Advanced Chromatography, Cuttings Analysis and Well Logging Integration: An Optimized Petrophysical Approach*

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Abstract

The characterization and petrophysical evaluation from conventional electric logs has become a real challenge when interpreting unconventional reservoirs or reservoirs characterized by the presence of fresh water and/or heavy oil fluids. The use of surface logging tools such as quantitative gas detectors in combination with the geochemical analysis of rock cuttings, utilizing XRD, XRF and Pyrolysis (TOC) instruments, has greatly aided the identification and characterization of hydrocarbon zones. In addition, it allows identification of the water content, which is obtained from Pixler ratios and aromatic hydrocarbon content. Another important consideration in evaluating the reservoir is a need to consider the effects of salinity, clay content, and laminations. The use of the advanced gas/geochemical analysis and its interpretation has solved models for hydrocarbon saturation in areas where high uncertainty exists or where, for economic or other reasons, it was not possible to acquire full sets of electric logs. This combination of surface logging techniques and interpretation method provides a reliable characterization solution.

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Advanced Chromatography, Cuttings analysis and Well Logging integration

An Optimized Petrophysical approach

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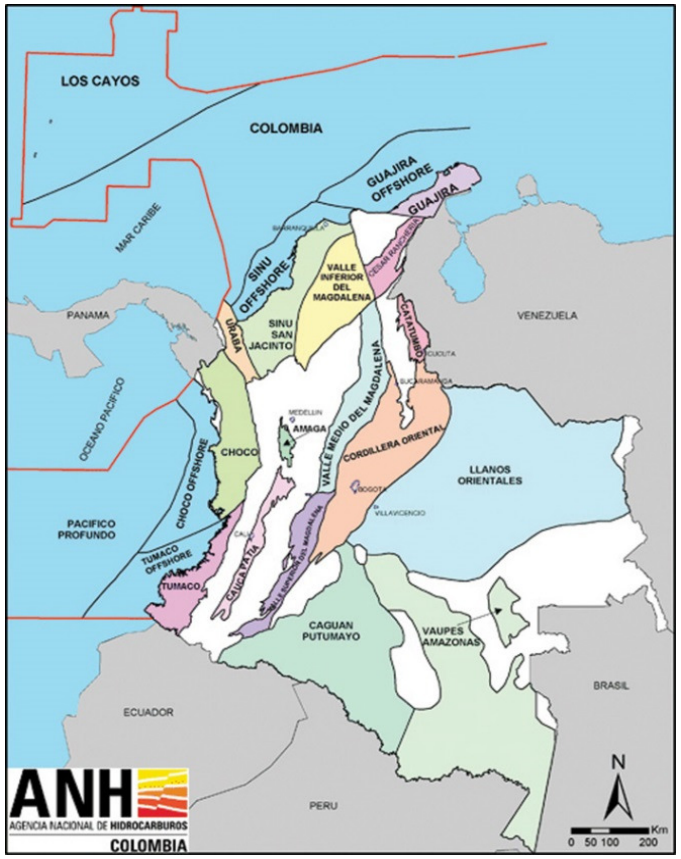
Rio de Janeiro | 18-19 May 2016

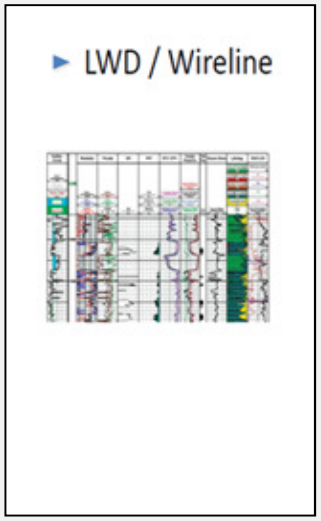
General Overview

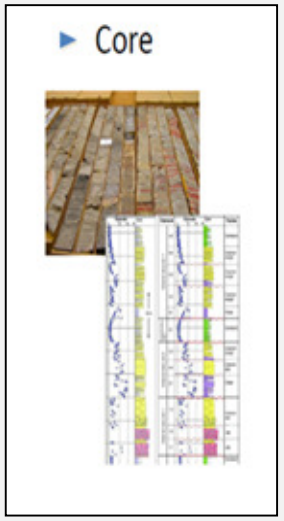
- Diversity on structural, stratigraphic and Petrophysic characteristics



Basin Distribution Map

Characterization Sources





Byproduct of drilling (free)

Ideal Scenario

Porosity Lithology Textural	Triple Combo - Spectral GR - SP + Dipolar Sonic + Image + Mineralogy
Porosity Distribution Geomechanic	Image + Dipolar Sonic + NMR
Permeability Index	NMR+ Pressure Points
Saturations	Saturation Tools/Dielectric Tools
Fluid Properties	NMR

Validated against RCA,SCA, PVT

Ideal Scenario

Petroleum Industry Reality

- **Economic CHALLENGES**
  - ✓ Keep Developing Reservoirs in a **OIL LOW PRICE SCENARIO**
- **Operational CHALLENGES**
  - ✓ Trip Time Savings/ Closing Wells.
  - ✓ Avoid Risk on OH Logging, **Mainly Special Services**
- **Characterization CHALLENGES**
  - ✓ Complex Lithology
  - ✓ Fluid Reservoir Characterization
  - ✓ Unconventional Reservoir
  - ✓ Others.

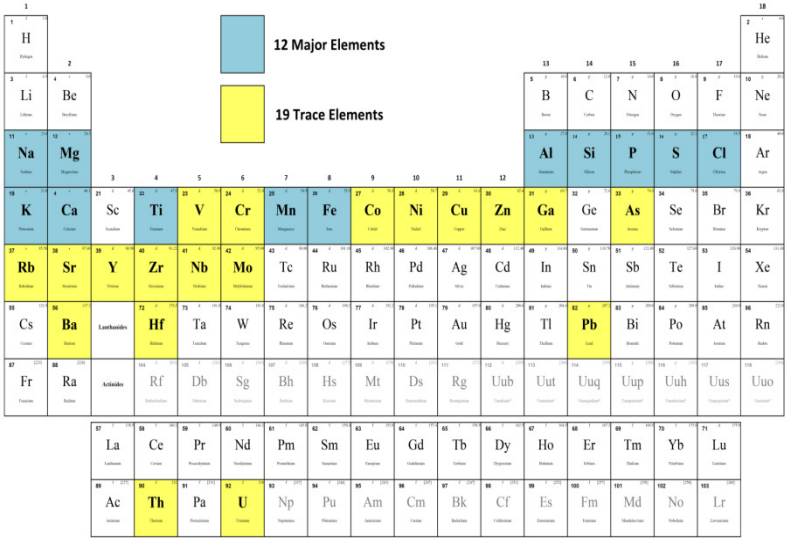
Optimized Data Acquisition

LWD/WL	→	Triple Combo/ Quad Combo
X Rays Fluorescence X Rays Diffraction	→	Lithology, Rock Properties
Pyrolysis Advanced Chromatography	→	Total Hydrocarbon, Fluid Quality

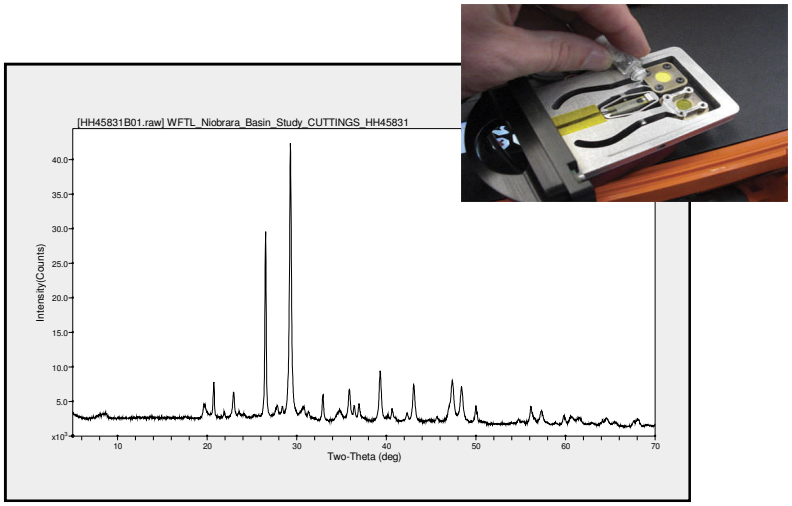
- Interest Zones Identification (Real Time or Not)
- More Accurate Evaluation of Production Scenarios
- Reliable Solution for Reservoir characterization

Geochemical Analysis

X Rays Fluorescence



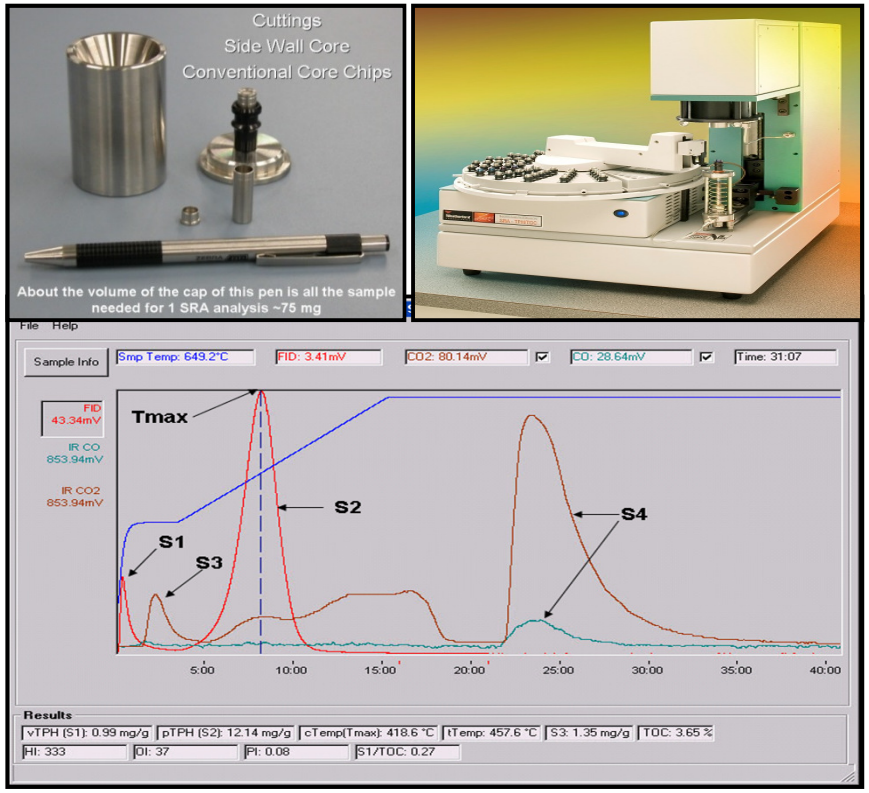
X Rays Diffraction



- Quartz
- K-Feldspar
- Plagioclase
- Calcite
- Dolomite
- Siderite
- Pyrite
- Anhydrite
- Total Clay

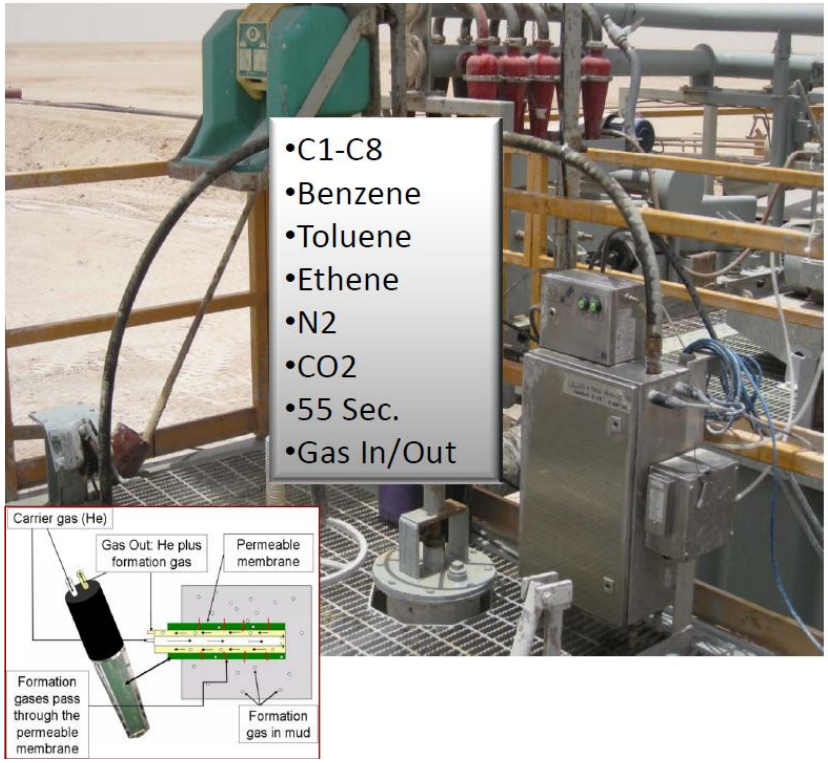
Geochemical Analysis

Pyrolysis Equipment



- Free Hydrocarbon Content (Gas/Oil) – **S1**
- Remaining Generative Potential – **S2**
- Organic Richness– **TOC**
- Thermal Maturity – **Tmax**

Advanced Chromatography



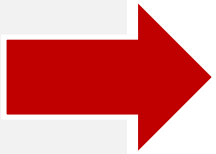
Delta System

OUT IN

Gas Out = Formation Gas + Recycling gas + Mud additives

Advanced Chromatography

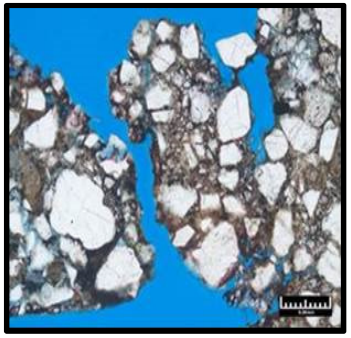
- Total Hydrocarbons Content: **THC**
- Index Fluid Mobility: **FM**
- Index Fluid Saturation: **FS**
- Aromatics/ Alkanes Ratio
- C1/C2 Ratio
- **C6/C7 Ratio**
- C1% Ratio
- Liquids Ratio
- **Gas/Liquids ratio**

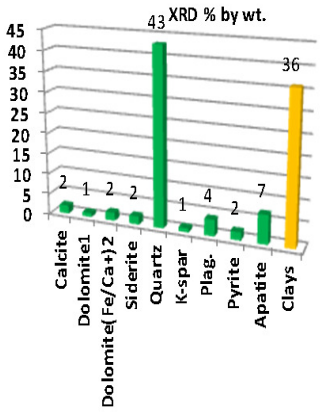


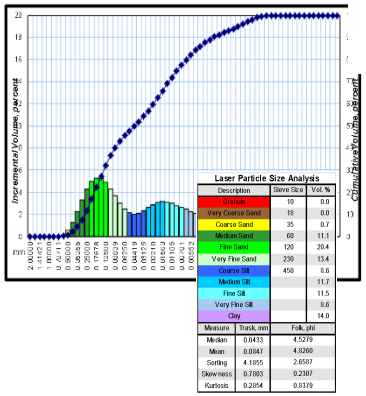
- Delimitation of Interest Zones
- Fluid Typification
- Change in Fluid Typing
- Connectivity or compartmentalization
- Correlation
- Geosteering

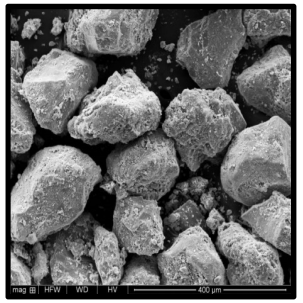
Cuttings Lab analysis

Analysis	Min sample (g)	Destructive?
Photography	N/A	N
Thin Section	2	Y
XRD	2/10	Y
XRF	5	Y
SEM	1	Y
Laser Grain Size	1	Y
Grain Density	15	Y
Acid Solubility	5 (per fluid)	Y
Cap Pressure	15	Y
CST	15	Y



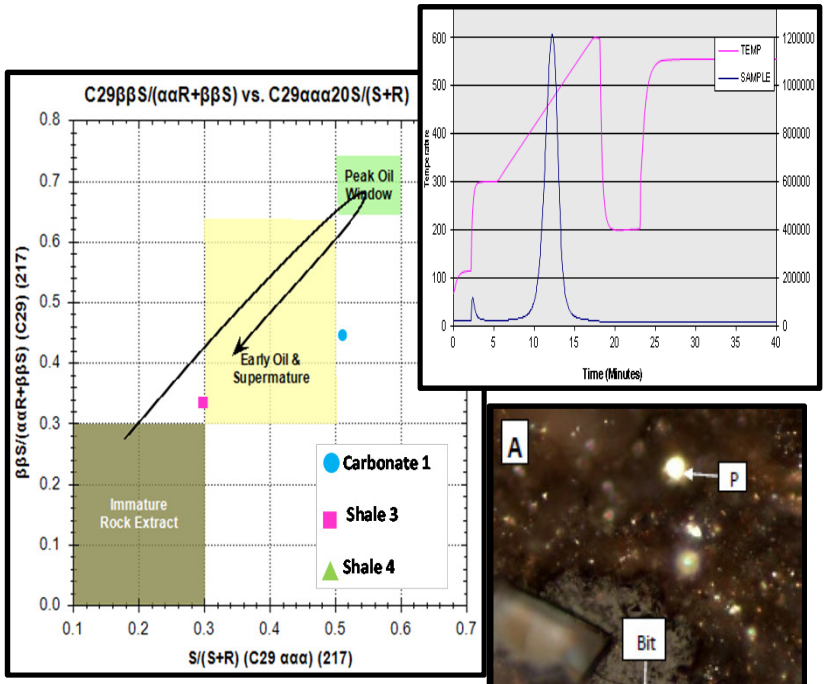






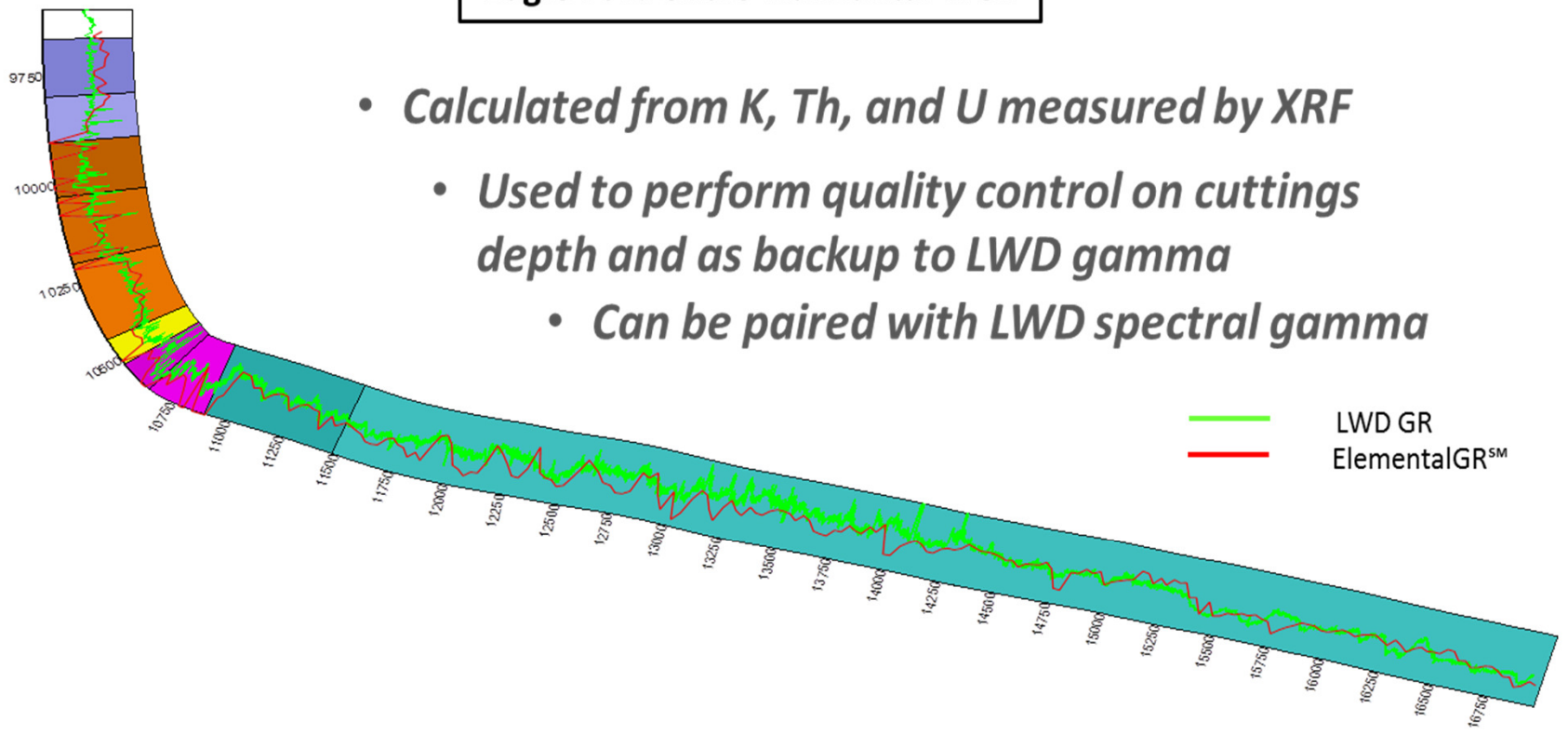
Cuttings Lab analysis

Analysis	Min sample (g)	Destructive?
Gas Comp	N/A	N
Extract Fingerprinting	1 g	Y
Biomarker GC-MS	5	Y
TOC by LECO	1	Y
Pyrolysis	1	Y
Vitrinite Reflectance	5	Y



Elemental GR Calculated from K, Th, U

Eagle Ford Shale Horizontal Well



- *Calculated from K, Th, and U measured by XRF*
  - *Used to perform quality control on cuttings depth and as backup to LWD gamma*
    - *Can be paired with LWD spectral gamma*

Real Cases

Fitting Solutions to Challenges

OPERATIONAL

- **Saving Operational Times**
  - ✓ Minimize Rig Time
  - ✓ Minimize Operational Risk (**Tight Hole & Open Hole Logging Hold ups**)

CHARACTERIZATION

- **Assuring a Complete set of Information**
  - ✓ Reservoir Characterization
  - ✓ Stimulation Jobs
  - ✓ Completions
  - ✓ Others.

Making More of Existing Data

Porosity Lithology Textural	Triple/Quad Combo + XRD + XRF
Permeability Index	Advanced Chromatography
Saturations	Triple/Quad+ Advanced Chromatography
Fluid Properties	Advanced Chromatography

Validated against RCA,SCA, PVT