Paleogeographic reconstruction of the Peon area in the Northern North Sea: Implications for ground conditions

Aurora M. Garcia[1], Benjamin Bellwald[2], Tor O. Sømme[3], Orlando M. Bautista[4], Sverre Planke[1,5], Ingrid Anell[1], Reidun Myklebust[6], Ivar Midtkandal[1]

[1]Department of Geosciences, University of Oslo, Oslo, Norway, a.m.garcia@geo.uio.no; [2]Norwegian Geotechnical Institute, Oslo, Norway; [3]Equinor, Oslo, Norway; [4]Department of Geosciences, UiT The Arctic University of Norway, Tromsø, Norway; [5]Volcanic Energy Basin Research, Oslo, Norway; [6]TGS, Oslo, Norway

The North Sea is a pivotal area for offshore windfarm development. Within the Norwegian Channel, with depths varying from 200-700 m, six different fields (Vestavind A-F) have being delimeted as areas of interest. This region, however, was shaped by multiple avances of the Norwegian Ice Stream throughout the Quaternary, which affected sediment composition and distribution – directly impacting ground conditions.

Sub-bottom profilers and ultra-high-resolution 2D seismic are standard geophysical dataset for subsurface characterization. In the Northern North Sea, extensive 3D and HR3D seismic data enable regional insights, including paleogeographic reconstructions. For this study, 3D seismic data, including P-cable data, from the shelf and slope, is used to reconstruct the paleogeographic conditions in which the sediments infilling the Northern Norwegian Channel were deposited. High-amplitude reflections were mapped and seismo-geomorphological analyses were caried out, using amplitude extractions and spectral decomposition, and combined with well information.

The interpretation is focused on two main areas on the shelf: i) around of the Peon gas discovery where we have a good control of the paleo-environments for the last ~0.5 Ma, and ii) on the outer shelf northwest of Peon, where parts of the deposits can be directly correlated to the deposits of the North Sea Fan on the slope. The Peon area is characterized by nine units, spanning from the Upper Regional Unconformity (URU) to the seabed (Bellwald et al., 2022). The 50 m thick Peon sandstone is deposited directly over the glacial unconformity is lenticular in shape and has previously been interpreted as an outwash fan, deposited at the ice margin (Bellwald et al., 2022). Further ice-sheet oscillations were responsible for depositing the eight overlying units of harder tills and softer glaciomarine sediments. In the reflections limiting the units of the overburden, there are abundant pockmarks, as well as iceberg ploughmarks and glacial lineations. Shallow seismic anomalies and high-amplitude reflections above the reservoir level indicate migration and accumulation of gas within the overburden.

Northwest of Peon, the equivalent package is generally thinner, but a few reflections can be correlated laterally. On the same stratigraphic level as the Peon sandstone, there is another lense-shaped deposit (potentially another outwash fan), interpreted till units and a deep erosive channel. The channel is roughly 30 km long, starting 20 km from the shelf break and eroding into the slope. Its head is only ~60 ms below the seabed and is characterized by a series of stacked high amplitude reflections, around 800 m wide and under 40 ms deep. It gets progressively wider and deeper towards the shelf break, reaching up to 6 km wide and 400 ms deep. The infill of the structure is heterogeneous, with chaotic and semi-transparent units at the base and some more continuous high amplitudes towards the middle and top. Those continuous reflections can be mapped within the channel and into the North Sea Fan on the slope, where a network of channels can be seen transporting sediment and meltwater deeper in the basin. The channel morphologies change rapidly upward (within ~150 ms time window), from densely spaced, anabranching channels to more isolated and meandering occurrences.

The different till units pose a challenge for the foundation of wind turbines, due to the horizontal and vertical variable soil conditions and possible overconsolidation of the material by repeated ice activity. Soft clays, on the other hand, will not provide sufficient stability for marine infrastructure, and further act as weak layers for slope failure on the paleo-shelf environment.

References

Bellwald, B., Planke, S., Vadakkepuliyambatta, S., Buenz, S., Batchelor, C., Manton, B., Zastrozhnov, D., Walker, F., Garcia, A., Myklebust, R., Kjølhamar, B., 2022: Quaternary and Neogene Reservoirs of the Norwegian Continental Shelf and the Faroe-Shetland Basin. *First Break 40,* 43–54.