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REPORT TITLE/ TITTEL

Source Rock Analysis and Evaluation of Well 6507/12-1

CLIENT/ OPPDRAGSGIVER

Oljedirektoratet

RESPONSIBLE SCIENTIST/ PROSJEKTANSVARLIG

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SUMMARY/ SAMMENDRAG

Samples of selected lithologies from well 6507/12-1 were evaluated with reference to source rock potential using results from total organic carbon determination, Rock-Eval pyrolysis and visual kerogen analysis.

The dominant lithologies were dark grey and brown-grey claystones. All samples contained type III kerogens. The dark grey claystones are rated mainly as rich source rocks for gas although the high proportion of cuticula in some samples indicates a rich source potential for both gas and heavy oil.

KEY WORDS/ STIKKORD

SOURCE ROCK ANALYSIS AND EVALUATION OF WELL 6507/12-1

Experimenal procedure and description of interpretation criteria

Total Organic Carbon (TOC)

Picked cuttings of the various lithologies in each sample were crushed in a centrifugal mill. Aliquots of the samples were then weighed into Leco crucibles, treated with hot HC1 to remove carbonate and washed twice with distilled water to remove traces of HC1. Water was removed by evaporation at 50°C. The samples were then analysed on a Leco E C 12 carbon analyser and the total organic carbon content was determined. TOC values were interpreted in terms of richness; i.e. 2-10% = rich; 1-2% = good; 0.3-1.0% = fair, 0.1-0.3% = poor.

Rock-Eval Pyrolysis

100 mg crushed sample was transferred to a platinum crucible with a base and cover made of sintered steel, and analysed on a Rock-Eval pyrolyser. Evaluation of maturity, kerogen type and potential for production of hydrocarbons was based upon values obtained for the T_{max}, hydrogen index, oxygen index and production index (see Espitalié et al., 1977).

Processing of Samples and Evaluation of Visual Kerogen

Crushed samples of the selected lithologies were treated with hydrochloric and hydrofluoric acids to remove minerals. A series of microscopic slides of strew mounts of the residue were prepared:

T-slides represent the total acid-insoluble residue.
N-slides represent a screened residue (15 µ mesh).
O-slides contain palynodebris remaining after flotation ($ZnBr_2$) to remove interferring heavy minerals.
X-slides contain chemically oxidized residues, (oxidation may be required in cases where sapropel embeds palynomorphs or when a high degree of coalification prevents the identification of the various groups).

T and/or O slides are necessary to evaluate kerogen composition and palynofacies-which are closely related to sample lithology.

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Screened or oxidized residues are normally required to concentrate the larger fragments, and to study palynomorphs (pollen, spores, dinoflagellates) and cuticles for paleodating and colour evaluation.

Visual evaluations of kerogen were undertaken utilising residues mounted in glycerine jelly and studied by Leitz Dialux in normal light (halogene) using x10 and x63 objectives. With x63 magnification it is possible to distinguish single particles of diameters ca. 2 µ and, if required, make a more refined classification of the screened residues (particles >15 µ).

Colour evaluation is based upon the colour tones of spores and pollen (preferably) with support from other types of kerogen (woody material, cuticles and sapropel). These colours are dependant upon the maturity, but also are influenced by paleo-environmental factors (lithology of the rock, oxidation and decay processes). The colour tones and the estimated colour index of an individual sample may therefore deviate from those of neighbouring samples. The techniques used in visual kerogen studies are adopted from Staplin (1969) and Burgess (1974).

The evaluation of maturity from the estimated colour indices is based upon a general scheme which is calibrated against vitrinite reflectance values (R_o).

Ro	0.45	0.6	0.9	1.0	1.3
Colour index	2-	2	2+	3-	3
Maturity intervals	Moderate mature	Mature (oil window)			Condensate window

References

Burgess, J.D., 1974: Microscopic examination of kerogen (dispersed organic matter) in petroleum exploration. Geol. Soc. Amer. Spec. Rprt. 153, 19-30.

Espitalié, J., Laporte, J.L., Madec, M., Marquis, F., LePlat, P., Paulet, J. and Bautefeu, A., 1977: Méthode rapide de charactérisation des roche méres, de leur potentiel pétrolier et de leur degré dévolution. Rev. Inst. Fr. Pétrole, 32.

Staplin, F.L., 1969: Sedimentary organic matter, organic metamorphism and oil and gas occurrence. Bull. Can. Petrol. Geol. 17(1), 47-66.

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Sample 2565 m

Approx. one third of this residue was apparently amorphous material; the remaining organic matter being of a cuticular and woody nature.
Colour index: 1/1+.

Sample 2598 m

As for the sample above but a lower content of amorphous material.
Colour index: 1/1+.

Samples 2616 m, 2649 m, 2691 m

Woody material was dominant but strongly sapropelised. Amorphous material was subordinate. The content of cuticles was variable; they were strongly sapropelised. Well preserved pollen and spores.
Colour index: 1/1+.

Sample 2691 m (Claystone, dark grey)

The residue appeared to contain more true amorphous material but was dominated by a mixture of woody matter, cuticles, pollen, spores and indeterminate herbaceous matter.
Colour index: 1/1+.

Samples 2787 m, 2796 m

Cuticles dominant with woody matter, pollen, spores and indeterminate herbaceous material also present. The presence of Aratrisporites scabratus and Limbosporites lundbladii constitutes material of Triassic age.
Colour index: 2-/2, 2.

Samples 2811 m (Claystone, grey-brown), 2811 * (Claystone, grey)

Cuticles, indeterminate herbaceous and woody material were dominant.

Sample 2811* seemed significantly richer in material evaluated to be of true amorphous nature. The organic material seemed more coherent than in samples above.
Colour index: 2/2+, (may be too high as maturation index).

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Samples 2892 m, 2913 m

The residues seemed to be dominated by woody material and by cuticles, pollen and spores. The fragments were too opaque to be studied without chemical oxidation.
Colour index: 2/2+ or 2+.

Samples 2967 m * (Claystone, dark grey), 2967 m (Claystone, brown-grey)

The residues contained a mixture of cuticles, indeterminate herbaceous material, woody material, pollen and spores.
Colour index: 2+/3- (2- caved lithology). The colour index may be too high, being evaluated from oxidised material.

CONCLUSION

Based on the Rock-Eval pyrolysis and visual kerogen examination, all the analysed samples are found to be of kerogen type III. The dark grey claystones are found to be capable of producing significant amounts of hydrocarbons upon heating and these are rated as rich source rocks for gas. Some of the samples contain a significant proportion of cuticula which will produce heavy, paraffinic oil and these are rated as rich source rocks for gas and heavy oil.

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Figure 1

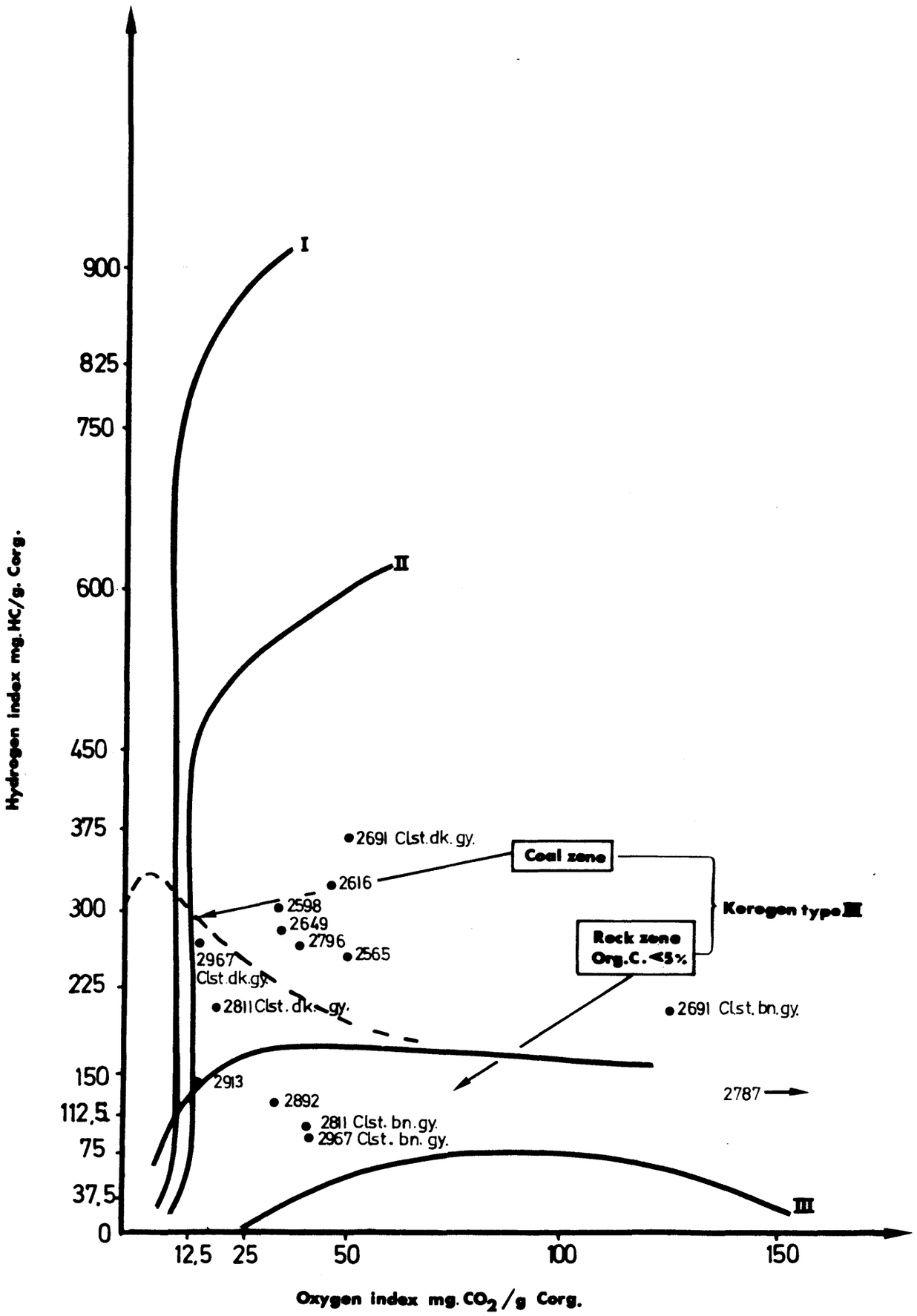
I
II
III
900
825
750
600
450
375
300
225
150
112,5
75
37,5
0
12,5
25
50
100
150
Hydrogen index mg.HC/g. Corg.
Oxygen index mg. CO_2 / g Corg.
2691 Clst.dk. gy.
Coal zone
2616
2598
2649
2796
2565
Keregen type III
2967
Clst dk.gy.
Rock zone
Org.C.<5%
2811 Clst. dk. gy.
2691 Clst. bn.gy.
2913
2892
2787
2811 Clst. bn.gy.
2967 Clst. bn. gy.

TABLE I

OD 6507/12-1

IKU No	Depth	TOC	Lithology
K-8379	2565	4,50	Claystone, grey
K-8380	2598	24,36	Claystone, dark grey
K-8381	2616	14,2	Claystone, dark grey
K-8382	2649	26,54	Claystone, dark grey
K-8384	2691	18,87	Claystone, dark grey
K-8384	2691	1,87	Claystone, brown, grey
K-8385	2787	1,98	Claystone, grey
K-8386	2796	11,64	Claystone, grey
K-8387	2811	2,41	Claystone, brown, grey
K-8387	2811	24,82	Claystone, dark grey
K-8388	2892	5,15	Claystone, dark grey
K-8398	2913	25,52	Claystone, coaly
K-8390	2967	10,71	Claystone, dark grey
K-8390	2967	2,08	Claystone, brown, grey

025/B/7/mk

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TABLE II

ROCK EVAL PYROLYSES

IKU No.	DEPTH (m)	S1	S2	S3	TOC (%)	HYDR. INDEX	OXYGEN INDEX	OIL OF GAS CONTENT S1+S2	PROD. INDEX S1/(S1+S2)	TEMP. max (C)
K8379	2565 Clst sy	1.07	11.60	2.29	4.50	258	51	12.66	.08	333
K8380	2598 Clst dk sy	1.64	72.61	7.81	24.36	298	32	74.25	.02	421
K8381	2616 Clst dk sy	3.02	45.41	6.33	14.20	320	45	48.43	.06	427
K8382	2649 Clst dk sy	1.40	71.30	8.12	26.54	269	31	72.70	.02	424
K8384	2691 Clst dk sy	5.43	67.38	9.30	18.87	357	49	72.82	.07	424
K8384	2691 Clst bn-sy	.38	3.86	2.31	1.87	207	123	4.24	.09	431
K8385	2787 Clst sy	.17	1.62	14.95	1.98	82	755	1.79	.10	436
K8386	2796 Clst dk sy	.78	30.85	4.19	11.64	265	36	31.64	.02	422
K8387	2811 Clst bn-sy	.25	2.53	.95	2.41	105	40	2.78	.09	437
K8387	2811 Clst dk sy	1.48	51.67	4.20	24.82	208	17	53.14	.03	426
K8388	2892 Clst dk sy	.36	5.83	1.54	5.15	113	30	6.18	.06	440
K8389	2913 Clst coaly	4.66	33.15	3.18	25.52	130	12	37.81	.12	429
K8390	2967 Clst dk sy	.65	28.32	1.79	10.71	264	17	28.97	.02	428
K8390	2967 Clst bn-sy	.18	2.02	.90	2.08	97	43	2.20	.08	438

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VISUAL KEROGEN ANALYSIS

TABLE NO.: III

WELL NO.: 6507/12-1

Sample	Depth	Composition of residue	Particle size	Preservation-palynomorphs	Thermal maturation index	Remarks
K 8379	2565m	Cut,WR!,W,P,S,He/Am	F-M-L	good	1/1+	Dense, dark coal fragments, inert, fusinite. Abundant Ch.major, bisaccates and other conifers. Abund.longr.spores.
K 8380	2598m	He,Cut,W,WR!,P,S/Am	F-M-L	good	1/1+	Dense, opaque aggregates of mostly sapropelised terrestrial material. Grey brown aggr. indicate presence of carbonate. Long ranging spores abundant.
K 8381	2616m	W,WR!,P,S,He,Cut/Am	F-M-L	good	1/1+	As above. Rich in material of woody nature, spores, and pollen.
K 8382	2649m	He,W,WR!,Cut,P,S/Am	F-M-L	good	1/1+	As above. Aggregates rich in strongly decomposed probably woody material.

ABBREVATIONS

Am	amorphous	Cy	cysts, algae	W	woody material	F	fine
He	herbaceous	P	pollen grains	C	coal	M	medium
Cut	cuticles	S	spores	RI	reworked	L	large

032/F/jlh/1

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VISUAL KEROGEN ANALYSIS

TABLE NO.: III
WELL NO.: 6507/12-1

Sample	Depth	Composition of residue	Particle size	Preservation-palynomorphs	Thermal maturation index	Remarks
K 8384	2691m	W,Cut,He,P,S,WR!/Am	F-M-L	good	1/1+	As above. (Clst. dark grey)
K 8384	2691m	W,Cut,He,P,S/Am	F-M-L	fair	1/1+	Sparse residue. Fragments/ aggregates with a homogenous sapropelised matrix embedding inertinite and other terrestria fragments. (Clst. grey brown)
K 8385	2787m	Cut,W,P,S,He,WR!/Am	F-M-L	good	2-/2	Sapropelised cuticles, longr. pollen and spores, inertinite and fusinite, semifusinite. C. thiergartü, Aratrisporites.
K 8386	2796m	Cut,P,S,WR!,W,He/Am	F-M-L	good	2	Increased amounts of inertinite Limbosporites lundbladii.

ABBREVATIONS

Am	amorphous	Cy	cysts, algae	W	woody material	F	fine
He	herbaceous	P	pollen grains	C	coal	M	medium
Cut	cuticles	S	spores	R!	reworked	L	large

032/F/jlh/2

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VISUAL KEROGEN ANALYSIS

TABLE NO.: III
WELL NO.: 6507/12-1

Sample	Depth	Composition of residue	Particle size	Preservation-palynomorphs	Thermal maturation index	Remarks
K 8387	2811m	Cut,He,P,S,W,WR!/Am	F-M-L	good	2/2+	Dark opaque fragments only with translucent margins. Fusinite/ semifusinite and some inertinite.
K 8387	2811m	Cut,WR!,P,S,He,W/Am	F-M-L	good	2/2+	Fragments composed of terrestrial material embedded i a homogenous matrix, evaluated tentatively as also including some true amorphous material. A Triassic assemblage with mixtures of Early Jurassic material.
K 8388	2892m	W,WR!,Cut,He,P,S/Am	F-M-L	good	2/2+	Denser aggregates (firmer struc tures than above). Stronger reaction to chemical oxidation.

ABBREVATIONS

Am	amorphous	Cy	cysts, algae	W	woody material	F	fine
He	herbaceous	P	pollen grains	C	coal	M	medium
Cut	cuticles	S	spores	R!	reworked	L	large

032/F/jlh/3

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VISUAL KEROGEN ANALYSIS

TABLE NO.: III
WELL NO.: 6507/12-1

Sample	Depth	Composition of residue	Particle size	Preservation-palynomorphs	Thermal maturation index	Remarks
K 8389	2913m	W,P,S,Cut,WR!/Am	F-M-L	very good	2+	Opaque fragments of believed woody nature (mainly).
K 8390	2967m	Cut,He,W,P,S,WR!/Am	F-M-L	very good	?2+/3-	Aggregates of terrestrial material in a homogenous matrix Some carbonate. Riccisporites tuberculatus, R. umbonatus, Limbosporites lundbladii, Ovalipollis, spp.
K 8390	2967m	Cut,He,W,P,S,WR!/Am	F-M-L	very good	2- 2+/3-	As above, but far richer in coarse, tough cuticular fragments, light coloured pollen suggest presence of caved lithologies.

ABBREVATIONS

Am	**amorphous**	**Cy**	**cysts, algae**	**W**	**woody material**	**F**	**fine**
He	**herbaceous**	**P**	**pollen grains**	**C**	**coal**	**M**	**medium**
Cut	**cuticles**	**S**	**spores**	**R!**	**reworked**	**L**	**large**

032/F/jlh/4