REGIONAL STUDY OF THE NEOGENE DEPOSITS IN THE SOUTHERN VIKING GRABEN AREA – A SITE FOR POTENTIAL CO_2 STORAGE

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Introduction

Since 1996 Statoil and its Sleipner partners have injected CO_2, extracted from the Sleipner Vest gas, into saline reservoir sands of the Utsira Formation in the central North Sea at a depth of approximately 900 m. This is the first case of industrial scale CO2 storage in the world (1 million tons per year). The Saline Aquifer CO_2 Storage (SACS) project is conducted by a consortium of oil companies and research institutions. This paper presents regional geological interpretation in the southern Viking Graben area. Sands of the Mio-Pliocene Utsira Formation and the Nordland Shale have been identified and their stratigraphical architecture outlined from seismic sections and well-logs. Detailed geophysical and geological aspects at the injection site are treated in Arts *et al.* (this volume) and Brevik *et al.* (this volume).

The Utsira Sand

The Utsira Formation, as it was defined in the type well 16/1-1 by Isaksen and Tonstad (1989), can be divided into a lower sand dominated unit, and an upper unit of interbedded clays and minor sands (Gregersen, 1997). It is within the lower unit, here termed the Utsira Sand, that the CO_2 is being injected. The base and top of the Utsira Sand are mapped using well-logs and seismic data (Fig. 1) to evaluate the extent and volume of this main reservoir interval and also to locate seal-closures. 2-D seismic sections and more than 100 wells have been used and interpreted on workstations.

The lower boundary of the Utsira Sand (Base Utsira Sand) is normally easily recognised on well-logs as abruptly upward-decreasing gamma ray and sonic and increasing resistivity values. On seismic sections there is bi-directional downlap of reflectors within the sands onto the shales below (Fig. 1). This lower boundary with the Lower Nordland Shales is locally and shale diapirs (fossil mud-volcanoes) have been interpreted at the interface (Gregersen et al., 1997; Arts et al., this volume). The upper boundary of the Utsira Sand (Top Utsira Sand) corresponds to the top of the thick interval with a blocky log pattern, where gamma-ray values increase and resistivity values decrease into overlying shales. On seismic data the top of the sand occurs below a thin interval with concordant reflections, the upper boundary of which (Base Pliocene Prograding Unit) is defined by downlap of Pliocene prograding systems. Although the seal appears on present evidence to mainly consist of clay, additional wells and seismic data and the results of laboratory tests will be integrated to evaluate more fully the sealing capacity of these clays. It is thought possible that local Pliocene-Quaternary sands and small faults could reduce the sealing quality.

The Utsira Sand has been mapped mainly in the Norwegian sector but also to the south into the British part of the southern Viking Graben area. It attains its greatest thickness of more than 280

ms twt (~300 metres) in the Sleipner area and pinches out to the west and east (Fig. 2), while the extension towards north and south is not yet confirmed.

Individual sandbodies seem to have an elongated shape, some with limited extensions of a few kilometres and thicknesses of a few tens of meters, and seem to be stacked in intervals (Fig. 1). The sandbodies locally represent sub-reservoir sand units, sometimes separated by clay seals, which reduce the vertical reservoir communication. A number of individual intervals with characteristic blocky log-patterns and bounding clayey intervals seem to correlate over great distances. The integrated seismic/log correlation shows, that other sand or sand/shale bodies, previously assigned to the Utsira Sand on the basis of well logs actually belong to other sedimentary units.

Regional geology

The basinally-restricted Utsira Sand is fine-/ to medium-grained, unconsolidated sand. It contains variable amounts of glauconite and shell material, suggesting deposition in a marine environment, while lignite and the well-rounded, matured quartz sand suggest that parts of the sediments are derived from nearshore/land areas and subsequently transported towards the basin centre. Whilst the depositional environment is still a matter of debate, it is thought possible that they represent shallow marine sands redeposited in water depths in excess of 100 m. The Utsira Formation and Pliocene systems are derived from southwest Scandinavia and probably also from parts of Scotland or the Shetland area subjected to Neogene uplift. Contemporary subsidence narrowed and deepened the North Sea basin and the Miocene sands and clays accumulated in the depocenter along the rim of the Utsira High and the Viking Graben axis.

Oligocene-Quaternary sand units, informally described by oil companies as the ”Hutton Sand”, are recognised just west of the Utsira Formation in the UK sector, along the Shetland Platform margin. Initial seismic stratigraphic studies indicate, that the upper part of the Hutton Sand unit downlap onto the Utsira Formation towards the basin-centre (Gregersen et al., 1997). The ”Hutton Sand” is derived from the Scotland/Shetland area, also as a consequence of Neogene uplift.

The Neogene uplift of the near coastal and onshore areas, forced sediments to prograde towards the basin centre, and resulted in prominent Pliocene progradational systems, downlapping a shale drape, above the Utsira Formation. The mainly clayey and silty Pliocene systems are erosionally truncated towards east, probably by a glacial-related unconformity at the beginning of the Quaternary.

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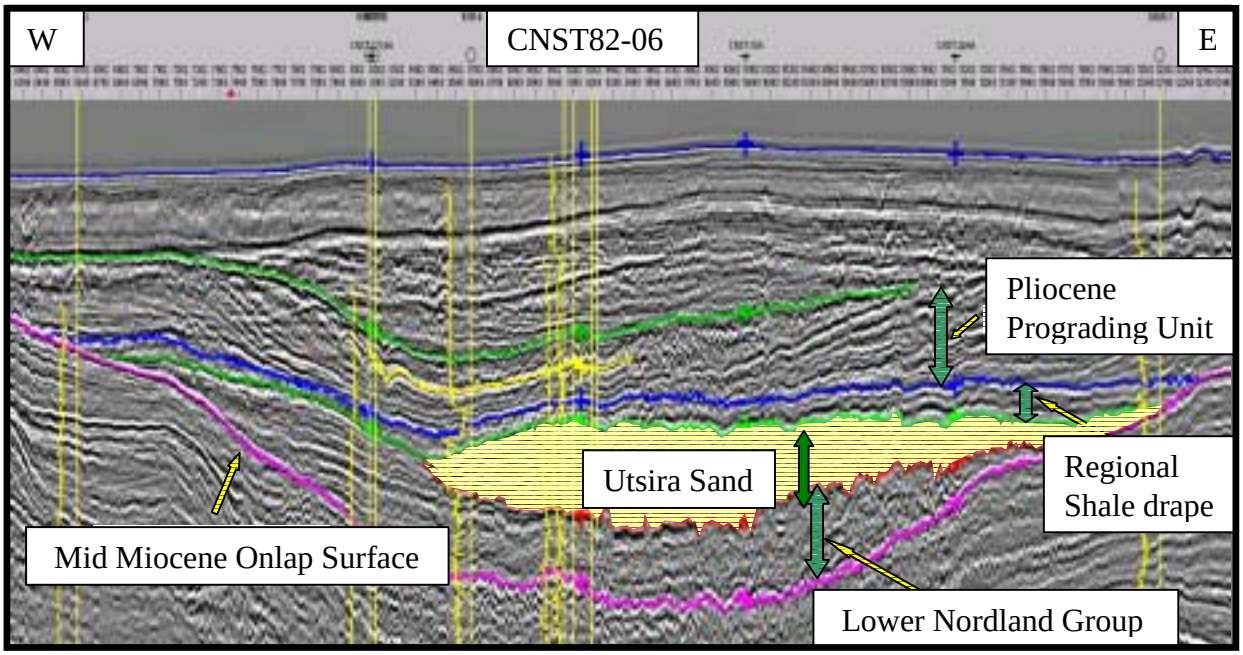

Fig. 1. West-east seismic section (CNST82-06) and well-cross-section through the Utsira Sand and the Pliocene prograding system in the Sleipner area. Location is indicated in Fig. 2.

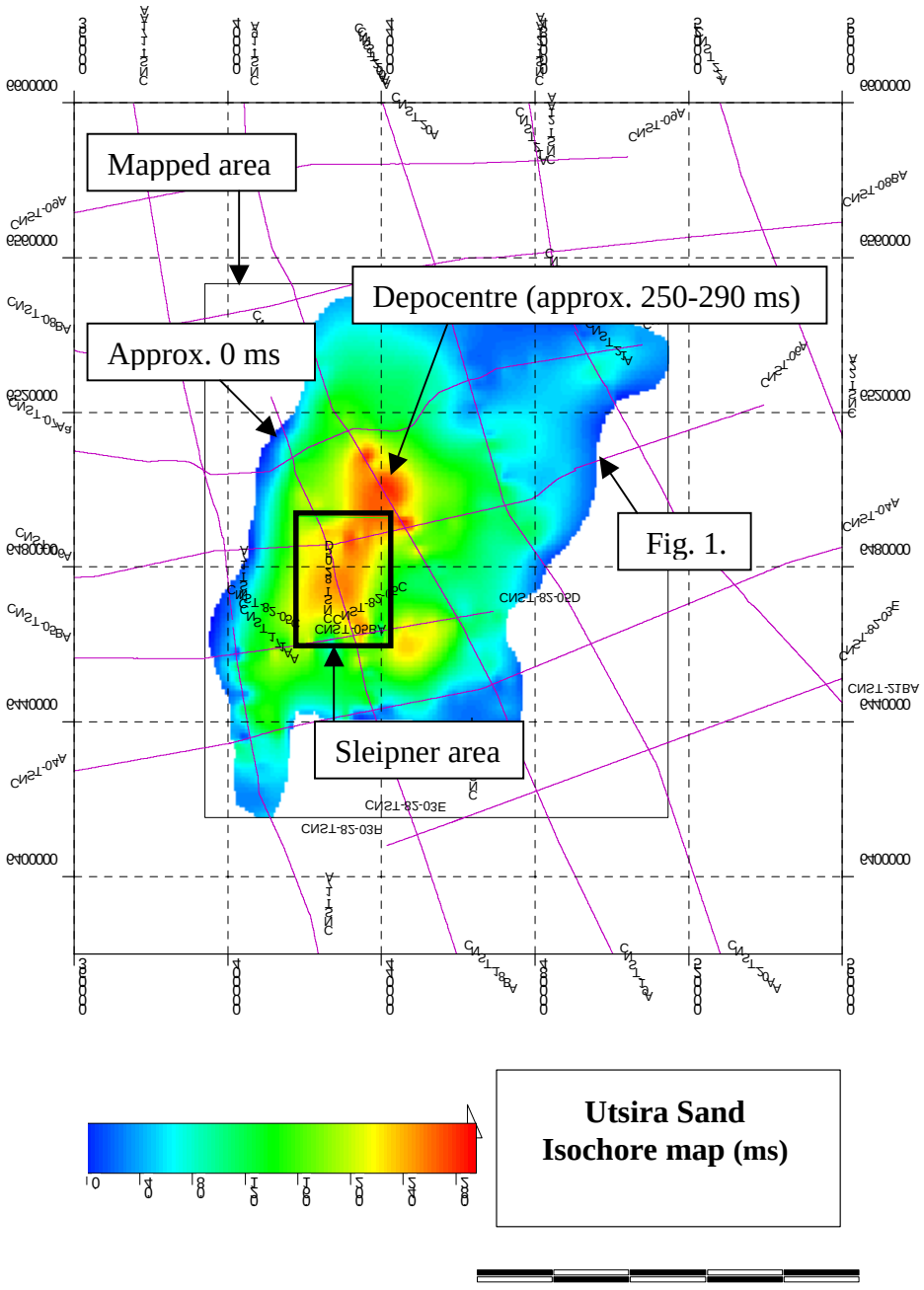

Fig. 2. Two-way time isochore map (milliseconds) of the Utsira Sand. The Sleipner area (site for the CO_2 injection) is located within the depocentre. Location of Fig. 1 is also indicated.