Core Image Property Logging
for rock typing and core-to-log upscaling purposes

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Caprocks JIP Objective: “To integrate seismic, petrophysical, rock mechanical and geochemical data to produce methodologies with which to (a) quantify seal risk and (b) define the rates, mechanisms and pathways by which petroleum migrates vertically through kilometre-scale sequences of fine-grained sediments.”
Introduction

Nile Delta case study, offshore Egypt
Pliocene slope channels + overbank
Hemipelagites, turbidites, debris flows etc.
Analyzed 650 m core in 4 priority wells

Objective
Obtain grain size logs from core images

Motivation
Support rock typing...and caprock flow models
Integrated Rock Typing Approach

Core domain

Borehole domain

3D seismic domain

Rock typing

Integration

Electrofacies

Core

Information

Zones?

Output

Zones?!

Well logs

Formation

Conventional channel reservoir

Geology
Integrated Rock Typing Approach

Core domain

Rock typing

Validation

Pore System

Grain Matrix

0.7 m

Core

Geology

Zones?

Petrophysics

Pixel logs

Zones!

Output

Integration

Zones?! Borehole domain

Electrofacies

Well logs

Formation
Rationale

Grain sizes from photographs?

Pixels in greyscale: 0 (black) to 255 (white)
Ideal clay (<2µm): dark + uniform shading
Ideal sand (>63µm): light + grain shadows
... how about silt (2–63 µm)?

Statistical parameters from pixel rows

Working hypothesis: horizontal bedding
Preprocessing: non-rock → white (255)
Generate parameter logs per row

Arithmetic average
Mode and median
Variance

Brightness logs
Coarseness logs
Grain size analysis of core plugs

Sampling and processing

Plugs taken after core slabbing, sampling bias on clay-rich strata
Sample preparation: gentle saturation-freeze-thaw cycles
Laser Particle Size Analyses
Model Calibration Workflow

Iterative approach

- Use of data from single (reference) borehole
- Set sample depth offset
- Set resolution of pixel curves
- Regression of clay & sand

Regression

\[
\text{Clay} \, [\%] = 140 + 6.83\cdot CI_{\text{ave}} - 7.75\cdot CI_{\text{med}} - 0.242\cdot CI_{\text{var}} \quad | \quad R^2 = 0.95
\]

\[
\text{Sand} \, [\%] = -8 - 0.796\cdot \exp(\frac{CI_{\text{ave}}}{20}) + 0.918\cdot \exp(\frac{CI_{\text{med}}}{20}) + 0.0675\cdot CI_{\text{var}} \quad | \quad R^2 = 0.99
\]
Image Log Harmonization Workflow

Compensation for differential core handling prior photography

Moisture-related issues
Image duplication issues

Well B20?
Image Log Harmonization Workflow

Normalization and model limitations
Sampling bias: ≤ 20% sand grain size
Dark sandstone anomalies suspected (B19)
Commonly unimodal sandstone brightness
Results

Mudrock facies processing
Rock type QC via ternary grain size diagrams
ANN electrofacies recognition
Facies-based flow modeling
Conclusions

Grain size logs from core images
- Robust empirical formulae for clay and sand modeling
- Linear function for moisture normalization
- Applications for mudrock characterization
  - Sampling bias, dark sandstone issues

Fit-for-purpose core handling required
- Post-slabbing plug samples required, reduce sampling bias
- Control plug depth & core moisture
- Avoid digital core image duplication (‘stitching’)

Applications & Outlook
- Method supports rock typing in mud-rich sediments
- Thin-bed analysis (net reservoir, frequency content)
- Seal risk analysis (e.g. silt content), flow model applications
- Bedding angle & (2D) object recognition, RGB processing...