Petrophysical Analysis of Siliceous Ooze Sediments, Ormen Lange Field, Norway

Skeletal remains of siliceous algae form biogenic fine grained highly porous pelagic siliceous ooze sediments that were found above the reservoir of the Ormen Lange gas field which is located in the southern part of the Norwegian Sea (Figure 1a). The Palaeocene sandstone of the "Egga" Formation is the main gas reservoir (NDP). In this study, we are interested in the siliceous ooze intervals only.

A possible hydrocarbon prospect of siliceous ooze is proposed, but siliceous ooze is significantly different in structure from most commonly known hydrocarbon reservoir rocks. For instance, the pore structure is complex and the solids are mechanically fragile and hydrous. Normal petrophysical methods used in formation evaluation might not be suitable for interpreting siliceous ooze. For example, density and neutron logging tools are calibrated to give correct porosity readings in a limestone formation, but apparent porosity indications in any other lithology, such as siliceous ooze, are wrong and they should be corrected. The apparent bulk density log should be influenced by the hydrogen in opal as also the neutron porosity tools because they are sensitive to the amount of hydrogen in a formation and to a lesser extent upon other elements. It is normally assumed that the contribution to the neutron porosity measurement comes entirely from the hydrogen in fluids fully occupying the pore space. But, elements other than hydrogen that exist in the rock matrix do contribute to the signal; and hydrogen is also present in the solid. Some minerals of siliceous ooze, such as opal, have hydrogen in their structures which influences the measured hydrogen index (HI). The neutron tool obtains the combined signal of the HI of the solid phase and of the water that occupies the true porosity. The HI is equal to true porosity for completely freshwater saturated limestone. In this study, all the possible contributions to the neutron porosity measurement have been considered. Therefore, the slowing down power of all siliceous ooze minerals is taken into account.

In this study we aimed to develop and use a new procedure to analyse and interpret logging data acquired through siliceous ooze sediments. Our main objectives were to characterize and evaluate the petrophysics of siliceous ooze and to find the true porosity and water saturation to test its hydrocarbon reservoir potential. We used and integrated core analysis data with logging data from four Ormen Lange wells, and included X-ray diffraction analysis (XRD) data. Additionally, other available information such as petrographic thin-section analysis, core computed tomography scans (CT-scans), scanning electron microscope (SEM), and other published data were used here to interpret lithology and the unusual physical properties of the studied intervals. The integration of all these data revealed that the studied siliceous ooze is a mixture of opal and non-opal (shale). Our results proved to be reasonably consistent. The studied intervals apparently do not contain hydrocarbons.

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