The Shale Activity Test (SAT)

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Abstract

Shale (compacted clay or mudstone) has potential properties of swelling, softening and micro-fracturing when exposed to the fresh water. A conventional swell test on shale is very slow, takes months to achieve full swelling potential and provides a very limited amount of quantitative petrophysical parameters which could be used to predict shale behavior during interaction with drilling and completion fluid. This paper introduces the shale activity test (SAT) on shale samples interacted with water, which is based on a continuous measurement of density fluctuation in time due to swelling (volume increase in the same mass of sample in water) and sub-sequent micro fracturing.

Measurements obtained from SAT could be used to design a new approach to calculate mechanical properties of shale formations in the well bore affected by drilling or completion. The test is run in real time with the Rate of Swelling (ROS) being the output parameter as measurement of variations of density. This parameter could be calibrated with any other parameters of a conventional swell test for four distinctive behaviors of the shale: non-swelling, nonlinear swelling, linear swelling and periodical swelling. Each behavior corresponds to a particular shale type.

During the test, first the swelling process develops and is reflected on the chart as a decrease in density. Then, subsequent fractures parallel to the sedimentary layered surfaces take place, and are reflected on the chart as an increase in density. The ratio of density change over the time is called Rate of Swelling (ROS). In some shales the ROS is represented by a saw tooth ripple on the main trend of shale activity. ROS secondary variations represent the mechanical models of micro laminations filled with thin films of seasonal clay/silt deposition. The frequency and quantity of the ripples are subsequently used to predict the well stability and fracability properties of the shale. Since the ROS can be measured within a substantial range of mud salinities and in oil base mud, the ROS applicability covers most type wells.

The SAT has been successfully applied to well stability evaluations in both conventional and unconventional oil fields. The final results of the test played the critical role in the determination of the best perforation zones, sweet spots within a horizontal well, and formation fracability for the completion stage.

This paper presents the fundamentals of the test, associated technology, and a comprehensive geo-algorithm for the application of SAT measurements in well log analysis.