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# Improved Calibration of Borehole Stability Models in Shales Using Hollow Cylinder Laboratory Tests

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## SUMMARY

To improve the understanding of behavior related to the borehole geometry in shales, and to generate better input data to borehole stability simulators to be used when estimating the stable mud weight window, we have developed an experimental methodology whereby we perform rock mechanical laboratory tests on various shales in a hollow cylinder geometry. We present our methodology, including both laboratory measurements, how such data and other data are fed into our borehole stability simulator, as well as results for specific cases. These tests allow for a better understanding of failure mechanisms causing borehole instabilities and providing calibration data to borehole stability models. When integrated into proper borehole stability simulators it thus represents an applicable tool for attaining improved drilling performance while drilling through shales.

Borehole stability problems when drilling through shales are generally known to represent a substantial cost. Better well planning may reduce such costs. A pre-requisite is, however, access to sufficient rock mechanical data on the relevant formations, as well as a rock mechanical simulator that incorporates important effects, including also for instance time-dependent fluid-induced effects introduced by the mud itself. When core material is available, such mechanical input data have traditionally been generated from rock mechanical triaxial tests, giving information on strength and static mechanical parameters. However, due to its geometry, the borehole represents a situation with modified stresses and thereby altered mechanical behavior. This geometry adds complexity, in particular with respect to behavior close to and after initiation of borehole failure.

To improve the understanding of behavior related to the borehole geometry in shales, and to generate better input data to borehole stability simulators to be used when estimating the stable mud weight window, we have developed an experimental methodology whereby we perform rock mechanical laboratory tests on various shales in a hollow cylinder geometry. Samples are drilled from shale seal peels at various angles to the bedding plane. During tests, external deformations are monitored together with the radial deformation for the borehole. To quantify mud-shale interaction effects on borehole stability, relevant muds may be used during testing. Moreover, to investigate the influence of borehole dynamical effects like ECD, dedicated test procedures have been designed towards such applications.

These data are subsequently fed into our borehole stability simulator to improve its calibration for the specific shale. In particular, the hollow cylinder tests also allow us to calibrate better for effects of plasticity, which may significantly improve the stability of the borehole, and of strength anisotropy. The latter is of potential importance when drilling deviated wells.

We present our methodology, including both laboratory measurements, how such data and other data are fed into our borehole stability simulator, as well as results for specific cases.

These tests allow for a better understanding of failure mechanisms causing borehole instabilities and providing calibration data to borehole stability models. When integrated into proper borehole stability simulators it thus represents an applicable tool for attaining improved drilling performance while drilling through shales.

*Please note that a more extensive written abstract would be difficult to produce at present due to confidentiality restrictions.*