Image and fracture analysis

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Hole 1309D, mid Atlantic
Types of downhole image tools

- Electrical Resistivity: FMS (Formation MicroScanner), FMI (Formation MicroImager), RAB (Resistivity-At-Bit), etc

- Ultrasonic: UBI (Ultrasonic Borehole Imager), BHTV (BoreHole TeleViewer), etc

- Video.
Clear drilling fluid is required for downhole video - not often the case.

J. Nelson, COLOG
Unwrapped borehole images

Vertical Well

Horizontal Well

0°  180°  360°
The first downhole images?

Thompson / Loran 1904,
Downhole video

J. Nelson, COLOG
Resistivity Images

Needs water-based drilling fluid (not oil-based)
FMS (Formation Micro-Scanner)  
Resistivity Images
FMI
FMS Processing

Processing is required to convert the 64 electrical current traces recorded into a color-scale resistivity image.

1. **Speed correction.** For "stick and slip" - irregular tool motion.

2. **Equalization.** Between button electrodes and between pads.

3. **Button correction.** e.g., "dead buttons" the defective trace is replaced by traces from adjacent good buttons.

4. **EMEX voltage correction.** During logging, the voltage that drives the current is continuously regulated so that current flows even through very resistive formations.
Stick and slip 1
Stick and slip 2

Raw image  static  dynamic
FMS images
Site 1003,
Bahamas
Transect:
Lithostratigraphy
FMS images, Site 1166, Antarctic

<table>
<thead>
<tr>
<th>Lithostratigraphic Units</th>
<th>FMS (Static Corr.)</th>
<th>FMS (Dynamic Corr.)</th>
<th>Lithologic description and characteristic log response (units are log units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ia</td>
<td></td>
<td></td>
<td>Diamict - small clasts (Unit 2a) Low resistivity matrix, with small resistive clasts Medium gamma-ray Medium-high density Low porosity</td>
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<tr>
<td>Ib</td>
<td></td>
<td></td>
<td>Diamict - large clasts (Unit 2c) High resistivity with large resistive clasts Medium gamma-ray Irregular density and porosity Poor hole conditions</td>
</tr>
<tr>
<td>Ig</td>
<td>240</td>
<td></td>
<td>Massive sand (Unit 4) Structureless and massive High resistivity Low gamma-ray High density Low porosity</td>
</tr>
<tr>
<td>Id</td>
<td>2402</td>
<td></td>
<td>Deformed sands (Unit 4b) Dipping beds High resistivity Variable gamma-ray High density Low and variable porosity</td>
</tr>
<tr>
<td>II</td>
<td>2508</td>
<td></td>
<td>Laminated silty sand (Unit 5) Horizontal planar laminae Medium resistivity High gamma-ray Low density Variable porosity</td>
</tr>
<tr>
<td>III</td>
<td></td>
<td></td>
<td>Laminated sand y silt (Unit 5) Horizontal planar laminae Low resistivity High and variable gamma-ray Low density High porosity</td>
</tr>
</tbody>
</table>
Iberian Margin

Bedding: sandstone/claystone alternations

Figure 6
Alternating layers of ungraded foraminifer-rich sandstone (light grey) and nannofossil claystone (brown), interpreted as contourites. Middle Eocene, Iberian margin. ODP Legs 173 (core) and 149 (FMS).
Contributed by Adrian Newton and Peter Harvey, University of Leicester, UK.
Soft-sediment deformation

Figure 4
Slumping in nannofossil chalk / nannofossil claystone. Late Maastrichtian, Blake Nose, western North Atlantic. ODP Leg 171B, Hole 1005C.
Contributed by Trevor Williams, University of Leicester, UK.
**FMI and RAB images**

Full 360° coverage of the borehole wall makes some features much easier to identify!

Prilliman et al, 1977
Ultrasonic Borehole Imager
UBI images

Hole 1256D
UBI and FMS comparison
Borehole Breakouts

Mark the minimum stress direction
Core orientation

DMT Core Scanner

Camera - line scanner

Core on rollers
Bedding and fault dip

fault

bedding
Natural and induced fractures

Natural Fractures: Past stress conditions

Induced Fractures: Present stress conditions

T. Wilson
Core orientation using BHTV images

Match features in core and downhole image. Then rotate core to north.
Fracture reorientation

Paulsen et al., 2002
Example of faulting ~same age as deposition of rock

Vein folded by compaction
Applications of boreole imagery

Fractures in core and borehole walls, for tectonic evolution:
  • faulting history
  • relation fluids & deformation
  • paleostress
  • contemporary stress

Also:
  Lithostratigraphy
  Bedding: structural & sedimentary dips
  Paleocurrents - sed. structures
  Orienting Paleomagnetic samples