# Faulty geology halts project

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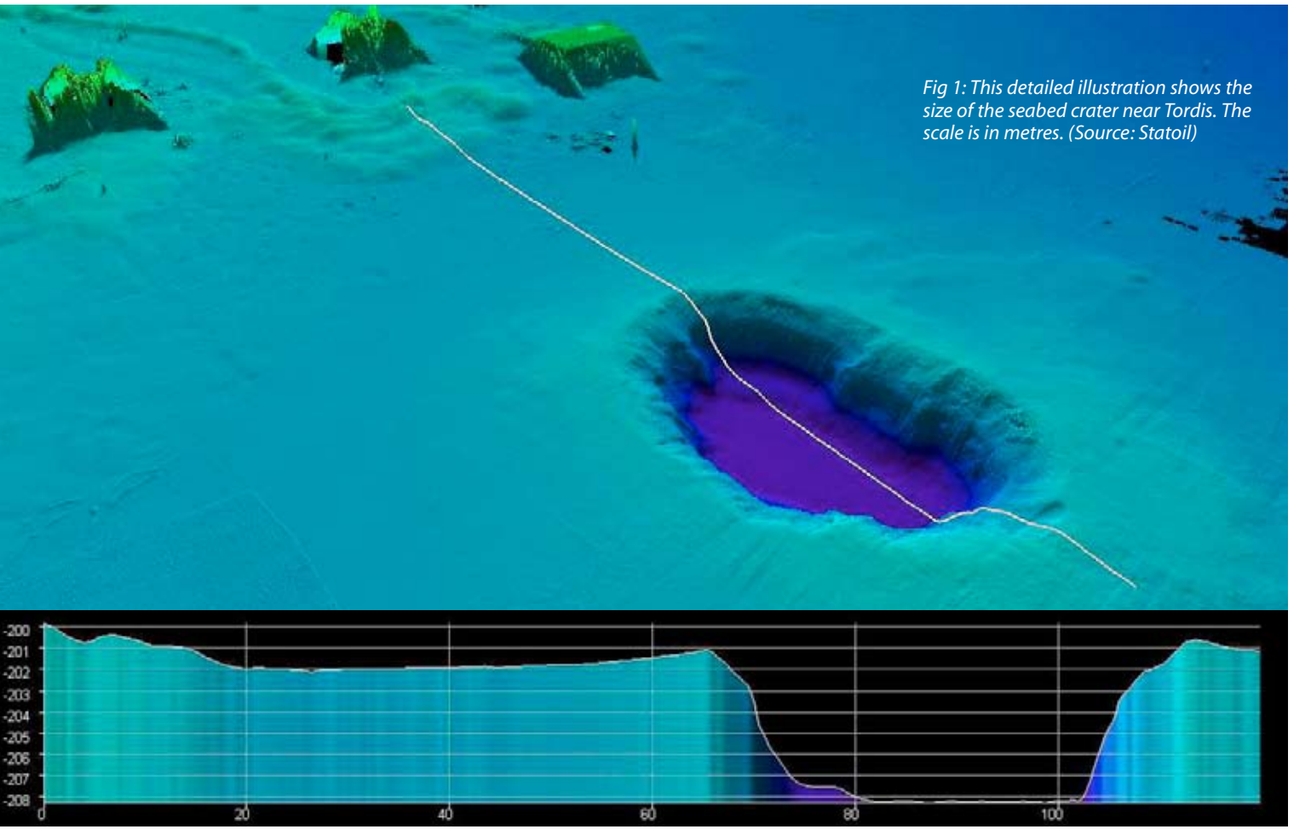


*Fig 1: This detailed illustration shows the size of the seabed crater near Tordis. The scale is in metres. (Source: Statoil)*

## Stratigraphic studies by the NPD in the wake of an oil leak on Tordis have shown that the Utsira formation is not present where an injection well was drilled for this North Sea field.

An oil slick was reported close to Tordis on 14 May last year. Studies of the seabed identified a large crater close to the field's underwater installations on 30 May.

Measuring 30-40 metres across in the longitudinal direction and about seven metres deep (fig 1), this was found to be the source of an escape of oily water.

Tordis lies between the Snorre and Gullfaks fields in the Tampen area (fig 2), and was proven and developed by the former Saga Petroleum company.

Statoil is currently operator for the oil field, which has been developed with several subsea installations tied back to the Gullfaks C platform.

Oil production began from Tordis in 1994, but has been declining for a number of years. The water cut is also rising, with the produced water piped to and separated out on Gullfaks C.

As one of several measures to boost output from the field, its licensees resolved in 2005 to install a facility for seabed separation there.

This equipment would also have a positive environmental impact by sharply reducing discharges of produced water. Built by FMC Technologies, it represented a world first.

Adopting seabed separation on Tordis was regarded as a technological innovation which could be highly significant for future subsea developments.

In operation from early 2008, the separator removed water and sand from the wellstream for injection into a sandstone deposit 1 000 metres beneath the seabed.

But injection was halted in the early hours of 31 May 2008 after it proved to be the leak source. Roughly 1 100 barrels of oil had already escaped by then – so what went wrong?

Statoil had thought the injected water would be held in the Utsira formation, which it assumed was present as a large structure with a big storage capacity.

Extending beneath much of the North Sea, this sub-surface feature was deposited from 12.5 to 4.5 million years ago as porous and permeable quartz-rich sand.

Statoil uses it on Sleipner East 300 kilometres further south to store injected carbon dioxide. But NPD has found that the formation does not exist where the Tordis injector was drilled.

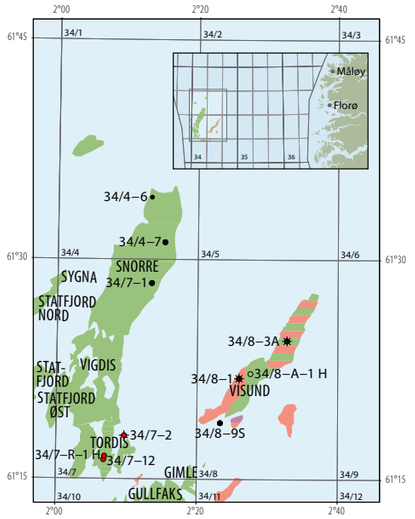


*Fig 2: Location of the investigated wells 34/7-2, 34/7-R-1 H and 34/7-12 in the Tordis area (red symbols). The 34/4-6, 34/4-7 and 34/7-1 wells on Snorre and the 34/8-3A, 34/8-1, 34/8-A-1 H and 34/8-9S wells on Visund (black and open symbols) have been checked earlier by the NPD.*

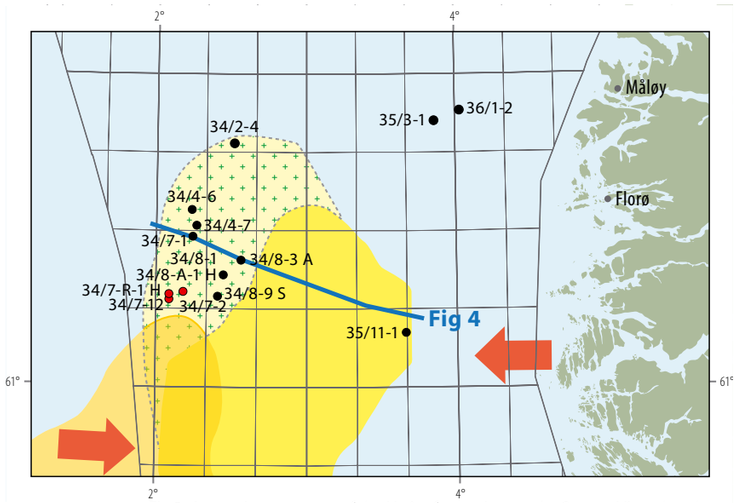


*Fig 3. Approximate extent of the Utsira formation on the Snorre, Visund and Tordis fields in the Tampen area of the North Sea. It consists largely of light quartz sand in the areas shown in light and dark yellow, and of dark green glauconitic sand in the area marked in yellow with green stars. Investigated wells are indicated by red symbols in the Tordis area and by black symbols on Snorre and Visund. Red arrows depict the direction in which sediment has been transported. The blue line shows the location of a seismic profile presented in fig 4.*

That work showed the Utsira is also poorly developed – in other words, only about 20-60 metres thick – over these areas (fig 4).

It found that well reports and interpreted logs from the oil companies placed the Utsira roughly 100 metres too high, in strata deposited less than about 2.75 million years ago.

Access to both sidewall and conventional drill cores was very helpful, and made it possible to date the Utsira in wells on Snorre and on Visund's west flank to about five million years.

Statoil also had sidewall cores from two of the three wells investigated in the Tordis area. Analyses show that the Utsira is not present in the two wells on the actual field.

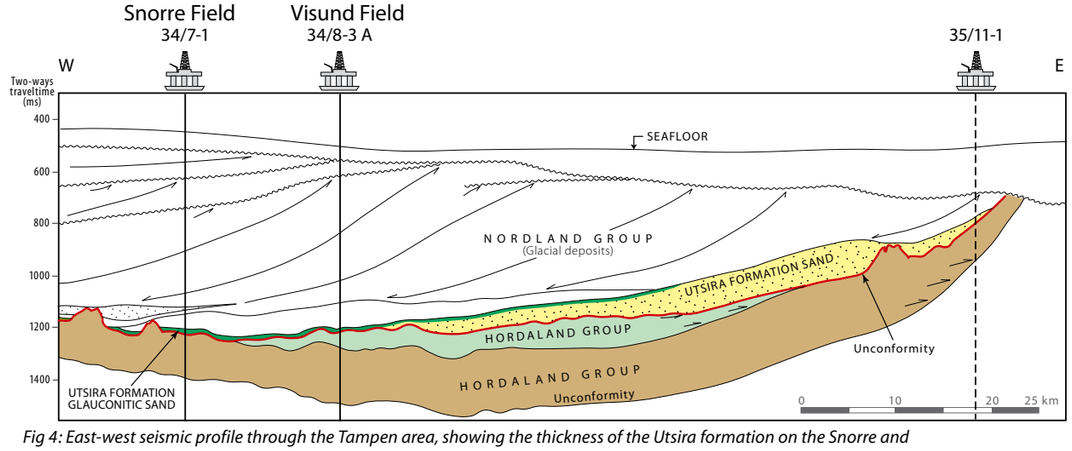


*Fig 4: East-west seismic profile through the Tampen area, showing the thickness of the Utsira formation on the Snorre and Visund fields. The location of the profile is shown in fig 3.*

In this area, sediments from the Nordland group laid down 2.75-2.4 million years ago lie immediately above materials in the Hordaland group deposited some 26 million years in the past.

The well immediately north of the field has encountered the Utsira, in a layer about 10 metres thick. This is identical with the formation on Snorre and Visund's west flank, and is also dated to about five million years. In addition to the information provided by fossil fauna, clear evidence is provided in one of the Tordis wells that the Utsira is not present.

A sidewall core taken close to the bottom of the unit and interpreted by Statoil as the Utsira includes a sharp-edged piece of quartzite measuring 1.8 by one centimetres (fig 5).

This derives from the mainland, and can only have been carried so far out onto the continental shelf by glaciation. But studies of scientific cores from the Norwegian Sea shows that the ice ages only began about 2.75 million years ago in northern Europe.

Borehole reports and interpreted logs from Saga and Statoil for the three wells in the Tordis area interpreted the lowest 80-100 metres of these glacial deposits as the Utsira.

As explained above, this is not correct and corresponds to exactly the same erroneous interpretation made in the Snorre and Visund wells.

While the inaccurately interpreted units do contain a number of sand layers, the fossil fauna show they were deposited in much deeper water than the Utsira.

Resulting from subsea mud and sand currents, such turbidite deposits do not usually have wide regional distribution and often result in relatively poor reservoir quality.

When oily water injection began on Tordis, only a relatively limited volume was probably stored in these sands before the pressure rise caused fracturing of the overlying shales. The fractures eventually reached the surface, allowing the injected water to escape.

A similar leakage was reported on Visund in 2007. Heaping of sediments observed on the seabed beneath the platform seemed to be associated with an injection well for drill cuttings.

Questions have been raised in the wake of the Tordis incident, particularly by environmental organisations, about the security of storing carbon dioxide in the Utsira.

This formation has good reservoir properties in many areas and appears to be overlain by cap rocks, although detailed geological surveys are the only way to assure that these provide a seal.

However, the Tordis leak cannot be used as a general argument against storage in the Utsira since this structure is not actually present in the area.

A more detailed article and the report from the NPD's stratigraphic study of the Tordis field can be found at *www.npd.no*. ❄


*Fig 5: Sharp-edged quartzite stone found in a sidewall core close to the base of the unit interpreted by Statoil as the Utsira formation. This piece of rock hails from the mainland and must have been carried to the Tordis area during the ice age – long after the Utsira was deposited.*

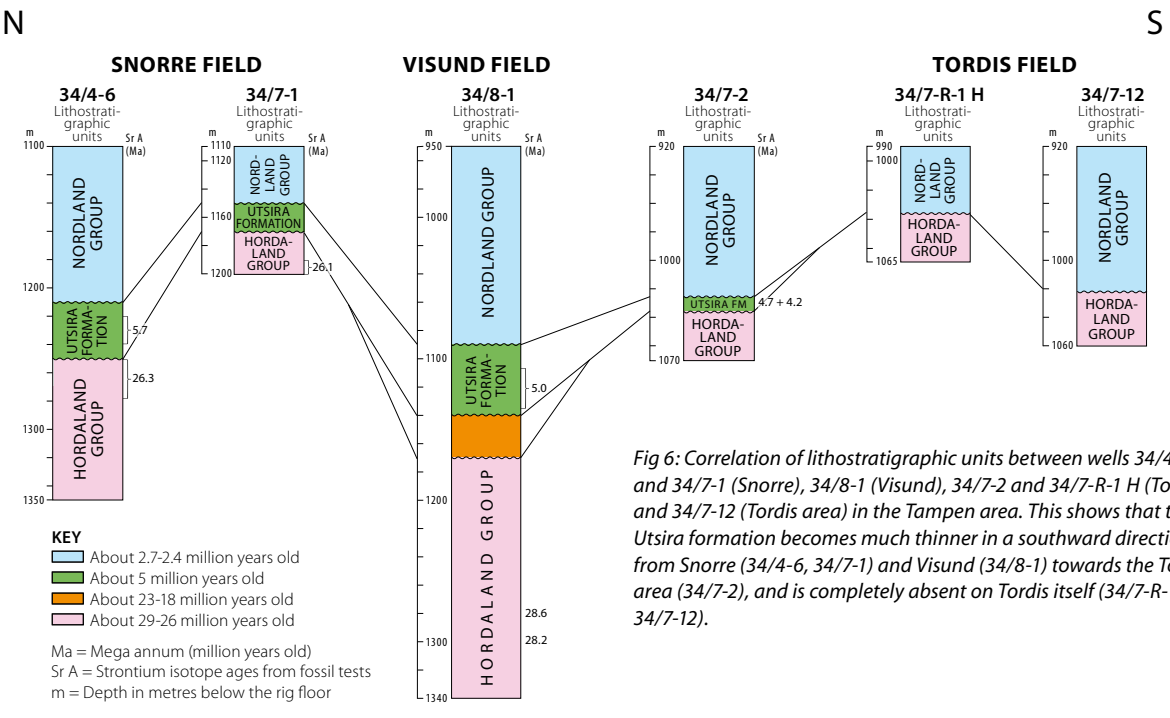


*Fig 6: Correlation of lithostratigraphic units between wells 34/4-6 and 34/7-1 (Snorre), 34/8-1 (Visund), 34/7-2 and 34/7-R-1 H (Tordis) and 34/7-12 (Tordis area) in the Tampen area. This shows that the Utsira formation becomes much thinner in a southward direction from Snorre (34/4-6, 34/7-1) and Visund (34/8-1) towards the Tordis area (34/7-2), and is completely absent on Tordis itself (34/7-R-1 H, 34/7-12).*