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BASIC WELL LOGGING SERVICE AND TOOLS IN OIL AND GAS INDUSTRY

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Abstract: Well logging, also known as borehole logging is the practice of making a detailed record (a well log) of the geologic formations penetrated by a borehole. The log may be based either on visual inspection of samples brought to the surface (geological logs) or on physical measurements made by instruments lowered into the hole (geophysical logs). Some types of geophysical well logs can be done during any phase of a well's history: drilling, completing, producing, or abandoning. Well logging is performed in boreholes drilled for the oil and gas,groundwater, mineral and geothermal exploration, as well as part of environmental and geotechnical studies.

Index Terms **- Oil, Hole, Drilling, Minerals etc.**

I. INTRODUCTION

1. WELL LOGGING

Well logging, also known as borehole logging is the practice of making a detailed record(a well log) of the geologic formations penetrated by a borehole. The log may be based either onvisual inspection of samples brought to the surface (geological logs) or on physical measurements made by instruments lowered into the hole (geophysical logs). Some types of geophysical well logs can be done during any phase of a well's history: drilling, completing, producing, or abandoning. Well logging is performed in boreholes drilled for the oil and gas, groundwater, mineral and geothermal exploration, as well as part of environmental and geotechnical studies. Well log is a continuous record of measurement made in bore hole, in response to variation in some physical properties of rocks through which the bore hole is drilled. Traditionally Logs are display on grid papers. Now the log may be taken as films, images, and in digital format. The Logging service companies utilize a wide variety of logging units, depending on location (onshore or offshore) & requirements of the logging run. Each unit will contain many components such as logging cable, winch to raise and lower the cable in the well, self-contained 120-volt AC generator, set of surface control panels, down-hole tools (sonde and cartridges) and digital recording system. The entire process involves the application of many electronic systems and it gives key information which helps in litho logy and minerals grade/quality identification, inter-borehole correlation, structure mapping, dip determination, in-situ stress orientation, porosity calculation and fluid salinity determination. Electric line is the common term for the armored, insulated cable used to conduct current to down-hole tools used for well logging.

2. WELL LOGGING OBJECTIVES:

Well logs or wire line logs are continuous readings of well depth versus different petro physical characteristics of the rock trough which the well is drilled.
The main purpose of well logging is:

- To provide data for evaluating petroleum reservoirs.
- To aid in testing, completion and repairing of the well.
- To calculate the oil reserve in an oil pool we need to know the following
- Thickness of the oil-bearing formation.
- Porosity of the formation.
- Oil saturation.
- Lateral extent of the pool.

3. **TYPES OF WELL LOGGING:**

Well logging is classified into three broad categories:

- Open Hole Logging
- Cased Hole Logging
- Production Logging

Open hole logging:

Open hole logging operations or reservoir evaluation, involves the deployment of tools into a freshly drilled well. As the tool string traverses the wellbore, the individual tools gather information about the surrounding formations. A typical open hole log will have information about the density, porosity, permeability, lithology, presence of hydrocarbons, and oil and water saturation. Logging surveys taken before the hole is cased are called open hole logs. The logs included inthis group are:

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

Cased Hole Logging:

Cased-hole well logging has long been a bag of disparate sensors and services to measure downhole flow, casing condition, cement integrity or formation properties. While in the past nearly all of these measurements have been detrimentally affected by the generally unknown conditions of the borehole environment, recent breakthroughs point to a better understanding of this area. Logging surveys taken after the casing is lowered are usually categorized as cased holelogs. The surveys included in this group are:

- Gamma Ray
- Neutron
- Temperature
- Chlorine
- Pulsed Neutron
- Cement Bond Log Tracer Logs

Production Logging:

Production logs are used to evaluate fluid production and movement both inside and outside of the casing downhole. The production logging tools are small in diameter and are run through tubing for evaluation of the well as it is producing. Well logging surveys taken to improve production or repair the well are termed asproduction logs. Surveys included in this category are:

- Flowmeter
- Pressure
- Temperature Noise
- Capacitance
- Fluid Density
- TDT
- RST

The main applications of the production logs include:

- Locating sources down hole of undesired fluid phase production such as water entries
- Isolating mechanical problems such as leaking pipes, leaking packers, and fluid movement in cement channels behind pipe
- Evaluating the effectiveness of well treatment or work over operations by comparing the before and after job surveys
- Accumulating baseline well performance information for comparison with later monitor surveys
- In EOR projects, maintaining injection efficiency by evaluating the injection profiles of individual wells in a field

LOGGING CABLES:

The logging cable is an integral and important part of the logging system that helps to suspend and hold the sonde in the length of borehole at the desired depth. Apart from it, logging cable is a system that uses cables to transport material from the woods to the landing surface. The logging cable acts as a conductor for electrical signals to and from the sonde to the surface. Furthermore, logging cable is a form of downhole cable which is used for monitoring well in the oil and gas sector. The logging cable is distributed over a measuring heave between the well and winch.

Functions:
1. Running in and pulling out the tool and control of tool speed.
2. Electrical interface between the downhole logging tool and the surface processing andrecording equipment
3. Depth measurement.

Modern logging cables are of two types:

- Mono-conductor cables
- Multiconductor cables.

Mono-conductor Cables:

Mono-conductor cables are mainly used for completion services such as shooting perforating guns, setting wire line packers and plugs and for production logging services such as flow meters, temperature, and pressure and density logs in producing wells. Mono-conductor cables are usually 0.25-0.5 inch in diameter. The smaller diameters are used where high well head pressure is used.

Fig: Mono-conductor Cables

Multiconductor Cables:

Multiconductor cables are mainly used for open hole logging services. These are slightlylonger in diameters and contain individual In related conductors in the core. Multiconductor cables have a bearing strength near 18000 16. A type Charmscombe 0 or 7/16" in diameter.

Fig: Multiconductor Cables

THE LOGGING TOOL:

Logging tools vary in complexity from a simple electrode carrying mandrel to a sophisticated system of electronic circuits, enclosed in a pressure resistant metal housing and capable of operating at high temperatures. The sonde is generally attached below an electronic cartridge, which carries in a protective housing the electronic modules or hardware for the down hole instrument. Where several tools are being run in combination each of the sondes and cartridges in the tool string has a pass through facility for the signals to or from tools lower in thestring. Each sonde-cartridge set can be connected electrically and mechanically to the bridal orcable head by a quick connect system consisting of pins and sockets and a thread ring.

Centralizers or stand-off may be attached to the sonde and cartridge. Logging tools vary in sizesand shapes. A typical logging string is 3 5/8" in diameter and 35 ft long. Most tools are built to withstand 20,000 psi pressure and 350°F to 400°F temp. Modem tools are "modularized" to allow combination tool strings by appropriate mixing and matching. The need for pressure control equipment will limit the total length of the tool string that can be safely assembled and run in the hole.

Fig: logging tool assembly

MODERN LOGGING TOOLS:

FORMATION FLUID CONTENT INDICATORS

- Induction
- Laterolog
- Micro-focused (micro resistivity) devices
- Pulsed neutron Inelastic gamma (carbon/oxygen)
- MRI
- NMR

POROSITY-LITHOLOGY INDICATORS

- SONIC (ACOUSTIC)
- Density
- Neutron
- Natural Gamma Ray
- Spectral Gamma Ray

RESERVOIR GEOMETRY INDICATORS

- Dipmeter
- FMS/FMI
- Star Imager
- Circumferential Acoustic Scanning

FORMATION SAMPLING TOOLS:

- Formation Tester RFT, MDT
- Sidewall Coring

AUXILIARY TOOLS

- Spontaneous Potential
- Caliper

LOGGING TOOLS BASED ON FAMILY

Resistivity Tools:

INDUCTION TOOLS:

Induction tools belong to the resistivity tool family and attempt to measure true formation resistivity, Rt. They work like metal detectors by inducting currents in the formation. Induction logs are called by a variety of names and initials such as, induction logs, ISF , DIL or DIFL.

Fig: induction logging tool

LATEROLOG TOOL:

Laterolog resistivity tool injects electric currents into geological formations and records the potential drop across a specific length along the open hole well. Laterolog measurements arerelated to the electrical resistivity of the formation. Laterolog tools are reliable in boreholes drilled with water-based muds.

The most important tool in the family of Laterolog Tools is the Dual Laterolog- Micro spherically Focused log (MSFL). The DLL-MSFL can be run with SP, GR, caliper andsome porosity tools.

Fig :Dual Laterolog Logging Tool.

MICRO-RESISTIVITY DEVICES:

Micro-resistivity devices attempt to measure the formation resistivity close to the borehole wall. The MSFL is usually run with the dual laterolog and not separately, but the proximity and micro Interolog tools are run as separate surveys usually with a microlog (ML).The ML is a special type of log and gives good indications of porous and permeable zones.

Fig: micro-resistivity scanning imaging logging tool

DIPMETER

Dipmeter come in several versions; four-arm dipmeters and six-arm dipmeters. High resolution dipmeters record all the necessary information for computing formation dip and azimuth. A secondary application is the use of the dipmeter measurements of hole deviation and direction to determine hole geometry, location and true vertical depth of points in deviated wells.

Fig: dipmeter logging tool

SONIC LOGGING

Sonic logging is a well logging tool that provides a formation's interval transit time, designatedas which is a measure of a how fast elastic seismic compression and shear waves travel through the formations. Geologically, this capacity varies with many things including lithology and rock textures, most notably decreasing with an increasing effective porosity and increasing with an increasing effective confining stress. This means that a sonic log can be used to calculate the porosity, confining stress, or pore pressure of a formation if theseismic velocity of the rock matrix, and pore fluid, are known, which is very useful for hydrocarbon exploration.

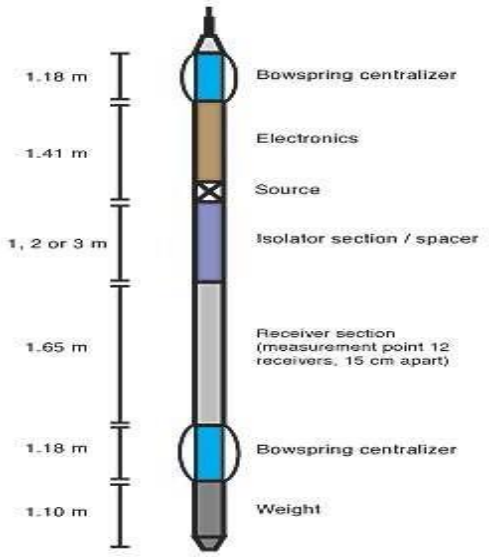

Fig: sonic logging

Radioactive Tools

GAMMA RAY TOOL:

Gamma ray tools measure the natural radioactivity of the formation. Gamma rays are bursts of high energy electromagnetic waves which are spontaneously emitted by some of the radioactive elements as they decay to a more stable state. Three most common elements in rockswhich emit gamma rays are uranium, thorium and potassium.

Fig: gamma ray tool

SPECTRAL GAMMA RAY TOOL

This tool measures the number and energy of naturally occurring gamma rays in theformation and inguishes between elements and daughter products of three main radioactive families; uranium and potassium.

Fig Spectral Gamma Ray & CCL Tool

DENSITY TOOL

Compensated density tools are the primary porosity measuring devices. A GR, caliper and neutron log are normally run with the density. A modern version of the density tool is known as litho density tool. In addition to measuring bulk density, it measures the photoelectricfactor (Pe) which is indicator of formation lithology.

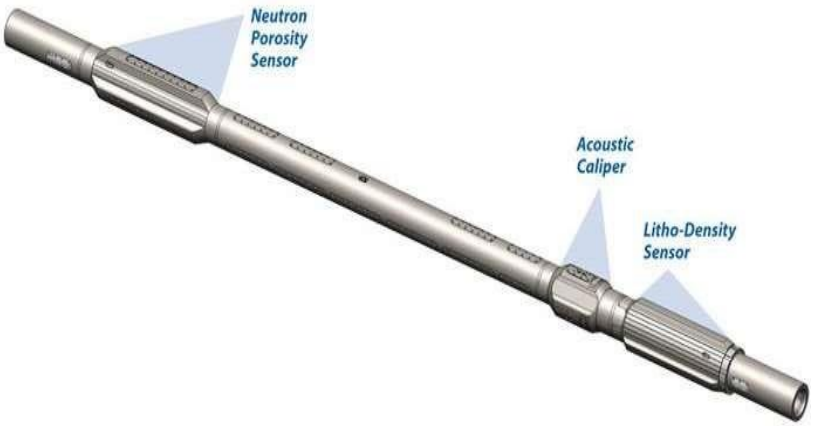

Fig: litho density tool

NEUTRON TOOL

There are several types of neutron tools. Today's standard is the dual spaced neutron which records ON, the neutron porosity index. It is normally recorded for an assumed lithology.Reading the porosity curve requires close attention to the porosity scale and assumed matrix.

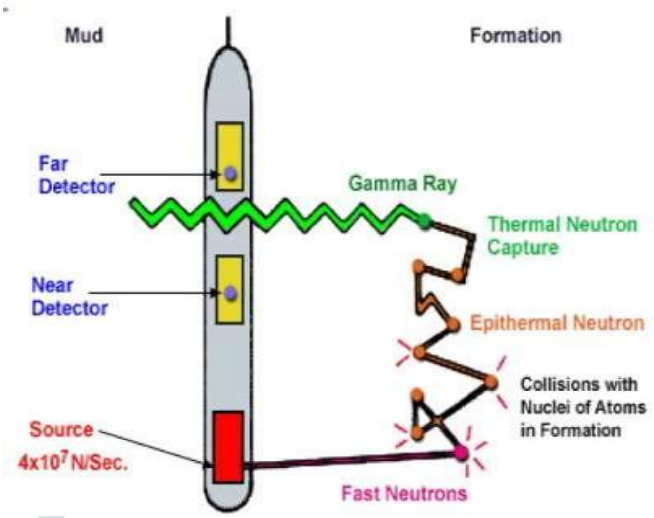

Fig: neutron tool

PULSED NEUTRON CAPTURE TOOL

The pulsed neutron capture tool makes a measurement that helps distinguish oil from salt water in the formation in cased holes. It may also be used in open holes as a last resort when drillpipe becomes stuck.

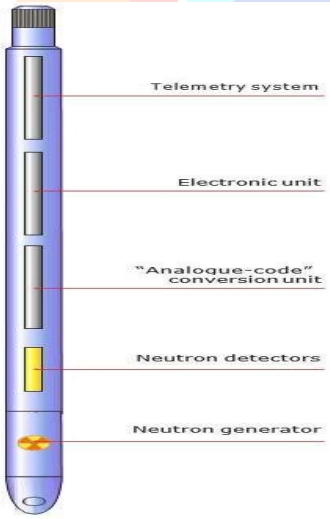

Fig:Pulsed Neutron Capture Tool

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