Benha University
Faculty of Science
Dept. Of Geology

Time: two hours.
First Semester 201٦-201٧
Date: ٢٢/0١/201٧

Introduction to well logging (459G) for Fourth Level Students (Geophysics)

جامعة بنها – كلية العلوم – قسم الجيولوجيا

المستوى الرابع(جيوفيزياء)

يوم الامتحان: الاحد

تاريخ الامتحان: ٢٢ / 1 / ٢٠١٧

الماده: مقدمه فى سجلات الابار(٤٥٩ ج)

الممتحن: د/ وفاء الشحات عفيفى الشحات

أستاذ مساعد بقسم الجيولوجيا بكلية العلوم

الاسئله ونموذج الاجابه

ورقه كامله

Benha University | **Time: two hours.**

Faculty of Science | **First Semester 201٦-201٧**

Dept. Of Geology | **Date: ٢٢/0١/201٧**

Introduction to well logging (459G) for Fourth Level Students (Geophysics)

Answer the following questions:

Question1. (12Marks)

Define six terms of the following:

- **a)** Matrix
- **b)** Shale, silt and clay,
- **c)** sondes,
- **d)** Well logging,
- **e)** Petrophysics,
- **f)** Formation evaluation,
- **g)** Seal.

Question2. (24 Marks)

Write on four only of the following:

a- Dipmeter Tool

b- Effects of Circulating Fluid on Logs

c- Hydrocarbon Saturation Indications

d- Induction Tools

e- Electrode tools

Question 3. (12 Marks)

What are the differences between Gamma Ray log and spectral Gamma Ray log?

BEST WISHES

Introduction to well logging (459G) for Fourth Level Students (Geophysics)

Answer of Question1. (12 Marks)

Define six terms of the following:

a- Matrix

Matrix encompasses all the solid constituents of the rock (grains, matrix , cement), excluding shale.

b- Shale, silt and clay

A *shale* is a fine-grained, indurated sedimentary rock formed by the consolidation of clay or silt. It is characterized by a finely stratified structure (laminae 0.1-0.4 mm thick) and/or fissility approximately parallel to the bedding. It normally contains at least 50% silt with, typically, 35% clay or fine mica and 15% chemical or authigenic minerals.

A *silt* is a rock fragment or detrital particle having a diameter in the range of 1/256 mm to 1/16 mm. It has commonly a high content of clay minerals associated with quartz, feldspar and heavy minerals such as mica, zircon, apatite, tourmaline, etc...

A *clay* is an extremely fine-grained natural sediment or soft rock consisting of particles smaller than 1/256 mm diameter.

c- Sondes:- differ in function from measurement to another based on the required physical property to be measured (GR , Resistivity, Neutron, Sonic, Density, Magnetic, Thermal, etc)

•*Sonde normally consists of two main parts:*

•**Sensor:** It is an electronically complicated part used for picking the required property.

•**Cartridge:** Surrounding the sensor in the modern tools and do three functions: * Powering the sensor to be ON/OFF. * Processing the acquired data (First step of processing). * Data transmission along cables to the up-hole instruments.

d- Well logging

Log is a continuous record of measurement made in bore hole respond to variation in some physical properties of rocks through which the bore hole is drilled.

e- Petrophysics

Is the study of rock properties and their interactions with fluids (gases, liquid hydrocarbons, and aqueous solutions).

f- Formation evaluation

Is the process of using bore hole measurements to evaluate the characteristics of subsurface formation.

g- Seal Impermeable cap-rock (such as a thick layer of salt, Anhydrite or shale, or a dense and unfractured limestone)

Question2. (24 Marks)

Write on three only of the following:

a- Dipmeter

The Dipmeter logging tool has been used in exploration, the tool helps to locate and identify geologic structures that serve as traps.

The Dipmeter Tool

The arms of the dipmeter have pads containing several electrodes which measure the conductivity of the formation. Assuming geologic features are continuous across the space of the borehole, those features should show up in each record of measurement.

The dipmeter measures conductivity simultaneously at four points spaced 90o apart around the borehole; the parallel tracks of the measurements to be correlated are, therefore, no more than a few inches apart. Vertically, measurements are taken sixty times per foot (0.2 inches apart).

These microconductivity electrodes are small enough to resolve structures with linear dimensions down to about 1-2 cm. Water-based muds give the best electrical contact for the pads. For non-conductive borehole fluids, special “knife-blade” electrodes must be used to provide the contact with the formations.

Without knowing the orientation of the tool in space, the only item that can be determined is the apparent dip (the slope of a geologic feature relative to the plane defined by the four conductivity pads). To measure this angle against true dip, three angles must be measured:

- Borehole inclination
- Azimuth from magnetic north.
- Hole-drift azimuth.

Borehole inclination and the first of the two azimuths can be measured directly. A “relative bearing” measurement is also made, and it is from this angle that the second azimuth is computed.

Problems with Dipmeter Interpretation

The most common parameter which interferes with dipmeter reading is collectively known "noise." Borehole noise due to wall rougosity, fracturing or uneven filters cake thickness (the worst problem). Another problem is geologic noise, resulting from lack of integrity in the bedding planes across the few centimeters of borehole diameter (causing the plane not to be detected by all the electrodes). Electronic noise in the sensors, cable and recorder is never entirely eliminated, though this is usually less pronounced than the other two noises.

b- Effects of Circulating Fluid on Logs

1. Water-base fluids, including oil emulsions, serve as an electrical bridge to a formation. Filtrate will usually displace all formation water from the invaded zone. In zones containing hydrocarbons, a residual oil or gas saturation will remain in the invaded zone.
The depth of invasion is usually deeper in low porosity, low permeability zones.
2. In a few wells drilled with an oil emulsion mud, the filter cake resistivity has been very high.
3. Traces of oil may invade the formation when oil emulsion fluid is used.
4. Any of the logs can be run in water-base muds.
5. In oil-base fluids the induction, radioactivity, and acoustic logs may be used. The SP is not used.
6. If oil is the continuous phase and invades the formation displacing formation, it will leave a residual saturation of formation water and gas if present.
7. Oil-based "Black Magic" has blown asphalt, surfactants, ground oyster shells and little water.
8. In wells drilled with air or gas, the induction and radioactivity logs may be used.

c- Hydrocarbon Saturation Indications

1. Where porosity values are assumed to be fairly constant, permeable zones having higher resistivity than adjacent sands indicate hydrocarbon saturation. The resistivity index may be estimated by the ratio (Rt/Ro).
2. When the deep reading resistivity curves have higher values than the shallow resistivity curves (Rt greater than Rxo), hydrocarbons are indicated.
3. A comparison of the deep investigation resistivity curve and a porosity log indicates hydrocarbons where resistivity values and porosities increase in the same zone.
4. Gas is indicated by lower porosity values on the neutron log. It is better than either the density or acoustic logs.

d- Induction Tools:

These logs were originally designed for use in boreholes where the drilling fluid was very resistive (oil-based muds or even gas). It can, however, be used reasonably also in water-based muds of high salinity, but has found its greatest use in wells drilled with fresh water-based muds.

The sonde consists of 2 wire coils, a transmitter (Tx) and a receiver (Rx). High frequency alternating current (20 kHz) of constant amplitude is applied to the transmitter coil. This gives rise to an alternating magnetic field around the sonde that induces *secondary currents* in the formation. These currents flow in coaxial loops around the sonde, and in turn create their own alternating magnetic field, which induces currents in the receiver coil of the sonde. The received signal is measured, and its size is proportional to the *conductivity* of the formation.

Calibration:

Induction logs are calibrated at the wellsite in air (zero conductivity) and using a 400ms test loop that is placed around the sonde. The calibration is subsequently checked in the well opposite zero conductivity formations (e.g., anhydrite), if available.

e- Electrode tools:

Modern Resistivity Log:

Laterologs: (LL)

It is a type of modern electrodes which have a number of electrodes.

- **LL3** has 3 current emitting electrodes (vertical resolution is 1ft).
- **LL7** has 7 current emitting electrodes (vertical resolution is 3ft).
- **LL8** is similar to the LL7, but has the current return electrode (vertical resolution is 1ft).

Dual Laterologs: (DLL)

It is the latest version of the laterolog. As its name implies, it is a combination of two tools, and can be run in a deep penetration (LLd) and shallow penetration (LLs) mode. These are now commonly run simultaneously and together with an additional very shallow penetration device. The tool has 9 electrodes.

Both modes of the dual laterolog have a bed resolution of 2 feet. The resistivity readings from this tool can and should be corrected for borehole effects and thin beds, and invasion corrections can be applied.

The dual laterolog is equipped with centralizes to reduce the borehole effect on the LLs. A micro resistivity device, usually the MSFL, is mounted on one of the four pads of the lower of the two centralists.

NOTE: Separation of the LLs and LLd from each other and from the MSFL is indicating the presence of a permeable formation with hydrocarbons.

Spherically Focused Log: (SFL)

The *spherically focused log* (SFL) has an electrode arrangement that ensures the current is focused quasi-spherically. It is useful as it is sensitive only to the resistivity of the invaded zone.

Micro-Resistivity Logs

Micro Log: (ML)

It is a rubber pad with three button electrodes placed in a line with 1 inch Spacing The result from this tool is two logs called the 2"normal curve (ML) & the1½"inverse curve (MIV).

The difference between the two curves is an indicator of mudcake (so it is used in making sand counts).

Micro laterolog: (MLL)

Proximity Log: (PL)

This tool was developed from the MLL. It is used to measure *RXO*. It has a depth of penetration of 1½ ft., and is not affected by mudcake. It may, however, be affected by *Rt* when the invasion depth is small.

Micro Spherically Focused Log: (MSFL)

It is commonly run with the DLL on one of its stabilizing pads for the purpose of measuring *RXO*. It is based on the premise that the best resistivity data is obtained when the current flow is spherical around the current emitting electrode The current beam emitted by this device is initially very narrow (1"), but rapidly diverges. It has a depth of penetration of about 4" (similar to the MLL).

Question 3. (12 Marks)

What are the differences between Gamma Ray log and spectral Gamma Ray log?

Gamma Ray Tools:

The *gamma ray* log measures the total natural gamma radiation emanating from a formation. This gamma radiation originates from potassium-40 and the isotopes of the Uranium-Radium and Thorium series. The gamma ray log is commonly given the symbol *GR*. Its main use is the discrimination of shales by their high radioactivity.

Note that shales, organic rich shales and volcanic ash show the highest gamma ray values, and halite, anhydrite, coal, clean sandstones, dolomite and limestone have low gamma ray values. Care must be taken not to generalize these rules too much. For example a clean sandstone may contain feldspars (Arkose sandstones), micas (micaceous sandstones) or both (greywacke), or Glauconite, or heavy minerals, any of which will give the sandstone higher gamma ray values than would be expected from a clean sandstone. Gamma ray may come from the drilling mud itself (some drilling muds are very radioactive).

Calibration:

The gamma ray log is reported in pseudo-units called API units. The API unit is defined empirically by calibration to a reference well at the University of Houston. This reference well is an artificial one that is composed of large blocks of rock of accurately known radioactivity ranging from very low radioactivity to very large radioactivity.

Benha University		Time: two hours.
Faculty of Science		First Semester 201٦-201٧
Dept. Of Geology		Date: ٢٢/0١/201٧

Introduction to well logging (459G) for Fourth Level Students (Geophysics)

Spectral Gamma Ray: (SGR)

The *spectral gamma ray* log measures the natural gamma radiation emanating from a formation split into contributions from each of the major radio-isotopic sources.

The spectral gamma ray tool uses the same sensor as the total gamma ray tool.

The output from the sensor is fed into a multi-channel analyzer that calculates the amount of radiation coming from the energies associated with each of the major peaks. This is done by measuring the gamma ray count rate for 3 energy windows around the energies 1.46 MeV for potassium-40, 1.76 MeV for the uranium-radium series, and 2.62 MeV for the thorium series. These readings represent the gamma ray radioactivity from each of these sources.

Their sum should be the same as the total gamma ray value measured by the total gamma ray tool.

Calibration:

The spectral gamma ray tool is calibrated using 4 sources of accurately known composition, one each containing only K40, U238, and Th232, and one containing a mixture. Each of the sources is placed next to the detector and the tool is used to make a measurement. The calibration is designed such that the calibrated readings of the tool accurately report difference in the amount of radiation from each of the radiation sources.

It is the micro-scale version of the laterolog. The tool is pad mounted, and has a central button current electrode. The depth of investigation of the MLL is about 4 inches.