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MATURATION STUDY ON WELL-SITE PICKED LITHOLOGIES USING
VITRINITE REFLECTANCE, WELL 6507/12-1 -
OFFSHORE NORWAY

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SUMMARY

The maturity pattern of well 6507/12-1 has been evaluated using vitrinite reflectance as the only technique. The conclusions are:

The vitrinite reflectance increase with depth is very steep and continuous reaching the top of the immature transitional zone (R_o = 0.35) at 2300 m (Jurassic) and the early mature zone (R_o = 0.55) at approximately 3500 m (Triassic).

I MATURATION STUDY ON WELL-SITE PICKED LITHOLOGIES USING VITRINITE REFLECTANCE, WELL 6507/12-1

This account describes the results from a maturity study, using vitrinite reflectance, undertaken on well 6507/12-1. The study is carried out on hand-picked lithologies on the well-site. That is, the well site geologist has searched for lithologies particularly suited for this type of analysis. This sampling procedure has, in this well, been successful yielding material of excellent quality for vitrinite reflectance analysis.

I.1 Maturity profile

A vitrinite reflectance versus depth profile through well 6507/12-1 is presented in Figure I.1. Further sample details are listed in Table I.2, and some characteristic maturity features are listed in Table I.1. The profile (Fig. I.1) is based on data obtained from material picked by the well-site geologist looking for coals and carbominerites which offer the best material for vitrinite reflectance studies. 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 sample coverage presented in this report is, due to sampling instructions, restricted to intervals where coals and carbominerites are obtained. The reliability of the maturity gradient should therefore be complemented by further analysis of normal clastic samples in the remaining intervals. 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 R_o = 0.3 (Heroux et al. 1979).

Extrapolation of the average curve to the sea bed indicates a hypothetical minimum value of R_o = 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 (R_o = 0.35) with possibilities for some early wet gas generation Heroux et al. 1979, Leythaeuser et al. 1979, Connan & Casson 1980) at approximately 2300 m (Jurassic) and the early mature zone (R_o = 0.55) very tentatively at 3500 m (Triassic). The peak generation zone (R_o = 0.70) (Hood et al. 1975) is not reached in this well (TD = 3720 m). The coal deposits at 2400 - 2700 m show up a vitrinite (huminite) reflectance of R_o = 0.35 - 0.40 implying that they have to be ranked as lignite to subbituminous C.

II METHODICAL ASPECTS

II.1 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 & Ergun (1958, 1967), Kötter (1960), Murchison (1964), De Vries & 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 & Foster (1975), Dow (1977) Robert (1980) and Teichmüller (1979). A paper by Bostic & Alpern (1977) explains the principles of sampling, preparation and constitment 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 and cavings.

II.2 Techniques used in this study

The samples selected for study were not subjected to any chemical or heating treatment. Crushed samples were 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 is a Zeiss Universal Microscopephotometer. Viewing and measurements were made through a Zeiss Epi 40.0/0.85 Pol oil objective using our immersion oil with refractive index n = 1.518. Illumination was through a green filter with peak transmission at 546 mm, and the Microscopephotometer sensed a field about 3 μm in diameter. For photometer calibration a Bausch & Lomb glass-standard with reflectance R_o = 0.533 was used. The readings were carried out using a stationary stage. This has nowadays become standard in vitrinite reflectance studies of clastic samples; it is far less time consuming, permits smaller particles to be measured and the results obtained do not deviate significantly from

from those obtained using a rotating stage as long as the reflectance values are below R_o = 1.4 (De Vries & Bokhoven 1968). None of the samples analysed in the study exceeded this value. On each sample as many particles as possible up to 40 sometimes 50 were measured. The readings were grouped at intervals of 0.02 R_o and presented histogram. Each histogram distribution was divided into populations of which a true value was arithmetically and visually interpreted.

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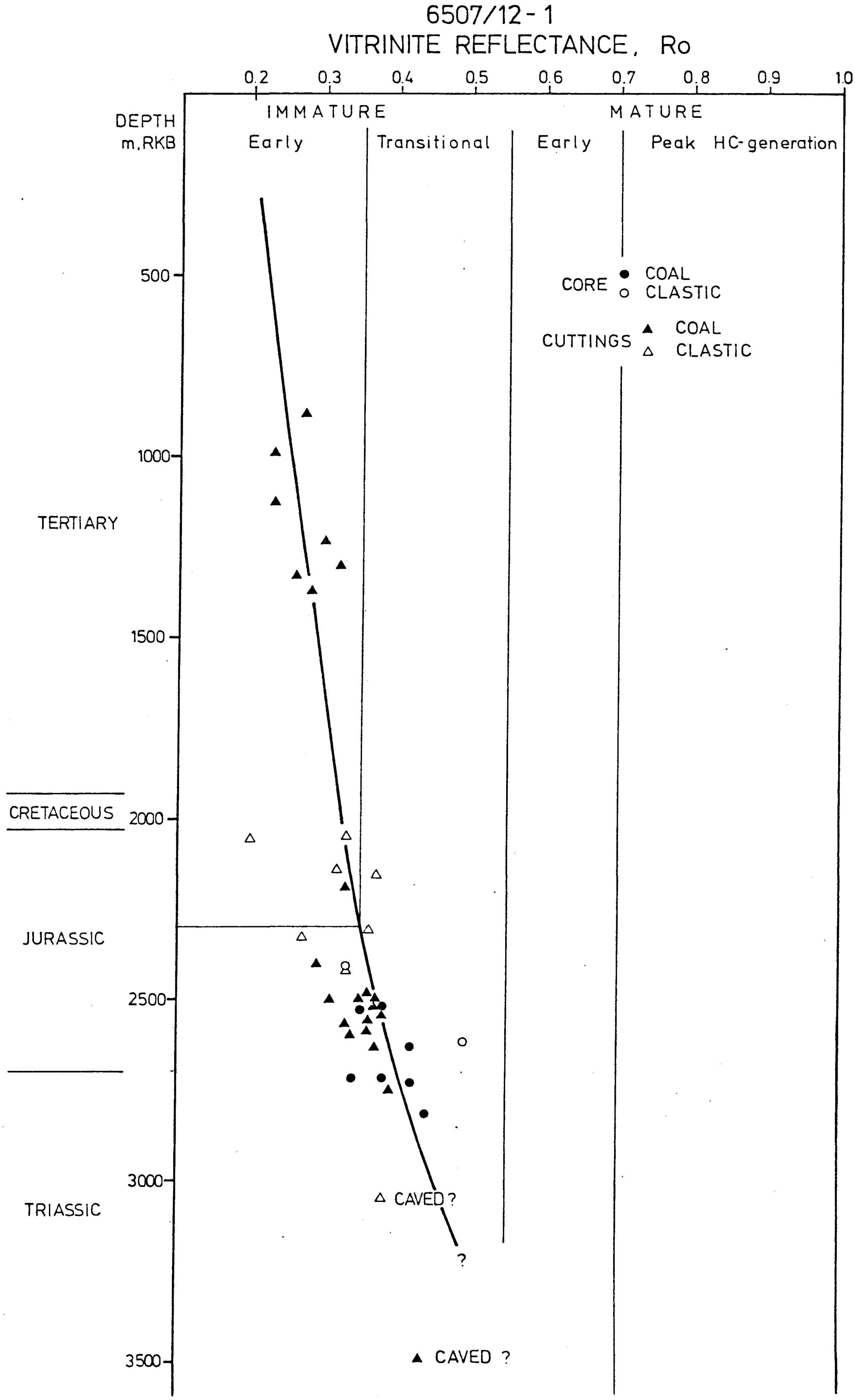
Fig. I.1. Linear plot of vitrinite reflectance versus depth in well 6507/12-1 offshore Norway.



6507/12-1
VITRINITE REFLECTANCE, Ro
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
IMMATURE
MATURE
DEPTH
m.RKB
Early
Transitional
Early
Peak HC-generation
500
1000
1500
2000
2500
3000
3500
TERTIARY
CRETACEOUS
JURASSIC
TRIASSIC
CORE
COAL
CLASTIC
CUTTINGS
COAL
CLASTIC
CAVED ?
?
CAVED ?

Vitrinite reflectance (R_o) at depth:	
1000 m	0.25
2000 m	0.32
3000 m	0.45 ?
Well bottom	0.60 (3720 m)
Depth and stratigraphy at:	
R_o = 0.25	950 m (Tertiary)
R_o = 0.35	2300 m (Jurassic)
R_o = 0.55	3500 m (Triassic)
Vitrinite reflectance gradient (R_o/100 m):	
0.30 - 0.50 R_o	0.013
0.30 - 0.80 R_o	-

Table I.1. Tabulation of source maturation characteristics.

Table I.2. Tabulation of vitrinite reflectance data

Sample no.	Depth	Sample type	Lithology	Vitrinite reflectance, R_o	(N)
3	800 - 930	Cuttings	Coal	0.27	(24)
4	970 - 990	Cuttings	Dk. minerals	-	
5	990 - 1000	Cuttings	Coal	0.23	(7)
6	1020 - 1040	Cuttings	Claystone	-	
7	1100 - 1150	Cuttings	Coal	0.23	(12)
8	1190 - 1280	Cuttings	Coal	0.32	(30)
9	1300	Cuttings	Coal	0.32	(26)
10	1330	Cuttings	Coal	0.26	(25)
11	1370	Cuttings	Coal	0.28	(23)
12	1500	Cuttings	Dk. minerals	-	
13	1500	Cuttings	Claystone	-	
14	2050	Cuttings	Claystone	0.33	(11)
15	2052	Cuttings	Claystone	0.20	(4)
16	2334	Cuttings	Claystone	0.37	(21)
17	2145	Cuttings	Claystone	0.37	(40)
18	2313	Cuttings	Claystone	0.36	(40)
19	2140	Cuttings	Claystone	0.32	(3)
20	2190	Cuttings	Coal	0.33	(40)
21	2600	Cuttings	Coal	0.33	(40)
22	2569	Cuttings	Coal	0.34	(40)
23	2499	Cuttings	Coal	0.35	(40)
24	2547	Cuttings	Coal	0.39	(40)
25	2404.35	Core	Siltstone	0.33	(29)
26	2520	Cuttings	Coal	0.37	(40)
27	2530	Core	Claystone	0.35	(40)
28	2592	Cuttings	Coal	0.36	(50)
29	2562	Cuttings	Coal	0.36	(40)
30	2502	Cuttings	Coal	0.37	(50)
31	2487	Cuttings	Coal	0.36	(40)
32	2415	Cuttings	Claystone	0.33	(3)
33	2415	Cuttings	Coal	0.29	(27)
34	2412	Cuttings	Claystone	-	
35	2496	Cuttings	Coal	0.31	(50)
36	2814.50	Sidewall core	Coal	0.44	(50)

Sample no.	Depth	Sample type	Lithology	Vitrinite reflectance, R_o	(N)
37	2632.00	Sidewall core	Coal	0.42	(50)
38	2733.00	Sidewall core	Coal	0.42	(40)
39	2523.98	Core	Coal	0.38	(40)
40	2710.70	Core	Coal	0.38	(40)
41	2751	Cuttings	Coal	0.39	(40)
42	2632	Cuttings	Coal	0.37	(40)
43	2707.40	Core	Coal	0.34	(40)
44	2707.16	Core	Claystone	0.49	(12)
45	3051	Cuttings	Claystone	0.38	(24)
46	3492	Cuttings	Coal	0.43	(17)