Core Imaging - Short Course
Introduction – Why image cores?

Jules Reed
Lloyd’s Register
jules.reed@lr.org
Reasons for core imaging

- Reservoir Characterisation
  - Description, Lithology, Mineralogy, Flow units, Orientation, net pay
- Sample selection – sample heterogeneity
- Program design pitfalls – mineralogy and core prep
- Saturation determination (e.g. SS only viable method)
  - Local fluid saturations
  - Fluid dynamics
- Diagnostics (e.g. formation damage)
Introduction

- Core Photography (White light & UV)
  - High resolution photography
- Microscopy (thin section)
- Scanning Electron Microscopy (plus EDX, EDS)
- Infra-red spectroscopy
- X-ray fluorescence, x-ray diffraction
- Gamma / X-ray / CT
- Magnetic - NMR, MRI, magnetic susceptibility
Core Imaging – small sample to represent the whole
Core Photography

White Light

UV

Confirm lithology
Observe HC content (UV)
Differentiate pay zones
High res images (1990’s) allowed determination of grain and pore sizes
• Thin section

Point count

Legacy microscopy technique
Whilst TSA & XRD provide content volumes

SEM shows clay location and morphology

Discrete Kaolinite
Pore-bridging Illite
Pore lining Chlorite
Pore Filling Smectite
Import of clay location and morphology

- Discrete Clays
  - little effect on permeability

- Pore lining/bridging
  - reduce pore throat size
  - increase tortuosity
  - reduce permeability

- Clay morphology altered by cleaning/drying
Mineral mapping – drill cuttings

Courtesy QEM-scan
Mineral mapping – whole core

1ft

False Colour IR Image  Chlorite %  Mica % (Phengite)  Liquid Oil  Oil Composition  OH Index

Courtesy Spectra-map
Multi-image tools

Gamma Density (g/cc)
P-wave Velocity (m/s)
Magnetic Susceptibility (SI^2, S)
Electrical Resistivity (Ohm.m)
RGB Colour (0-255)
Core Image

Depth (m)

Gammas
P-wave Velocity
Magnetic Susceptibility
Electrical Resistivity
RGB Colour
Core Image

Courtesy Geotek Ltd
Combining & correlating to well logs

Courtesy Techlog
Reasons for core imaging

- Reservoir Characterisation
  - Description, Lithology, Mineralogy, Flow units, Orientation, net pay
- Sample selection – sample heterogeneity
- Program design pitfalls – mineralogy and core prep
- Saturation determination (e.g. SS only viable method)
  - Local fluid saturations
  - Fluid dynamics
- Diagnostics (e.g. formation damage)
CT scan – damage evaluation

- Essential to understand potential core damage to assess sample selection and evaluate core analysis results
- Limited resolution

Chevron implies transit/handling damage

Gas Expansion

Shock Damage

Longitudinal Fracturing

Shearing during coring
CT scanning – selection/evaluation tool

- To observe visually difficult lithological features
- To observe features before removing core from preservation
CT scanning – selection/evaluation tool – Whole Core
CT scanning – selection/evaluation tool – Core Plugs
Reasons for core imaging

- Reservoir Characterisation
  - Description, Lithology, Mineralogy, Flow units, Orientation, net pay
- Sample selection – sample heterogeneity
- Program design pitfalls – mineralogy and core prep
- Saturation determination (e.g. SS only viable method)
  - Local fluid saturations
  - Fluid dynamics
- Diagnostics (e.g. formation damage)
Mineralogy – to aid sample prep / test design

- Excess temperatures/evaporative cycles (hot Soxhlet)
  - Dehydrate/collapse smectite, illite, chlorite
- Methanol can weaken hydroxyl groups between clay layers (particularly kaolinite)
  - High rate flush cleaning
    - fines movement (kaolinite, chlorite & illite)
- Chamosite ($\text{Fe}^{2+}$-rich chlorite) is oil wet
Reasons for core imaging

- Reservoir Characterisation
  - Description, Lithology, Mineralogy, Flow units, Orientation, net pay
- Sample selection – sample heterogeneity
- Program design pitfalls – mineralogy and core prep
- Saturation determination (e.g. for SS, ISSM only viable method)
  - Local fluid saturations
  - Fluid dynamics
- Diagnostics (e.g. formation damage)
Saturation and other measurements

- Geomechanics properties
- In-situ saturation measurement (ISSM)
- Fluid flow
Reasons for core imaging

- Reservoir Characterisation
  - Description, Lithology, Mineralogy, Flow units, Orientation, net pay
- Sample selection – sample heterogeneity
- Program design pitfalls – mineralogy and core prep
- Saturation determination (e.g. SS only viable method)
  - Local fluid saturations
  - Fluid dynamics
- Diagnostics (e.g. formation damage)
Formation damage diagnostics

SEM, in particular, can be used to assess cause of formation damage