# FINAL WELL REPORT

# GEOLOGY

# AND

# RESERVOIR EVALUATION

# WELL

# 15/12-15

# Table of Content

# 1 Objectives

**Main objective:**

Drill to Middle Jurassic/Triassic strata with the aim to explore the hydrocarbon bearing potential of Oxfordian age (Upper Jurassic) sandstones analogues to the Varg West.

**Secondary objectives:**

- Assess hydrocarbon potential of Kimmeridge age sandstone immediately above the main Oxfordian reservoir.
- Measure reservoir pressure and fluid gradients.
- Assess the reservoir quality of the Upper Jurassic target reservoir. Assess reservoir geometry.
- Confirm geophysical model in terms of depth to top and base reservoir.

# 2 Operational summary

The well was drilled at location 58° 2` 43.92`` N and 1° 52` 22.98`` E (UTM 6434481.04 N 433470.04 E) by the Odfjell Drilling's rig 'Deepsea Trym'. Wellbore entry date was 19 November 2004 with completion date 21 December 2004 and was conducted without any serious injuries or discharge to the environment. The drilling contractor was Odfjell Drilling while the main operational contractor was Halliburton. Well 15/12-15 was drilled down to 3300m (all depths are MD RKB) logging with LWD. The well penetrated the secondary target reservoir (Kimmeridgian age) at 3045 m and the main reservoir target (Oxfordian age) at 3140.5 m. The sand was water bearing and the well was permanently plugged and abandoned.

Water based mud was used in the well (Environmul).

Maximum deviation in the well was 1.91 degrees at 2842 m. At TD the distance from vertical was 27.6 m towards ENE.

The log data recorded exhibit good quality. The hole appears to be in-gauge in most of the reservoir section, based on the SCOR curve (Smoothed Density Quality), the APPC curve (acoustic caliper) and surface parameters. The data in the sections that are over-gauged is corrected based on the ACAL curve by Halliburton.

No environmental corrections, other than what was applied by Halliburton, have been applied to the data. All log data originate from LWD, and no depth shifts were therefore necessary.

# 3 Results

Well 15/12-15 penetrated the Oxfordian sandstone of reservoir zone 1 (RZ 1-1) at 3140.5m MD. The sand was encountered 92 m TVDSS deeper than expected, and was water-wet. The overlying Kimmeridgian sands within the Heather Formation were approximately 96 metres thicker than prognosed and were also water-wet (Figure 4-1). A week possible fluorescents was reported from cuttings within the reservoir but analysis undertaken by Applied Petroleum Technology revealed no evidence for hydrocarbons of any kind.

The reservoir was found to be pressure depleted. After completion of the logging program, the well was permanently plugged and abandoned.

# 4 Biostratigraphy

Biostratigraphical evaluation was carried out offshore during drilling and additional samples were analysed onshore. The samples were primarily from the Jurassic formations. Micropalaentological and palynological analyses have formed the basis for the biostratigraphical interpretation of the well. The analyses were performed on ditch cuttings. Table 3-1 shows the individual palynological analysis results. For more details about the biostratigraphy, see Appendix I 'Well 15/12-15 – Biostratigraphy' by APT (Applied Petroleum Technology).

The first sand encountered was of Kimmeridgian age (Heather Formation), indicating re-deposition of Late Oxfordian sand in Kimmeridgian time. Below this, Late Oxfordian sand (RZ1-1 and RZ1-2) was penetrated. Reservoir zone 2 appears to be missing while a sand rich succession of Middle Oxfordian age was encountered, reservoir zone 3-1 and a thin RZ 3-2. This sand is the same as in the upper part of the discovery well 15/12-12.

# 5 Well to seismic correlation

This was undertaken by PGS Reservoir after the drilling operation was concluded and their report is attached as Appendix II.

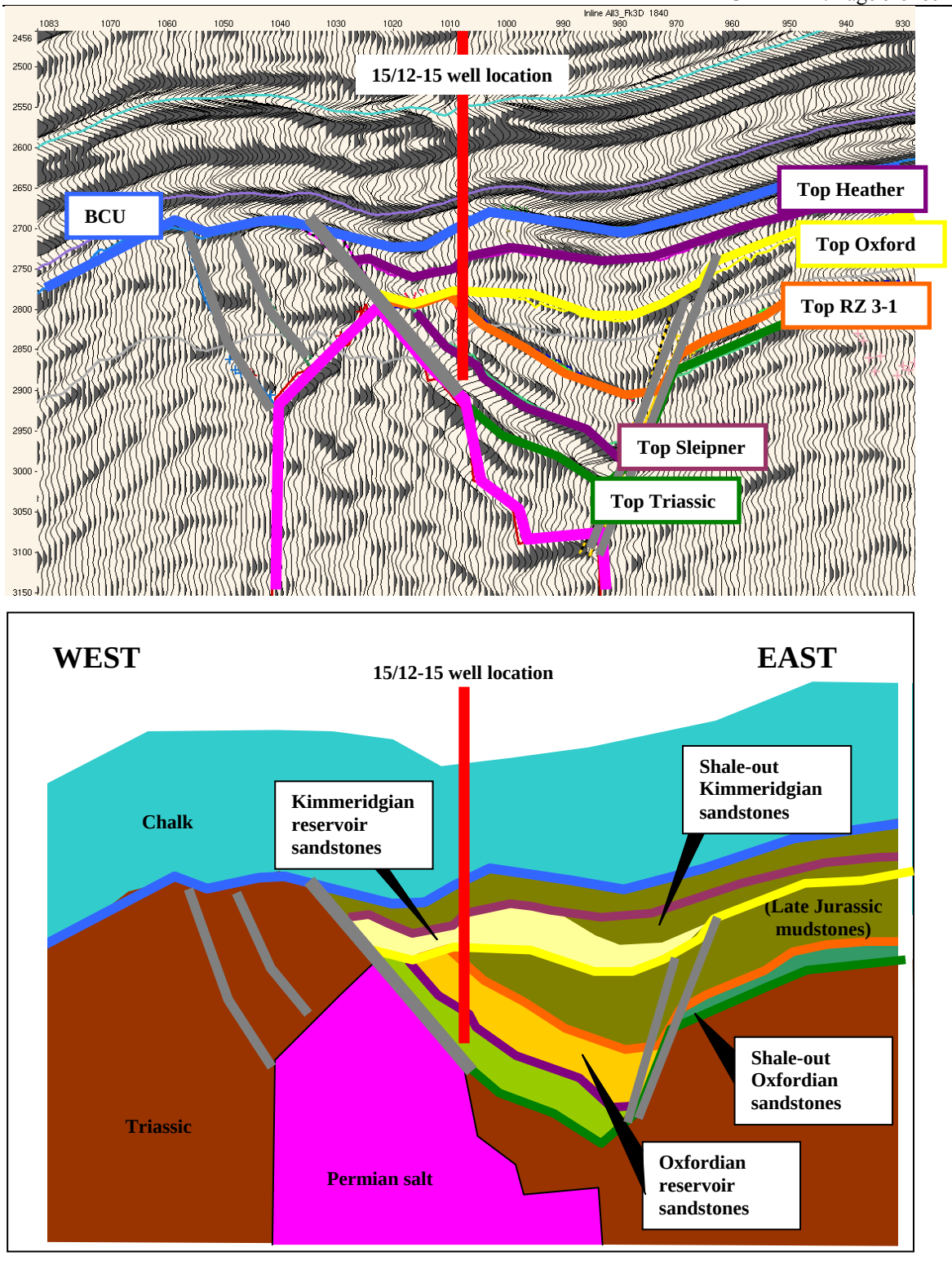


***Figure 4-1. East-west seismic section through reservoir section of well 15/12-15 and schematic interpretation of the geology as encountered in the well of the same line below.***

| Summary Biostratigraphy 15/12-15 | | | |
|---|---|---|---|
| **Depth** | **Bio Event no.** | **Age** | **Lithostratigraphy** |
| 2190 | | Eocene | Hordaland |
| 2927 | | Valanginian | Cromer Knoll (Heather) |
| 2936 | | Ryazanian | Heather (reworked) |
| 2963 | B 11 | Middle-Early Kimmeridgian | Heather (Draupne cvgs?) |
| 2978 | B 11 | | Heather (Draupne cvgs?) |
| 2999 | B 19 | Middle-Early Kimmeridgian | Heather |
| 3008 | B 19 | | Heather (Draupne cvgs?) |
| 3062 | B 19 | | Heather |
| 3089 | B 19 | | Heather |
| 3125 | B 19 | | Heather |
| 3134 | B 19 | | Heather |
| 3143 | B 26-B28? | Late Oxfordian | RZ 1-1 |
| 3152 | B 26-28 | | RZ 1-1 |
| 3161 | B 27-31 | | RZ 1-2 |
| 3170 | B 27-31 | | RZ 1-2 |
| 3179 | B 27-31 | | RZ 1-2 |
| 3188 | B 52-55 | Middle Oxfordian | RZ 3-1 |
| 3197 | B 57 | | RZ 3-1 |
| 3206 | | | |
| 3215 | B 57 | | RZ 3-1 |
| 3224 | | | |
| 3233 | B 57 | | RZ 3-1 |
| 3242 | B 57 | | RZ 3-1 |
| 3251 | | | |
| 3260 | | | |
| 3275 | B61 | Early Oxfordian | RZ3-2 |
| 3278 | B 73 | Bajocian?-Bathonian | Sleipner Fm, Middle Jur. |

***Table 3-1: Biostratigraphical analysis well 15/12-15 (all depths in mMDRKB): Bioevents number refers to the highly detailed biostratigraphical break-down of the reservoir section established by Pertra***

# 6 Lithostratigraphy

All depths are in m MD (RKB elevation is 25 m).

The summary is compiled based on the biostratigraphical interpretation made on ditch cuttings. MWD logs were used to aid lithological interpretation and to place formation boundaries. The formation tops are summarised in Table 4-1.

Above 1370 mMD the well was drilled with returns to seabed, and the interpretations in this section is based on MWD logs only. An east-west seismic section through the well path elucidating the main formations and casing program is shown in Figure 4-2

| Summary Lithostratigraphy | | | | | | |
|---|---|---|---|---|---|---|
| **Formations** | **Prognosis** | | **Actual** | | **Difference** | |
| | **mMD/RKB** | **mTVD/MSL** | **mMD/RKB** | **mTVD/MSL** | **mMD** | **mTVD** |
| Seabed | 113 | 88 | 113 | 88 | - | - |
| Utsira | 1144 | 1119 | 1069.5 | 1044.5 | -74.5 | -74.5 |
| Hordaland | 1288 | 1263 | 1301.5 | 1276.5 | +13.5 | +13.5 |
| Rogal/Balder | 2447 | 2422 | 2448 | 2423 | +1 | +1 |
| Shetland | 2631 | 2606 | 2655 | 2630 | +24 | +24 |
| Cromer Knoll | | | 2881 | 2856 | | |
| Draupne Fm. (BCU) | 2892 | 2867 | 2956.35 | 2931.35 | +64.35 | +64.35 |
| Heather Fm. | | | 2962 | 2937 | | |
| Kimm. Sst. | 3018 | 2993 | 3044.85 | 3020 | +26.80 | +27 |
| RZ 1-1 | 3049 | 3024 | 3140.5 | 3115.5 | +91.5 | +91.5 |
| RZ 1-2 | | | 3159.7 | 3134.7 | | |
| RZ 3-1 | 3092 | 3067 | 3185 | 3160 | +93 | +93 |
| RZ 3-2 | | | 3275 | 3247 | | |
| Sleipner | | | 3279 | 3253.50 | | |
| Triassic | 3188 | 3163 | * | * | | |
| TD | 3238 | 3213 | 3300 | 3275 | +62 | +62 |

* = well never penetrated the Triassic

***Table 4-1: Lithostratigraphy***

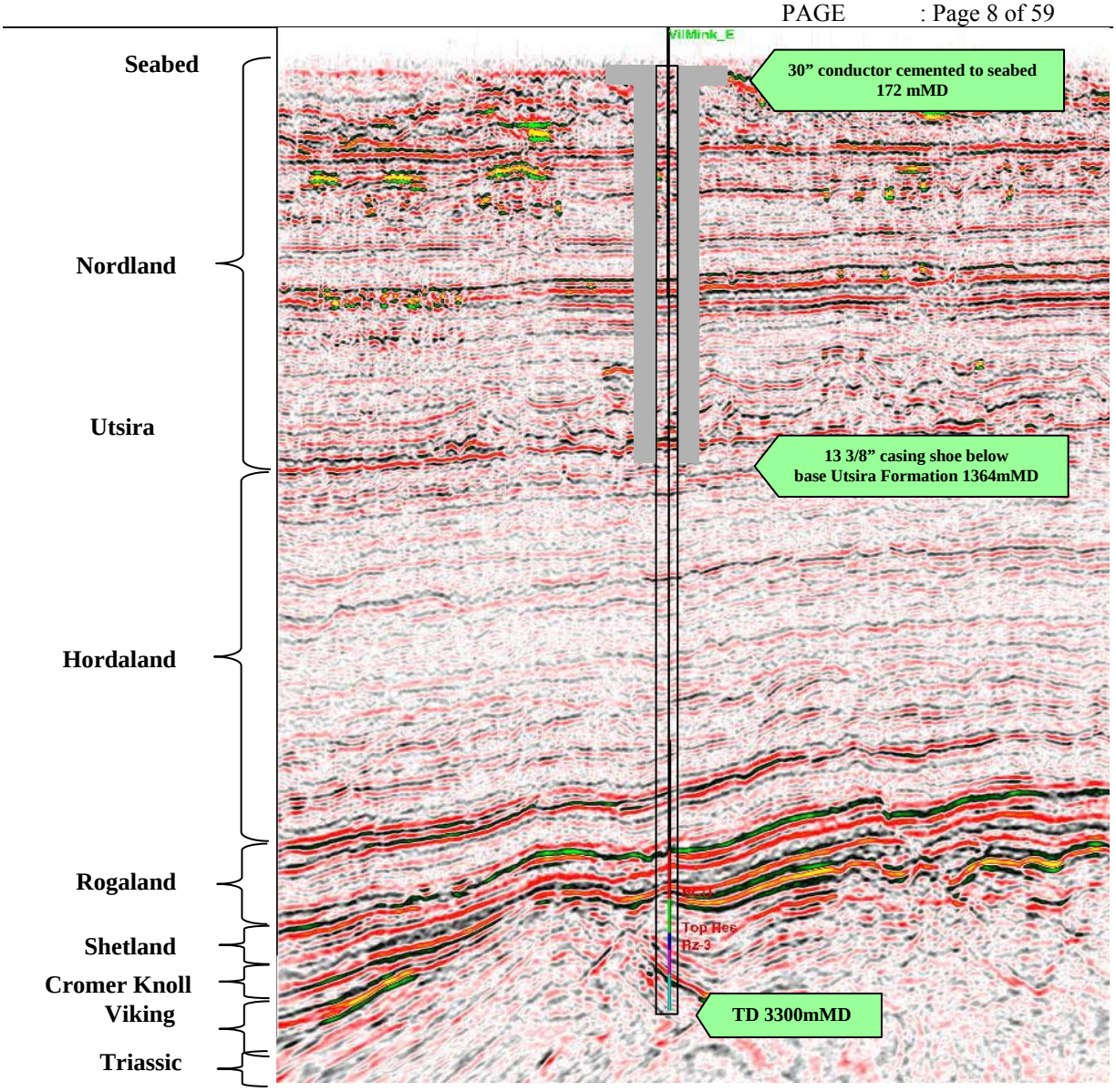


***Figure 4-2. Seismic section through well path well 15/12-15 (for details of reservoir section see Figure 4-1).***

## 6.1 Nordland Gr. ( 113-1301.5 m)

This interval was drilled with returns to seabed.

## 6.2 Hordaland Gr. (1301.5 – 2448.0 m)

Claystone with stringers of Limestone and minor Dolomite.

Claystone: Olive brown to olive black and brownish black. Towards the base of the interval the Claystone becomes greenish grey to medium dark grey. The Claystone is firm, occasionally moderately hard, sub-blocky and contains micro Pyrite.

Limestone: Very light grey to yellowish brown to brownish grey, hard to firm, occasionally soft, brittle, sub-blocky, argillaceous in parts, occasionally slightly silty, glauconitic and cherty.

Dolomite: Olive grey to yellowish brown to moderate brown, hard to very hard, blocky and crystalline.

## 6.3 Rogaland Gr. (2448.0 – 2655.0 m)

**Balder (2448.0 – 2459.0 m):**

Claystone and Tuffaceous Claystone.

Claystone: Dark greenish grey, hard, occasionally very hard, blocky to subblocky, splintery, non-calcareous.
Tuff Clayst: Varicolored, pale blue to grey bluish green to greyish green to grey bluish green, blocky, laminated, sucrosic, non calcareous, black speckles in parts.

**Sele (2459.0 – 2512.0 m):**

Claystone with Limestone stringers and traces of Dolomite.

Claystone: Medium grey to olive grey to olive black, firm to hard, blocky to sub-blocky, non-calcareous, slightly silty, occasionally micropyritic.
Limestone: Light olive grey to brownish grey, soft to firm, occasionally hard, dolomitic in parts
Dolomite: Yellowish brown, very hard, splintery.

**Lista (2512.0 – 2635.5 m):**

Claystone with Limestone stringers.

Claystone: Medium bluish grey, dark greenish grey, brownish to light brownish grey towards bottom, firm, blocky to sub-blocky, non calcareous, slightly silty, traces of carbonaceous material.

Limestone: Off white to light olive grey to light brownish grey, soft to firm, occasionally hard, glauconitic in parts.

**Våle (2635.5 – 2655 m):**

Calcareous Claystone.

Claystone: Medium grey to medium dark grey, firm, sub-blocky in parts, very calcareous, carbonaceous speckles.

## 6.4 Shetland Gr. (2655.0 – 2881.0 m)

Limestone and Marl.

Limestone: Predominately off white, also multicoloured varying between very light grey to pinkish grey, light brownish grey to medium grey, greenish grey to olive grey and yellowish brown to moderate brown, firm to soft, blocky to sub-blocky, slightly argillacesous, slightly glauconitic.

Marl: Light olive grey, greenish grey, dark yellowish brown, soft to firm, blocky to sub-blocky with traces of and Glauconite, argillaceous to slightly silty in parts.

## 6.5 Cromer Knoll Gr. (2881.0 – 2956.35m)

Varicoloured Marls with Limestone stringers.

Marl: Moderate brown to light olive grey to medium light grey, blocky and occasionally argillaceous.

Limestone: Very light grey, firm to moderate hard, blocky, microcrystalline, slightly argillaceous in parts.

## 6.6 Viking Gr (2956.36 – 3279.0 m)

### Draupne Fm. (2956.35 - 2962.0m)

Claystone with thin Limestone stringers in upper part grading to silty Sandstone with Limestone stringers in lower part.

Claystone: Olive black, soft to firm, sub-blocky and very calcareous, slightly silty, traces of carbonaceous material slightly laminated.

Limestone: Very light grey, firm to moderately hard, blocky, microcrystalline, slightly argillaceous in parts.

### Heather Fm. (2962 – 3044.80 m)

Siltstone with downhole decreasing amount of claystone

Limestone: Very light grey, firm to moderately hard, blocky, microcrystalline, slightly argillaceous in parts.

Claystone: Olive black, soft to firm, sub-blocky and very calcareous, slightly silty, traces of carbonaceous material slightly laminated.

### Kimmeridgian sand unit (3044.80 – 3140.5 m)

Sandstone with down-hole decreasing content of siltstone

Siltstone: Olive black, soft, blocky, calcareous cement, slightly argillaceous, slightly micaceous, occasionally very finely sandy.

Sandstone: Olive black, firm, blocky, silty, translucent Quartz, very fine grains, moderately sorted, subangular to subrounded, calcareous cement, slightly micaceous, slightly carbonaceous,

### Oxfordian, RZ 1-1 (3140.5 – 3159.7 m)

Sandstone

Sandstone: Olive grey to medium light grey, clear translucent Quartz, very fine to coarse grains, occasionally very coarse, predominantly very fine to medium, locally predominantly fine to coarse, moderately to poorly sorted, predominantly loose, calcareous and silica cement in parts, locally silty, occasionally carbonaceous streaks and speckles, traces of mica.

### Oxfordian, RZ 1-2 (3159.7 – 3185.0m)

Sandstone as described for RZ 1-1 above

**Oxfordian, RZ 3-1 (3185.0 – 3272.0m)**

Sandstone with minor Claystone:

Sandstone: Silty grading sandy Siltstone in parts, olive grey, clear translucent Quartz, very fine to coarse, occasionally very coarse, predominantly fine to medium, moderate to poorly sorted, subangular to subrounded, calcareous cement in parts, argillaceous and silty and kaolinitic(?) matrix.

**Oxfordian, RZ 3-2 (3275.0 -3279.0m)**

Sandstone and siltstone:

Siltstone: Olive grey to olive black, soft, sandy, argillaceous, calcareous in parts.
Sandstone: Silty, olive grey to olive black, sub-blocky, translucent to milky white Quartz, very fine to medium, predominantly fine, moderately sorted, subangular to subrounded, subspherical, calcareous and silica cement, firm to hard, argillaceous matrix.

## 6.7 Vestland Gp. (3275.0 - 3300m)

**Sleipner Fm. (3272.0 – 3300 m)**

Siltstone and sandstone with Coal beds and Limestone stringers:

Siltstone: Olive grey to olive black, soft, sandy, argillaceous, calcareous in parts.
Sandstone: Silty, olive grey to olive black, sub-blocky, translucent to milky white Quartz, very fine to medium, predominantly fine, moderately sorted, subangular to subrounded, subspherical, calcareous and silica cement, firm to hard, argillaceous matrix.
Coal: Black, firm to moderately hard, brittle, blocky, argillaceous in parts, micropyrittic, grading black carbonaceous Claystone in parts.
Limestone: White to yellowish grey, soft, blocky, microcrystalline.

# 7 Well-site Sample Description

**Pertra as** **Wellsite Sample Description** Page: 2 of: 19

| | | | | | |
|---|---|---|---|---|---|
| Country: | Norway | Area: | North Sea | Field: | Villmink |
| Well: | 15/12-15 | | Sidetracked from well: | | |
| Drill floor Elev. (m): | 25m | Company: | Pertra AS | | |
| Hole size: | 12 1/4" | Geologists: | Steinar Eikemo / Asbjørn Hiksdal | Date: | 02.12.2004 |

| Depth | Lithology | Lithological Description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|
| 1540 | 100 | Clst: olv gry, IP brnsh gry, frm - sft, sbblky, slily slty | |
| 1550 | 100 | Clst: a.a | |
| 1560 | 100 | Clst: a.a | |
| 1570 | 100 | Clst: a.a | |
| 1580 | 100 | Clst: a.a | |
| 1590 | 100 | Clst: a.a | |
| 1600 | 90 | Clst: olv gry - olv blk, sft-frm, sbblky, slily slty, calc - v calc, r Micropyr | |
| | 10 | Ls: yelsh gry - lt gry, frm, blky, microxln | |
| 1610 | 100 | Clst: a.a | |
| | Tr | LS: a.a | |
| 1620 | 100 | Clst: a.a | |
| | Tr | LS: a.a | |
| 1630 | 100 | Clst: a.a | |
| 1640 | 100 | Clst: a.a | |
| | Tr | LS: a.a | |
| 1650 | 100 | Clst: olv gry - dk grnsh gry, frm, sbblky, i/p v calc, i/p wxy | |
| | Tr | LS: a.a | |
| 1660 | 100 | Clst: olv gry - dk grnsh gry, frm, sbblky, v calc, grad v arg Ls | r Tr 1-2cm |
| | Tr | LS: a.a | Cvgs |
| | | | not pressure |
| 1670 | 100 | Clst: a.a | |
| | Tr | LS: a.a | |
| 1680 | 100 | Clst: a.a | |
| | Tr | LS: a.a | |

**Pertra as** **Wellsite Sample Description** Page: 3 of: 19

| | | | | | |
|---|---|---|---|---|---|
| Country: | Norway | Area: | North Sea | Field: | Villmink |
| Well: | 15/12-15 | | Sidetracked from well: | | |
| Drill floor Elev. (m): | 25m | Company: | Pertra AS | | |
| Hole size: | 12 1/4" | Geologists: | Steinar Eikemo / Asbjørn Hiksdal | Date: | 02.11.2004 |

| Depth | Lithology | Lithological Description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|
| 1690 | | Missing | |
| 1700 | 100 | Clst: olv gry - olv blk, frm, sbblky, v calc | |
| | Tr | Ls: yel gry - v lt gry, frm, arg, microxln, | |
| | Tr | Dol: yelsh brn, hd, brit, blky, crpxln, | |
| | | | |
| 1710 | 100 | Clst: a.a | |
| | Tr | LS: a.a | |
| | | | |
| 1720 | 100 | Clst: a.a, decreasing calc amount | |
| | Tr | Dol: a.a | |
| | | | |
| 1730 | 100 | Clst: olv gry - olv blk, frm, sbblky, occ calc | |
| | Tr | Ls: a.a | |
| | | | |
| 1740 | | Missing | |
| 1750 | | Missing | |
| 1760 | 90 | Clst: olv gry - olv blk, frm, sbblky, slily calc | |
| | 10 | Ls: lt olv gry - lt brnsh gry, frm, sbblky, crpxln | |
| | r Tr | Dol: a.a | |
| | | | |
| 1770 | | Missing | |
| 1780 | 100 | Clst: a.a | |
| | Tr | LS: a.a | |
| | | | |
| 1790 | | Missing | |
| 1800 | 80 | Clst: a.a, v calc | |
| | 20 | Ls: brnsh gry, sbblky, v arg, grad Mrl | |
| | | | |
| 1810 | 100 | Clst: olv blk - grnsh blk, frm, sbblky, v calc | |
| | Tr | Ls: a.a | |
| | | | |
| 1820 | 100 | Clst: a.a, i/p v calc | |
| | Tr | LS: a.a | |
| | | | |
| 1830 | | Missing | |
| | | | |
| 1840 | 100 | Clst: olv blk - brnsh blk, frm, i/p calc | |
| | | | |
| 1850 | 100 | Clst: a.a, i/p calc | |
| | Tr | Dol: a.a, v hd | |
| | | | |
| | | | |

**Pertra as** **Wellsite Sample Description** Page: 4 of: 19

| | | | | | |
|---|---|---|---|---|---|
| Country: | Norway | Area: | North Sea | Field: | Villmink |
| Well: | 15/12-15 | | Sidetracked from well: | | |
| Drill floor Elev. (m): | 25m | Company: | Pertra AS | | |
| Hole size: | 12 1/4" | Geologists: | Steinar Eikemo / Asbjørn Hiksdal | Date: | 02.12.2004 |

| Depth | Lithology | Lithological Description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|
| 1860 | 100 | Clst: olv gry - brnsh gry, frm, sbblky, pred v calc, i/p no calc | |
| | Tr | Ls: lt oly gry, frm, microxln, blky | |
| 1870 | 100 | Clst: a.a | |
| | Tr | Ls: pl yelsh brn, frm, microxln, blky, slily arg, glauc and dol | |
| 1880 | 100 | Clst: a.a, non calc | |
| | gdTr | Ls: lt olv gry, frm, blky, v arg | |
| 1890 | 100 | CLst: a.a, non calc | |
| | gdTr | Ls: pl yelsh brn - lt olv gry, occ v lt gry, frm, microxln, blky, slily arg, glauc and dol, tr chert | |
| 1900 | 100 | Clst: a.a, non calc | |
| | gdTr | Ls: a.a | |
| 1910 | 90 | Clst: a.a, non calc | |
| | 10 | Ls: pl yelsh brn - lt olv gry, occ v lt gry, frm, microxln, blky, slily arg - v arg, glauc and I/P dol, tr chert | |
| 1920 | 85 | Clst: a.a, non calc | |
| | 15 | Ls: a.a | |
| 1930 | 100 | Clst: a.a, non calc | |
| | gdTr | Ls: a.a | |
| 1940 | 100 | Clst: a.a, non calc | |
| | Tr | Ls: a.a | |
| 1950 | 90 | Clst: a.a, non calc | |
| | 10 | Ls: a.a | |
| 1960 | 90 | Clst: olv gry - brnsh gry, occ dk grnsh gry, frm, sbblky, non calc | |
| | 10 | Ls: pl yelsh brn - lt olv gry, occ v lt gry, frm, microxln, blky, slily arg - v arg, glauc and I/P dol, tr chert (located in vugs in limstone fragments) | |
| 1970 | 100 | Clst: a.a, non calc | |
| | Tr | Ls: a.a | |

**Pertra as** **Wellsite Sample Description** Page: 5 of: 19

| | | | | | |
|---|---|---|---|---|---|
| Country: | Norway | Area: | North Sea | Field: | Villmink |
| Well: | 15/12-15 | | Sidetracked from well: | | |
| Drill floor Elev. (m): | 25m | Company: | Pertra AS | | |
| Hole size: | 12 1/4" | Geologists: | Steinar Eikemo / Asbjørn Hiksdal | Date: | 03.12.2004 |

| Depth | Lithology | Lithological Description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|
| | | | |
| 1980 | 100 | Clst: olv gry - brnsh gry, frm, sbblky, no calc, | |
| | Tr | Ls: pa yelsh gry - v lt gry, frm - hd, blky, microxln, i/p glauc, cherty & dol | |
| | | slily arg | |
| | | | |
| 1990 | 100 | Clst:a.a | |
| | Tr | Ls:a.a | |
| | Tr | Sltst: lt olv gry, frm, sbblky, no calc, spk | |
| | | | |
| 2000 | 90 | Clst:a.a | |
| | 10 | Clst II: brnsh blk, frm- sft, sbblky, no calc, slily slty | |
| | Tr | Ls: a.a (chert) | |
| | | | |
| 2010 | 100 | Clst I: a.a | |
| | Tr | Clst II: a.a | |
| | Tr | Ls: a.a | |
| | | | |
| 2020 | 100 | Clst I: a.a | |
| | Tr | Clst II: a.a | |
| | Tr | Ls: a.a | |
| | | | |
| 2030 | | Missing | |
| | | | |
| 2040 | 70 | Clst:a.a | |
| | 30 | Ls:a.a | |
| | | | |
| 2050 | 85 | Clst:a.a | |
| | 15 | Ls:a.a | |
| | | | |
| 2060 | 100 | Clst:a.a Tr Clst II: a.a | |
| | Tr | Ls:a.a | |
| | | | |
| 2070 | 100 | Clst:a.a | |
| | Tr | Ls:a.a (chert) | |
| | | | |
| 2080 | 90 | Clst I: a.a | |
| | 10 | Clst II: a.a | |
| | | | |
| 2090 | 80 | Clst I: a.a | |
| | 20 | Clst II: a.a | |
| | Tr | Ls:a.a | |
| | Tr | Sltst: lt olv gry, frm, blky, no calc, spk | |

**Pertra as** **Wellsite Sample Description** Page: 6 of: 19

| | | | | | |
|---|---|---|---|---|---|
| Country: | Norway | Area: | North Sea | Field: | Villmink |
| Well: | 15/12-15 | | Sidetracked from well: | | |
| Drill floor Elev. (m): | 25m | Company: | Pertra AS | | |
| Hole size: | 12 1/4" | Geologists: | Steinar Eikemo / Asbjørn Hiksdal | Date: | 03.12.2004 |

| Depth | Lithology | Lithological Description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|
| | | | |
| 2100 | 90 | Clst I: a.a | |
| | 10 | Clst II: a.a | |
| | TR | Ls: a.a | |
| | | | |
| 2110 | 100 | Clst: olv gry - dk grnsh gry, frm, sbblky, no calc, slily slty, | |
| | Tr | Clst II: a.a | |
| | Tr | Ls: a.a | |
| | | | |
| 2120 | 100 | Clst: a.a | |
| | gd Tr | Ls: a.a (chrt, dol) | |
| | | | |
| 2130 | 100 | Clst: olv gry - dk grnsh gry, frm, sbblky, slily slty, no calc, | Cvgs: olv blk |
| | | Tr olv blk, Tr grnsh gry | hd, no calc |
| | Tr | Ls: yelsh gry, frm, microxln, | |
| | | | |
| 2140 | 100 | Clst: a.a | |
| | gd Tr | Ls: a.a | |
| | | | |
| 2150 | 100 | Clst: pred olv gry - dk grnsh gry a.a | |
| | | | |
| 2160 | 100 | Clst: a.a | |
| | | | |
| 2170 | 100 | Clst: a.a | |
| | r Tr | Ls: yelsh gry, frm, crptxln | |
| | | | |
| 2180 | 100 | Clst: dk grnsh gry - med blsh gry, frm, slily slty, olv gry, frm, no calc | |
| | | | |
| 2190 | 100 | Clst: a.a | |
| | | | |
| 2200 | 100 | Clst: a.a | |
| | | | |
| 2210 | | Missing | |
| | | | |
| 2220 | 100 | Clst: a.a | |
| | Tr | Ls: yelsh gry, frm, slty, crpxln | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**Pertra as** **Wellsite Sample Description** Page: 7 of: 19

| | | | | | |
|---|---|---|---|---|---|
| Country: | Norway | Area: | North Sea | Field: | Villmink |
| Well: | 15/12-15 | | Sidetracked from well: | | |
| Drill floor Elev. (m): | 25m | Company: | Pertra AS | | |
| Hole size: | 12 1/4" | Geologists: | Steinar Eikemo / Asbjørn Hiksdal | Date: | 04.12.2004 |

| Depth | Lithology | Lithological Description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|
| 2230 | 100 | Clst: olv gry - dk grnsh gry, occ med blsh gry, frm, slily slty, sbblky, no calc | |
| | Tr | Ls: yelsh gry - lt olv gry, frm, microxln | |
| 2240 | 100 | Clst: a.a | |
| 2250 | 100 | Clst: a.a | |
| | gdTr | Ls: a.a | |
| 2260 | 100 | Clst: a.a | |
| | gdTr | Ls: a.a | |
| 2270 | 100 | Clst: a.a | |
| | gdTr | Ls: a.a | |
| 2280 | | Missing | |
| 2290 | 90 | Clst: a.a | |
| | 10 | Ls: a.a | |
| 2300 | 100 | Clst: dk grnsh gry - olv gry, frm, slily slty, sbblky, non calc | |
| | Tr | Ls: a.a | |
| 2310 | 100 | Clst: a.a | |
| | Tr | Ls: a.a | |
| 2320 | 90 | Clst: dk grnsh gry, frm, slily slty, sbblky, non calc | |
| | 10 | Clst II: brnsh blk, frm, silty, sbblky, fiss, sli calc | |
| | Tr | Ls: yelsh gry - lt olv gry, frm, microxln, slily arg, I/P dol, glauc, cherty | |
| 2330 | 100 | Clst: dk grnsh gry, frm, slily slty, sbblky, non calc | |
| | Tr | Clst II: brnsh blk, frm, silty, sbblky, fiss, sli calc | |
| | Tr | Ls: a.a | |
| 2340 | 100 | Clst: a.a | |
| | Tr | Ls: a.a | |
| 2350 | 100 | Clst: a.a | |
| | Tr | Ls: a.a | |
| 2360 | 100 | Clst: a.a | |
| | Tr | Ls: a.a | |

**Pertra as**

# Wellsite Sample Description

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| | | | | | |
|---|---|---|---|---|---|
| Country: | Norway | Area: | North Sea | Field: | Villmink |
| Well: | 15/12-15 | | Sidetracked from well: | | |
| Drill floor Elev. (m): | 25m | Company: | Pertra AS | | |
| Hole size: | 12 1/4" | Geologists: | Steinar Eikemo / Asbjørn Hiksdal | Date: | |

| Depth | Lithology | Lithological Description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|
| 2370 | 80 | Clst: dk grnsh gry, frm, slily slty, sbblky, non calc | |
| | 20 | Clst III: olv gry, frm, slily slty, I/P silty, sbblky, fiss, non calc, micromic | |
| | Tr | Ls: yelsh gry - lt olv gry, frm, microxln, slily arg, I/P dol, glauc, cherty | |
| | | | |
| 2380 | 90 | Clst: a.a | |
| | 10 | Clst III: a.a | |
| | Tr | Ls: a.a | |
| | | | |
| 2390 | 100 | Clst: a.a | |
| | gdTr | Clst III: a.a | |
| | Tr | Ls: a.a | |
| | | | |
| 2400 | | Missing | |
| | | | |
| 2410 | 90 | Clst: a.a | |
| | 10 | Clst III: a.a | |
| | gdTr | Ls: a.a | |
| | | | |
| 2420 | 75 | Clst: a.a | |
| | 25 | Clst III: a.a | |
| | rTr | Ls: a.a | |
| | | | |
| 2430 | 60 | Clst: a.a | |
| | 40 | Clst III: a.a | |
| | Tr | Ls: a.a | |
| | | | |
| 2440 | 50 | Clst: a.a | |
| | 50 | Clst III: a.a | |
| | gdTr | Ls: a.a, I/P hd, brit | |
| | | | |
| 2450 | 50 | Tuff Clst: varcol, p bl - gry bl grn - gry grn, frm, blky, lam, sucr, non calc, I/P | Balder tuff |
| | | blk spk | |
| | 50 | Clst: brnsh blk, frm, sbblky, v calc | |

**Pertra as**

# Wellsite Sample Description

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| | | | | | |
|---|---|---|---|---|---|
| Country: | Norway | Area: | North Sea | Field: | Villmink |
| Well: | 15/12-15 | | Sidetracked from well: | | |
| Drill floor Elev. (m): | 25m | Company: | Pertra AS | | |
| Hole size: | 12 1/4" | Geologists: | Steinar Eikemo / Asbjørn Hiksdal | Date: | 11.12.2004 |

| Depth | Lithology | Lithological Description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|
| 2455 | 90 | Clst:dk grns gry, hd, occ vhd, flaky - sbblky, splintery, non calc | |
| | 10 | Tuff Clst: varcol, p bl - gry bl grn - gry grn, frm, blky, lam, sucr, non calc, I/P | Balder tuff |
| | | blk spk | |
| | | | |
| 2460 | 80 | Clst: a.a | Blky cavings |
| | 20 | Clst: olv blk - brnsh blk, frm, sbblky, slily silty, non calc | |
| | Tr | Tuff Clst: a.a | |
| | | | |
| 2464 | 80 | Clst: multicol med gry - olv blk, grading to olv blk, frm, occ hd, sbblky, slily slty, | Blky Cavings |
| | | non calc, micro pyr | |
| | 20 | Clst dk grns gry, hd , occ vhd, flk - sbblky, splintery I/P, non calc | |
| | | | |
| 2466 | 100 | Clst: multicol med gry - olv blk, grading to olv blk, frm, occ hd, sbblky, slily slty, | Blky Cavings |
| | | non calc, micro pyr | |
| | Tr | Clst dk grns gry, hd , occ vhd, flk - sbblky, splintery I/P, non calc | |
| | | | |
| 2468 | 90 | Clst: multicol med gry - olv blk, grading to olv blk, frm, occ hd, sbblky, slily slty, | Blky Cavings |
| | | non calc, micro pyr | |
| | 10 | Clst dk grns gry, hd , occ vhd, flk - sbblky, splintery I/P, non calc | |
| | | | |
| 2470 | 100 | Clst: a.a | |
| | | | |
| 2472 | 100 | Clst: a.a | |
| | | | |
| 2480 | 100 | Clst: olv blk - olv gry, frm, blky, lam, non calc | POOH |
| | | | Bit balling ? |
| | | | |
| 2490 | 100 | Clst: olv blk - olv gry, frm, blky - sbblky, non calc, sl micropyr | Blky cvgs, |
| | | | occ Splin & |
| 2500 | 100 | Clst: slily slty, else a.a. | plty cvgs |
| | | | |
| 2510 | 100 | Clst: a.a. | Cvgs a.a. |
| | Tr | Ls: lt olv gry - lt brnsh gry, sft- frm, blky, sl crmbly, sl spk/slty | |
| | | | |
| 2520 | 100 | Clst: a.a. | Cvgs a.a. |
| | r Tr | Ls: occ hd, dol, else a.a. | |
| | | | |
| 2530 | 100 | Clst: olv gry - olv blk, occ dk gnsh gry, else a.a. | Less cvgs |
| | | | |
| | | | |
| | | | |
| | | | |

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| | | | | | |
|---|---|---|---|---|---|
| Country: | Norway | Area: | North Sea | Field: | Villmink |
| Well: | 15/12-15 | | Sidetracked from well: | | |
| Drill floor Elev. (m): | 25m | Company: | Pertra AS | | |
| Hole size: | 12 1/4" | Geologists: | Magne Tillung / Asbjørn Hiksdal | Date: | 12.12.2004 |

| Depth | Lithology | Lithological Description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|
| 2540 | 100 | Clst: olv gry - dk gnsh gry, frm, blky - sbblky, non calc, sl slty | Some blky |
| | r | Ls: lt brnsh gry - pl yelsh brn, frm - sft, blky, sl arg | & plty cvgs |
| 2550 | 100 | Clst: pred m dk gry, dk gnsh gry, carb Spk, lam l.P., else a.a. | Cvgs a.a. |
| 2560 | 100 | Clst: med bl gry - dk grnsh gry, frm, sbblky, non calc, sl slty, carb Spk, I/P glauc Agg | |
| | r | Ls: a.a | |
| 2570 | 100 | Clst: a.a | |
| | r | Ls: a.a | |
| 2580 | 100 | Clst: a.a, I/P micpyr sterk | |
| | Tr | off white - yelsh gry, frm-sft, blky, micxln, sl arg, carb sterk, I/P glauc | |
| 2590 | 100 | Clst: a.a | |
| | Tr | Ls: a.a | |
| 2600 | 100 | Clst: a.a, grad to lt brnsh gr - brnsh gry, occ brnsh blk | |
| 2610 | 100 | Clst: a.a, incr amt col lt brnsh gr - brnsh gry, occ brnsh blk Clst | |
| | rTr | Ls: a.a | |
| 2620 | 70 | Clst: lt brnsh gry-brnsh gry, occ brnsh blk, frm , sbblky, non calc | |
| | 30 | Tuff Clst: mcol pl grn - grnsh gry - dusky grn, frm -hd, blky-sbblky, non calc, I/P sucrosic, blk spk, glauc | |
| | r | Ls: a.a | |
| 2630 | 70 | Clst: a.a | |
| | 30 | Tuff Clst: a.a | |
| | r | Ls: a.a | |
| 2640 | 100 | Clst: med gry-md dk gry, frm, sbblky, calc, I/P v calc, glauc | Våle Fm |
| | r | Ls: a.a | |
| 2650 | 80 | Clst: a.a | |
| | 20 | Ls: off wh, frm, occ hd, brit, micxln | |
| 2660 | 50 | Clst: a.a | Shetland/Ekofi |
| | 50 | Ls: a.a | |

**Pertra as** **Wellsite Sample Description** Page: 11 of: 19

| | | | | | |
|---|---|---|---|---|---|
| Country: | Norway | Area: | North Sea | Field: | Villmink |
| Well: | 15/12-15 | | Sidetracked from well: | | |
| Drill floor Elev. (m): | 25m | Company: | Pertra AS | | |
| Hole size: | 12 1/4" | Geologists: | Magne Tillung / Asbjørn Hiksdal | Date: | 11.12.2004 |

| Depth | Lithology | Lithological Description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|
| 2670 | 100 | Ls: pred off wh, grd pnk gry - lt brnsh gry, frm, occ hd, brit, occ hd | |
| 2680 | 100 | Ls: pred off wh, pk gry - lt brn gry, v lt gry, frm, occ hd, brit, microxln, occ sl arg | |
| 2690 | 100 | Ls: a.a. | |
| 2700 | 100 | Ls: a.a. | |
| 2710 | 100 | Ls: a.a. | |
| 2720 | 100 | Ls: a.a. | |
| 2730 | 100 | Ls: a.a. | |
| 2740 | 100 | Ls: a.a. | |
| 2750 | 100 | Ls: a.a. | |
| 2760 | 100 | Ls: sl arg - arg, else a.a. | |
| 2770 | 100 | Ls: a.a. | |
| 2780 | 100 | Ls: v lt gry - off wh, pksh gry, frm, brit, blky, microxln, occ sl arg | |
| 2790 | 100 | Ls: a.a. | |
| 2800 | 100 | Ls: occ m lt gry, else a.a. | Incr arg Mtrx |
| 2810 | 100 | Ls: v lt gry - off wh, incr m gry - m lt gry, incr arg Mtrx, else a.a. | v |
| 2820 | 100 | Ls: a.a. | |
| 2830 | 100 | Ls: v lt gry - lt gry, less arg Mtrx, else a.a. | |
| 2840 | 100 | Ls: a.a. | |
| 2850 | 100 | Ls: v lt gry - lt gry, occ m lt gry, occ arg lam | |
| 2860 | 100 | Ls: a.a. | |
| 2870 | 100 | Ls: bcm slty/glauc, gnsh gry, olv gry, I.P. lt gry- pksh gry, frm - occ mod hd, blky, slty/glauc I.P.m microxln, arg | |

**Pertra as**

# Wellsite Sample Description

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| | | | | | |
|---|---|---|---|---|---|
| Country: | Norway | Area: | North Sea | Field: | Villmink |
| Well: | 15/12-15 | | Sidetracked from well: | | |
| Drill floor Elev. (m): | 25m | Company: | Pertra AS | | |
| Hole size: | 12 1/4" | Geologists: | Magne Tillung / Asbjørn Hiksdal | Date: | 12.12.2004 |

| Depth | Lithology | Lithological Description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|
| 2880 | 100 | Ls: pred mod brn - dk yelsh brn, sft - frm, blky - sbblky, slty/arg, grdg Mrl l.P., | |
| | | l.P. grnsh gry - olv gry, slty/glauc | |
| 2885 | 100 | Ls/Mrl: pred dk yelsh brn, occ lt olv gry - gnsh gry, sft - frm, sbblky, slty/arg | |
| | | grdg Mrl, occ glauc | |
| 2888 | 100 | Ls/Mrl: gnsh gry - lt olv gry, occ dk yelsh brn, sft - frm, sbblky, arg/slty Mtrx, | |
| | | grdg Mrl, sl glauc | |
| 2894 | 100 | MRL: lt olv gry - gnsh gry, sft - frm, spk carb Mat, else a.a. | |
| 2900 | 100 | Mrl: occ dk yelsh brn, else a.a. | |
| 2906 | 100 | Mrl: a.a. | |
| 2909 | 100 | Mrl: a.a. | |
| 2912 | 100 | Mrl: lt olv gry - gnsh gry, l.P. mod brn - dk yelsh brn, else a.a. | |
| 2915 | 60 | Mrl: mod brn, r Tr lt olv gry, frm, blky, arg (not slty) | |
| | 40 | Ls: v lt gry, frm - mod hd, blky, microxln, sl arg l.P. | |
| 2921 | 100 | Mrl: pred lt olv gry - m lt gry, l.P. mod brn - grysh brn, else a.a. | |
| | Gd Tr | Ls: a.a. | |
| 2927 | 10 | Mrl: mod brn, lt olv gry | |
| | 20 | Ls: lt gry a.a. | |
| | 70 | Clst: olv blk, sft - frm, sbblky, sl slty, v calc, carb Spk/Sterk, sl micropyr, sl lam | |
| 2933 | 10 | Mrl:a.a. | |
| | 10 | Ls: lt gry, occ pl brn, else a.a. | |
| | 80 | Clst: a.a., v calc grdg Mrl | |
| 2936 | Gd Tr | Mrl: a.a. | |
| | 10 | Ls: a.a. | |
| | 90 | Clst: a.a. | |

**Pertra as** **Wellsite Sample Description** Page: 13 of: 19

| | | | | | |
|---|---|---|---|---|---|
| Country: | Norway | Area: | North Sea | Field: | Villmink |
| Well: | 15/12-15 | | Sidetracked from well: | | |
| Drill floor Elev. (m): | 25m | Company: | Pertra AS | | |
| Hole size: | 12 1/4" | Geologists: | Magne Tillung / Asbjørn Hiksdal | Date: | 12.12.2004 |

| Depth | Lithology | Lithological Description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|
| | | | |
| 2942 | 100 | Clst: olv blk, frm - sft, sbblky, occ blky, v calc grdg Mrl l.P, sl slty, sl cab, | |
| | | micropyr, micromic | |
| | Gd Tr | Mrl: pl brn - mod brn a.a. | |
| | Tr | Ls: lt gry - lt olv gry, frm, blky, microxln | |
| | | | |
| 2945 | 100 | Clst: a.a. | |
| | Tr | Ls: a.a. | |
| | Tr | a.a. | |
| | | | |
| 2951 | 100 | Clst: a.a. | |
| | Tr | Ls: a.a. | |
| | Tr | Mrl: a.a. | |
| | | | |
| 2957 | 90 | Clst: slty, calc, olv blk, sft - frm, blky, slily carb, calc cmt | Cvgsfrom |
| | 10 | Mrl: a.a. | Low Hord. & |
| | Tr | Ls: off wh - lt gry, frm, blky, microxln Incl & Gr | Basal Lista |
| | | | |
| 2960 | Tr | Clst: olv blk, frm, sbblky, calc, sl carb, Mic | Cvgs a.a. |
| | 100 | Sltst: olv blk, sft, blky, calc cmt, occ vf Sd Gr | |
| | Tr | Ls: off wh - lt gry, frm, blky, microxln Incl & Gr | |
| | | | |
| 2963 | 100 | Clst: a.a. | Cvgs a.a. |
| | Tr | Ls: a.a. | |
| | | | |
| 2969 | 100 | Sltst: calc a.a. | Cvgs a.a. |
| | Tr | Ls: a.a. | |
| | | | |
| 2972 | 100 | Sltst: a.a. | Cvgs a.a. |
| | Tr | Ls: a.a., v glauc l.P. | |
| | | | |
| 2978 | 100 | Sltst: a.a. | Cvgs a.a. |
| | Tr | Ls: a.a. | |
| | | | |
| 2981 | 90 | Sltst: a. a. | Cvgs a.a. |
| | 10 | Ls: pred off wh, cryptoxln, else a.a. | |
| | | | |
| 2987 | 100 | Sltst: calc, sdy, olv blk, sft, blky, calc cmt, sdy, trnsl vf Qtz Gr, sbrndd, | |
| | | slily mic | |
| | Tr | Ls: a.a. | |
| 2990 | 100 | Sltst: calc, sdy, olv blk, sft, blky, calc cmt, sdy, trnsl vf Qtz Gr, sbrndd, | |
| | Tr | Ls: a.a. | |

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| | | | | | |
|---|---|---|---|---|---|
| Country: | Norway | Area: | North Sea | Field: | Villmink |
| Well: | 15/12-15 | | Sidetracked from well: | | |
| Drill floor Elev. (m): | 25m | Company: | Pertra AS | | |
| Hole size: | 12 1/4" | Geologists: | Magne Tillung / Asbjørn Hiksdal | Date: | 12.12.2004 |

| Depth | Lithology | Lithological Description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|
| | | | |
| 2996 | 100 | Sltst: calc, sdy, olv gry - olv blk, sft, blky, vf trnsl Qtz Gr, sbang - sbrndd, calc | |
| | | cmt, slily mic | |
| | Tr | Ls: off wh - lt gry, frm, brit, glauc, sl arg, microxln | |
| | | | |
| 2999 | 100 | Sltst: a.a., l.P. carb Strk w/micropyr | |
| | Tr | Ls: a.a. | |
| | | | |
| 3005 | 100 | Sltst: a.a., l.P. v sdy | |
| | r | Ls: a.a. | |
| | | | |
| 3008 | 100 | Sltst: a.a. | |
| | r | Ls: a.a. | |
| | | | |
| 3011 | 100 | Sltst: a.a. | |
| | r | Ls: a.a. | |
| | | | |
| 3017 | 100 | Sltst: a.a., incr Mic, gen incr Gr size | |
| | Tr | Ls: a.a., l.P. v glauc | |
| | | | |
| 3023 | 100 | Sltst: grdg slty Sst, l.P. | |
| | Tr | Ls: a.a. | |
| | | Shows:No dir cut, Fl cut: bluish wh, slow, unif, Ring cut: yelsh wh, unif,dull | Weak show |
| 3026 | 90 | Sst: slty, calc, olv blk, frm, blky, trnsl Qtz Gr, vf, mod srt, sbang - sbrndd, | |
| | | calc cmt, sl mic, carb | |
| | 10 | Sltst: calc, sdy, a.a. | |
| | r | Ls: a.a. | |
| | | | |
| 3029 | 50 | Sst: slty, calc, a.a. | |
| | 50 | Sltst: sdy, calc, a.a. | |
| | r | Ls: a.a. | |
| | | Shows:No dir cut, Fl cut: bluish wh, slow, unif, Ring cut: yelsh wh, unif,dull | Weak show |
| 3032 | 50 | Sst: slty, calc, a.a. | |
| | 50 | Sltst: sdy, calc, a.a. | |
| | r | Ls: a.a. | |
| | | Shows:No dir cut, Fl cut: bluish wh, slow, unif, Ring cut: yelsh wh, unif,dull | Weak show |
| 3035 | 50 | Sst: slty, calc, a.a. | |
| | 50 | Sltst: sdy, calc, a.a. | |
| | r | Ls: a.a. | |
| | | Shows:No dir cut, Fl cut: bluish wh, v slow, unif, Ring cut: yelsh wh, unif,dull | Faint - no show |
| | | | |
| | | | |

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| | | | | | |
|---|---|---|---|---|---|
| Country: | Norway | Area: | North Sea | Field: | Villmink |
| Well: | 15/12-15 | | Sidetracked from well: | | |
| Drill floor Elev. (m): | 25m | Company: | Pertra AS | | |
| Hole size: | 12 1/4" | Geologists: | Magne Tillung / Asbjørn Hiksdal | Date: | 13.12.2004 |

| Depth | Lithology | Lithological Description: cement, hardness, sed. structures, accessories, fossils, porosity, cont. [15] | Remarks |
|---|---|---|---|
| | | | |
| 3044 | 50 | Sst: slty, calc, olv blk, frm, blky, trnsl Qtz Gr, vf, mod srt, sbang - sbrndd, | |
| | | calc cmt, slty, carb | |
| | 50 | Sltst: calc, sdy, olv gry - olv blk, sft, blky, vf trnsl Qtz Gr, sbang - sbrndd, calc | |
| | | cmt, slily mic, lam carb Sterk, sdy grdg silty Sst I.P. | |
| | r | Ls: off wh - lt gry, frm, brit, glauc, sl arg, microxln | |
| | | Shows:No dir cut, Fl cut: bluish wh, slow, unif, Ring cut: yelsh wh, unif,dull | Weak show |
| 3047 | 50 | Sst: a.a. | |
| | 50 | Sltst: a.a. | |
| | r | Ls: a.a. | |
| | | Shows:No dir cut, Fl cut: bluish wh, slow, unif, Ring cut: yelsh wh, unif,dull | Weak show |
| 3053 | 60 | Sst: a.a. | |
| | 40 | Sltst: a.a., carb Mtrx incr | |
| | r | Ls: a.a. | |
| | | | |
| 3056 | 50 | Sst: a.a., I.P glauc | |
| | 50 | Sltst: a.a. | |
| | | | |
| 3059 | 50 | Sst: a.a. | |
| | 50 | Sltst: a.a. | |
| | | | |
| 3062 | 50 | Sst: a.a. | |
| | 50 | Sltst: a.a. | |
| | | Shows:No dir cut, Fl cut: bluish wh, v slow, unif, Ring cut: yelsh wh, unif,dull | Faint - no show |
| 3068 | 60 | Sst: a.a. | |
| | 40 | Sltst: a.a. | |
| | | | |
| 3071 | 30 | Sst: a.a. | |
| | 70 | Sltst: a.a. | |
| | | Shows:No dir cut, Fl cut: bluish wh, v slow, unif, Ring cut: yelsh wh, unif,dull | |
| 3080 | 60 | Sst: a.a. | |
| | 40 | Sltst: a.a. | |
| | | | |
| 3083 | 50 | Sst: a.a., micropyr agg | |
| | 50 | Sltst: a.a. | |
| | | Shows:No dir cut, Fl cut: bluish wh, v slow, unif, Ring cut: yelsh wh, unif,dull | Faint - no show |
| 3089 | 70 | Sst: a.a., occ f - m Qtz Gr, mod srt, micropyr agg | |
| | 30 | Sltst: a.a. | |
| | | hows:No dir cut, Fl cut: bluish wh, v slow, unif, Ring cut: yelsh wh, unif,dull | Faint - no show |
| 3098 | 70 | Sst: a.a. | |
| | 30 | Sltst: a.a. | |
| 3104 | 70 | Sst: a.a. | |
| | 30 | Sltst: a.a. | |

**Pertra as**

# Wellsite Sample Description

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| | | | | | |
|---|---|---|---|---|---|
| Country: | Norway | Area: | North Sea | Field: | Villmink |
| Well: | 15/12-15 | | Sidetracked from well: | | |
| Drill floor Elev. (m): | 25m | Company: | Pertra AS | | |
| Hole size: | 12 1/4" | Geologists: | Magne Tillung / Asbjørn Hiksdal | Date: | 13.12.2004 |

| Depth | Lithology | Lithological Description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|
| 3107 | 70 | Sst: slty, calc, olv blk, frm, blky, trnsl Qtz Gr, vf, occ f - m, mod srt, | |
| | | sbang - sbrndd, calc cmt, slty, carb | |
| | 30 | Sltst: calc, sdy, olv gry - olv blk, sft, blky, vf trnsl Qtz Gr, sbang - sbrndd, calc | |
| | | cmt, slily mic, lam carb Sterk, sdy grdg silty Sst I.P. | |
| 3113 | 70 | Sst: a.a. | Faint - no show |
| | 30 | Sltst: a.a. | |
| 3116 | 70 | Sst: a.a. | |
| | 30 | Sltst: a.a. | |
| 3122 | 70 | Sst: a.a., occ brnsh gry | Faint - no show |
| | 30 | Sltst: a.a. | |
| 3125 | 80 | Sst: a.a. | |
| | 20 | Sltst: a.a. | |
| 3131 | 90 | Sst: a.a. | |
| | 10 | Sltst: a.a. | |
| | Tr | Sltst 2: lt blsh gry, frm-hd, flaky, splnt, non calc | |
| 3134 | 90 | Sst: a.a. | Faint - no show |
| | 10 | Sltst: a.a. | |
| | Tr | Sltst 2: a.a. | |
| 3140 | 100 | Sst: a.a., grad olv gry, micropyr | |
| | Tr | Sltst 2: a.a. | |
| 3143 | 100 | Sst: a.a., bcm sft, fri, vf - crs, mod - pr srt, micropyr agg | |

**Pertra as** **Wellsite Sample Description** Page: 17 of: 19

| | | | |
|---|---|---|---|
| Country: Norway | Area: North Sea | Field: Villmink | |
| Well: 15/12-15 | Sidetracked from well: | | |
| Drill floor Elev. (m): 25 | Company: Pertra AS | | |
| Hole size: 12 1/4" | Geologists: Magne Tillung / Asbjørn Hiksdal | Date: 13.12.2004 | |

| Depth | Lith % | Grain size Min | Max | Dom | Srt | Ang | Sph | Lithological description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 3146 | 100 | vf | crs | vf-m | m-pr | sr | ss | Sst: olv gry - m lt gry, vf - crs, pred vf - m, mod - pr srt, pred | No shows |
| | | | | | | | | lse, clr - trnsl Qtz, sbang - sbrndd, sl - non calc, micropyr, | |
| | | | | | | | | Rk Flour or Kaol? | |
| 3152 | 100 | vf | crs | vf-m | m-pr | sr | ss | Sst: a.a. | No shows |
| 3155 | 100 | vf | v crs | f-crs | pr | sr | ss | Sst: vf - v crs, pred f - crs, pr srt, sl calc cmt l.P. | No shows |
| 3161 | 100 | vf | crs | f-crs | m-pr | sr-r | ss-s | Sst: vf - crs, pred f - crs, mod - pr srt, sbrndd - rndd, | No shows |
| | | | | | | | | sbsph - sph, calc cmt l.P. | |
| 3167 | 100 | vf | crs | f-crs | m-pr | sa-r | ss | Sst: abd calc Cmt, Kao Mtrx or Rk Flour?, else a.a. | No shows |
| 3170 | 100 | vf | crs | f-m | m-pr | sa-sr | ss | Sst: vf - crs, pred f - m, mod srt, sbang - sbrndd, l.p. crshd & | No shows |
| | | | | | | | | ang, sl calc cmt, sil cmt, Kao Mtrx? | |
| 3176 | 100 | vf | crs | vf-m | m-pr | sa-sr | ss | Sst: a.a., pred vf - m, Tr Mic | No shows |
| 3179 | 100 | vf | m | vf-m | m | a-sr | ss | Sst: wl cmt w/sil & calc & Kao? Cmt, mnr lse Gr, carb/slty | No shows |
| | | | | | | | | Strks/Spks | |
| 3185 | 100 | vf | crs | vf-m | m | sr-a | ss | Sst: vf - crs, pred vf - m, calc/sil/Kao? Cmt, I.P., lse I.P., else a.a. | No shows |
| 3188 | 100 | slt | crs | vf-m | m-pr | sa-sr | ss | Sst: slty grdg sdy Sltst | No shows |
| 3197 | 100 | slt | crs | slt-m | pr | sa-sr | ss | Sst: slty grdg sdy Sltst, olv gry - olv blk, slt - crs, pred slt - m, | No shows |
| | | | | | | | | arg/slty Sterk, micropyr, micromic, calc cmt | |
| 3203 | 100 | vf | crs | vf-m | m-pr | sa-sr | ss | Sst: slty, olv gry, sft, blky, vf-m, Tr crs, mod-pr srt, sbang- | No shows |
| | | | | | | | | sbrndd, calc cmt I/P, arg/slty/kao Mtrx | |
| 3206 | 100 | slt | crs | slt-m | m-pr | sa-sr | ss | Sst: slty grdg sdy Sltst, slt - c, pred slt - m, m - pr srt, sl calc | No shows |
| | | | | | | | | cmt, arg/slty/kao Mtrx | |

Angularity: s=sub, a=ang, r=rnd. Sphericity: s=spherical, ss=sub spherical, e=elongate, se=sub elongate

**Pertra as** **Wellsite Sample Description** Page: 18 of: 19

| | | | |
|---|---|---|---|
| Country: Norway | Area: North Sea | Field: Villmink | |
| Well: 15/12-15 | Sidetracked from well: | | |
| Drill floor Elev. (m): 25 | Company: Pertra AS | | |
| Hole size: 12 1/4" | Geologists: Magne Tillung / Asbjørn Hiksdal | Date: 13.12.2004 | |

| Depth | Lith % | Grain size Min | Max | Dom | Srt | Ang | Sph | Lithological description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 3212 | 100 | vf | vcrs | vf-m | m-pr | sa-r | ss-s | Sst: a.a, vf-vcrs, pred vf-m,mod-pr srt, else a.a | No shows |
| 3215 | 100 | vf | vcrs | vf-m | m-pr | sa-sr | ss-s | Sst: a.a slty grdg sdy sltst, arg/slty lam & spk | No shows |
| 3221 | 100 | vf | vcrs | vf-m | m-pr | sa-sr | Ss-Se | Sst: a.a, r vcrs - gran, sbelong | No shows |
| 3224 | 100 | vf | vcrs | vf-m | m-pr | sa-sr | Ss-s | Sst: slty, vf-vcrs, pred vf-m, mod -pr srt, sbang-sbrndd | No shows |
| 3230 | 100 | vf | vcrs | vf-m | m-pr | sa-sr | Ss-s | Sst: olv gry, l/P ltgry, calc cmt, else a.a | No shows |
| | r | | | | | | | Clst: grnsh gry, dsky brn, cvgs? | |
| 3233 | 100 | vf | vcrs | vf-m | m-pr | sa-sr | Ss-s | Sst: a.a | No shows |
| | Tr | | | | | | | Clst: pred dsky brn | |
| 3239 | 100 | vf | vcrs | vf-m | m-pr | sa-sr | ss | Sst: a.a | No shows |
| 3242 | 100 | vf | vcrs | vf-m | m-pr | sa-sr | ss | Sst:Slty grdg sdy Sltst, l/P lse pred slty/ arg Mtrx | No shows |
| | r | | | | | | | Clst: m gry, mod hd, blky, spk w/ carb Mat | |
| 3248 | 100 | vf | vcrs | vf-m | m-pr | sr-sa | ss | Sst: m lt gry, olv gry, sft, sbblky, occ grdg sdy Sltst, vf-vcrs, | |
| | | | | | | | | pred f - m, mod - pr srt, sbrndd - sbang, sbsph, l.P. sl calc | |
| | | | | | | | | cmt, sl arg/slty Mtrx, Kao? | |
| 3251 | 100 | vf | vcrs | vf-m | m-pr | sa-sr | ss | olv gry - m gry (slty), lt gry (calc) | |
| | r | | | | | | | Clst: m gry, frm - mod hd, splin, blky, wxy lstr | |
| 3257 | 100 | vf | crs | vf-m | m-pr | sa-sr | ss | Sst: pred olv gry - dk gry, occ lt gry m lt gry (calc), else a.a. | |
| | r | | | | | | | Clst: m dk gry - dk gnsh gry, else a.a. | |
| 3260 | 100 | vf | m | vf-m | m | sa-sr | ss | Sst: vf - m, mod srt, else a.a. | |
| 3275 | 100 | vf | crs | vf-m | m | sa-sr | ss | Sst: olv gry - olv blk, slty | |
| | r | | | | | | | Clst: a.a. | |

Angularity: s=sub, a=ang, r=rnd. Sphericity: s=spherical, ss=sub spherical, e=elongate, se=sub elongate

**Pertra as**

## Wellsite Sample Description

Page: 19 of: 19

| | | | |
|---|---|---|---|
| Country: Norway | Area: North Sea | Field: Villmink | |
| Well: 15/12-15 | Sidetracked from well: | | |
| Drill floor Elev. (m): 25 | Company: Pertra AS | | |
| Hole size: 12 1/4" | Geologists: Magne Tillung / Asbjørn Hiksdal | Date: 13.12.2004 | |

| Depth | Lith % | Grain size Min | Max | Dom | Srt | Ang | Sph | Lithological description: Rock name, mod.lith, colour, grainsize, sorting, roundness, matrix cement, hardness, sed. structures, accessories, fossils, porosity, cont. | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 3278 | 40 | slt | m | | | | | Sltst: olv gry - olv blk, sft, sdy, vf - m Qtz Gr, arg Mtrx, calc I.P. | No shows |
| | 60 | | | | | | | C: blk, frm - mod hd, blky, brit, arg I.P., micropyr | |
| 3284 | 90 | slt | m | f | m | a-sr | ss | Sst: olv gry - olv blk, slty, sft, trnsl - wh Qtz, ang - sbrndd, | Abd Rk Flour |
| | | | | | | | | sbsph, vf - m, pred f, mod srt, calc cmt, arg Matrx | No shows |
| | 10 | | | | | | | C: blk, frm - mod hd, blky - flk, brit, arg, I.P. micropyr | |
| 3287 | 50 | slt | m | f | m | a-sr | ss | Sst: a.a. | No shows |
| | 50 | | | | | | | C: a.a. | |
| 3290 | 40 | slt | m | f | m | sa-sr | ss | Sst: a.a. | No shows |
| | 60 | | | | | | | C: a.a. | |
| 3293 | 30 | slt | m | f | m | sa-sr | ss | Sst: I.P. calc & sil cmt, else a.a. | No shows |
| | 50 | | | | | | | C: grdg carb Clst, else a.a. | |
| | 20 | | | | | | | Ls: wh - yelsh brn gry, sft, blky, microxln | |
| 3296 | 60 | slt | m | f | m | sa-sr | ss | Sst: a.a., sil cmt | No shows |
| | 20 | | | | | | | C: a.a. | |
| | 20 | | | | | | | Ls: a.a. | |
| 3300 | 80 | slt | m | | w | sr | ss | Sst: a.a., sil cmt | No shows |
| | 20 | | | | | | | C: a.a. | (TD= 3300mMD) |

Angularity: s=sub, a=ang, r=rnd. Sphericity: s=spherical, ss=sub spherical, e=elongate, se=sub elongate

# 8 Hydrocarbon Shows

The evaluation of hydrocarbon shows at the well-site was carried out in a conventional manner. A standard hydrocarbon total gas detector system (Sperry Sun) and a gas chromatograph for automatic and continuous gas analysis, recorded as PPM by volume of C1 through nC5, was operational through the entire drilled section.

Hydrocarbon shows on ditch cuttings were evaluated according to procedures described in Pertra's "Operations Geology Requirements & Guidelines".

## 8.1 Gas Record

Total gas levels were generally low throughout the well, with slightly higher levels in the Heather siltstone, and especially in the coal beds in Sleipner Fm. Connection gases started appearing from 1882m, possibly as early as 1710m, and continued down to 2145m.

## 8.2 Fluorescence

Fluorescence was evaluated from base Cretaceous to TD of the well. The results are summarised below.

| Interval (m MD) | Source | Lithology | Shows Description |
|---|---|---|---|
| Kimmeridgian silt to sand unit 3023-3047m | Cuttings | Siltstone/ Sandstone | No direct fluorescence; blue white, slow, uniform cut fluorescence; yellowish white, uniform, dull ring cut fluorescence. |
| Kimmeridgian sand unit 3062-3134m | Cuttings | Sandstone /Siltstone | No direct fluorescence; blue white, very slow, uniform cut fluorescence; yellowish white, uniform, dull ring cut fluorescence. |

***Table 7-1 Fluorescence observed in well 15/12-15***

# 9 Coring

No core was cut in well 15/12-15.

# 10 Logging

## 10.1 LWD Logging

The LWD logging was performed by Halliburton. No major logging problems occurred. The logging runs are summarised below (Table 9-1).

More details about the LWD logging can be found in the "End of Well Report, Well 15/12-15 from Halliburton.

| Section | Run # | Service | Interval (m MD) | Comment |
|---|---|---|---|---|
| 17.5” | 200 | DGR (Digital gamma-ray)<br>EWR (Electro magnetic wave resistivity tool<br>DM (Directional model tool) | 175-1370 m | End of 17.5” section |
| 12.25” | 300 | DGR, DM and EWR in addition:<br>CTN (Compensated thermal neutron)<br>ALD (Azimuth density tool)<br>ACAL (Acoustic calliper)<br>BAT (Bimodal acoustic tool [sonic] | 1370-2173 m | Pulser failure; no lost data |
| 12.25” | 400 | DGR-EWR-CTN-ALD-ACAL-BAT-DM | 2173-2454 m | Uncertain conductor support |
| 12.25” | 500 | DGR-EWR-CTN-ALD-ACAL-BAT-DM | 2454-2482 m | Very slow progress |
| 12.25” | 600 | DGR-EWR-CTN-ALD-ACAL-BAT-DM | 2482-3300 m | End of well |

***Table 9-1: LWD logging***

## 10.2 MDT Pressure

To verify the pressure regime in the reservoir, one run with MDT was run by Schlumberger. The 5 pressure points were recorded without any sticking problems. Maximum 5 minutes were used for each measurement. The table below summarises the wire-line run and measured reservoir pressure.

| Logs | Date | Interval (m MD) | Run | Comment |
|---|---|---|---|---|
| MDT-GR-ACTS-ECRD | 14-15.12.04 | 3148.5 - 3172 m | 1A | 5 pressure tests |

***Table 9-2: Wire-line logging***

| Test # | Depth | | Hydrostatic pressure (Bar) | | Formation Pressure (Bar) | | Mobility mD/cp |
|---|---|---|---|---|---|---|---|
| | mMD/RKB | mTVD/SS | Before | After | Bars | Eq.mw | |
| 1 | 3162 | 3137 | 420.37 | 419.72 | 253.840 | 0.818 | 1.7 |
| 2 | 3161.5 | 3136.5 | 420.30 | 420.33 | 254.978 | 0.828 | 15.67 |
| 3 | 3148.5 | 3123.5 | 418.64 | 418.68 | 253.590 | 0.821 | 59.81 |
| 4 | 3151 | 3126 | 419.01 | 419.02 | 253.854 | 0.821 | 29.05 |
| 5 | 3172 | 3147 | 421.76 | 421.74 | 256.110 | 0.823 | 16.7 |

***Table 9-3: Measured reservoir pressure***

# 11 Petrophysical Results

This section presents the petrophysical evaluation results of the reservoir section. The methodology used in the evaluation is also summarised.

## 11.1 Summary

The well encountered the reservoir 91.5 meters deeper than prognosed. The waterfilled Oxfordian reservoir consisted of 44m of very fine to very coarse-grained sandstones with an average porosity of 25% and a net/gross of 1 (RZ1-1), and, 94m of very fine to very coarse, poorly sorted, sandstone with an average porosity of 17% and net/gross of 0.7 (RZ 3-1 and 3-2) . The reservoir was found to be pressure depleted compared to the general original reservoir pressure. The approximately 96m of Kimmeridgian silt and sandstone has an average porosity of 13% and a net/gross of 0.3, which is equivalent to the porosity cut-off values used within the Varg Field.

## 11.2 Log Data Acquisition

LWD data acquired in the wellbore is listed in Table 9-1.

## 11.3 Petrophysical Evaluation Procedure

The petrophysical model consists of a simple shaley sand log analysis model. Log analysis was conducted using an effective porosity approach where shale volume is determined from a linear gamma ray relationship. Porosity is calculated from the density log corrected for shale volume. The water saturation was evaluated using the Archie equation. Permeability was not calculated as no cores were taken in the well.

## 11.4 Petrophysical log analysis

Input curves to the petrophysical analysis were: SGRC for volume of shale calculation, SBDC for porosity calculation and SEDP for calculation of the water saturation (Table 10-1, 10-2 and 10-3).

| Abbreviation | Name of curve |
|---|---|
| SGRC | Smoothed Gamma Ray Combined |
| SROP | Rate of penetration |
| APPC | Acoustic caliper |
| SEDP | Smoothed Deep Phase Resistivity |
| SEMP | Smoothed Medium Resistivity |
| SEXP | Smoothed Shallow Resistivity |
| TNPL | CTN Thermal neutron porosity |
| SBDC | Smoothed Bulk Density Fixed |
| SCOR | Smoothed Density Quality |
| DTCP | Post processed compressional |
| DTSP | Post processed shear (final) |

***Table 10-1: Abbreviations for MWD data (curves) used in the text and on the composite plot***

The following parameters were used in the analysis:

| Reservoir Zone | Heather siltstone | Kimmeridgian sand | RZ 1 (1-1 & 1-2) | RZ 3 (3-1 &3-2) | Sleipner | Comments |
|---|---|---|---|---|---|---|
| Top (m MD RKB) | 2962.0 | 3044.80 | 3140.50 | 3185 | 3279 | |
| Bottom (m MD RKB) | 3044.80 | 3140.50 | 3185 | 3279 | 3300 | |
| Shale parameters | | | | | | |
| GRma (API) | 70 | 80 | 80 | 80 | 70 | |
| GRsh (API) | 120 | 135 | 130 | 130 | 130 | |
| ρsh (g/cc) | 2.50 | 2.51 | 2.52 | 2.52 | 2.52 | |
| Porosity parameters | | | | | | |
| ρma (g/cc) | 2.65 | 2.65 | 2.65 | 2.65 | 2.65 | |
| ρfluid (g/cc) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | |
| Saturation parameters | | | | | | |
| Rw @ 127 °C (Ωm) | 0.0153 | 0.0153 | 0.0153 | 0.0153 | 0.0153 | Field parameter |
| a | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | Field parameter |
| m | 1.97 | 1.97 | 1.97 | 1.97 | 1.97 | Field parameter |
| n | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | Field parameter |

***Table 10-2: Petrophysical computation parameters***

Notes:
Water based mud
Reservoir temperature: 118.8 °C @ 3140 m TVD

| **Reservoir Zone** | Draupne and Heather (mud and siltstones) | Kimmeridgian (sand and siltstone) | RZ-1-1 and RZ1-2 | RZ-3-1 | RZ 3-2 | Sleipner |
|---|---|---|---|---|---|---|
| Top (m MD RKB) | 2956.35 | 3044.80 | 3140.50 | 3185 | 3275 | 3279 |
| Bottom (m MD RKB) | 3044.80 | 3140.50 | 3185 | 3275 | 3279 | 3300 |
| Gross (m) | 88.45 | 95.70 | 45 | 90 | 4 | 5 |
| Net (m) | 0 | 31.39 | 45 | 60.66 | 0* | 0 |
| Top (m TVDSS) | 2931.35 | 3020 | 3115.5 | 3160 | 3250 | 3253.5 |
| Bottom (m TVDSS) | 3020 | 3115.5 | 3160 | 3247 | 3253.5 | 3275 |
| Net/Gross (frac.,TVD) | 0 | 0.328 | 1 | 0.674 | 0 | 0 |
| Porosity (%) | ---- | 0.132 | 0.247 | 0.165 | --- | ---- |
| Sw (%) | ---- | 0.992 | 1 | 0.993 | --- | ---- |
| Cut-offs: | | | | | | |
| Porosity (%) | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Vsh (%) | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |

***Table 10-3: Net sand log averages well 15/12-15***

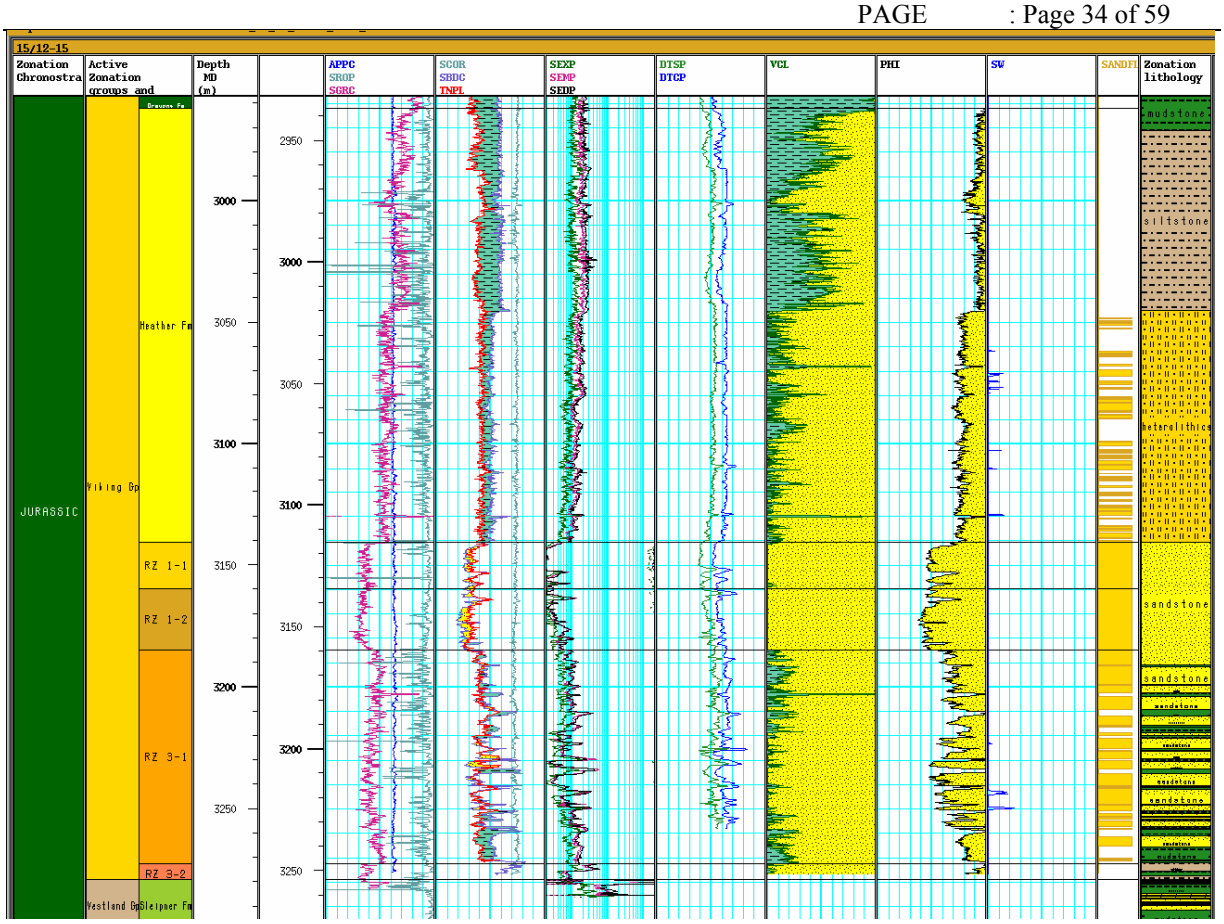


***Figure 10-1: CPI plot 15/12-15***

## 11.5 Cuttings

In 15/12-15 the cuttings sample interval was 10 meters from 1380 (13 3/8" casing shoe at 1364m to BCU). From 2800 to 3300 meters (TD) the sample interval was 3 meters (all depths given in MD RKB). Basically the samples were taken every third meter but in some cases samples were lost due to high ROP. Through the whole section two dry and two wet samples were collected.

## 11.6 Petrophysical Formulas

Porosity: $$\Phi_e = \frac{\rho_{ma}-\rho_b}{\rho_{ma}-\rho_f} - \frac{\rho_{ma}-\rho_{sh}}{\rho_{ma}-\rho_f} V_{sh}$$

Water saturation, Archie equation:

$$S_{we} = \left( \frac{aR_w}{\varphi_e^m R_t} \right)^{\frac{1}{n}}$$

Notations:

| | |
|---|---|
| $\Phi_e$ | = effective porosity |
| $\rho_{ma}$ | = matrix density |
| $\rho_b$ | = bulk density |
| $\rho_{sh}$ | = shale density |
| $\rho_f$ | = apparent fluid density |
| $V_{sh}$ | = shale volume |

$S_{we}$ = water saturation effective, non invaded zone
$R_t$ = true resistivity, non invaded zone
$R_w$ = formation water resistivity
$a$ = Archie factor
$m$ = cementation exponent
$n$ = saturation exponent

# 12 Pore Pressure, Overburden, Fracture pressure and Temperature

## 12.1 Pore Pressure

**Pore pressure**: A lot of attention was focused on the mud weight vs. pore pressure/hole stability situation in the 12 ¼" section. In the Varg area the maximum pore pressure has been estimated to be close to 1.43 sg while the Varg South has a maximum pore-pressure of 1.30 sg. To drill the pore pressure build-up section and the reservoir, which can be depleted from the original 1.22 sg a maximum mud weight of 1.35 sg would be required. The well was considered to be linked to the Varg South pore pressure regime. However a linkage to the Varg pore pressure model could not be eliminated (Fig. 11-1)

The pore pressure estimations were done from the start of the buildup (at the upper part of the Hordaland Group), continued into the Rogaland Group, Shetland Gp and Cromer Knoll Gp, before entering the Upper Jurassic Heather siltstones and Oxfordian reservoir section.

Continuous pore pressure estimation was performed by the wellsite and operation geologists in cooperation with the Halliburton pore pressure engineers.

The indicators used for pore pressure evaluation were:

**Gas levels** (drilled gas, connection gas)

**Dxc**

**MWD** (resistivity, sonic, density)

**Cavings**

**Hole conditions**.

**Gas levels:** Total gas levels were generally low throughout the well, with slightly higher levels in the Heather siltstone, and especially in the coal beds in Sleipner Fm. Possible connection gases started appearing from 1882m, possibly as early as 1710m, and continued down to 2145m. This indicates drilling close to balance from 1700m to 2150m.

**DxC** and **MWD Resistivity** calculations and trend analysis indicate an increased pore pressure from around 1480m to 1700m to a level of 1.32 sg EMW, which was maintained through the lower part of the Hordaland Gp. From ~2240m a slight decrease in pore pressure can be seen from the DxC and Resistivity trends. In the Shetland Gp the calculations are not applicable, while in the Heather Fm the pore pressure is indicated to approximately 1.30 sg EMW.

**MWD Sonic** data trends indicate a more gradual pore pressure build-up than the DxC and MWD resistivity methods; from around 1560m a gradual increase in pore pressure to a maximum of 1.32 sg EMW at ~2175m is indicated, below this a level of 1.28-1.26 sg EMW is indicated.

More detailed information can be found in the Halliburton pore-pressure reports.

**Cavings** was registered from middle-lower Hordaland Gp, at around 2130m returns depth, in only small amounts. From ~2460m (just into the Rogaland Gp) there was an increase in cavings, which started to decrease again from ~2530m, and was never a major concern further down the well. The form of the cavings was mainly blocky. Only a small percentage was splintery/platy at any depth. In other wells in the Varg area cavings usually appear at this stratigraphic level; lower Hordaland to upper Rogaland Gp, sometimes as massive cavings influx associated with gas peaks (e.g. 15/12-A-9). The cause of this pattern may be formation or pressure related, but can also be related to the regional faulting/fracturing pattern. Other wells in the Varg area have been drilled with considerably higher mud-weights, but often with much larger amounts of cavings than the present well.

**Hole stability** was generally good. Some minor restrictions were registered during tripping @ 2060-2082, 2265-2317, 2415mMD. The restrictions seemed to be rather stable.

A major concern during drilling and MDT logging was possible depletion in the reservoir, which could cause serious overbalance and problems with differential sticking and mud loss. The reservoir was depleted with 160 bar overbalance and the Oxfordian RZ1 sandstone showed good reservoir quality and mobility. Still no noticeable sticking or loss problems were registered.

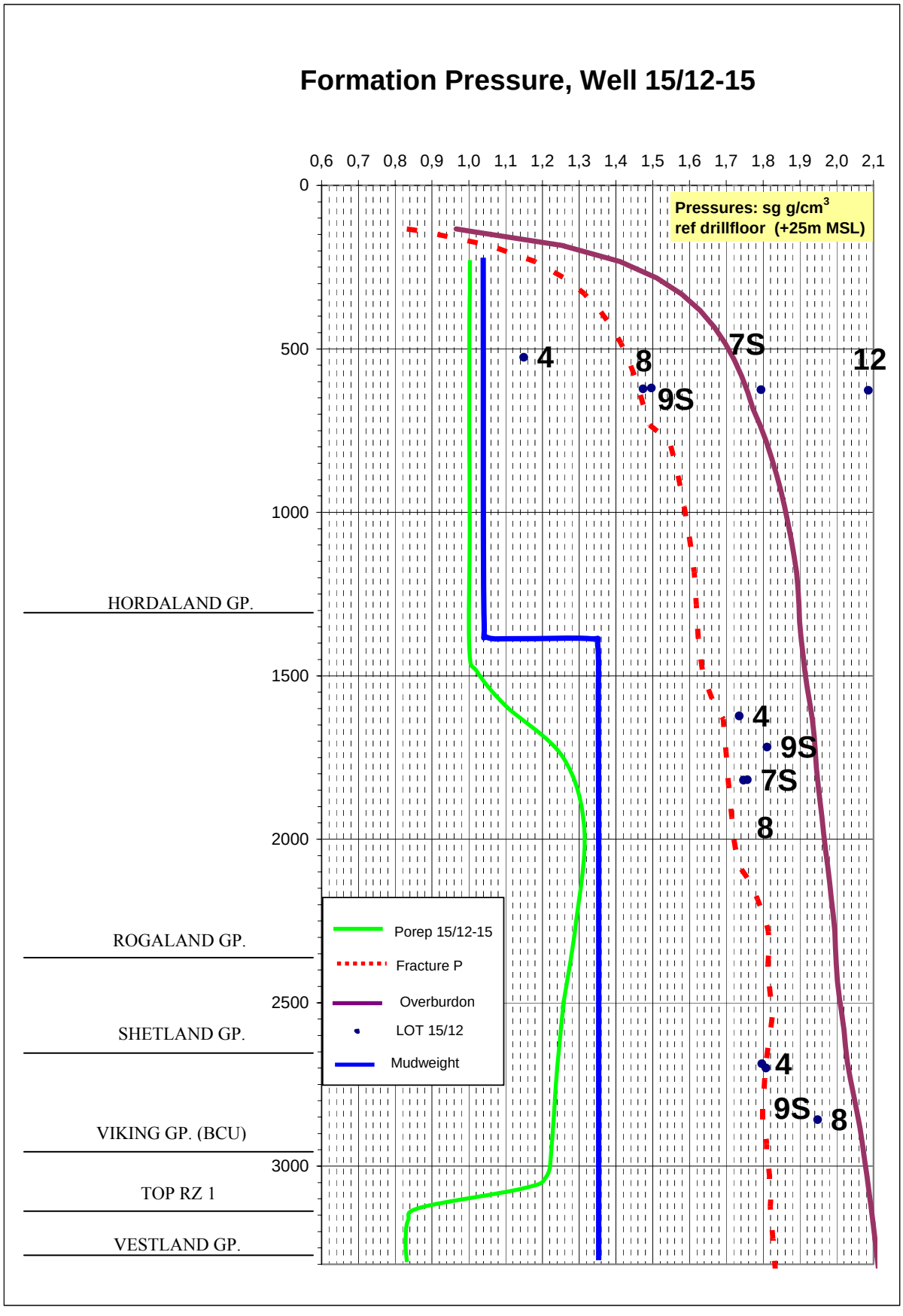


***Figure 10-1: Formation pressures 15/12-15***

## 12.2 Formation Strength

A leak off test of 1.74 sg equivalent mud weight was performed below the 13 3/8" casing shoe 15/12-15. No mud losses or hole instability problems were experienced during the drilling.

## 12.3 Overburden Gradient

The overburden gradient is based on available well data in the area.

## 12.4 Temperature Recordings

Maximum temperatures were recorded during each MWD run and at MDT run on wireline.

| Run # | Max depth mRKB | Max temp 'C | Comments |
|---|---|---|---|
| 200 | 1370 | 22 | MWD, 17 ½" hole |
| 300 | 2173 | 60 | MWD, 12 ¼" hole |
| 400 | 2454 | 69 | MWD, 12 ¼" hole |
| 500 | 2482 | 74 | MWD, 12 ¼" hole |
| 600 | 3300 | 88 | MWD, 12 ¼" hole |
| 1A | 3162 | 118 | Wireline, MDT |

***Table 10--1: Temperature recordings***

## 12.5 Temperature Gradient

Figure 10-3 shows a generalised temperature gradient plot for the Varg area (black line on the Figure - including well 15/12-15). The estimated background temperature gradient for the area is 3.6 °C/100 m and the estimated reservoir temperature at 3137 m (MSL) is 118.8 °C (while measured temperature was 118; see Table 10-1). However, locally above the reservoir, the temperature gradient will be higher due to the high thermal conductivity of the salt diapirs associated with the Varg field (dashed line on the Figure). The temperature measurement from the pressure testing on wireline (see Figure 11-1) shows a temperature gradient similar (although somewhat higher) to the overall temperature gradient of 3.6°C/100 m. However, the discrepancy between the general trend and the MWD measurements is due to cooling of the mud especially in the shallower sections of the well, resulting in too low temperature readings. In spite of this inaccuracy there is a good overall correlation between the overall temperature estimated within the reservoir and what was physically measured on the wireline.

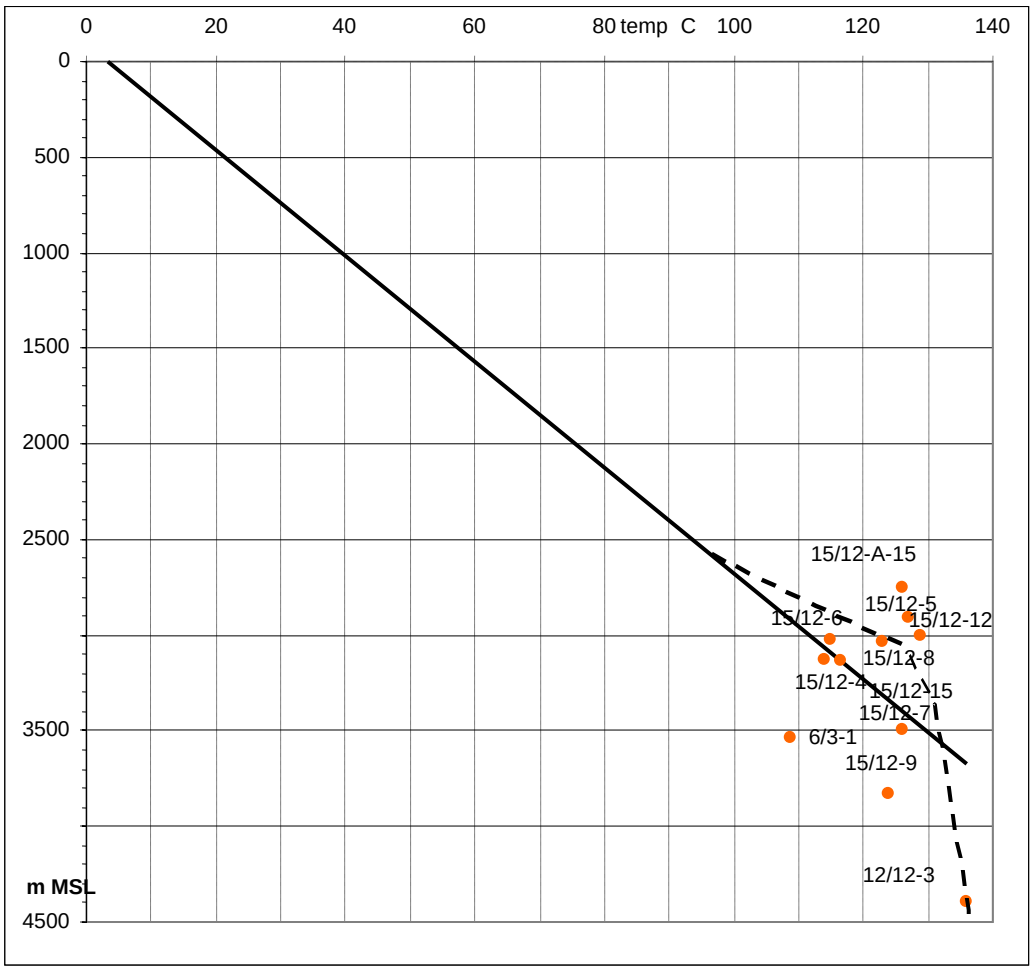


***Figure 10-3: Temperature gradient***

# 13 Appendix I Biostratigraphy Report

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| | |
|---|---|
| **Report number**<br><br>**APT04-727 // WSS NO. 0089/1204/01** | **Classification**<br>**Confidential** |
| **Report Title**<br><br>**A WELLSITE PALYNOLOGICAL / PALYNOFACIES EVALUATION OF THE JURASSIC SEQUENCE FROM**<br><br>**WELL 15/12-15, VARG FIELD,**<br>**NORWEGIAN CONTINENTAL SHELF**<br><br>**Amended Edition** | **Submitted**<br><br>**18 January 05**<br><br>**Amended edition:**<br><br>**7 September 05** |
| **Client**<br>**PERTRA a.s** | **Service Order** |
| **Client Reference:**<br><br>**Erling Siggerud** | **Number of pages:**<br>**13** |
| **Authors:**<br><br>**Darrin Stead and David Graham Bell** | |
| **Data files:**<br><br>**1) Report text, MS-Word (this report)**<br>**2) Range chart, 15/12-15 Adobe PDF**<br><br>**Amended edition:**<br><br>This report has been amended to include 1) additional detail on the Middle Eocene sample at 2190m noted in the offshore report. Details are given on page 5, 2) the preliminary offshore palynology report as an appendix and 3) entry of the final formation top depths on the range chart. | |

**PAGE**



**ENCLOSURES**



3. Quantitative Palynological Distribution Chart

## 1.0 INTRODUCTION

This report presents the results and interpretation of a wellsite palynological/palynofacies evaluation and subsequent hotshot analysis of the Late Jurassic sequence in Pertra AS well 15/12-15, Varg Field, Norwegian Continental Shelf.

A total of 21 ditch cuttings samples were prepared and analysed at the wellsite over the interval 2927m – 3278m. A further seven samples from within this range were also examined later from samples forwarded by PERTRA to APT's laboratory. The sample depths quoted are measured depths.

The uppermost sample at 2190m was originally prepared to test the offshore unit and no work was done on it. This has been briefly re-examined for the amended edition of this report.

Palynological analysis involved counts of 200 palynomorphs per slide, where recovery allowed, followed by scanning for additional taxa. Palynofacies analysis of material involved visual assessment of individual palynofacies constituents. Pertra AS made available a previous palynological study on the Varg 15/12 Area (Whitaker 2002). The palyno-events developed in that report have been utilized in this study.

Palynomorph distribution is presented on the distribution chart Enclosure 1.

Personnel involved in this report are:

D. T. Stead: Palynology/ reporting
D. G. Bell: Palynology

# 2.0 STRATIGRAPHICAL SUMMARY

## 2.1 BIOSTRATIGRAPHY

| AGE | PALYNO-EVENT | TOP DEPTH |
|---|---|---|
| Paleogene, Middle Eocene | | 2190.00m (FSE) |
| No samples examined 2190-2927m | | |
| Early Cretaceous, Valanginian | | 2927.00m |
| Early Cretaceous, Ryazanian | | 2936.00m |
| Late Jurassic, Middle to Early Kimmeridgian | B11 | 2963.00m |
| | B19 | 2999.00m |
| ----- Possible non-sequence ------ | | |
| Late Jurassic, Late Oxfordian | B28-31(or older) | 3143.00m |
| | RZ1-RZ2 | |
| ----- Possible non-sequence ----- | | |
| Late Jurassic, Middle Oxfordian | B52 | 3185.00m |
| | RZ3.1 | |
| | B57 | 3197.00m |
| | B58 | 3251.00m |
| Late Jurassic, Early Oxfordian | B61 (or older) | 3275.00m |
| | RZ3.2 | |
| ----- Non-sequence ------ | | |
| Middle Jurassic, Bajocian to ?Bathonian | B73 | 3278.00m (LSE) |

FSE = First sample examined

LSE = Last sample examined

## 3.0 STRATIGRAPHICAL DISCUSSION

### 3.1 TERTIARY

**INTERVAL:** 2190m only

**AGE:** Eocene (probably Late Lutetian-Bartonian - Middle Eocene)

**LITHOSTRATIGRAPHY:** Hordaland Group

**PALYNOLOGY:** This sample was prepared to test the offshore unit and was reported only as being of Eocene age. A brief re-examination of this sample confirms the Eocene age given in the offshore report. The assemblage is moderately rich, preservation is fair only. The following species were logged:

*Deflandrea phosphoritica* (common), *Areosphaeridium pectiniforme* gp (common), *A. michoudii, A. dictyophorum, Phthanoperidinium comatum, Cordosphaeridium* cf *funiculatum, Rhombodinium draco* (moderately common), *Thalassiphora pelagica* (common), *T. delicata, Hystrichosphaeropsis* sp., *Heteraulacacysta campanula, Wetzeliella* spp. and (caved) *Svalbardella cooksoniae* and other Early Oligocene species.

The assemblage is from the upper parts of the Eocene. Good index fossils are lacking but the presence of moderately common Rhombodinium draco together with Thalassiphora delicata suggest that the sample is most likely to be of Late Lutetian or Bartonian age (Middle Eocene). Some of the species logged are known from and are common in the Late Eocene (Priabonian).

## 3.2 EARLY CRETACEOUS

**INTERVAL:** 2927m (FSE) - 2963m

**AGE:** Valanginian - Ryazanian

**LITHOSTRATIGRAPHY:** Cromer Knoll Group

**PALYNOLOGY:** Two samples have been analysed from this interval. These are at depths 2927m and 2936m. Forms recorded from the sample analysed at 2927m include *Cymososphaeridium* spp. (typically Hauterivian to Valanginian), *Muderongia simplex* subsp. *perforata* and relatively common *Spiniferites ramosus* group. This last form suggests a Valanginian age. The sample is dominated by forms derived from the Heather Formation. These include *Rhynchodiniopsis cladophora, Cribroperidinium globatum, Pareodinia ceratophora,* common microforaminiferal test linings and common *Callialasporites* spp. The presence of the dinoflagellate cyst *Cribroperidinium*? *longicorne* further indicates some reworking from the Draupne Formation. SOM is also common to abundant. This is a typical feature of Heather and Draupne Formation sediments. It is suggested that this sample is from the Cromer Knoll Group, of Valanginian age with reworking from both the Heather Formation and, to a lesser extent, the Draupne Formation. A reworked Heather interval within the Cromer Knoll Group has been noted in other wells from the Varg Field, e.g., well 15/12-12-A-10 at 3170m.

At 2963m Early Cretaceous forms recorded include *Batioladinium* spp., *Gonyaulacysta helicoidea* group, *Cymososphaeridium* sp., *Hystrichodinium voigtii, Stiphrosphaeridium arbustum, Kleithriasphaeridium* spp. and *Cassiculosphaeridium magna.* The first downhole occurrence of *Gochteodinia villosa* suggests an age no younger than Ryazanian. Reworking from the Heather Formation is again noted, although it is possible that these forms are caved from the reworked unit at 2927m.

**STRATIGRAPHICAL COMMENT:** The wireline log interpretation also indicates Cromer Knoll sediments within this interval. The presence of a reworked Heather Formation unit within the Cromer Knoll Formation has been noted in other wells drilled in the Varg Field.

## 3.3 LATE JURASSIC

**INTERVAL:** 2963 – 3143m

**AGE:** Kimmeridgian

**LITHOSTRATIGRAPHY:** Heather Formation

**PALYNOEVENTS:** B11-19

**PALYNOLOGY:** Eight samples have been analysed from this interval. These are 2963m, 2978m, 2999m, 3008m, 3062m, 3089m, 3125m and 3134m. At 2963m the occurrence of *Pareodinia ceratophora* (Event B4), *Cribroperidinium globatum* (Event B6), *Gonyaulacysta jurassica* (Event B8), and common microforaminiferal test linings (B11) indicate penetration of Heather Formation, at event B11. This is supported by the common to abundant occurrence of the sporomorph *Callialasporites* spp. (Event B5). The occurrence of common small tasmanitids may be derived from a Draupne Formation (caved), though this is not clear. The occurrence of *Nannoceratopsis pellucida* indicates reworking from RZ2.2 or RZ3.

A similar assemblage is recorded from the sample at 2978m and Event B11 again indicated. Reworking from RZ2.2 or RZ3 is indicated by the presence of *Compositosphaeridium polonicum.*

The first downhole occurrence of *Scriniodinium crystallinum* at 2999m indicates Event B19. There is no evidence for any additional palynoevents in the remaining interval, from 3008m to 3143m. Forms recorded from this interval include *Endoscrinium luridum, Gonyaulacysta jurassica, Systematophora* spp., *Scriniodinium crystallinum, Ambonosphaera* spp., *Cribroperidinium globatum* group, *Rhynchodiniopsis cladophora, Pareodinia ceratophora* and microforaminiferal test linings. The presence of *Cribroperidinium*? *longicorne* at 3008m may indicate caving from the Draupne Formation or from higher in the Heather. *Rhynchodiniopsis cladophora* is common at 3062m.

**STRATIGRAPHICAL COMMENT:** Forms which may be derived from the Draupne Formation have been recorded at 2963m and 3008m. However, the Draupne Formation has not been conclusively seen in any of the analysed samples from the overlying sequence. The implication is that a thin Draupne layer may exist between 2936m and 2963m.

**INTERVAL:** 3143 - 3185m

**AGE:** Late Oxfordian

**LITHOSTRATIGRAPHY:** RZ1-RZ2

**PALYNOEVENTS:** B28-31 or older

**PALYNOLOGY:** Four samples have been analysed from this interval, at 3143m, 3152m, 3161m and 3170m. The first downhole occurrence of relatively common *Sirmiodinium grossii* is recorded at 3143m (probably Event B28 or older). Microforaminiferal test linings are also common (Event B26). There is a decrease in the recovery of organic matter compared to the overlying samples, with an increase in the amount of mineral matter seen. The sample is also sandier than previous samples. The total evidence suggests penetration of RZ 1, possibly at around Event B28. However the possibility that older reservoir levels may be represented is not excluded.

The sample at 3152m is very similar with no evidence for any additional events. The first downhole occurrence of *Leptodinium mirabile* is recorded at 3161m. This suggests Events B28 indicative of RZ 1-2, and is consistent with the age assessment. *Leptodinium mirabile* is again recorded at 3170m in association with abundant *Rigaudella aemula*; the latter may be caved at that level.

Other forms recorded from this interval include *Rhynchodiniopsis cladophora, Cribroperidinium globatum* group, *Scriniodinium crystallinum, Sirmiodinium grossii, Gonyaulacysta jurassica, Endoscrinium galeritum* and *Pareodinia ceratophora.* Bisaccate pollen and *Cerebropollenites mesozoicus* are both common to abundant. The preservation of palynomorphs throughout this section is very poor and degraded, and unidentifiable palynomorphs are common.

**INTERVAL:** 3185 – 3275m

**AGE:** Middle Oxfordian

**LITHOSTRATIGRAPHY:** RZ3.1

**PALYNOLOGY EVENTS:** B52 – B58

**PALYNOLOGY:** The first downhole occurrence of *Rigaudella aemula* at 3179m indicates penetration of RZ3.1, Event B52. Other forms recorded from this sample include *Endoscrinium galeritum, Sirmiodinium grossii* and common microforaminiferal test linings. *Rigaudella aemula* is again recorded in the underlying sample, at 3188m and is consistently recorded throughout the interval. A single *Epiplosphaera* sp. is recorded at 3188m, which tentatively may indicate Event B55. At 3197m there is a noted increase in numbers of the acritarch *Micrhystridium* spp. recorded. This indicates Event B57. *Gonyaulacysta jurassica longicornis* is also recorded for the first time at this depth. The first downhole occurrence of *Ctenidodinium ornatum* is recorded at 3242m. This supports the assessment that Event B57 has been recorded. *Rigaudella aemula* is abundant at this depth. The first downhole occurrence of *Trichodinium scarburghense* is recorded at 3251m. This indicates Event B58. Other forms recorded from this interval include common microforaminiferal test linings, *Scriniodinium crystallinum, Rhynchodiniopsis cladophora, Gonyaulacysta jurassica, Endoscrinium galeritum, Endoscrinium galeritum, Sirmiodinium galeritum, Tubotuberella apatela, Chytroeisphaeridia cerastes* and *Nannoceratopsis pellucida.* The sporomorph forms *Cerebropollenites mesozoicus, Perinopollenites elatoides* and bisaccate pollen are all common to abundant through the interval.

**STRATIGRAPHICAL COMMENT:** The analysis of samples at the wellsite indicated that RZ 3.1 had been penetrated at 3188m. Subsequent hot-shot analysis of samples indicates that penetration is higher, at 3179m. However, a characteristic change in the wireline logs at 3185m is used as top of RZ 3-1.

**INTERVAL:** 3275 - 3278m

**AGE:** Early Oxfordian

**LITHOSTRATIGRAPHY:** RZ3.2

13.1.1.1.1 PALYNOLOGY EVENTS: **B61**

**PALYNOLOGY:** The first downhole occurrence of the dinoflagellate cyst *Wanaea fimbriata* is recorded at 3275m. This indicates penetration of RZ3.2, Event B61. Other forms recorded include *Pareodinia ceratophora, Trichodinium scarburghense, Nannoceratopsis pellucida, Endoscrinium galeritum, Gonyaulacysta jurassica, Tubotuberella apatela, Scriniodinium crystallinum, Rigaudella aemula, Rhynchodiniopsis cladophora* and microforaminiferal test linings. The sporomorph forms *Cerebropollenites mesozoicus, Perinopollenites elatoides* and bisaccate pollen remain common.

**STRATIGRAPHICAL COMMENT:** Analysis of the selected samples at the wellsite indicated reservoir unit RZ3.1 at 3260m overlying Sleipner Formation sediments at 3278m. Hot-shot analysis of an infill sample at 3275m indicates the presence of reservoir unit RZ3.2.

## 3.5 MIDDLE JURASSIC

**SAMPLE:** 3278m (LSE)

**AGE:** Bajocian - ?Bathonian

**LITHOSTRATIGRAPHY:** Sleipner Formation

13.1.1.1.2 PALYNOLOGY EVENT: **B73**

**PALYNOLOGY:** Very good recovery of palynomorphs at 3278m (LSE). An influx of *Cyathidites minor* is recorded, dominating the assemblage. Other forms include *Osmundacidites wellmanii Cerebropollenites mesozoicus, Perinopollenites elatoides, Inaperturopollenites* spp., *Ischyosporites* spp., *Todisporites minor, Classopollis* spp., *Leptolepidites* spp. and *Callialasporites dampieri.* This assemblage is typical of Middle Jurassic sediments in the North Sea, probably of Bajocian-?Bathonian age. Penetration of the Sleipner Formation, Event B73 is indicated.

**STRATIGRAPHICAL COMMENT:** There is a non-sequence between the top of the Sleipner Formation and the reservoir.

## 4.0 REFERENCES

Whitaker, M. (2002): Palynological data from the Varg 15/12 area. Norsk Hydro E & P Research Centre, Bergen.

# Enclosure 1 – definition of reservoir zones

| Reservoir | | Event | Approximate ammonite zone-equiv. | Palynomorph Event Characterisation |
|---|---|---|---|---|
| zones | sub-z | | | |
| | | | | |
| Heather | H1 | B1 | eudoxus-mut | Acme P. pannosum |
| Heather | H1 | B2 | | Base Geiselodinium spp. |
| Heather | H1 | B3 | | Base regular P. pannosum |
| Heather | H1 | B4 | | Top local P. ceratophora |
| Heather | H1 | B5 | mutabilis | Top common Callialasporites spp. |
| Heather | H1 | B6 | | Occurrence local C globatum-granuligerum gp |
| Heather | H1 | B7 | | Influx local C. globatum-granuligerum gp |
| Heather | H1 | B8 | | Top G. Jurassica (+/-regular) |
| Heather | H1 | B9 | cymodoce | Influx local C. globatum-granuligerum |
| Heather | H1 | B10 | | To persistent G jurassica |
| Heather | H1 | B11 | | Top common local MFT |
| Heather | H1 | B12 | | Top minor influx local Pteridophyte spores |
| Heather | H1 | B13 | | Base minor influx local Pteridophyte spores |
| Heather | H1 | B14 | | Base common local MFT |
| Heather | H1 | B15 | | Base regular local P. mixtispinosum |
| Heather | H2 | B16 | baylei | Top common R. cladophora |
| Heather | H2 | B17 | | Top common G. jurassica |
| Heather | H2 | B18 | | Influx Systematophora. penicillata (fasciata) |
| Heather | H2 | B19 | | Top S. crystallinum |
| Heather | H2 | B20 | | Base regular E. ovatum |
| Heather | H2 | B21 | rosenkrantzii | Base common S. areolata (rigid)local |
| RZ1 | RZ1.1 | B22 | | Top local Gleichenditites spp. |
| RZ1 | RZ1.1 | B23 | | Top local L. austroclavatidites |
| RZ1 | RZ1.1 | B24 | | Base frequent C. globatum-granuligerum |
| RZ1 | RZ1.1 | B25 | | Top common E. galertum-Ambonosphaera |
| RZ1 | RZ1.1 | B26 | | Top common local MFT labyrinthia |
| RZ1 | RZ1.1 | B27 | | Common L. mirabile |
| RZ1 | RZ1.1 | B28 | | Acme S. grossii |
| RZ1 | RZ1.2 | B29 | regulare | Occurrence S. orbis |
| RZ1 | RZ1.2 | B30 | | Base Egmontodinium-L. Sp 12 |
| RZ1 | RZ1.2 | B31 | | Base frequent L. mirabile |
| RZ1 | RZ1.2 | B32 | | Base G. dimorphum |
| RZ1 | RZ1.2 | B33 | | Base common MFT labyrinthia |
| RZ1 | RZ1.2 | B34 | | Influx local Ambonosphaera sp. |
| RZ1 | RZ1.2 | B35 | | Top MBI (3 sb) local |
| RZ1 | RZ1.2 | B36 | | Influx (local) R. Cladophora |
| RZ1 | RZ1.3 | B37 | | Top MFT chambers dominant, local |
| RZ1 | RZ1.3 | B38 | | Top MFT complete dominant, local |
| RZ1 | RZ1.3 | B39 | | Base MB2 (5BD) local |
| RZ2 | RZ2.1 | B40 | serratum | Top M5 local |
| RZ2 | RZ2.1 | B41 | | Top common acritarchs, local |
| RZ2 | RZ2.1 | B42 | | Occurrence local S. crystallinum |
| RZ2 | RZ2.1 | B43 | | Occurrence local P. "tabulata" |
| RZ2 | RZ2.1 | B44 | | Influx frequent E. galeritum (local) |
| RZ2 | RZ2.1 | B45 | | Top regular Ellipsoidictyum - C. magna |

| | | | | |
|---|---|---|---|---|
| RZ2 | RZ2.1 | B46 | | Base regular C. globatum-granuligerum |
| RZ2 | RZ2.1 | B47 | | Acme G. jurassica (broad based) local |
| RZ2 | RZ2.1 | B48 | | Base S. cf vestitum |
| RZ2 | RZ2.2 | B49 | glosense | Top C. polonicum |
| RZ2 | RZ2.2 | B50 | | Top N. pellucida |
| RZ3 | RZ3.1 | B51 | | Top rare R aemula, top rare G. jurassica longicornis |
| RZ3 | RZ3.1 | B52 | | Regular R. aemula, G. jurassica longicornis |
| RZ3 | RZ3.1 | B53 | tenuiseratum | Top common R. aemula, top regular C. cerastes |
| RZ3 | RZ3.1 | B54 | | Degraded palynomorphs |
| RZ3 | RZ3.1 | B55 | | Ellipsoidictyum-Epiplosphaera sp. |
| RZ3 | RZ3.1 | B56 | | Influx R. aemula common |
| RZ3 | RZ3.1 | B57 | | C. ornatum (?top), Influx acritarchs, Batiacasphaera sp. |
| RZ3 | RZ3.1 | B58 | densi-plicatum | Top T. scarburghense, Stephanelytron sp., E. galeritum, base MFT labyrinth |
| RZ3 | RZ3.1 | B59 | | Influx small G. jurassica, C. polonicum N. pellucida (reg), Ellipsoidictyum sp. (COM) |
| RZ3 | RZ3.1 | B60 | cordatum | Base G. jurassica longicornis |
| RZ3 | RZ3.2 | B61 | | Top W. fimbriata, Top frequent T scarburghense, K. diceras |
| RZ3 | RZ3.2 | B62 | | Acritarch type A |
| RZ3 | RZ3.2 | B63 | | R. aemula (base of influx) |
| RZ3 | RZ3.2 | B64 | | Acritarch type A |
| RZ3 | RZ3.3 | B65 | | Cleistosphaeridium sp., A. australis (top) |
| RZ3 | RZ3.3 | B66 | | Surculosphaeridium spp. (common) |
| RZ3 | RZ3.3 | B67 | | Ambonosphaera spp. Batiacasphaera sp.. P. evittii, C. ornatum |
| RZ3 | RZ3.3 | B68 | | Dingodinium minutum, Base W. fimbriata, Retitriletes spp (common) |
| RZ3 | RZ3.3 | B69 | | S. crystallinum com/abu. Atopodinium sp. W. digitata/ thysanota |
| RZ3 | RZ3.3 | B70 | athleta | W. digitata, N. spiculata-pellucida |
| RZ3 | RZ3.3 | B71 | | P. ceratophora COM |
| Hugin | Hu | B72 | | K. stegasta com |
| Sleipner | SL | B73 | | Cyathidites/Deltoidospora minor (com), Q. anelleformis C. mesozoicus, Callialasporites sp. |

# Enclosure 2 - Offshore report prepared during and immediately after drilling operations

## Preliminary palynological report, 15/12-15

14 December 2004

**Eocene**

2190m: Sample prepared to ´test´unit. A brief analysis indicates an Eocene age at this depth. See main report for details.

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**Early Cretaceous, Cromer Knoll**

2927m: Sample contains principally Heather forms such as *Rhynchodiniopsis cladophora, Cribroperidinium globatum, Pareodinia ceratophora,* common microforaminiferal test linings and common *Callialasporites* spp. Also some Draupne forms noted, e.g., *Cribroperidinium? longicorne.* Early Cretaceous forms also noted, including *Cymososphaeridium* spp (typically Hauterivian to Valanginian), *Muderongia simplex* subsp. *Perforate* and relatively common *Spiniferites ramosus* group. This last form suggests Valanginian. Given the wireline log interpretation this form is interpreted as Cromer Knoll, Valanginian with Late Jurassic (mainly Heather but also some Draupne) reworking. A reworked Heather interval within the Cromer Knoll has been noted in other wells during this project.

2936m: Reworked Heather forms again noted (although these may be caved from the aboved reworked unit). Early Cretaceous forms recorded include *Batioladinium* spp., *Gonyaulacysta helicoidea* group, *Cymososphaeridium* sp., *Hystrichodinium voigtii, Stiphrosphaeridium arbustum, Kleithriasphaeridium* spp. and *Cassiculosphaeridium magna.* The first downhole occurrence of *Gochteodinia villosa* suggests no younger than Ryazanian.

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**Late Jurassic, Kimmeridgian**

2963m: The occurrence of *P. ceratophora* (B4), common to abundant *Callialasporites* spp. (Event B5), *C. globatum* (B6), *G. jurassica* (B8),and common microforaminiferal test linings (B11) indicate penetration of Heather Formation, at event B11. The occurrence of common small tasminitids may indicate some caving from Draupne Formation. The occurrence of *Nanoceratopsis pellucida* indicates reworking from RZ2.2 or RZ3.

2978m: As above. Reworking indicated by *C. polonicum* (Rz2.2 or RZ 3).

2999m: First downhole occurrence of *Scriniodinium crystallinum* indicates Event B19, Heather Formation.

3008m: As above, B19. The presence of *Cribroperidinium? longicorne* indicates caving from Draupne Formation.

Note: Draupne forms have been noted at 2963m and 3008m. These have been interpreted as caved. However, the Draupne Formation has not been conclusively seen in any of the analysed samples. The implication is that a thin Draupne layer possibly exists between 2936m and 2963m.

3062m: No evidence for change; common *R. cladophora.* Event B19, Heather Formation.

3089m: As above

3125m: As above

3134m: As above

**Late Jurassic, Oxfordian**

3143m: Reduced recovery of palynomorphs, increase in palynomacaral 4. A higher energy environment of deposition is indicated. A sandier sample than seen previously. First downhole occurrence of *S. grossi* (relatively common). Also relatively common microforaminiferal test linings (B26) Based on all this evidence it is suggested RZ1.1 is penetrated, possibly as low as B28.

3152m: Very poor preservation. Mostly mineral matter and Cenozoic caving. Common microforaminiferal test linings indicate B26. *S. grossi* again recorded. No evidence for change, RZ1.1, B26-28

3170m: Similar to above. First downhole occurrence of *Leptodinium mirabile* – B27? RZ1.1, B26-28

3188m: First downhole occurrence of *Rigaudella aemula* (common) indicates B52-53, RZ3.1. *Epiploshaera* sp. also noted (B55?). Suggest RZ3.1 B52-55.

3197m: Noted increase *Micrhystridium* spp. – B57, RZ3.1. *Gonyaulacysta jurassica longicornis* recorded.

3215m: No evidence for change.

3233m: As above

3242m: Abundant ***R. aemula.*** First downhole occurrence *Ctenidodinium ornatum.* B57 RZ3.1

3260m: As above

**Middle Jurassic**

3278m: Influx of sporomorphs. Abundant *Cyathidites minor.* Also *Osmundacidites* spp., *Cerebropollenites mesozoicus, Callialasporites dampieri, Classopollis* spp., *Perinopollenites elatoides* and *Inaperturopollenites* spp. Sleipner Formation, Event B73.
Middle Juraasic

# 14 Appendix II Well to seismic correlation

A zero offset synthetic seismogram was created from the sonic and density logs acquired with the Halliburton MWD tool. The wavelet used for the synthetic seismogram was extracted from the seismic data statistically. As the seismic data was processed for zero-phase it was natural to assume that the data is such for the extraction process.

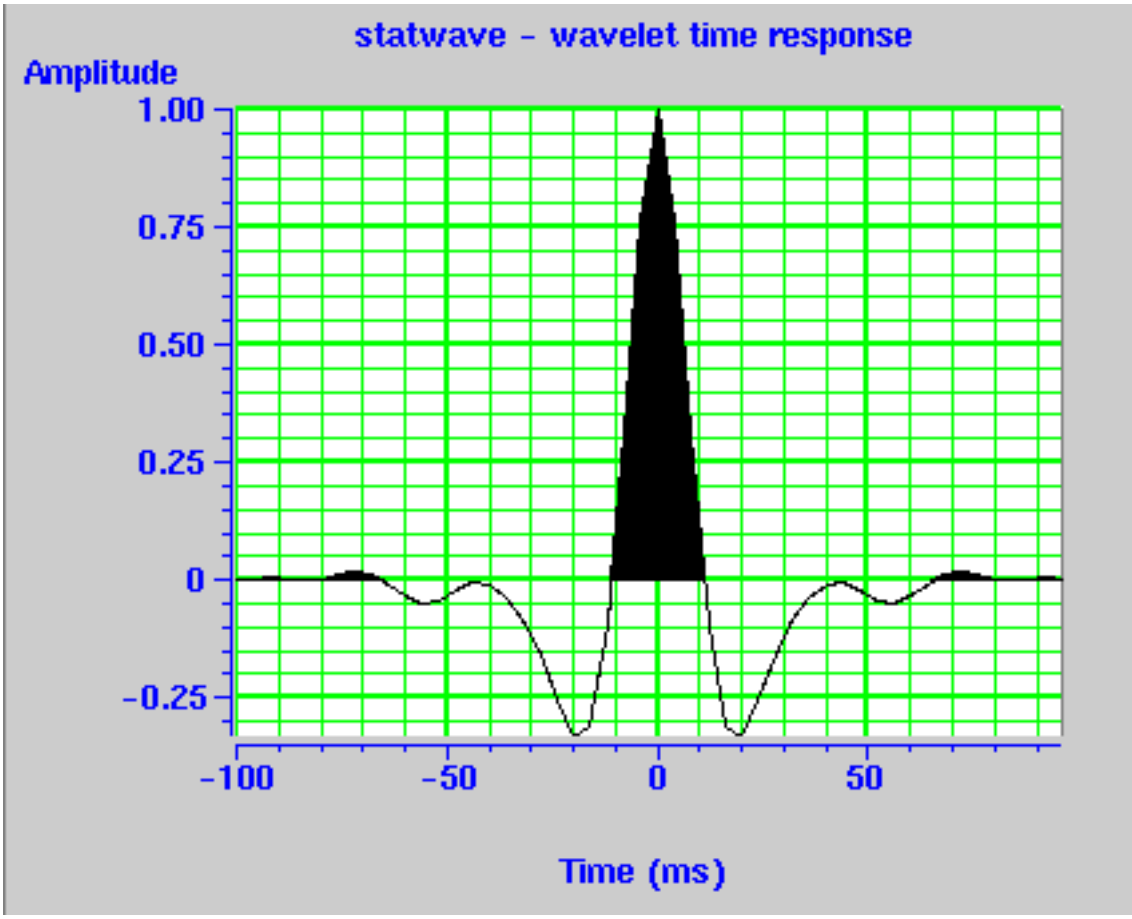


Figure 1. Statistically extracted wavelet.

The statistics for the wavelet were derived from the following volume of seismic data

| | | | |
|---|---|---|---|
| Time from | 2200 | To: | 2700 ms |
| Xline from | 950 | To: | 1000 by 1 |
| Inline from | 1830 | To: | 1840 by 1 |

| | |
|---|---|
| Wavelet length | 200 ms |
| Taper length | 25 ms |
| Sample rate | 4 ms |
| Phase rotation | 0 degrees |
| Assumption | constant phase |

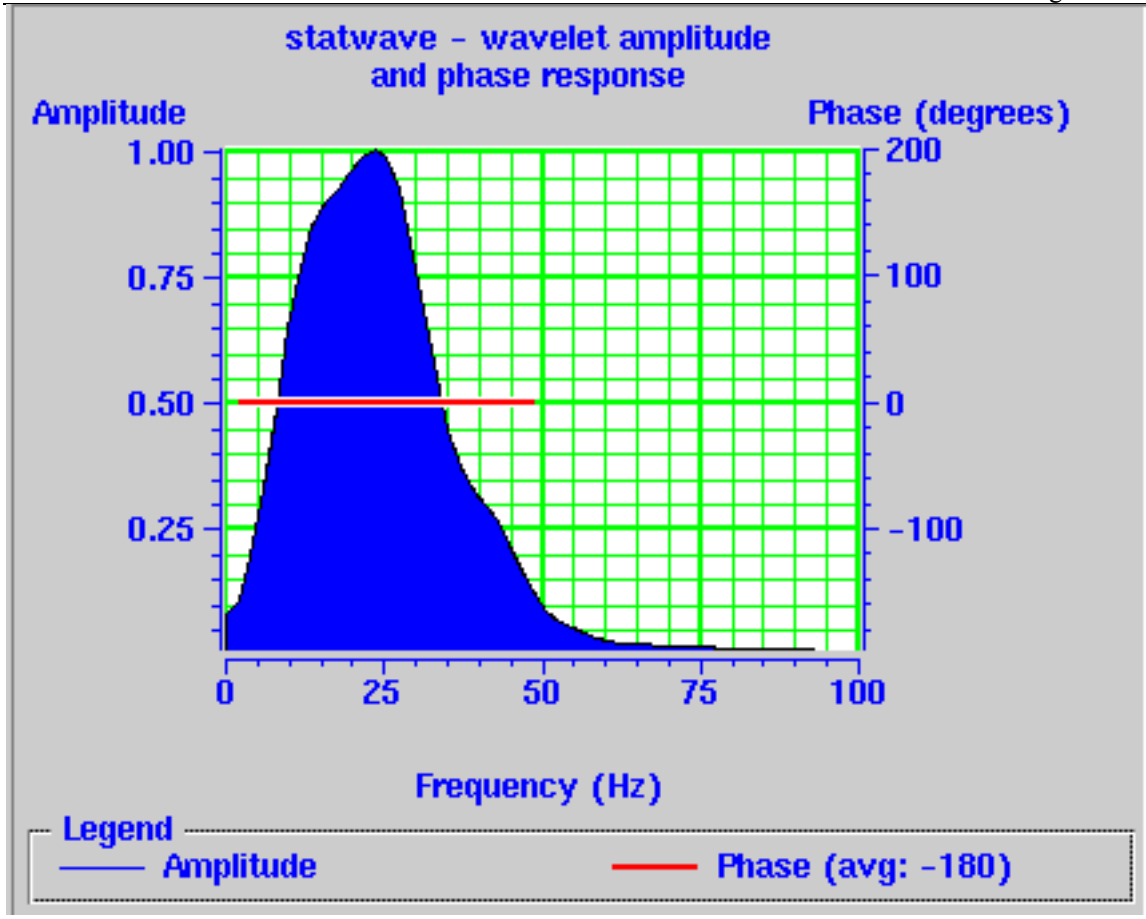


Figure 2 Frequency spectrums for the wavelet.

As figure 2 shows the central peak is at 25 Hz with a minimum of about 5 Hz and maximum of about 50 Hz. Note the plot is not in Db. Additionally the figure shows that the wavelet is zero phase (red line).

The wavelet was convolved with the reflection series generated from the computed acoustic impedance thus creating the synthetic seismogram. This zero offset synthetic seismogram was correlated to the seismic data utilizing eLog from the Hampson-Russell suite of geophysical tools. As no check shots or VSP were recorded the correlation process is based purely on waveform matching and stretch and squeezing of the synthetic to match the seismic (Figure 3).

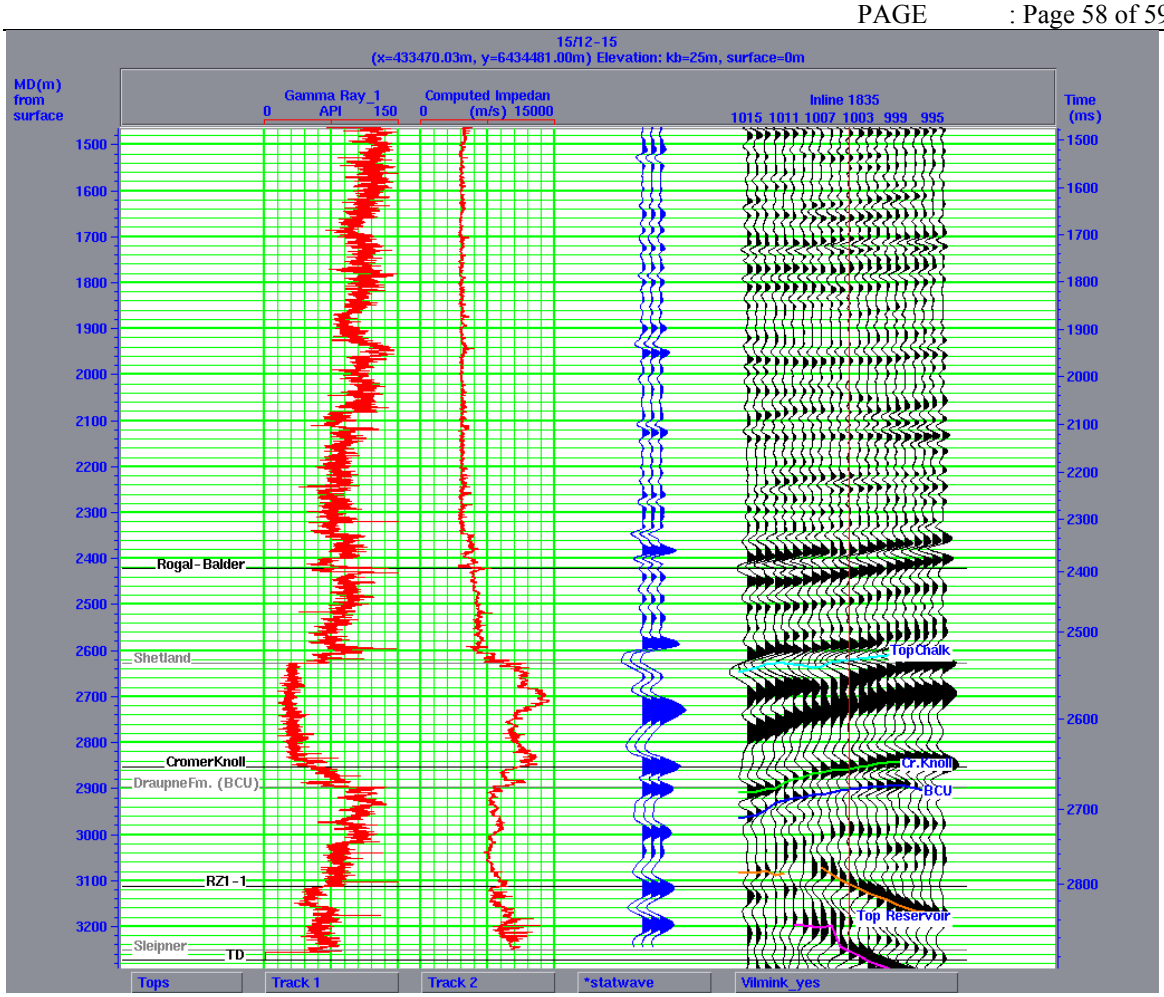


Figure 3. Selected well logs, synthetic and a portion of the seismic about the well location.

Figure 3 shows the final result of the correlation between the synthetic and real seismic along with the gamma ray log and the computed acoustic impedance. The synthetic trace is shown in blue. The correlation is fairly good. The red vertical trace on the seismic is the well location. Figure 4 shows the synthetic seismic inserted in the seismic. The good correlation between the synthetic and the real seismic is more easily seen in this figure.

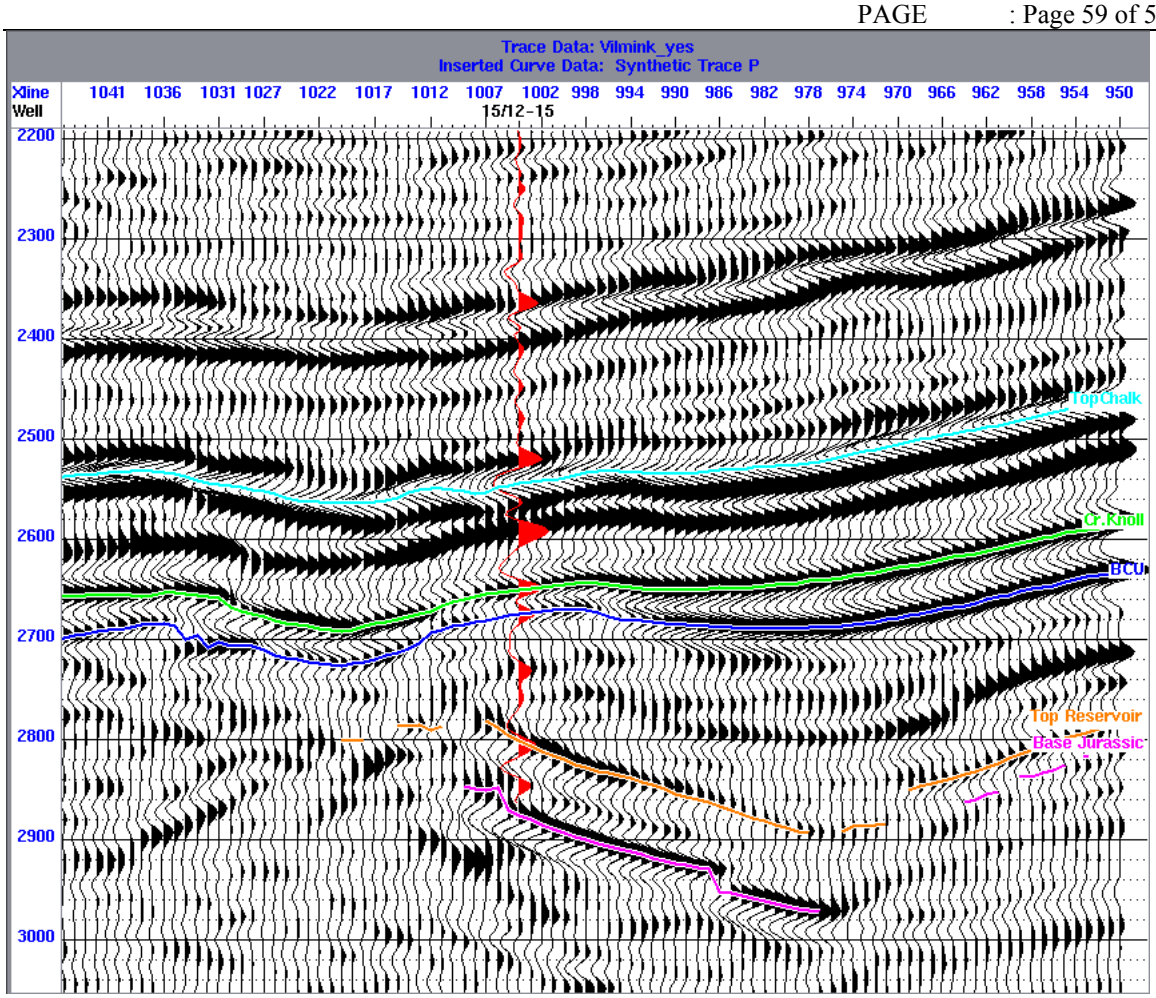


Figure 4 Synthetic seismogram inserted in the seismic volume.