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Subglacial geomorphology reveals connections between glacial dynamics and deeper hydrocarbon reservoir leakages at the Polar north Atlantic continental margin

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Three-dimensional (3D) seismic data from the Barents Sea continental shelf and margin reveal spatial links between subsurface distributions of inferred glacitectonic geomorphic landforms and seismic indications of fluid flow from deeper hydrocarbon reservoirs. Particularly 3D seismic techniques allow detailed mapping and visualization of buried glacial geomorphology and geophysical indications of fluid flow and gas accumulations.
Several subsurface glacitectonic landforms show pronounced depressions up to 200 m deep and several km wide. These appear in many locations just upstream from hills of similar sizes and volumes, and are inferred to be hill-hole pairs. The hills are interpreted as thrusted and compressed slabs of sediments and bedrock which have been removed from their original location by moving glaciers during the last glacial, leaving the holes as depressions. The mapped depressions seem often to appear in sediments of different lithology and age. The appearance of mega-scale glacial lineations indicates that fast-flowing ice streams, draining the former Barents Sea and Fennoscandian ice sheets were the main agents of these glacitectonic landforms.
Mapped fluid flow migration pathways from deeper reservoirs and shallow gas accumulations show evidence of active fluid migration systems over longer time periods, and their spatial relationship with the glacitectonic landforms is documented for several areas of the Barents Sea continental shelf.
A conceptual model is proposed for the depressions, where brittle glacitectonic deformation takes place along a weak layer at the base of gas-hydrate cemented sediments. Fluid flow from deeper hydrocarbon reservoirs is inferred to be associated with cycles of glaciations and unloading due to glacial erosion and ice retreat, causing gas to expand, which in turn potentially breaks the traps, reactivates faults and creates new faults.
Gas hydrate stability modeling indicates that the south-western Barents Sea is today outside the stability area for methane gas hydrates of structure I, but hydrates of this type would have been stable when grounded ice covered the area. Structure II hydrates, with a few percent of heavier hydrocarbons are likely stable within the area today.

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