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Analysis of image and drilling logs for formation instability uncertainty analysis

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Motivation

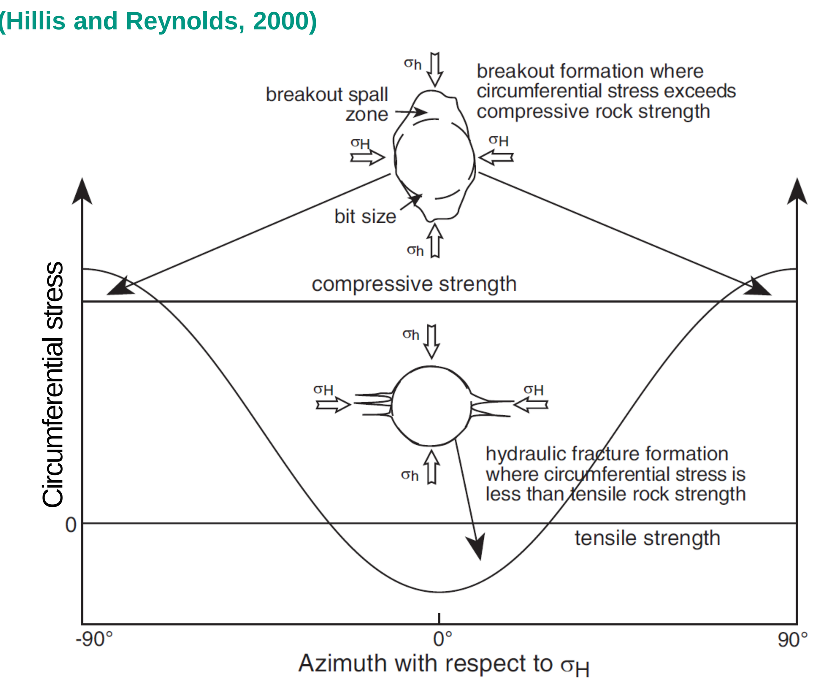
- Azimuthal LWD logs provide images of the borehole wall, which are widely used for the analysis of borehole breakouts
- These breakouts develop when the circumferential stress around the borehole wall exceeds the compressive strength of the rock
- Uncertainty on how drilling processes (such as tripping) influence the development of breakouts

Conclusion and Perspectives

- Observation of a relation between drilling processes and breakouts
- Negative pressure variations may have contributed to the development of breakouts
- Breakouts tend to grow both azimuthally and in their depth extent
- Future research could benefit from the availability of relogs and/or multiple image logging tools in the same wellbore

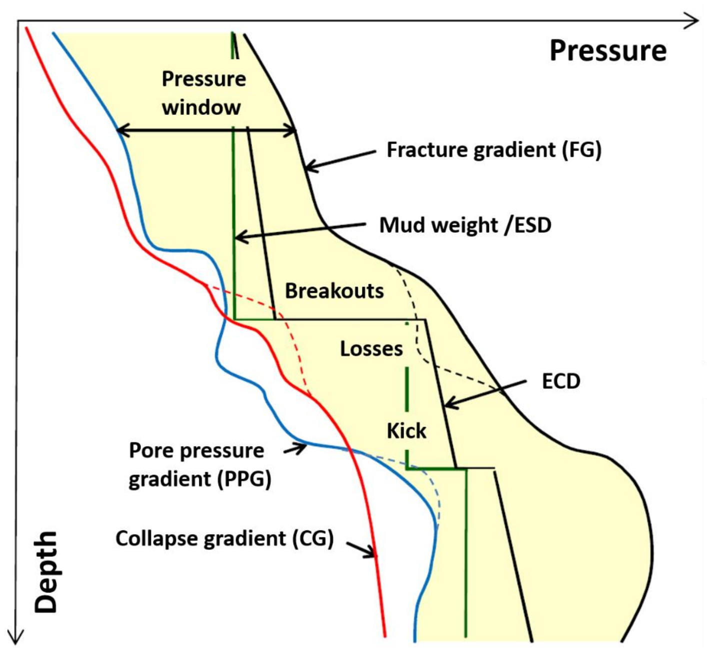
Theoretical background

Schematic cross sections of borehole breakouts (Hillis and Reynolds, 2000)



- Borehole breakouts (Tingay et al., 2008):
  - Occurrence of breakouts when stresses around the borehole are higher than the stress required to generate compressive failure of the borehole wall
  - Orientation parallel to minimum horizontal stress σ_h
  - Mud weight has to be adjusted accordingly to prevent breakouts

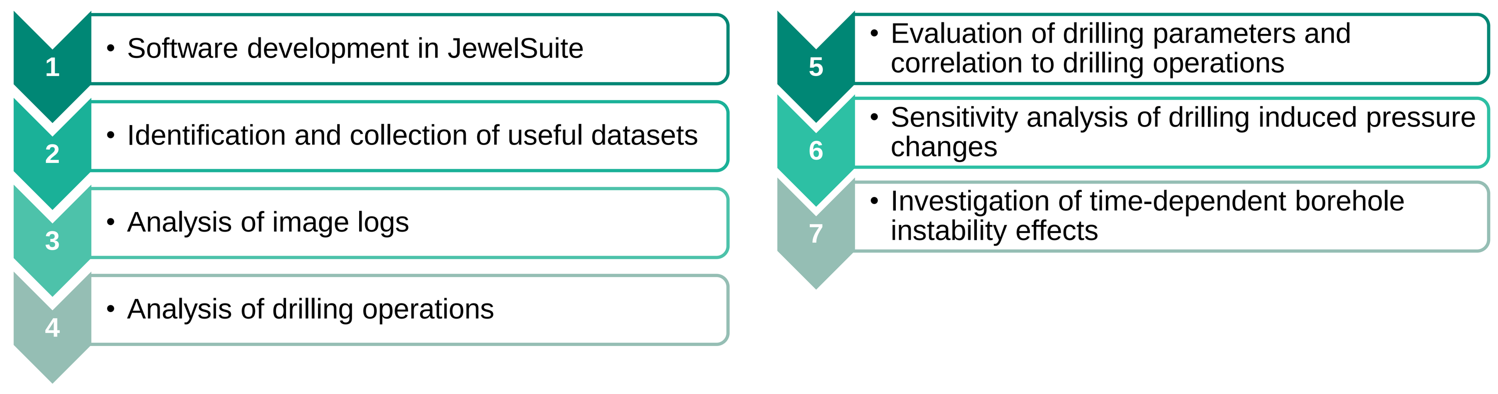
Pressure window
Modified after Wessling et al. (2012)



- Overview of relevant drilling processes (SOG, 2019):
  - Pipe trips: (Partial) removal of the drill string
  - Connections: Extension of the drill string by an additional segment

Methodology and software development

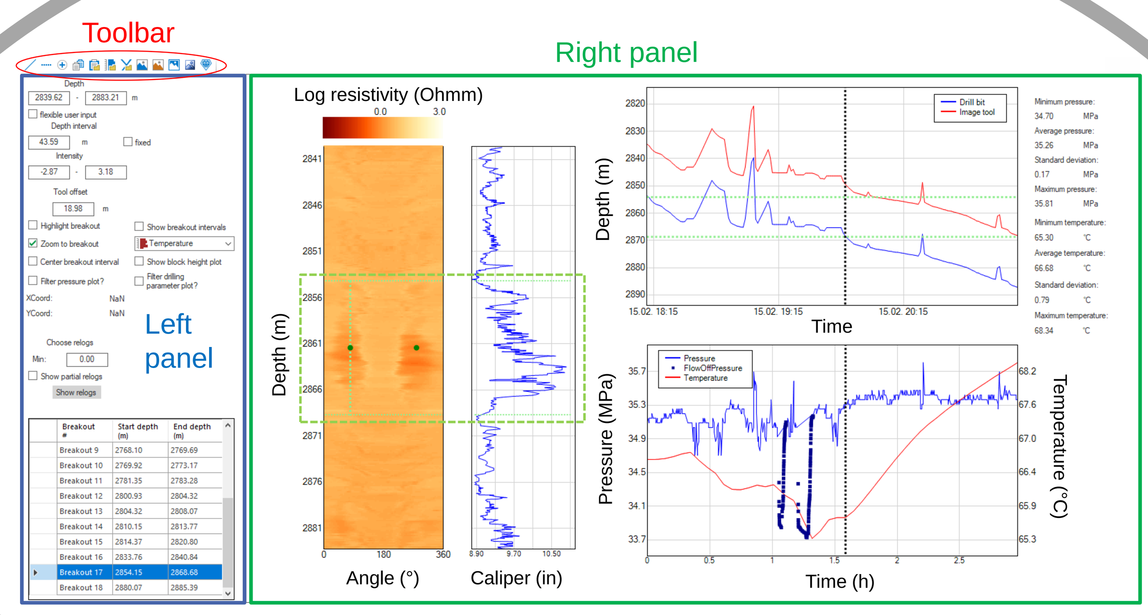
Methodology



Software development

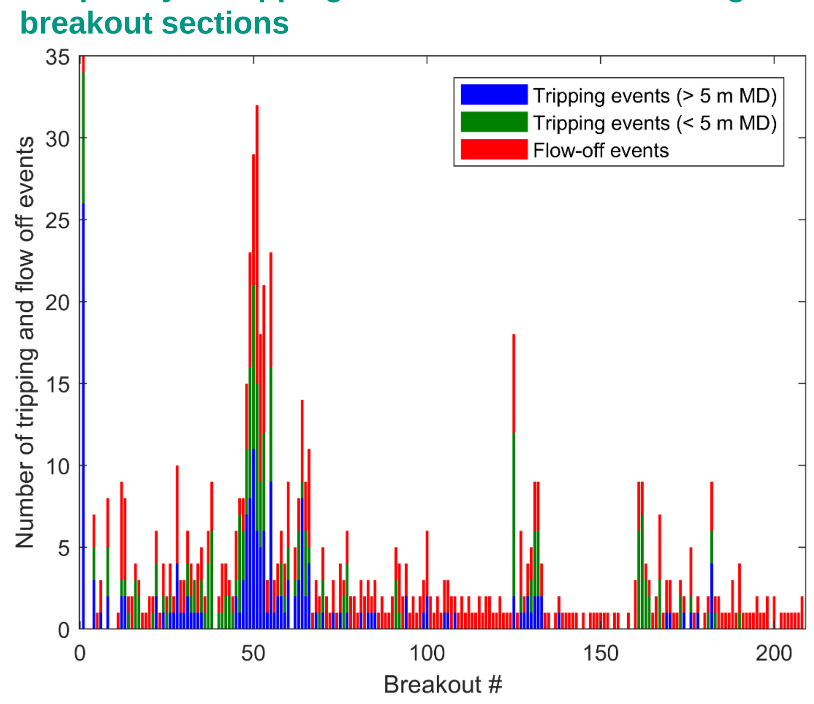
- Basis for development: Previously developed MATLAB prototype
- Programming language: C# (development environment: Microsoft Visual Studio)
- Platform: JewelSuite (BHGE 3D Reservoir Software)
- Major challenge: Visualization of image log data (no implementation in the JewelSuite framework available) → pixel-by-pixel realization
- Design: The main graphical user interface of the software is divided into:
  - Left Panel: multiple user controls to manipulate the displayed data in the plots
  - Right Panel: plots for image, caliper, bit and image tool depth as well as time based pressure and temperature data
  - Toolbar: multiple user controls to e.g. load/save breakout data or screenshots of the view

Software prototype

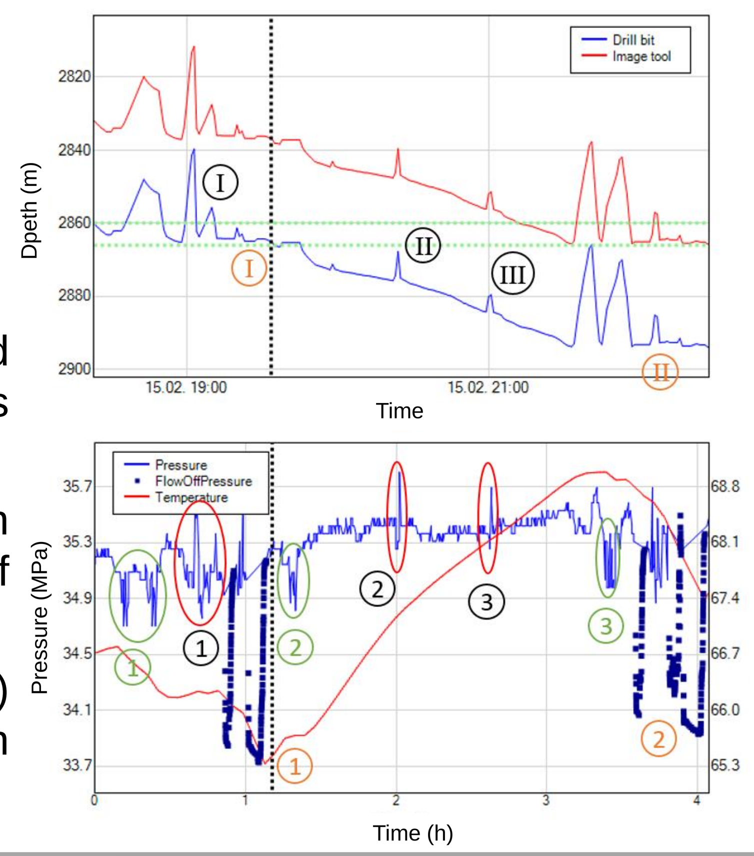


Influence of drilling processes

Frequency of tripping and flow-off events during breakout sections



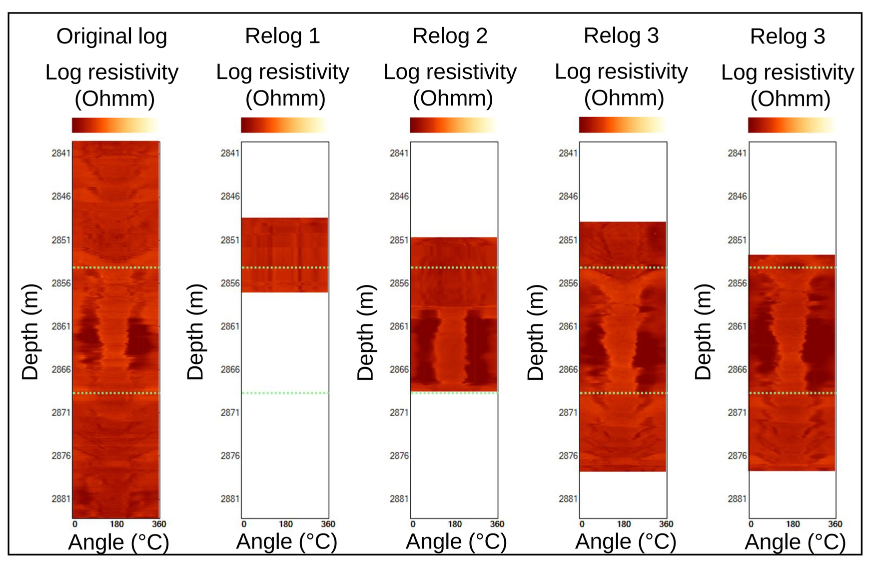
Relationship between drilling processes and pressure anomalies (mostly negative)



- Clear relation between breakouts and tripping operations / flow-off events → Cause for occurrence?
- Frequency of tripping events within breakout intervals one order of magnitude higher than outside
- Flow-off events (switched-off pumps) also occur more frequently within breakout intervals

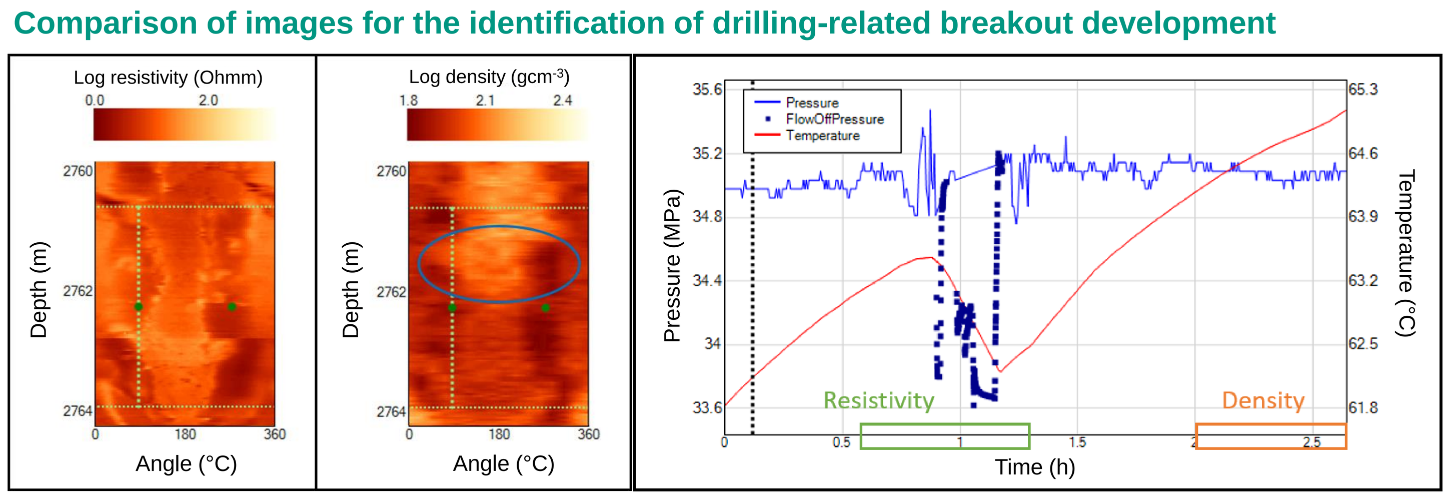
Temporal breakout evolution

Relog images of the same wellbore section



- Observations of increased breakout depth extent and opening angles by using relog images
- Comparison of different images in the same BHA potentially enables the temporal analysis of breakout evolutions

Comparison of images for the identification of drilling-related breakout development



References

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