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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

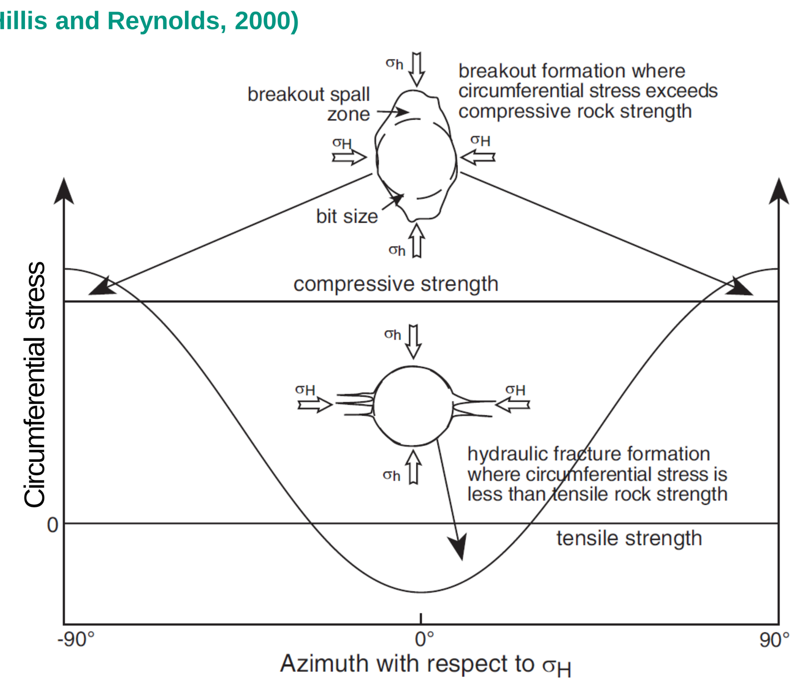
Conclusion and Perspectives

- 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

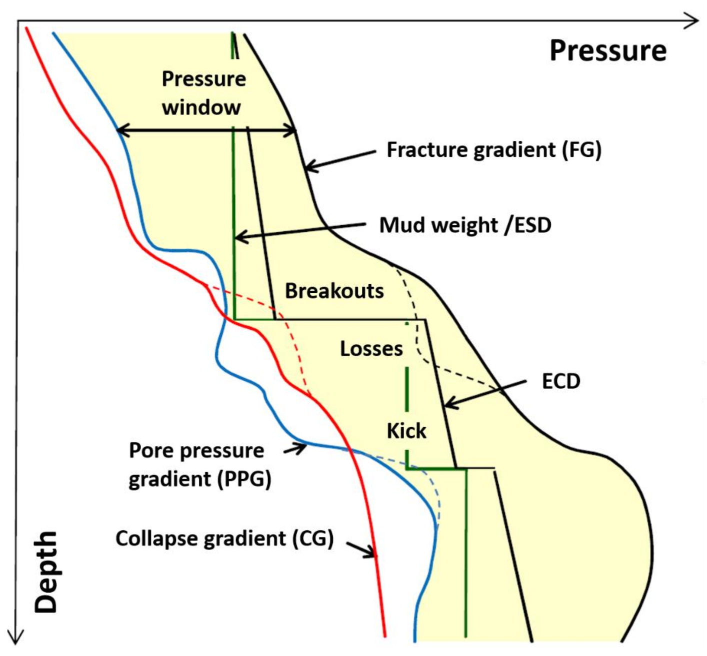
Theoretical background

- 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

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



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

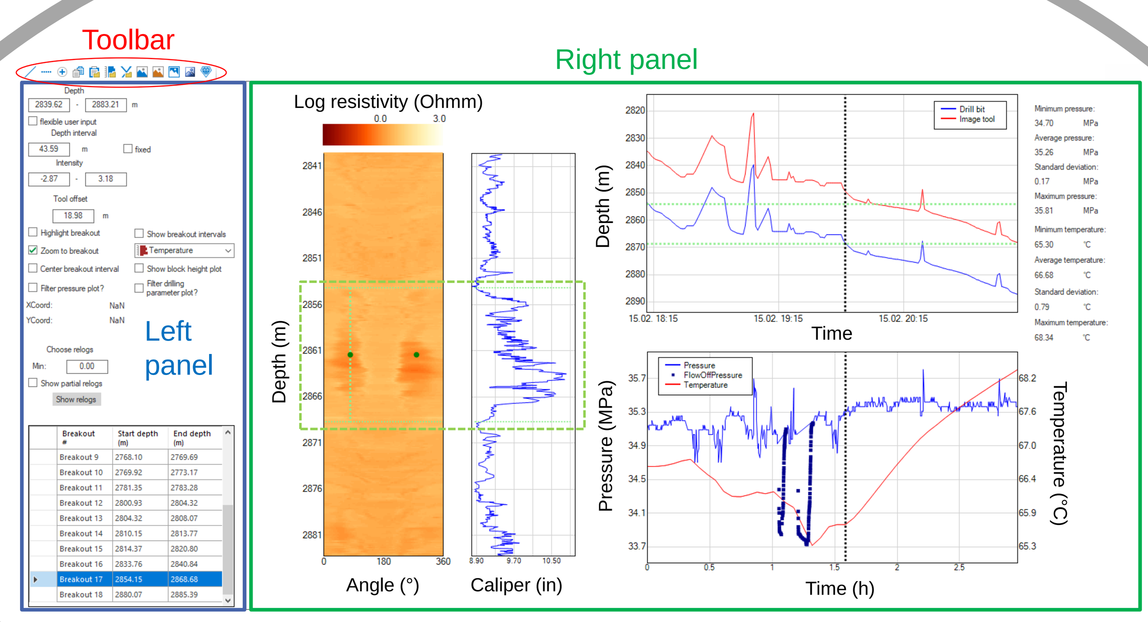
Methodology

1. Software development in JewelSuite
2. Identification and collection of useful datasets
3. Analysis of image logs
4. Analysis of drilling operations
5. Evaluation of drilling parameters and correlation to drilling operations
6. Sensitivity analysis of drilling induced pressure changes
7. Investigation of time-dependent borehole instability effects

Software development

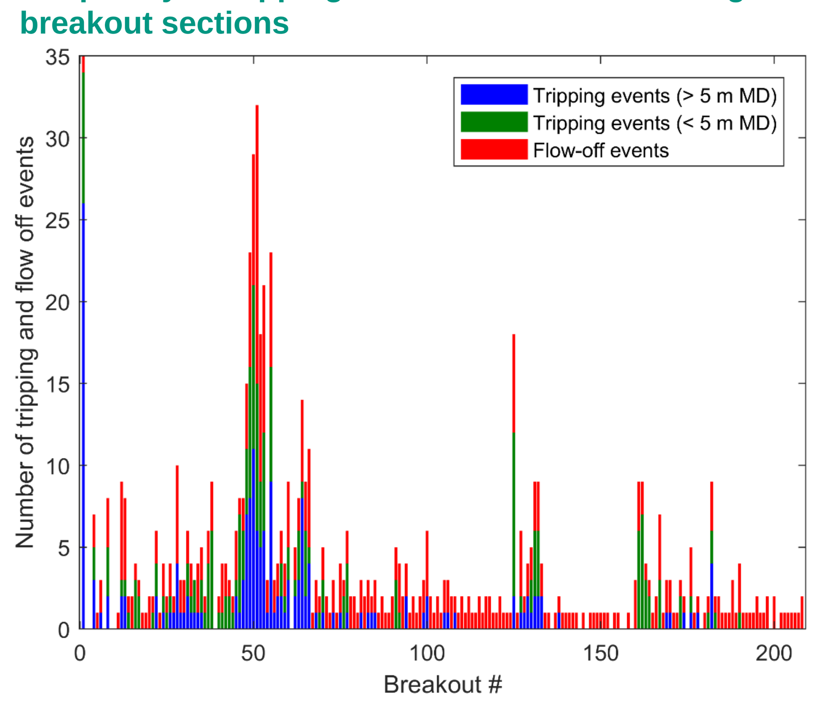
- Basis for development: Previously developed MATLAB prototype
- Programming language: C# (development environment: Microsoft Visual Studio)
- Platform: JewelSuite (BHGE 3D Reservoir Software)
- Major challenge: Visualization of image log data (no implementation in the JewelSuite framework available) → 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

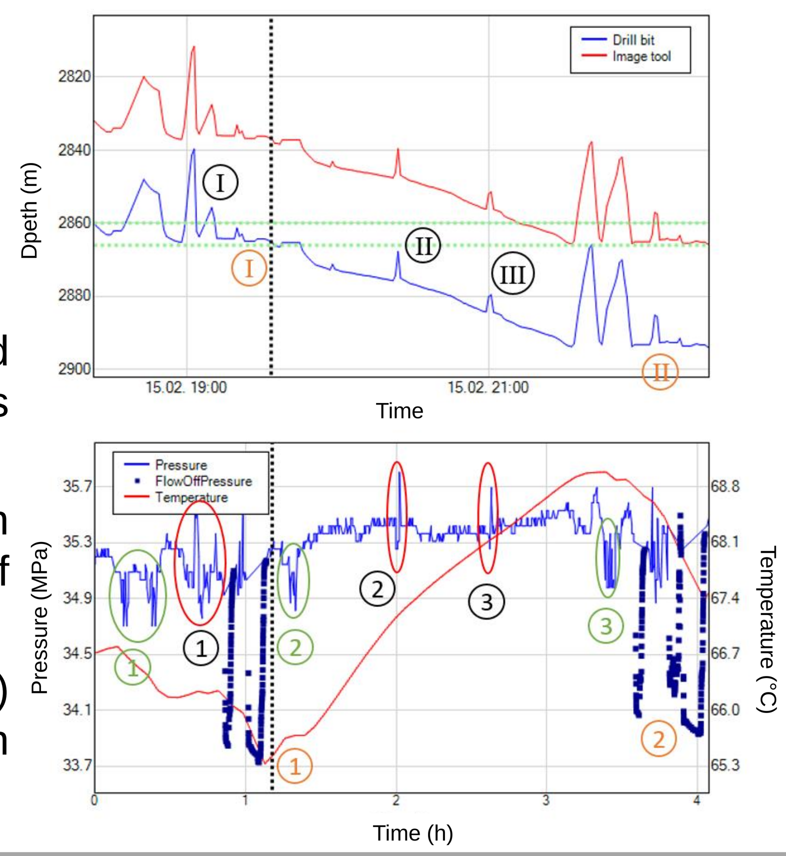


Influence of drilling processes

Frequency of tripping and flow-off events during breakout sections



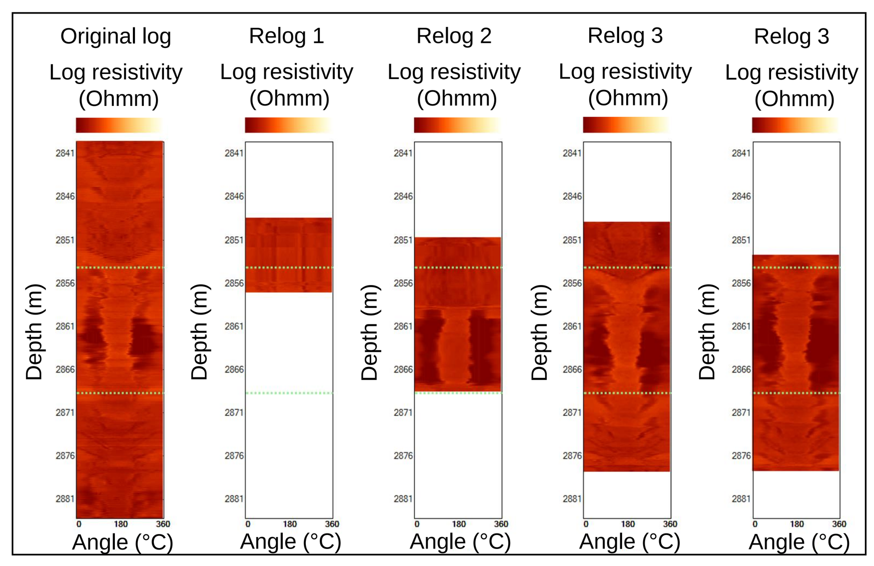
Relationship between drilling processes and pressure anomalies (mostly negative)



- 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

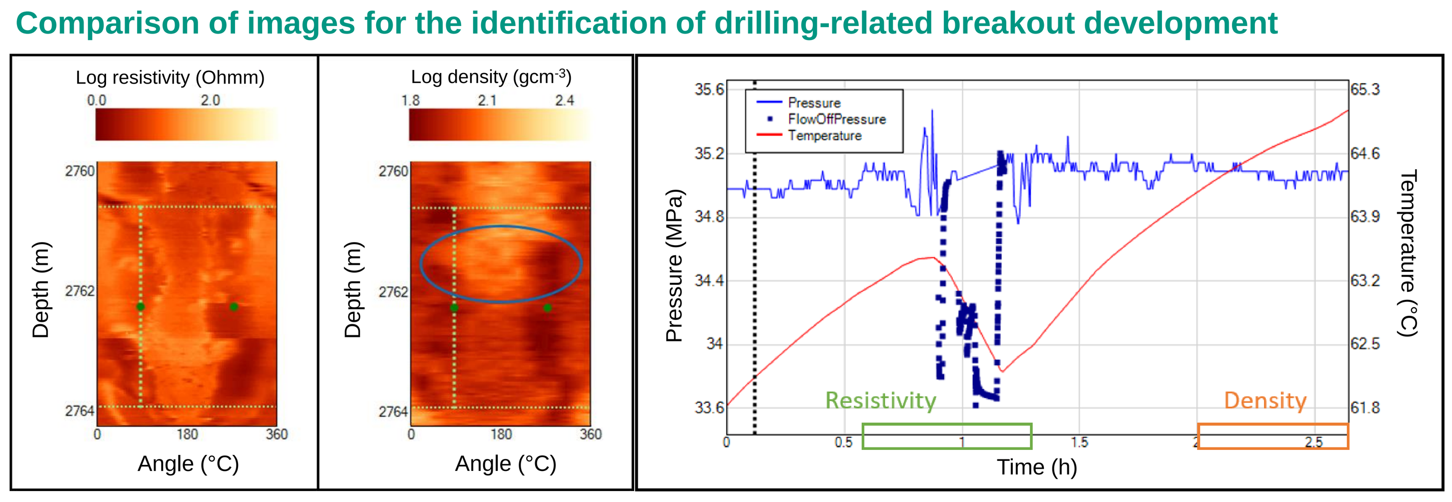
Temporal breakout evolution

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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