Formation of slot-shaped borehole breakout within weakly cemented sandstones

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Breakout (wall failure) of boreholes within the earth can take several forms depending upon physical properties of the surrounding rock and the stress and flow conditions. Three distinctive modes of breakout are (I) extensile breakout observed in brittle rocks (e.g., Haimson and Herrick, 1986), (II) shear breakout in soft and clastic rocks (Zoback et al., 1985), and (III) fracture-like, slot-shaped breakout within highly porous granular rocks (Bessinger et al., 1997; Haimson and Song, 1998). During fluid production and injection within weakly cemented high-porosity rocks, the third type of failure could result in sustained and excessive sand production (disintegration of the rock fs granular matrix and debris production). An objective of this research is to investigate the physical conditions that result in the formation of slot-shaped borehole breakout, via laboratory experiments.

Our laboratory borehole breakout experiment was conducted using synthetic high-porosity sandstone with controlled porosity and strength. Block samples containing a single through-goring borehole were subjected to anisotropic stresses within a specially designed tri-axial loading cell. A series of studies was conducted to examine the impact of (i) stress anisotropy around the borehole, (ii) rock strength, and (iii) fluid flow rate within the borehole on the formation of slot-shaped borehole breakout. The geometry of the breakout was determined after the experiment using X-ray CT.

As observed in other studies (Hamison and Song, 1998; Nakagawa and Myer, 2001), flow within a borehole plays a critical role in extending the slot-shaped breakout. The results of our experiments indicated that the width of the breakout was narrower for stronger rock, possibly due to higher resistance to erosion, and the orientation of the breakout plane was better defined for a borehole subjected to stronger stress anisotropy. In most cases, the breakout grew rapidly once the borehole wall started to fail. This gru-away h failure growth is induced by monotonically increasing stress concentration at the breakout tips, although this effect may be augmented by the finite size of the sample.

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