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Chimneys And Channels: History Matching The Growing CO2 Plume At The Sleipner Storage Site

G. Williams^{1*}, A. Chadwick²¹British Geological Survey, The Lyell Centre, Research Avenue South, ²British Geological Survey, Nicker Hill

Summary

A revised analysis of seismic data at Sleipner has revealed large-scale, roughly north-trending, channels at a range of levels in the Utsira Sand. The seismic data also reveal localised chimneys within the reservoir and overburden, some of which show evidence of having provided vertical conduits for earlier natural gas flow. Reservoir flow models were set up with flow properties constrained by the observed levels of CO₂ accumulation in the reservoir and the arrival time of CO₂ at the reservoir top just prior to the first repeat survey in 1999. The initial model with laterally homogeneous sand units separated by thin semi-permeable mudstones achieved a moderate match to the observed time-lapse seismics. Subsequent flow models, progressively incorporating higher permeability vertical chimneys through the mudstones and large-scale channelling within the reservoir sands, yielded a progressive and marked improvement in the history-match of key CO₂ layers within the plume. The preferred plume simulation flow model was converted into a seismic property model using Gassmann fluid substitution with an empirical Brie mixing law. Synthetic seismograms generated from this show a striking resemblance to the observed time-lapse data, both in terms of plume layer reflectivity and also of time-shifts within and beneath the CO₂ plume.

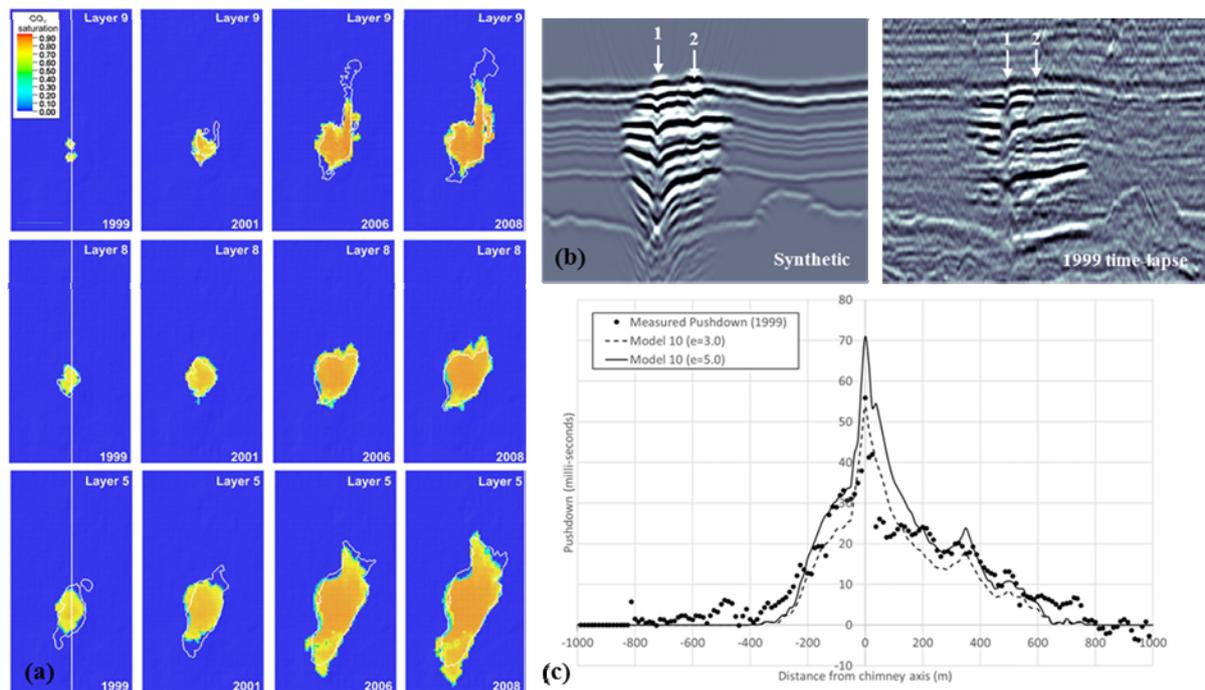


Figure 3 (a) Evolution of key layers 9, 8 and 5 in the CO₂ plume for the best fit reservoir model (Model 10 in Table 1). White polygons delimit the CWC observed on time-lapse seismic data. (b) Comparison of a synthetic seismic section computed from Model 10 along the white line of section in (a) and a nearby inline from the 1999 seismic survey. (c) Comparison of pushdown of the Base Utsira reflection measured on the 1999 time-lapse data (solid black circles) and the synthetic seismic section assuming a patchy Brie mixing model with $e=3$ (stippled black line) and $e=5$ (solid black line).

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