Benha University	**Time: two hours.**
Faculty of Science	**First Semester 2015-2016**
Dept. Of Geology	**Date: 09/01/2016**

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

جامعة بنها – كلية العلوم – قسم الجيولوجيا

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الاسئله ونموذج الاجابه

ورقه كامله

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Answer the following questions:

Question1. (12Marks)

Define six terms of the following:

a) Water and gas conning

b) Cased holes,

c) A logging unit,

d) Measuring While Drilling (MWD),

e) Dual Laterologs: (DLL),

f) Oil-Base Mud,

g) Gas Analyzer,

h) Cavings.

Question2. (18 Marks)

Write on three only of the following:

a- Neutron Tools

b- Problems specific to well-log measurements

c- Repeatability and Calibrations

d- Determination of Basic Reservoir Characteristics from Logs

Question 3. (12 Marks)

How can you determine the rock composition using well log analysis?

Question4. (6 Marks)

Give Reason:

a) The drilling mud must be dense and viscous

a- Bentonite, Barite and caustic Soda should be added to mud fluid.

BEST WISHES

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Answer of Question1. (12 Marks)

a) ***Water and gas coning:*** Coning is a production problem in which gas cap gas or bottom water infiltrates the perforation zone in the near-wellbore area and reduces oil production. Gas coning is distinctly different from, and should not be confused with, free-gas production caused by a naturally expanding gas cap.

b) ***Cased holes*** Casing is thin-walled, steel pipe that is run in the hole to prevent borehole collapse as drilling progresses. The casing is cemented (cement job) to the borehole wall.

c) ***A logging unit*** is an instrument for taking measurements. For land rigs, the unit is mounted on a truck. The logging Truck mainly consists of mechanical Winches and ordinary driving machine.

d) ***Measuring While Drilling (MWD)*** It is the evaluation of physical properties, usually including pressure, temperature and wellbore trajectory in three-dimensional space, while extending a wellbore. MWD is now standard practice in offshore directional wells.

e) ***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.

f) ***Oil-Base Mud*****:** Oil is the liquid phase of oil-base Mud.Advantages of oil-base Mud: Stabilizing formation and reduce downhole drilling problems

g) ***Gas Analyzer*****:**It analyzes hydrocarbon gases in mud & detects Hydrogen Sulphide & Carbon dioxide (Non hydrocarbon Gases).

h) ***Cavings***: cuttings from previously drilled intervals rather than from the bottom of the hole.

Answer of Question 2. (18Marks)

****Write on three only of the following:***

a- ***Neutron Tools***

The *neutron* log is sensitive mainly to the amount of hydrogen atoms in a formation. Its main use is in the determination of the porosity of a formation. The tool operates by bombarding the formation with high energy neutrons. These neutrons undergo scattering in the formation, losing energy and producing high energy gamma rays. The scattering reactions occur most

efficiently with hydrogen atoms. The resulting low energy neutrons or gamma rays can be detected, and their count rate is related to the amount of hydrogen atoms in the formation.
The source which emit neutrons is (**Am-Be**) source.

Calibration:

These tools are calibrated in blocks of limestone, sandstone and dolomite of high purity and accurately known porosity. The tools are calibrated, not to give readings in API neutron porosity units, but to give the porosity directly in percent.
The calibration of the CNL tool is checked at the well site before and after each logging run by the use of a neutron source of accurately known activity placed a standard distance from each detector.

Tool Operation:

SNP: This tool is designed for use in open holes only. The tool has a source and a single detector with 16 inch spacing, which are mounted on a skid that is pressed against the borehole wall. Because the tool is pressed against the borehole wall, the drilling mud does not affect the measurement, and the attenuation due to the mud cake is reduced. The detector is sensitive to epithermal neutrons so the SNP tool readings are unaffected by the presence of chlorine in high salinity muds and formation fluids.

CNL: This tool is designed to be sensitive to thermal neutrons, and is therefore affected by the chlorine effect. It has two detectors situated 15 inch and 25 inch from the source. The CNL tool has a very strong source of neutrons to ensure that the measured count rates are sufficiently high to obviate any significant errors associated with statistical fluctuations.

The Hydrocarbon Effect:

The presence of hydrocarbon liquid (oil) does not affect the tool response as it has approximately the same hydrogen index as fresh water. Hydrocarbon gas, however, has a much lower hydrocarbon index resulting from its low density, and its presence will give rise to *underestimations* in porosity.

b- ***Problems specific to well-log measurements***

1. **Borehole effects, invasion**

Drilling mud

The influence of the drilling mud on a log response depends on several factors:

Hole diameter

The larger the hole, the greater the volume of fluid around the logging tool, and the stronger its effect on the log reading. Above a certain hole-size, there may be very little or no signal from the formation.

Mud-type and mud-density

Whether or not a certain log can or should be run depends on the type of drilling mud in the hole. For instance, acoustic signals are poorly transmitted in an air-filled hole; oil or air will not conduct current; a salt-saturated mud, because of its high conductivity, will contribute a large borehole signal to the induction log; Mud-salinity affects conductivity, resistivity, and hydrogen index measurements, among others. The density of the mud influences the absorption of gamma rays. Charts are available to correct for these borehole effects

Invasion

The mud is kept at a slightly higher pressure than the formation pore-fluids, by careful control of the mud-density. Because of this pressure difference, there is a tendency for the mud to infiltrate porous, permeable beds. This is known as invasion. The solid particles in the mud are usually larger than the pores, and only the liquid content can invade the formation.

The mud-filtrate displaces some of the formation fluid. The depth of invasion depends on the porosity and permeability of the rock, the "water-loss'' factor of the mud (the quantity of water which is liberated from the mud), and the pressure difference between well-bore and formation.

For a given mud-type, in contact with a formation of a certain permeability and wettability, under a given pressure differential, the depth of invasion is larger the smaller the porosity.

Changes have occurred both in the nature of the fluids and their proportions. Since the logging tools will always read at least some of the invaded zone signal, these changes must be taken into account when attempting to evaluate the fluid saturation of the virgin zone

Casing and cement

The presence of casing and cement precludes certain logging measurements (resistivity for instance). Generally, only nuclear (and some acoustic) measurements can be made through casing.

Fluid mobility

Although a troublesome phenomenon from a reservoir evaluation point of view, invasion can be used as an indication of the mobility of the reservoir

2. **The effect of tool geometry**

Tool diameter, excentralization

There is a minimum hole diameter (or casing inner diameter) through which a tool of a certain size may safely pass. For most logging services, there exists a range of tool diameters appropriate to the common hole-sizes, including special " slim-hole'' equipment.

The logging tool may take any of three positions relative to the hole axis**;** centralized, excentralized against the wall and stood-off from the wall by a small amount.

Correct tool positioning is mandatory for some measurements, and is ensured by mechanical means; one or several multi-armed centralizers (BHC); one-armed excentralizer (CNL, FDC); rubber stand-off (induction logging).

c- *Repeatability and Calibrations*

At the end of a log, a repeat section and calibration tail are usually attached. The

repeat section verifies that the tool is functioning consistently. For radio-active logs, several repeat sections may be run for subsequent stacking (averaging) to reduce statistical variations (e.g. NGS and TDT).
A calibration record is made on film and tape before and after the survey, to show that the equipment was correctly adjusted, and that no drift in adjustment has occurred during the log. For certain tools, a "master calibration" is made at the workshop prior to the logging operation, using laboratory equipment. The well-site calibration repeats this adjustment using portable calibration ''jigs'' (FDC, CNL, GR...*)*. Other tools have their own internal calibrators (IL, LL ...), and may be adjusted while down-hole.

b- Determination of Basic Reservoir Characteristics from Logs

Porosity Determination
1. Density Logs measure effective porosity and are less affected by shale. Porosity values will be high with gas in pore spaces and with shallow invasion. Corrections will be necessary.
2. Acoustic Logs show good porosity in intergranular and intercrystalline porosity.They do not indicate all secondary porosity (vugs and fractures). Porosity values will be high in shaly zones.
3. Neutron Logs are frequently recorded with density or acoustic logs. Porosity values are high in shaly zones and low in gas zones.
4. Positive separation on Contact or Micro logs indicate porosity values which are dependent on knowledge of residual hydrocarbon saturation and are more accurate in moderate to low resistivity formations.
Permeable Bed Location
1. SP Curve Deflection: The SP current depends primarily on formation water being in contact with mud filtrate, so there must be some permeability. There is, however, no direct relationship for a qualitative evaluation. Shaliness or hydrocarbon saturation will reduce the magnitude of the deflection.
2. Resistivity Separation: For a formation to be invaded by a drilling filtrate, it must be permeable. The resistivity differences between shallow and deep investigation curves will indicate this invasion when Rmf is greater than Rw. In hydrocarbon zones the resistivity difference will be less depending on the amount of flushing (Residual Hydrocarbon Saturations), but will usually still be evident. Contact logs are useful for this purpose.
3. Caliper logs show the presence of filter cake, thus a hole diameter less than the bit size is an excellent indicator of permeability.

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.

Bed Boundary Determination

1. The SP curve is very good for picking bed boundaries in fresh drilling muds and sand-shale sequences. Much of the SP character is lost in salt muds or in highly resistive and carbonate rocks.
2. The shallow investigation resistivity curves may be used for bed boundary determination. Normal curves will be distorted by one half the spacing distances at each boundary. Focused current logs are excellent for this purpose. Induction logs have poor vertical resolution in thin beds.
3. The Gamma Ray log is very useful for determination bed boundaries both in open hole and cased holes. With normal logging speeds and correct time constants the vertical resolution is very good.

Question 3. (12 Marks)

How can you determine the rock composition using well log analysis?

Interpretation of the well-logs will reveal both the mineralogy and proportions of the solid constituents of the rock (i.e. Grains, matrix and cement), and the nature and proportions (porosity, saturations) of the interstitial fluids.

Log analysts distinguish only two categories of solid component in a rock-“matrix” and “shale”. This classification is based on the sharply contrasting effects they have, not only on the logs themselves, but on the petrophysical properties of reservoir rocks (permeability, saturation, etc.). Shale is in certain cases treated in terms of two constituents, “clay” and “silt”. We will discuss this log-analyst terminology in more detail.

Matrix

For the log analyst, matrix encompasses all the solid constituents of the rock (grains, matrix *, cement), excluding shale. A simple matrix lithology consists of single mineral (calcite or quartz, for example).

A complex lithology contains a mixture of minerals: for instance, a cement of a different nature from the grains (such as a quartz sand with calcitic cement).

A clean formation is one containing no appreciabIe amount of clay or shale.
(Thus we may speak of a simple shaly sand lithology, or a clean complex lithology, and so on).

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. It contains clay minerals (hydrous silicates, essentially of aluminium, and sometimes of magnesium and iron) and minor quantities of finely divided quartz, decomposed feldspars, carbonates, iron oxides and other impurities.

* For a sedimentologist, matrix is “The smaller or finer-grained, continuous material enclosing, or filling the interstices between the larger grains or particles of a sediment or sedimentary rock; the natural material in which a sedimentary particle is embedded”

** For a log analyst, matrix is “all the solid framework of rock which surrounds pore volume”.

Fluids

The arrangement of the grains usually leaves spaces (pores and channels) which are filled with fluids: water, air, gas, oil, tar, etc. Just how much fluid is contained in a rock depends on the space, or *porosity,* available.

With the exception of water, these pore-fluids have one important property in common with the large majority of matrix minerals- they are poor electrical conductors. Water, on the other hand, conducts electricity by virtue of dissolved salts.

The electrical properties of a rock are therefore strongly influenced by the water it contains. The quantity of water in the rock is a function of the porosity, and the extent to which that porosity is filled with water (as opposed to hydrocarbons).

Porosity

Porosity is the fraction of the total volume of a rock that is not occupied by the solid constituents.

There are several kinds of porosity:

(a) Total porosity, consists of all the void spaces (pores, channels, fissures, vugs) between the rock grains

(b) Effective porosity, consists of the interconnected pore spaces

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Answer of Question 4. (6Marks)

Give Reason:

a) The drilling mud must be dense and viscous to carry cuttings & keep it from filling

b) Bentonite, Barite and caustic Soda should be added to mud fluid (mud additives)

Bentonite is used to increase the Viscosity, **Barite is** used to increase the Density and **Caustic Soda** is used to increase the Alkalinity