INTERPRETING MAXIMUM HORIZONTAL FIELD STRESS FROM BOREHOLE BREAKOUT IN ACOUSTIC TELEVIEWER IMAGES

SUMMARY

Borehole breakout analysis of acoustic televiewer images, combined with multi-hole field stress models, can deepen our understanding of the inherent orientated stresses within any rock mass.

This makes for safer and more productive mine planning and operations.

PROBLEM

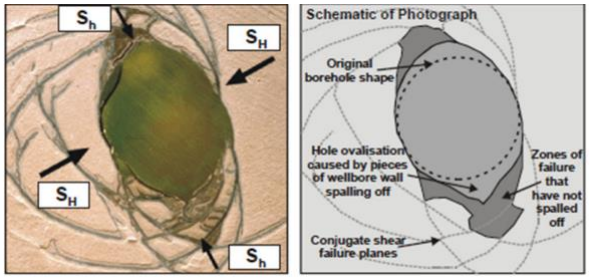
The folding or faulting of a rock mass is a definitive indicator of its inherent stresses. Yet it can be challenging to map the orientation or magnitude of these stress fields, particularly in what appears to be competent formations away from any major structures. Standard drilling and core logging practices tend to yield minimal field stress information, and what is gathered needs to be defined in either orientation or magnitude. A lack of a well-defined field stress model can severely affect mine design and operational safety.

SOLUTION

Although the acoustic televiewers (ATV) are primarily deployed to map planar geological and structural features that intersect the borehole, they also can adapt to mapping the vertical to near vertical occurrences of borehole breakout where present in the borehole wall.

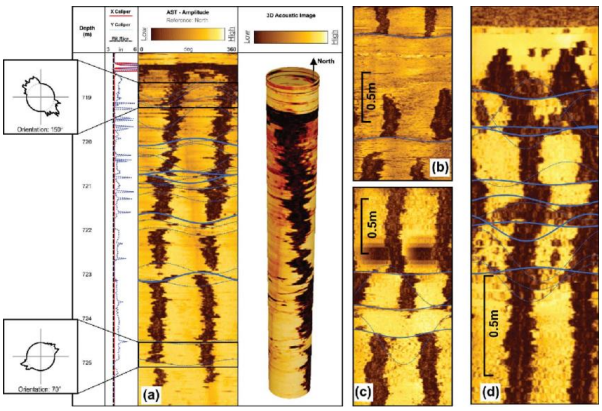
Borehole breakout occurs when the removal of the core sample creates a cavity in the rock mass. The field stress in the rock mass acts upon the vacated cavity introducing an ovality to the borehole cavity.

This deformation is proportional to the magnitude of the horizontal stress to the point of mechanical failure in the wall rocks at points perpendicular to the maximum stress orientation.



Schematic diagram of breakout from lab experiments. SH and Sh refer to the orientations of maximum and minimum horizontal stress, respectively (Kundan et al. 2015)

Acoustic televiewers capture a continuous ultra-high resolution orientated image of the borehole wall. As this image is captured in situ, it facilitates the interpretation of the maximum horizontal stress orientation from the breakout occurrences in the image.



Borehole breakout as indicated in ATV images (Kundan et al. 2015)

A relative magnitude of the maximum horizontal stress can be inferred from the degree of deformation of the borehole cavity and the horizontal extent of the breakout across the ATV image.

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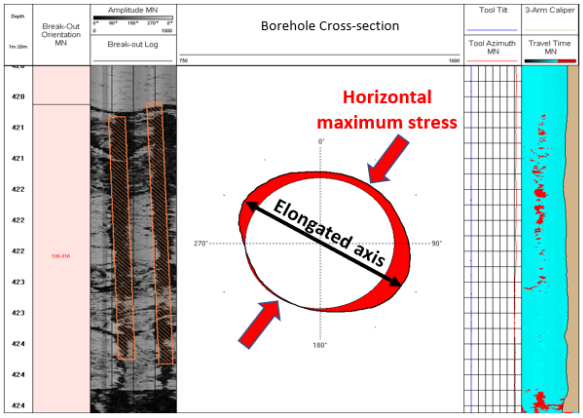


Borehole breakout in ATV image log and corresponding cross-section. (Mahlatji et al. 2009)

As the entire ATV image can be interrogated for breakout occurrences large and small, rotations in the maximum horizontal stress can also be interpreted over the borehole length.

The 360-degree ATV images also allow for the visual distinction between breakout and other drilling-induced borehole wall features like washouts and key seats, adding certainty to the breakout interpretations.

IMPACT

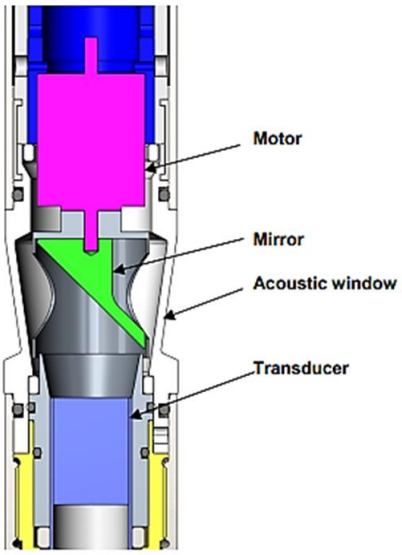
ATV images are generally employed in geological and localized planer structure interpretations. Including breakout analysis in the data analysis workflow can extract the maximum amount of usable information from the ATV image data.

Combining single-hole borehole breakout analysis into more extensive field stress interpretations deepens our understanding of the rock mass before mine development.

TECHNOLOGY

Wireline logging is performed by lowering a 'logging tool', attached to the end of a wireline (logging cable), into a borehole and recording in-situ petrophysical properties making use of the onboard sensors. The logging tools developed over the years can measure a wide variety of different physical formation properties, from simple gamma ray measurements to orientated high resolution acoustic images of the borehole wall.

Acoustic Televiewer: (ATV) generates images of the borehole wall by transmitting ultrasound pulses from a fixed transducer, with a rotating acoustic mirror, and recording the amplitude and travel time of the signals reflected at the interface between the borehole fluid and the formation (borehole wall). The reflection amplitude is controlled by the acoustic impedance of the formation. Variations of the acoustic impedance both vertically and radially are mapped in the generated image. Changes in borehole diameter result in variations in acoustic travel-time and these variations are used to generate a second image of the travel time data. The Amplitude and Travel Time images are represented as “false” color images as no color information is captured by the acoustic pulses. The ATV tool has its own on-board navigation system consisting of a flux-gate magnetometer array, to measure tool orientation with respect to magnetic north, and accelerometers to measure tool inclination. ATV images may be presented with respect to borehole high side, in inclined boreholes, and magnetic north for vertical boreholes. Interpretation of the ATV images allows for the true dip and dip direction determination of low to high angle geological and structural features that intersect the borehole. ATV image quality is negatively affected by tool eccentricity within the borehole, very large borehole diameters and wall conditions (rugosity).



Cross section of an acoustic televiewer indicating the various components critical to the transmission and reception

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