



भारतीय प्रौद्योगिकी
संस्थान
(भारतीय खनि विद्यापीठ)
धनबाद

IIT
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**INDIAN INSTITUTE
OF TECHNOLOGY**
(INDIAN SCHOOL OF MINES)
DHANBAD

GPC510 - Well logging

Semester - Winter 2023; Lecture-2

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TEACHING OUTLINE

Week 1

Tutorial 1 – Introduction, teaching overview, and assessment

Tutorial 2 – Well log definition, history, log format, types, units

Tutorial 3 – Borehole effects, environmental impacts

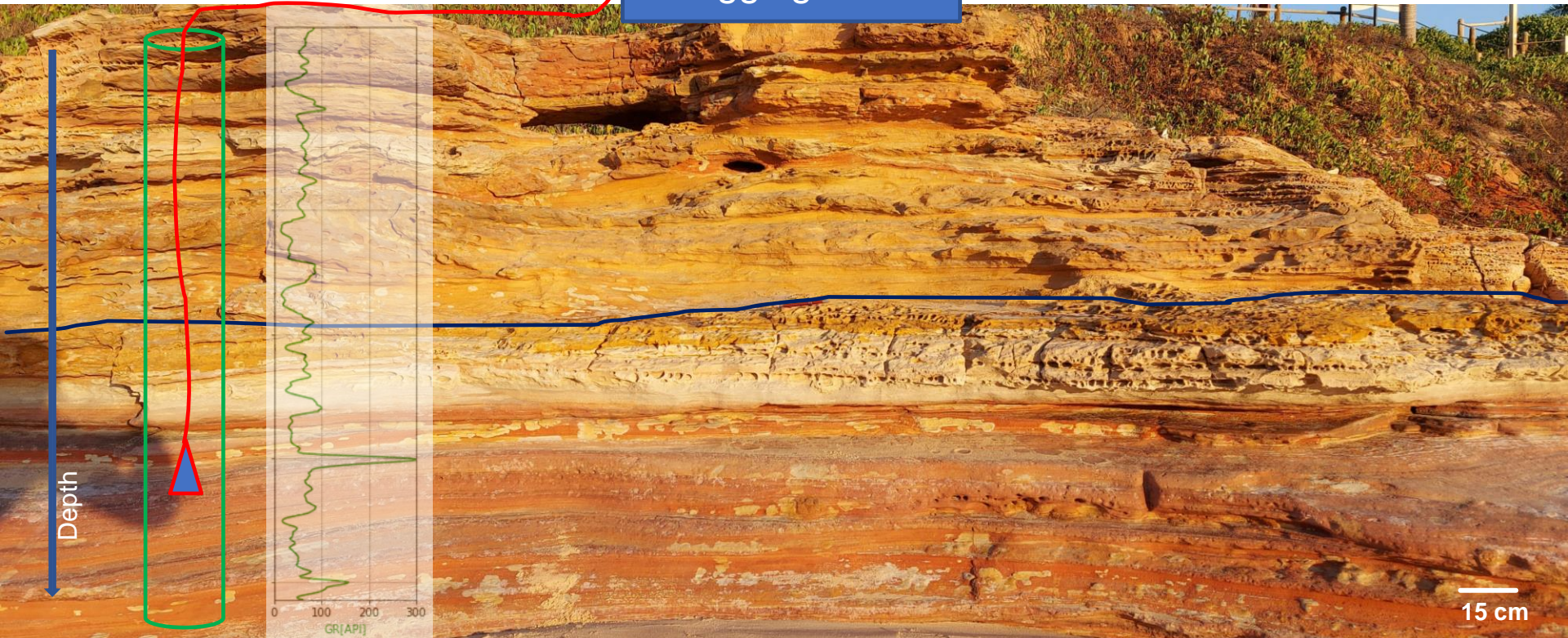
AGENDA

- Introduction
- Definition of “well-log”
- Purpose of “well-log”
- History
- Logging units and operation
- Log types
- Log format

INTRODUCTION

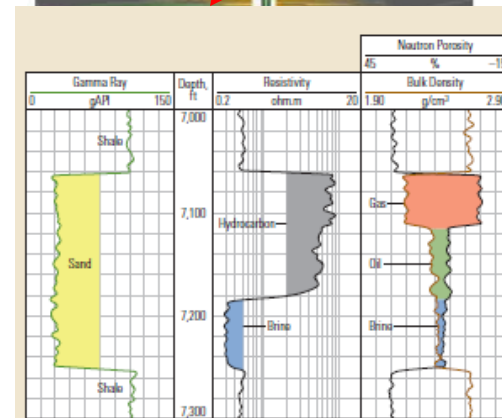
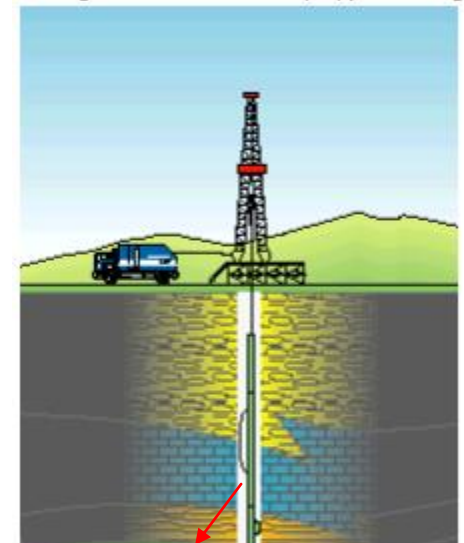
- Study of rocks – Outcrop, surface geophysics, and drilling data

Logging truck



DEFINITION – WELL-LOG

- Continuous measurement of physical properties of subsurface rock formations in a drilled bore hole
- Can be referred as “wireline logs” or “well-logs”
- Traditionally, the recording of the measurements were stored on film, gridded paper, magnetic tape, etc
- Currently all are recorded in digital format, stored in cloud platform

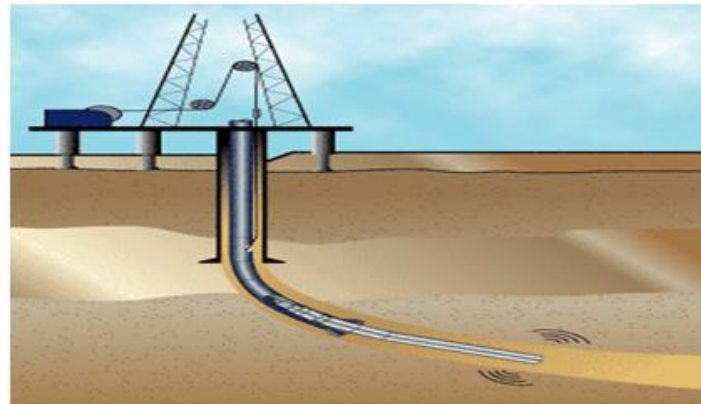
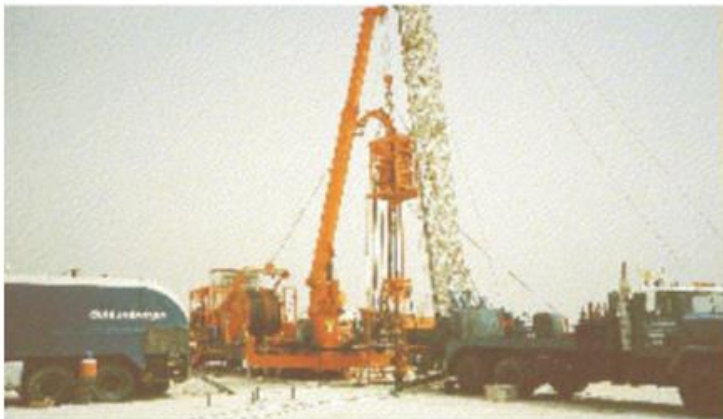


PURPOSE

- Understand geology of rock formation (composition, structure, organic content) forming sedimentary basin accumulating hydrocarbons
- Minerals grade/quality
- Geochemical characterization
- Depth to lithological boundaries
- Inter-borehole correlation
- Geological modelling
- Rock strength and in situ stress distribution
- Pore pressure estimation

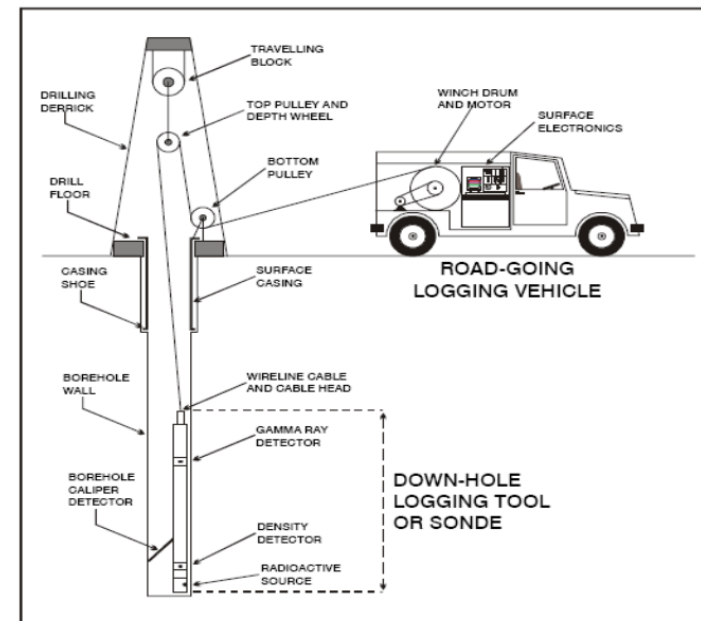
HISTORY

- First electric resistivity well-log acquired by Marcel and Conrad Schlumberger in 1927 (Location: Pechelbronn, France)
- A tool was used known as SONDE
- In 1929, commercial resistivity logging started in Venezuela, Russia and USA



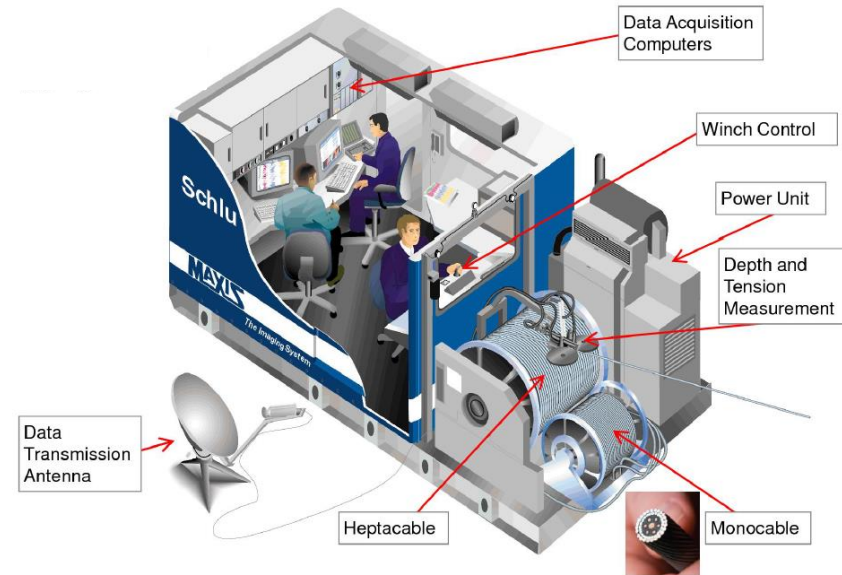
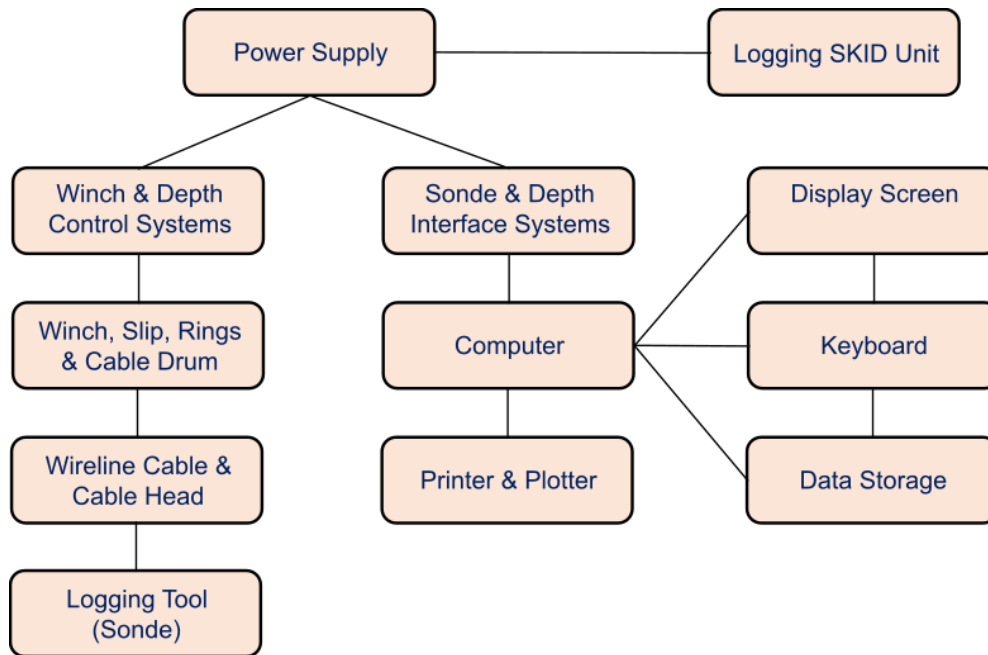
LOGGING UNITS

- Service companies use a variety of logging units (onshore or offshore) depending upon logging run. Each of the unit contains the following:
 - Logging cable/wire
 - Winch to raise and lower the cable
 - Self-contained 120-volt AC generator
 - Surface control panels
 - Set of downhole tools (sondes and cartridges)
 - Digital recording system



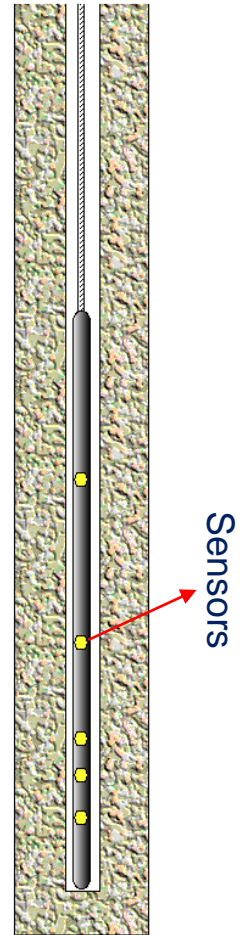
Example of a logging setup

HOW LOGGING OPERATION RUNS?

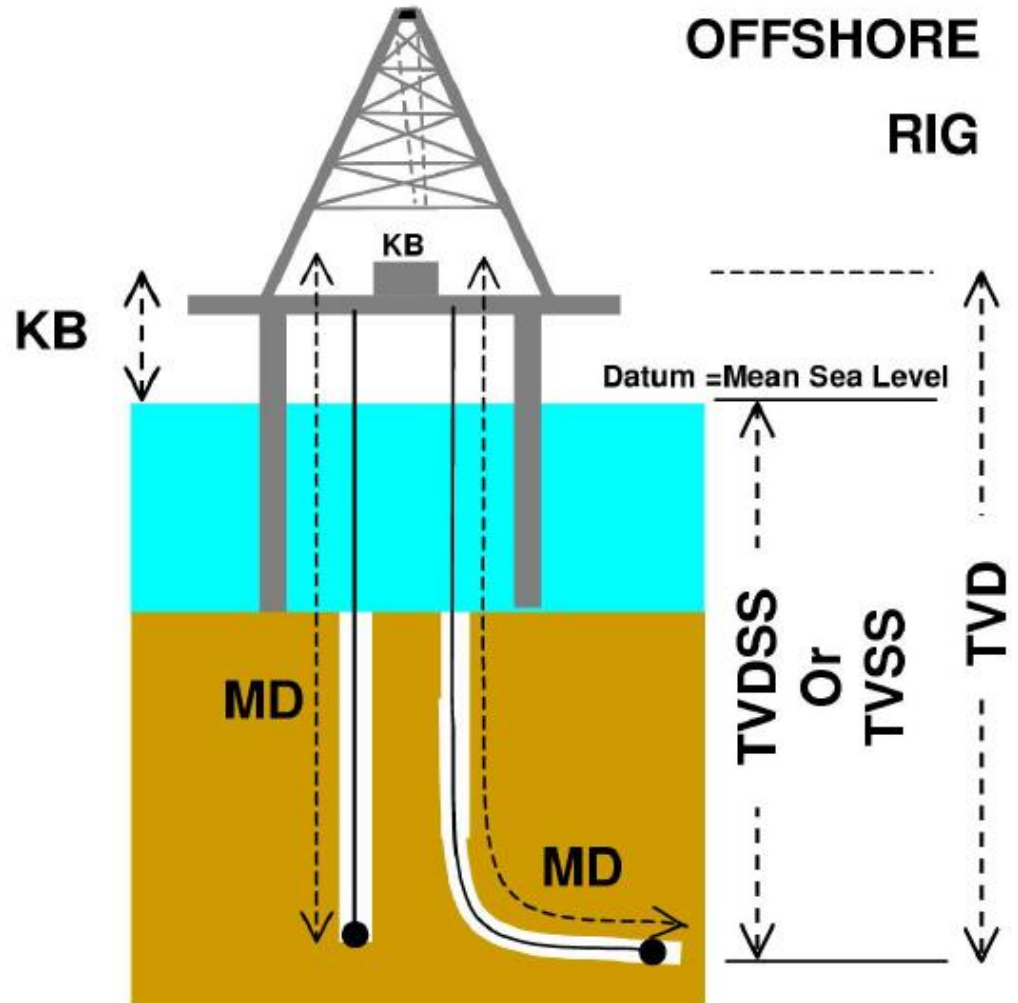
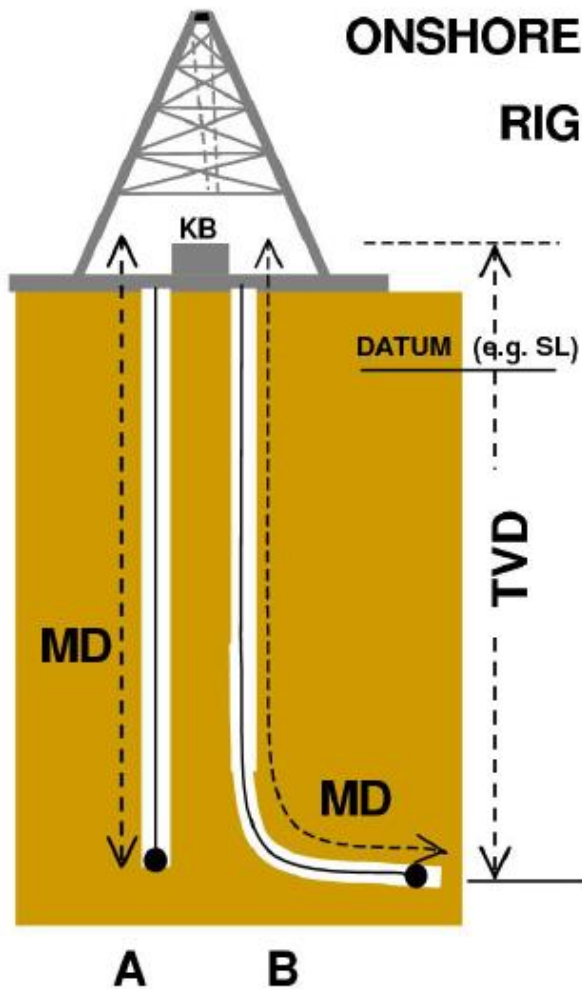


THE LOGGING RUN

- Logs are recorded when the tools are raised from bottom of the hole (easy maintenance of uniform cable tension, good depth recording)
- Total depth (TD) is measured with reference to ground level (GL) or Kelly Bushing (KL) of the drilling platform
- For an initial recording pass, the tool is raised upto 100 to 200 ft to generate “repeat section”
- The tool is lowered again to start logging “main run”
- The speed of logging tools varies (example: 1800 – 3600 ft/hr)

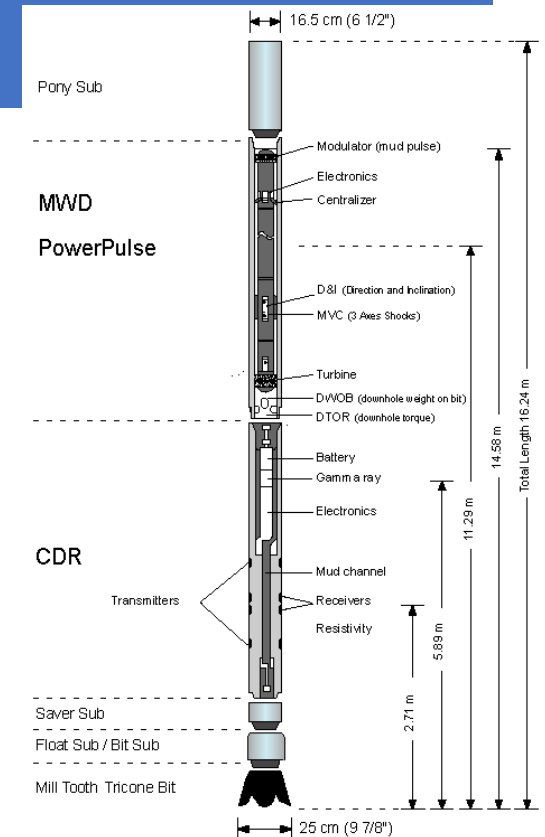


DEPTH MEASUREMENT



LWD – LOGGING WHILE DRILLING

- With the requirement of complex drilling scenario, like horizontal and directional drilling become common, logging measurement also changed
- If the drilled well-bore is beyond 60 degree, it is not possible to push the tools to retrieve physical measurement
- LWD sensors provide wireline-quality petrophysical data (resistivity, acoustic, density) while drilling
- Real time data can be transmitted via mud pulses to the surfaces which help to design well placement and drilling associated hazards
- The tool is battery powered and uses programmable read-only memory chips to store logging data until they are downloaded.
- The tool take measurements at evenly spaced time intervals and are synchronized with a system on the drilling rig that monitors time and drilling depth.



TOOLS CLASSIFICATION

- Measurements are grouped into two types: (i) natural phenomena (passive system) (ii) induced phenomena (source + detector (s))

Tool Types	Schlum.	W. Atlas	
Induction and/or Resistivity devices	DIL/DLL	DIFL/DLL	
Micro resistivity	MSFL	ML	
Litho-density and Neutron porosity	LDT/CNL	CDL/CNL	
Acoustic	LSS	ACL	
Caliper	CAL	CAL	
Natural gamma	GR	GR	Passive
Spontaneous potential	SP	SP	
Dipmeter	SHDT	HRDIP	
Pressure testing devices	RFT	FMT	
Rock and fluid sampling devices	CST	SWC	

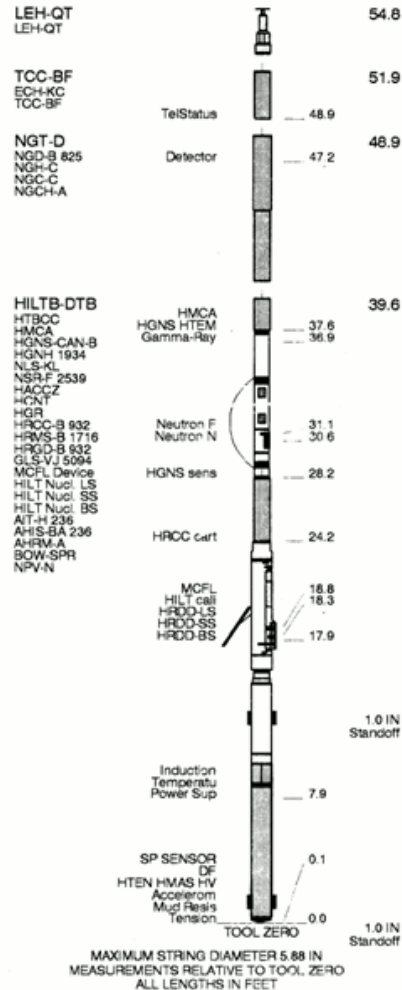
LOG FORMAT

- At the top of the log is the header which records all necessary information required for data interpretation
- Main part contains the curves recorded during “main run” [log columns are referred as Track 1, 2, 3 etc]
- Curves are displayed either in linear or logarithmic scale
- Tail end of the log contains “repeat run” as quality control
- Log is ended with calibration part associated with the tests on the tools of that borehole

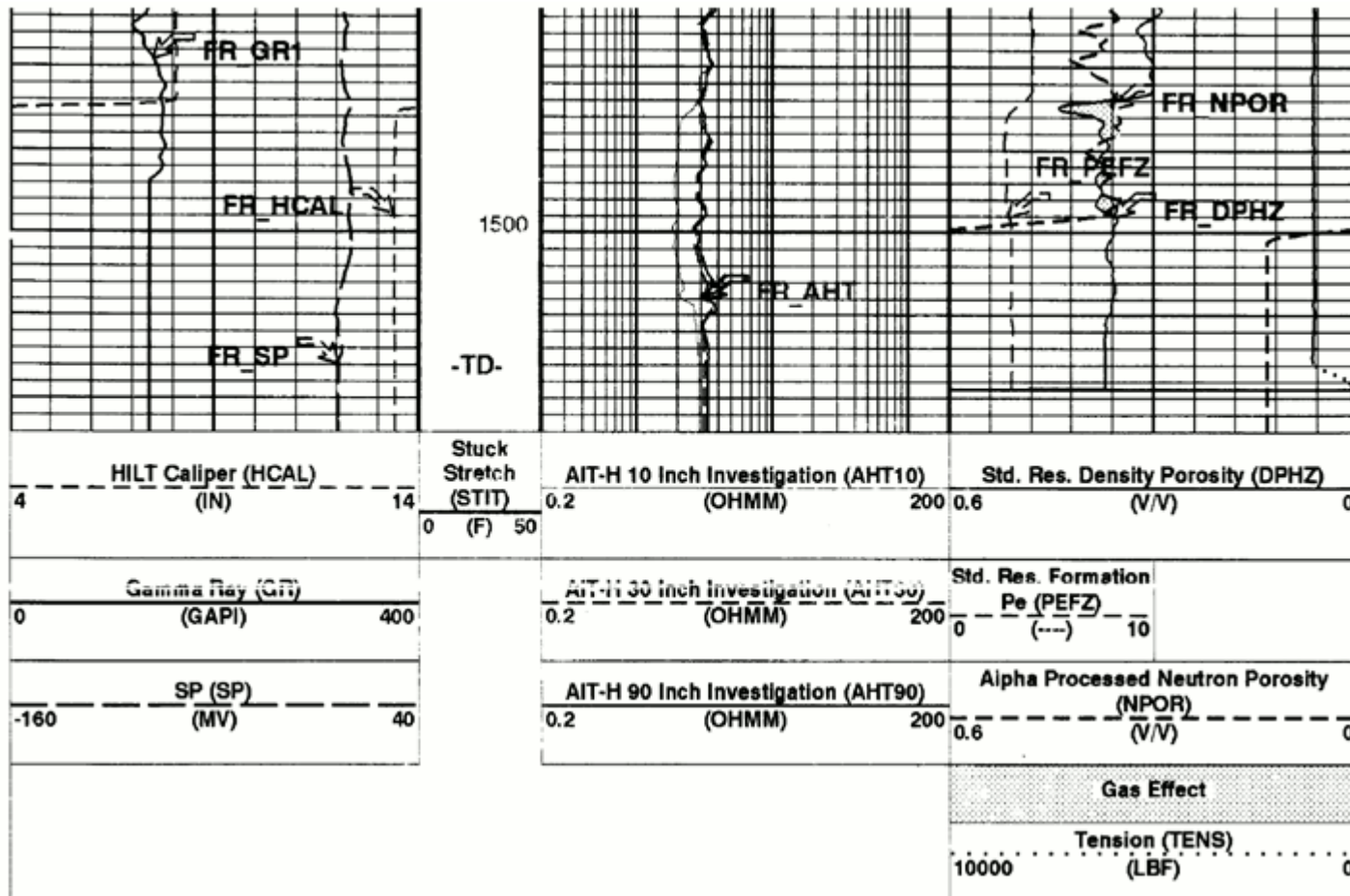
well information		operator well name location		
Other surveys				
well information logging unit personnel				
remarks				
equipment numbers				
scales & curves				
Track 1	Track 2	Track 3	Depth	
main log section				
scales & curves				
repeat run				
calibrations				

LOG HEADER - EXAMPLE

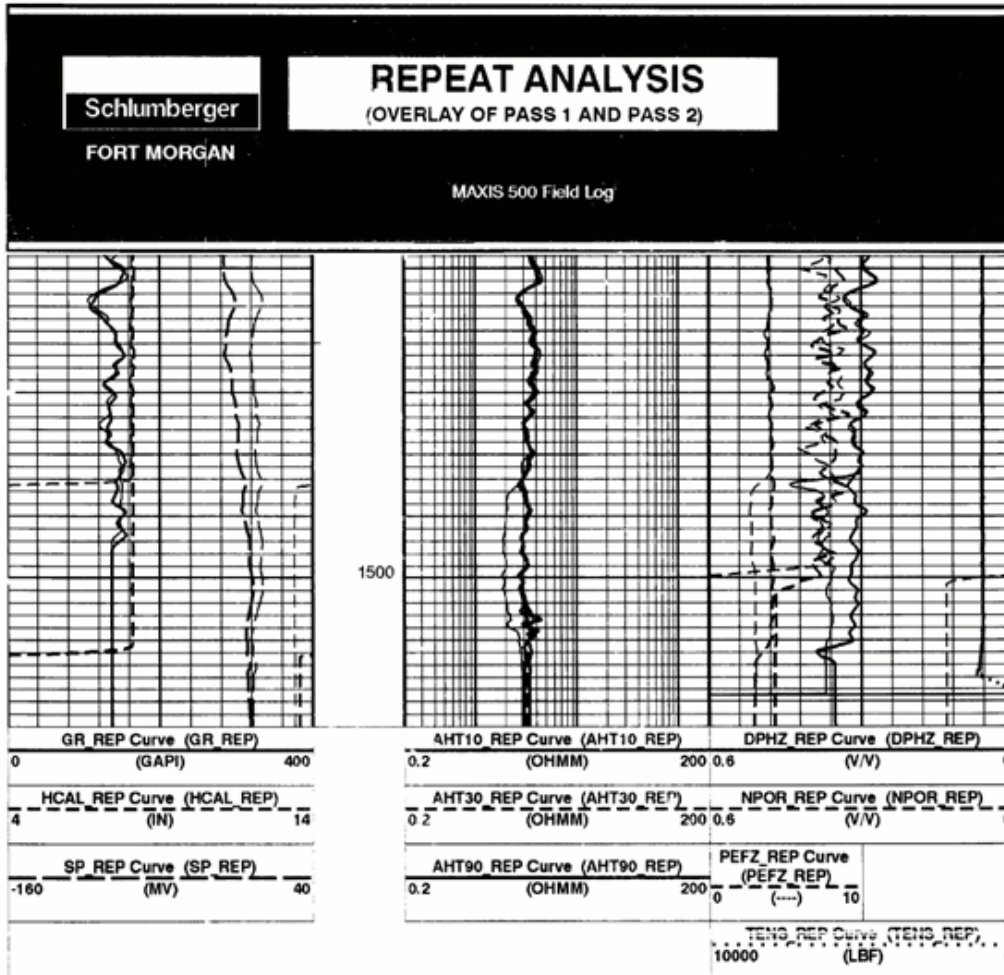
Schlumberger			
Company: Bill Barrett Corporation			
Well: Helman P 12-24			
Field: Wildcat			
County: Sherman		State: Kansas	
Platform Express			
Triple Combo			
NE NW SW Sec 24 T6S R40W 2514' FSL & 782' FWL		Elev.: K.B. 3633 ft G.L. 3627 ft D.F. 3632 ft	
Permanent Datum: Ground Level		Elev.: 3627 ft	
Log Measured From: Kelly Bushing		6.0 ft above Perm. Datum	
Drilling Measured From: Kelly Bushing			
API Serial No. 15-181-20639-00-00	Section 24	Township 6S	Range 40W
Logging Date 23-Mar-2005	Run Number One	RECEIVED OCT 20 2005 KCC WICHITA	
Depth Driller 1520 ft	Schlumberger Depth 1516 ft		
Bottom Log Interval 1508 ft	Top Log Interval 431 ft		
Casing Driller Size @ Depth 6.625 in @ 428 ft	Casing Schlumberger 431 ft		
Bit Size 7.875 in	Type Fluid In Hole KCL Polymer		
Density 8.7 lbm/gal	Viscosity 42 s		
Fluid Loss 7 cm3	PH 7		
Source Of Sample AIT Mud Sensor	RM @ Measured Temperature 0.138 ohm.m @ 42 degF		
RMF @ Measured Temperature 0.110 ohm.m @ 42 degF	RMC @ Measured Temperature 0.166 ohm.m @ 42 degF		
Source RMF Calculated	RMC Calculated		
RM @ MRT 0.088 @ 70	RMF @ MRT 0.070 @ 70		
Maximum Recorded Temperature 70 degF	Circulation Stopped 23-Mar-2005		
Logger On Bottom 23-Mar-2005	Time 11:30		
Unit Number 3055	Location Ft. Morgan, CO		
Recorded By Max Phoon, Clayton Wong	Witnessed By Curtis Ditzell		



LOG TAIL - EXAMPLE



REPEAT SECTION- EXAMPLE



END OF LECTURE

data collection



H_2 - CH_4 blend
Underground
Storage Reservoir



Geochemistry
analysis



DNA analysis



Subsurface
simulation
experiments

Thank you

Acid formation (H^+ , H_2S)