Biochemically reactive transport modelling to assess pre-abandonment environmental baselines of mature offshore hydrocarbon fields in the North Sea

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The Gorm field is expected to be the first large field in the Danish North Sea reaching decommissioning. Prior to initiation of the decommissioning work, the pre-abandonment environmental baseline needs to be quantitatively identified to support the subsequent monitoring programme. As part of the SEEP project, multiple geological, biological and geophysical data were collected to characterize the first 100 m below seabed of the overburden of the Gorm field. Besides, deep seismic and well log data were continuously gathered since the discovery of the field in 1971. Such comprehensive dataset provides the framework of this study that aims at developing an environmental and ecological model of the shallow overburden to quantify methane seepage, discriminate between natural vs anthropogenic origin, and ultimately deliver a validated baseline for decommissioning. To this purpose, a Thermo-Hydro-bioChemical (THbC) model[1] is under development capable of modelling gas flow, bio-geo-chemical alterations, and biogenic gas generation processes. The first step of the project that consists of building the ground model of the first 100 m below seabed is completed.

The results indicate that the primary migration pathways for biogenic and thermogenic methane to reach the seabed are associated with existing wells in the Gorm field and the distribution of glacial valleys formed during the Holocene and Weichselian periods. These valleys, infilled with porous and permeable sediments, erode the underlying shale formation through glacial and fluvial processes, thereby establishing hydraulic connections to deeper permeable sand layers. Their dimensions, up to 500 m wide and 30 m thick, can favor the flow of a large volume of methane towards the seabed. The lithological properties are characterized using core and CPT data together with previous works[2–4], while the petrophysical properties are mainly estimated from empirical relationships and compaction model with laboratory measurements conducted on unconsolidated shale. Besides, the seismic data analysis shows that a major glacial valley system is present above the field.

Importantly, production, injection, and abandoned wells are intersecting the valleys, forming a complex network of potential flow conducts for biogenic and anthropogenic methane to reach the seabed.

Following the construction of the static model of shallow subsurface, the 2-phase multi-component flow of leaking gases and relevant biogeochemical interactions (e.g., methane (an)aerobic oxidation and biogenic methane production) will be in coupled into a THbC modelling tool for the study of biogenic methane generation history in the region and leakage scenarios.

Reference

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