Well Logging

Chapter(2)/Coring –Types of logging

Dr.Abdulhussien N.Alattabi

College Of Petroleum Engineering/Alayen University

Defining Coring

Getting to the core of the matter

Most data used by exploration and development teams to describe the earth hundreds or thousands of meters below the surface are from indirect methods such as wireline or while-drilling logging tools. Although both sophisticated and invaluable to operator planning, logging measurements are subject to analysis and calibration and are limited as to how finely they can divide and measure the earth.

The only way to directly measure the earth's subsurface is by analyzing samples, or cores, that engineers extract from the formation using special bits or wireline-conveyed coring tools. Once the cores are cut, they are captured and retrieved to the surface.

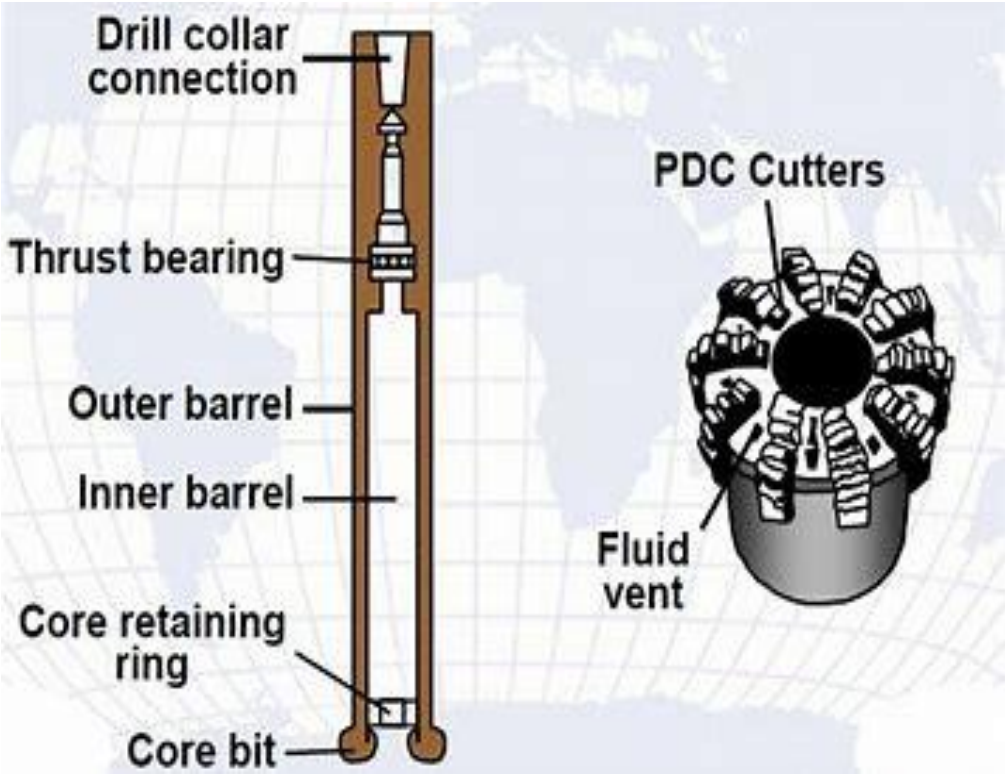
These cores are transported intact to laboratories located around the world to provide ground truth for calibration of well logs and to reveal variations in reservoir properties that might be undetectable through downhole logging measurements alone. Analysts use cores to characterize pore systems in the rock and model reservoir behavior to optimize production based on the analysis of core porosity, permeability, fluid saturation, grain density, lithology, and texture.

Conventional cores, also known as whole cores, are continuous sections of rock extracted from the formation during otherwise standard drilling operations. The coring bit is hollow so that as it cuts through the formation it creates and captures a solid cylinder of rock that can be brought to the surface as a single piece.

Sidewall cores (SWCs) are plugs of rock cut from the wellbore wall. These cores are usually acquired by wireline-conveyed tools; SWC operations are less expensive and time-consuming than those of conventional coring and can recover cores from multiple zones of interest in a single wireline run. Because SWCs are typically obtained after logging tools have been run, geologists can use log measurements to pick the depths at which the SWCs should be taken.

An article in the May 2015 issue of *Oilfield Review* "Defining Coring: Getting to the Core of the Matter" focuses on the basics of coring and describes the tools and methods operators use to retrieve cores from the Earth's subsurface.

The Defining Series provides E&P professionals with concise, authoritative, up-to-date summaries of a wide range of industry topics.



Fig(1) Parts of Coring instrument

Fig(2):

I. **Cores Stores**  **in the box.**

Coring

- One way to get more detailed samples of a formation is by coring, where formation sample is drilled out by means of special bit.
- This sample can provide:
  - Detailed lithological decscription.
  - Porosity, permeability, and fluid saturation.
- These parameters are measured in the laboratory and serve as a basis for calibrating the response of the porosity logging tools and to establish a porosity/permeability relationship.

- Two techniques commonly used at present. The first is the "whole core", a cylinder of rock, usually about 3" to 4" in diameter and up to 50 feet (15 m) to 60 feet (18 m) long.
- Taking a full core is an expensive operation that usually stops or slows drilling operation, and can be done only before the drilling has been done.

Coring Tool & Core Barrel

Coring

- The other, cheaper, technique for obtaining samples of the formation is "Sidewall Coring". In this method, a steel cylinder—a coring gun—has hollow-point steel bullets mounted along its sides and moored to the gun by short steel cables.
- The coring gun is lowered to the bottom of the interval of interest and the bullets are fired individually and the core will be retrieved.
- Advantages of this technique are low cost and the ability to sample the formation after it has been drilled.

Core Preservation

- Once the core is retrieve to surface then it is important that it should remain as unchanged as possible.
- The core should be prevented from drying out, coming into contact with oxygen or being mechanically damaged.
    - Core barrel is filled with resin to prevent the core from moving and to minimize the exposed surface area.
    - Freezing the core in freezer containers.
    - Core sample is wrapped in a plastic film, aluminium foil and then dipped in molten wax.

Core Analysis

Can be divided into two categories:

- Conventional Core Analysis.
- Special Core Analysis.

Conventional Core Analysis.

- The core is usually slabbed, cut lengthwise to make the structure visible.
- Provides information on lithology, residual fluid saturation, ambient porosity, ambient gas permeability and grain density.

Core Analysis

❖ **Special Core Analysis :**

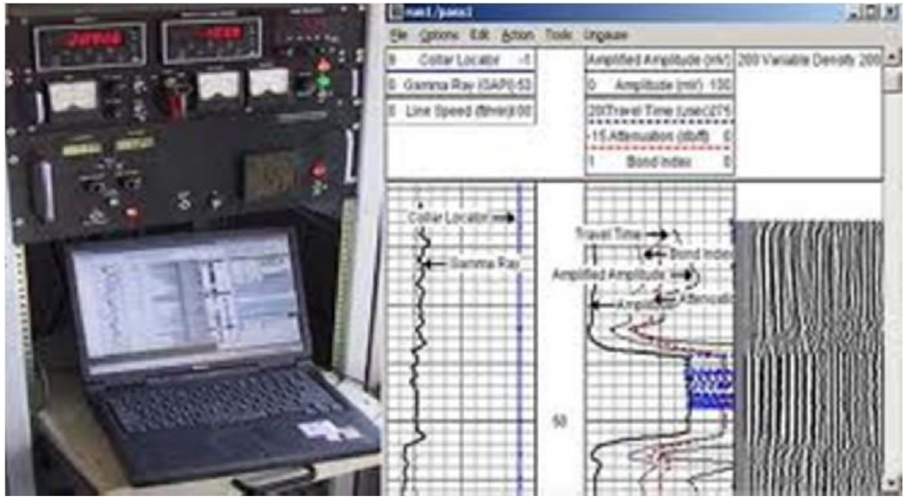
Provides the following information:

- Porosity and permeability at elevated confining stress.
- Electrical properties such as formation factor and resistivity index.
- Capillary pressure.
- Wettability and relative permeability.
- Mechanical rock properties such as compressibility.
- Waterflood sensitivity for injectivity and well performance.

- Waterflood sensitivity for injectivity and well performance.

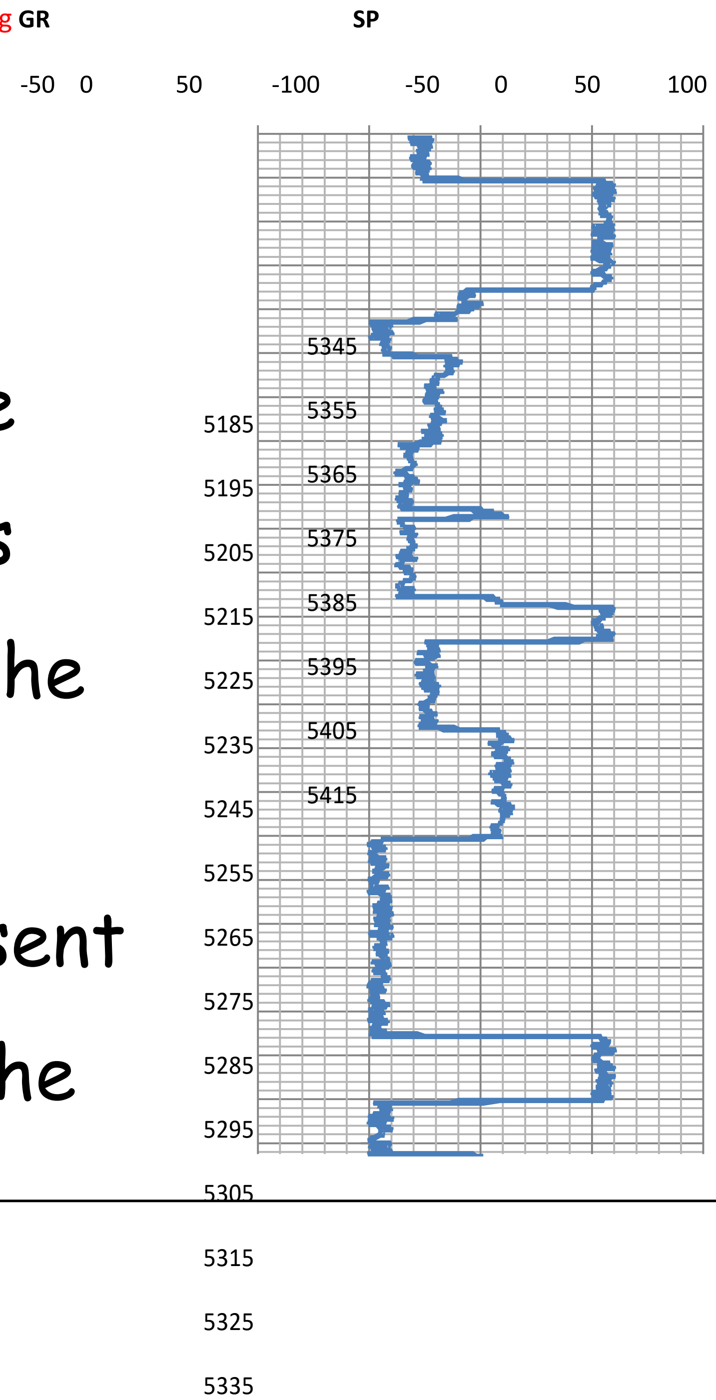
II. Open-hole Logging

- Open-hole logging, also known as well logging is the practice of making a detailed record (a *well log*) of the geologic formations penetrated by a borehole.
- Open hole logs are run before the oil or gas well is lined with pipe or cased



Principal of Well Logging

- A well log is a record of certain formation data versus depth.
- The appropriate downhole logging tools instrument called 'sonde', about 3.5 inches in diameter is lowered into mud-filled hole on logging cable.
- This tools will measure the electrical, acoustic, and radioactive properties of the formation.
- The result will be analyzed to determine which of the layers are porous and permeable, and likely to contain hydrocarbon.
- A depth calibration wheel records the length of cable in the hole.



- Survey is normally done from the bottom up. As the sonde is pulled up the hole, a continuous measurement signal is sent to the surface where the data is processed and recorded as a curve.

Types of boreholes

- *According to Casing operation*

➢ Cased holes

➢ Open holes

- *According to conductivity of the borehole*

✓ Conductive (water base drilling mud)

✓ Non-conductive boreholes (oil base mud, air drilled or cased holes)

Types of well logs

Wireline logs

(Electrical, Radioactive, Acoustic, mechanical, Thermal and Magnetic logs)

Formation Testers

(Repeated Formation Tester, Drill Stem Tests)

Types of Well Logging

Well logging is classified into three broad categories:

- Open Hole Logging
- Cased Hole Logging
- Production Logging

Open Hole Logging

Logging surveys taken before the hole is cased are called open hole logs. The logs included in this group are:

- Electrical surveys (induction, laterolog and microlog logs).
- Sonic logs. Caliper Logs.
- Dipmeter Logs. SP logs
- Radioactive surveys (density, neutron and gamma ray logs).

Electrical Logs

Electrical logs (Induction, laterolog, and microlog) measure the electrical properties of the formation along with the formation fluids.

Sonic/ Acoustic Logs

Sonic logs measure the elastic or (sound) wave Sonic logs measure the elastic or (sound) wave properties of the formation.

Caliper Logs

Caliper logs measure the size or geometry of the hole.

Dipmeter Logs

Dipmeter logs measure dip of the formations.

SP Logs

SP logs measure potential different between a shale-sand or shale-carbonate due to difference salinity of formation water shale-carbonate due to difference salinity of formation water and mud filtrate.

Radioactive Logs

Gamma ray & neutron logs measure radioactive and neutron absorption properties. Density logs measure electron density of

the formation which is related to formation density.

Cased Hole Logging

Logging surveys taken after the casing is lowered are usually categorized as cased hole logs. The surveys included in this group are:

- ❖ Gamma Ray
- ❖ Neutron
- ❖ Temperature
- ❖ Cement Bond Log

Some of these surveys like the gamma ray, neutron and temperature logs can be run in both open and cased hole wells.

Production Logging

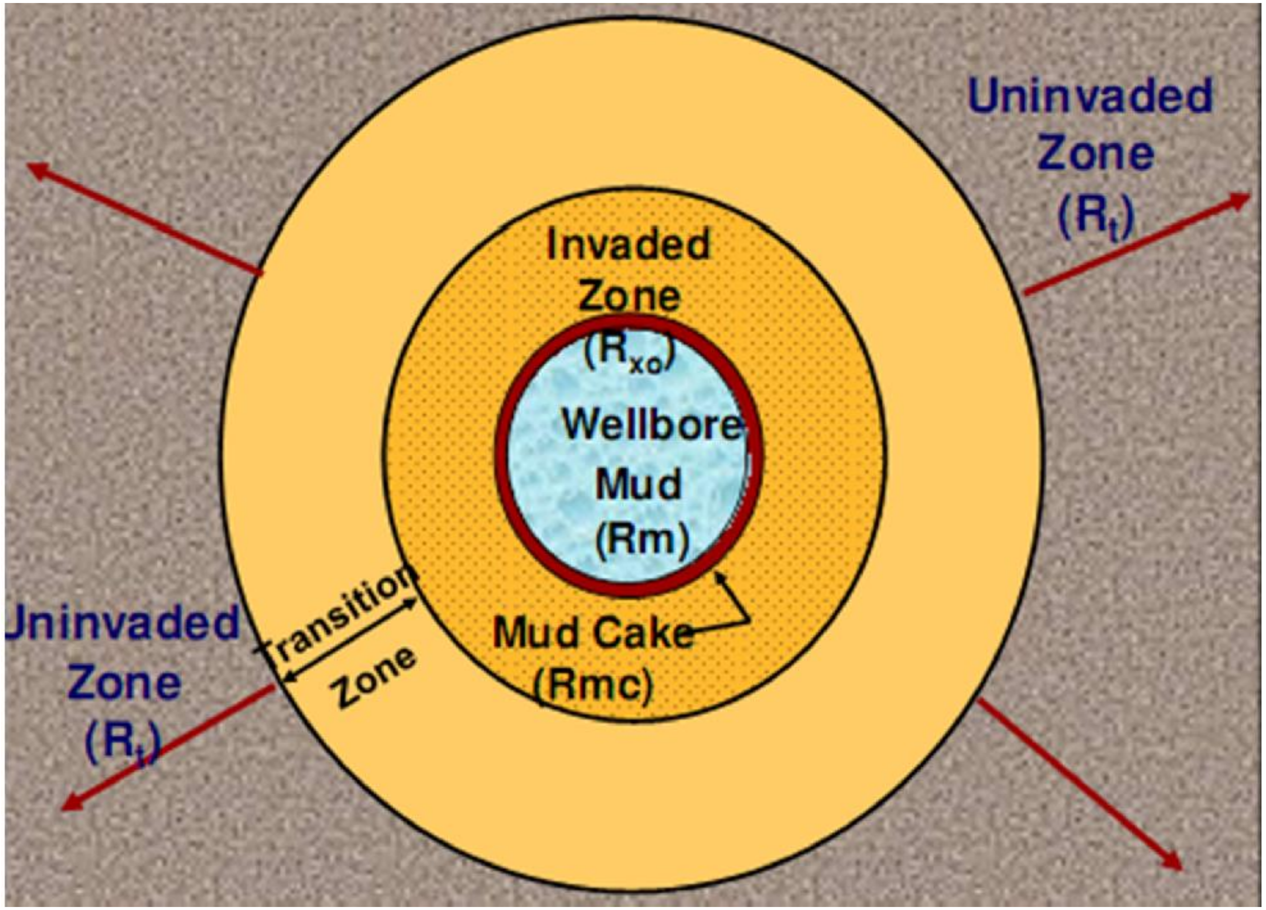
Well logging surveys taken to improve production or repair the well are termed as production logs. Surveys included in this category are:

- Flowmeter
- Pressure
- Temperature
- Fluid Density

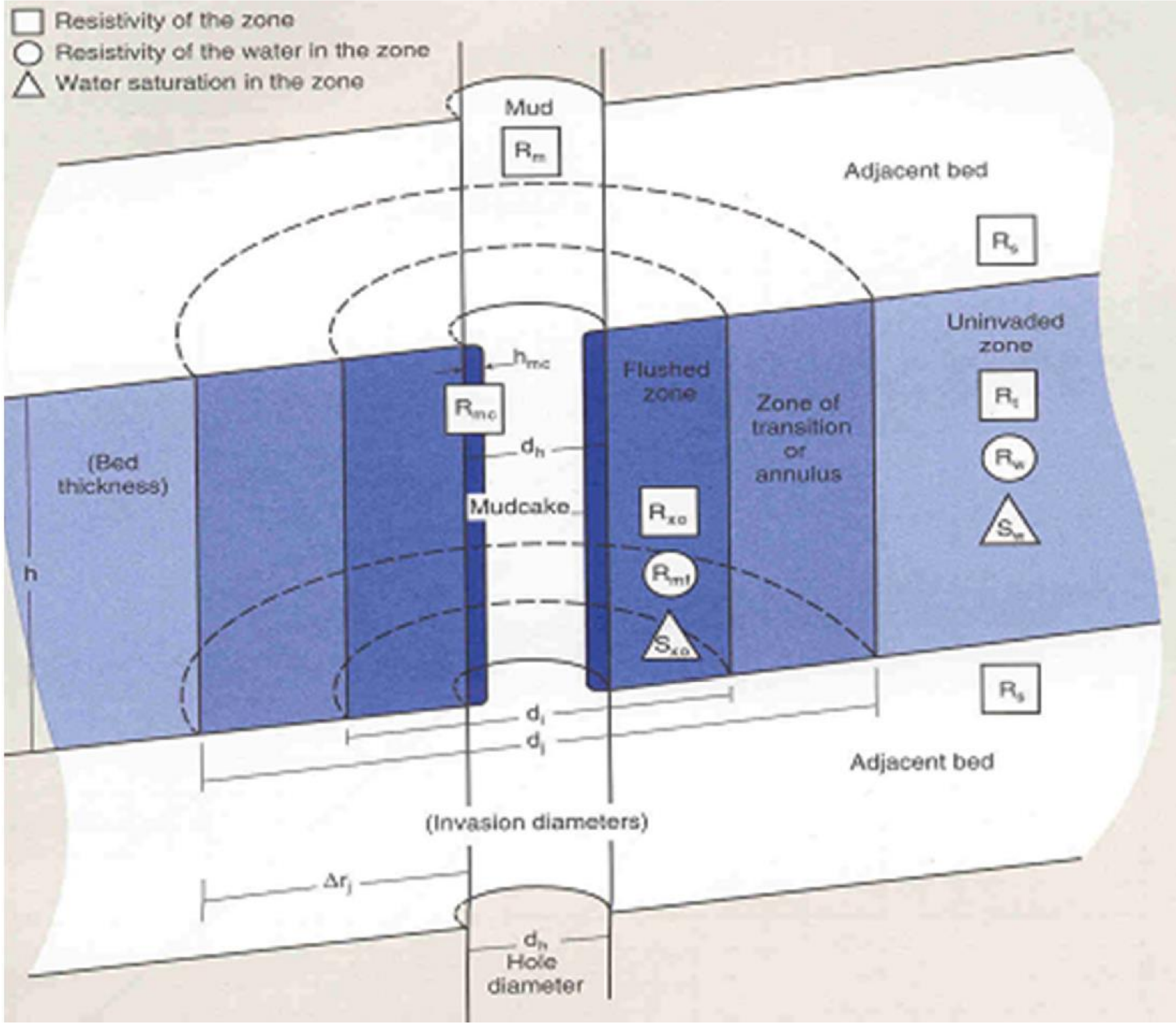
Petrophysical Logging Tools

Log Type	Tool Type	Physical Measurement	Derived Parameter	Interpreted Parameter
Resistivity				
-Induction	Array	Voltage (V)	R_t	S_w
-Laterolog	Array	V and Current (I)	R_t	S_w
-Micro laterolog	Pad	Current	R_{xo}	S_{xo}
Acoustic				
- Sonic	Array	Transit Time	PHI_s	Lithology
Nuclear				
-GR (Density)	Pad	Gamma Ray	RHO_B, PHI_D	Lithology
- Neutron	Mandrel	Neutron	RHO_N	Lithology
Auxiliary				
-Natural GR	Mandrel	Gamma Ray	None	V_{sh}
-SP	Electrode	mV	None	V_{sh}
-Caliper		(*various)	D_h, Volume	

MUD FILTRATE INVASION

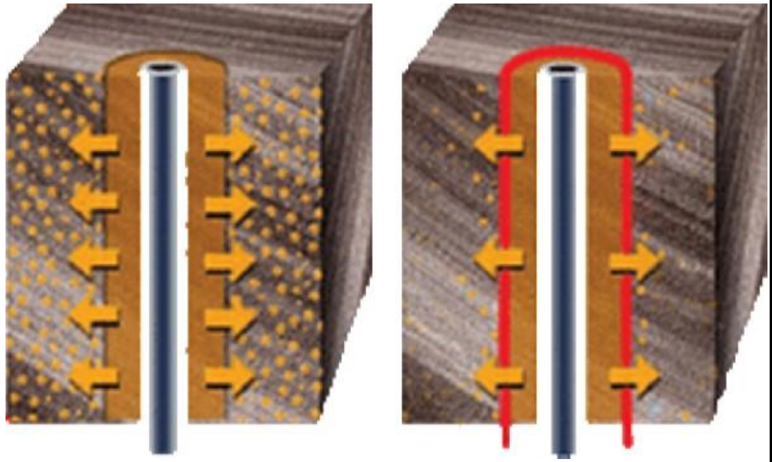


MUD FILTRATE INVASION



COMMON TERMINOLOGY

Borehole



- **Rm** : Borehole mud resistivity
- **Rmc** : Mudcake resistivity

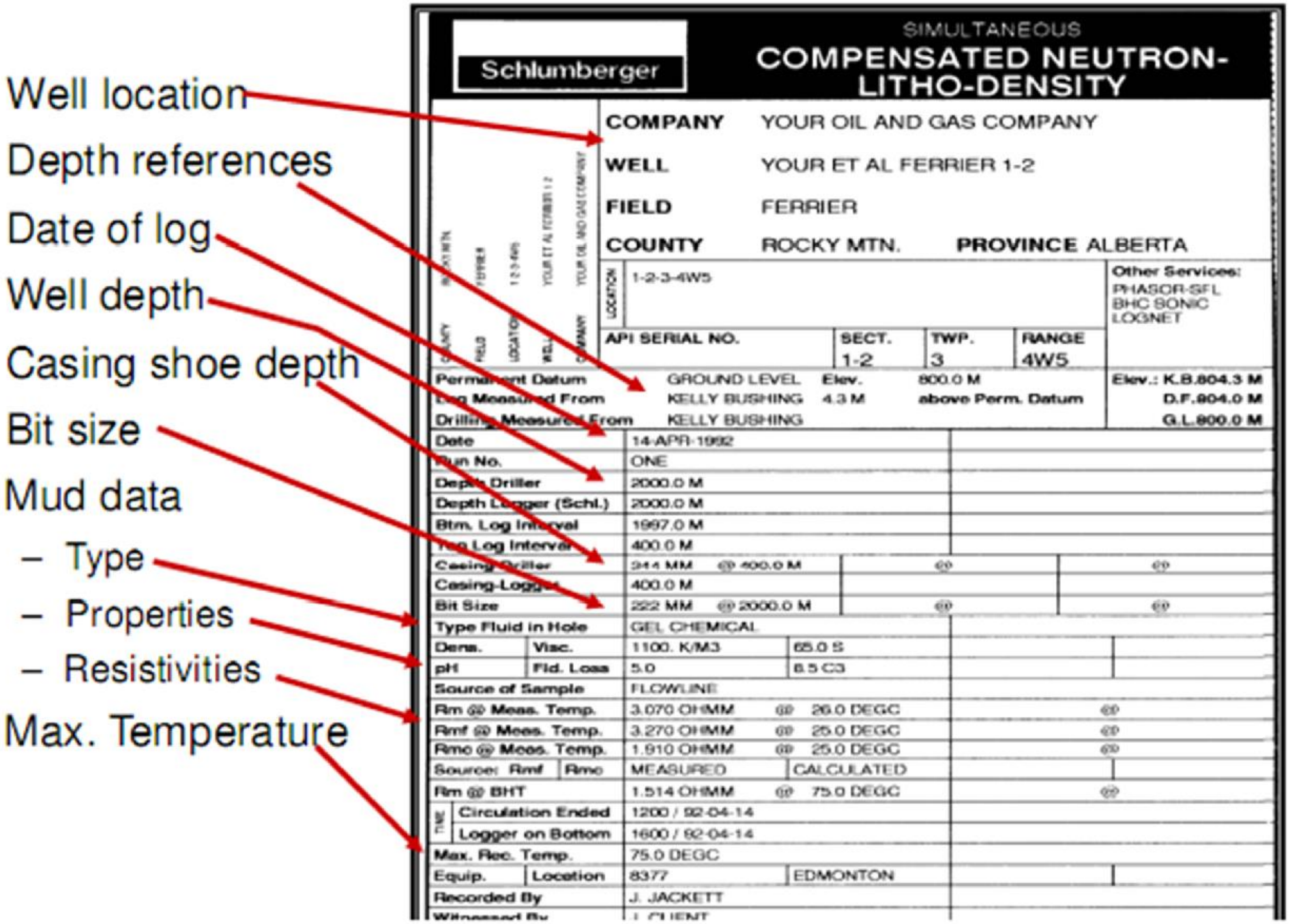
Invaded zone

- **Rmf** : Mud filtrate resistivity
- **Rxo** : Invaded zone resistivity
- **Sxo** : Invaded zone water saturation

Uninvaded zone

- **Rw** : Interstitial water resistivity
- **Rt** : Uninvaded zone resistivity
- **Sw** : Uninvaded zone water saturation

LOG PRESENTATION - THE HEADING



Schlumberger

SIMULTANEOUS
COMPENSATED NEUTRON-
LITHO-DENSITY

COMPANY	YOUR OIL AND GAS COMPANY		
WELL	YOUR ET AL FERRIER 1-2		
FIELD	FERRIER		
COUNTY	ROCKY MTN.	PROVINCE	ALBERTA

LOCATION 1-2-3-4W5

Other Services: PHASOR-SFL, BHC SONIC, LOGNET

API SERIAL NO.	SECT.	TWP.	RANGE
	1-2	3	4W5

Permanent Datum	GROUND LEVEL	Elev. 800.0 M		Elev.: K.B.804.3 M
Log Measured From	KELLY BUSHING	4.3 M	above Perm. Datum	D.F.804.0 M
Drilling Measured From	KELLY BUSHING			G.L.800.0 M

Date	14-APR-1992		
Run No.	ONE		
Depth Driller	2000.0 M		
Depth Logger (Schl.)	2000.0 M		
Btm. Log Interval	1997.0 M		
Top Log Interval	400.0 M		
Casing Driller	244 MM @ 400.0 M	@	@
Casing-Logger	400.0 M		
Bit Size	222 MM @ 2000.0 M	@	@
Type Fluid in Hole	GEL CHEMICAL		
Dens. / Visc.	1100. K/M3	65.0 S	
pH / Fld. Loss	5.0	8.5 C3	
Source of Sample	FLOWLINE		
Rm @ Meas. Temp.	3.070 OHMM @ 26.0 DEGC		@
Rmf @ Meas. Temp.	3.270 OHMM @ 25.0 DEGC		@
Rmc @ Meas. Temp.	1.910 OHMM @ 25.0 DEGC		@
Source: Rmf / Rmc	MEASURED	CALCULATED	
Rm @ BHT	1.514 OHMM @ 75.0 DEGC		@
TIME Circulation Ended	1200 / 92-04-14		
TIME Logger on Bottom	1600 / 92-04-14		
Max. Rec. Temp.	75.0 DEGC		
Equip. / Location	8377	EDMONTON	
Recorded By	J. JACKETT		
Witnessed By	J. CLIENT		