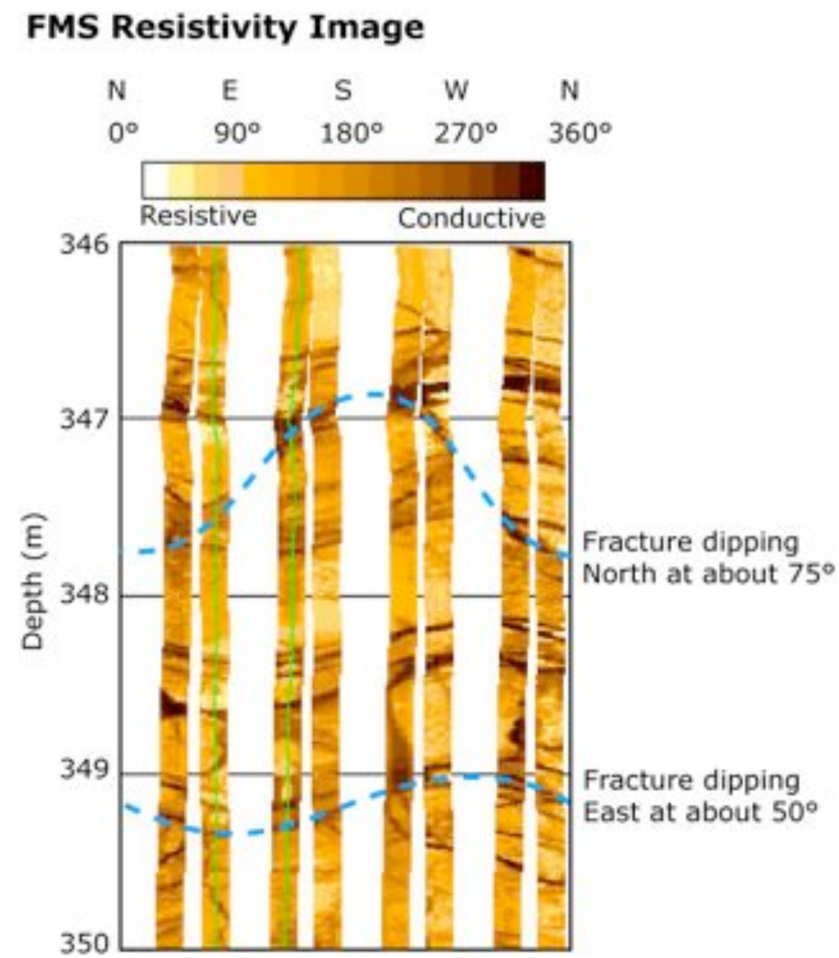
Image and fracture analysis

Trevor Williams
Borehole Research Group, LDEO



Hole 1309D, mid Atlantic

Types of downhole image tools

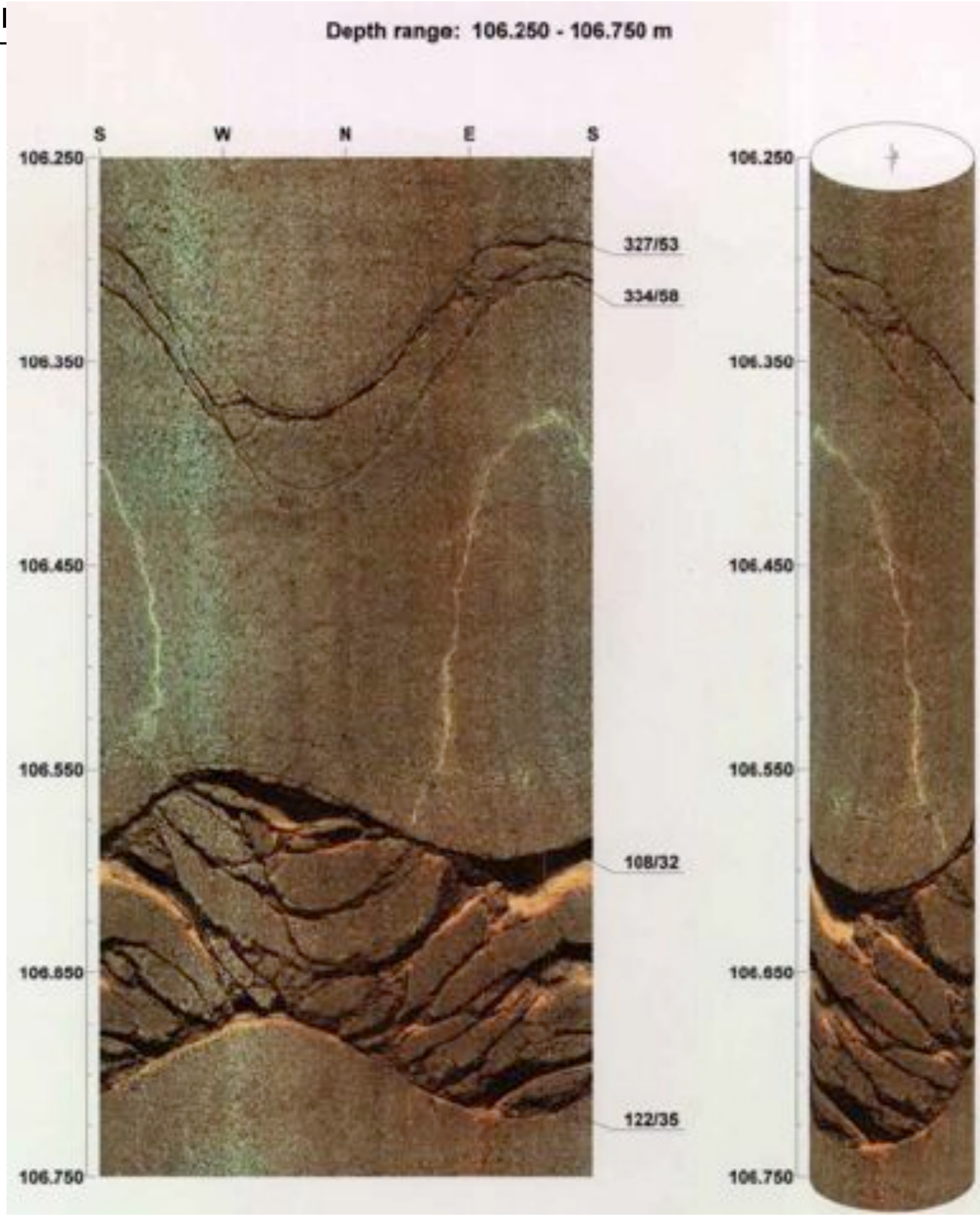
- Electrical Resistivity: FMS (Formation MicroScanner),
  FMI (Formation MicroImager),
  RAB (Resistivity-At-Bit), etc

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

- Video.

Downhole video

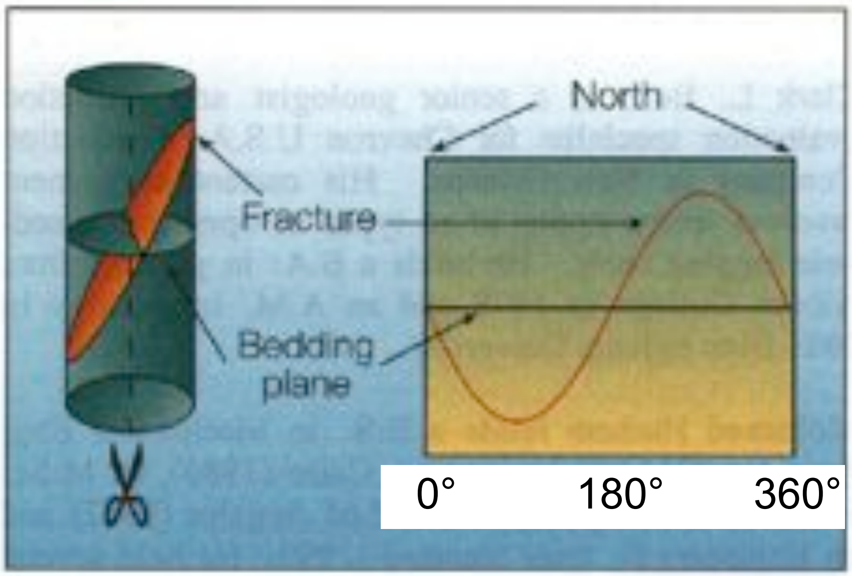
Clear drilling fluid is required for downhole video - not often the case.



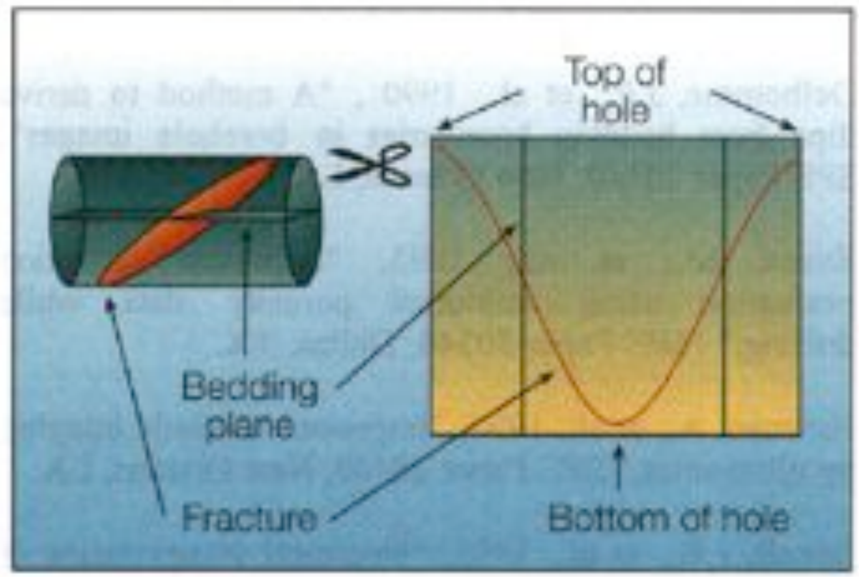
J. Nelson, COLOG

Unwrapped borehole images

Vertical Well



Horizontal Well



The first downhole images?

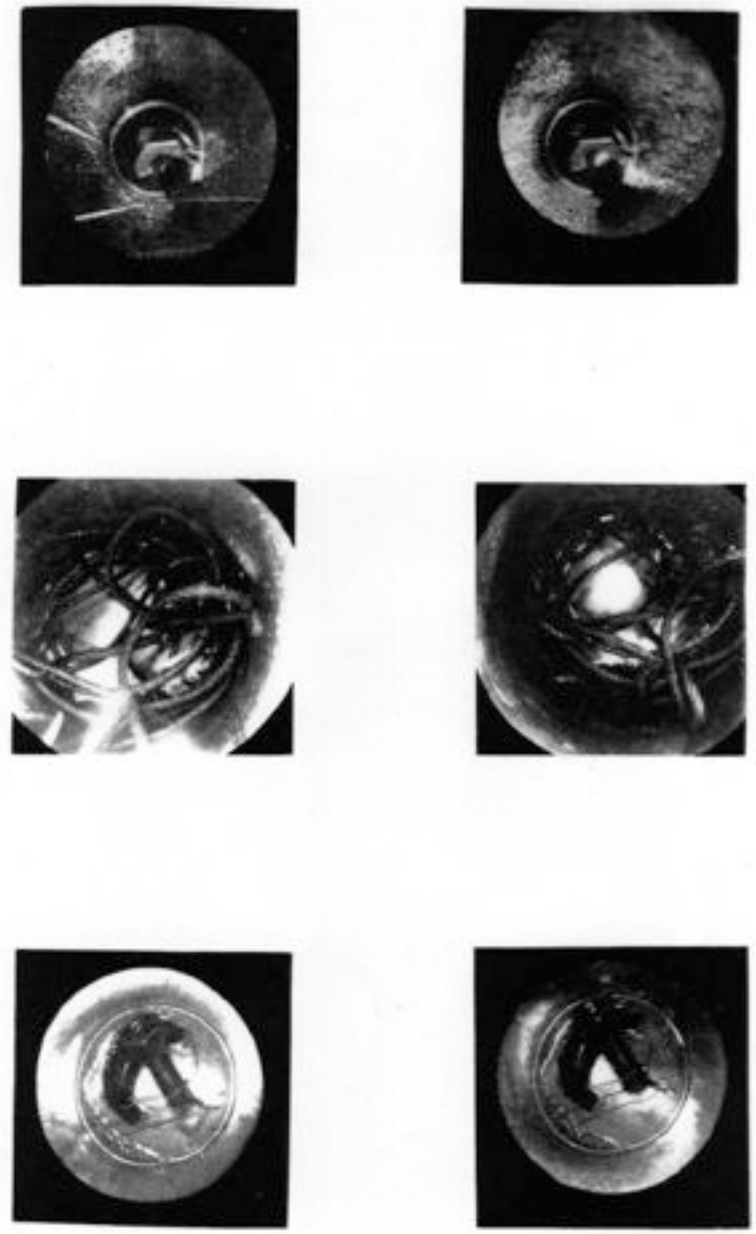
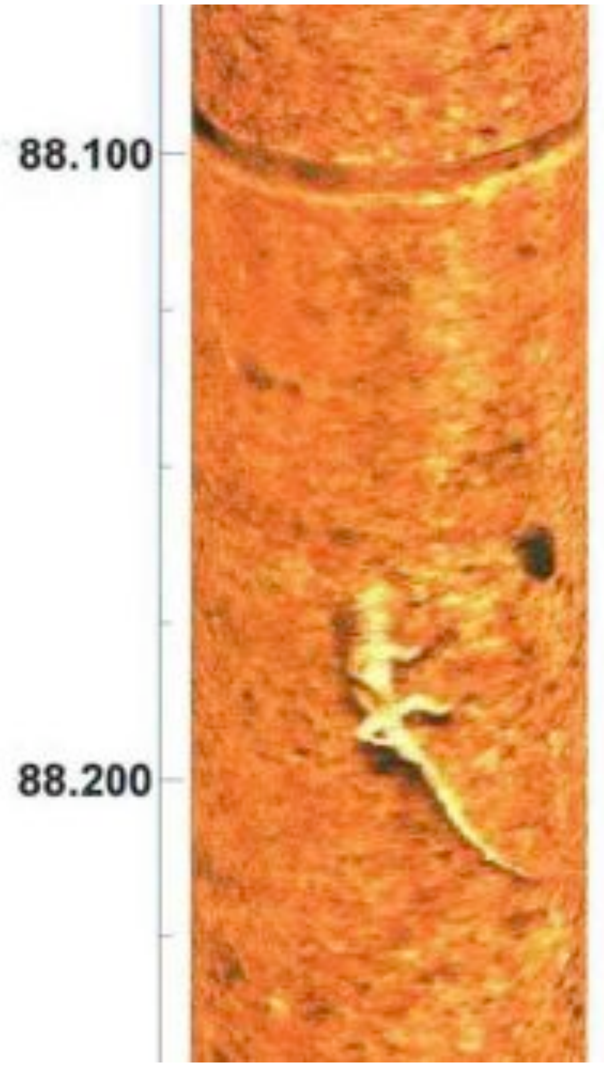


Fig. 39.—Photographs of Lost Articles in Baku Oil Wells.

Thompson / Loran 1904,

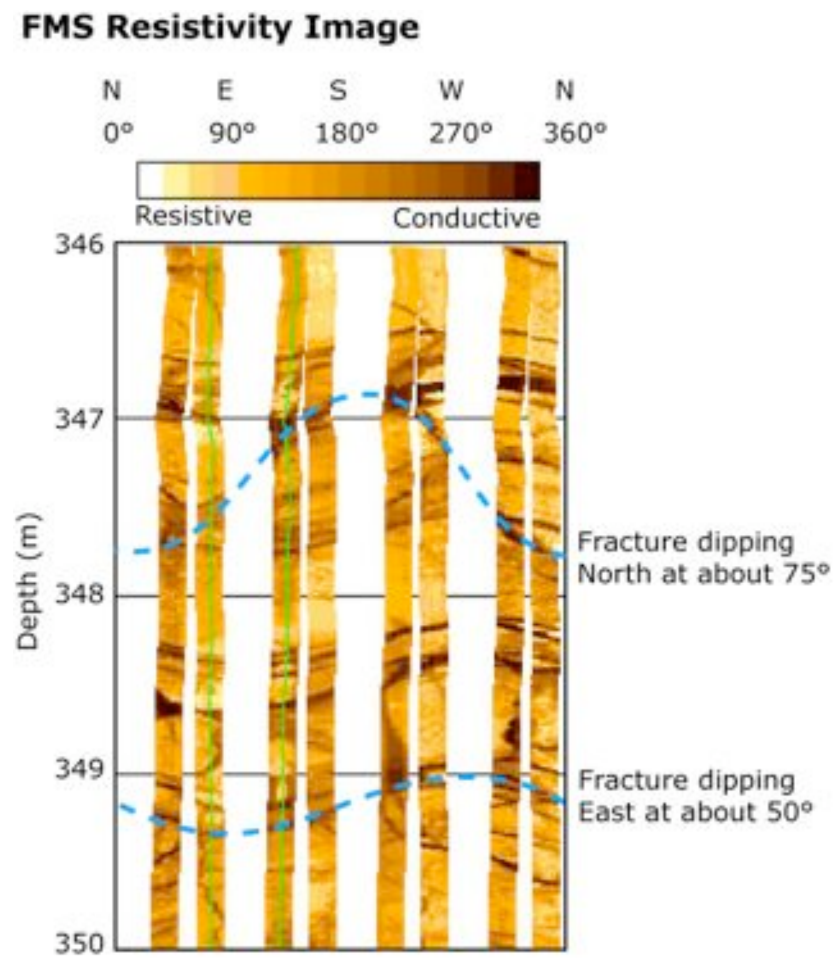
Downhole video



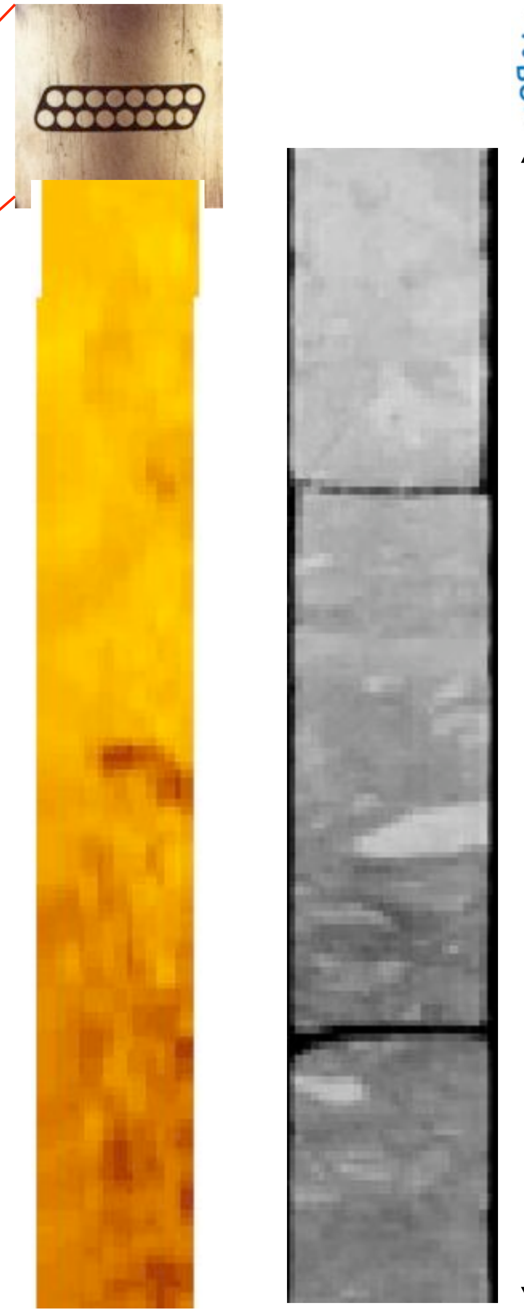
J. Nelson, COLOG

Resistivity Images

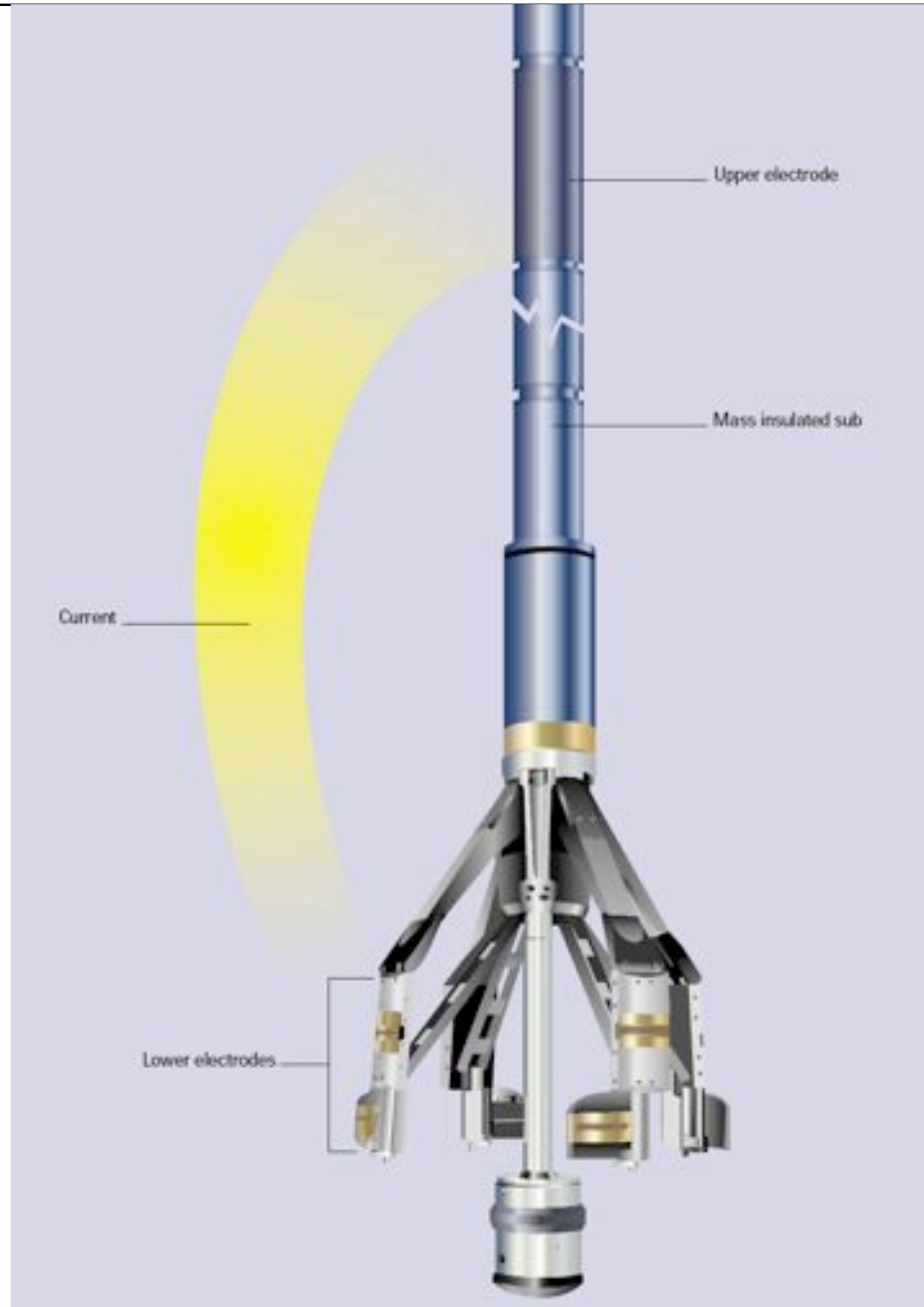
Needs water-based drilling fluid
(not oil-based)



FMS (Formation Micro-Scanner) Resistivity Images



FMI


Upper electrode
Mass insulated sub
Current
Lower electrodes

FMS Processing

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

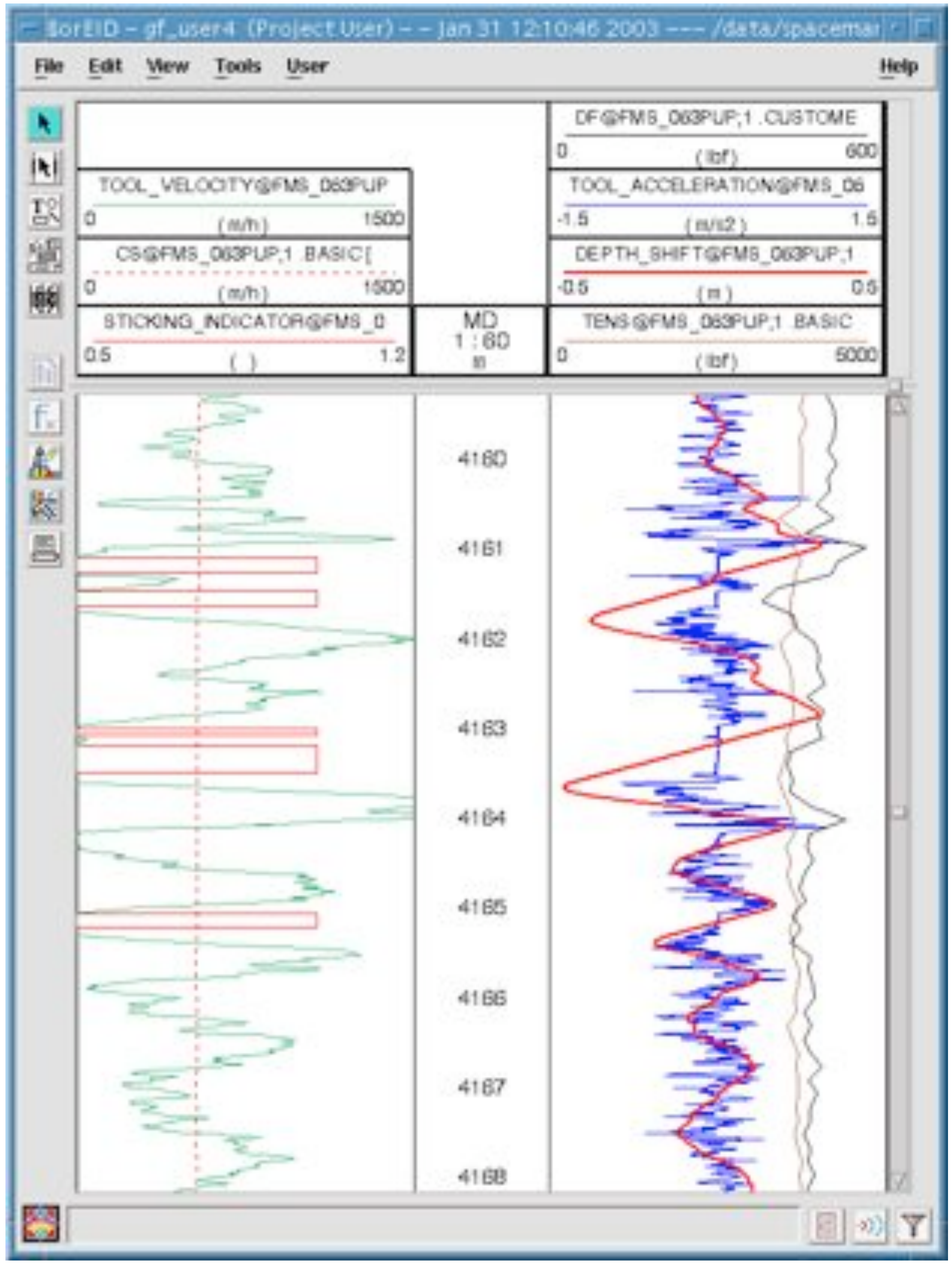
1. **Speed correction.** For "stick and slip" - irregular tool motion.

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

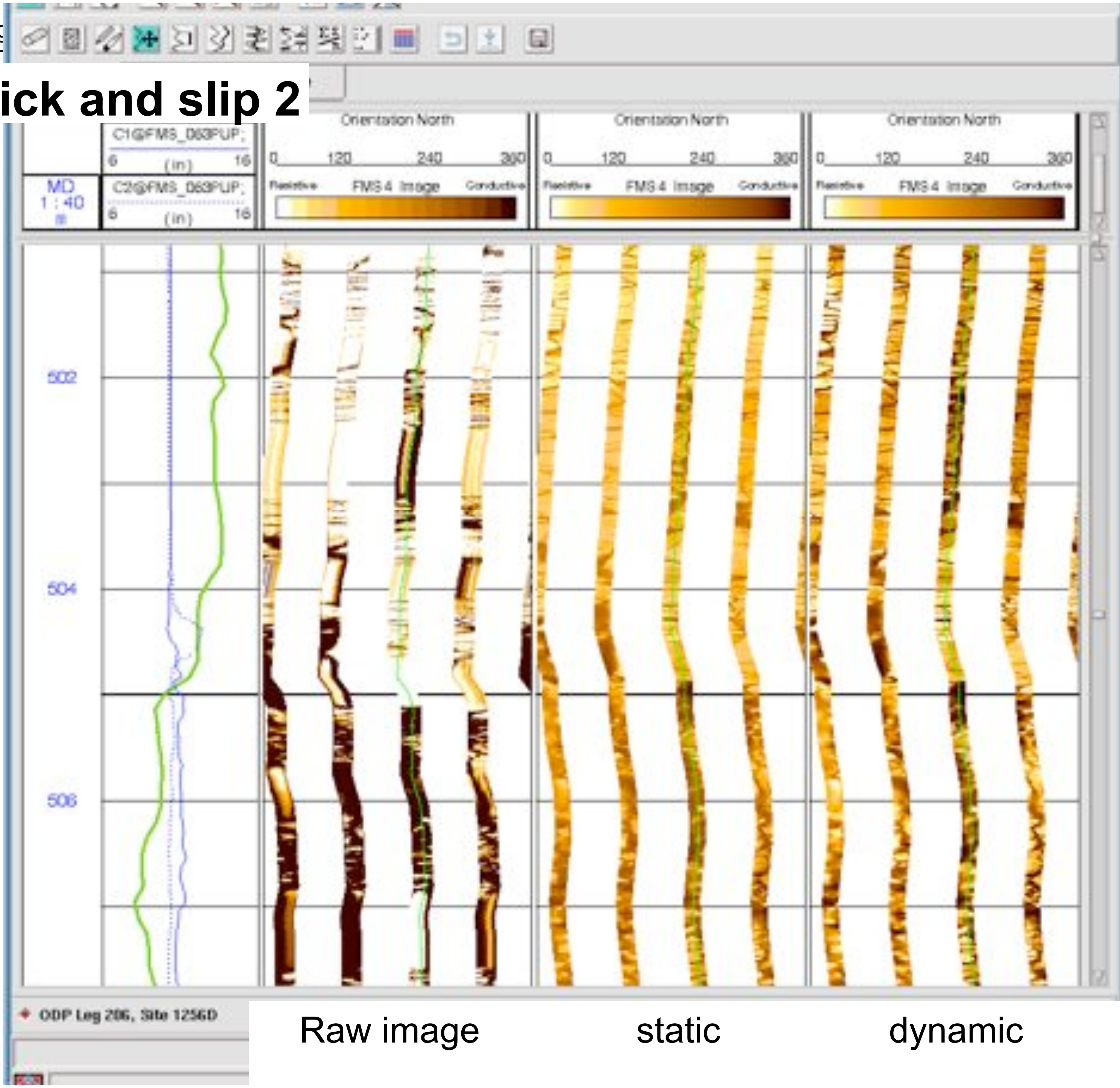
3. **Button correction.** e.g., "dead buttons" the defective trace is replaced by traces from adjacent good buttons.

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

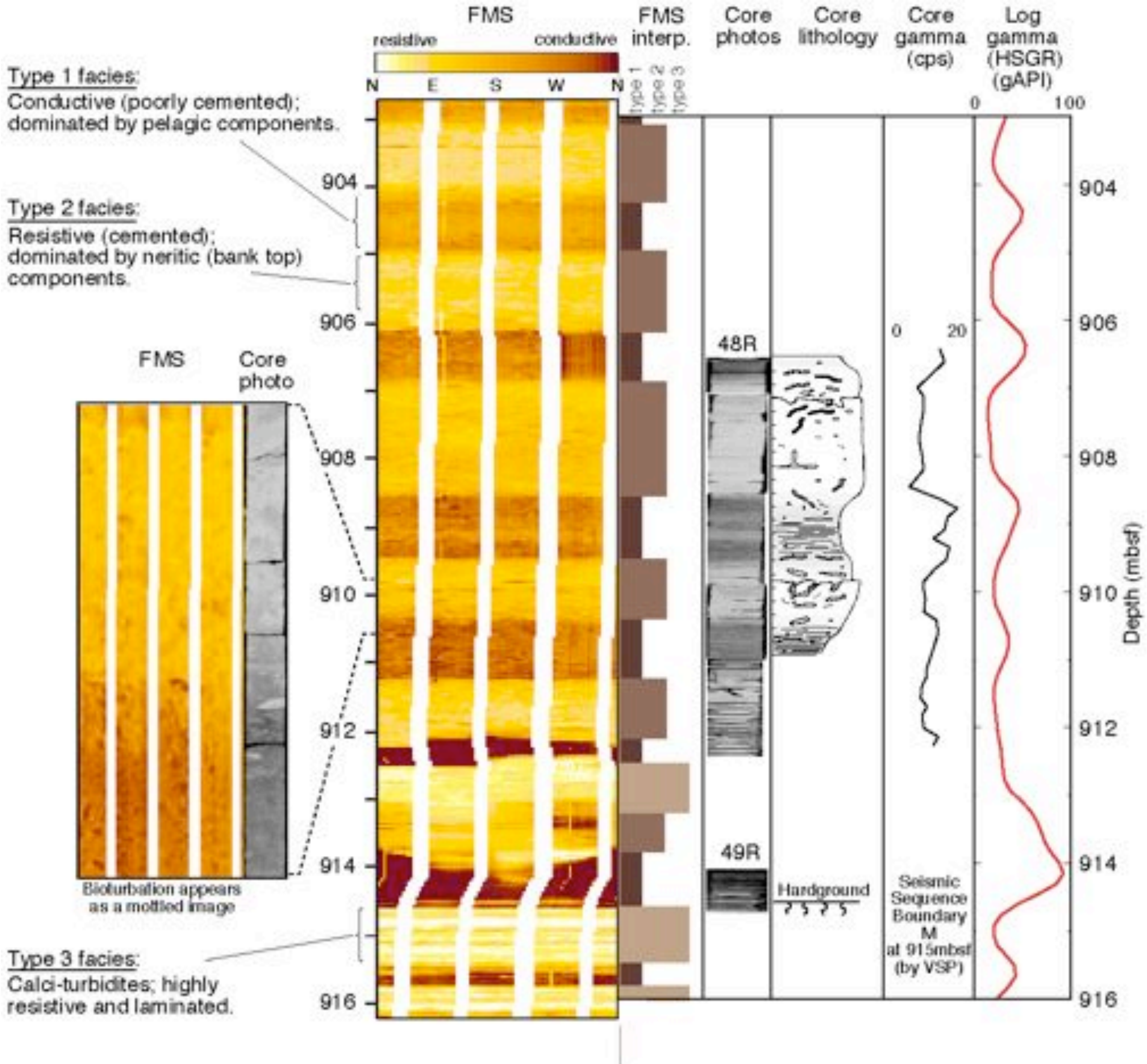


Stick and slip 2



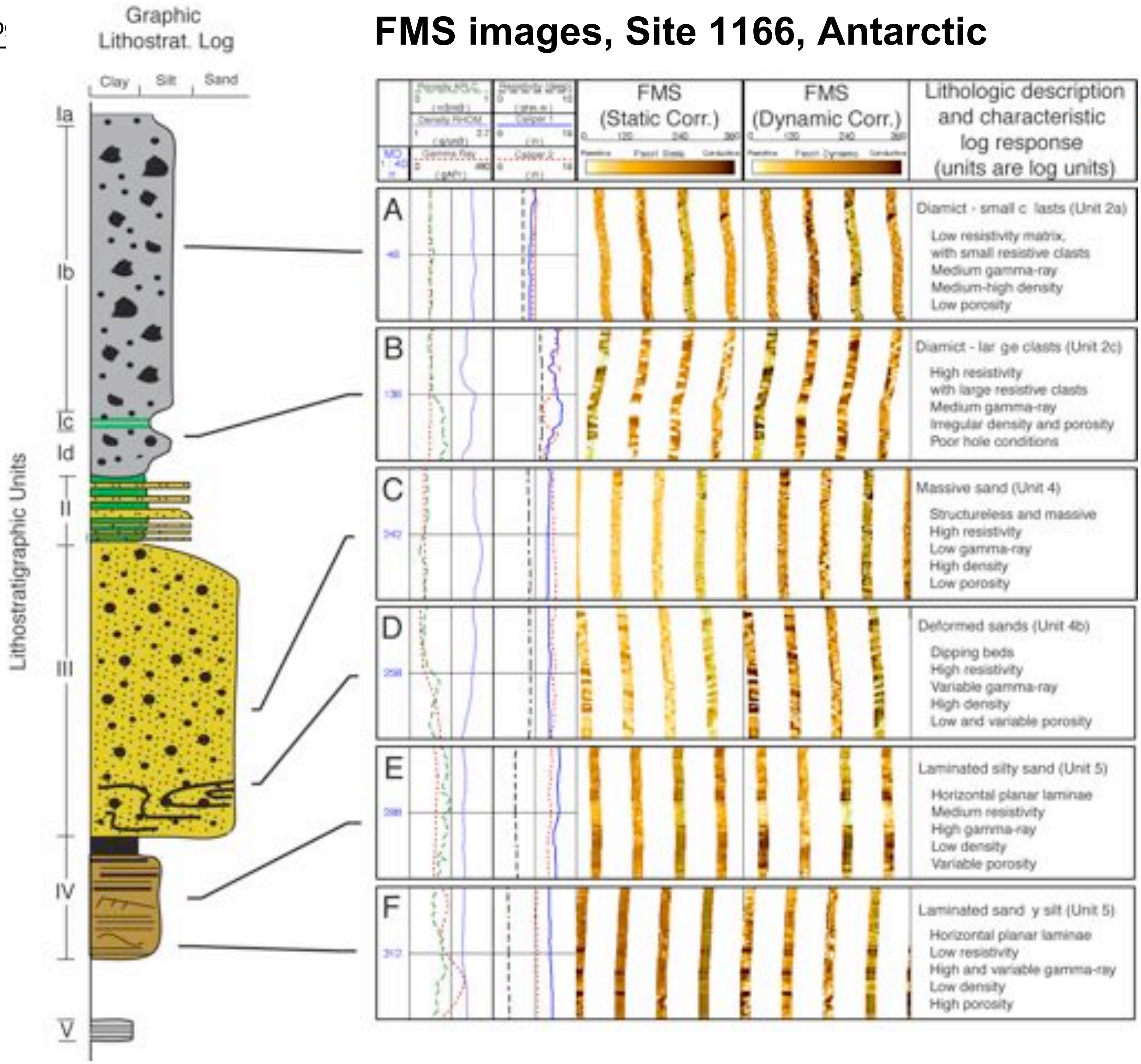
Raw image static dynamic

FMS images Site 1003, Bahamas Transect: Lithostratigraphy



Well Lo

FMS images, Site 1166, Antarctic



Iberian Margin

Bedding:
sandstone/claystone
alternations

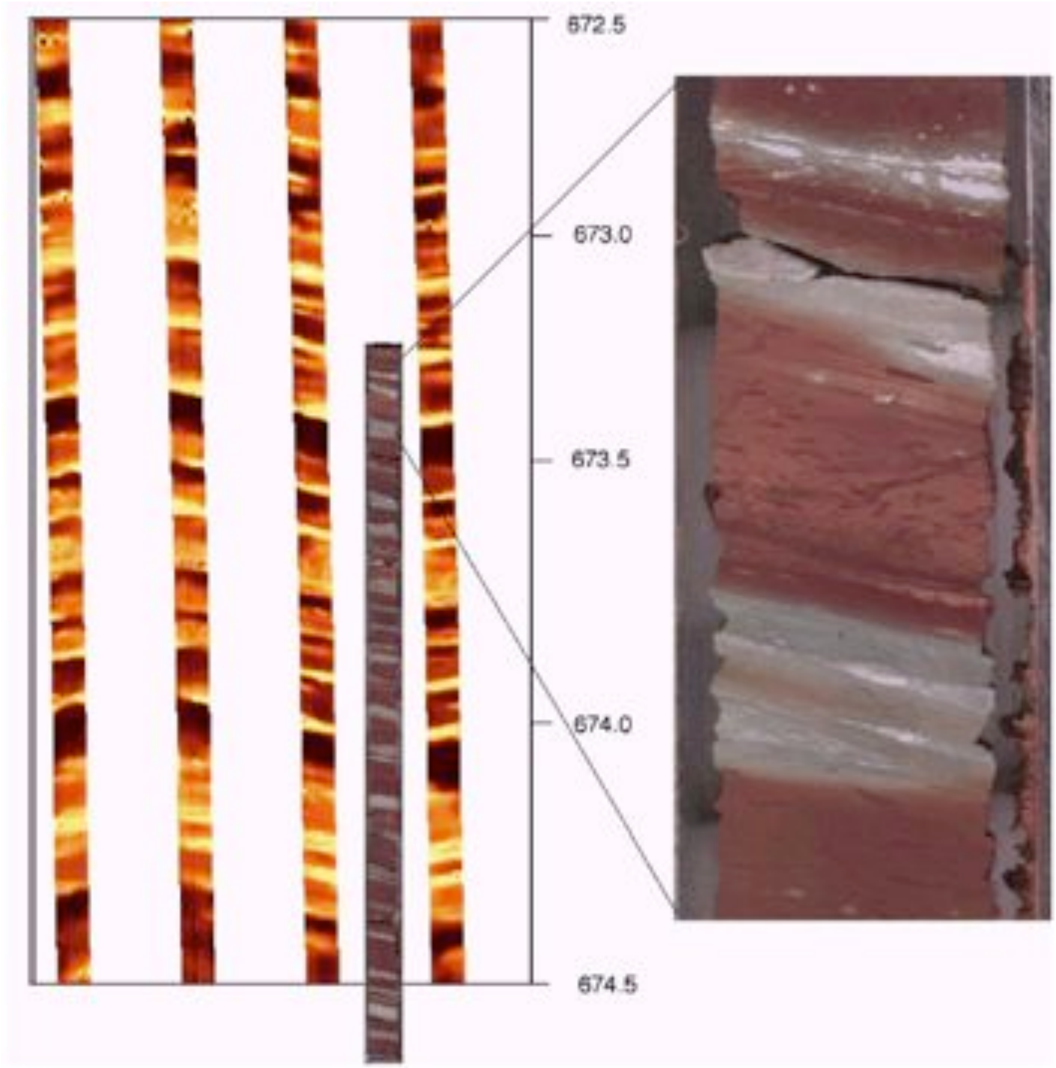


Figure 6
Alternating layers of ungraded foraminifer-rich sandstone (light grey) and nannofossil claystone (brown), interpreted as contourites. Middle Eocene, Iberian margin. ODP Legs 173 (core) and 149 (FMS).
Contributed by Adrian Newton and Peter Harvey, University of Leicester, UK.

Soft-sediment deformation

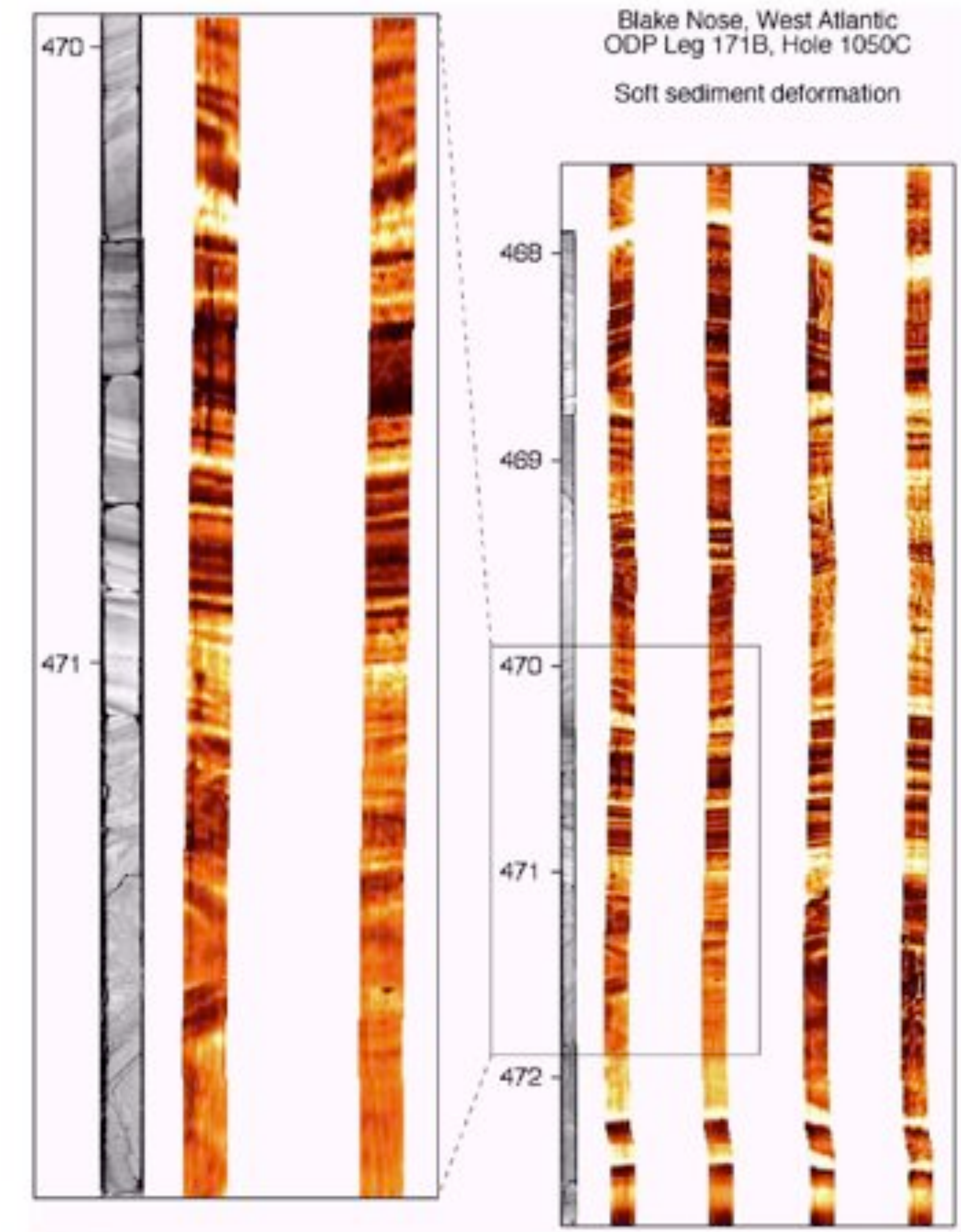
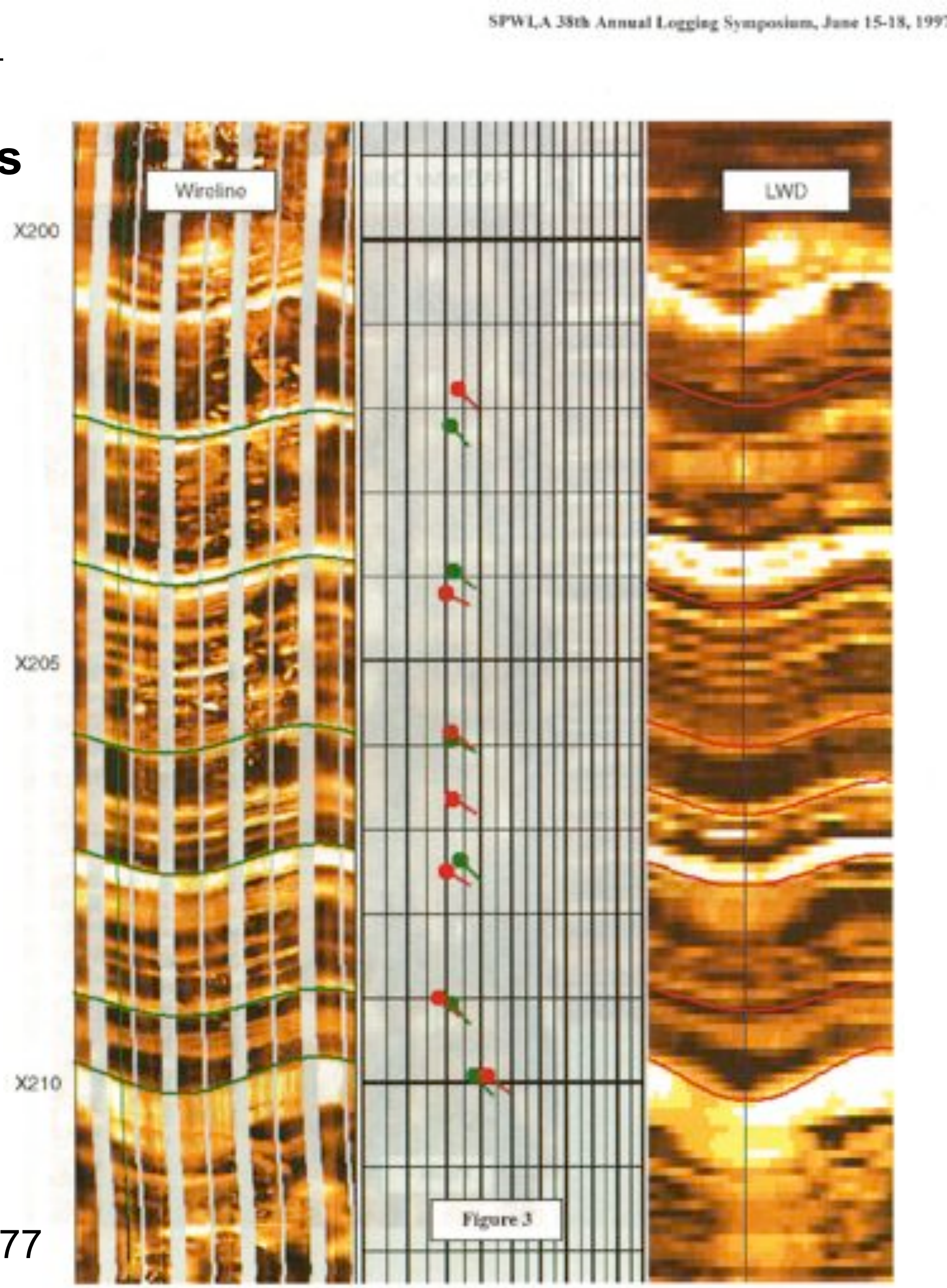


Figure 4
Slumping in nannofossil chalk / nannofossil claystone. Late Maastrichtian, Blake Nose, western North Atlantic. ODP Leg 171B, Hole 1005C.
Contributed by Trevor Williams, University of Leicester, UK.

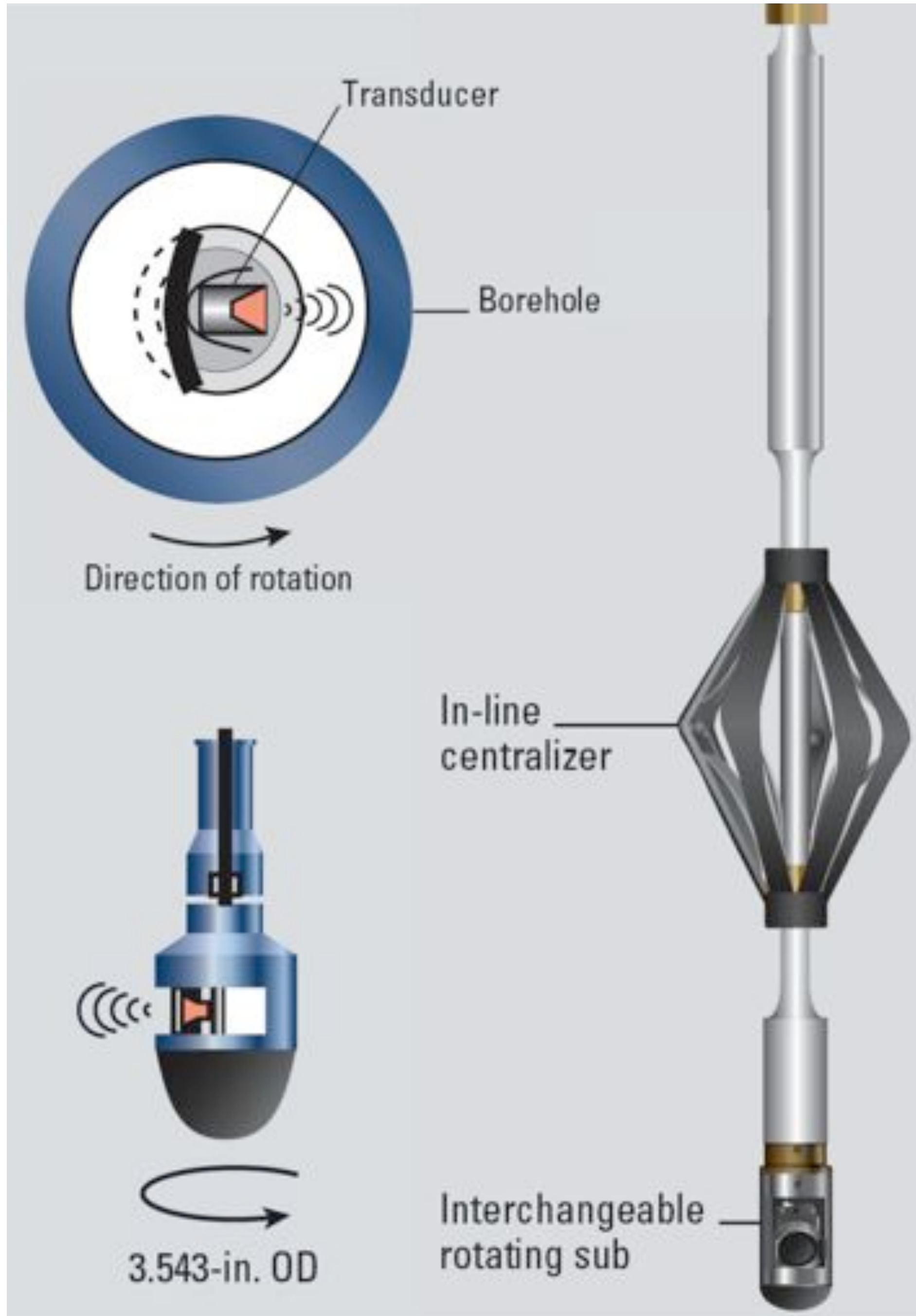
FMI and RAB images

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

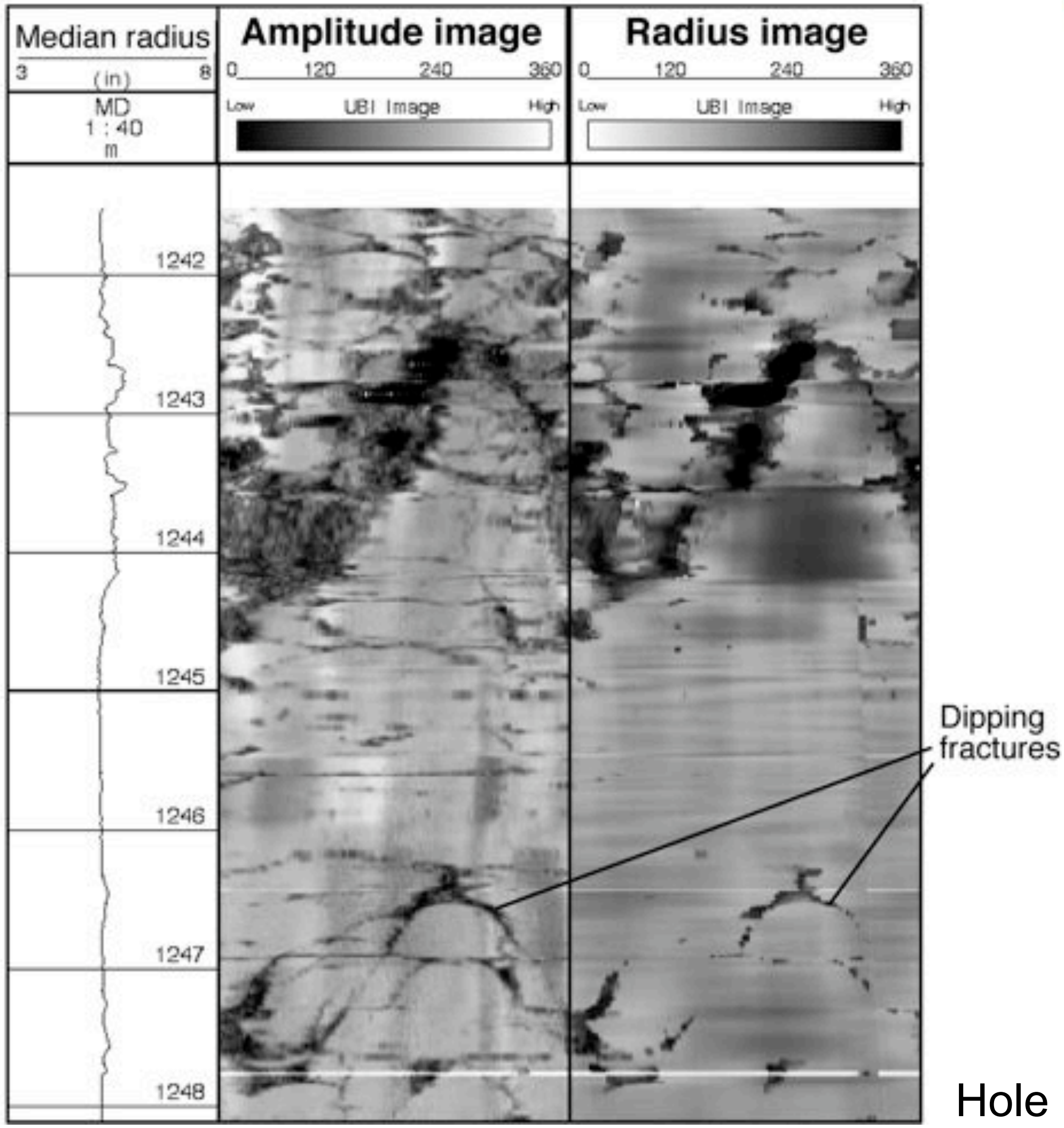


Prilliman et al, 1977

Ultrasonic Borehole Imager

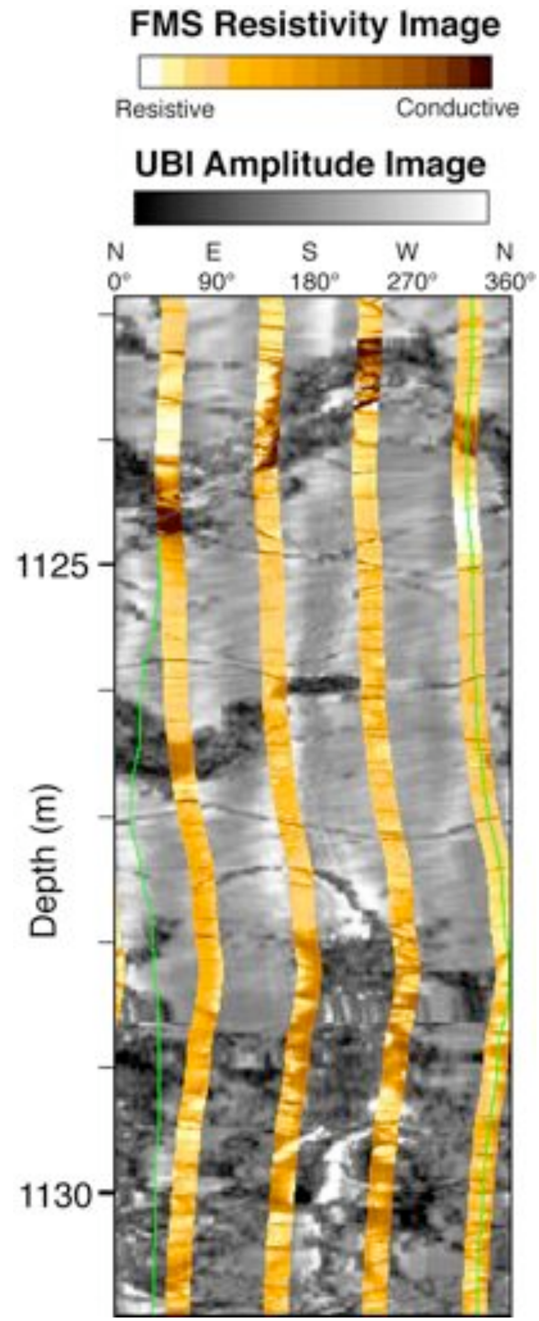


UBI images



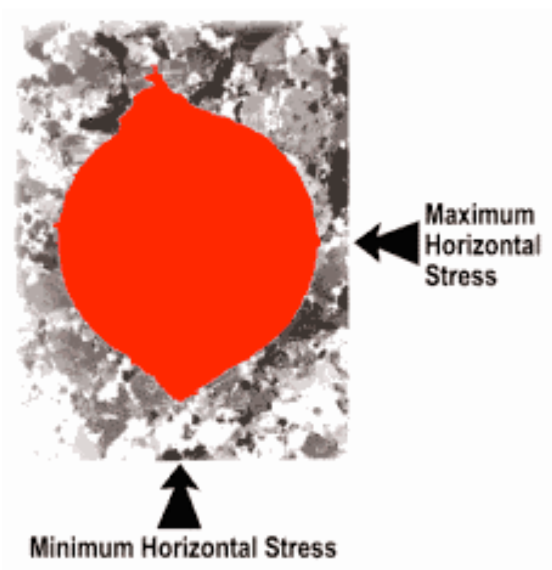
Hole 1256D

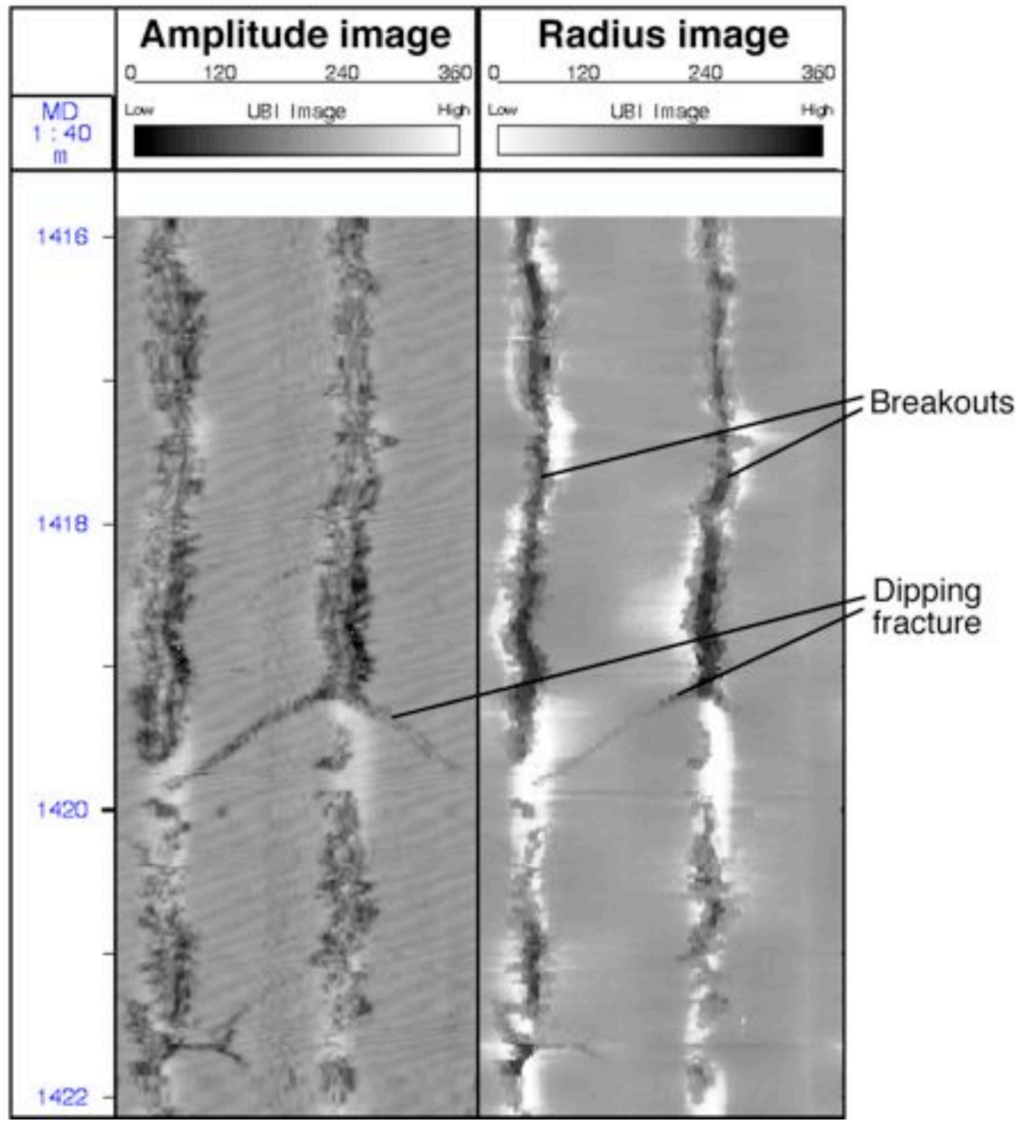
UBI and FMS comparison



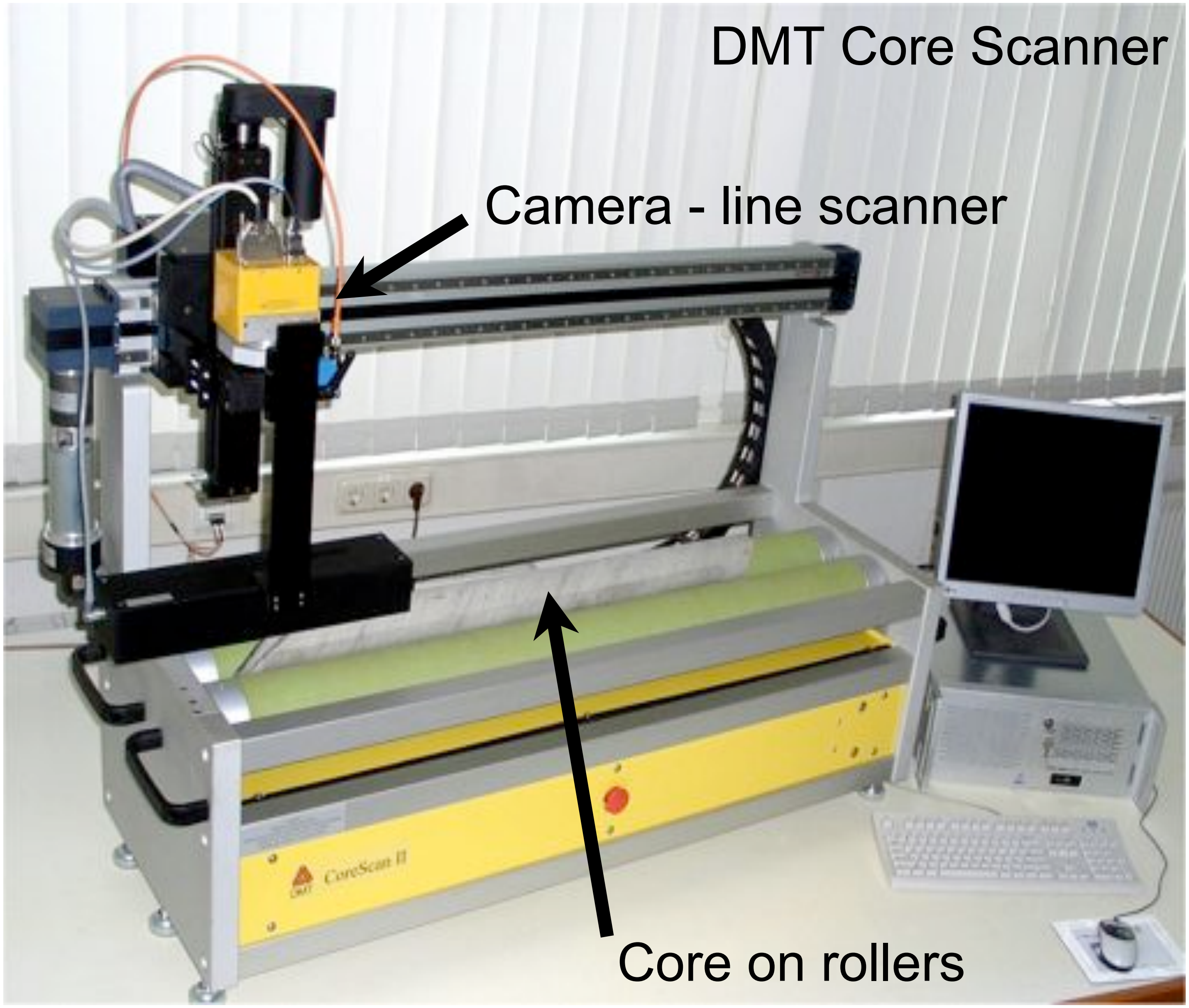
Borehole Breakouts

Mark the minimum stress direction

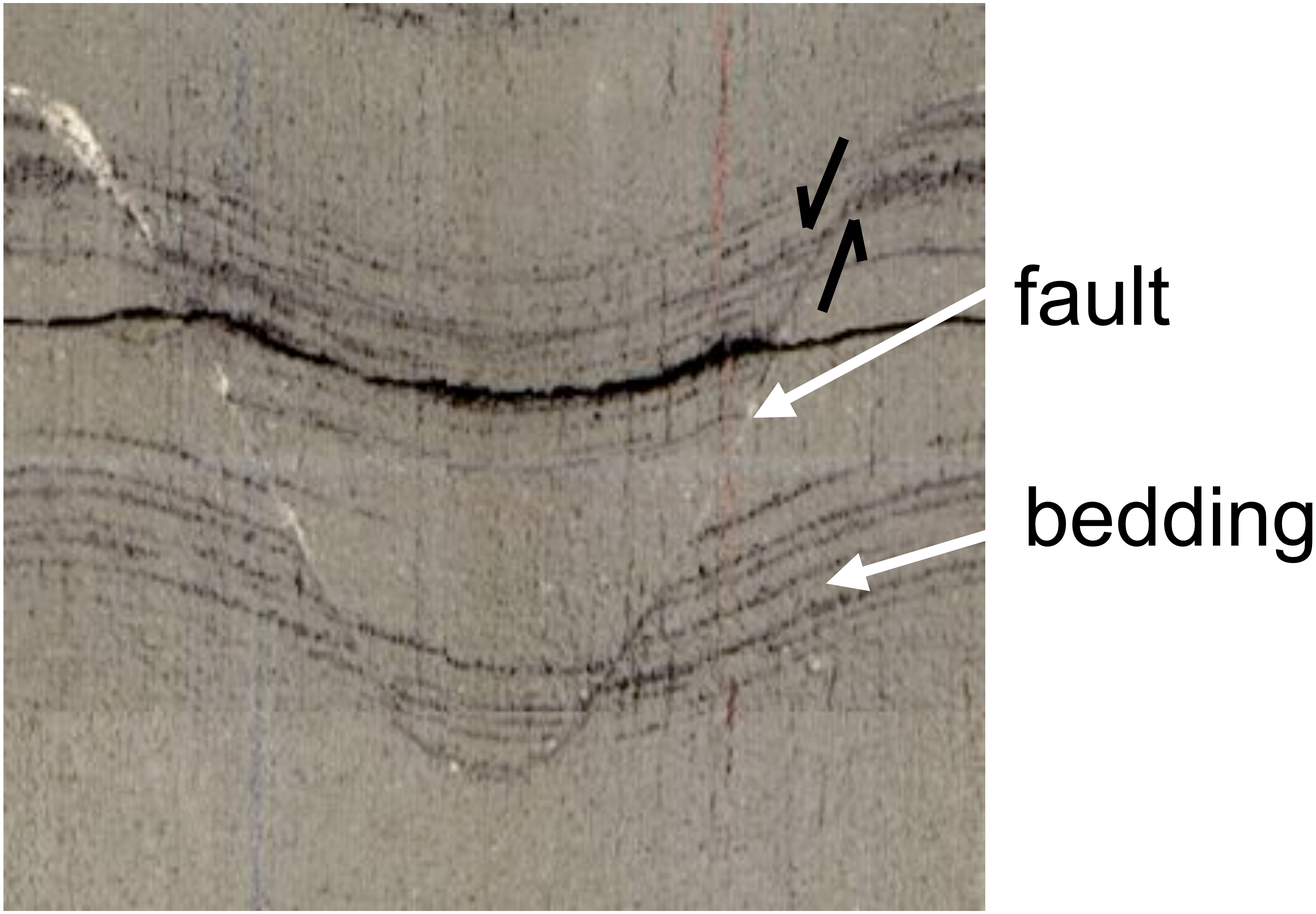




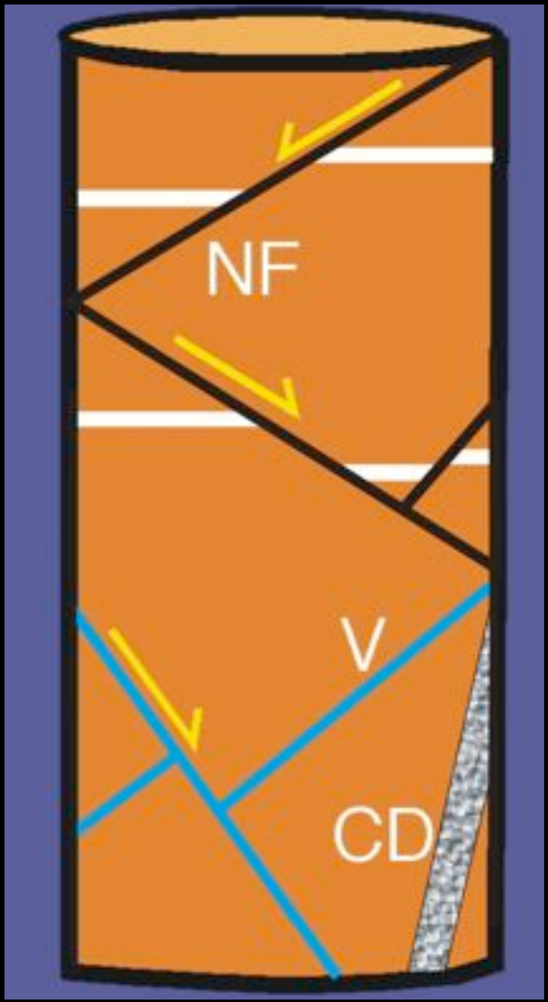
Core orientation



Bedding and fault dip

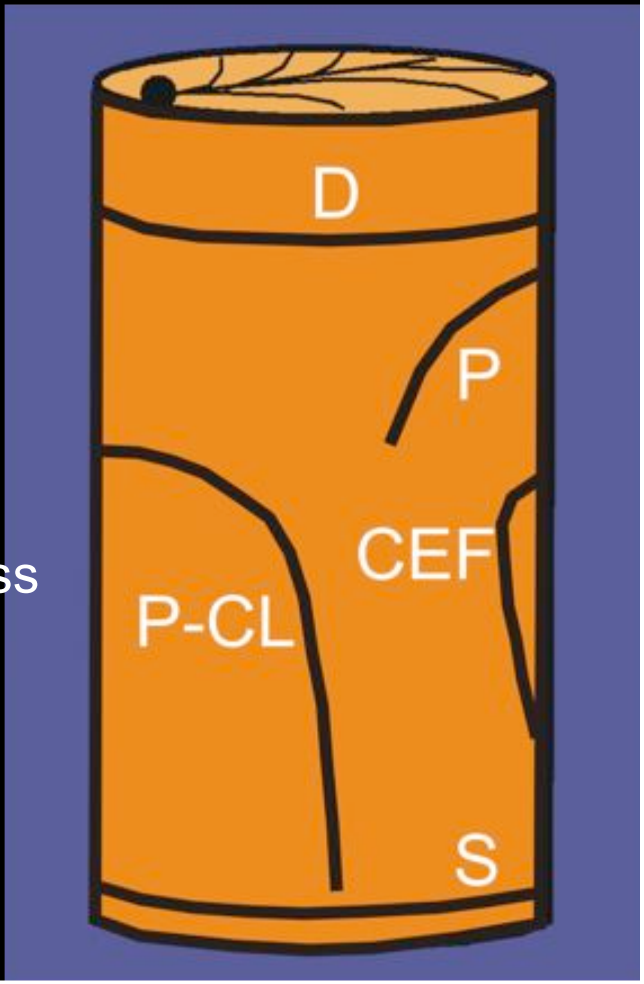


Natural and induced fractures



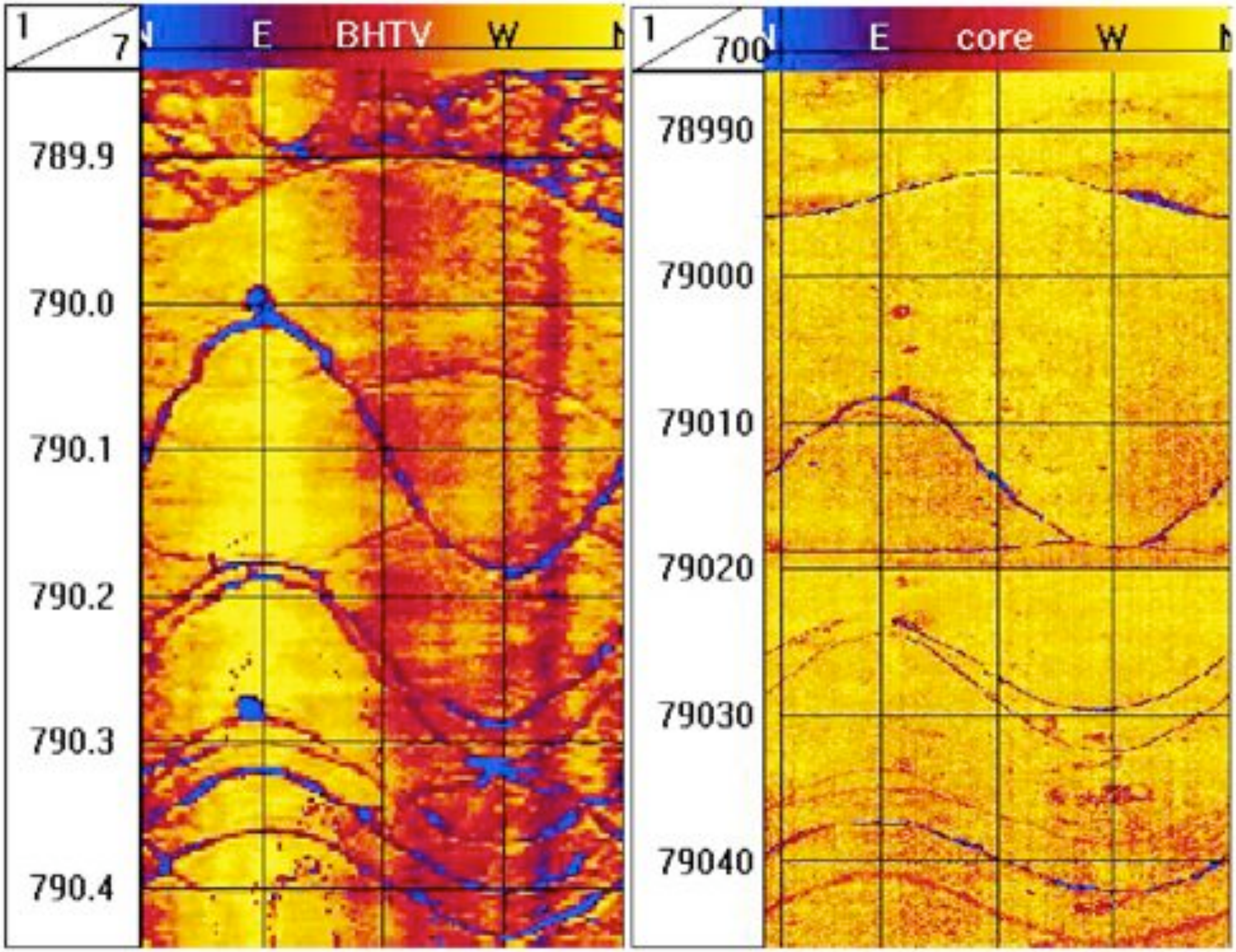
Natural
Fractures:
Past stress
conditions

Induced
Fractures:
Present stress
conditions



T. Wilson

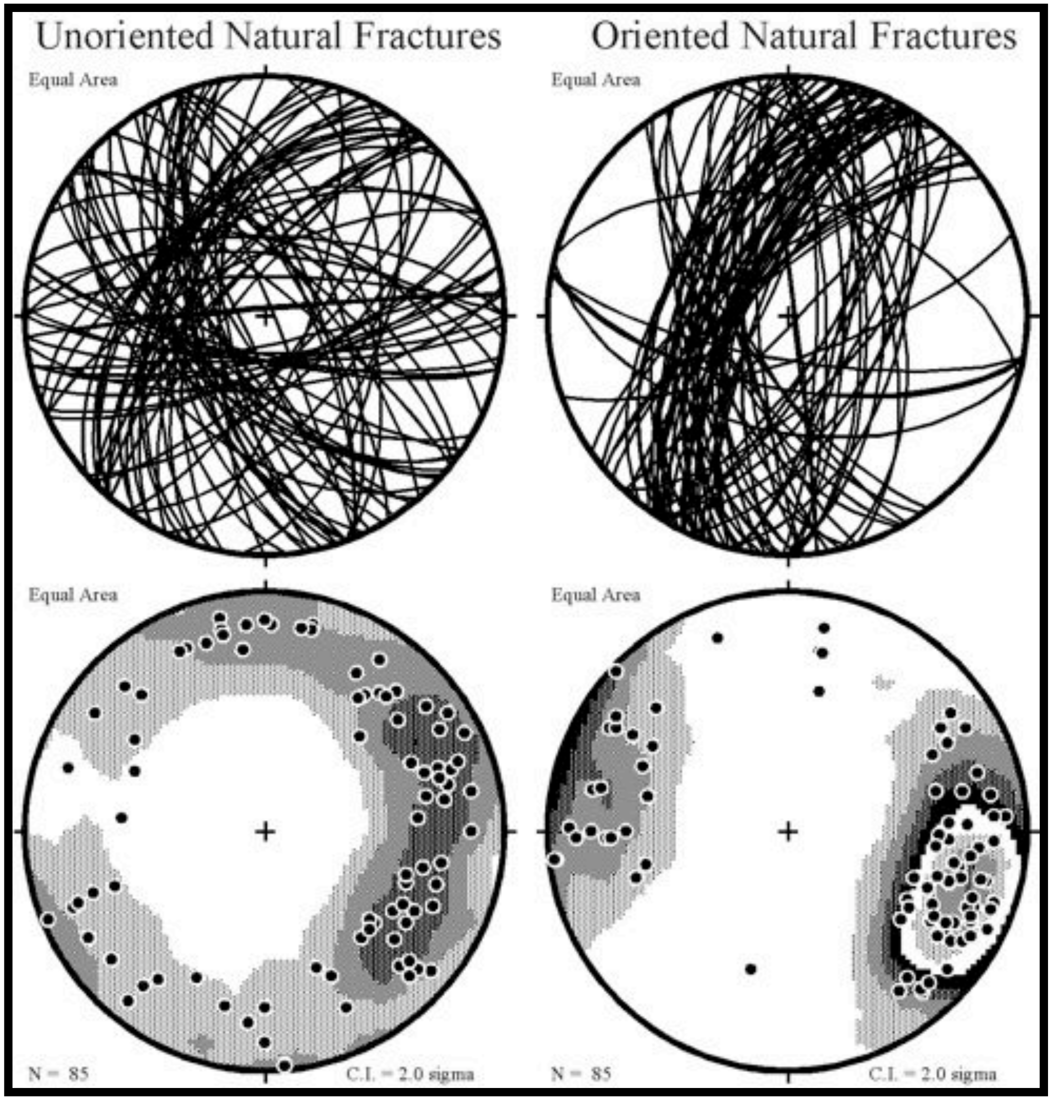
Core orientation using BHTV images



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

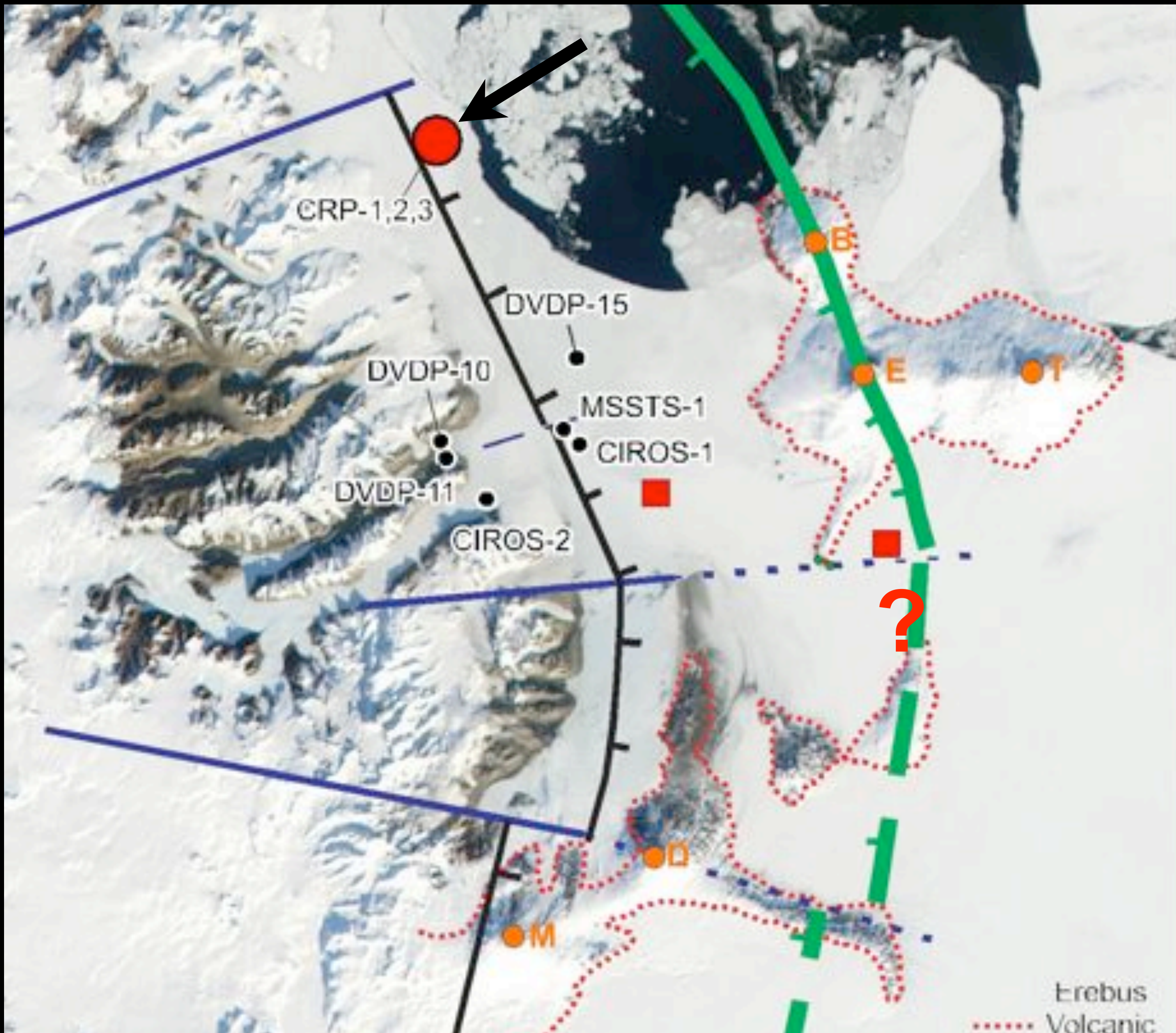
Fracture reorientation

core reference frame



geographic reference frame

Paulsen et al., 2002


CRP-1,2,3
DVDP-15
DVDP-10
MSSTS-1
CIROS-1
DVDP-11
CIROS-2
B
E
T
?
D
M
Erebus
Volcanic

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