Part 1:
Basic Log Analysis: The Practical Side of Things or Quick Look Log Analysis Prior to Running Cased Hole Logs for Well Evaluation

Understanding the Cause of Low Resistivity, Low Contrast (LRLC)

The Basics: laminated intervals, dispersed clay, structural clay, altered framework grains, grain size.

The normal wire line logging suite’s resolution is about 2 ft for the density/neutron--even less resolution for the induction/resistivity tool. For the Gulf of Mexico most of the LRLC pays are primarily a result of laminated sands. A minority of the LRLC pays are due to dispersed or structural clay.

Keys to Identifying Pay in Open Holes

- Knowing what works in a field or geographic area.
- Understanding the limits of open-hole logs.
- Recognizing low-resistivity pay and bad log data.
- A new look at an old field with newer seismic data can result in new drilling opportunities.
- Team work is essential to success.
Part 2: Quick Review of Log Analysis of Cased Holes*

- Typical example-gas-oil-water
- Select gas or oil recompletion
- Gas - low resistivity formations
- Shaly gas sands
- Five examples: (1) shallow gas – left behind tubing, (2) oil & gas migration into water formation, (3) gas – oil contact (oil migration into gas cap), (4) gas channel behind casing in producing oil, (5) monitor gas–oil contact (pressure maintenance).

Reference

PART 1: BASIC LOG ANALYSIS: THE PRACTICAL SIDE OF THINGS OR QUICK LOOK LOG ANALYSIS PRIOR TO RUNNING CASED HOLE LOGS FOR WELL EVALUATION

Richard Gartner
UNDERSTANDING THE CAUSE OF LRLC*

THE BASICS:

Laminated intervals**
Dispersed Clay
Structural Clay
Altered Framework Grains
Grain Size

*low resistivity, low contrast
UNDERSTANDING THE CAUSE OF LRLC

The normal wire line logging suite’s resolution is about 2’ for the density/neutron.

Even less resolution for the induction/resisitivity tool.

For the Gulf of Mexico most of the LRLC pays are primarily a result of laminated sands. A minority of the LRLC pays are due to dispersed or structural clay.
Keys to Identifying LRLC Pay

Knowing what works in a field or geographic area.

Understanding the limits of open hole logs.

Recognizing low resistivity pay & bad log data.

A new look at an old field with newer seismic data can result in new drilling opportunities.

Team work is essential to success.
SOME RULES OF THUMB

A Rw ESTIMATE

DIVIDE BY 10 THE APPARENT WET RESISTIVITY. IF IT’S .3 OHMS RW = .03.

QUICK WAY TO LOOK FOR PAY: TAKE THE WET SAND RT AND MULTIPLY BY 3; THEN LOOK FOR ZONES ABOVE THAT VALUE.

RT WET = .3 OHMS. LOOK FOR ZONES ABOVE .9 OHMS.

LOOK FOR ZONES WHERE THE GAMMA CLEANS UP BUT THE RESISTIVITY STAYS NEAR THE SHALE BASE LINE.

USE YOUR MUD LOGS.
BASIC LOG ANALYSIS: THE PARTICULAR SIDE OF THINGS OR QUICK LOOK LOG ANALYSIS

Required Tools:
Basic Calculator
Straight edge
Good Observational Skills
BASIC LOG ANALYSIS: THE PRACTICAL SIDE OF THINGS OR QUICK LOOK LOG ANALYSIS

SP SUPPRESSION
SP SUPPRESSION
BASIC LOG ANALYSIS: THE PRACTICAL SIDE OF THINGS OR QUICK LOOK LOG ANALYSIS

THE 3X RULE
RT = .12 OHMS  RW = .012

3X WET RT = .36 OHMS

WET SAND RT < .2 OHM

SAND RT = .4 OHM
BASIC LOG ANALYSIS: THE PRACTICAL SIDE OF THINGS OR QUICK LOOK LOG ANALYSIS

SHALE BASE LINE METHOD
A CLOSER LOOK

RWA

← Zone of Interest
1000' OF SECTION = 20' OF TVD PAY
100' OF SECTION = 2' OF TVD PAY

COMPLETED NATURAL THRU SLOTTED LINER
BASIC LOG ANALYSIS: THE PRACTICAL SIDE OF THINGS OR QUICK LOOK LOG ANALYSIS

THE SONIC LOG
ELPASO HI-472 A-1  D-13 SAND

3500' TVD

3600' TVD

3700' TVD

NET 22' GAS PAY

SONIC
Cycle Skipping

Gas attenuates the P wave sonic signal to the point that it is so delayed and low frequency that the tool cannot detect it. Then tool starts picking up the late arriving Stoneley waves thus “skipping a cycle.”

The Shear wave is not affected by Gas.
BASIC LOG ANALYSIS: THE PRACTICAL SIDE OF THINGS OR QUICK LOOK LOG ANALYSIS

MUD LOGS AND ANALOGS
Use of Analogs
USE ALL YOUR DATA
MUD LOG TELL YOU WHERE YOU NEED TO BE LOOKING

Use All of Your Data
Tested @ 1.4 MM per Day
The Effects of External Influences on the Well Bore and LRLC Pay Recognition

Mud Weights Can Hide the Good, the Bad and Ugly.

Extreme under or overbalanced Drilling can and will affect log evaluation in unconsolidated sediment.

Hole Angle (How the basic resistivity tool works)
Special Wire Line Tools for the Identification of LRLC Pay

FMI
MRI

3Dex or Scanner tool: multi-directional resistivity

Sidewall Cores

Conventional Cores
Rescue that well.....Part 2

Herman Vacca
Used with permission of SPWLA
Part 2:
Quick Review of Log Analysis of Cased Holes:

TYPICAL EXAMPLE-GAS-OIL-WATER
SELECT GAS OR OIL RECOMPLETION
GAS - LOW RESISTIVITY FORMATIONS
SHALY GAS SANDS

5 Examples:

SHALLOW GAS – LEFT BEHIND TUBING
OIL & GAS MIGRATION INTO WATER FORMATION
GAS – OIL CONTACT (OIL MIGRATION INTO GAS CAP)
GAS CHANNEL BEHIND CASING IN PRODUCING OIL
MONITOR GAS–OIL CONTACT (PRESSURE MAINT)
**TYPICAL EXAMPLE-GAS-OIL-WATER**

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<thead>
<tr>
<th>Correlation</th>
<th>SP</th>
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<tbody>
<tr>
<td></td>
<td>80.00 (<em>mv</em>) 20.00</td>
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<table>
<thead>
<tr>
<th>Sigma</th>
<th>N1 - F1</th>
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<tr>
<td>SIGM</td>
<td>F1</td>
</tr>
<tr>
<td>60.00</td>
<td>67.00</td>
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<tr>
<td>(0.00</td>
<td>(0.00)</td>
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<td>N1</td>
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<tr>
<td>5.00</td>
<td>4000.00</td>
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<td>(0.00</td>
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**Graphical Representation:**
- **SP Traced**
- **SIGMA**
- **F1**
- **N1**
- **GAS**
- **OIL**
- **WATER**
SELECT GAS OR OIL RECOMPLETION

Log Recorded inside:
5-1/2” Casing
2-3/8” Tubing

Traced SP

805 MCFGD
4.7 BOPD
0 Water

GAS:
$\Phi = 30$
$Sw = 37$

Oil:
$\Phi = 30$
$Sw = 22$

WATER:
$\Phi = 29$
$Sw = 75$

GAS:
$\Phi = 30$
$Sw = 40$

OIL:
$\Phi = 23$
$Sw = 29$

OIL
WATER

6332
6338

6250
6300
6350
6450

RATIO
Sigma
N1 - F1

100.00
(“mv”) 900.00

F1
N1

Gas

Gas-RATIO
Gas-SIGMA

667.00
4000.00

4.7 BOPD
0 Water
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<th>Resistivity</th>
<th>Depth</th>
<th>Ratio</th>
<th>Sigma</th>
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<td>4000</td>
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<td>8661</td>
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<tr>
<td>8657</td>
<td>Sw = 38%</td>
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<tr>
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<td>Sw = 58%</td>
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<td>Sw = 45%</td>
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<tr>
<td>8661</td>
<td>Sw = 58%</td>
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**Legend:**
- **SP:** Spontaneous Potential
- **GR:** Gamma Ray
- **Dual Completion:** Two Upper Zones
- **Gas Cut:** 75 Bbl Salt Water
- **Abandoned:** 75 Bbl Salt Water

**Graphical Data:**
- **8650:** 1.4 MMCFGD
- **8700:** 1.15 MMCFGD
- **8750:** 75 Bbl Salt Water Gas Cut Abandoned

**Annotations:**
- **N1:** 4000.00 (v)
- **F1:** 0.00

**Summary:**
- Gas - Low Resistivity Formations
- Dual Completion
- Two Upper Zones
- Gas Cut
- Abandoned
SHALY GAS SANDS

<table>
<thead>
<tr>
<th>GR</th>
<th>Sigma</th>
<th>N1 - F1</th>
<th>Depth</th>
<th>SP</th>
<th>Res-Normal</th>
<th>Res-Lateral</th>
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<td>80.00 (‘mv’) 20.00 0.00 ( ) 10.00 0.00 ( ) 2.00</td>
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<td>Hydrocarbon</td>
<td>Gas</td>
<td></td>
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<td></td>
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- GR: 400 MCFGD 650 FTP
- 7900
- 7950
- 8000
- 8050
- 8070 8074
- Sw = 58
- Sw = 52
- Sw = 100
- Sw = 52
- LATERAL
- Abandoned
**SHALLOW GAS – LEFT BEHIND TUBING**

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<tr>
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<th>RATIO</th>
<th>SIGM</th>
<th>F1</th>
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<tr>
<td>-80.00</td>
<td>6.00</td>
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<tr>
<td>(&quot;mv&quot;)</td>
<td>(</td>
<td>(</td>
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<td>20.00</td>
<td>40.00</td>
<td>20.00</td>
<td>667.00</td>
</tr>
</tbody>
</table>

- **Gas**
- **Hydrocarbon**

Log Recorded in: 5-1/2" Casing and 2-3/8" Tubing

- Traced SP
- GAS
- N1
- F1

- **Φ = 28**
  - Sw = 74
- **Φ = 38**
  - Sw = 100

- **Φ = 37**
  - Sw = 100

WATER
### ORIGINAL ELECTRICAL LOG – OIL/GAS MIGRATION
(RESISTIVITY SCALE AMPLIFIED TO 10 Ohm-m from 20 Ohm-m)

| Correlation | Resistivity (
<table>
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<th></th>
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<tbody>
<tr>
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<td>-160.00</td>
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<td>(<em>mv</em>)</td>
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<tr>
<td>40.00</td>
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**Apparent Water Bearing Formation**

- 1 Ohm-m

---

**Diagram:**
- Graphs showing apparent water bearing formation at 1 Ohm-m.
# OIL & GAS MIGRATION INTO WATER FORMATION

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Ratio</th>
<th>Sigma</th>
<th>N1 - F1</th>
<th>Resistivity</th>
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<tr>
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<td>SIGM</td>
<td>F1</td>
<td>64inchNORMAL</td>
</tr>
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<td>6.00</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
</tr>
<tr>
<td>GR</td>
<td>(())</td>
<td>(())</td>
<td>N1</td>
<td>SN</td>
</tr>
<tr>
<td>0.00 (&quot;API&quot;)</td>
<td>1.00</td>
<td>1.00</td>
<td>10.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Legend:**
- **SP**: Resistivity
- **GR**: Gamma Ray Absorption
- **N1**: Resistivity
- **F1**: Sigma
- **SN**: Normalized Spontaneous Potential
- **AmpSN**: Amplified Spontaneous Potential

**Note:**
- **RATIO**: Gas
- **SIGM**: Hydrocarbon
- **GAS**: Gas
- **OIL**: Oil
- **5751 5755**: Gas zone
- **5750**: Oil zone
<table>
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<tr>
<th>Correlation</th>
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<td>()</td>
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<td>20.00</td>
</tr>
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</table>

**Ratio**
- **Gas**
- **Hydrocarbon**

**Sigma**
- **Gas**

**N1 - F1**
- **OIL**
- **GAS**

**Resistivity**
<table>
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<tr>
<th></th>
<th>8 Hours</th>
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<tr>
<td><strong>Tubing Pressure (psi)</strong></td>
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<td>1150</td>
<td>1205</td>
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<tr>
<td><strong>Choke Size (in.)</strong></td>
<td>10/64</td>
<td>10/64</td>
<td>12/64</td>
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<td>12/64</td>
</tr>
<tr>
<td><strong>Oil (B/D)</strong></td>
<td>73</td>
<td>54</td>
<td>94</td>
<td>71</td>
<td>72</td>
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<tr>
<td><strong>Water (B/D)</strong></td>
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<td>0</td>
<td>0</td>
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<tr>
<td><strong>GOR</strong></td>
<td>4974:1</td>
<td>8309:1</td>
<td>9230:1</td>
<td>12707:1</td>
<td>12983:1</td>
</tr>
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</table>
GAS – OIL CONTACT (OIL MIGRATION INTO GAS CAP)

GAS – OIL CONTACT AT TIME OF LOG (4926 ft)

ORIGINAL GAS-OIL CONTACT

Btm 7” Csg.

Top 5” Liner

433 BOPD
204 BWPD
1799 GOR

GAS

OIL
GAS CHANNEL BEHIND CASING IN PRODUCING OIL WELL

Well Producing through Screen-High GOR Oil
GAS CHANNEL BEHIND CASING IN PRODUCING OIL WELL

Gas Channeling Down and into well through Screen

Gr Ratio Sigma F1

Well Flowing

F3-Shut-In Log

F3-Flowing Log
MONITOR GAS – OIL CONTACT (PRESSURE MAINTENANCE)

Limited Water Drive – Gas Cap Expanding

After 6 Yrs of Water Injection, 50-psi Press Inc. Logged to find current contact.

Original Reservoir Gas-Oil Contact (6625 ft) Gas-Oil Contact (6646 ft) at Time of Log

260 BOPD GOR 410:1 Trace-Water 6625 6633

RATIO SIGMA N1 - F1 Induction Log Microlog

6.00 (1) 1.00 40.00 (1) 10.00 667.00 (1) 10.00 0.00 (1) 10.00 0.00 (1) 5.00

Gas Hydrocarbon

N1 SN AmpSN

0.00 (1) 2.00

Positive Sep

Limited Water Drive – Gas Cap Expanding