ELSEVIER

Available online at www.sciencedirect.com
ScienceDirect

Energy Procedia 00 (2010) 000–000

www.elsevier.com/locate/XXX

GHGT-10

Layer spreading and dimming within the CO_2 plume at the Sleipner Field in the North Sea

Fran Boait [a], Nicky White [a], Andy Chadwick [b], David Noy [b], Mike Bickle [a]

[a]*Department of Earth Sciences, University of Cambridge, Cambridge, CB3 0EZ, UK*
[b]*British Geological Survey, Keyworth, Nottingham, NG12 5GG, UK.*

Elsevier use only: Received date here; revised date here; accepted date here

Abstract

The CO_2 plume at Sleipner has been imaged on 3D seismic surveys as a series of bright sub-horizontal reflections. Nine discrete CO_2 rich layers are inferred to have accumulated between a series of intra-reservoir mudstones beneath a substantial reservoir topseal. Time-lapse changes in reflectivity and in the lateral extent of these layers provide useful information about CO_2 flow within the reservoir. The deepest CO_2 layers within the growing plume have acoustically dimmed, stopped growing, and some have shrunk. Shallower layers have continued to grow. A combination of numerical flow models and analytical solutions of layer spreading yields useful insights into plume development. The observed seismic dimming and shrinkage of the deeper layers are, at least in part, caused by a reduction in the amount of CO_2 trapped in the deeper plume. This is probably due to increases in the effective permeability of thin intra-reservoir mudstones. These changes reduce net flux of CO_2 into the deeper layers of the plume with a corresponding increase of CO_2 flux towards the top of the reservoir.

Keywords: CO_2, Sleipner, sequestration, time-lapse, seismic imaging

1. Background

The Utsira Sand is a major saline aquifer, which was deposited during Middle Miocene to Lower Pliocene times in the North Sea Basin [1], extending over approximately 400 x 100 km^2. In the vicinity of the Sleipner Field it lies at a depth of 800-1000 m and is 200 - 300 m thick (Figure 1a). It consists of loosely consolidated sand with 35-40 % porosity. Permeability is in the range 1 to 3 x 10^{-12} m^2 [2]. Nearby wire-line logs show that the properties of the sand are largely uniform [3]. Thin (1-2 m thick) mudstones act as partially permeable barriers to fluid flow but the ultimate seal is the thick overlying Nordland Shale.

At the Sleipner platform, CO_2 is removed from natural gas extracted from the Sleipner West field. The recovered CO_2 is injected into the Utsira Sand through a 2 km long, deviated well (Figure 1b). Injection started in 1996 at a rate of about 1 million tonnes of CO_2 per year with a total of more than 12 million tonnes now stored.