Fig. 1: Well summary figure for the Lower-Upper Oligocene to Upper Pliocene in well 34/4-7 including gamma ray log, lithology, lithostratigraphic units, series/subseries, benthic foraminiferal assemblages, planktonic fossil assemblages, paleobathymetry, strontium isotope ages and analysed samples.

Sea floor = 380 metres below rig floor (mRKB)
DC = Ditch cuttings
SWC = Sidewall core
gAPI = American Petroleum Institute gamma ray units
G = Abundant glauconite
Δ = Ice-rafted pebbles
Lower-Upper Oligocene to Upper Pliocene in well 34/4-7


Based on analyses of benthic and planktonic foraminifera, pyritised diatoms and Sr isotopes in well 34/4-7 (61°31'09.83''N, 02°15'15.45''E, Snorre Field, Map 1), we recorded 20 m with Lower-Upper Oligocene sediments, 20 m with Upper Miocene-Lower Pliocene deposits and 180 m with Upper Pliocene sediments. The base of the Oligocene and the top of the Upper Pliocene were not investigated. The units were investigated with 22 ditch-cutting samples at ten metre intervals and ten sidewall cores (Fig. 1).

Biostratigraphy

Lower-Upper Oligocene (1220-1200 m, Hordaland group)
Benthic foraminifera of the *Turrilina alsatica* assemblage and pyritised diatoms of the Diatom sp. 3 assemblage, together with a Sr isotope age (27.6 Ma) obtained from the sample at 1210 m, indicate an age close to the Early/Late Oligocene boundary (28.5 Ma) for this unit (Fig. 1). The benthic foraminiferal assemblage is correlated with the upper part of Subzone NSB 7b and lower part of Subzone 8a of King (1989) and probably the upper part of Zone NSR 7B of Gradstein & Bäckström (1996). The diatom assemblage is correlated with the lower part of Subzone NSP 9c of King (1989). All of these fossil zones are described from the North Sea area.

Upper Miocene-Lower Pliocene (1200-1180 m, Utsira Formation)
Benthic calcareous foraminifera of the *Ehrenbergina variabilis* assemblage and planktonic foraminifera of the *Neogloboquadrina atlantica* (sinistral) assemblage indicate a Late Miocene-Early Pliocene age for this interval (Fig. 1). In addition to the nominate species the planktonic foraminiferal fauna includes *G. bulloides* and a specimen of *N. atlantica* (dextral). The benthic foraminiferal assemblage is correlated with the *G. subglobosa* – *E. variabilis* zone of Stratlab (1986, Norwegian Sea continental shelf) and tentatively Subzone 13b of King (1989, North Sea).

*E. variabilis* is recorded from the Upper Oligocene to Lower Miocene of Germany (Grossheide & Trunco 1965, Spiegler 1974) and from the Upper Oligocene to Lower Pliocene on the Norwegian continental shelf (Skarbø & Verdenius 1986). *N. atlantica* (sinistral) is known from the Late Miocene to Late Pliocene deposits on the Voring Plateau (Spiegler & Jansen 1989). In the same area, *N. atlantica* (dextral) occurs in a part of the Upper Pliocene and in the Upper Miocene. The occurrence of *N. atlantica* (dextral) in this unit may point to a Late Miocene age, but it may also be caved from the Upper Pliocene.

Upper Pliocene (1180-1000 m, Nordland Group)
Benthic foraminifera of the *Cibicides grossus* assemblage and *Elphidiella hannai* assemblage and planktonic foraminifera of the *Neogloboquadrina atlantica* (sinistral) assemblage (upper main part) give a Late Pliocene age (on the time scale of Berggren et al. 1995) for this unit (Fig. 1). In addition to the nominate species, the benthic foraminiferal assemblages also includes *Elphidium excavatum* (mainly in the *Elphidiella hannai* assemblage), *Cassidulina teretis* (mainly in the *Cibicides grossus* assemblage), *Nonion affine* (mainly in the *Cibicides grossus* assemblage), *Buccella tenerrima, Islandiella islandica* (mainly in the *Cibicides grossus* assemblage). The benthic foraminiferal assemblages are correlated with Subzone
NSB 15a of King (1989, North Sea) and Zone NSR 12 of Gradstein & Bäckström (1996, North Sea and Haltenbanken area). The planktonic foraminiferal fauna also includes *Globigerina bulloides*, *Neogloboquadrina pachyderma* (dextral) and *Globorotalia inflata* (few). Spiegler & Jansen (1989) described a *N. atlantica* (sinistral) Zone from the Voring Plateau (Norwegian Sea) from Upper Miocene to Upper Pliocene deposits. The LAD of *N. atlantica* (sinistral) in that area is approximately 2.4 Ma.

**Sr isotope stratigraphy**

Calcereous benthic foraminifera from 1210 m (ditch cuttings) gave an age of 27.6 Ma (early Late Oligocene). Calcereous benthic foraminifera from one sidewall core at 1192 m and from the interval 1200-1180 m (ditch cuttings) were also analysed. The obtained $^{87}$Sr/$^{86}$Sr ratios from the sample at 1192 m gave an age of 5.1 Ma (earliest Early Pliocene) and the sample from 1200-1180 gave an age of 5.5 Ma (latest Late Miocene, Table 1, Fig. 1).

<table>
<thead>
<tr>
<th>Litho. unit</th>
<th>Sample</th>
<th>Corrected $^{87}$Sr</th>
<th>2S error</th>
<th>Age (Ma)</th>
<th>Laboratory</th>
<th>Analysed fossils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utsira Fm</td>
<td>1192 m (SWC)</td>
<td>0.709032</td>
<td>0.000013</td>
<td>5.13</td>
<td>IFE</td>
<td>Calcareous benthic index foraminifera</td>
</tr>
<tr>
<td>Utsira Fm</td>
<td>1200-1180 m (DC)</td>
<td>0.709020</td>
<td>0.000013</td>
<td>5.46</td>
<td>IFE</td>
<td>Calcareous benthic index foraminifera</td>
</tr>
<tr>
<td>Hordaland Gr</td>
<td>1210 m (DC)</td>
<td>0.708077</td>
<td>0.00039</td>
<td>27.64</td>
<td>IFE</td>
<td>Calcareous benthic index foraminifera</td>
</tr>
</tbody>
</table>

Table 1: Strontium isotope data from well 34/4-7. IFE = Analysed at the Institute for energy technology (at Kjeller, Norway). Sr ratios are corrected to NIST 987 = 0.710248. The numerical ages were derived from the SIS Look-up Table Version 3:10/99 of Howard & McArthur (1997). NIST = National Institute for Standard and Technology. Modified after Eidvin & Rundberg (2001).

**Lithology**

*Lower–Upper Oligocene (1220–1200 m, Hordaland Group)*

The Oligocene sediments consist mainly of silty mudstones (Fig. 1).

*Upper Miocene to Lower Pliocene (1200–1180 m, Utsira Formation)*

The samples in this unit are dominated by glauconitic sand. Some quartzose sand, silt and clay are also recorded, but most of these may be caved (Fig. 1).

*Upper Pliocene (1180–1000 m, Nordland Group)*

The Upper Pliocene unit consists of poorly sorted clastics (diamicton). Clay is dominant, but silt, sand and ice-rafted pebbles (mainly of crystalline rocks) are recorded throughout, and between approximately 1095 and 1160 m there is an interval consisting of two blocky sand bodies separated by a thinner mudstone (Fig. 1). This unit can be correlated between all the wells we have investigated from the Snorre Field and well 34/2-4 to the north (Map 1, Eidvin & Rundberg (2001). The sand fraction is dominantly quartzose, but glauconite is present in most samples. Studies of ice-rafted detritus (IRD) in ODP-cores from the Norwegian Sea show that the first expansion of the northern glaciers down to sea level started at about 2.75 Ma (Jansen & Sjøholm 1991, Fronval & Jansen 1996). The maximum age for this unit is therefore considered to be 2.75 Ma belonging mainly to the Gelasian Stage.

**References**

Time Scale and Global Stratigraphic Correlation. Society for Sedimentary Geology Special Publication 54, 129-212.


