Amplified Geochemical Imaging, LLC

SUMMARY REPORT

Applied Petroleum Technology Canada, Ltd.
Slick Samples
Geochemical Evaluation

Order No. 01410.2

9th September 2016

Prepared For:

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Canada

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Introduction

Applied Petroleum Technology of Canada (APTEC) has collected four (4) surface slick samples using the AGI Slick kit and slick samples in the Canadian waters offshore Nova Scotia. A brief description of the AGI slick sampling applications and advantages is attached within Appendix C.

The samples were collected from a vessel, and the location of the samples is shown on Figure 1. Samples were then returned to the AGI laboratory in Newark, DE for subsequent analysis. Appendix A shows the field log provided by APTEC for the samples returned as part of this program.

This summary report will document the field sampling as well as the analytical procedures that were used to evaluate the samples. Preliminary conclusions are presented along with the actual mass data table providing some context and comparison between the available samples.

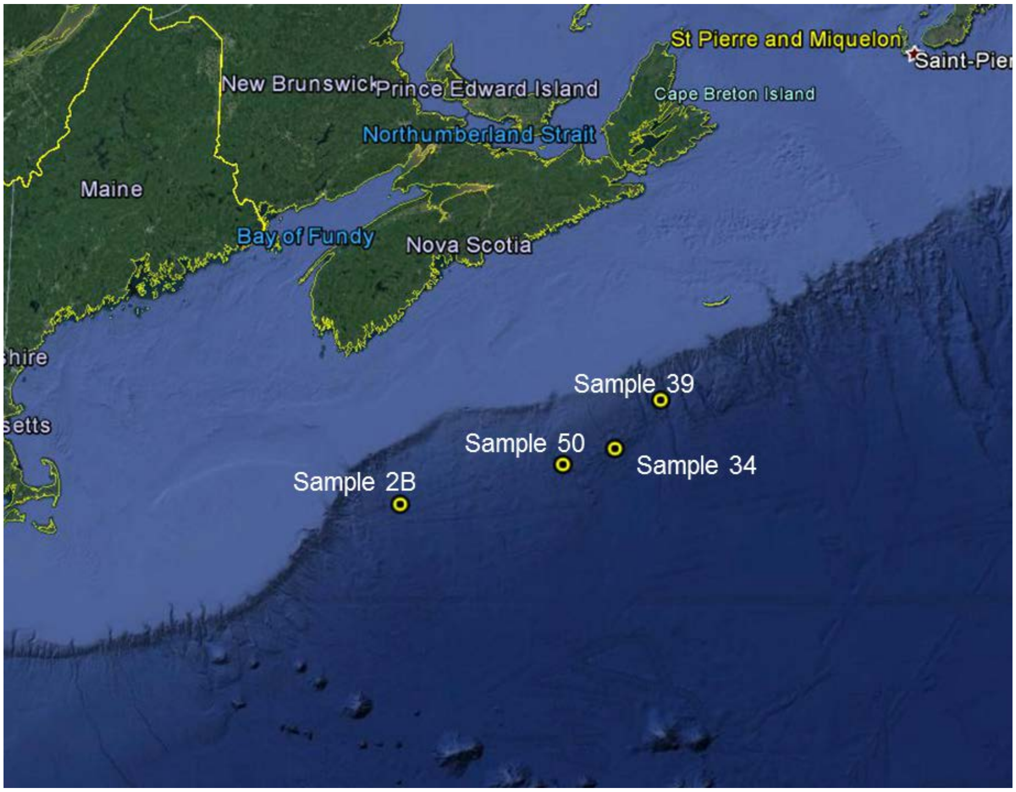

Figure 1: Location Map showing the sample locations.

Background image courtesy of Google Earth.

Field Conditions

Although no vessel information or date/time of sample collection was noted on the field log, it is worth pointing out that the following comments were noted at each of these locations:

Sample 2B: “calm conds, large sparse bubbles, sampling during coring, prob pollen”

Sample 34: “1-2m swell, minor cresting, mud on outside core barrel had oily appearance, taken during coring”

Sample 39: “calm seas, no swell, taken during core retrieval”

Sample 50: “calm seas, oil sheen during core retrieval”

Sample Analysis

The samples arrived at the AGI laboratory on July 11, 2016 in satisfactory condition. These were then scanned as part of the AGI LIM (laboratory information management) system, and prepared for analysis.

The analytical process for each sample involves thermal desorption followed by gas chromatographic separation and mass selective detection (GC/MS), in two operating modes. One mode allows for the quantitation of compounds using reference standards, and the other qualifies biomarker compounds based on a reference oil. This combined method has been developed specifically for the AGI Slick sampler. Analytical QA/QC includes analysis of method and instrument blanks as well. The complete compound list is shown in Appendix E, and the data are included in Appendix B.

The data were analyzed and processed without any significant issues, and the data quality passes all QA/QC measures established for this methodology.

Results and Discussion

The data developed from these samples is available digitally under Appendix B. Data have been processed in order to evaluate any indications of petroleum source and maturity. Figure 2 shows a graphic chart of each sample in terms of the n-alkane response, and this figure includes the compounds pristane and phytane. This response is low to moderate in our experience, and may indicate a weathered petroleum source.

The total ion chromatogram for each of the four samples is shown in Figure 3, and this also suggests a weathered petroleum source as evidenced by the unresolved complex mixture (UCM or hump) between approximately 7 and 20 minutes, which is particularly noticeable in sample 50; see the red rectangle on Figure 3. This is also present in samples 39 and 34 to a lesser extent. The relatively smooth surface of this hump suggests a highly weathered sample.

However, there may also be an earlier UCM, particularly in sample 39, which elutes between 4 and 6 minutes approximately; see the blue rectangle on Figure 3. The peaks within this window appear to reflect a more “fresh” sample that is not as weathered as the late-eluting peak.

The biomarker analysis indicates that sample 2016011-50 contains a relative abundance of biomarkers at levels that are above our detection limit. Consequently, these data can be used to provide evidence of the source origin and maturity. Figure 4 (as an example) shows a ternary plot of the distribution of sterane isomers, which suggests that this is likely to be derived from an open marine source comparable to the Hekkingen Formation (Upper Jurassic age) of the Norwegian Barents Sea.

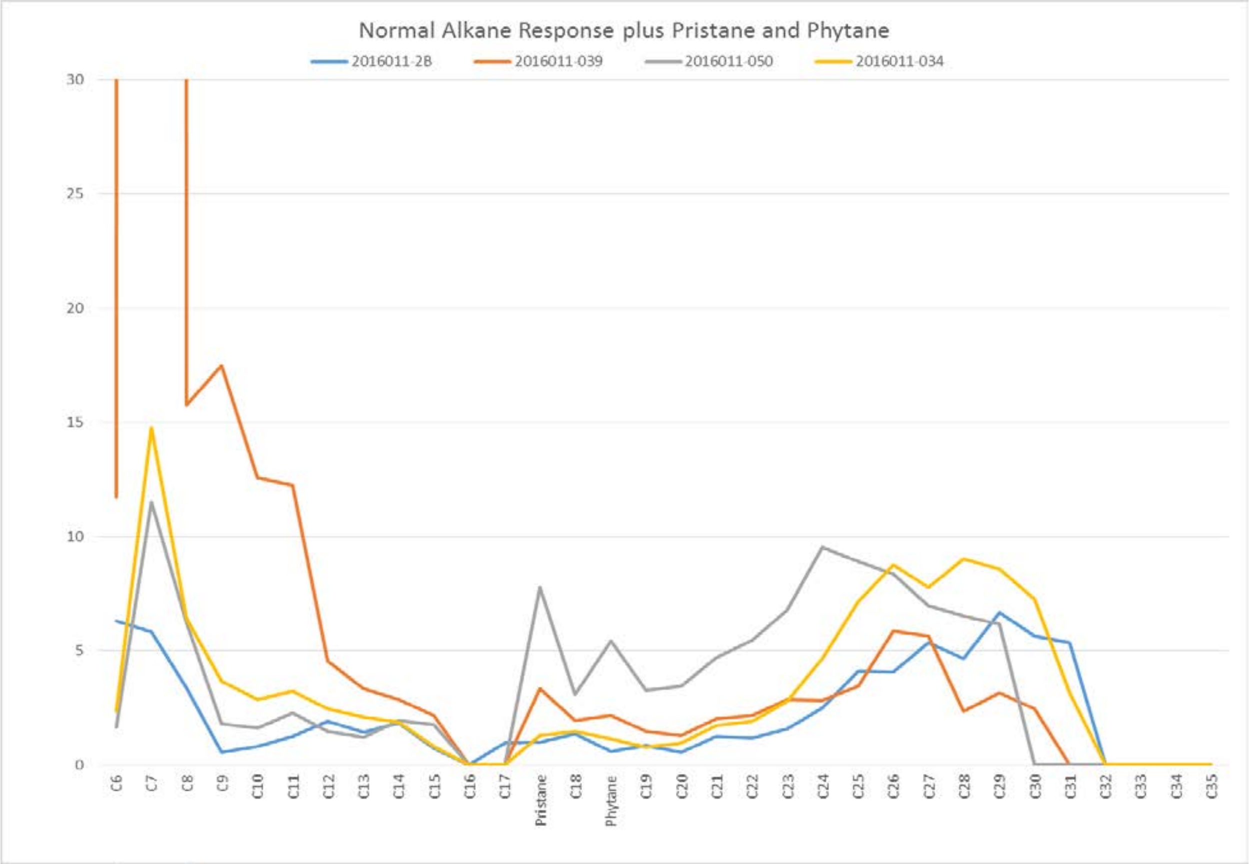

Figure 2: Normal alkane compounds (plus pristane and phytane).

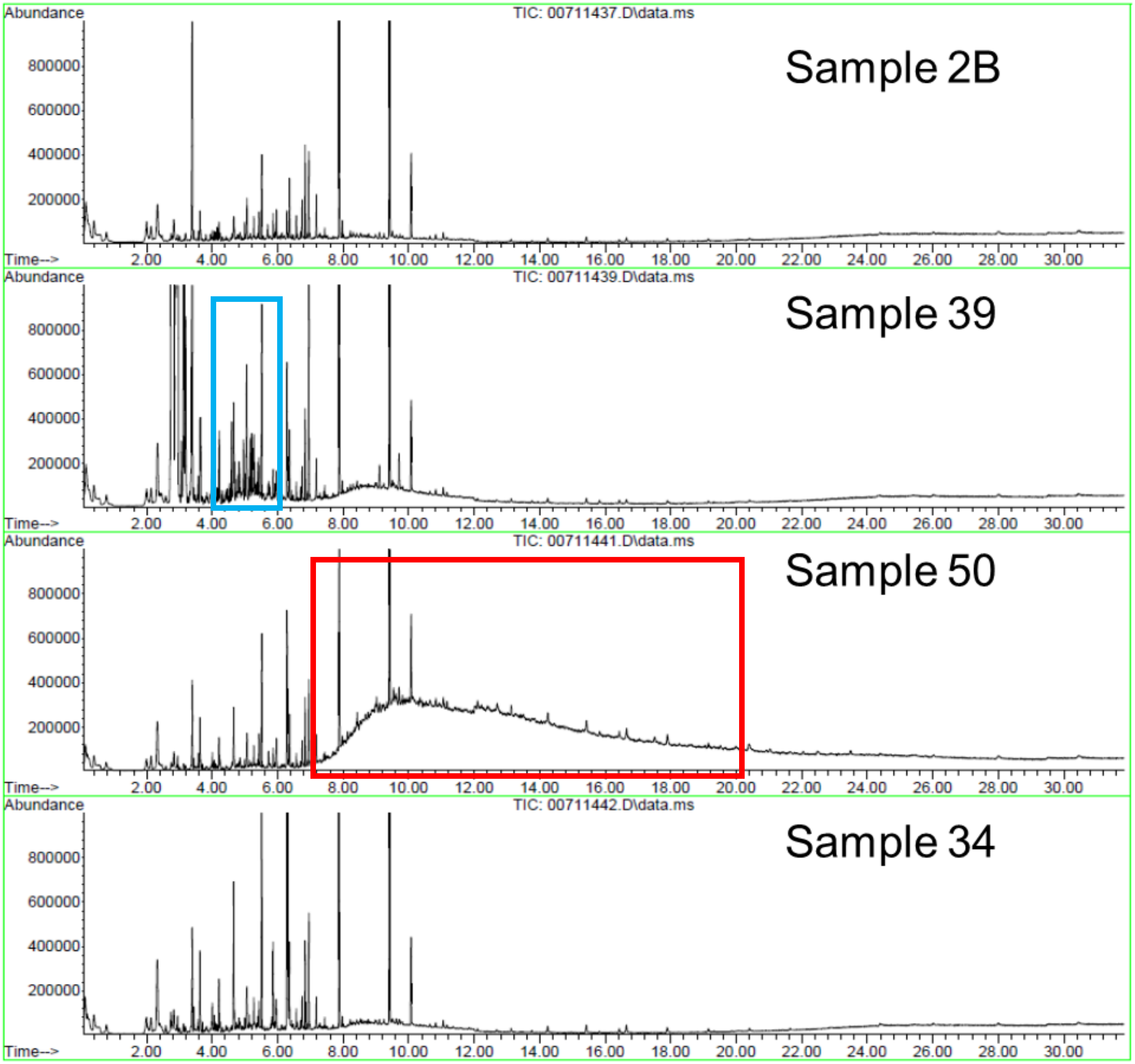

Figure 3: Total Ion Chromatograms for each of the samples. These charts are also included in Appendix B.

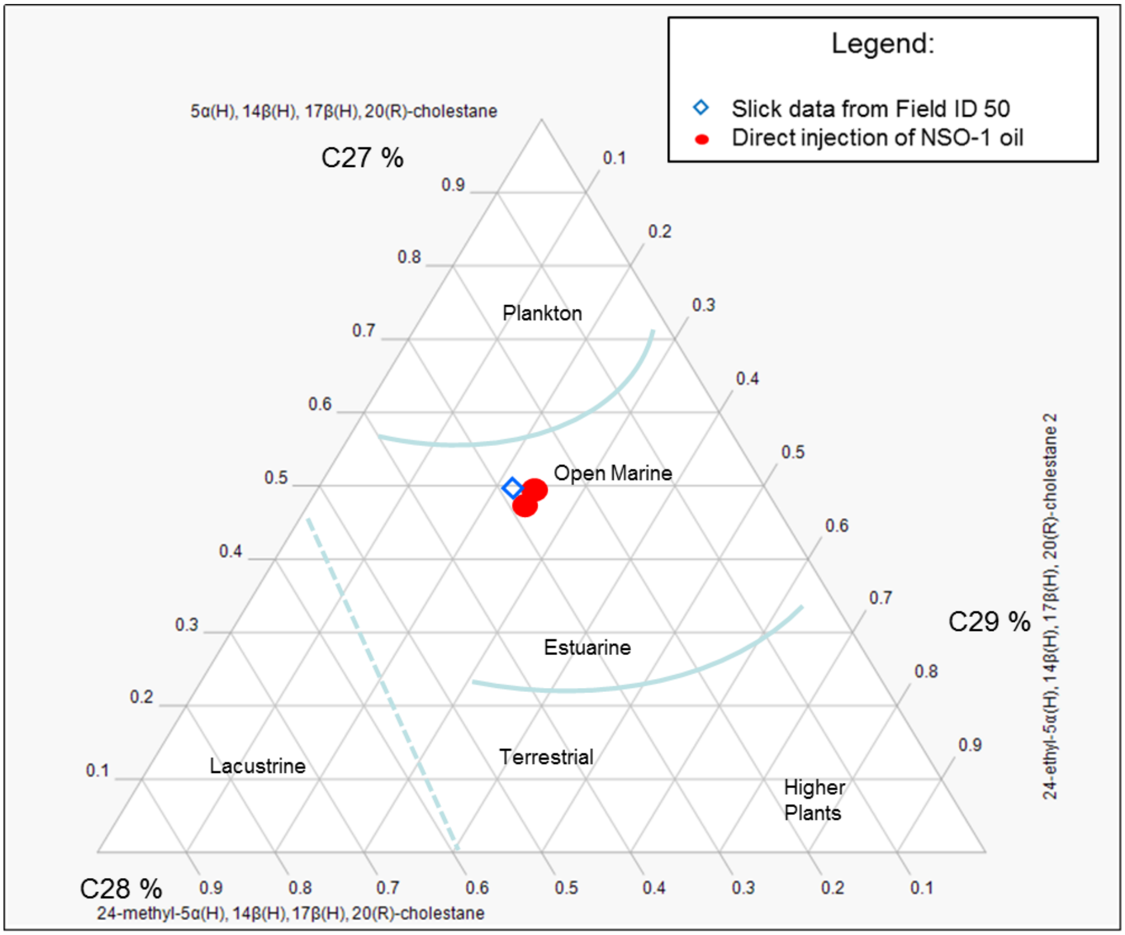

Figure 4: Modified from Shanmugam (1985), the distribution of sterane isomers shows that the slick sample is consistent with an open marine source, which is also represented by the NSO-1 oil from the Hekkingen Formation of the Upper Jurassic age in the Norwegian Barents Sea.

Conclusions

The results of initial testing the slick samples that were obtained as part of this study appear to reflect a highly weathered petroleum source, and the volume of mass from that analysis appeared to be sufficient to further evaluate the samples for biomarkers. The biomarker data from 3 of the samples was insufficient to allow any processing. However the biomarker data from one sample (711441 – Field ID 50) was sufficiently above the noise level, and can provide insight into the possible age and origin of the source material. The sterane ternary plot derived from the biomarkers suggests an open marine source.

Questions regarding this report, or any of the data processing techniques used by AGI in the evaluation of its geochemical data, may be directed to the author of this report at the following address:

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Phone: +1-302-266-2428

Comments and discussion regarding this geochemical service are welcome and encouraged.

APPENDIX A

Field Documentation

Name	Lat	Long	Water Depth (m)	Sample Type	Reasons/Notes
2016011-2B	41°43.77858	64°46.93586	2533	Slick	calm conds, large sparse bubbles, samplng during coring, prob pollen
2016011-034	42°19.8797	61°33.7894	3220	Slick	1-2m swell, minor cresting, mud on outside core barrel had oily appearance, taken during coring
2016011-039	42°52.1792	60°50.3057	2256	Slick	calm seas, no swell, taken during core retrieval
2016011-050	42°09.9726	62°21.1720	2721	Slick	calm seas, oil sheen during core retrieval

APPENDIX B

Digital Data

Data Table for APTEC.xlsx

Total Ion Chromatograms

TIC-1410-2-scan.pdf

TIC-1410-2-SIM.pdf

APPENDIX C

Description of Service

The AGI Slick Sampling service is an advanced and unique surface geochemical prospecting tool capable of directly detecting and quantifying many petroleum related organic compounds in the range of C6 (hexane) to C35 (pentatriacontane) and well as the higher molecular weight biomarkers and related compounds.

When properly utilized, the AGI Slick sampling service can help to locate and characterize/ differentiate thermogenic hydrocarbons found at the sea surface, and provide the basis for determining the possible source of these hydrocarbons. The combined use of AGI low molecular weight (LMW) biomarker analysis, biomarker analysis (stable isotope ratio determination) and interpretation provides a powerful exploration tool.

These techniques in conjunction with other conventional techniques such as basin modeling within the geological framework can greatly assist in exploration as well as mature E&P activities.

Quality Control

As part of the normal quality control measures for this methodology, AGI will process blank samples (method blanks and instrument blanks) along with standards in order to evaluate the instrument precision and reproducibility. Method and Instrument blanks establish the background level of noise for each analytical run, and may be used to blank-subtract the mass levels detected on the field samples. Instrument tuning is accomplished daily by using standard injections of 1-bromo-4-fluorobenzene (BFB).

Biomarker Analysis involved standard preparations of the North Sea Oil-1 (provided as an industry standard oil by the Norwegian Petroleum Directorate), which are used to establish performance criteria for the AGI instruments. The response factors for each of the standards processed with the field samples are compared visually against the analytical method standard response in order to identify the biomarker compounds. Any positive detections are quantified based on the standard response, and are reported in terms of peak area.

Aliphatic response (normal alkanes between C6 and C35 plus isoprenoids pristane and phytane) is calibrated using a response factor, which is generated from the average response of standards included in each analytical run. Each compound is reported in terms of nanograms of mass (ng) from each sample.

APPENDIX D

Suggested Instructions for use of the AGI Slick Sampler

Data recording

Once you have spotted a slick or area for sampling, log information on a field log, including:

- Latitude & Longitude by GPS
- Date and time
- Surface weather conditions (wind, speed, direction, wave heights)
- Physical description of the slick including the presence of bubbles rising and breaking the surface. Digital photo of slick if possible
- Serial number of the slick sampler used

Fishing rod

- Using the portable fishing rod that comes with each kit, simply fold up the white rod tip and secure the sampler as described below.

Attaching sampler to fishing line

- Put on a new, clean pair of nitrile gloves (provided with kit).
- Remove the sampler from the jar. <u>Do not touch the unprotected functional tail with your bare hands or any other materials.</u>
- Tie the light weight fishing line through the loop or make a loop in the line and pass it through the sampler loop and over the end of the sampler for attachment. Now the sampler will be on the terminal end of the line.
- Attach a neutrally buoyant bobber/weight to the fishing line about 2 feet (50-60 cm) from the sampler (between the sampler and the casting rod). Press each end of the bobber to expose spring-loaded hooks, catch the line and release to secure.

Casting and Sampling

- The boat’s bow wave can push the slick away from the boat, so it is best to cut speed and coast near or to the side of the slick from the downwind side.
- Cast the sampler onto the slick.
- Reel in the sampler very slowly allowing at least two minutes for it to contact the slick.
- Place the sampler into the jar and cut it from the fishing line. Cap the jar tightly being careful not to catch the sampler under the threads of the cap. Place back in box for shipment back to AGI.
- Consider sampling multiple spots in a slick, particularly if the slick has a heterogeneous appearance; i.e., gray sheen, rainbow sheen or blobs that look like lily pads.
- In a general sampler area or excursion, some people will sample an area void of slicks to create a background blank used to compare with the slick results.

Decontamination

- Cut off and discard neutrally buoyant bobber/weight and fishing line that may have contacted the slick.
- Throw away used nitrile gloves.

Returning used samplers

- When preparing your customs paperwork, be sure to use the same description contained on the customs paperwork used by AGI for shipping to you. <u>DO NOT describe as “oil samples”.</u>
- They may be shipped at ambient temperatures but don’t allow prolonged exposure to the sun, which could degrade the sample.
- Please notify AGI of shipment details.

APPENDIX E

List of Compounds

The following list of compounds are quantified in mass units (ng) using standards introduced during the analysis. All standards analyzed during the sequence contain all of the compounds listed below.

Normal Alkanes

Hexane	C_6	Heneiconsane	C_{21}
Heptane	C_7	Docosane	C_{22}
Octane	C_8	Tricosane	C_{23}
Nonane	C_9	Tetracosane	C_{24}
Decane	C_{10}	Pentacosane	C_{25}
Undecane	C_{11}	Hexacosane	C_{26}
Dodecane	C_{12}	Heptacosane	C_{27}
Tridecane	C_{13}	Octacosane	C_{28}
Tetradecane	C_{14}	Nonacosane	C_{29}
Pentadecane	C_{15}	Triacontane	C_{30}
Hexadecane	C_{16}	Hentriacontane	C_{31}
Heptadecane	C_{17}	Dotriacontane	C_{32}
Octadecane	C_{18}	Tritriacontane	C_{33}
Nonadecane	C_{19}	Tetratriacontane	C_{34}
Eicosane	C_{20}	Pentatriacontane	C_{35}

Isoprenoids

Pristane	C_{19}
Phytane	C_{20}

The following biomarkers are qualified using the NSO-1§ standard for positive identification. These compounds are reported in area count units based on the retention time of these compounds in the NSO-1 standard.

Report Row	Compound Name	Code	Fragment
1	$C_{23}H_{42}$ tricyclic terpane	23/3	191 area
2	$C_{24}H_{44}$ tricyclic terpane	24/3	191 area
3	$C_{25}H_{46}$ tricyclic terpane	25/3	191 area
4	$C_{24}H_{42}$ tetracyclic terpane	24/4	191 area
5	18α(H)-22,29,30-trisnorneohopane	27Ts	191 area
6	17α(H)-22,29,30-trisnorhopane	27Tm	191 area
7	17α(H), 21β(H)-28,30-bisnorhopane	28ab	191 area
8	17α(H), 21β(H)-25-norhopane	25nor30ab	191 area
9	17α(H), 21β(H)-30-norhopane	29ab	191 area
10	18α(H)-30-norneohopane	29Ts	191 area
11	15α-methyl-17α(H)-27-norhopane (diahopane)	30d	191 area
12	17β(H), 21α(H)-30-norhopane (normoretane)	29ba	191 area
13	17α(H), 21β(H)-hopane	30ab	191 area
14	17β(H), 21α(H)-hopane (moretane)	30ba	191 area
15	Gammacerane	30G	191 area
16	17α(H), 21β(H), 22(S)-homohopane	31abS	191 area
17	17α(H), 21β(H), 22(R)-homohopane	31abR	191 area
18	17α(H), 21β(H), 22(S)-bishomohopane	32abS	191 area
19	17α(H), 21β(H), 22(R)-bishomohopane	32abR	191 area
20	17α(H), 21β(H), 22(S)-trishomohopane	33abS	191 area
21	17α(H), 21β(H), 22(R)-trishomohopane	33abR	191 area
22	17α(H), 21β(H), 22(S)-tetrakishomohopane	34abS	191 area
23	17α(H), 21β(H), 22(R)-tetrakishomohopane	34abR	191 area
24	17α(H), 21β(H), 22(S)-pentakishomohopane	35abS	191 area
25	17α(H), 21β(H), 22(R)-pentakishomohopane	35abR	191 area
26	17α(H), 21β(H)-25,28,30-trisnorhopane	25nor28ab	177 area
27	17α(H), 21β(H)-25,30-bisnorhopane	25nor29ab	177 area
28	17α(H), 21β(H)-25-norhopane	25nor30ab	177 area
29	13β(H), 17α(H), 20(S)-cholestane (diasterane)	27dbS	217 area
30	13β(H), 17α(H), 20(R)-cholestane (diasterane)	27dbR	217 area
31	5α(H), 14α(H), 17α(H), 20(S)-cholestane	27aaS	217 area
32	5α(H), 14α(H), 17α(H), 20(R)-cholestane	27aaR	217 area
33	24-ethyl-13β(H), 17α(H), 20(S)-cholestane (diasterane)	29dbS	217 area
34	24-ethyl-13β(H), 17α(H), 20(R)-cholestane (diasterane)	29dbR	217 area

Continued on next page

§ - North Sea Oil-1 sample obtained with Norwegian Institute Guide to Organic Geochemical Analyses (NIGOGA).

*-Based on NIGOGA

Report Row	Compound Name	Code	Fragment
35	24-ethyl-5α(H), 14α(H), 17α(H), 20(S)-cholestane	29aaS	217 area
36	24-ethyl-5α(H), 14β(H), 17β(H), 20(R)-cholestane	29bbR	217 area
37	24-ethyl-5α(H), 14β(H), 17β(H), 20(S)-cholestane	29bbS	217 area
38	24-ethyl-5α(H), 14α(H), 17α(H), 20(R)-cholestane	29aaR	217 area
39	5α(H), 14β(H), 17β(H), 20(R)-cholestane	27bbR	218 area
40	5α(H), 14β(H), 17β(H), 20(S)-cholestane	27bbS	218 area
41	24-methyl-5α(H), 14β(H), 17β(H), 20(R)-cholestane	28bbR	218 area
42	24-methyl-5α(H), 14β(H), 17β(H), 20(S)-cholestane	28bbS	218 area
43	24-ethyl-5α(H), 14β(H), 17β(H), 20(R)-cholestane	29bbR	218 area
44	24-ethyl-5α(H), 14β(H), 17β(H), 20(S)-cholestane	29bbS	218 area
45	24-propyl-5α(H), 14β(H), 17β(H), 20(R)-cholestane	30bbR	218 area
46	24-propyl-5α(H), 14β(H), 17β(H), 20(S)-cholestane	30bbS	218 area
47	Phenanthrene	Phen	178 area
48	3-Methylphenanthrene	3mPhen	192 area
49	2-Methylphenanthrene	2mPhen	192 area
50	9-Methylphenanthrene	9mPhen	192 area
51	1-Methylphenanthrene	1mPhen	192 area
52	C_{21} MA	A1	253 area
53	C_{22} MA	B1	253 area
54	β(S)C_{27} MA & β(S)C_{27} DMA	C1	253 area
55	β(R)C_{27} DMA & β(R)C_{27} MA & α(S)C_{27} MA	D1	253 area
56	β(S)C_{28} MA & α(R)C_{27} DMA & β(S)C_{28} DMA	E1	253 area
57	α(S)C_{27} DMA	F1	253 area
58	α(R)C_{27} MA & α(S)C_{28} MA & β(R)C_{28} MA & β(R)C_{28} DMA & β(S)C_{29} MA & β(S)C_{29} DMA	G1	253 area
59	α(S)C_{29} MA & α(R)C_{28} MA & β(R)C_{29} MA & β(R)C_{29} DMA	H1	253 area
60	α(R)C_{29} MA	I1	253 area
61	C_{20} TA	a1	231 area
62	C_{21} TA	b1	231 area
63	(S)C_{26} TA	c1	231 area
64	(R)C_{26} TA & (S)C_{27} TA	d1	231 area
65	(S)C_{28} TA	e1	231 area
66	(R)C_{27} TA	f1	231 area
67	(R)C_{28} TA	g1	231 area

MA = Monoaromatic Steroid

DMA = Dia monoaromatic Steroid

TA = Triaromatic Steroid

APPENDIX F

References

Shanmugam, G., 1985, Significance of coniferous rain forests and related organic matter in generating commercial quantities of oil, Gippsland Basin, Australia: AAPG Bulletin, v. 69, p. 1241-1254