GAMMA RAY AND SPONTANEOUS POTENTIAL LOGGING CORE

Introduction

LEARNING OBJECTIVES

By the end of this lesson, you will be able to:

- ✓ Identify three or more ways to convey openhole logging tools into the borehole, and the impact of hole angle
- ✓ Explain why log calibrations and "repeat sections" are performed
- ✓ Recognize the key elements of an openhole log "print" and list at least five types of data on the heading
- ✓ Describe the relationship between logging tool depth of investigation and bed resolution
- ✓ Explain what is meant by "curve blocking" and explain why it is useful

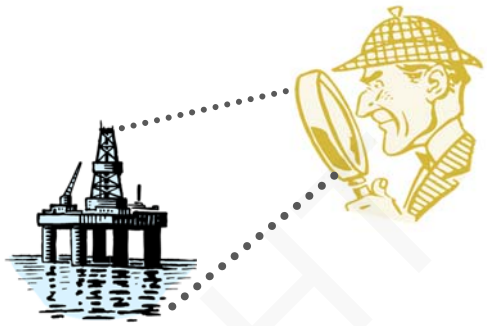
THE PETROPHYSICAL "DETECTIVE"

Petrophysical evaluation

- Identify, quantify subsurface hydrocarbon resources
- Evaluate fluid, rock properties
- Conduct single or multi-well studies

Deliverables

- Static and Dynamic reservoir description
- Fluid distribution (at and away from wellbore)
- Calibrated determination of rock properties using multiple data types



MEASUREMENTS ARE BOTH DIRECT, INDIRECT!

Direct measurements:

- Direct comparison
  - (e.g., ruler, weighing scales)
  - Very few in petrophysics
  - Velocity is a direct measurement

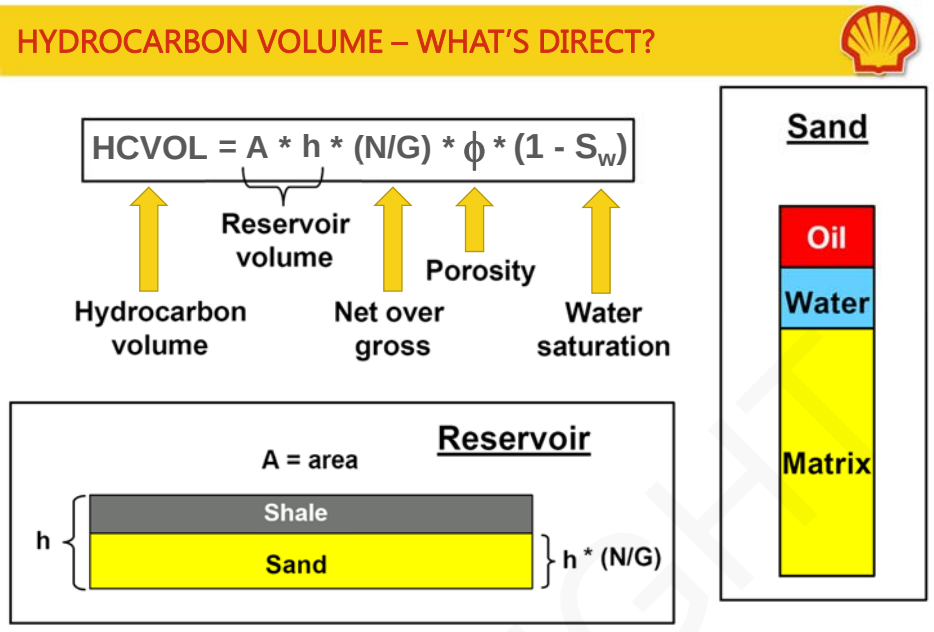
Indirect measurements:

- Via the effect on something else
  - (e.g., temperature via Hg expansion)
  - Porosity is an indirect measurement

Calibration is always required

- Logging tool "calibration" is a verification that the logging tool is functioning properly and reading correctly across an appropriate range

HYDROCARBON VOLUME – WHAT'S DIRECT?



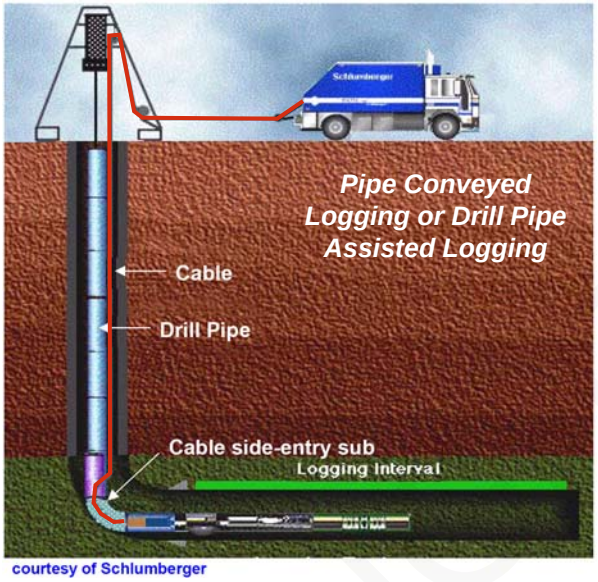
TRADITIONAL LOGGING COMPANIES

Traditional Logging Companies for Open Hole Logging

Wireline
- Schlumberger
- Baker - Atlas
- Halliburton
- Weatherford (formerly Reeves)

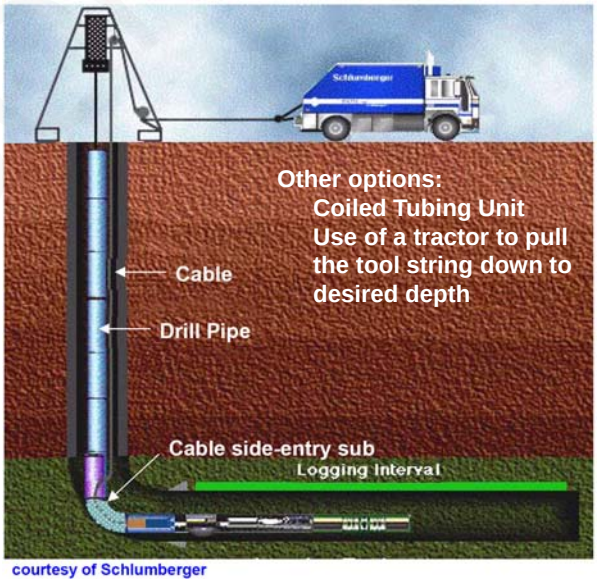
Logging while drilling
- Anadrill (part of Schlumberger)
- Baker-Hughes Inteq (including Teleco)
- Sperry (part of Halliburton)
- Weatherford (Precision)

HORIZONTAL WELL LOGGING



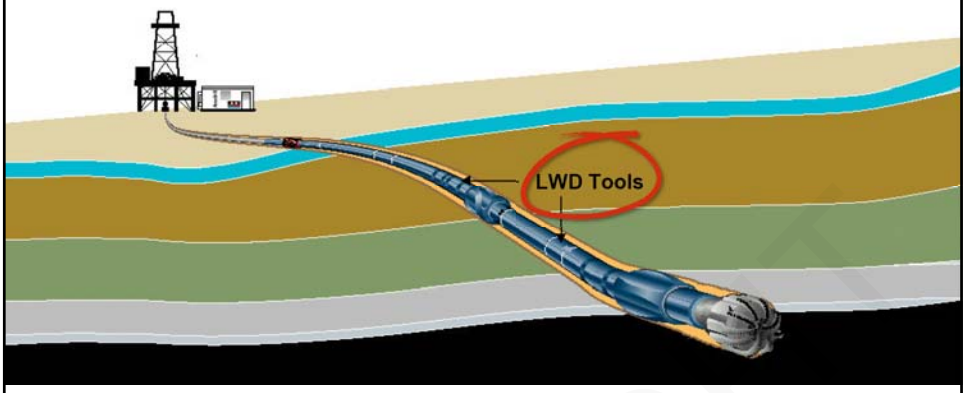
courtesy of Schlumberger

HORIZONTAL WELL LOGGING



courtesy of Schlumberger

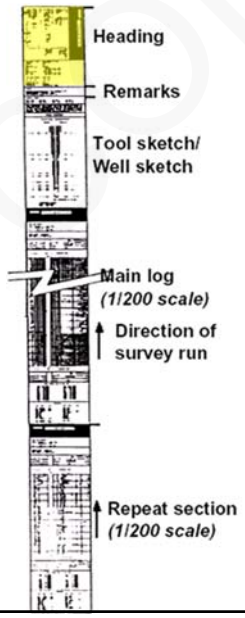
LOGGING WHILE DRILLING



Logging While Drilling (LWD) is the alternative to wireline logging.

LWD tools are built into drill collars and contain very sophisticated electronics designed to withstand extreme vibrations and high temperatures and pressures.

KEY ELEMENTS OF THE LOG



COMPANY: PetroSkills
WELL: BPP-1
FIELD: BPP
RIG: Floating-124

HEADING

PEx(HALS)-DSI-NGS
SUITE - 1 , RUN – 1
SCALE: 1/200

LOCATION: WA-6-L
EASTINGS: 126789.3
NORTHINGS: 36784.7

Elev.: R.T. 25.9 M
G.L. -127.6 M
D.F. 25.9 M

Permanent Datum: L.A.T
Log Measured From: D.F.
Drilling Measured From: D.F.

Elev.: O.M.
25.9 M above Perm. Datum

Rig: | Field: | Location: | Well: | Company: | STATE: Alafun | Max. Well Deviation 2.7 DEG | Longitude | Latitude

Logging Date			12-APR-1998		
Run Number			1		
Depth Driller			3495 M		
Schlumberger Depth			3450.5 M (HUD)		
Bottom Log Interval			3477.5 M		
Top Log Interval			153.5 M		
Casing Driller Size @ Depth			9.625 IN @ 1566.84 M		@
Casing Schlumberger			1568.5 M		
Bit Size			8.500 M		
Type Fluid in Hole			KCl / PHPA		
MUD: Density	Viscosity		1.22 G/C3	70 S	
MUD: Fluid Loss	PH		3.4 C3	9.5	
MUD: Source of Sample			Pits		
RM @ Measured Temperature			0.089 CHMM @ 29 DEGC		@
RMF @ Measured Temperature			0.078 CHMM @ 29 DEGC		@
RMC @ Measured Temperature			0.186 CHMM @ 28 DEGC		@
Source RMF	RMC		Sample Pressed	Sample Pressed	
RM @ RMT	RMF @ MRT		0.038 @ 111	0.030 @ 111	@ @
Maximum Recorded Temperature			111 DEGC	111	109
Circulation Stopped	Time		12-APR-1998		12:00
Logger on Bottom	Time		13-APR-1998		5:20
Unit Number	Location		242	MWA	
Recorded by			D. Paston / B.Charba / A. Mcmillan		
Witnessed by			R. Blake / M. Bilek / S. Weston		

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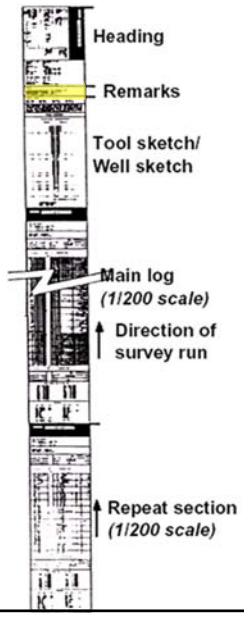

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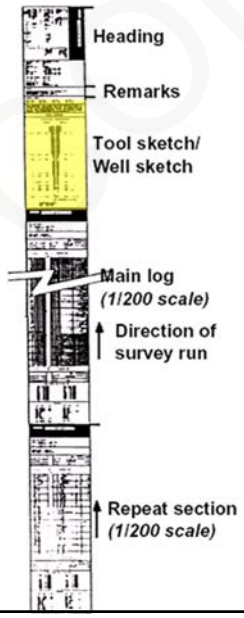

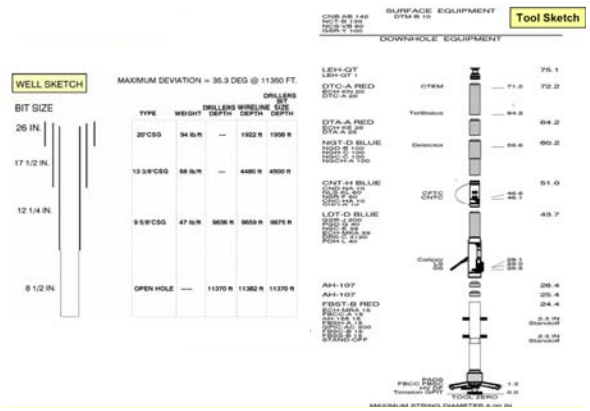

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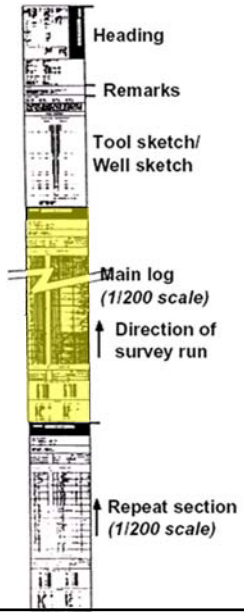

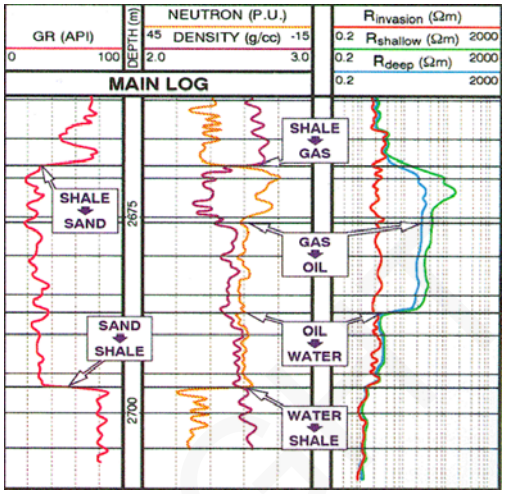

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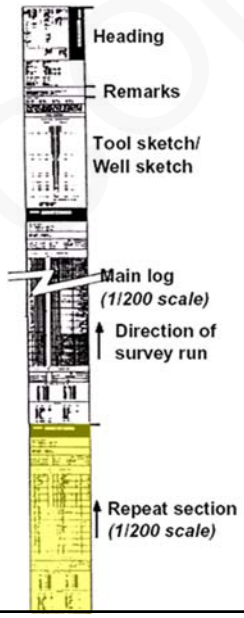

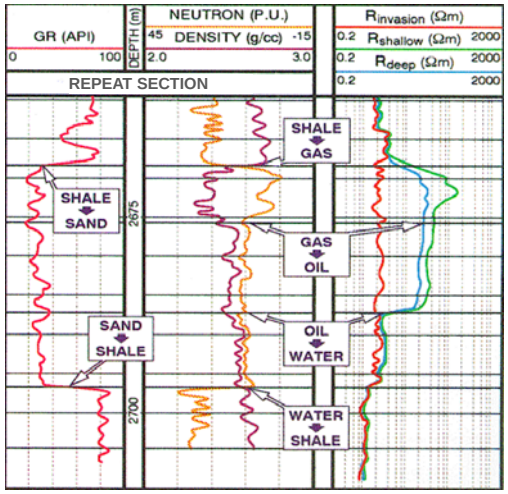

KEY ELEMENTS OF THE LOG

After survey calibration

Before survey calibration

Shop calibration

Data quality form *(optional)*

SHOP SUMMARY

PERFORMED:

LDTC DETECTOR CALIBRATION SUMMARY

DENSITY RESISTIVITY SONDE NUMBER	: 2714
NUCLEAR SERVICE CARTRIDGE NUMBER	: 930
POWERED DETECTOR HOUSING NUMBER	: 1854
POWERED GAMMA-GAMMA DETECTOR NUMBER	: 1869
LDT LOGGING SOURCE NUMBER	: 6770
LDT CALIBRATION MODE	: WATE

MASTER CALIBRATED

	BKGD	AL+FE	AL	UNITS
LL	10.7	73.0	82.1	CPS
LU	72.9	113.4	125.4	CPS
LS	55.2	130.5	144.7	CPS
LITH	5.5	29.7	44.7	CPS
SSI	13.7	150.3	166.4	CPS
SSE	9.2	224.0	246.5	CPS

HV SETTINGS

HV LS: 1630.5 V
HV SS: 1357.8 V

SPECTRUM QUALITY RATIOS

	COMPUTED VALUE	NOMINAL VALUE	TOLERANCE
GRLS	.655	0.65	+/- 0.03
GRSS	.675	0.72	+/- 0.10
GRLI	.309	0.32	+/- 0.06
GLIR	1.357	1.35	+/- 0.06
GR	1.002	1.00	+/- 0.02

BKGD: AL: AL+FE:

CP 32.2

FIG. 17.6 : Evolution of the calibration presentation.
Computer-generated presentation with quality ratios.
Courtesy of Schlumberger

KEY ELEMENTS OF THE LOG

After survey calibration

Before survey calibration

Shop calibration

Data quality form *(optional)*

PRESENTATION		COMMENTS
1. HEADING COMPLETENESS/ACCURACY	X	Company Name misspelled
2. FILM/PRINT QUALITY		
3. CURVE/PIP/SCALES/INSERTS		
4. TD/FR/CSG IDENTIFICATION		
5. STANDARD PRESENTATION		
6. IMPORTANT CONSTANTS LISTED		
7. REMARKS		
8. WELL SKETCH/TOOL SKETCH		
9. OTHERS		

CALIBRATION	DLL	MSFL	COMMENTS
1. SHOP CALIBRATION VALIDITY			
2. BEFORE SURVEY ACCURACY			
3. AFTER SURVEY DRIFT			
4. OTHERS			

OPERATING TECHNIQUE			COMMENTS
1. DEPTH MATCHING			
2. LOGGING SPEED		X	3600 FPH +
3. CENTRALIZATION	X		no upper centralizer
4. RESPONSE IN KNOWN CONDITIONS		X	no caliper check in csg
5. SETTING OF CONSTANTS			
6. PRESENCE OF STANDARD CURVES			
7. RELOGGING OF ANOMALIES		X	
8. TAPING QUALITY			
9. OTHERS			

DATA QUALITY			COMMENTS
1. OCCASIONALLY NOISY	3		Stuck at 9500'
2. ANOMALOUS RESPONSE		6	Did not relog anomaly
3. SERIOUS ANOMALOUS RESPONSE			
4. REPEATABILITY			
5. OTHERS			

Use the codes in the Data Quality section to explain anomalies.

1. ROUGH HOLE
2. BOREHOLE FLUID
3. TOOL STICKING
4. ANISOTROPY/FRACTURE
5. GAS
6. PAD CONTACT
7. TOOL LIMITATIONS EXCEEDED
8. TOOL FAILURE
9. POOR OPERATING TECHNIQUE
10. OTHERS

IMPORTANT INFORMATION: LOG HEADER

COMPANY: PetroSkills
WELL: BPP-1
FIELD: BPP
RIG: Floating-124

Schlumberger

PEx(HALS)-DSI-NGS
SUITE - 1 , RUN – 1
SCALE: 1/200

LOCATION: WA-6-L
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Header Key Information:

- Depths
- Casing depths
- Permanent datum
- Type of mud and properties
- Resistivities
- Rig elevation

THE "REMARKS": SEE ANY PROBLEMS?

ALL INTERPRETATIONS ARE OPINIONS BASED ON INFERENCES FROM ELECTRICAL OR OTHER MEASUREMENTS AND WE CANNOT, AND DO NOT GUARANTEE THE ACCURACY OR CORRECTNESS OF ANY INTERPRETATIONS, AND WE SHALL NOT, EXCEPT IN THE CASE[illegible]S OR WILLFUL NEGLIGENCE ON OUR PART, BE LIABLE OR RESPONSIBLE FOR ANY LOSS, COSTS, DAMAGES OR EXPENSES INCURRE[illegible]INED BY ANYONE RESULTING FROM ANY INTERPRETATION MADE BY ANY OF OUR OFFICERS, AGENTS OR EMPLOYEES. THESE INTERPR[illegible]ARE ALSO SUBJECT TO CLAUSE 4 OF OUR GENERAL TERMS AND CONDITIONS AS SET OUT IN OUR CURRENT PRICE SCHEDULE.

OTHER SERVICES1
OS1: FMI-DSIX-GR
OS2: CMR-GR
OS3: MDT-GR, MSCT-GR
OS4: VSP (CGG)
OS5: CST-GR

OTHER SERVICES2
OS1:
OS2:
OS3:
OS4:
OS5:

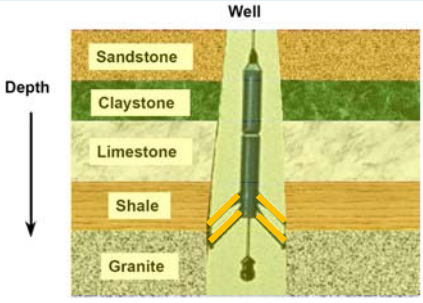
REMARKS:

First run in hole. Tool string eccentred as per tool sketch.
3 x 1.0" standoffs used on DSI, 2 x 1.0" standoffs used on HALS.
GR and CNT eccentred by bowspring.
Additional mud data: KCl w/v% = 7%;
Barite w/v% = 3.9%,
KCl equivalent = 81,900 mg/L;
Total mud chlorides = 39,000 ppm;
Chemicals: KCl, caustic soda, flowspan, Drlspac reg and SL, soltex, circal.
Tide correction = 1.4 m.
Circulation time = 1.5 hours (10:30 - 12:00).
DSI firings: Upper Dipole, Lower Dipole, P & S and DFMD.
GR, CNL, TLD and AIT environmentally corrected.
Neutron porosity corrections: borehole salinity, mud cake, hole size, mud weight, standoff, pressure/temperature.
Surface re-zero = 9.1 m.
Logger did not tag TD. HUD at 3480.5m.
Log was spliced at 2770m due to software problems.
The NGS appears to be off depth in some places. This is due to the NGS data not being speed/tension corrected (PEx is corrected)

The Remarks section includes:

- What occurred during logging
- Services provided
- Tool string makeup
- Total depth remarks
- Environmental corrections

OPEN HOLE LOGGING TOOLS



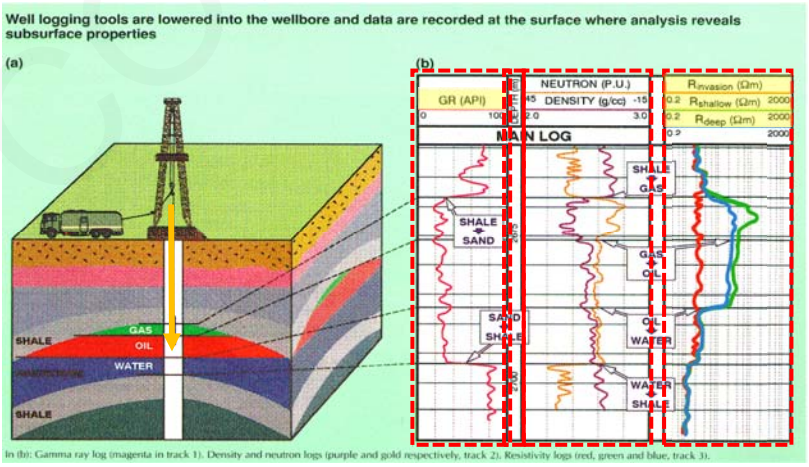
Open Hole Logs

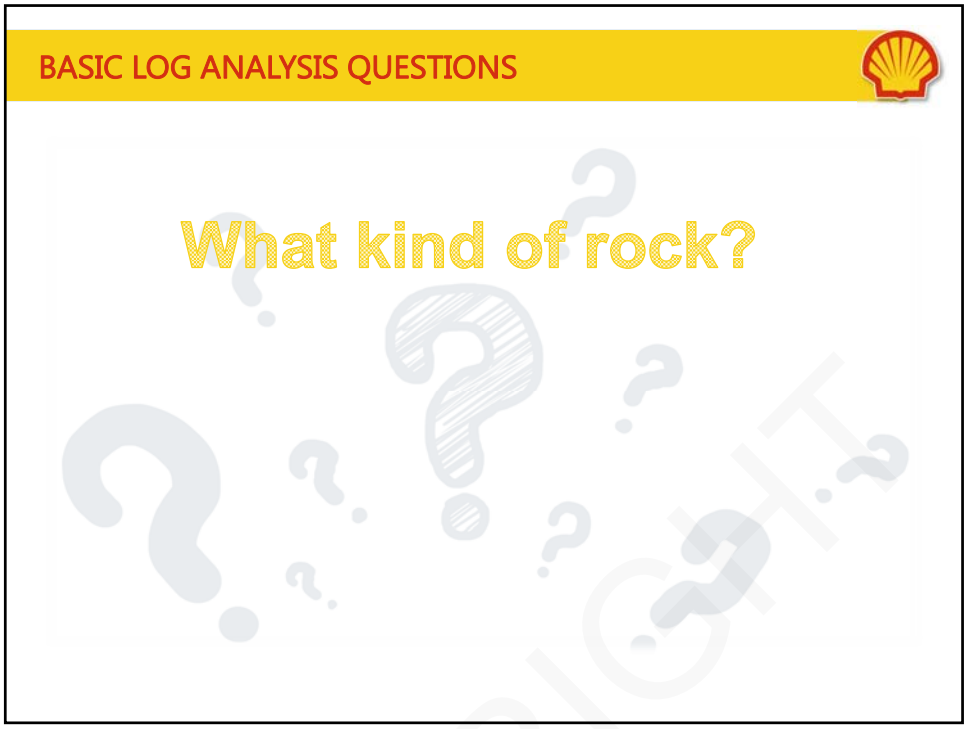
- Gamma Ray and SP logs
- Resistivity (Laterolog, Induction)
- Nuclear (Density, Neutron)
- Acoustic
- Nuclear Magnetic Resonance
- Formation Imaging
- Sampling (pressures and fluids)

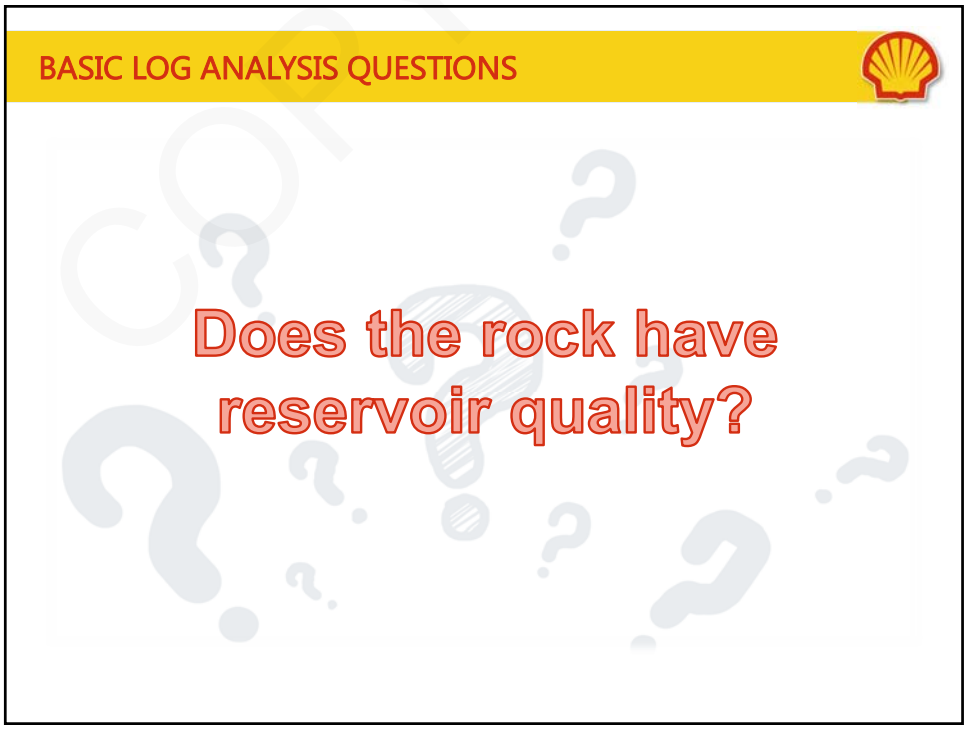
Formation Properties

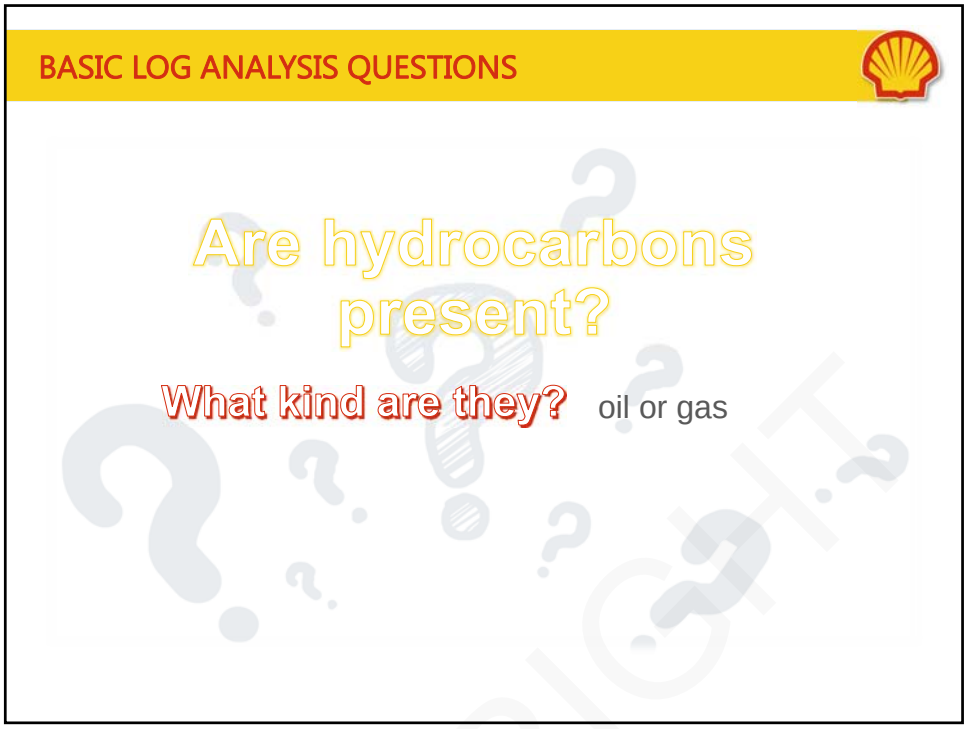
- Rock type
- Porosity
- Permeability
- Fluid type (oil, gas, water)
- Fluid Volume (saturation)
- Formation tops
- Fractures

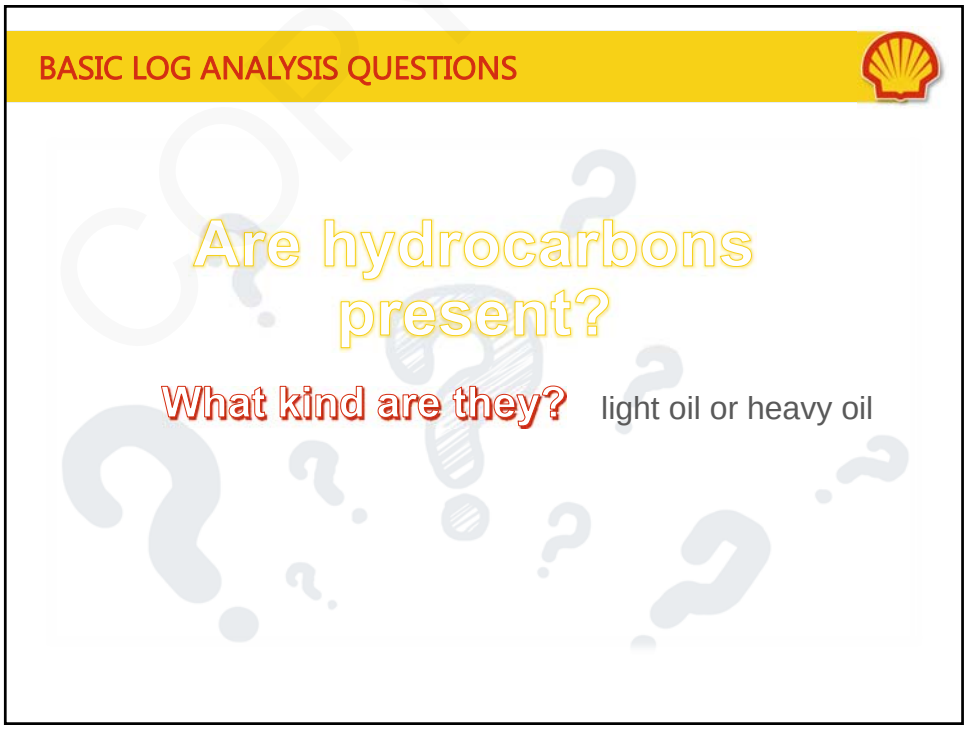
PRINCIPLE OF LOG INTERPRETATION











BASIC LOG ANALYSIS QUESTIONS

Are hydrocarbons present?

What kind are they? sweet gas or sour gas

BASIC LOG ANALYSIS QUESTIONS

Are hydrocarbons present?

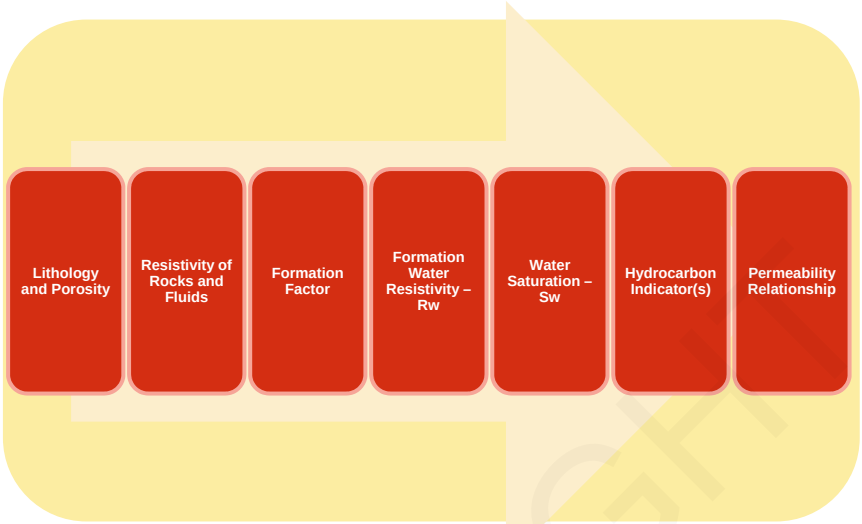
What kind are they?

How much is there?

There are "Quick-Look" and more "Advanced" Techniques

Net Pay, Porosity, Water Saturation, and Permeability

PARAMETERS NEEDED



END PRODUCT – "ANSWER LOG"

Delineates Lithology, Fluids

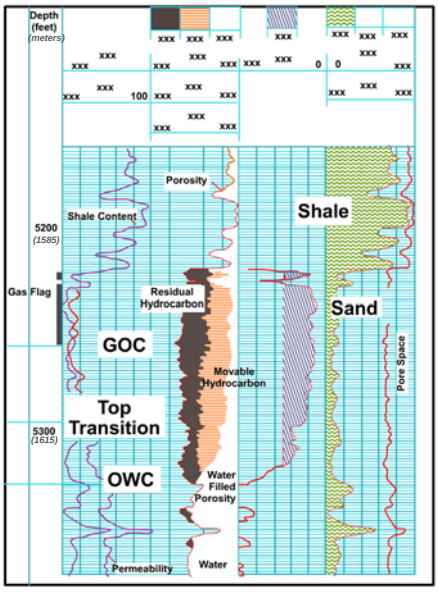
- Sandstone, limestone, dolomite, etc. (Reservoir)
- Shale, etc. (Non-reservoir)
- Oil, Gas, Water

Quantifies

- Porosity
- Water, Oil saturation
- Net Feet of Pay

But, more information is needed

- Does apparent pay flow?
- Is mineralogy affecting log response?
- What does water saturation (Sw) calculation mean?
- Is it a "calibrated" result?



BASIC LOG INTERPRETATION

Understanding Tool Physics and Tool Response

Depth of investigation and resolution

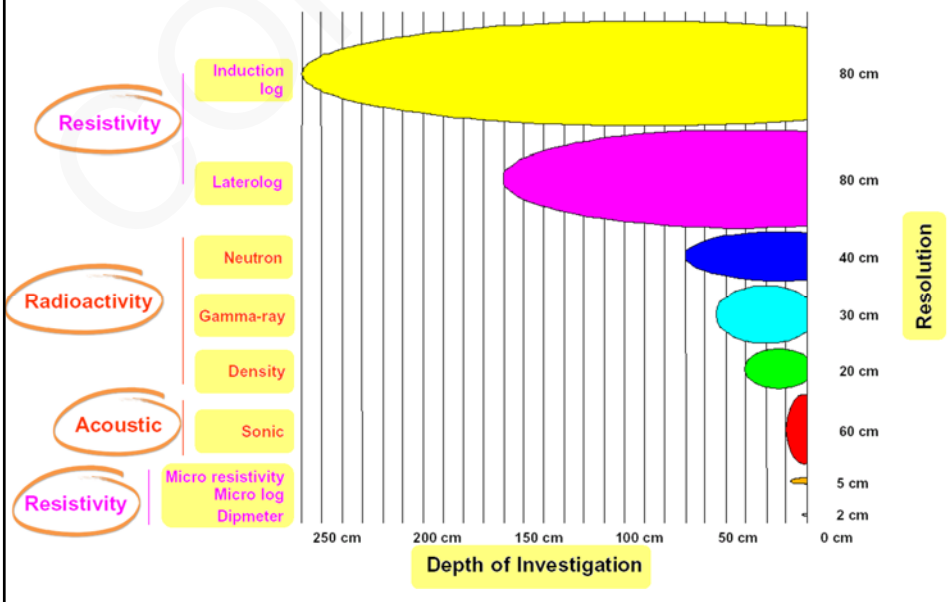
Tools utilized and brief description of operating principles

Principles of interpretation specific to tools to determine:

- Net-Gross
- Porosity
- Resistivity
- Saturation
- Permeability

Overlays, "quick-looks," and cross-plots

DEPTH OF INVESTIGATION AND RESOLUTION OF LOGGING TOOLS



READING LOG RESPONSES

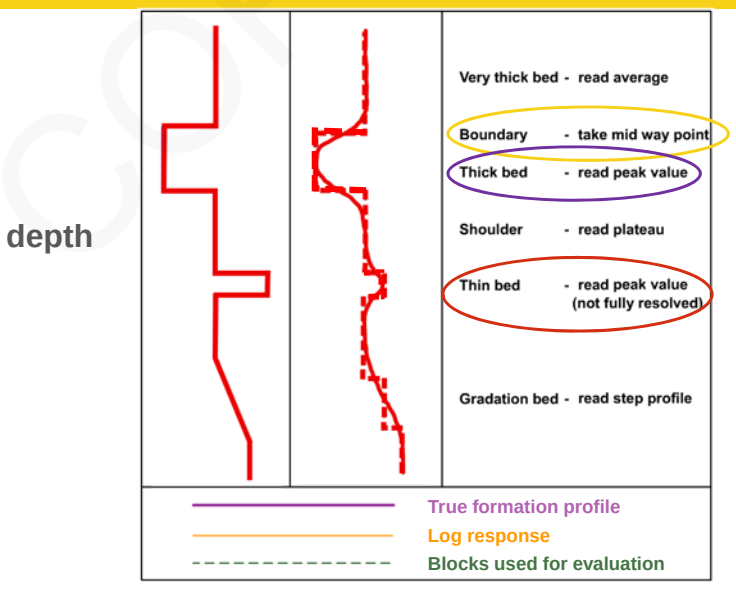
Logging tools have vertical resolution limits

Adjacent beds lithology contrasts affect log response

Quick look evaluation blocking averages readings over intervals

Block boundaries at same depth on all log curves for well evaluated

CURVE BLOCKING TO HIGHLIGHT ZONES



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