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Extensive, Gas-charged Quaternary Sand Accumulations of the Northern North Sea and North Sea Fan

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Sediments deposited by marine-based ice sheets are dominantly fine-grained glacial muds, which are commonly known for their sealing properties for migrating fluids. However, the Peon and Aviat hydrocarbon discoveries in the North Sea show that coarse-grained glacial sands can occur over large areas in formerly glaciated continental shelves. In this study, we use conventional and high-resolution 2D and 3D seismic data combined with well information to present new models for large-scale fluid accumulations within the shallow subsurface of the Norwegian Continental Shelf. The data include 48,000 km^2 of high-quality 3D seismic data and 150 km^2 of high-resolution P-Cable 3D seismic data, with a vertical resolution of 2 m and a horizontal resolution of 6 to 10 m in these data sets. We conducted horizon picking, gridding and attribute extractions as well as seismic geomorphological interpretation, and integrated the results obtained from the seismic interpretation with existing well data.

The thicknesses of the Quaternary deposits vary from hundreds of meters of subglacial till in the Northern North Sea to several kilometers of glacigenic sediments in the North Sea Fan. Gas-charged, sandy accumulations are characterized by phase-reserved reflections with anomalously high amplitudes in the seismic data as well as density and velocity decreases in the well data. Extensive (>10 km^2) Quaternary sand accumulations within this package include (i) glacial sands in an ice-marginal outwash fan, sealed by stiff glacial tills deposited by repeated glaciations (the Peon discovery in the Northern North Sea), (ii) sandy channel-levee systems sealed by fine-grained mud within sequences of glacigenic debris flows, formed during shelf-edge glaciations, (iii) fine-grained glacimarine sands of contouritic origin sealed by gas hydrates, and (iv) remobilized oozes above large evacuation craters and sealed by megaslides and glacial muds. The development of the Fennoscandian Ice Sheet resulted in a rich variety of depositional environments with frequently changing types and patterns of glacial sedimentation. Extensive new 3D seismic data sets are crucial to correctly interpret glacial processes and to analyze the grain sizes of the related

deposits. Furthermore, these data sets allow the identification of localized extensive fluid accumulations within the Quaternary succession and distinguish stratigraphic levels favorable for fluid accumulations from layers acting as fluid barriers.