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Effect of Salt Precipitation on Transport Properties of Lacustrine Shale Reservoir: a Case Study from Jianghan Basin, China

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Many lacustrine organic-rich shales formations, deposited in saline basins or the salification stage of freshwater basins, are interbedded with carbonates, sulfates and chlorates minerals. Dissolution and precipitation of salt always happen during extraction of hydrocarbons from lacustrine shale reservoirs. The dissolution of sulfates and chlorates minerals causes reservoir deformation, while the precipitation of salt crystals in confined spaces reduces the permeability of porous network. To data there is no detailed study of the parameters influencing the reduction of pore space by salt crystals and the consequences for transport properties.
In this paper, laboratory experiments were performed to investigate the mechanism of salt precipitation on transport properties of a shale reservoir from Jianghan Basin, China. Static salting-out tests were conducted for univariate analysis of the effect of salt precipitation on petrophysical properties of shale samples. After that, scanning electron microscope was utilized to observe the existence of salt crystals. Dynamic flooding experiments were designed to investigate the effect of salt precipitation, salt particles migration, and effective stress on dynamic permeability of samples. Different scenarios were discussed to link pore clogging with salt damage, and a permeability damage coefficient was proposed to comprehensively characterize the influence of these scenarios on permeability of shales.
Experimental results indicate that porosity and permeability of shale samples can be decreased by 40%-59% and 64%-80% due to salt precipitation, respectively. There are mainly three kinds of salt precipitations: scattered salt particles, salt granulated aggregates, and salt layers. Diameters/thickness of these salt precipitations varies from 1 to a dozen of micrometer. It is shown that pore clogging resulting from salt granulated aggregates is the common problem for damage to flow channel. The damage degree due to salt precipitation is related to the mineral compositions and structure of shales. The proposed permeability damage coefficients of these shales are between 0 to 0.3. Shale samples rich in clay minerals show much more severe permeability reduction than samples rich in sulfates and chlorates minerals. The former is mainly caused by the increased stress sensitive after salt dissolution, while the latter results from salt precipitation. Based on the permeability damage coefficient, an exponential function was developed to model the evolution of permeability as a function of stress sensitive, salt precipitation, and salt particles migration. This study advanced the fundamental understanding about the dynamic damage process of transport properties in lacustrine shale reservoirs.

References

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