Borehole Image Textural Analysis and Integrated Petrophysics - Applications in Delaware and Midland Basins*

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Search and Discovery Article #41465 (2014)**
Posted October 27, 2014

*Adapted from oral presentation given at the Geoscience Technology Workshop, Permian and Midland Basin New Technologies, Houston, Texas, September 4-5, 2014

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Abstract

The borehole image provides high-resolution circumferential resistivity image data that can bed used to describe surface area conductivity and from that derive distributions of pore throat, permeability and porosity. This paper presents some of the approach that can be used to derive this information with-in the Carbonate sequence of these basins and presents a couple of examples showing how the information can help target fracture zones.

Reference Cited

Glover, P.W.J., I.I. Zadjali, and K.A. Frew, 2006, Permeability prediction from MICP and NMR data using an electrokinetic approach: Geophysics, v. 71/4, p. F49-F60.

HARVEY ROCK PHYSICS

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Principal

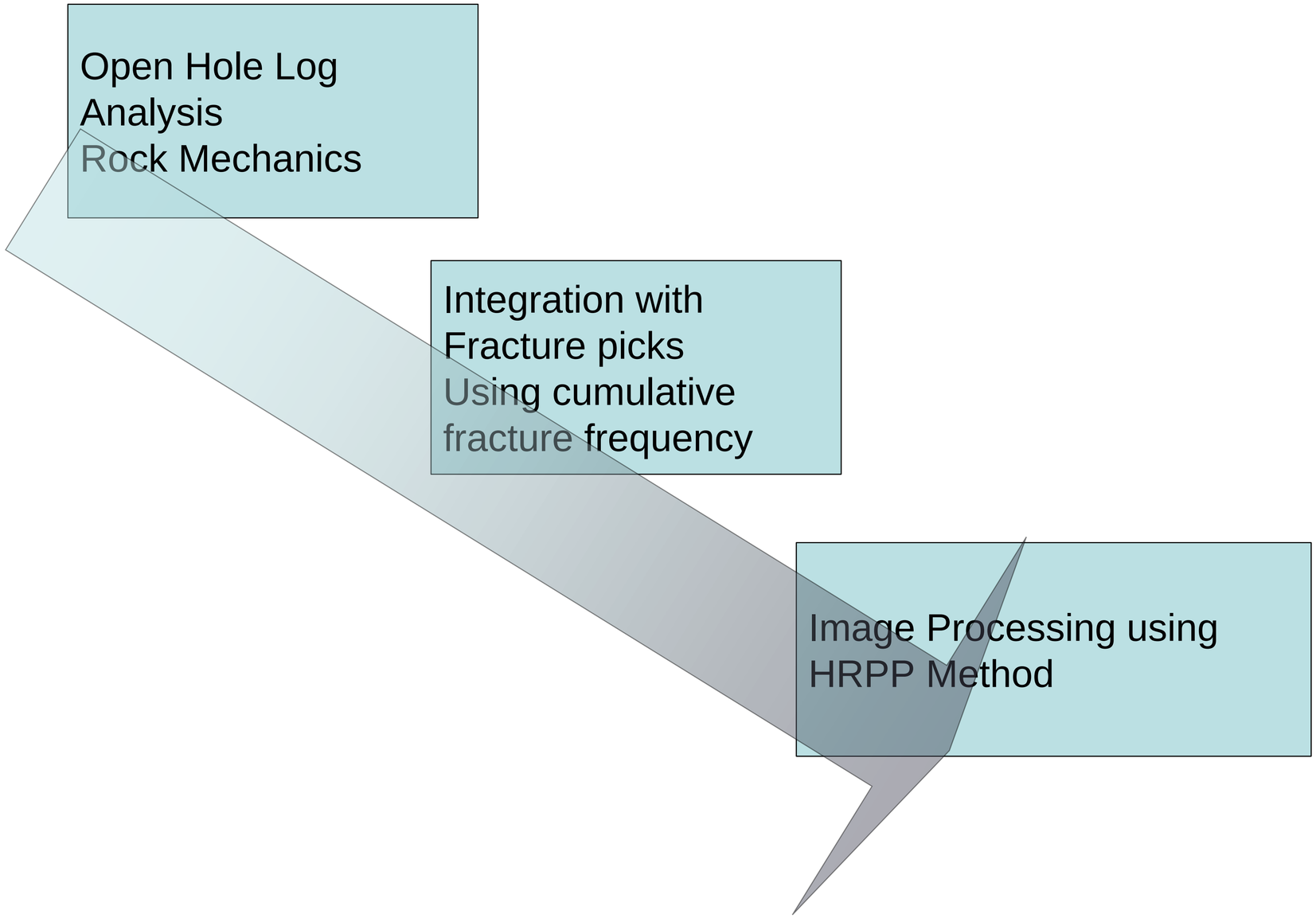
Motivation

- Objective
  - Utilise the integrated HRPP approach to identify potential intervals for completion using completion technology

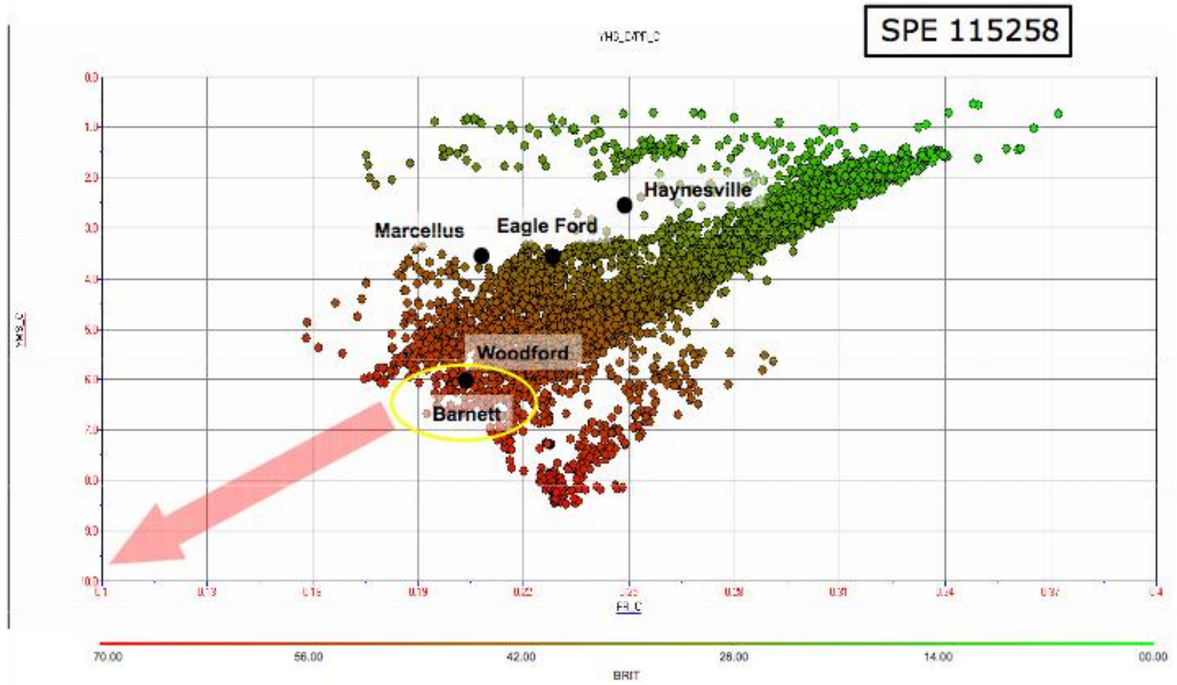
- Methodology
  - Integrate Fracture Picking
  - Rock Mechanics Analysis
  - HRPP Pore throat analysis

- Conclusions
  - Fracture picking to create pseudo-fractures
  - Rock Mechanics Analysis to identify brittleness
  - Porethroat analysis to identify favourable intervals

Workflow

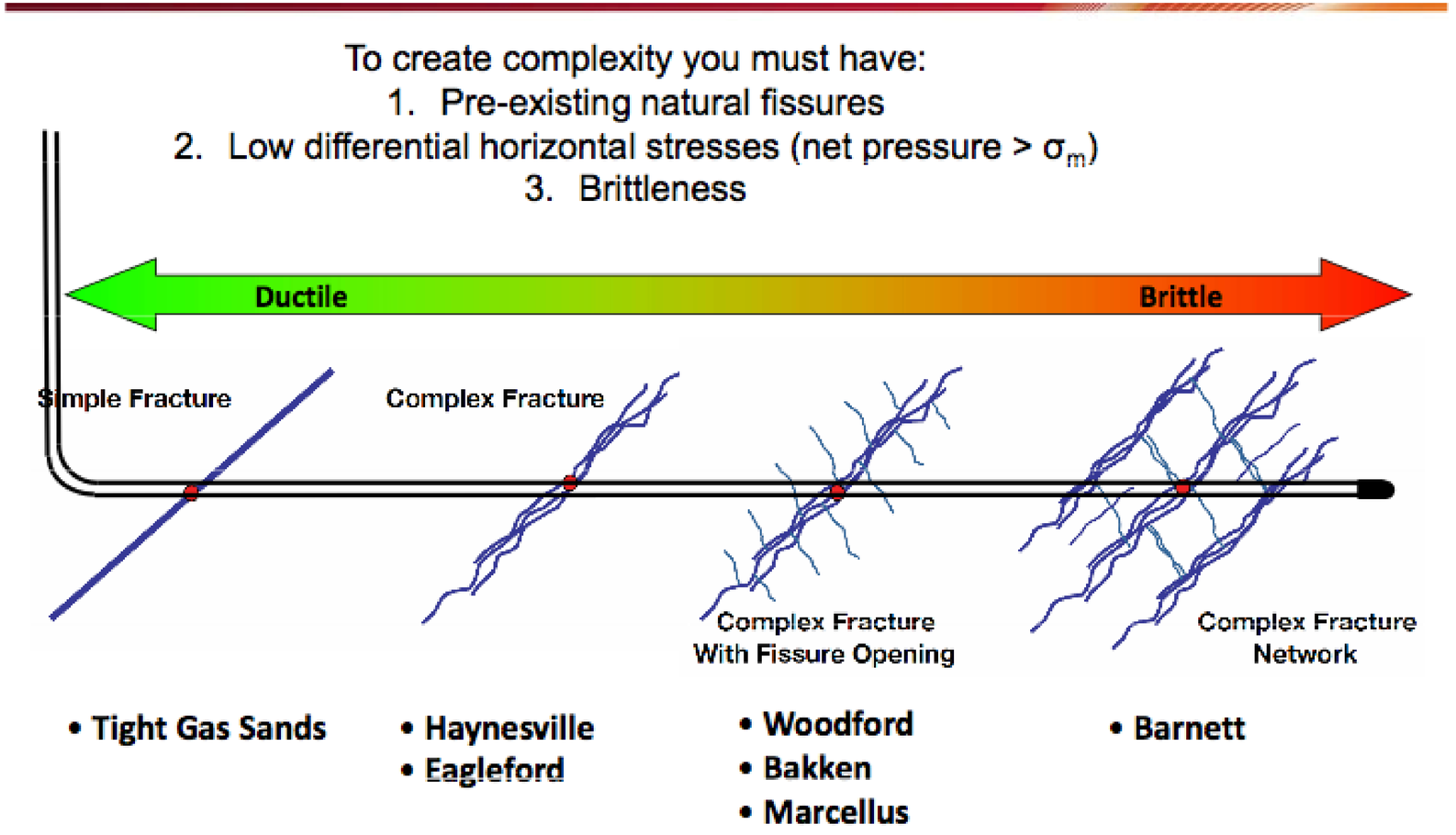

Open Hole Log
Analysis
Rock Mechanics
Integration with
Fracture picks
Using cumulative
fracture frequency
Image Processing using
HRPP Method

Brittleness



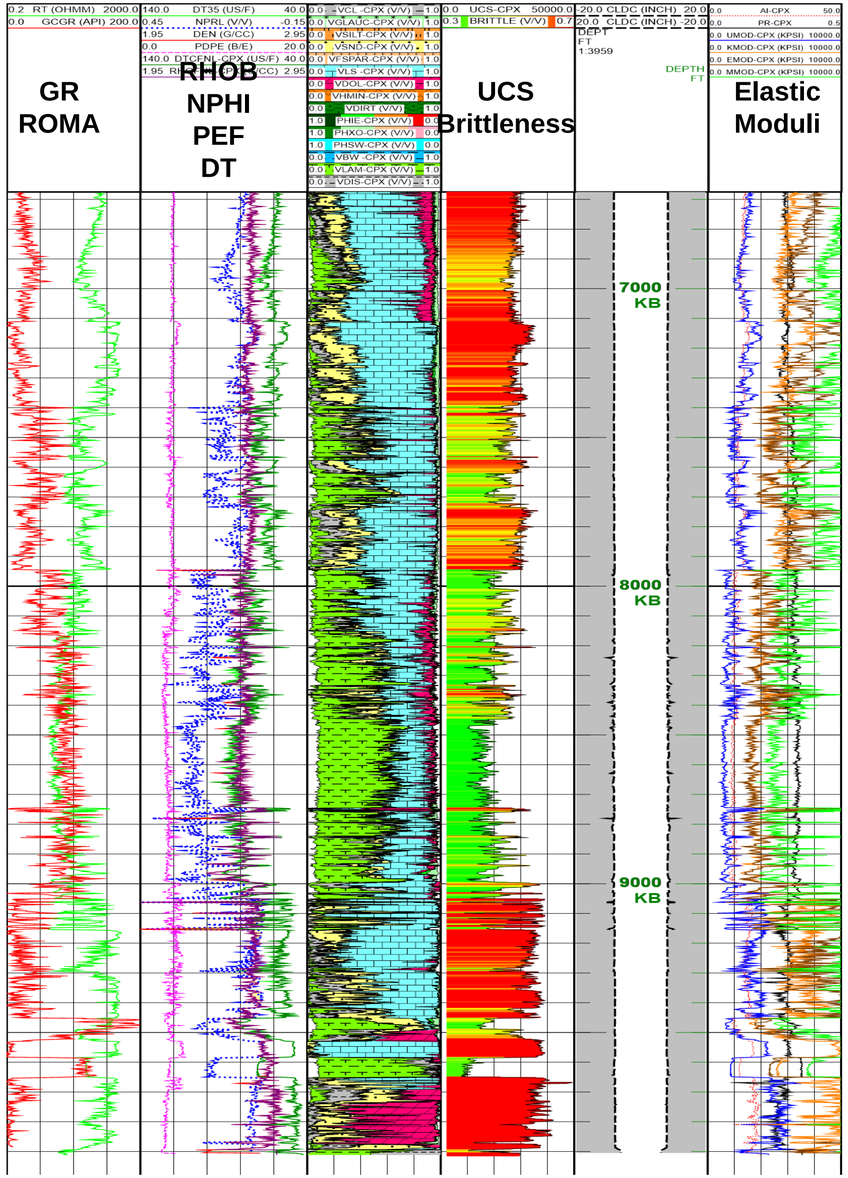
Applying brittleness one can estimate the type of fracture system.
By combining with the grain size and pore throat work intervals where the fractures will access more of the pore structure can be identified.

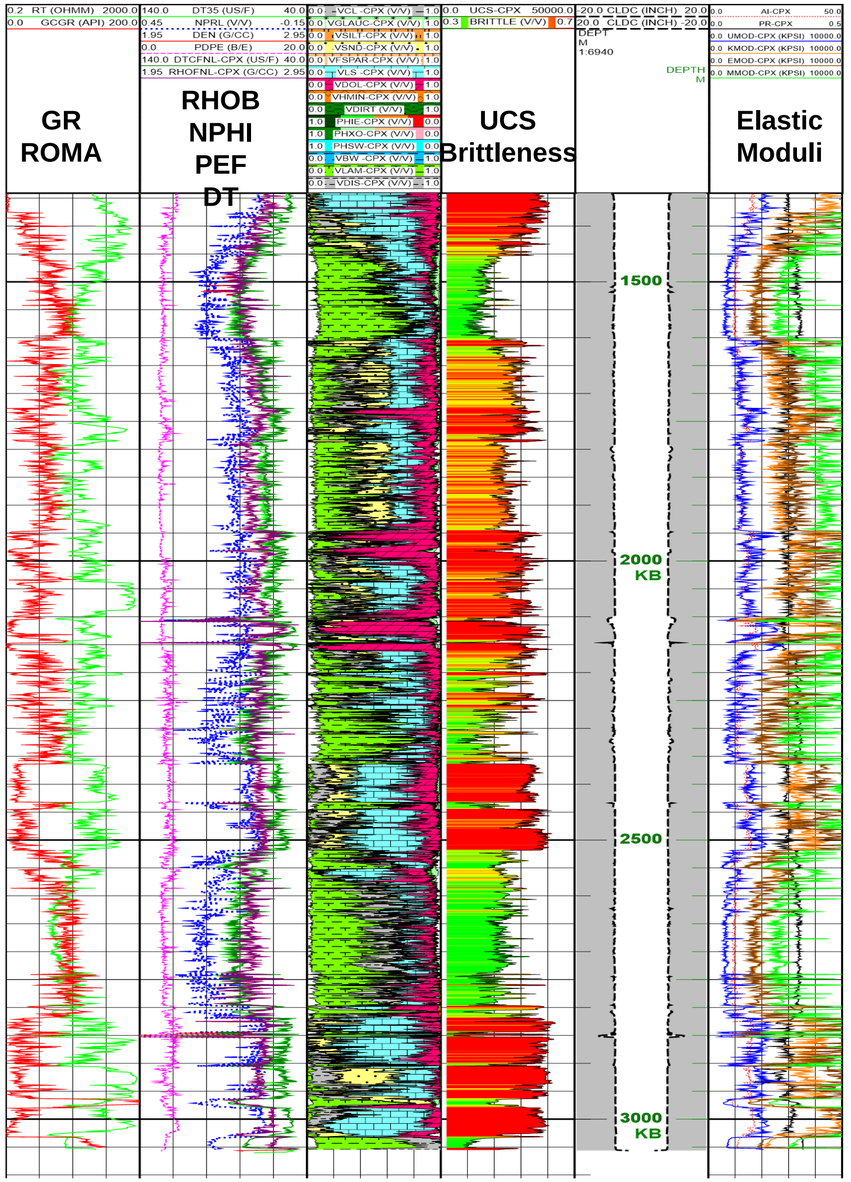
Brittleness



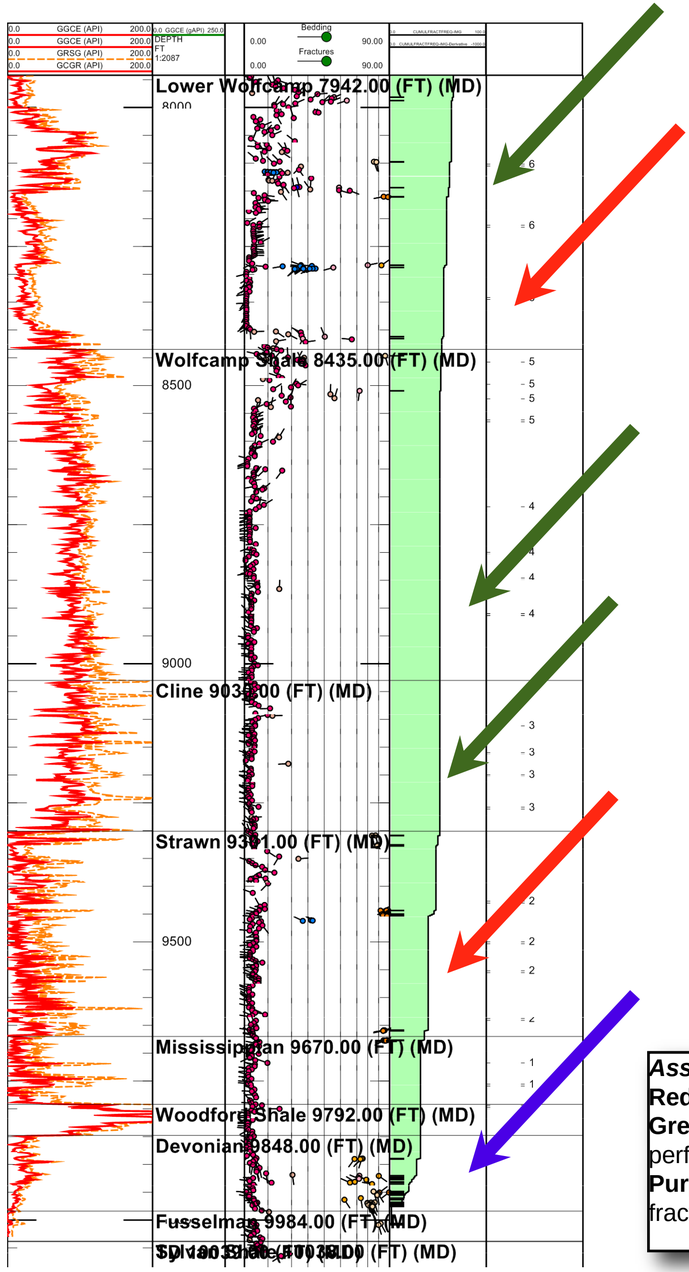
Presenter's notes: Applying brittleness one can estimate the type of fracture system. By combining with the grain size and pore throat work, intervals where the fractures will access more of the pore structure can be identified.

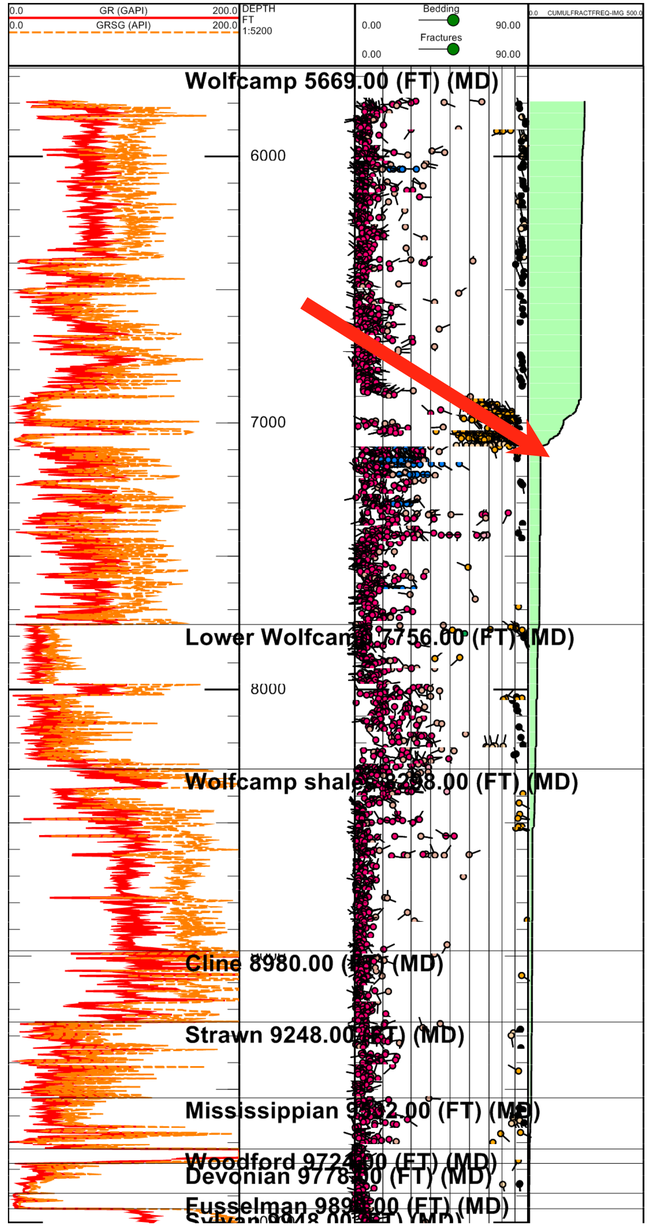
Examples


GR
ROMA
RHOB
NPHI
PEF
DT
UCS
Brittleness
Elastic
Moduli
7000
KB
8000
KB
9000
KB


GR
ROMA
RHOB
NPHI
PEF
DT
UCS
Brittleness
Elastic
Moduli
1500
2000
KB
2500
3000
KB

Fractures to represent production zones

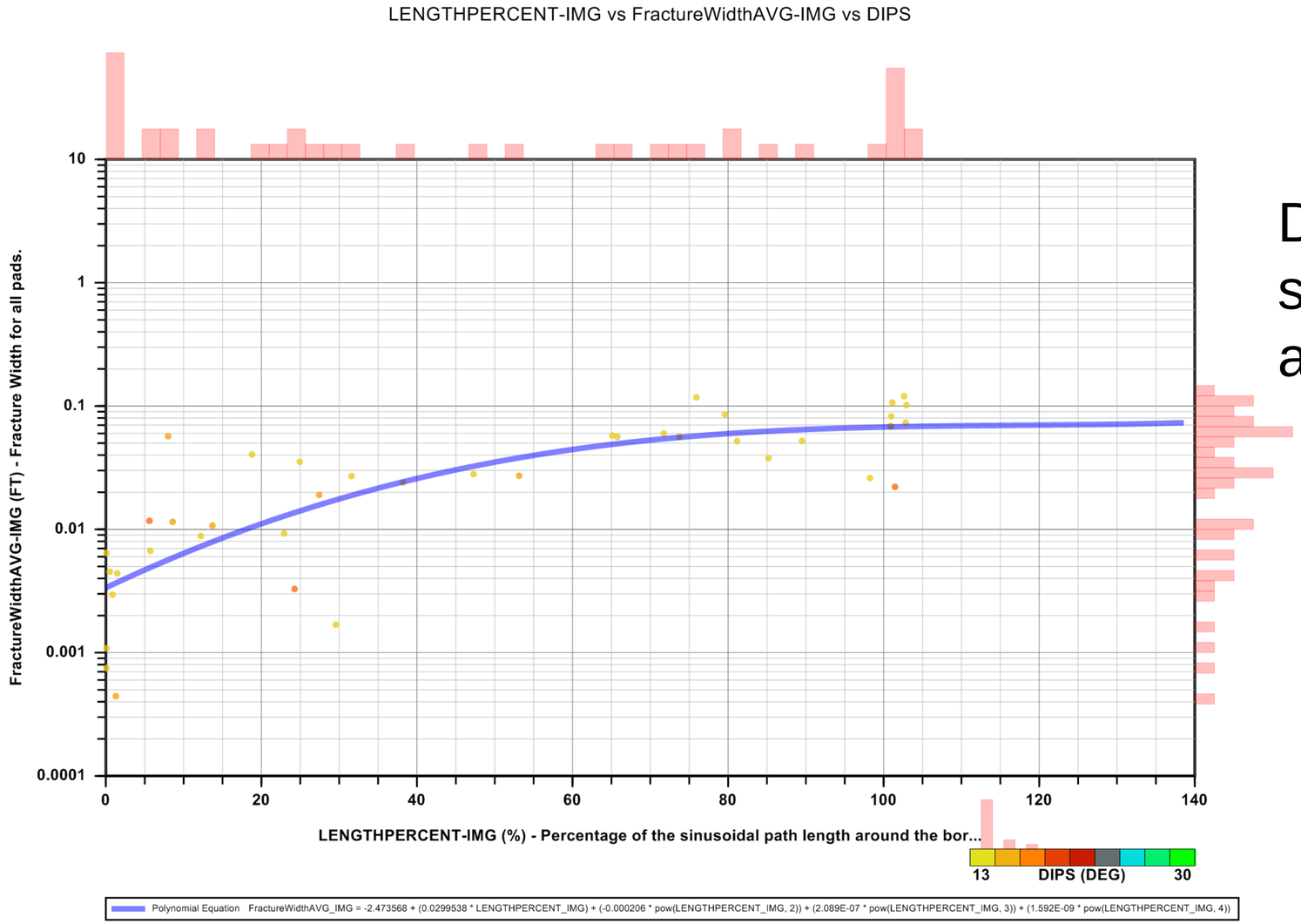




Association - Fractures/Perforations
Red - Fractures approximate perforations
Green - No fractures associated with perforations
Purple - No Perforations with interpreted fractures

Fracture Width and circumferential length

- Fracture Width versus Circumferential Length as %



Determine cross sectional fracture area

Theory of measurement

- Bruggeman-Hanai-Sen (BHS) equation

$$\frac{\sigma - \sigma_m}{\sigma_f - \sigma_m}\left(\frac{\sigma_f}{\sigma}\right)^D = \phi,$$

ø is the interconnected porosity
σ is conductivity of rock
Subscript m is conductivity of grains
Subscript f is conductivity of pore fluid
D is polarization factor.

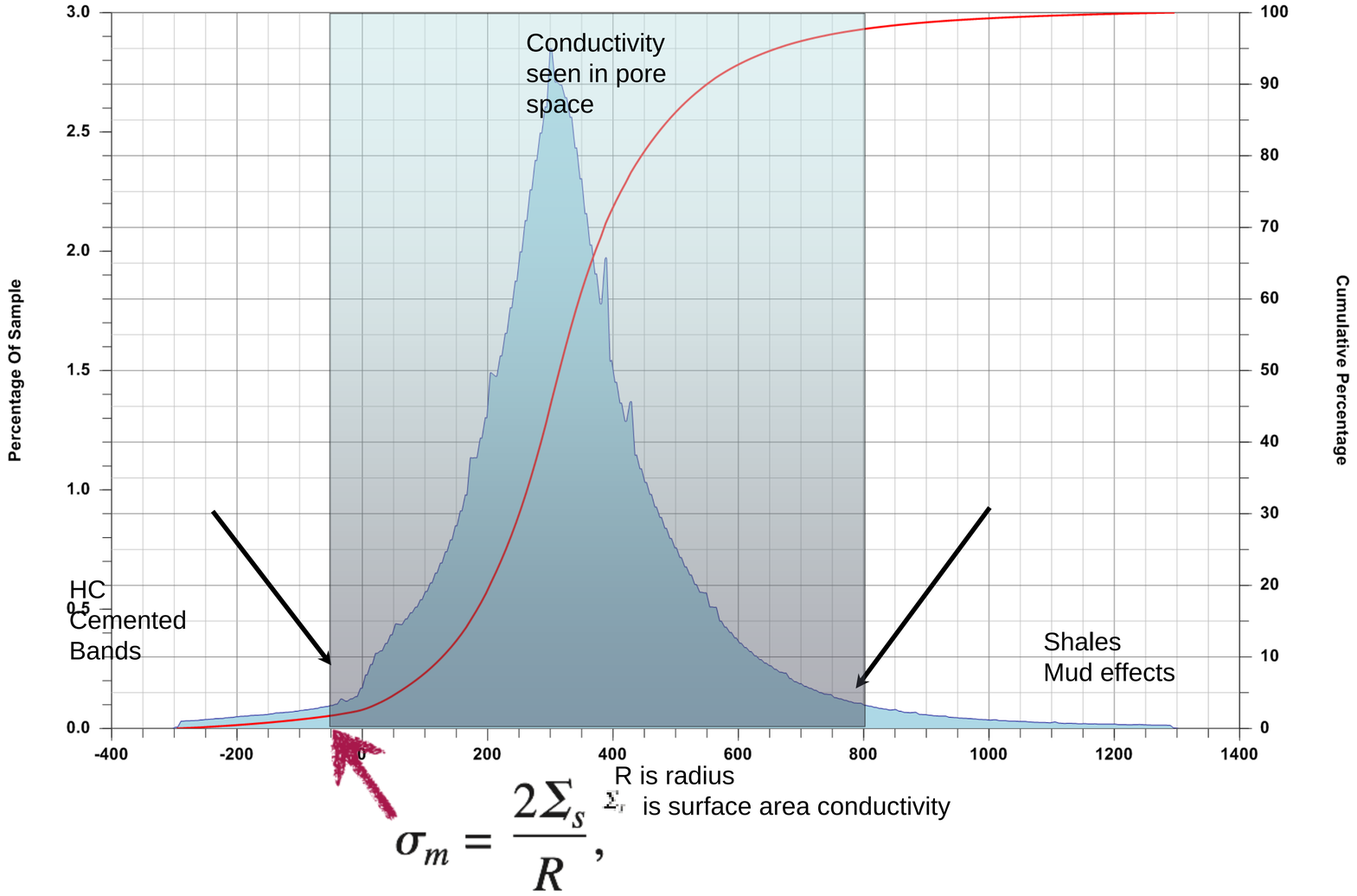
- Conductivity is sum of surface conductivity divided by the radius

$$\sigma_m = \frac{2\Sigma_s}{R},$$

R is radius
Σ_s is surface area conductivity

Permeability prediction from MICP and NMR data using an electrokinetic approach, Glover et al, GEOPHYSICS, VOL. 71, NO. 4 JULY-AUGUST 2006; P. F49–F60, 6 FIGS., 2 TABLES. 10.1190/1.2216930

Applying Measurement



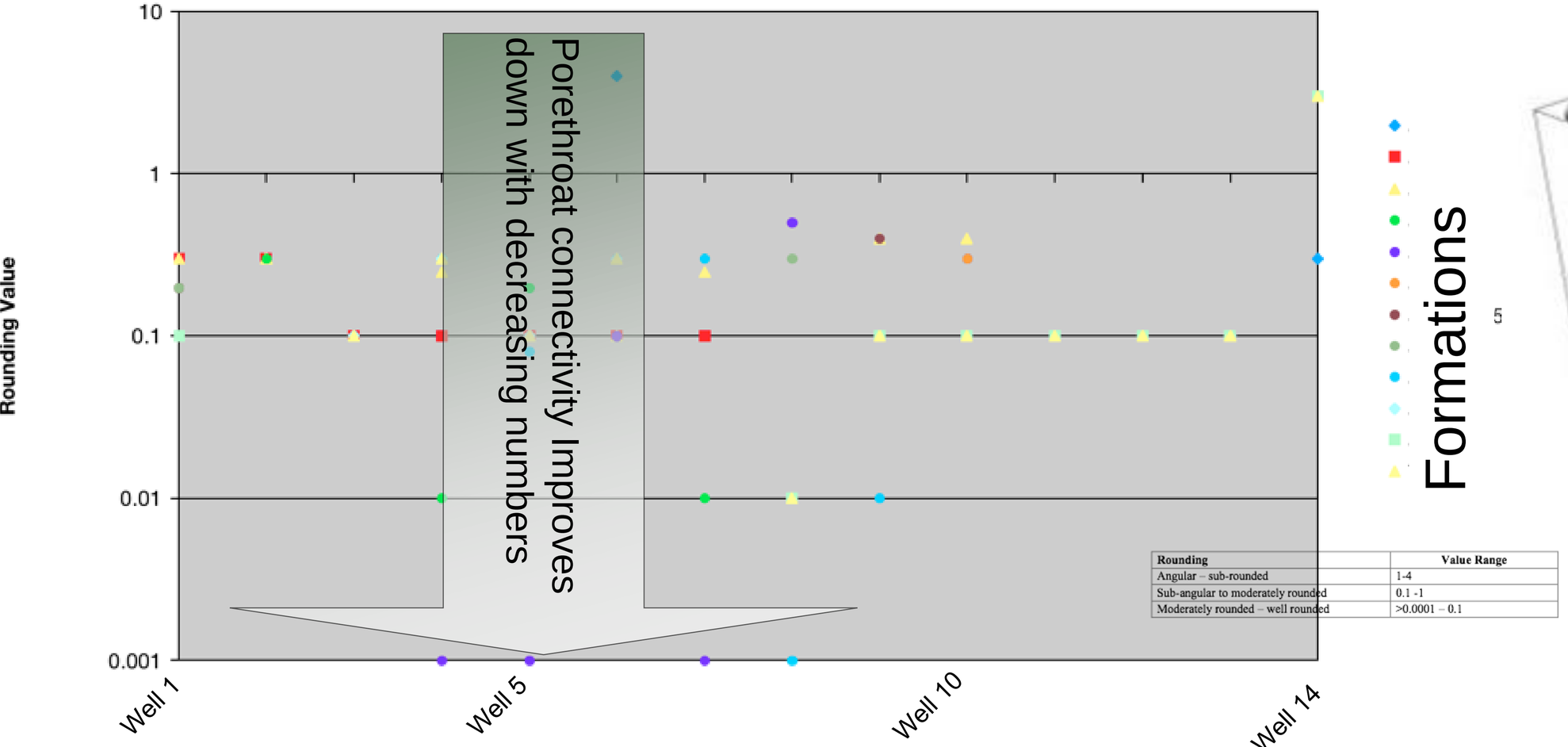
R is radius

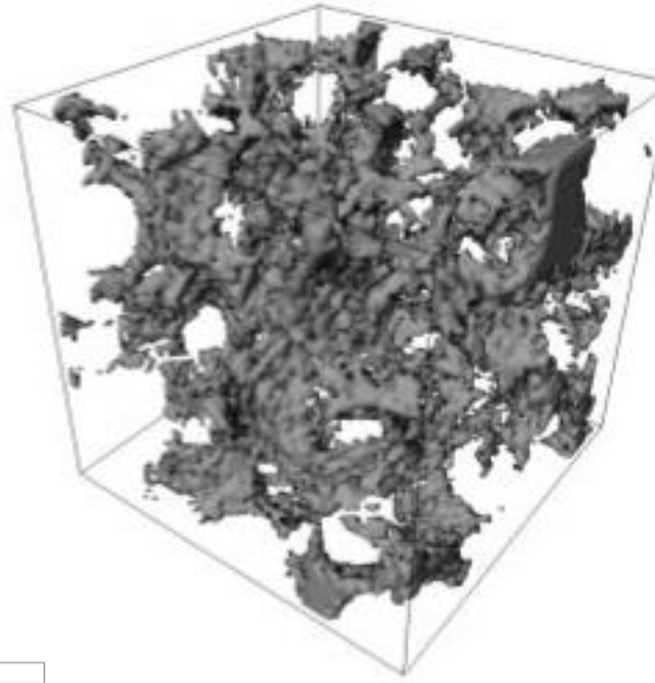
Σ_s is surface area conductivity

$$\sigma_m = \frac{2\Sigma_s}{R},$$

- σ_m represents the conductivity of the grains
- The upper bound represents conductivity of the shales.
- σ_f which represents fluid is a significantly higher value

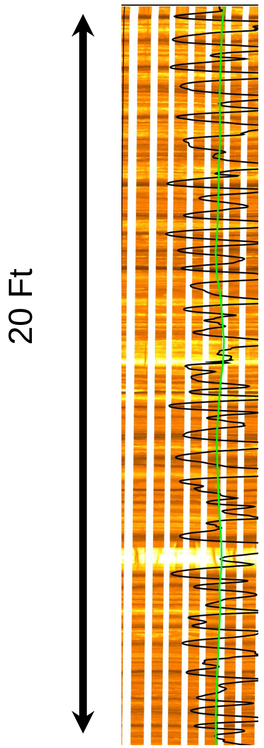
Tortuosity Parameters



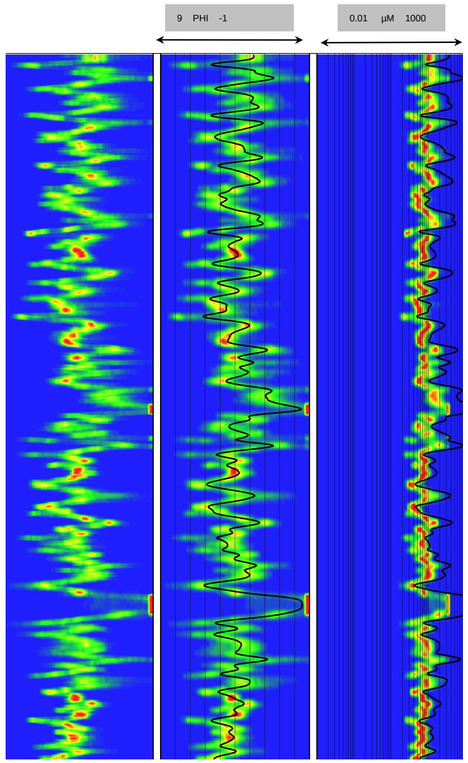


The formations are represented by different colours and show the Tortuosity parameter for each formation in a number of wells.

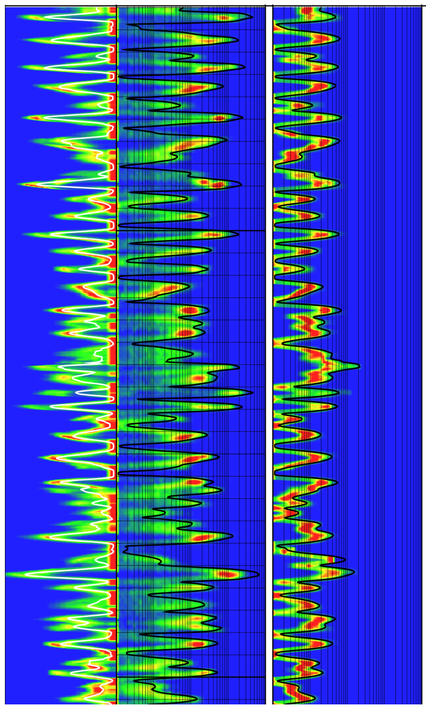
Surface Area
reduce to just surface area map and volumetrics



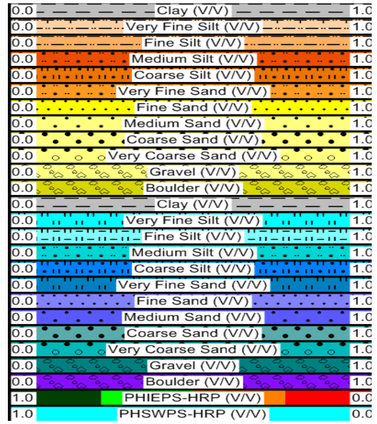
Static Image

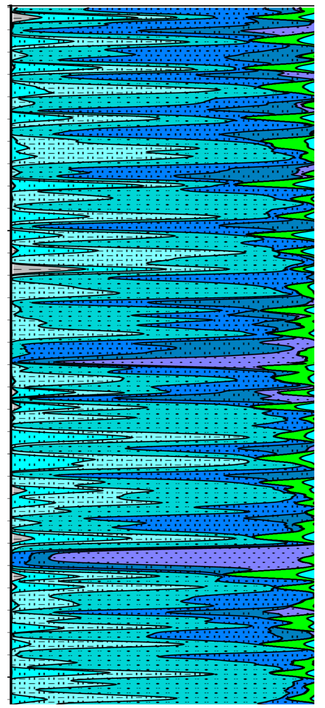


Surface Area Map



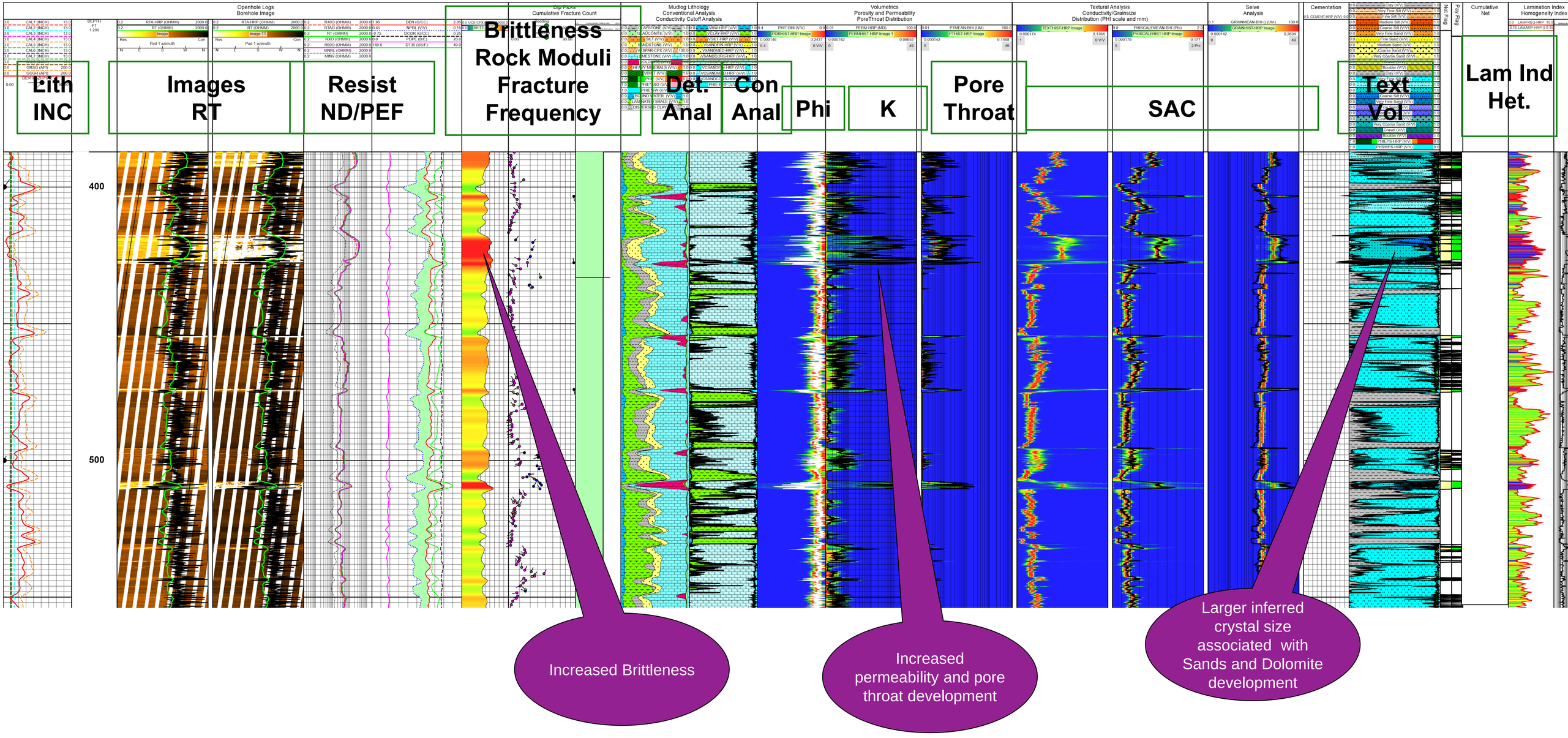
Porosity
Permeability
Porethroat



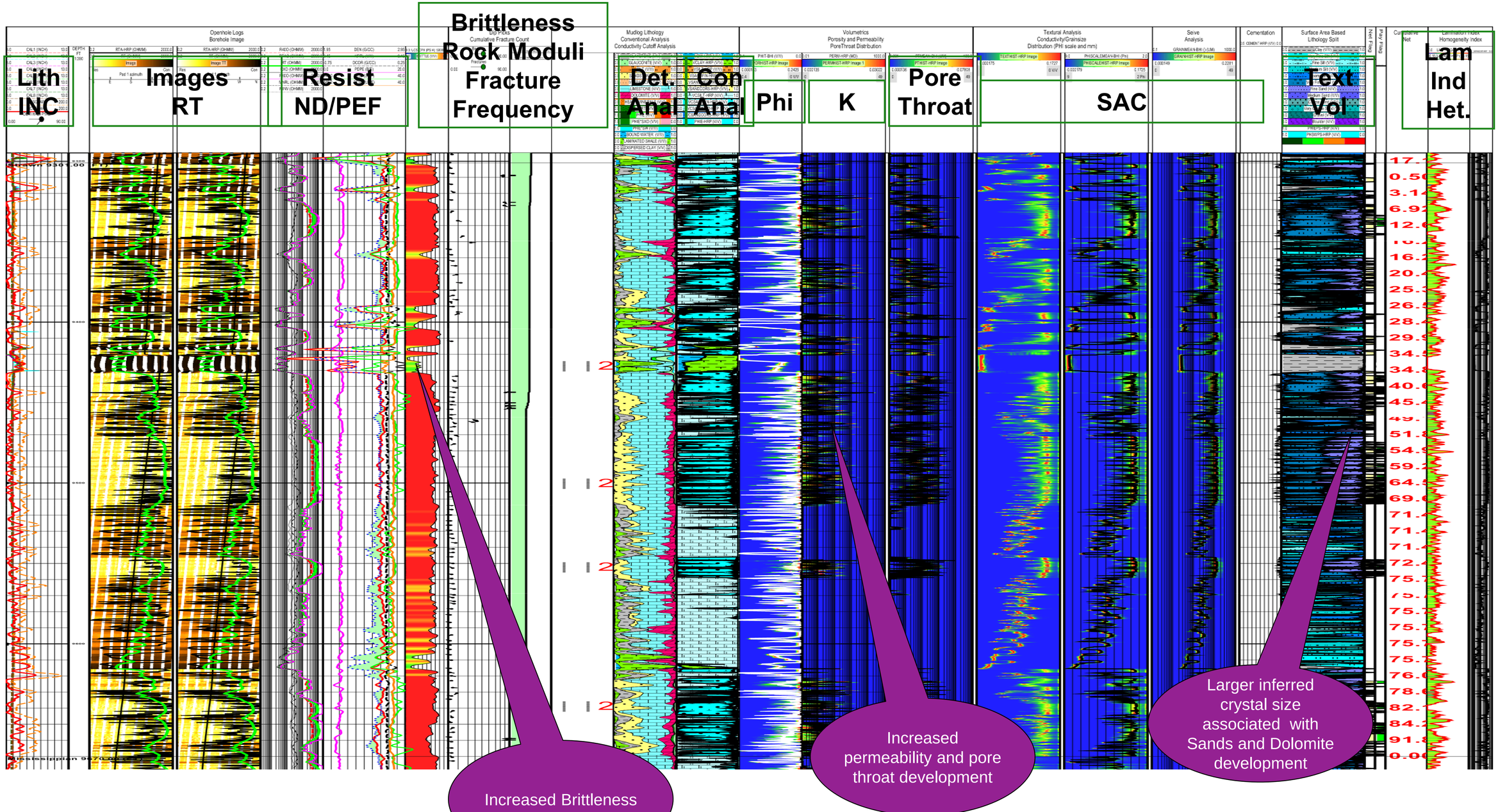


Phi Scale Volumetrics

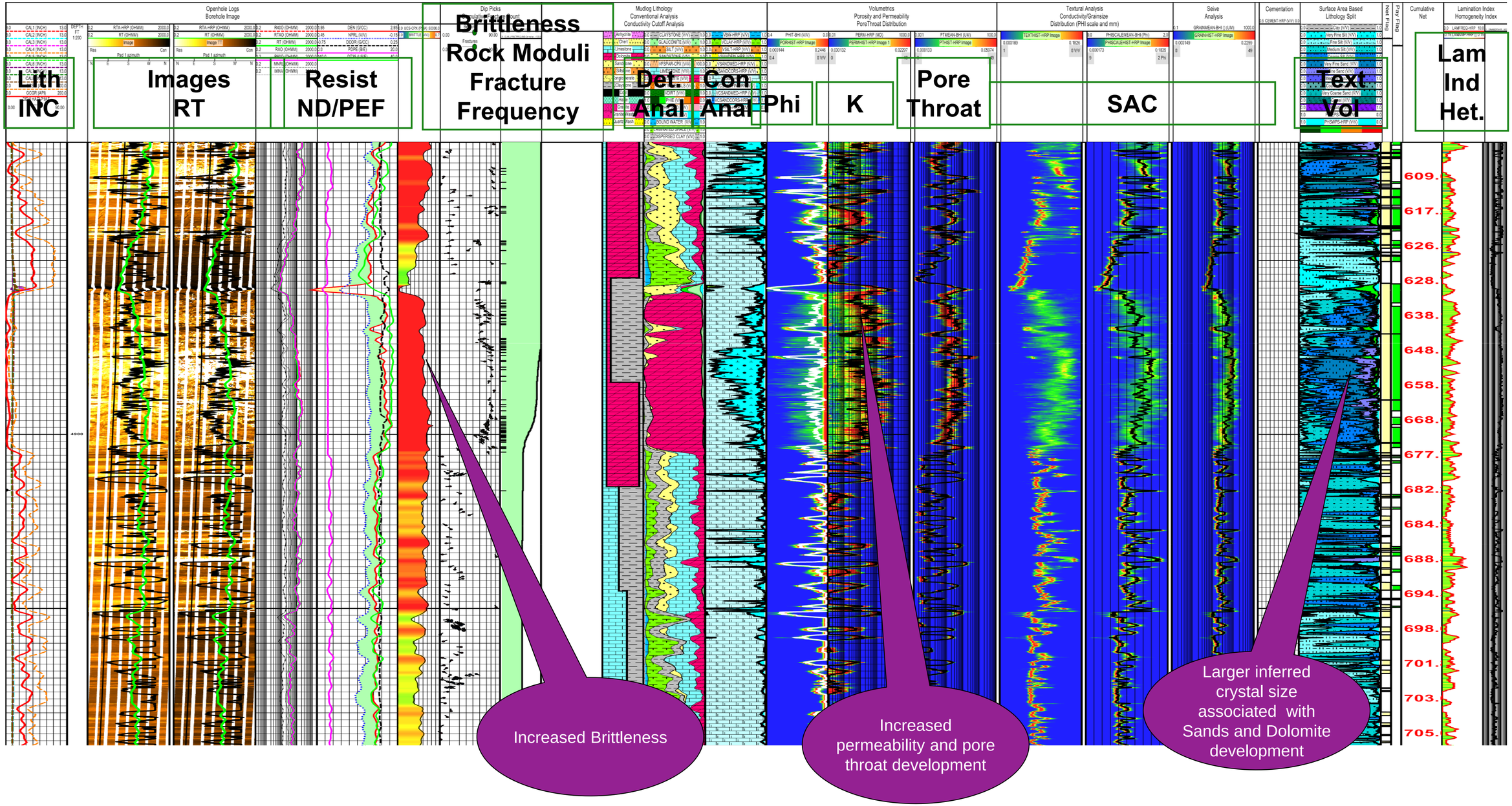
Pore Throat Textural Analysis 1



Pore Throat Textural Analysis 2



Pore Throat Textural Analysis



Conclusions

- Identify intervals with natural fractures. These are considered key to propagating a complex fracture system
- Present continuous profiles of the porosity, permeability and crystal surface area within the interval examined, allowing association with natural fractures and prospective candidate intervals to be properly evaluated prior to perforating.