Chalk as a reservoir

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Reservoir properties of chalk depend on the primary sediment composition as well as on subsequent diagenesis and tectonic events. Chalks of the North Sea almost exclusively have mudstone or wackestone texture. Microfossils may have retained their porosity where degree of diagenesis is low, or be partly or fully cemented where diagenesis is more pronounced. It is a chalk characteristic that permeability is controlled by the porosity and internal surface of the mud matrix, whereas the larger pores play an insignificant role. Cemented microfossils may take up a significant volume in a wackestone, and the best reservoir properties are typically found in mudstone intervals.

Chalk mudstones vary a lot though. The best mudstones are purely calcitic, well sorted and may have been redeposited by traction currents. Other mudstones are rich in very fine grained silica, which takes up pore space and thus reduces porosity at the same time as it increases specific surface and thus cause permeability to be low. In the Central North Sea the silica is quartzitic. silica rich chalk intervals are typically found in the Ekofisk and Hod formations. In addition to silica, Upper Cretaceous and Palæogene chalks typically contain small amounts of clay minerals. Chalk of the Lower Cretaceous Tuxen Formation can contain so much clay that it has a negative effect on the reservoir properties.

With respect to solid volume a chalk may contain more than 95% calcite, but the internal surface of the same chalk may be only 50% calcite, leaving the remaining internal surface to the fine grained silica and clay. The high specific surface of these components causes clay- and silica rich intervals to have high irreducible water saturation. Although chalks typically are found to be water wet, chalk with mixed wettability is reported, possibly as a reflection of the mixed mineralogy of the internal surface. Internal surface thus varies stratigraphically, but it also varies among hydrocarbon reservoirs, possibly reflecting a varying temperature. This is because the biogenic calcite making up the chalk, subsequent to deposition stabilizes chemically by recrystallization. This process requires energy and is promoted by temperature. This recrystallization in principle does not influence porosity, but only specific surface, which decreases during recrystallization, causing permeability to increase. The central North Sea is a warm basin, so stylolite formation in the chalk is controlled by effective burial stress. The stylolites are zones of calcite dissolution and probably are the source of calcite for porefilling cementation which is typical in water zone chalk and also affect the reservoirs to different extent. The relatively high porosity in hydrocarbon reservoirs can be a result of hydrocarbon emplacement quenching stylolites and stopping or retarding pressure dissolution.

In some chalk reservoir intervals, hydrocarbon emplacement has been so early that the reservoirs are practically un cemented. These reservoir intervals have hardly any stylolites and can have porosity above 40% or even 50% and thus also have relatively high permeability. Such intervals have the problem though, that increasing effective stress caused by hydrocarbon production results in mechanical compaction and overall subsidence. Most other chalk intervals are to some extent cemented and cannot compact mechanically at realistic effective stresses and only deform elastically. All chalk intervals though, may react by fracturing to changes in shear stress. So where natural fractures are not prevalent, fractures may be generated hydraulically. Fractures play a significant role in the production of hydrocarbons from chalk reservoirs.

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