain steranes	25.3

TRITERPANE AND STERANE DISTRIBUTIONS



Copyright © DGSI, 1997

TRITERPANE REPORT (m/z 191)

Alaska Outcrops

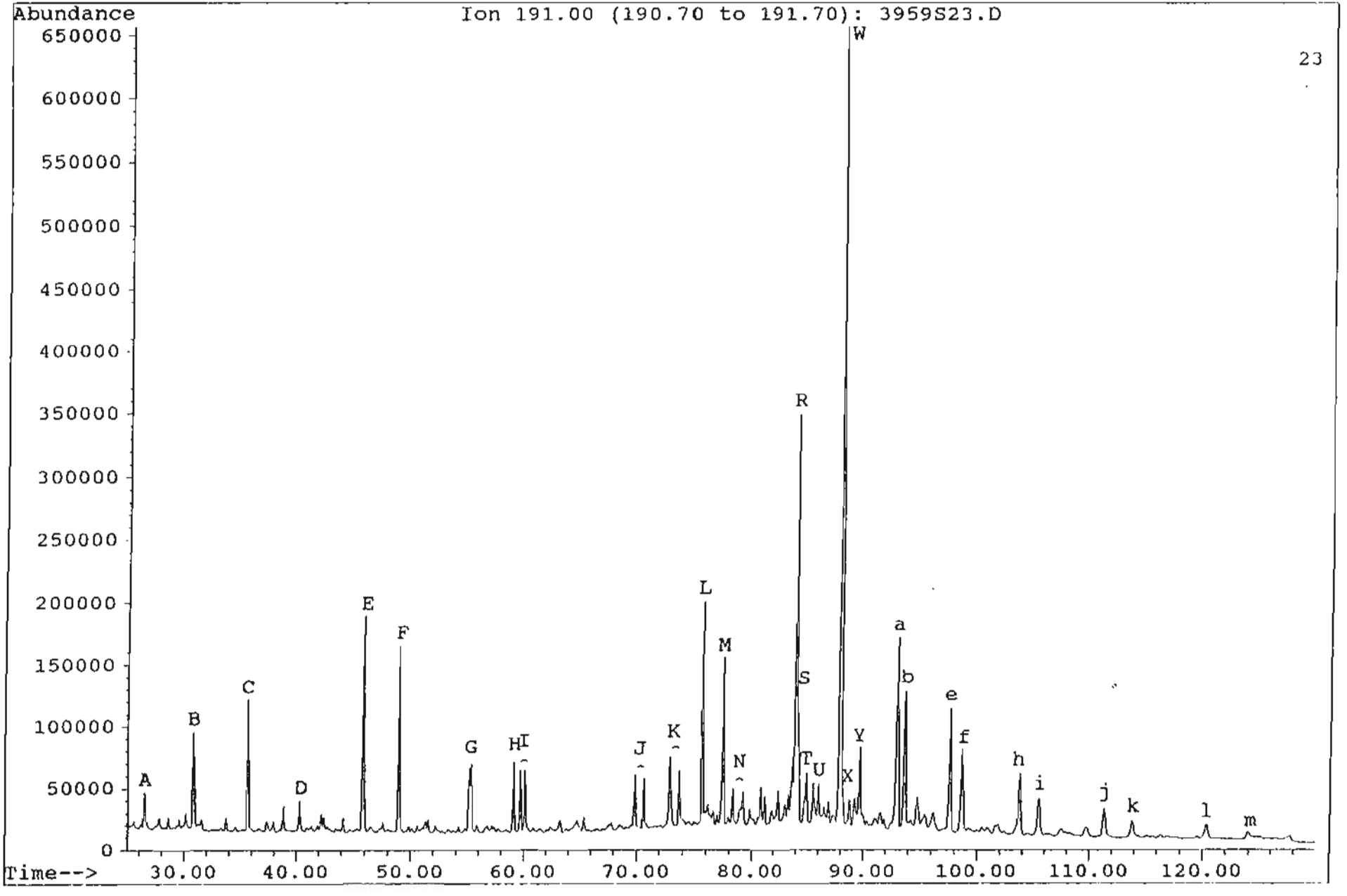
DGSI Project: 97/3959

Sample No. 23 | Other ID: 96 MAW 11 | DGSI Project: 97\3805

No.	ID	Triterpane Name	Ret Time	Area	Area%
1	A	C_{19} Tricyclic Terpane	26.486	3688641	0.96
2	B	C_{20} Tricyclic Terpane	30.810	8409591	2.20
3	C	C_{21} Tricyclic Terpane	35.626	11141317	2.92
4	D	C_{22} Tricyclic Terpane	40.291	2760985	0.72
5	E	C_{23} Tricyclic Terpane	45.859	17156628	4.50
6	F	C_{24} Tricyclic Terpane	48.973	14525398	3.81
7	G	C_{25} Tricyclic Terpane (22R)	55.150	4756801	1.25
8	G	C_{25} Tricyclic Terpane (22S)	55.325	5554358	1.46
9	H	C_{24} Tetracyclic Terpane	59.075	5511356	1.44
10	I	C_{26} Tricyclic Terpane (22R)	59.690	4988485	1.31
11	I	C_{26} Tricyclic Terpane (22S)	60.100	4656493	1.22
12	J	C_{28} Tricyclic Terpane (22R)	69.881	4582499	1.20
13	J	C_{28} Tricyclic Terpane (22S)	70.610	4201397	1.10
14	K	C_{29} Tricyclic Terpane (22R)	72.870	7967748	2.09
15	K	C_{29} Tricyclic Terpane (22S)	73.695	5490869	1.44
16	L	C_{27} 18aH-Trisnorhopane (Ts)	75.621	19353043	5.07
17	M	C_{27} 17aH-Trisnorhopane (Tm)	77.456	15523809	4.07
18	N	C_{30} Tricyclic Terpane (22R)	78.309	3725934	0.98
19	N	C_{30} Tricyclic Terpane (22S)	79.223	3148861	0.83
20	O	C_{28} 17aH,18aH,21bH-28,30-Bisnorhopane		0	0.00
21	P	C_{31} Tricyclic Terpane (22R)		0	0.00
22	Q	C_{29} 17aH,21bH 25-Norhopane		0	0.00
23	P	C_{31} Tricyclic Terpane (22S)		0	0.00
24	R	C_{29} 17aH,21bH-Norhopane	83.959	37717857	9.88
25	S	C_{29} 18aH-Norneohopane (29Ts)	84.184	9805401	2.57
26	T	C_{30} 17aH Diahopane	84.952	7649121	2.00
27	U	C_{29} 17bH,21aH-Normoretane	86.028	4490797	1.18
28	V	C_{30} 18aH+18bH-Oleanane		0	0.00
29	W	C_{30} 17aH,21bH-Hopane	87.964	78714057	20.62
30	X	C_{30} 30-Nor-29-homo-17aH-hopane	88.207	3166391	0.83
31	Y	C_{30} 17bH,21aH-Moretane	89.703	8411869	2.20
32	Z	C_{33} Tricyclic Terpane (22R)		0	0.00
33	Z	C_{33} Tricyclic Terpane (22S)		0	0.00
34	a	C_{31} 17aH,21bH-Homohopane (22S)	93.020	20788651	5.45
35	b	C_{31} 17aH,21bH-Homohopane (22R)	93.864	15155851	3.97
36	c	C_{30} Gammacerane		0	0.00
37	d	C_{34} Tricyclic Terpane (22R)		0	0.00
38	d	C_{34} Tricyclic Terpane (22S)		0	0.00
39	e	C_{32} 17aH,21bH-Bishomohopane (22S)	97.610	14216578	3.72
40	f	C_{32} 17aH,21bH-Bishomohopane (22R)	98.838	10000092	2.62
41	g	C_{35} Tricyclic Terpane (22R)		0	0.00
42	g	C_{35} Tricyclic Terpane (22S)		0	0.00
43	h	C_{33} 17aH,21bH-Trishomohopane (22S)	103.753	8223863	2.15
44	i	C_{33} 17aH,21bH-Trishomohopane (22R)	105.442	5269109	1.38
45	j	C_{34} 17aH,21bH-Tetrahomohopane (22S)	111.336	4418511	1.16
46	k	C_{34} 17aH,21bH-Tetrahomohopane (22R)	113.829	2706703	0.71
47	l	C_{35} 17aH,21bH-Pentahomohopane (22S)	120.346	2485452	0.65
48	m	C_{35} 17aH,21bH-Pentahomohopane (22R)	123.982	1337152	0.35

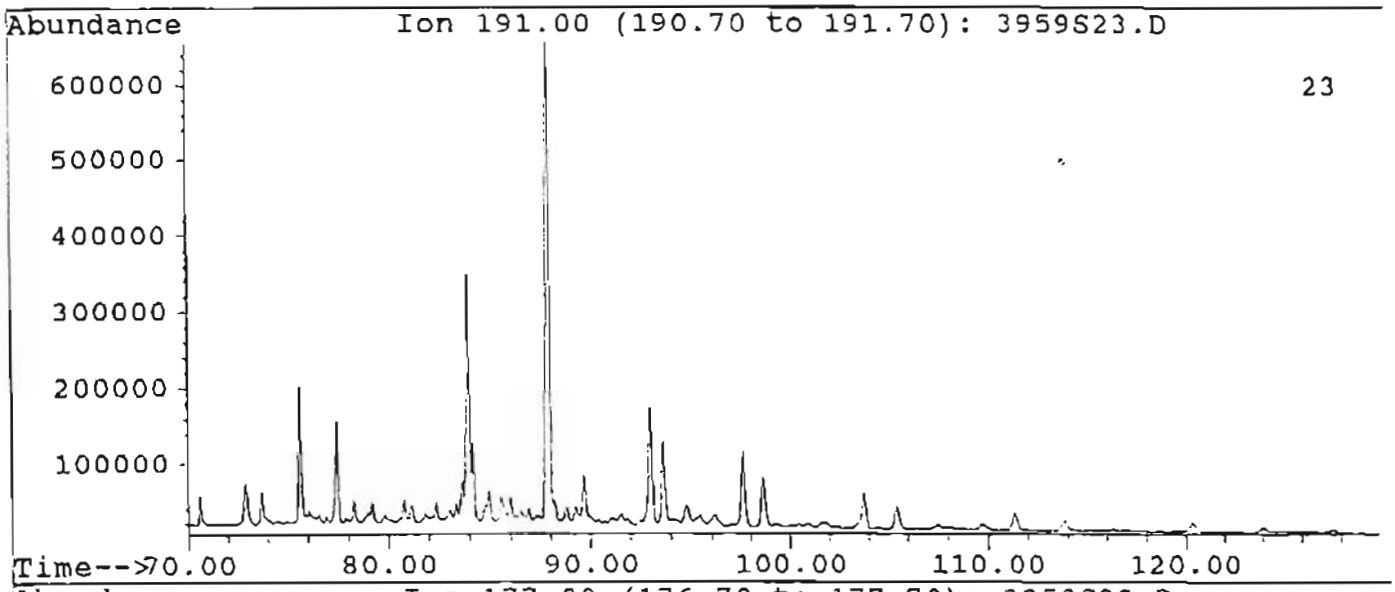
Copyright©, DGSI, 1997

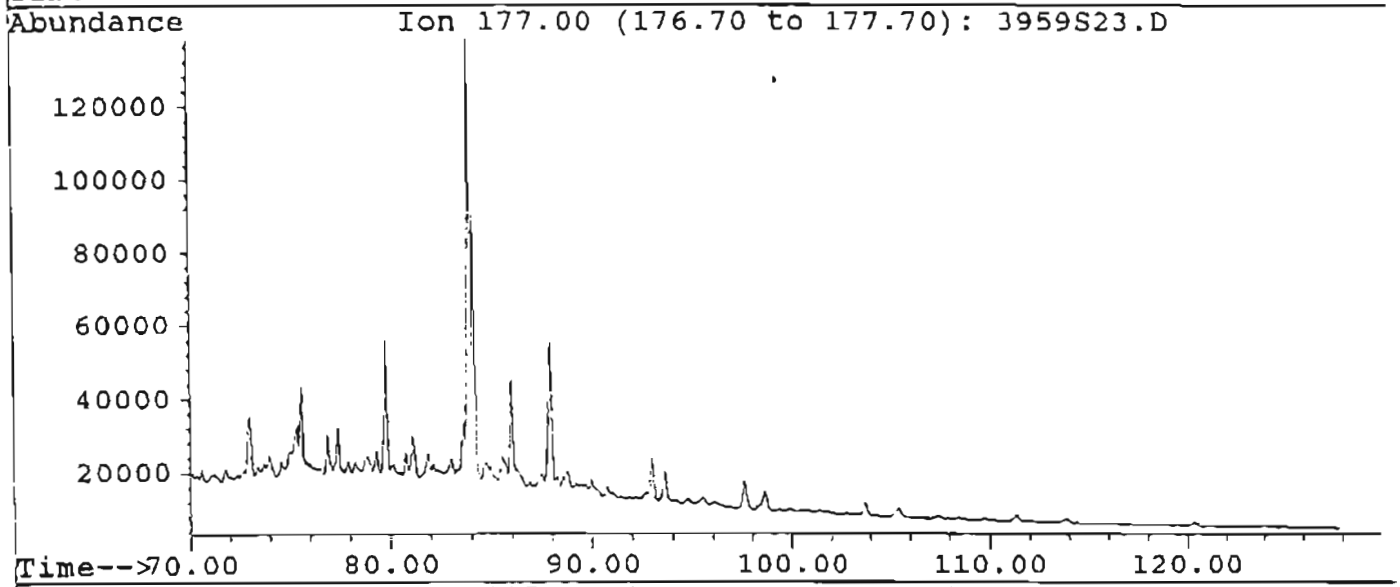
Alaska Outcrops
96 MAW 11
DGSI Project: 97/3959

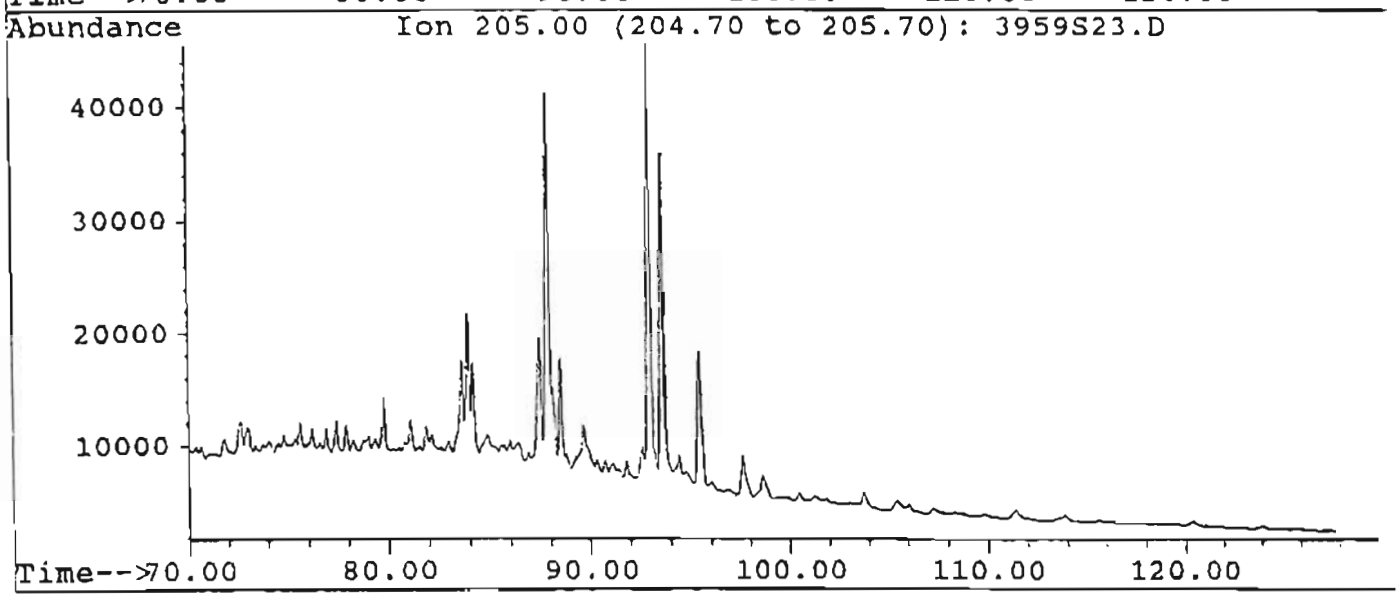


176

Alaska Outcrops
96 MAW 11
DGSI Project: 97/3959







STERANE REPORT (m/z 217)

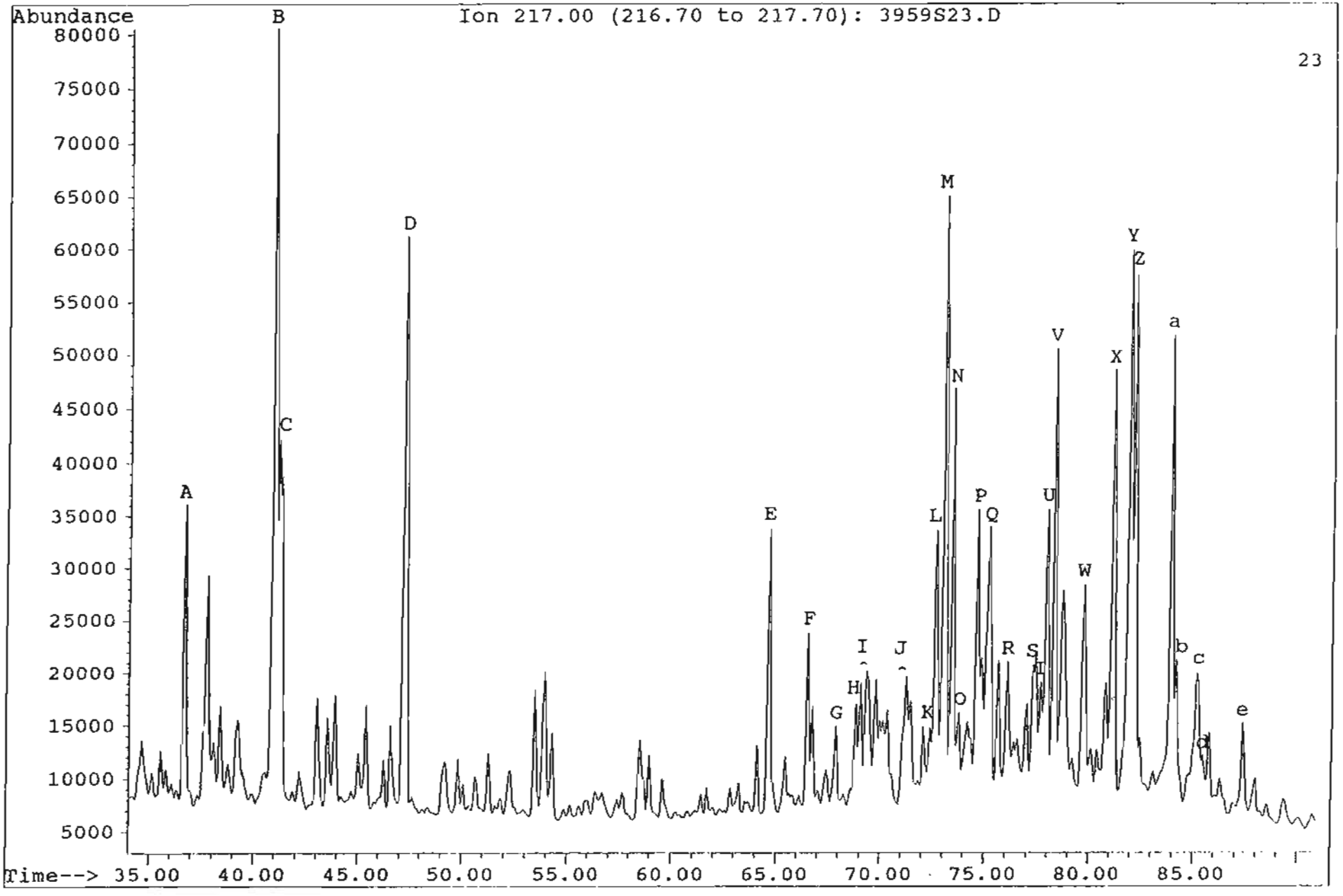
Alaska Outcrops

DGSI Project: 97/3959

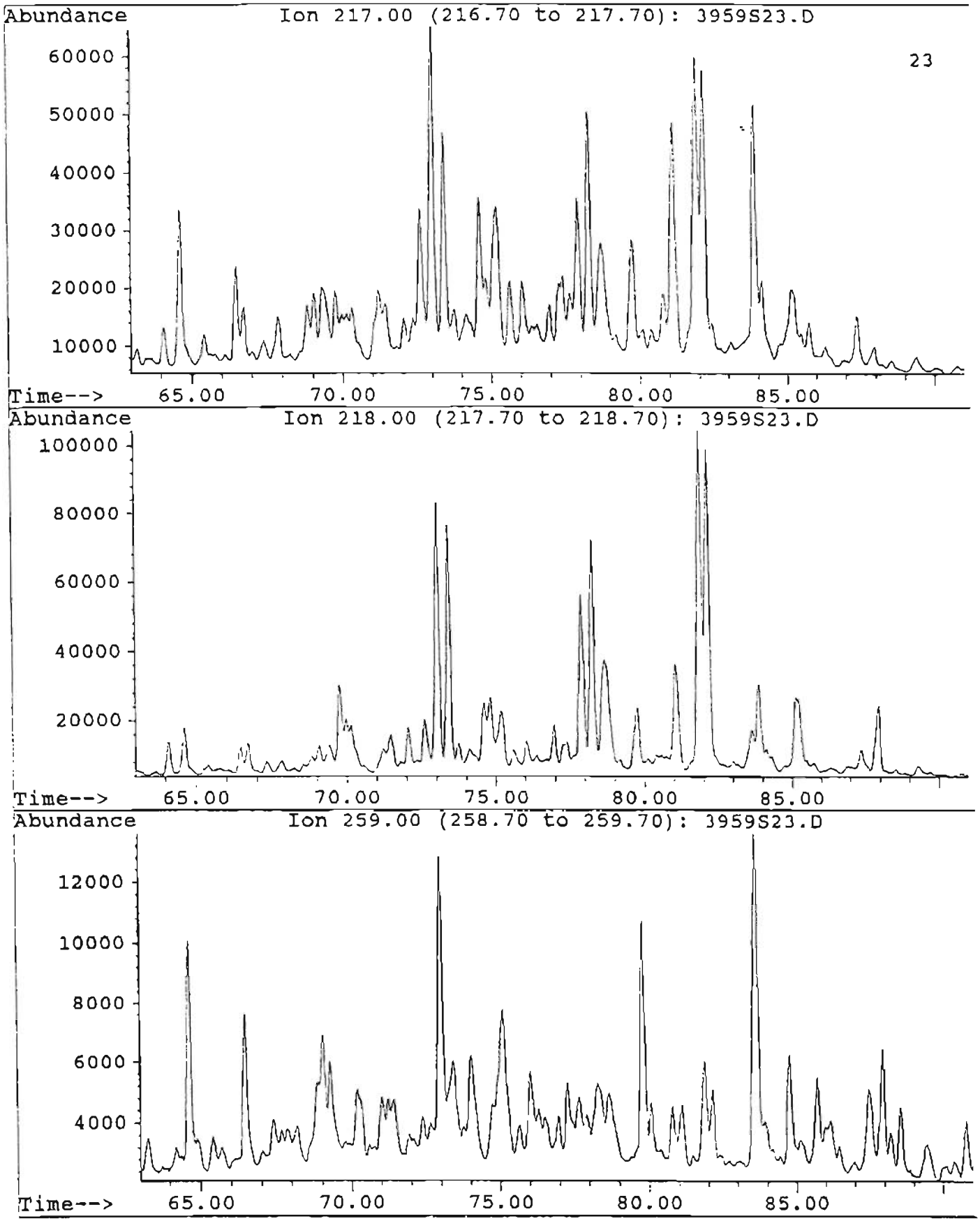
Sample No. 23 Other ID: 96 MAW 11 DGSI Project: 97\3805

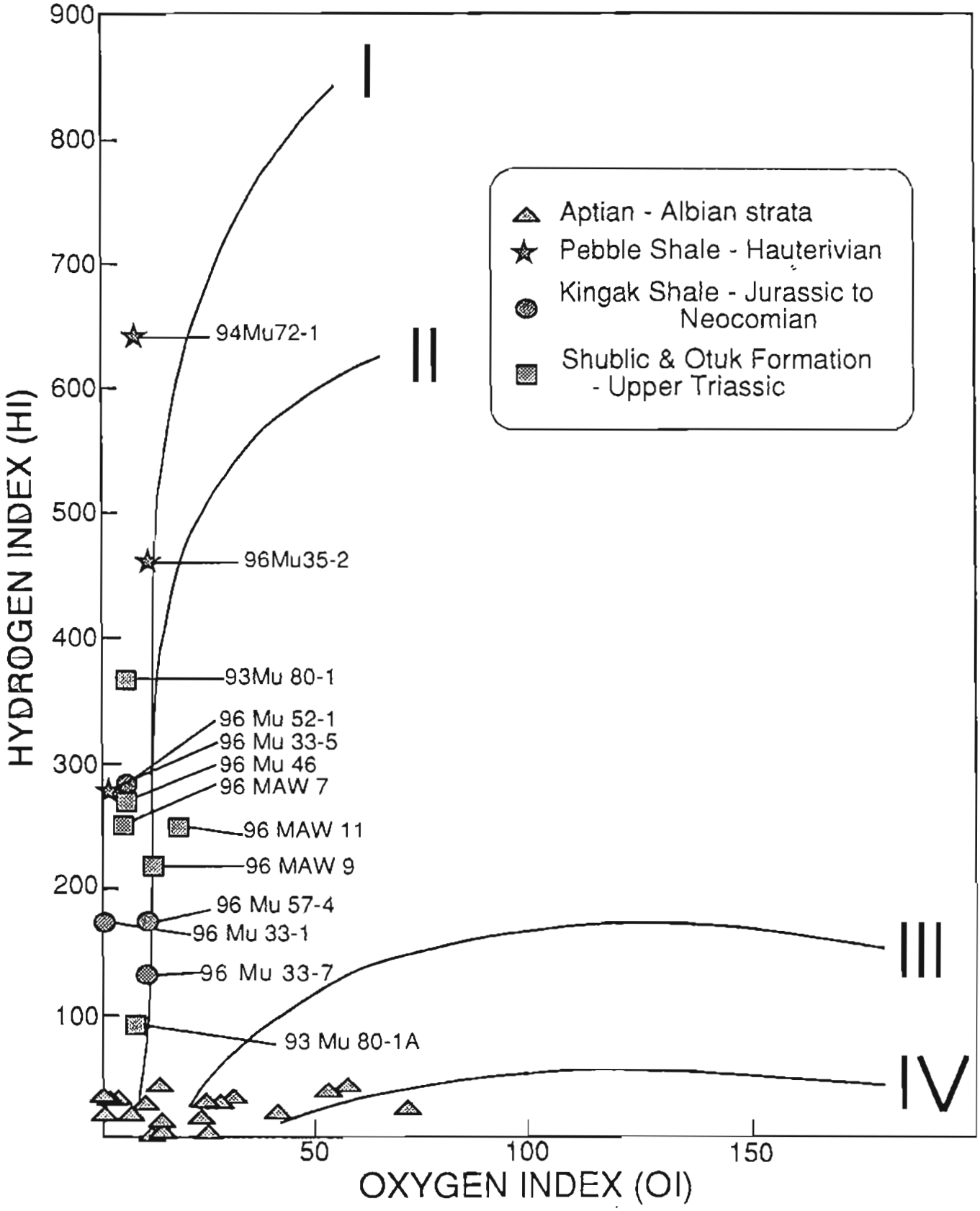
No.	ID	Sterane Name	Ret Time	Area	Area%
1	A	C_{21} diasterane	36.67	2979178	3.02
2	B	C_{21} abb sterane	40.92	8694418	8.80
3	C	C_{22} diasterane	41.13	5582321	5.65
4	D	C_{22} abb sterane	47.21	7765163	7.86
5	E	C_{27} ba diasterane (20S)	64.63	2829162	2.86
6	F	C_{27} ba diasterane (20R)	66.48	1586503	1.61
7	G	C_{27} ab diasterane (20S)	67.85	888123	0.90
8	H	C_{27} ab diasterane (20R)	68.81	969748	0.98
9	I	C_{28} ba diasterane (20S)	69.32	1966043	1.99
10	J	C_{28} ba diasterane (20R)	71.21	1823091	1.85
11	K	C_{28} ab diasterane (20S)	72.36	607723	0.62
12	L	C_{27} aaa sterane (20S)	72.62	3101348	3.14
13	M	C_{27} abb ster-(20R)+C_{29} ba dia-(20S)	73.02	6519165	6.60
14	N	C_{27} abb sterane (20S)	73.41	4030044	4.08
15	O	C_{28} ab diasterane (20R)	73.73	925459	0.94
16	P	C_{27} aaa sterane (20R)	74.61	3043703	3.08
17	Q	C_{29} ba diasterane (20R)	75.17	4411800	4.47
18	R	C_{29} ab diasterane (20S)	76.04	1504112	1.52
19	S	C_{28} aaa sterane (20S)	77.27	1258502	1.27
20	T	C_{29} ab diasterane (20R)	77.65	873792	0.88
21	U	C_{28} abb sterane (20R)	77.93	3121059	3.16
22	V	C_{28} abb sterane (20S)	78.29	4448670	4.50
23	W	C_{28} aaa sterane (20R)	79.73	2615082	2.65
24	X	C_{29} aaa sterane (20S)	81.11	5339267	5.41
25	Y	C_{29} abb sterane (20R)	81.87	6209881	6.29
26	Z	C_{29} abb sterane (20S)	82.13	5599362	5.67
27	a	C_{29} aaa sterane (20R)	83.88	4967428	5.03
28	b	C_{30} aaa sterane (20S)	84.14	1364231	1.38
29	c	C_{30} abb sterane (20R)	85.14	2039095	2.06
30	d	C_{30} abb sterane (20S)	85.46	532086	0.54
31	e	C_{30} aaa sterane (20R)	87.36	1157412	1.17

Alaska Outcrops
96 MAW 11
DGSI Project: 97/3959



Alaska Outcrops
96 MAW 11
DGSI Project: 97/3959




900
800
700
600
500
400
300
200
100
HYDROGEN INDEX (HI)
50
100
150
OXYGEN INDEX (OI)
I
II
III
IV
Aptian - Albian strata
Pebble Shale - Hauterivian
Kingak Shale - Jurassic to Neocomian
Shublic & Otuk Formation - Upper Triassic
94Mu72-1
96Mu35-2
93Mu 80-1
96 Mu 52-1
96 Mu 33-5
96 Mu 46
96 MAW 7
96 MAW 11
96 MAW 9
96 Mu 57-4
96 Mu 33-1
96 Mu 33-7
93 Mu 80-1A