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GEOCHEMICAL REPORT FOR NORWEGIAN PETROLEUM DIRECTORATE ON SHALLOW BOREHOLES IN NORTHERN BARENTS SEA

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The raw data is provided in digital format (excel tables) for each well. The data tables are numbered as follows:

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Geochemical logs and relevant graphs for each well.

CHAPTER 1

Introduction

1.1 GENERAL DESCRIPTION

This report is based on the analyses of core samples from 8 shallow boreholes from the Barents Sea Figure 1.1.

The scope of work comprises the assessment of source rock potential on approximately 1020 meters of rocks from Carboniferous, Permian and Triassic of the northern Barents Sea.

Approximate total cored thicknesses are as follows:

Triassic: 850 m

Permian: 140 m

Carboniferous: 30 m

1.2 ANALYTICAL PROGRAM

The complete analytical program was to be executed in three work packages (taken from the tender document):

1. A screening phase consisting of 420 TOC and Rock-Eval analyses. Included in this phase are also 75 vitrinite reflectance analyses
2. A follow-up phase of maximum 50 selected samples to be analysed by relevant methods, which can include SAT-ARO-POL-ASPH, 13C isotopic composition of fractions, 13C isotopic composition of kerogen, GC-FID SAT fraction, GC-MS SAT and ARO fractions, pyrolysis-GC, visual Kerogen analyses and kinetic analysis of organic matter.
3. Reporting phase which shall include all results and documentation, with relevant graphical presentations and an interpretation section, to be provided both in electronic pdf-format and in paper.

This report is based on the first phase of screening analyses.

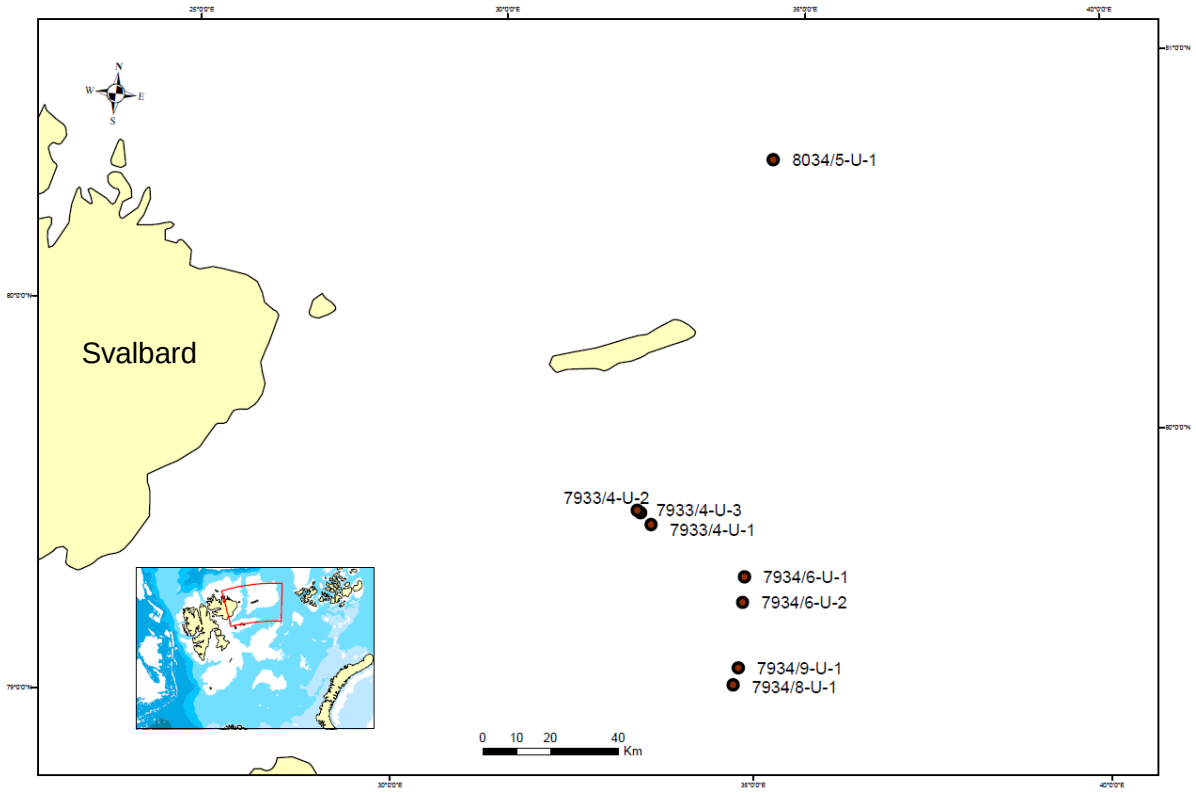

Figure 1.1 Location of the 8 wells

1.3 STRATIGRAPHY

The following depth intervals of the 8 wells were subjected to screening analyses. The analytical method used was that described in the Norwegian Industry Guide to Organic Geochemical Analyses (NIGOGA 4).

Well name	*Interval (m)*	*Interval sampled (m)*	*Number of samples for TOC & RE*	*Number of samples for Vitrinite Reflectance*
8034/5-U-1	14.5 - 52.0	24.2 - 51.2	9	3
7934/6-U-1	3.1 - 182.3	8.0 - 178.1	36	11
7934/6-U-2	8.8 - 200.0	14.5 - 191.9	45	11
7934/8-U-1	12.6 - 196.05	17.8 - 196.0	93	12
7934/9-U-1	5.0 - 164.7	12.0 - 162.6	61	11
7933/4-U-1	6.6 - 134.1	7.5 - 134.0	70	11
7933/4-U-2	3.5 - 14.5	5.0 - 14.5	6	3
7933/4-U-3	7.7 - 196.05	10.7 - 199.4	100	13
Total			420	75

Table 1.1 Analysed intervals for the 8 wells.

CHAPTER 2

Source rock assessment

2.1 SOURCE ROCK PARAMETERS

Source rocks are formed as a result of a combination of biochemical, physical and geological process that produces sedimentary rocks containing carbon and hydrogen-rich organic matter. The amount and type of organic material incorporated into the sediment depend on environmental and depositional conditions.

The evaluation of potential source rocks in the 8 wells is based on the analysis of 420 core samples, distributed along the well profiles. The interval between samples is approximately 2 meters for each sample. Dark shales were the main target in the sampling (when possible) to assure good sample quality in terms of organic rich material.

The total organic carbon (TOC) measurement is one of the main analyses in source rock assessment. This initial carbon is then followed by other screening analyses such as Rock-Eval pyrolysis and vitrinite reflectance to provide information about the type of kerogen in the rock and the maturity level at present day.

TOC indicates the quantity of the organic matter and consequently determine the best samples (high TOC values) for follow up analyses to address quality and maturity. In this project, all the 420 samples were analysed on TOC analysis and the same samples run on Rock-Eval pyrolysis. A total of 75 samples, selected based on TOC values, were submitted for vitrinite reflectance analysis.

Rock-Eval pyrolysis is a technique that has become an industry standard in source rock assessment. The result of this analysis comprises mainly three peaks (S1, S2 and S3). The first peak, S1, corresponds to free oil and gas from the rock samples without cracking the kerogen. This first stage occurs during the heating up to 300ºC. The second peak, S2, corresponds to the hydrocarbons generated from the samples during the heating stage of pyrolysis (temperature > 300ºC). These hydrocarbons result from the cracking of hydrocarbons and from the thermal breakdown of kerogen. The third peak, S3, corresponds to CO_2 that evolves from thermal cracking of kerogen during pyrolysis. Important indices are derived from the three peaks mentioned above and TOC values. The hydrogen index, HI, is derived from the ratio of hydrogen (S2) to TOC. The HI is proportional to the amount of hydrogen contained within the kerogen. High HI indicates greater potential to generate oil (see section 2.2 for interpretation thresholds). The oxygen index, OI, can be calculated from the ratio of CO_2 (S3) to TOC and is related to the amount of oxygen contained in the kerogen. Both HI and OI can be used for determining the kerogen type and maturation.

In addition, other parameters can be derived from Rock-Eval pyrolysis such as the production index (PI) and the petroleum potential (PP). The PI is derived from the relashionship between hydrocarbons generated during the first stage of heating and the second stage of pyrolysis (S1 and S2). The ratio S1/(S1+S2) indicates the evolution of the organic matterwith increasing of maturity. However, anomalous high values of this ratio (>0.6%) can also be due to migrated hydrocarbons. The PP represents the maximum quantity of hydrocarbons generated by a mature source rock. It is defined as the sum of S1 and S2. The PI and PP are useful in tracking kerogen type and maturation.

Finally, the pyrolysis temperature recorded during the maximum generation of hydrocarbons (S2), called T_{max}, is used to determine the thermal maturation that the kerogen has already experienced, giving an insight of the thermal evolution of the organic matter along the well profile. This parameter is usually related to vitrinite reflectance values for evaluating the maturity of source rocks. The vitrinite reflectance is a tool for assessing maturation of organic matter by measuring the reflection of the light on vitrinite maceral. As temperature increases, the vitrinite maceral experiments an irreversible aromatization reaction that increases reflectance.

2.2 INTERPRETATION LIMITS

In order to stablish a standard interpretation for all the wells under examination, the interpretation limits for the source rock parameters are shown below:

For TOC (source rock richness)

TOC %	*Level*
0.0-0.3	Poor
0.3-1.0	Fair
1.0-2.0	Good
2.0-5.0	Rich
>5.0	Very Rich

For Rock Eval pyrolysis (source rock quality)

Ro= 0.5%		*Ro= 0.8-1.0%*		*Interpretation*	
HI	OI	HI	OI	*Kerogen type*	*HC Species*
>700	10-40	200-250	10-20	I	Paraffinic Oil
350-700	20-60	250	10-20	II	Oil
200-350	40-80	100-150	20-40	II/III	Oil/Gas
100-200	50-150	50-150	20-60	III	Gas-condensate, heavy oil
0-100	20-200	<50	20-100	IV	No potential

For Rock Eval pyrolysis T_{max} and Vitrinire Reflectance Ro (source rock maturity)

Vitrinite	*T_{max}*		*Generation*	*Expulsion*
%Ro	II	III		
0.3		425	Immature	
0.4	420			
0.5	430	435	Oil threshold, early mature	Early Condensate (sometimes)
0.6	435	440	Start main oil generation, top oil window	
0.7			Start peak oil generation, gas generation threshold from coal	Start liquid expulsion from rich source rocks
0.7-0.8			Peak oil generation	
0.8	440		End peak oil generation	
0.9	445		Late mature	
0.9-1.0				
1.0	450	460	Base oil window	Start condensate expulsion from lean source rocks
1.1				
1.1-1.2				
1.3			Base condensate window, oil floor	Start gas expulsion
1.5			Peak gas generation coal	
1.5-2.0				
2.0			Wet gas floor	

2.3 RESULTS AND DISCUSSION

The results of the analyses are tabulated in Appendix 1, and provided as digital file in Excel format. The results are sorted by well and presented in separate. Relevant graphs are presented along with the geochemical log based on Rock-Eval parameters for each of individual well in Appendix 2.

The discussion will be presented herein by well, where all the parameters described in section 2.1 will be taken into consideration and correlated to each other. The preliminary formation ages and intervals (provided by NPD) will be mentioned to aid the interpretation.

Well 8034/5-U-1

The well has only a short core lengh (TD=52m) and is characterized by containing mainly carbonate with some dark grey to dark green shale intervals. The carbonates appear to be locally dolomitized.

The TOC values vary from 0.06% to 1.81% i.e., from poor to good source rock potential. However, the TOC average is around 0.4% indicating that the interval overall has fair source rock potential in terms of organic matter.

The Rock-Eval parameters however reveal an overall low source rock potential. The HI and OI indicate mainly Type III/IV kerogen, being only able to generate at best gas. The maturity levels vary from 417-487ºC for T_{max} and 0.54-0.62 %Ro for vitrinite reflectance, indicating early to top oil window.

According to preliminary NPD information, only Permian strata were penetrated in this well.

Well 7934/6-U-1

This well was drilled to a TD of 182.3m. The well comprises shale varying from light grey in the upper part dusky grey in the lower levels, intercalated with siltstone layers. A thick section of sandstone is found in the lower part of the well, between approximately 110 and 174 m approximately. There are also some intervals with coal throughout the core, but more frequent between 23-44 m and 82-96 m.

The TOC values vary from 0.9% to 62.9%. The highest TOC values correspond to coal intervals. All in all, the average of the TOC in this well is around 2% i.e., good source rock potential. The best interval in terms of amount of organic matter is from 83.6 m to 99.8 m having an average of 5% TOC, i.e a rich source rock in terms of organic matter.

The Rock-Eval parameters show good source rock potential between 23.6 m and 99.8 m. This interval is not homogenous, several coal beds are present as mentioned above, however, the coals appear to also have an excellent source rock potential for generating oil and gas as shown in the graphs in Appendix 2. Hydrogen indices vary from 64 to 441 mg HC/g TOC indicating Type II-III kerogen, which corresponds to marine transitional into terrestrial organic matter input. This type of kerogen can generate oil and gas at sufficient maturity. The interval from 83.6 m to 99.8 m appears to be the best source rock interval, containing black shale with an average of 5% TOC and an HI of 300 mg HC/g TOC.

The maturity levels vary from 412 to 440ºC for T_{max} and 0.42-0.58 %Ro for vitrinite reflectance, indicating early to top oil window.

According to the formation tops provided by the NPD, this well appears to have only lithologies of the Upper Triassic De Geerdalen Formation. The depositional environment of

this formation is of a regressive nature with evidence of deltaic influence and fluvial dominance, besides wave- and tidal influence, this resulting in lateral facies variability and different depositional elements (Rød, R.S. et al. 2014). The section from 23.6 to 99.8 m, with the occurrence of coal beds could correspond to deltaic environments. The samples towards the base of this interval (83.6-99.8) may correspond to a facies change into more anoxic conditions favourable to better organic matter preservation. The S2/S3 ratio and the HI show an increase in this interval, indicating a better source rock potential for oil and gas. However, the coals seem to be able to generate liquid hydrocarbons as well, this being indicated by the high values of PP (>30 mgHC/gRock).

Well 7934/6-U-2

This well was drilled to a TD of 200 m, and has similar lithology characteristics to those of well 7934/6-4-2, except for the absence of the thick section of sandstone in the lower part of the well. The well appears to have shales varying from light grey at the top to dusk grey in the bottom, with some intervals in between having dark to dusk black shale. There are also some intervals with thin coal beds throughout the section.

The TOC values vary from 0.5% to 61.4%. The highest TOC values correspond to the coaly intervals. All in all, the TOC values average is around 3%, i.e. rich source rock potential. There are various intervals with TOC values higher than 5% along the well, within these intervals, 78.5 m to 94.0 m appears to be the richest one with an average of 10% TOC. In addition to that, the coals present in this well seem to have a good to excellent organic matter quality to generate oil and gas at mature level source rock, according to the amount of organic matter present.

The Rock-Eval parameters show good source rock potential between the intervals 58.3-142.7 m and 171.6-181.8 m. Coals beds are present in the upper interval indicating more oxidizing depositional conditions at this level compared with the lower interval having good source rock potential. The HI values vary from 53 to 380 mg HC/g TOC, i.e. Type III-II kerogen, with a subtle HI increase towards the lower part of the well, more specifically the second interval described as with high source rock potential. There is, however, one sample at 40.8 m with 6% TOC and an HI of 744 mg HC/g TOC, i.e. suggesting Type I kerogen. This sample could represent a locally more lacustrine environment in this well, where, according to the lithology description, the depositional environment varies from more terrestrial and oxic condition to the top of the well to more marine anoxic environment towards the base. The overall source rock properties in this well are however similar to that in the well 7934/6-U-1.

The maturity levels vary from 417 to 444ºC for T_{max} and 0.33 to 0.49 %Ro for vitrinite reflectance, indicating early oil window.

As in well 7934/6-U-1, the formation penetrated in this well is of the Upper Triassic De Geerdalen Formation. In this case, the interval between 58.3 to 181.8 m seems to correspond to the deltaic section in the well 7934/6-U-1, this having high values of TOC (>3% TOC) and intercalated coal beds. Towards the base of this interval, there occur a number of samples with averages of TOC and HI of 3.7% and 256 mgHC/gTOC, i.e good source rock potential for oil and gas. However, as in well 7934/6-U-1, the section with coal beds also seems to have a good source rock potential.

Well 7934/8-U-1

This well was drilled to a TD of 196 m. The well is predominantly shaly, varying from dark grey shale in the upper to middle part of the well section at ~ 100 m the shales start to change to light to being medium grey, down to the bottom of the well.

The TOC values are about the same throughout the well, averaging 1.2% TOC, i.e. good source rock potential. The best interval is from 90 to 112 m with the TOC value averaging 1.5%.

Hydrogen indices vary from 32 to 292 mg HC/g TOC, indicating Type III-II kerogen. The shale samples from 90 to 112 m show the best interval in the well in terms of kerogen type, this being of Type II/III, i.e. oil and gas prone. The rest of the samples show low potential, having at best kerogen Type III, i.e. gas prone.

The maturity levels vary from 426 to 440^{0}C for T_{max} and 0.47 to 0.54 %Ro for vitrinite reflectance, indicating early to top oil window.

This well was described as having Flatsalen and Geerdalen formations from (15-110m and 110-196 m respectively). The Flatsalen Formation belongs to the Kapp Toscana Group, which comprises shales, siltstones and sandstones of Late Triassic to Middle Jurassic (Bathonian) age in Svalbard and on the Barents Sea Shelf. The Flatsalen Formation is a marine shale unit with upwards coarsening packages, forming an overall coarsening-upwards succession. Open marine facies is dominant, with fossils of marine bivalves and ichthyosaur bones (Mørk et al. 2013). The best source rock interval in this well (90-112 m) may correspond to the marine shale unit of the Flatsalen Formation. However, The Geerdalen Formation in this well does not seem to have any source rock potential. It is important to mention that the Geerdalen Formation seen in this well does not have the deltaic unit (with high TOC values and occurrence of coals) described in the wells 7934/6-U-1 and 7934/6-U-2.

Well 7934/9-U-1

This well was drilled to a TD of 164.7 m. The shale in this well is medium to dark grey in the upper part intercalated with siltstone samples, and dusk black shale for the interval 83.1 to 155.7 m, where it is interbedded with coals, especially towards the bottom of the interval. The underlying dusk shales also have coal levels.

The TOC values vary from 0.5% in shales to 63.9% in the coals. The TOC profile shows two zones; the first from 12 m to 82.1 m with similar good TOC values of around 1.4% TOC. This interval is characterized by dark grey shale and dark grey to green siltstone. In the second zone, the TOC values change dramatically to higher values, up to 60% (due to coals) in some intervals averaging 11% TOC. This second zone is characterized by dusky to dark black shale with coal intervals.

The Rock-Eval parameters show good to excellent source rock potential in the interval 83.1 to 155.7 m. This interval is not homogenous, but contains dusky to black shales with TOC values between 1 and 10% interbedded with coals. In terms of kerogen type, the HI varies from 50 to 252 mgHC/gTOC, i.e. up to Type II/III kerogen corresponding to being oil and gas prone. As in well 7934/6-U-1 and 7934/6-U-2, the coals also seem to have a good source rock potential for generating oil and gas. Within this interval, there is a single sample at 127 m with 2.3%TOC and an HI of 732 mgHC/gTOC, i.e. indicating Type I kerogen, which could correlate with the level in the well 7934/6-U-2 at 40.8 m having a Type I kerogen.

The maturity levels in the well vary from 417 to 444^{0}C for T_{max} and 0.33 to 0.49 %Ro for vitrinite reflectance, indicating early to top oil window.

This well has penetrated only the Upper Triassic De Geerdalen Formation (according to the NPD information). The deltaic unit described above and with high TOC (>3% TOC) and intercalated with coal beds is seen between 93.1 and 141.6 m. This section seems to have the same source rock potential as described in the wells 7934/6-U-1 and 7934/6-U-2, this being favourable for generating oil and gas.

Well 7933/4-U-1

This well was drilled to a TD of 134.1 m. The well comprises mainly dark to black shale i.e, different to the shales in the quadrant 7934 wells regarding the type of organic matter, this being more marine anoxic in this well compared to more terrestrial in the quadrant 7934 wells. The black shales are calcareous (occasionally with fossils) from 64 m to 128 m, indicating more shelf-associated depositional conditions.

The TOC values vary from 0.54% to 11.2% with an average of 3.3% TOC, i.e. rich levels of organic carbon. Generally, there are two main intervals with TOC values higher than 3%TOC; the first interval represented by two samples at 54.6 and 56.5 m, the second interval with rich level of organic matter being from 74.7 to 134 m.

The Rock-Eval parameters show very good to excellent source rock potential in the two intervals mentioned above. The HI values for these intervals range from 358 to 630 mgHC/gTOC, i.e. Type II oil prone kerogen.

The maturity levels in the well vary from 431 to 446^{0}C for T_{max} and 0.41 to 0.54 %Ro for vitrinite reflectance, indicating early to top oil window for Type II kerogen.

This well contains the Tschermakfjellet and Botneheia formations (according to the NPD information). The Tschermakfjellet Formation is present between 7 and 75 m, whereas the lower part of the well belongs to the Botneheia Formation. The Tschermakfjellet Formation consists of dark grey shales with upward increasing intercalated siltstone laminae and a corresponding decrease in siderite nodules (Mørk et al. 1982). Fossiliferous beds with ammonoids, bivalves, gastropods and brachiopods occur in eastern areas (Korčinskaja 1982; Dagys et al. 1993). On the other hand, the Middle Triassic Botneheia Formation comprises an organic carbon−rich, fine−grained clastic succession (up to 100 m thick) that makes the best petroleum source unit in the region (Svalbard). The Botneheia Formation records a second order transgressive−regressive cycle in the Triassic succession of Svalbard that was developed in an open shelf environment. It embraces two superimposed, third order transgressive pulses followed by stepwise regression (Krajewski, 2008). In this well, two intervals of good potential source rock were identified; one at 54.6-56.5 m which corresponds to the Tschermakfjellet Formation and a thicker interval from 74.7 to TD which corresponds to the Botneheia Formation. Both intervals having Type II kerogen, i.e. oil prone, and with TOC values averaging 5 %TOC.

Well 7933/4-U-2

This well was drilled to a of TD 15.5 m. The well section is short, being analysed by only 6 samples. The shales analysed are medium to dark grey and the TOC values are similar for all, averaging 1.4%TOC, i.e. a good level of organic carbon.

The Rock-Eval parameters show very good source rock potential, with HI values ranging from 352 to 410 mgHC/gTOC indicating a Type II kerogen, i.e oil prone. This well seems to have the same marine characteristic as those in well 7933/4-U-1.

The maturity levels in the well vary from 436 to 438^{0}C for T_{max} and 0.42 to 0.49 %Ro for vitrinite reflectance, indicating early to top oil window for Type II kerogen.

This well is considered to have penetrated a (?Lower)Triassic sequence according to preliminary information. The shale samples analysed indicate a good source rock with Type II kerogen as in well 7933/4-U-1.

Well 7933/4-U-3

This well was drilled to a TD of 199.5 m. The well comprises shales from the upper part down to 89.6 m depth that vary from dark grey to dark black shale to the bottom of this interval. The lower section from 90 m to TD comprises carbonate rocks that become dolomitic, especially from 142.7 to 162.7 m.

The TOC values vary from 0.02% to 3.32%, with the lower section of the well, dominated by carbonates rocks, having the lowest TOC values. On the contrary, the upper section specifically from 12.6 to 45.6 m, has consistent values of around 1.22% TOC, indicating a good level of organic carbon.

The Rock-Eval parameters show a good source rocks potential in the upper part of the well, from 12.6 to 39.5 m, having an HI of around 287 mgH/gTOC. This value corresponds to Type II/III kerogen, i.e. oil and gas prone. Apart from this, there are 4 samples from the lower section with good values of TOC, albeit mediocre HI, such as 79.7 m (TOC= 3.32%; HI= 246mgHC/gTOC), and the interval from 167.2-171.6 m (average TOC=1.8%; average HI= 147mgHC/gTOC), however, these restricted intervals cannot be considered as source rocks of any significance.

The T_{max} measured in this well varies significantly, this being especially in the carbonate section (91.6-199.4 m), where the variation of the T_{max} seems to be affected by the low amount of S2, making the T_{max} measure unreliable. On the contrary, the shale section from 10.7 to 89.6 m shows a more normal T_{max} trend which varies from 436 to 449^{0}C, i.e. top to late mature oil window. Likewise, the vitrinite reflectance values range from 0.53 to 0.70 %Ro indicating early to peak oil window. The subtle discrepancy in the maturity level in this well can be attributed to the low amount of S2 even in the shale section, making the T_{max} values higher than they should be. For that reason, the vitrinite reflectance seems to be more reliable than the T_{max} in this case, and is therefore given greater credence.

This well has penetrated Triassic, Permian and Carboniferous formations. The Triassic formation penetrated was Vikinghøgda Formation. The formation consists of three members: the Deltadalen Member (composed of mudstones with sandstones and siltstones), the Lusitaniadalen Member (dominated by mudstones with thin siltstone beds and some limestone concretions) and the Vendomdalen Member (composed of dark shales with dolomite interbeds and nodules). The section analysed (12.6-39.5 m), corresponding to the Vikinghøgda Formation, shows the best source rock potential in the well, having a Type II/III kerogen favourable for generating oil and gas. The Permian formations penetrated in this well (Kapp Starostin and Ørn formations) interval (41- 169.7 m) have TOC values of around 0.4% TOC and HI around 70 mgHC/gTOC, indicating a low source rock potential. Likewise, the Carboniferous sequence shows no source rock potential in this well.

CHAPTER 3

Conclusions

3.1 SOURCE ROCK POTENTIAL

The present study was focused on the assessment of possible source rocks from Triassic, Permian and Carboniferous formations found in stratigraphic wells located east of Svalbard drilled by the NPD.

The best source rock potential was found in the Middle Triassic Botneheia Formation (well 7933/4-U-1), characterized by marine black shale, having around 5 %TOC and HI around 500 mgHC/gTOC, i.e Type II kerogen favourable for oil generation. The Vikinghøgda Formation (Early Triassic) in well 7933/4-U-3, has around 1.2 %TOC and HI around 300 mgHC/gTOC, i.e Type II/III kerogen, favourable for mixed oil and gas generation.

The sequences of Late Triassic age found in wells 7933/4-U-1, 7934/6-U-1, 7934/6-U-2, 7934/9-U-1 and 7934/8-U-1 are variable, going from marine shale in the Tschermakfjellet Formation, through a deltaic environment in the De Geerdalen Formation, to marine shale in the Flatsalen Formation. The Tschermakfjellet Fm. (well 7933/4-U-1) has a good potential for oil and gas towards the base of the formation, and a small interval (54-57 m) with Type II kerogen, similar to the kerogen type in the Botneheia Formation. In contrast, the sequence in the De Geerdalen Formation shows a more terrestrial input varying from grey shale to coal. There is a consistent interval with dark shales and coal beds in wells 7934/9-U-1, 7934/6-U-2 and 7934/6-U-1 with good potential, with HI ranging from 150 to 250 mgHC/gTOC, i.e. Type III to Type II/III kerogen. Interestingly, the coal beds seem to have a good potential for oil and gas generation. Likewise, the Flatsalen Fm. present in well 7934/8-U-1, has a good source rock interval from 91.9 to 112 m, having TOC values around 1.5 %TOC and an HI of around 200 mg/gTOC, this being an indicative of Type II/III kerogen, i.e. oil and gas generation.

The Permian and Carboniferous successions, in wells 8034/-U-1 and 7933/4-U-3, show poor source rock quality. There are only some samples, one at 79.7 m (Permian) and from 167.2-171.6 m (Carboniferous) in the well 7933/4-U-3 with TOC values up to 3% and HI ranging from 130 to 250 mgHC/gTOC, however, the limited samples with these characteristics make these successions less likely to be considered as good source rocks in this area.

3.2 THERMAL MATURITY

The thermal maturity was evaluated in the wells using T_{max} and vitrinite reflectance. The results indicate an overall maturity level ranging from early to top oil window for the Triassic successions in the wells located to the south of well 8034/5-U-1. The Permian and Carboniferous formations in well 7933/4-U-3 and 8034/5-U-1 seem to have a subtly higher maturity, up to 0.7 %Ro, associated with peak oil window. From these results it is inferred that the good potential source rocks in the area, especially those of Middle Triassic age, are at least in the main stage of oil generation.

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Abbreviations

List of abbreviations used for lithology description

(sorted alphabetically)

ang	= angular
bar	= Barite (mud additive)
bit	= bituminous
bl	= blue/blueish
blk	= black
br	= brittle
brn	= brown/brownish
Ca	= Carbonate (limestone/chalk/dolomite/siderite)
calc	= calcareous
carb	= carbonaceous
cem	= cement used as additive (under "cont") or to describe cemented S/Sst
chert	= chert
chk	= chalk/chalky
cly	= clayey/shaly
cngl	= conglomeratic
Coal	= Coal
Coal-ad	= Coal-like additive (e.g. chromlignosulfonate)
Congl	= Conglomerate
Cont	= Contamination(s)
crs	= coarse grained
dd	= dried drilling mud
dol	= Dolomite/dolomitic
drk	= dark (colour)
dsk	= dusk/dusky (colour)
evap	= Salt/Gypsum/Halite (natural "Other" or as additive "Cont")
f	= fine grained
fe	= ferruginous
fib	= fibres (mud additive/contamination)
fis	= fissile
fos	= fossiliferous
glauc	= glauconite/glauconitic
gn	= green/greenish
gy	= grey/greyish
hd	= hard
ign	= Igneous (material derived from igneous source)
Kaolin	= Kaolin(ite)
kln	= kaolinitic
l	= loose
lam	= laminated/laminae
lt	= light (colour)
m	= medium (colour or grain size)
Marl	= Marl (calcareous claystone/mudstone)
mic	= micaceous
Mica-ad	= Mica used as mud additive
mrl	= marly
No Mat.	= No material left over after washing

ns	= nutshells (mud additive)
ol	= olive
ool	= Oolite/oolitic
or	= orange
Other	= Other lithology/mineral, specified after this word
pi	= pink/pinkish
pl	= pale (colour)
prp	= paint/rust/plastic contaminations/additives
pu	= purple
pyr	= Pyrite/pyritic
red	= red/reddish
rnd	= round/rounded
s	= sandy
sft	= soft
S/Sst	= Sand and/or sandstone
Sh/Clst	= Shale and/or claystone
sid	= Siderite/sideritic
sil	= siliceous/cherty
slt	= silty
Sltst	= siltstone
st	= stained (with natural oil or oil-like additive)
tar-ad	= Tar-like additive (e.g. "Black Magic")
trbfgs	= turbodrilled fragments
Tuff	= Tuff
tuff	= tuffaceous
v col	= various colours
w	= white
wx	= waxy
y	= yellow/yellowish

General

HC	=	Hydrocarbons
HI	=	Hydrogen Index (100 x S2/TOC)
OI	=	Oxygen Index (100 x S3/TOC)
PI	=	Production Index (S1/(S1+S2))
PP	=	Petroleum Potential (S1+S2)
Ro (%)	=	Measured Vitrinite Reflectance in Percent
Rock-Eval	=	Oil show and source rock evaluation instrument
S1	=	Amount of Free Hydrocarbons, Rock-Eval
S2	=	Amount of Kerogen pyrolysate, Rock-Eval
S3	=	Amount of Oxidised Organic Material
SCI	=	Spore Colour Index (maturity indicator)
TCD	=	Thermal Conductivity Detector
TAI	=	Thermal Alteration Index (maturity indicator)
Tmax	=	Temperature of maximum pyrolysate yield, Rock-Eval
TOC	=	Total Organic Carbon