KB = 25 m
Vanndyp = 261 m
RKB havbunn = 286 m

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REPORT TITLE

MATURATION STUDY USING VITRINITE REFLECTANCE, WELL 6507/12-2 OFFSHORE MID-NORWAY

Report No. 22/82

SUMMARY

The maturity of well 6507/12-2 has been evaluated using vitrinite reflectance. The conclusions are:

The increase in vitrinite reflectance with depth is very steep and continuous reaching the top of the immature transitional zone (Ro = 0.35) at 2250 m (Jurassic Coal Unit), the early mature zone (Ro = 0.55) at 3350 m (Triassic) and the top of the zone of peak hydrocarbongeneration (Ro = 0.7) at 4250 m (Triassic).

KEY WORDS

1. ....
2. ....
3. ....
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MATURITY STUDY USING VITRINITE REFLECTANCE, WELL 6507/12-2

This account describes the results from a maturity study, using vitrinite reflectance, undertaken on well 6507/12-2. The study is carried out on sidewall cores, and hand-picked lithologies on the well-site (the well site geologists have searched for lithologies particularly suited for this type of analysis). This sampling procedure has been successfull yielding material of favourable quality for vitrinite reflectance analysis.

Maturity profile

A vitrinite reflectance versus depth profile is presented in Figure 1. Further sample details are listed in Table 2 and Enclosure 1, and some characteristic maturity features are listed in Table 1.

Koch (1974) mentioned that to draw a fully reliable vitrinite reflectance versus depth gradient, which should be the goal of every maturity study using vitrinite reflectance, it is preferential to have at least two reliable data points every 100 m. The data coverage presented in this report does not fulfill this demand. This is due to unfavourable lithologies especially in the Triassic where considerable parts of the section are barren of reliable vitrinite particles. This should be kept in mind when the reliability of the maturity gradient is considered. The average curve drawn through the profile is weighted against the good quality data. The spreading of the data, particularly at shallow depths, is due to considerable natural spreading of vitrinite reflectance for values less than Ro = 0.3 (Heroux et al, 1979).

Extrapolation of the average curve to the sea bed indicates a hypothetical minimum value of Ro = 0.20 which is suggested by Dow (1977) to be the absolute minimum value close to the surface.

The vitrinite reflectance increases continuously and steeply with depth reaching the top of the immature transitional zone (Ro = 0.35) with possibilities for some early wet gas generation (Heroux et al, 1979; Leythaeuser et al, 1979; Connan and Cassou, 1980) at approximately 2250 m (Coal Unit, Jurassic), the early mature zone (Ro = 0.55) at 3350 m (Triassic), and the top of the peak generation zone (Ro = 0.70) (Hood et al, 1975) at 4250 m (Triassic). The lower end of the peak generation zone (Ro = 1.0) is not reached in this well (TD = 5000m). The Coal Unit shows up a vitrinite reflectance of Ro = 0.36 - 0.47 implying that it has to be ranked as lignite to sub-bituminous in coal terminology.

METHODICAL ASPECTS

General

The vitrinite reflectance method has proven to be an indispensable tool in organic geochemical studies, and particularly in source rock studies for the assessment of the hydrocarbon maturation potential. The method has also proven to be a useful tool in solving certain geological problems related to geothermal effects. It is when properly interpreted probably the best maturity indicator available today: it is discriminatory; measurements are carried out by photometry providing objective, accurate and highly reproducible data; it is useful over a very wide range of maturation and is particularly useful in the maturation range of interest in exploration for hydrocarbons; it is applicable to most sedimentary rock types; it has largely been standardized for the last 20 years, correlated with physical and chemical parameters of coals and hydrocarbon generation in source rocks, and thoroughly tested on an international scale to provide a high degree of accuracy and reproducibility. The method and various aspects have been described by McCartney and Ergun (1958, 1967), Kötter (1960), Murchison (1964), De Vries and Bokhoven (1968) and Teichmüller (1971). Various aspects of the application of vitrinite reflectance to vitrinitic material finely disseminated in clastic sediments have been thoroughly treated by Bostick (1971, 1979), Bostick and Foster (1975), Dow (1977), Robert (1980) and Teichmüller (1971). A paper by Bostick and Alpern (1977) explains the principles of sampling, preparation and constituent selection for vitrinite reflectance measurements.

The vitrinite reflectance method was originally designed for rank determinations on coals which offer the ultimate sample quality for such studies: coals, unless weathered, thermally affected or of very low rank, provide nearly always excellent and very reliable vitrinite reflectance data. When the method was extended from coals to finely disseminated organic material in clastic sediments, a huge advance was made in the practical applicability of the method especially concerning source rock studies. This important extension, however, introduced certain limitations which it is important to be aware of when vitrinite reflectance data obtained from clastic sediments are to be interpreted. Vitrinite reflectance data of this type which are reliable and readily interpreted, are relatively rare; poor and even barren samples are very frequent. This is due to a number of factors including type of lithology selected for study, small particle size, poor particle quality, bitumen staining, low reflecting vitrinite, weathering, lack of vitrinite, difficult identification of vitrinite, high pyrite contents and cavings.

Techniques used in this study

Normal palynological preparation techniques were used to concentrate the organic matter from the sediments. Crushed samples were dissolved in hydrofluoric acid after any carbonates had been removed with hydrochloric acid and washing. The samples were not subjected to any oxidative or heating treatment. The remaining organic residues were then embedded in a cold setting epoxy resin to make briquettes, which were subsequently ground flat and polished using magnesiumoxide as the final step.

Equipment used was a Leitz MPV3 photometermicroscope. Viewing and measurements were made through a Leitz Oel 50X/0.85 P objective using oil immersion with refractive index n = 1.518. Illumination was through a green filter with peak transmission at 546 nm, and the photometer sensitive field was about 3 µm in diameter. For photometer calibration a Leitz glass-standard with a reflectance of Ro = 0.517 was used. The readings were carried out using a stationary stage. This has become more or less standard in vitrinite reflectance determinations on clastic samples. It is far less time consuming, permits smaller particles to be measured and the results obtained do not deviate significantly from those obtained using a rotating stage as long as the vitrinite reflectance values stay below Ro = 1.4 (De Vries and Bokhoven, 1968). None of the samples analysed in this study exceeded this value. On each sample as many particles as possible up to 50 were measured. The readings were presented in histograms, a representative population was selected for each sample from observations made during measuring, and an arithmetically mean was calcualted from this population and interpreted as the representative vitrinite reflectance value.

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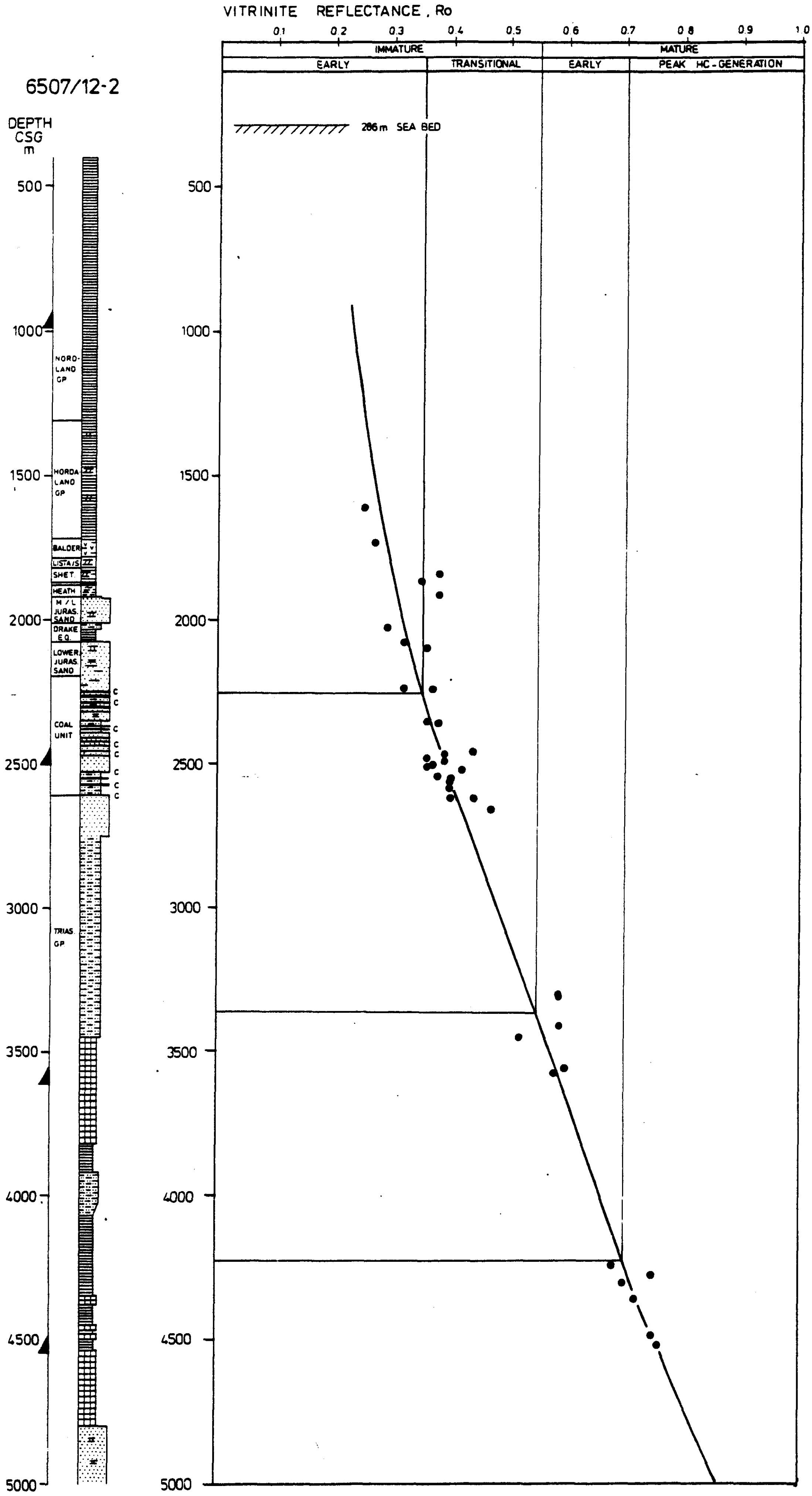

Figure 1. Linear plot of vitrinite reflectance versus depth, well 6507/12-2.

Vitrinite reflectance (Ro) at depth:	
1000 m	: 0.23
2000 m	: 0.32
3000 m	: 0.48
4000 m	: 0.66
5000 m	: 0.86
Well bottom	: 0.86 (5000 m)
Depth and stratigraphy at:	
Ro = 0.25	: 1500 m Hordaland Group
Ro = 0.35	: 2250 m Coal Unit
Ro = 0.55	: 3350 m Triassic
Ro = 0.70	: 4250 m Triassic
Vitrinite reflectance gradient (Ro/100 m)	
0.30 - 0.50	Ro : 0.016
0.30 - 0.80	Ro : 0.018

Table 1. Tabulation of some maturity characteristics, well 6507/12-2.

[illegible] Ro = 0.20 %

Table 2. Tabulation of vitrinite reflectance data, well 6507/12-2.

Sample depth (m)	Sample type	Vitrinite reflectance (Ro)
1612	swc	0.25
1731	swc	0.27
1816	swc	-
1835	swc	0.38
1865	swc	0.35
1913	swc	0.38
2026	swc	~~0.29~~
2078	swc	0.32
2094	swc	0.36
2235	swc	0.32
2238	swc	0.37
2350	swc	0.36
2357	swc	0.38
2460	cuttings	0.44
2470	cuttings	0.39
2480	cuttings	0.36
2490	cuttings	0.39
2500	cuttings	0.37
2510	cuttings	0.36
2520	cuttings	0.42
2543	cuttings	0.38
2553	cuttings	0.40
2556 A	cuttings	0.40
2556 B	cuttings	0.40
2586	cuttings	0.40
2616 A	cuttings	0.40
2616 B	cuttings	0.44
2652	cuttings	-
2661	cuttings	0.47
2812	swc	-
2825.5	swc	-

Sample depth (m)	Sample type	Vitrinite reflectance (Ro)
3053	SWC	-
3062	SWC	-
3080.5	SWC	-
3175	SWC	-
3270	SWC	-
3280	SWC	-
3296.5	SWC	0.59
3305	SWC	0.59
3412.1	SWC	0.59
3435	SWC	-
3451.5	SWC	0.52
3456.6	SWC	0.60
3476	SWC	0.58
3649	SWC	-
4218	SWC	-
4234	SWC	0.68
4273	SWC	0.75
4298	SWC	0.70
4348	SWC	-
4356	SWC	0.72
4484	SWC	0.75
4517	SWC	0.76
4522	SWC	-

$Y = a x + b$ der $b = \log_{10} 0.20$ × dyp [illegible]

$\log_{10} R_o = a \cdot$ dyp [illegible] $+ \log_{10} 0.20$ [illegible]

a = Gradient = 0.0001 $\log_{10} R_o$ [illegible] /m [illegible]

$\log_{10} R_o$ = [illegible] $+ \log_{10} 0.20$ [illegible]

der R_o [illegible]

[illegible] = 0.47

Enclosure 1. Vitrinite reflectance histograms, well 6507/12-2.