CHAPTER ONE

Introduction

Low-resistivity pay or low-contrast pay was first discovered in the Pleistocene sandstone in offshore Gulf of Mexico, Louisiana, USA. Through years of exploration and study, low-resistivity pay has become recognized as a worldwide phenomenon, occurring in the basins from North Sea and West Africa to Indonesia and China.

Some petrophysists believe that low-resistivity pay is of a range of (0.5-5 ohm.m) in deep resistivity logs. In fact, low contrast is the characteristic of low-resistivity pay. That is, the contrast resistivity between pay zone and adjacent shale bed or water zone is low. This situation is frequently observed in reservoirs with fresh water in China, low resistivity pay is defined as that the resistivity ratio of pay zone to water zone equals or less than 2 (Boyd, 1995:Mao,1999).

1.1 Problem:

Low resistivity reading in oil formation

1.2 Objective:

To solve the low resistivity readings for pay zones.

1.3 Methodology:

The main methodology which stablished to identify the LRLC pay zone is to use one advance software to identify the pay zone(well log) in general and then make a well correlation between geological column data(masterlog) and well log (Eltayeb Adam, 2007).

1.4 Interactive Petrophysics IP:

Interactive Petrophysics Log Analysis Software is a new generation of fast and efficient PC-based software for reservoir log property analysis and summation.

1.5 Data Used:

- Geological data.
- Master log.
- Well report.
- Composite Logs for certain well.

1.6 Petrophysical Evaluation:

It has long been the practice to evaluate subsurface formations, based on well logs obtained in these formations. Log analysis can provide parameters such as porosity and water saturation. These parameters can be used to assess the hydrocarbon content of the formation. Core and well-test data needs to be integrated to validate and improve the results of log analysis.

The evaluation of shaly sands, from log analysis, provides estimates of total porosity, shale and quartz (in the shale model) or clay and sand (in the clay model), effective-porosity and water-saturation. The hydrocarbon in-place is obtainable once porosity and water content are estimated.

1.7 Basic Resistivity Concepts:

Resistivity is a property of a material and can be defined as the electrical resistance of a cube of material. By definition it is:

$$R = \frac{rA}{L} \qquad (1.1)$$

Where:

R = resistivity, (ohm-meters).

r = resistance, (ohms).

A = cross sectional area (meters2).

L = length, (meters).

In wireline logging, this is one of the principal parameters measured. Resistivity can also be stated in terms of conductivity where:

$$Resistivity = \frac{1000}{conductivity} \qquad (1.2)$$

Conductivity is measured in milliohm/meter.

1.8 Resistivity Logging:

The resistivity of a substance is its ability to impede the flow of electric current through the substance. Formation resistivities usually fall in the range from 0.2 to 1000 ohm meter. Resistivities higher than 1000 ohm-m are uncommon in permeable formations. In a formation containing oil or gas, both of which are electrical insulators resistivity is a function of formation factor, brine resistivity and water saturation which in term depends on true resistivity of the formation parameters resistivity is of particular importance because it is essential for saturation determination mainly of the hydrocarbon. Depending upon the environment under which resistivity logs are recorded. There are two types of resistivity Logs .They are Latero logs and Induction logs.

1.9 Dual Lateral Log (DLL):

The dual lateral log (DLL) has been one of primary resistivity measurement device. DLL is a focused electrode device designed to minimize influence from borehole fluids and adjacent formations.

The DLL consists of an electronics section and a mandrel section. The mandrel supports the electrodes which are connected to the electronic circuitry. The measurement current emitted from center electrode is forced to flow laterally into the formation by the focusing action of electrodes surrounding the center electrode. It provides two measurements of the subsurface resistivity simultaneously. The two measurements have differing depth of investigation are called deep resistivity (Rd) and shallow resistivity (Rs).

1.10 Dual Lateral Log Theory:

Dual lateral log (DLL) consist of a current emitting center electrode positioned between guard electrodes. A known current is passed through the current electrode with a return electrode at the surface Fig (1.1).

Sinuously a potential is applied to the focused electrode to keep zero potential difference between guard and center electrode thereby the current is focused into the formation. Thus the potential difference produced is equivalent to the formation resistivity. The lateral log current path is basically a series circuit consisting of the drilling fluid, Mud cake, flushed zone, invaded zone and the virgin zone, with the largest voltage drop occurring over the highest resistance zone.

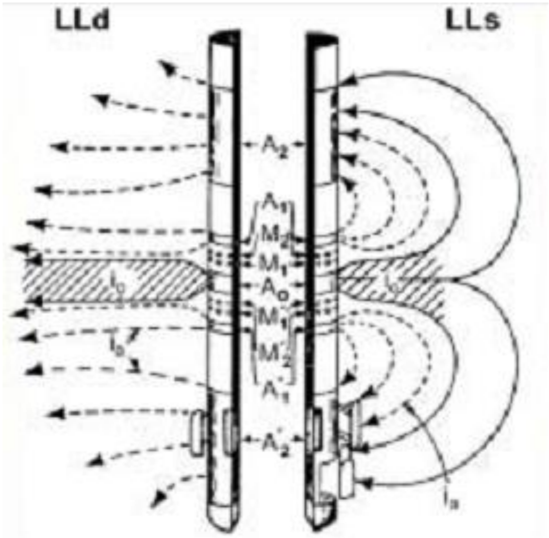

Fig (1.1) Dual lateral log (DLL)

The total amount of current emanating from an electrode must flow through any medium that encompasses the electrode. The depth of investigation of a lateral log is defined as the depth at which 50% of the total measured voltage is dropped.

1.11 Micro Lateral log Micro Spherically Focused Logs:

MLL is pad device.MIL has small vertical resolution and depth of investigation. Used to determine:

- Rxo, Exact thickness of formation beds.
- Rxo can be used with archie's equation to calculate the saturation of the flushed zone.

$$Sxo=\sqrt{\frac{a}{\emptyset^{m}} * \frac{Rxo}{Rmf}} \qquad (1.3)$$

Sxo= saturation of the flushed zone.

a= constant often taken to be (1).

Φ= porosity.

m= cementation factor.

Rxo= resistivity of flushed zone.

Rmf= resistivity of mud fluid

Equation (1.3) show Archie's equation, rewritten for saturation of the flushed zone, to determine moveable oil.

1.12 Micro Laterolog Theory:

Current from a measure electrode is forced into the flushed zone by guard electrodes returning to the return electrode. The current to the measure electrode is measured as is the voltage w r to the ground .The MLL is a single tool contains an arm with the pad attached as shown in fig (1.2).

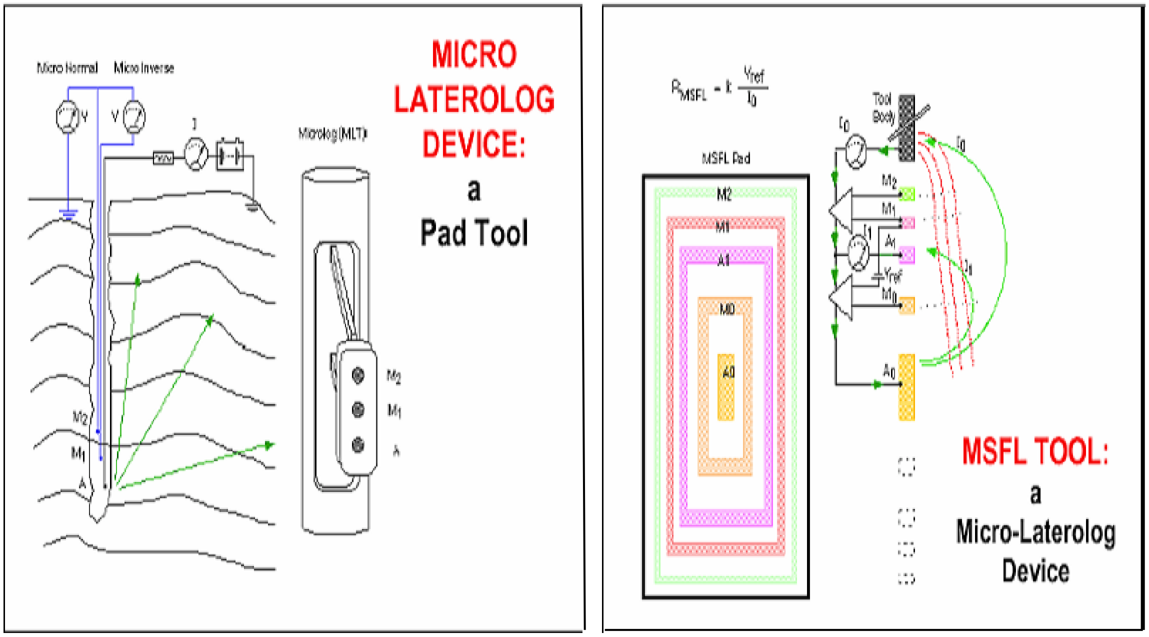

Fig (1.2) Micro laterolog device

The central electrode is the measure electrode. The eight other electrodes are guard electrodes.

1.13 Induction Logging:

Induction tools are based on principles of electromagnetic induction. A magnetic field is generated by an AC electrical current flowing in a continuous loop. The magnetic field from the transmitter coil induces ground loop currents in the formation. These ground current loops will in turn have an associated alternating magnetic field which will induce a voltage in the receiver coil, the magnitude of which is proportional to the formation conductivity.

- It works in oil based muds and air filled holes where latero tool fails.
- Tool accuracy is excellent for formations having low to moderate resistivity (up to 100 Ohm.m).

- The Dual Induction Latero (DIL) tool records three resistivity curves having different depths of investigation (ILD, ILM and LLS).

1.14 Applications of Resistivity Logs:

- True formation resistivity and flushed zone resistivity.
- Mud filtrate Invasion profile.
- Quick look hydrocarbon detection.
- Indication of producible hydrocarbon.
- Correlation of different formations.

1.15 Invasion Profiles:

Invasion of mud filtrate into the formation has a significant effect on the resistivity readings. Depending on whether the formation is water or oil bearing, changes in resistivity occur as you move through the flushed zone into virgin formation. In a water zone, there is no change in water saturation, only a change in water resistivity as mud filtrate dilutes the formation water. In a hydrocarbon-bearing zone the hydrocarbon saturation is reduced in the flushed zone and increases in the transition zone until the original saturation in the undisturbed formation is reached. These changes in water saturation, combined with changes in the resistivity of the fluids filling the pores, create resistivity profiles, Fig (1.3).

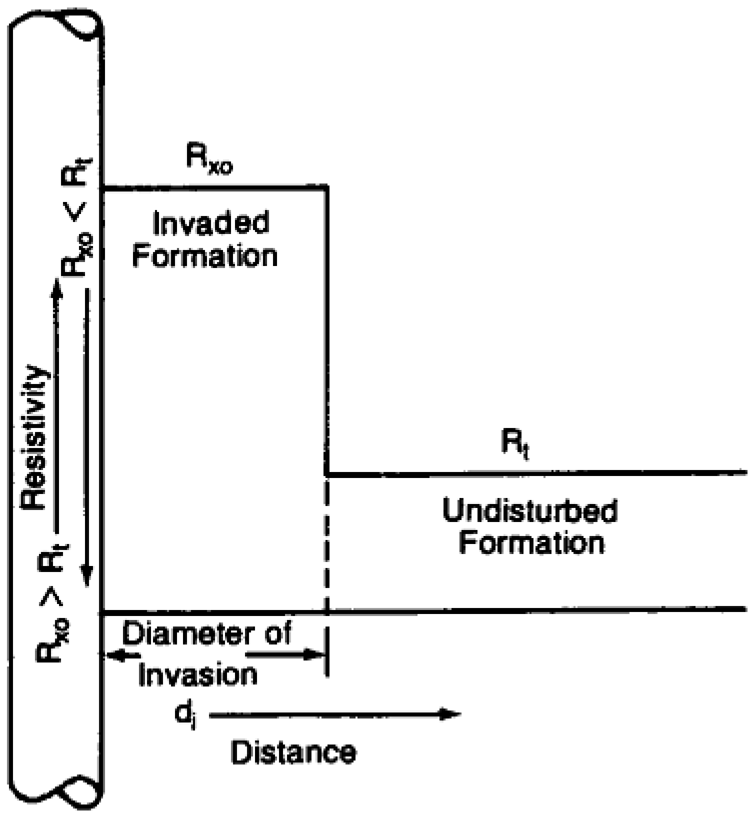

Fig (1.3) Invasion Profiles

1.15.1 Typical invasion profiles:

The transition profile is the most realistic model of true borehole conditions, showing invasion diminishing gradually, rather than abruptly, as moving out toward the uninvaded zone. The annulus profile reflects a temporary fluid distribution which should disappear with time. It represents a fluid distribution which exists between the uninvaded and invaded zone and indicates the presence of hydrocarbons. Beyond the outer boundary of the invaded zone is an annulus zone whose pores are filled with residual hydrocarbons and formation water.

The abrupt resistivity drop reflects a high concentration of formation water in the annulus zone, due to the fact that formation water has been pushed ahead of invading mud filtrate into the annulus zone, causing a temporary absence of hydrocarbons which in turn have been pushed ahead of the formation water. Thus the decrease in resistivity in the annulus zone, Fig (1.4).

In fresh water drilling muds, the mud resistivity is normally higher than the formation water. In a water bearing zone, the formation resistivity is higher in the flushed zone due to Rmf>Rw, and decreases with movement out into the undisturbed formation. In a hydrocarbon bearing zone, drilled with fresh a mud (Rmf>Rw), the resistivity behind the flushed zone may be higher or lower, depending on Sw and Rw.With a salt water-based mud (Rmf<Rw) the flushed zone normally has a lower resistivity, while the undisturbed zone either has the same or higher, depending upon if the formation contains equivalent or higher resistivity Water.

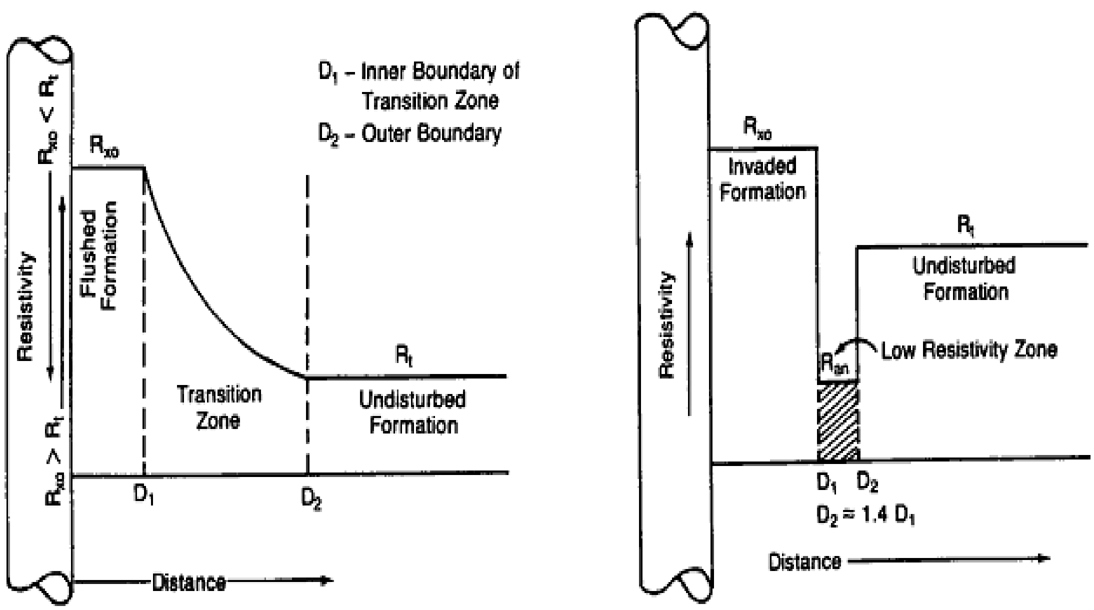

Fig (1.4) typical invasion profiles.

1.16 logging while drilling Resistivity Measurements:

Most formations logged for potential oil and gas saturation is made up of rocks which, when dry, will not conduct an electrical current, the rock matrix has zero conductivity or infinitely high resistivity. An electrical current will flow only through the interstitial water saturating the pore structure of the formation, and then only if the interstitial water contains dissolved salts. These salts dissociate into positively charged cations and negatively charged anion.

Under the influence of an electrical field these ions move, carrying and electrical current through the solution. Other things being equal, the greater the salt concentration, the lower the resistivity of the formation water and, therefore, of the formation. The greater the porosity of the formation and, hence, the greater the amount of formation water, the lower the resistivity. Of all the rock parameters measured by today’s logging tools, resistivity is of particular importance. It is the one measurement for which tools having a deep depth of investigation.

Resistivity measurements are employed, singly and in combination to determine formation resistivity in the non-invaded formation. Resistivity measurements are also used to determine the resistivity close to the borehole where mud filtrate has largely replaced the original pore fluids. Resistivity measurements, along with porosity and water resistivity, are used to obtain shallow and deep resistivity measurements can be compared to evaluate the production ability of the formation Drilling.