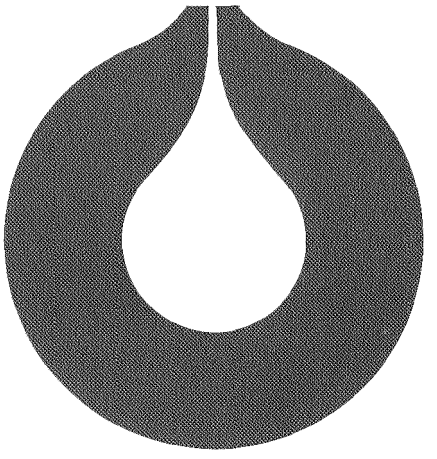


statoil

Den norske stats oljeselskap a.s

statoil
Den norske stats oljeselskap a.s

Classification

Requested by

A. Storli - 34/10.

Subtitle

Co-workers

Title

34/10-13 STATFJORD FORMATION

SEDIMENTOLOGICAL DESCRIPTION AND INTERPRETATION OF CORES

STATOIL
EXPLORATION & PRODUCTION
LABORATORY

by

O.A. Malm

APRIL 1982

LAB.82.19

Prepared

Approved

INTRODUCTION

Well 34/10-13 is located on a horst block in the eastern part of the 34/10-Delta East field. In this fault-block the Kimmerian unconformity has eroded away the Middle Jurassic Brent and the Lower Jurassic Cook reservoirs and the Statfjord Fm. is the major reservoir.

Here the formation has earlier been penetrated and partly cored in its upper part in the 34/10-11 well. 34/10-13 is the first well in 34/10- Delta East where a more or less continous core is available through the whole formation. Thus the well is an important reference point for earlier and future wells in the evaluation of the Statfjord Fm. reservoir in 34/10- Delta East. The object of this report is to give a description and interpretation of this core.

Comments will also be made to the relation between sand-texture/ mineralogy and reservoir-properties (porosity - permeability).

A detailed mineral/petrographic study of both sands and shales is now under way and will reported later.

THE CORES

The cored and described interval extends from 1931 m RKB (top) to 2087 m RKB (bottom) with a total recovery of about 134 meters of core. This covers most of the Statfjord Fm (1924 m - 2052 m RKB) except for the uppermost part (1924 m - 1931 m RKB).

The cores were recovered in a glass-fiber liner. The core and liner were cut into 90 cm pieces and frozen.

So far only the A-cut has been slabbed from the frozen cores and it is this that is described here.

This technique of core-handling has proved very successful with respect to preservation of primary core-textures and coherence, even in very loose or friable parts of the core.

Only a limited amount of the core is collapsed/strongly disrupted. This makes a meaningful description and interpretation of the cores possible.

DESCRIPTIONS

The cores were described on a 1:50 scale. The descriptions are here presented on seven (7) separate sheets arranged by depth. These are shown on the following pages in reduced scale and given in full scale (1:50) as enclosures.

A review (summary) sheet of the whole core-interval in the reduced scale (1:200) is also given as an enclosure. This also contains discussions and interpretations of sedimentary facies and environments of the cores.

The descriptions are intended to be self-explanatory and are not commented on further here.

INTERPRETATIONS

A discussion and interpretation of sedimentary facies and environments is given on the enclosed review-sheet in scale 1:200. The reader is referred to this.

SAND-TEXTURE AND RESERVOIR-PROPERTIES

The descriptions show that the reservoir sand-horizons can be broadly grouped into three major types based on texture (and mineralogy).

To detect differences in reservoir-properties between these types conventional poro-perm data (from Geco) are plotted with the descriptions.

Porosity

Except for minor carbonate cemented intervals the porosity of the coarse to very coarse sands is generally high (in the range 20-35%). Compared to the permeability, this factor is relatively independent of sand texture and mineralogy and not very useful as a measure of reservoir-quality. However, the coarse to very coarse sands with the lowest permeabilities (see below) also have the lowest porosities (20-25%).

Permeability

The coarse - very coarse sands can roughly be grouped into the following types with respect to grain-size, sorting (and mineralogy).

1) Coarse to very coarse gr., pebbly, poorly sorted sands (1946-1950 m, 1953-1965 m, 1973-1984 m, 2003-2009 m, 2027-2030 m).

2) Medium to coarse grained moderatly to well sorted sand (2011-2017 m).

3) Coarse to very coarse gr., poorly sorted sands with abundant kaolinite-clay, probably of secondary origin (2036-2041 m, 2047-2050 m, 2067-2070 m).

Type 1) which is volumetrically most important, in general shows permeabilities in the range 100-1000 mD.

Type 3) which is texturally somewhat similar to type 1) shows distinctly lower permeabilities, in the range 5-100 mD. This is due to the presence of abundant kaolinite-clay, probably formed in situ through post-depositional mineral transformations (diagenesis).

Type 2) is volumetrically subordinate but has extremely good permeabilities (1000-10000 mD) compared to the other sands. This probably is due to a much better sorting (even grain-size distribution) compared to the other sands.

More details on the connection between reservoar-properties and sand texture/mineralogy will be given in a later report when a mineral/petrographical study now under way is finished.

SPECIAL CORE DESCRIPTION

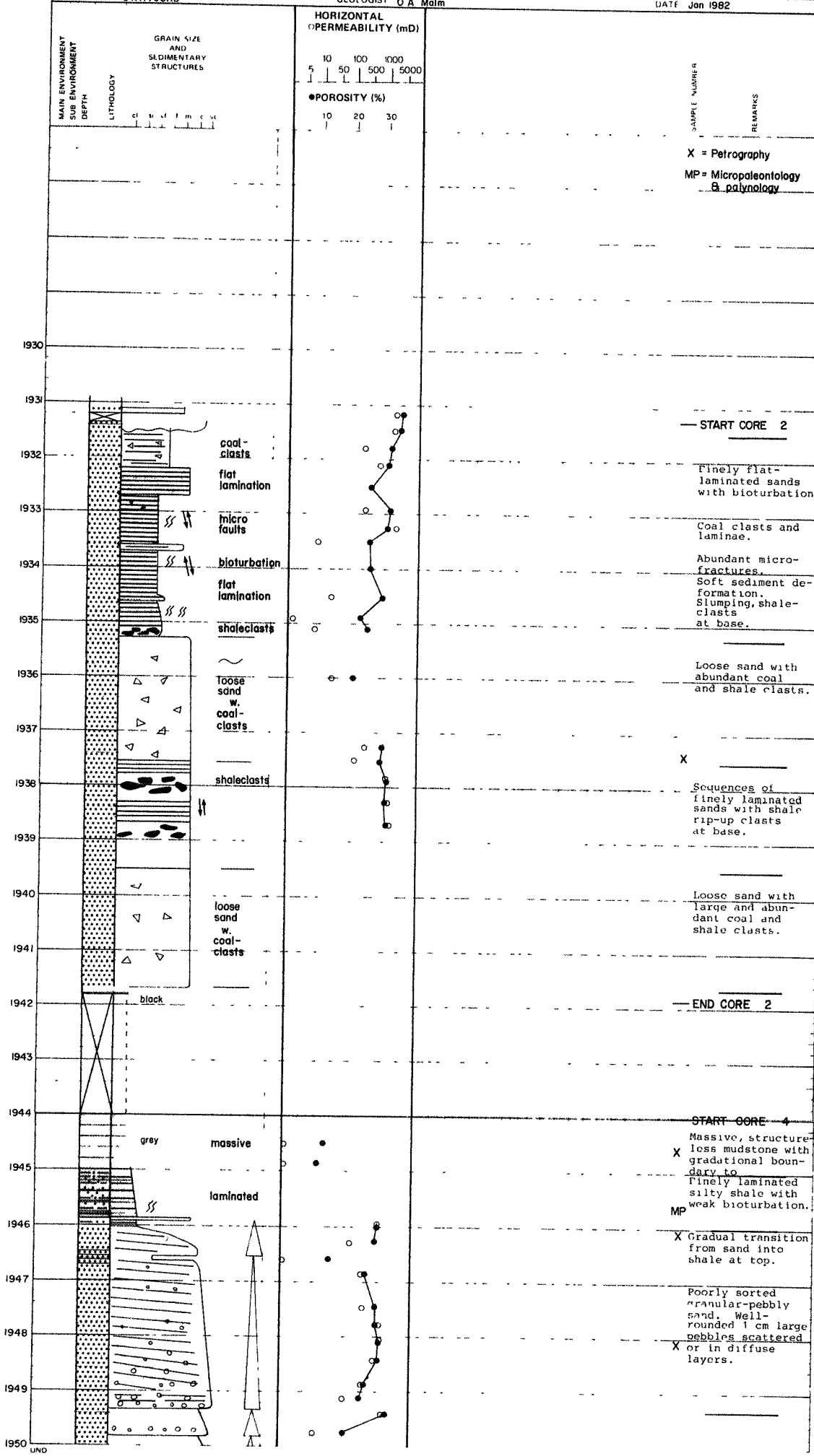
Sheet 1 of 1

FIELD 34/10 - DELTA EAST
CORE NO 1 2 3 & 4
FORM STATFJORD

WELL NO 34/10 - 13
INTERVAL from 1931 m to 1950 m
GEOLOGIST O A Malm

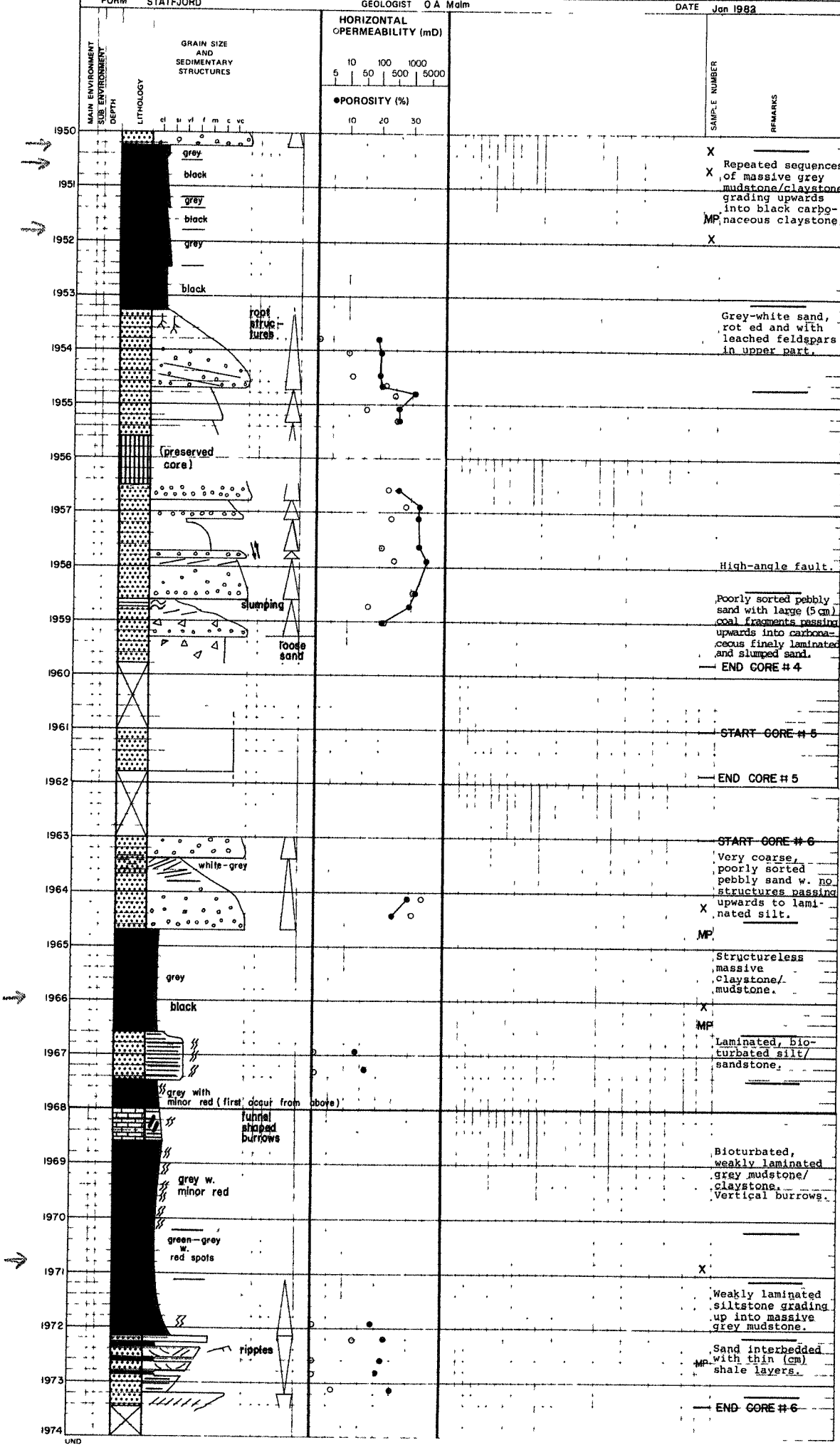
AREA NORTH SEA
REMARKS

DATE Jan 1982



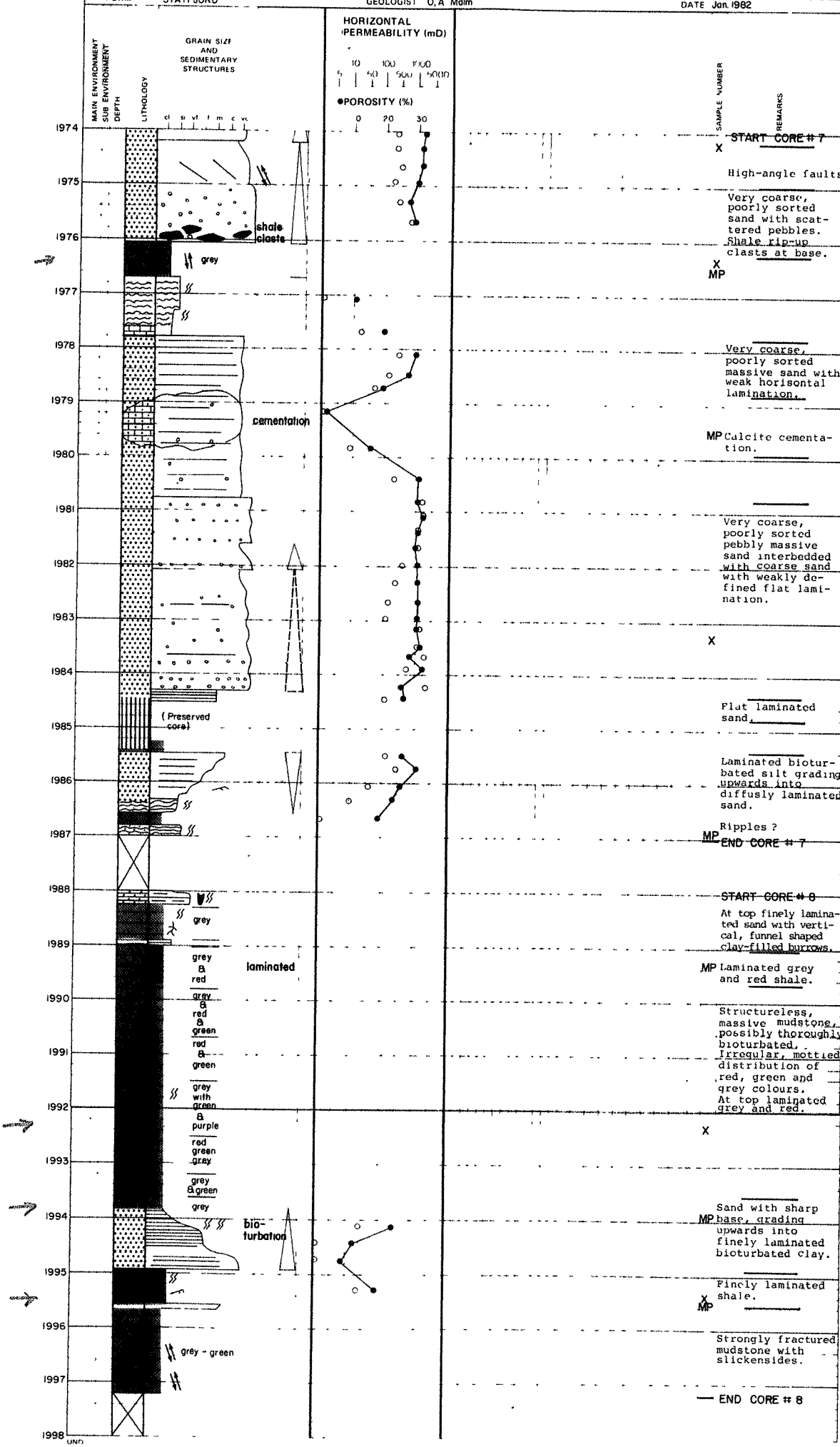
SPECIAL CORE DESCRIPTION

FIELD 34/10 - DELTA EAST | WELL NO 34/10-13 | AREA NORTH SEA
CORE NO 4 5 & 6 | INTERVAL from 1950 to 1974 m | REMARKS
FORM STATFJORD | GEOLOGIST O A Malm | DATE Jan 1983



SPECIAL CORE DESCRIPTION

FIELD 34/10 DELTA EAST
CORE NO 7 & 8
FORM STATFJORD
WELL NO 34/10 - 13
INTERVAL from 1974 to 1998 m
GEOLOGIST O.A Malm
AREA NORTH SEA
REMARKS
DATE Jan 1982



SPECIAL CORE DESCRIPTION

FIELD 34/10 - DELTA EAST
CORE NO 9 10 & 11
FORM STATFJORD

WELL NO 34/10 - 13
INTERVAL from 1999 m to 2023m
GEOLOGIST O A Malm

AREA NORTH SEA
REMARKS

DATE Jan 1982

MAIN ENVIRONMENT | SUB ENVIRONMENT | DEPTH | LITHOLOGY | GRAIN SIZE AND SEDIMENTARY STRUCTURES (cl s vf f m c ve)

HORIZONTAL PERMEABILITY (mD) 10 100 1000 5 50 500 5000

●POROSITY (%) 10 20 30

SAMPLE NUMBER | REMARKS

1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023 UND

(Preserved core)
grey - black
shale clasts
x-bedding
(Preserved core)
x-bedding
grey
grey
grey
yellow (-red)
grey
yellow
grey

— START ~~CORE # 9~~
Very coarse pebbly sand at base grading upwards into moderatly sorted sand w. low-angle lamination.

Diffusly laminated coarse to very coarse and pebbly sand.

MP Silty shale at base grading upwards into massive pebbly very coarse sand.
X

X
MP
Sand w. shale clasts at base grading up into claystone.

— END CORE # 9
— START CORE # 10

Planar multi-directional
MP cross-bedding.

Planar
X multi-directional cross-bedding.

— END CORE # 10

— START CORE # 11

Massive grey claystone with mottled green colouration.

X

Rootlets.
X

Massive structureless claystone.

SPECIAL CORE DESCRIPTION

Sheet 5 of 7

FIELD 34/10- DELTA EAST
CORE NO 11 & 12
FORM STATFJORD

WELL NO 34/10-13
INTERVAL from 2023 m to 2047 m
GEOLOGIST O A Malm

AREA NORTH SEA
REMARKS

DATE Jan 1982

MAIN ENVIRONMENT
SUB ENVIRONMENT
DEPTH
LITHOLOGY
GRAIN SIZE AND SEDIMENTARY STRUCTURES
cl s vf f m c vc

HORIZONTAL PERMEABILITY (mD)
5 10 50 100 500 1000 5000

●POROSITY (%)
0 20 30

SAMPLE NUMBER
REMARKS

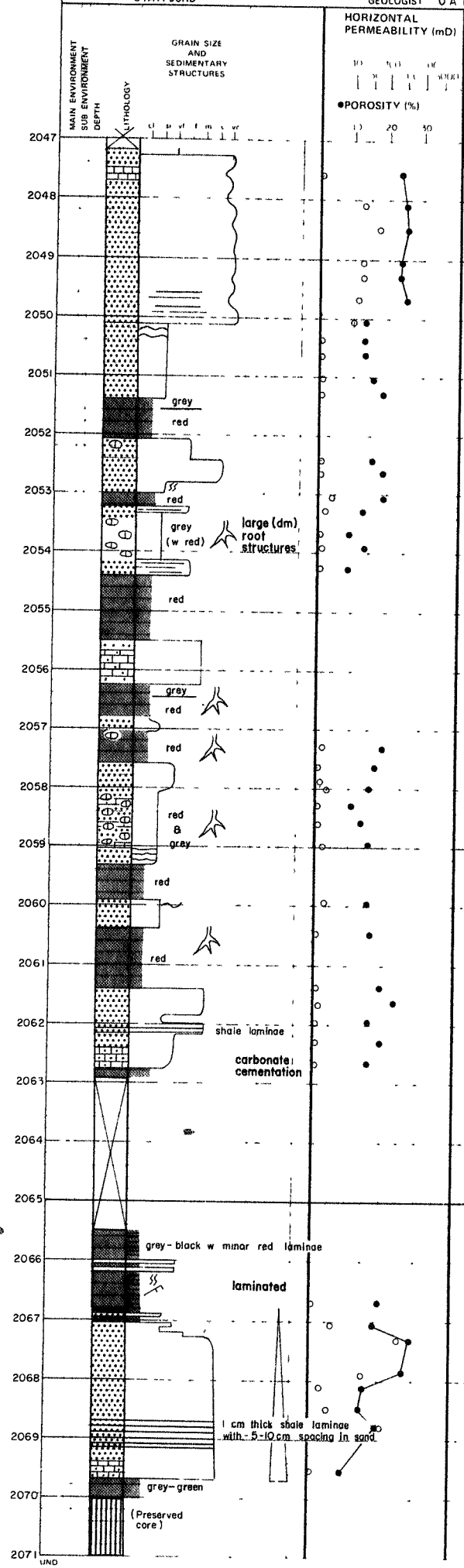
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047 UNO

grey
coal
(Preserved core)
grey
grey
grey (- green/yellow)
carbonate cementation
(Preserved core)
grey
red (- orange - yellow)
green & purple
calcite nodules

Interbedded fine sand, silt and clay with flat laminations and ripples (?).
MP
X
Abundant coal-laminae.
Ripples.
Massive, very coarse pebbly, poorly sorted sand.
MP 10-12 cm thick coal layer with pyrite.
X
X Strongly fractured claystone/mudstone with slickensides.
— END CORE 11
— START CORE 12
MP
Poorly sorted very coarsegr. sand. Strongly disrupted due to pedoturbation (?) and or collapse during coring.
Loose with grey-white colour due to abundant secondary kaolinite formed through
X leaching of feldspar and mica. Weak oil stain.
Massive siderite/dolomite cementation at base.
Irregularly laminated and bioturbated siltstone.
X Scattered calcite nodules. Massive calcite cement
X at base.
— END CORE # 12

SPECIAL CORE DESCRIPTION

FIELD 34/10 - DELTA EAST | WELL NO 34/10-13 | AREA NORTH SEA
CORE NO 13 & 14 | INTERVAL from 2047m to 2071m | REMARKS
FORM STATFJORD | GEOLOGIST O A Malm | DATE JAN 1982



SAMPLE NUMBER | REMARKS

— START CORE # 13

X Massive coarse - very coarse poorly sorted sand. Loose with grey-white colours due to abundant kaolinite. Disruption due to pedoturbation and /or collapse during coring.

X Weak oil-stain.

Calcite-nodules.

Large (dm-scale) root-structures filled with calcite.

MP

Massive calcite-cementation.

Large root-structures filled with silt/sand.

Calcite infilling of roots.

Calcite filled root-structures and nodules.

50 cm long, 2 cm thick root, in red claystone infilled with silt from above.

X

— END CORE # 13

— START CORE # 14

X Finely laminated grey and red shale in alternation.

Massive sand. Loose, grey-white due to abundant kaolinite.

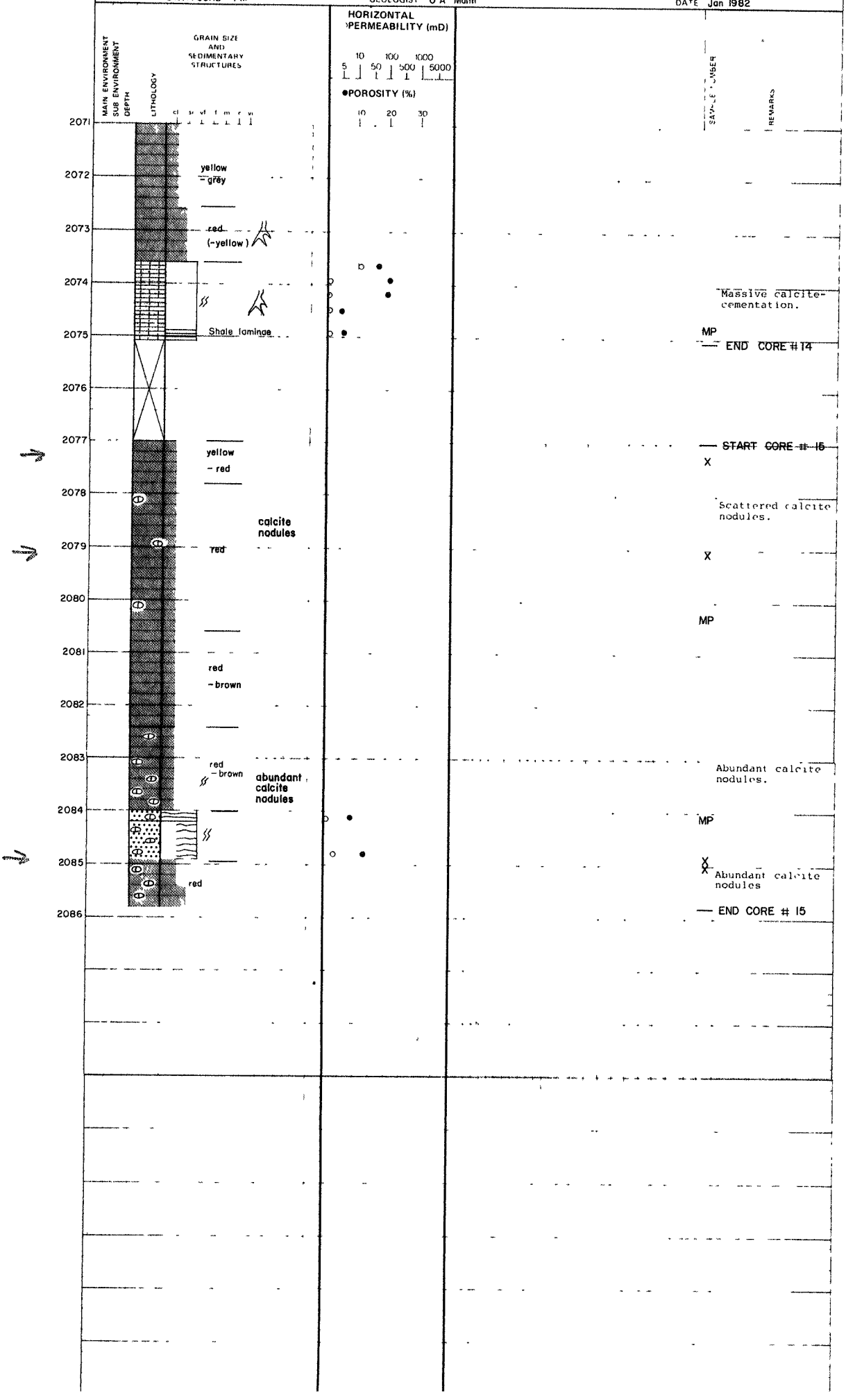
X Disrupted/collapsed in upper part.

Gradual transition

X into shale at top.

SPECIAL CORE DESCRIPTION

FIELD 34/10 DELTA EAST
CORE NO 14 & 15
FORM STATFJORD Fm
WELL NO 34/10-13
INTERVAL from 2071m to 2086m
GEOLOGIST O A Malm
AREA NORTH SEA
REMARKS
DATE Jan 1982



SPECIAL CORE DESCRIPTION

FIELD 34/10 - DELTA EAST | WELL NO. 34/10 - 13 | AREA NORTH SEA

CORE NO. 1.2.3 & 4 | INTERVAL from 1931 m to 1950 m | REMARKS

FORM. STATFJORD | GEOLOGIST O.A. Malm | DATE Jan. 1982

MAIN ENVIRONMENT | SUB ENVIRONMENT | DEPTH | LITHOLOGY | GRAIN SIZE AND SEDIMENTARY STRUCTURES (cl si vf f m c vc)

HORIZONTAL ○PERMEABILITY (mD) 5 10 50 100 500 1000 5000

●POROSITY (%) 10 20 30

SAMPLE NUMBER | REMARKS

X = Petrography

MP = Micropaleontology & palynology

1930

1931

— START CORE 2

1932

coal-clasts

flat lamination

Finely flat-laminated sands with bioturbation.

1933

micro faults

Coal clasts and laminae.

1934

bioturbation

Abundant micro-fractures.

flat lamination

Soft sediment de-formation.

1935

shaleclasts

Slumping, shale-clasts at base.

1936

loose sand w. coal-clasts

Loose sand with abundant coal and shale clasts.

1937

shaleclasts

X

1938

Sequences of finely laminated sands with shale rip-up clasts at base.

1939

1940

loose sand w. coal-clasts

Loose sand with large and abun-dant coal and shale clasts.

1941

1942

black

— END CORE 2

1943

1944

— START CORE 4

grey

massive

Massive, structure-less mudstone with gradational boun-dary to

X

1945

Finely laminated silty shale with weak bioturbation.

MP

laminated

1946

X Gradual transition from sand into shale at top.

1947

Poorly sorted granular-pebbly sand. Well-rounded 1 cm large pebbles scattered

1948

X or in diffuse layers.

1949

1950

UND

SPECIAL CORE DESCRIPTION

FIELD 34/10 – DELTA EAST | WELL NO. 34/10–13 | AREA NORTH SEA

CORE NO. 4.5 & 6 | INTERVAL from 1950 to 1974 m | REMARKS

FORM. STATFJORD | GEOLOGIST O.A. Malm | DATE Jan. 1982

MAIN ENVIRONMENT | SUB ENVIRONMENT | DEPTH | LITHOLOGY | GRAIN SIZE AND SEDIMENTARY STRUCTURES (cl si vf f m c vc) | HORIZONTAL ○PERMEABILITY (mD) 5 10 50 100 500 1000 5000 | ●POROSITY (%) 10 20 30 | SAMPLE NUMBER | REMARKS

1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
UND

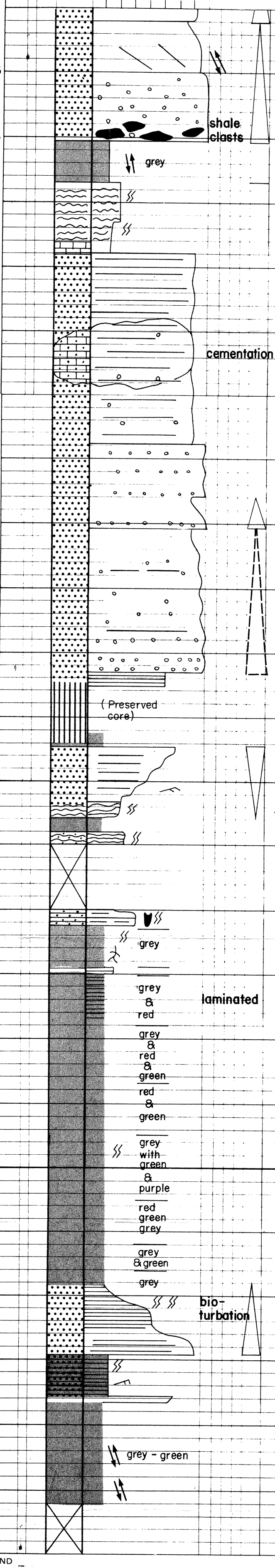
grey
black
grey
black
grey
black
root structures
(preserved core)
slumping
loose sand
white-grey
grey
black
grey with minor red (first occur. from above)
funnel shaped burrows
grey w. minor red
green–grey w. red spots
ripples

X
X
Repeated sequences of massive grey mudstone/claystone grading upwards into black carbonaceous claystone.
MP
X
Grey-white sand, rotted and with leached feldspars in upper part.
High-angle fault.
Poorly sorted pebbly sand with large (5 cm) coal fragments passing upwards into carbonaceous finely laminated and slumped sand.
END CORE # 4
START CORE # 5
END CORE # 5
START CORE # 6
Very coarse, poorly sorted pebbly sand w. no structures passing upwards to laminated silt.
X
MP
Structureless massive claystone/mudstone.
X
MP
Laminated, bioturbated silt/sandstone.
Bioturbated, weakly laminated grey mudstone/claystone. Vertical burrows.
X
Weakly laminated siltstone grading up into massive grey mudstone.
Sand interbedded with thin (cm) shale layers.
MP
END CORE # 6

SPECIAL CORE DESCRIPTION

FIELD 34/10 DELTA EAST | WELL NO. 34/10 - 13 | AREA NORTH SEA
CORE NO. 7 & 8 | INTERVAL from 1974 to 1998 m | REMARKS
FORM. STATFJORD | GEOLOGIST O. A. Malm | DATE Jan. 1982

MAIN ENVIRONMENT | SUB ENVIRONMENT | DEPTH | LITHOLOGY | GRAIN SIZE AND SEDIMENTARY STRUCTURES (cl si vf f m c vc) | HORIZONTAL ○PERMEABILITY (mD) 5 10 50 100 500 1000 5000 | ●POROSITY (%) 10 20 30 | SAMPLE NUMBER | REMARKS



1974 — START CORE # 7

1975 — High-angle faults.

1976 — Very coarse, poorly sorted sand with scattered pebbles. Shale rip-up clasts at base.

1976 — X MP

1978 — Very coarse, poorly sorted massive sand with weak horisontal lamination.

1979 — MP Calcite cementation.

1981 — Very coarse, poorly sorted pebbly massive sand interbedded with coarse sand with weakly defined flat lamination.

1983 — X

1985 — Flat laminated sand.

1986 — Laminated bioturbated silt grading upwards into diffusly laminated sand.

1987 — Ripples ?

1987 — MP END CORE # 7

1988 — START CORE # 8

1988 — At top finely laminated sand with vertical, funnel shaped clay-filled burrows.

1989 — MP Laminated grey and red shale.

1990 — Structureless, massive mudstone, possibly thoroughly bioturbated. Irregular, mottled distribution of red, green and grey colours. At top laminated grey and red.

1992 — X

1994 — Sand with sharp base, grading upwards into finely laminated bioturbated clay.

1995 — Finely laminated shale.

1995 — X MP

1996 — Strongly fractured mudstone with slickensides.

1997 — END CORE # 8

SPECIAL CORE DESCRIPTION

FIELD 34/10 - DELTA EAST | WELL NO. 34/10 - 13 | AREA NORTH SEA

CORE NO. 9, 10 & 11 | INTERVAL from 1999 m to 2023m | REMARKS

FORM. STATFJORD | GEOLOGIST O.A. Malm | DATE Jan. 1982

MAIN ENVIRONMENT | SUB ENVIRONMENT | DEPTH | LITHOLOGY | GRAIN SIZE AND SEDIMENTARY STRUCTURES (cl si vf f m c vc)

HORIZONTAL ○PERMEABILITY (mD): 5 10 50 100 500 1000 5000

●POROSITY (%): 10 20 30

SAMPLE NUMBER | REMARKS

1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023

(Preserved core)

grey – black

shale clasts

x-bedding

(Preserved core)

x-bedding

grey

grey

yellow (-red)

grey

yellow

grey

UND

— START CORE # 9

Very coarse pebbly sand at base grading upwards into moderatly sorted sand w. low-angle lamination.

Diffusly laminated coarse to very coarse and pebbly sand.

MP
X Silty shale at base grading upwards into massive pebbly very coarse sand.

X
MP Sand w. shale clasts at base grading up into claystone.

— END CORE # 9

— START CORE # 10

Planar multi-directional cross-bedding.

MP

X Planar multi-directional cross-bedding.

— END CORE # 10

— START CORE # 11

Massive grey claystone with mottled green colouration.

X

X Rootlets.

Massive structureless claystone.

SPECIAL CORE DESCRIPTION

FIELD 34/10- DELTA EAST | WELL NO. 34/10 - 13 | AREA NORTH SEA

CORE NO. 11 & 12 | INTERVAL from 2023 m to 2047 m | REMARKS

FORM. STATFJORD | GEOLOGIST O.A. Malm | DATE Jan. 1982

MAIN ENVIRONMENT | SUB ENVIRONMENT | DEPTH | LITHOLOGY | GRAIN SIZE AND SEDIMENTARY STRUCTURES (cl si vf f m c vc)

HORIZONTAL ○PERMEABILITY (mD): 5 | 10 | 50 | 100 | 500 | 1000 | 5000

●POROSITY (%): 10 | 20 | 30

SAMPLE NUMBER	REMARKS
MP	Interbedded fine sand, silt and clay with flat laminations and ripples (?).
X	
	Abundant coal-laminae.
	Ripples.
	Massive, very coarse pebbly, poorly sorted sand.
MP	10-12 cm thick coal layer with pyrite.
X	
X	Strongly fractured claystone/ mudstone with slickensides.
	END CORE 11
	START CORE 12
MP	Poorly sorted very coarsegr. sand. Strongly disrupted due to pedoturbation (?) and or collapse during coring.
	Loose with grey-white colour due to abundant secondary kaolinite formed through leaching of feldspar and mica. Weak oil stain.
	Massive siderite/ dolomite cementation at base.
	Irregularly laminated and bioturbated siltstone.
X	Scattered calcite nodules. Massive calcite cement at base.
	END CORE #12

2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047

grey

coal

(Preserved core)

grey

grey

grey (- green/yellow)

carbonate cementation

(Preserved core)

grey

red (- orange - yellow)

green & purple

calcite nodules

UND

SPECIAL CORE DESCRIPTION

FIELD 34/10 - DELTA EAST | WELL NO. 34/10-13 | AREA NORTH SEA

CORE NO. 13 & 14 | INTERVAL from 2047m to 2071m | REMARKS

FORM. STATFJORD | GEOLOGIST O.A. Malm | DATE JAN. 1982

MAIN ENVIRONMENT | SUB ENVIRONMENT | DEPTH | LITHOLOGY | GRAIN SIZE AND SEDIMENTARY STRUCTURES (cl si vf f m c vc)

HORIZONTAL ○PERMEABILITY (mD): 5 10 50 100 500 1000 5000

●POROSITY (%): 10 20 30

SAMPLE NUMBER	REMARKS
—	START CORE # 13
X	Massive coarse - very coarse poorly sorted sand. Loose with grey-white colours due to abundant kaolinite. Disruption due to pedoturbation and /or collapse during coring.
X	Weak oil-stain.
	Calcite-nodules.
	Large (dm-scale) root-structures filled with calcite.
MP	Massive calcite-cementation.
	Large root-structures filled with silt/sand.
	Calcite infilling of roots.
	Calcite filled root-structures and nodules.
	50 cm long, 2 cm thick root, in red claystone infilled with silt from above.
X	
	shale laminae
	carbonate cementation
—	END CORE # 13
—	START CORE # 14
X	Finely laminated grey and red shale in alternation.
	Massive sand. Loose, grey-white due to abundant kaolinite.
X	Disrupted/collapsed in upper part.
X	Gradual transition into shale at top.
	1 cm thick shale laminae with - 5-10 cm spacing in sand
	laminated
	grey - black w. minor red laminae
	grey—green
	(Preserved core)
	UND

SPECIAL CORE DESCRIPTION

FIELD 34/10 DELTA EAST | WELL NO. 34/10-13 | AREA NORTH SEA

CORE NO. 14 & 15 | INTERVAL from 2071m to 2086m | REMARKS

FORM. STATFJORD Fm. | GEOLOGIST O.A. Malm | DATE Jan. 1982

MAIN ENVIRONMENT | SUB ENVIRONMENT | DEPTH | LITHOLOGY | GRAIN SIZE AND SEDIMENTARY STRUCTURES (cl si vf f m c vc)

HORIZONTAL ○PERMEABILITY (mD) 5 10 50 100 500 1000 5000

●POROSITY (%) 10 20 30

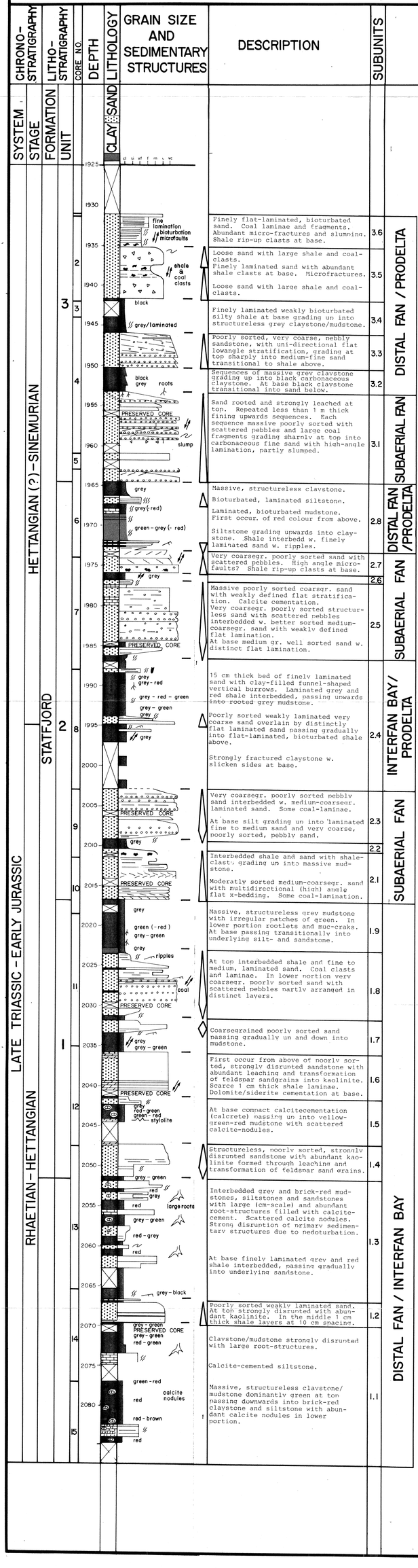
SAMPLE NUMBER | REMARKS

2071
2072 yellow – grey
2073 red (-yellow)
2074 Shale laminae — Massive calcite-cementation.
2075 MP — END CORE #14
2076
2077 yellow – red — START CORE # 15
2078 calcite nodules — X — Scattered calcite nodules.
2079 red — X
2080 MP
2081 red – brown
2082
2083 red – brown abundant calcite nodules — Abundant calcite nodules.
2084 MP
2085 red — X
2086 — END CORE # 15

UND

34/10-13 STATFJORD FORMATION
Sedimentological Description and Interpretation of Cores

SYSTEM: TRIASSIC – JURASSIC
STAGE: RHAETIAN – HETTANGIAN
FORMATION: HETTANGIAN (?) – SINEMURIAN
UNIT: STATFJORD
CORE NO: 1 2 3

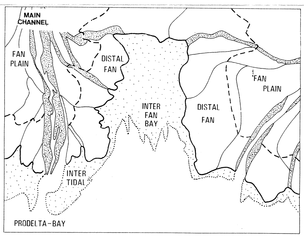


DESCRIPTION

SUBUNITS	DESCRIPTION
3.6	Finely flat-laminated, bioturbated sand. Coal laminae and fragments. Abundant micro-fractures and slumping. Shale rip-up clasts at base.
3.5	Loose sand with large shale and coal-clasts. Finely laminated sand with abundant shale clasts at base. Microfractures. Loose sand with large shale and coal-clasts.
3.4	Finely laminated weakly bioturbated silty shale at base grading up into structureless grey claystone/mudstone.
3.3	Poorly sorted, very coarse, nebbly sandstone, with uni-directional flat lowangle stratification, grading at top sharply into medium-fine sand transitional to shale above.
3.2	Sequences of massive grey claystone grading up into black carbonaceous claystone. At base black claystone transitional into sand below.
3.1	Sand rooted and strongly leached at top. Repeated less than 1 m thick fining upwards sequences. Each sequence massive poorly sorted with scattered pebbles and large coal fragments grading sharply at top into carbonaceous fine sand with high-angle lamination, partly slumped.
2.8	Massive, structureless claystone. Bioturbated, laminated siltstone. Laminated, bioturbated mudstone. First occur. of red colour from above. Siltstone grading upwards into claystone. Shale interbedd w. finely laminated sand w. ripples.
2.7	Very coarsegr. poorly sorted sand with scattered pebbles. High angle micro-faults? Shale rip-up clasts at base.
2.6	
2.5	Massive poorly sorted coarsgr. sand with weakly defined flat stratification. Calcite cementation. Very coarsegr. poorly sorted structurless sand with scattered pebbles interbedded w. better sorted medium-coarsegr. sand with weakly defined flat lamination. At base medium gr. well sorted sand w. distinct flat lamination.
2.4	15 cm thick bed of finely laminated sand with clay-filled funnel-shaped vertical burrows. Laminated grey and red shale interbedded, passing upwards into rooted grey mudstone. Poorly sorted weakly laminated very coarse sand overlain by distinctly flat laminated sand passing gradually into flat-laminated, bioturbated shale above. Strongly fractured claystone w. slicken sides at base.
2.3	Very coarsegr. poorly sorted nebbly sand interbedded w. medium-coarsegr. laminated sand. Some coal-laminae. At base silt grading un into laminated fine to medium sand and very coarse, poorly sorted, pebbly sand.
2.2	
2.1	Interbedded shale and sand with shale-clasts grading un into massive mudstone. Moderatly sorted medium-coarsegr. sand with multidirectional (high) angle flat x-bedding. Some coal-lamination.
1.9	Massive, structureless grey mudstone with irregular patches of green. In lower portion rootlets and muc-craks. At base passing transitionally into underlying silt- and sandstone.
1.8	At ton interbedded shale and fine to medium, laminated sand. Coal clasts and laminae. In lower portion very coarsegr. poorly sorted sand with scattered pebbles partly arranged in distinct layers.
1.7	Coarsegrained poorly sorted sand passing gradually un and down into mudstone.
1.6	First occur from above of poorly sorted, strongly disrunted sandstone with abundant leaching and transformation of feldspar sandgrains into kaolinite. Scarce 1 cm thick shale laminae. Dolomite/siderite cementation at base.
1.5	At base compact calcitecementation (calcrete) passing un into yellow-green-red mudstone with scattered calcite-nodules.
1.4	Structureless, poorly sorted, strongly disrunted sandstone with abundant kaolinite formed through leaching and transformation of feldspar sand grains.
1.3	Interbedded grey and brick-red mudstones, siltstones and sandstones with large (cm-scale) and abundant root-structures filled with calcite-cement. Scattered calcite nodules. Strong disrunption of primary sedimentary structures due to nedoturbation. At base finely laminated grey and red shale interbedded, passing gradually into underlying sandstone.
1.2	Poorly sorted weakly laminated sand. At top strongly disrunted with abundant kaolinite. In the middle 1 cm thick shale layers at 10 cm spacing.
1.1	Clavstone/mudstone strongly disrunted with large root-structures. Calcite-cemented siltstone. Massive, structureless claystone/mudstone dominantly green at ton passing downwards into brick-red claystone and siltstone with abundant calcite nodules in lower portion.

SUBUNITS: 3.6, 3.5, 3.4, 3.3, 3.2, 3.1 — DISTAL FAN / PRODELTA
SUBUNITS: 2.8, 2.7, 2.6, 2.5 — SUBAERIAL FAN
SUBUNITS: 2.4, 2.3, 2.2, 2.1 — INTERFAN BAY / PRODELTA
SUBUNITS: 1.9, 1.8, 1.7, 1.6, 1.5, 1.4, 1.3, 1.2, 1.1 — DISTAL FAN / INTERFAN BAY

DISCUSSION AND INTERPRETATION OF SEDIMENTARY FACIES AND ENVIRONMENT



GENERAL MODEL

IN ACCORDANCE WITH A REGIONAL SEDIMENTOLOGICAL STUDY OF THE STATFJORD FM. BY RØE, STEEL & LARSEN (*) AND RØE (**) THE FORMATION IS HERE INTERPRETED AS (PART OF) A FAN DELTA SYSTEM (ALLUVIAL FANS BUILDING OUT ALONG A LOW ENERGY COASTLINE).
IN 34/10-13 THE FORMATION IS CHARACTERIZED BY A PRONOUNCED ALTERNATION OF THICK (5-10 M) CLAYSTONES/MUDSTONES/SHALES AND COARSE-GRAINED SANDSTONES AND PROBABLY REPRESENTS THE DISTAL PARTS OF SUCH A FAN DELTA SYSTEM.

THE CLAYSTOMES/MUDSTONES

IN THE FACIES MODEL ADOPTED, CLAY/MUD DEPOSITION AND ACCUMULATION TAKE PLACE IN BETWEEN FAN LOBES AND IN FRONT OF THEM IN SHALLOW LAGOONS AND BAYS OF LACUSTRINE, BRACKISH AND MARINE WATERS.

THIS WELL

MOST OF THE CLAYSTONE HORIZONS SHOW SOME EVIDENCE OF BIOTURBATION WHICH SUGGEST VARYING DEGREE OF MARINE INFLUENCE THROUGHOUT THE DEPOSITION OF MOST OF THE FORMATION.
SHALLOW WATER WITH OCCASIONAL EVAPORATION TO DRYNESS IS INTERPRETED FROM MUD-CRACKS AND STRONG RED COLOURING DUE TO SUBAERIAL OXIDATION. LAGOON ENVIRONMENTS ARE INTERPRETED FROM BLACK CARBONACEOUS MUDSTONES, ROOTLETS AND ABUNDANT COAL FRAGMENTS IN SANDSTONES. DECREASING RED COLOURATION AND INCREASING LAMINATION AND BIOTURBATION UPWARDS INDICATE INCREASING MARINE INFLUENCE THROUGH TIME. ARID CONDITIONS AND PROLONGED SUBAERIAL EXPOSURE ARE INDICATED IN THE LOWER PART OF THE FORMATION BY ABUNDANT RED & GREEN COLOURATION AND STRONG PEDOTURBATION (LARGE ROOTS) WITH FORMATION OF CALCRETES (SOIL PROFILES WITH CALCITE PRECIPITATION/CEMENTATION).

THE SANDSTONES

THE STUDIES REFERRED TO ABOVE INDICATE A SUBDIVISION OF THE SANDS INTO TWO MAIN FACIES ASSOCIATIONS:

1) SUBAERIAL FACIES
   - A) MAIN CHANNEL FACIES (CONFINED FLOW)
   - B) FAN PLAIN FACIES (UNCONFINED FLOW)
2) DISTAL FAN FACIES (PARTLY SUBAQUEOUS)

THE SUBAERIAL FACIES ARE DESCRIBED AS POORLY SORTED MEDIUM/VERY COARSEGRAINED PARTLY CONGLOMERATIC, SOMETIMES WITH MUDCLASTS, COAL STREAKS AND COAL FRAGMENTS. MOST COMMON SEDIMENTARY STRUCTURES ARE DIFFERENT TYPES OF CROSS-STRATIFICATION OR PARALLEL LAMINATION. IN GENERAL A) ARE THICKER BEDDED, OVERALL COARSER WITH MORE DISTINCT X-STRATIFICATION THAN B) WHICH HAVE LESS WELL-DEFINED LAMINATION, ARE OVERALL LESS COARSE AND HAVE ABUNDANT CLAY CLASTS AND DRAPES. BOTH A) AND B) ARE CHARACTERIZED BY A REPETITION OF THIN (< 1 M) FINING UPWARDS SEQUENCES INDICATING RAPIDLY VARYING DISCHARGE (FLOOD PERIODS ?).

THE DISTAL FAN FACIES ARE OVERALL FINER GRAINED AND ARE OFTEN ARRANGED INTO SMALL (< 60 CM) UPWARD COARSENING SEQUENCES OR INVERSE-NORMAL GRADED (CU-FU) SEQUENCES. THERE IS A MARKED ABSENCE OF CROSS-STRATIFICATION. GRADATIONAL BOUNDARIES, FLAT LAMINATION, BIOTURBATION SOFT SEDIMENT DEFORMATION AND SLUMPING ARE COMMON.

BOTH THE SUBAERIAL AND DISTAL FAN FACIES INCLUDE COARSE-GRAINED, MASSIVE, POORLY SORTED SANDSTONES WITH A HIGH CLAY-MATRIX CONTENT. THESE ARE INTERPRETED TO REPRESENT HIGH DENSITY CURRENTS/MASSFLOWS.

THIS WELL

SOME OF THE SAND SEQUENCES DISPLAY STRUCTURAL AND TEXTURAL CHARACTERISTICS WHICH MAKE IT POSSIBLE TO GROUP THEM WITHIN THE FRAMEWORK DESCRIBED ABOVE.

- EXAMPLES OF CHANNELS FACIES (CONFINED FLOW) COULD BE SUBUNITS 2.7 AND 2.1 WHICH BOTH DISPLAY MULTIDIRECTIONAL CROSS-STRATIFICATION.
- EXAMPLES OF FAN PLAIN FACIES COULD BE SUBUNITS 3.1, 2.3 WHICH BOTH DISPLAY REPEATED THIN (< 1 M) UPWARD FINING SEQUENCES TYPICAL OF BRAIDED STREAMS (UNCONFINED FLOW).
- EXAMPLES OF DISTAL FAN FACIES COULD BE 3.6 AND MANY OF THE OTHER FINELY LAMINATED AND BIOTURBATED SANDS FOUND THROUGH MOST OF THE FORMATION.
- EXAMPLES OF MASS FLOWS COULD BE 2.5, 1.8, 1.6, 1.4 AND 1.2 WHICH ARE ALL POORLY SORTED AND FAIRLY MASSIVE.

HOWEVER, THESE GROUPINGS ARE SPECULATIVE AND THE SUBDIVISION INTO FACIES ASSOCIATIONS SHOWN HERE IS THEREFORE ONLY TENTATIVE.

IT SHOULD BE NOTICED THAT MOST OF THE SAND HORIZONS SHOW GRADUAL TRANSITIONS TO THE CLAYSTONES ABOVE AND BELOW, AND ARE, LIKE THESE, OFTEN LAMINATED AND BIOTURBATED IN THE TRANSITION-ZONES. THIS INDICATES THAT DEPOSITION OF THE SANDS OFTEN STARTED AND TERMINATED INTO STANDING WATER (LAGOONS AND BAYS). IT IS THEREFORE INTERPRETED THAT DEPOSITION OF A MAJOR PART OF THE COARSE SANDS ALSO TOOK PLACE IN STANDING WATER BY FLUVIAL SYSTEMS (TRACTION CURRENTS AND MASS FLOWS) DISCHARGING INTO LAGOONS AND BAYS. IF THIS IS SO THE STATFJORD FM. OF 34/10-13 CAN BE CLASSIFIED AS AN OVERALL DISTAL FAN DELTA DEPOSIT.

REFERENCES

* S.L. RØE, R. STEEL, V. LARSEN: "STATFJORD FORMATION IN BLOCKS 33/9, 33/12, 34/10, 30/6, 30/3, 31/4, 31/2, A FACIES ANALYSIS FROM CORES". INTERN RAPPORT. STATOIL, JUNI 1981.

** S.L. RØE, "THE STATFJORD FORMATION". INTERN RAPPORT. STATOIL, DEC. 1981.

statoil
Den norske stats oljeselskap a.s

34/10-13 STATFJORD FM.
Sedimentological Description and Interpretation of Cores

O.A. Malm
Geologisk Laboratorium

Skala:	
Original arb. av:	O.A.M.
Tegnet av:	V.M.
Kontrollf av:	
Dato:	25.3.82
Revidert: 1)	
2)	
3)	
Arkiv nr.:	
Tegning nr.:	X-04218