Faulty geology halts project

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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 carbon dioxide. But NPD has found that the formation does not exist where the Tords injector was drilled.

This result is consistent with the conclusions of an earlier study by the directorate 10 years ago on Snorre and Visund, which lie north and north-east of Tordis (fig 3).

That work showed the Utsira is also poorly developed – in other words, only about 20-60 metres thick – in 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.

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

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**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.

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**Fig 6:** Correlation of lithostratigraphic units between wells 34/4-6 and 34/7-1 (Snorre), 34/8-1 (Visund), 34/7-2 and 34/7-1 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 (34/7-1 H, 34/7-12).

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"Deep dissolution" is a distinctive form of the long-term chemical decomposition which affects all rocks on the Earth’s surface. It occurs in tropical climates with high temperatures and humidity, where rock is converted to thick layers of gravel and sand plus various clay minerals. This soil layer can be up to 100 metres thick, and may penetrate to depths of 200 metres along fractures and faults. Even hard gneiss must yield to these climatic conditions.

But finding deep dissolution at Hamarøy in Norway’s northern Nordland county is more unexpected. The gneiss is so decomposed that it can be easily dug out, even though its original structures are still visible. These deposits could be residues of a soil cover from the time when Norway lay significantly closer to the equator, or it may be that rocks are more exposed to dissolution in the Norwegian climate than has been assumed. Deep dissolution could create possible reservoir formations on the continental shelf, since bedrock exposed to this process has been found to contain hydrocarbons in a number of places.”

Torge Soltbak and Jarund Strandset (photo).

More images at www.stromsoe.no.