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Review of Geological Controls on Resistivity in Uplifted Basins: Insights From the Norwegian Barents Shelf

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ABSTRACT

Resistivity is primarily controlled by the presence of electrically conductive fluids, i.e. brine, capable of transmitting an electric current through the investigated geological formation. In sedimentary basins, where the matrix primarily comprises insulating material, resistivity is primarily controlled by: 1) porosity, 2) brine conductivity, 3) brine connectivity and 4) brine saturation. In recent years, the use of controlled-source electromagnetic (CSEM) data allows for pre-drill resistivity mapping at both prospect and regional scale. However, interpretation of CSEM data relies, amongst others, on understanding and quantifying the geological parameters controlling resistivity. In this contribution, we present a brief review of the geological parameters controlling resistivity variation, and demonstrate these using case studies from > 100 exploration boreholes from the Barents shelf. We analyze wireline well data both in the hydrocarbon-bearing layers and in the shale and carbonate-dominated over- and underburden. The highest resistivity (> 10 000 ohm.m) is evident in the relatively shallowly buried, highly porous and hydrocarbon-bearing sandstones of the Upper Triassic-Middle Jurassic Realgrunnen Subgroup, which are reported from 37 boreholes. Pay zone resistivity is primarily controlled by reservoir quality (i.e. porosity and Vshale) and fluid phase (i.e. gas vs oil and water saturation). The Realgrunnen Subgroup reservoir is, in places, capped by Upper Jurassic organic rich shales of the Hekkingen Formation. In the investigated wells, these shales exhibit enhanced resistivity compared to the background, though rarely exceeding 20 ohm.m. Marine mudstones often show good correlation between measured organic richness and the resistivity/sonic velocity log signatures. In the shallow subsurface, temperature and salinity-related effects control vertical resistivity variation. In contrast to in normally compacted basins where vertical resistivity variations in the shallow subsurface are controlled by the effects of temperature and salinity, resistivity variations in the exhumed Barents shelf are related to effects of porosity reduction due to extensive mechanical and chemical compaction. We conclude and illustrate that the present-day resistivity distribution on the Barents shelf is affected by diagenesis, fluid distribution and total organic carbon of shales. This well-based study can serve as a foundation for improved interpretation of CSEM data.