GEOSCIENCE

Since 1972

"PROBING THE DEPTHS"

GAMMA RESISTIVITY SELF POTENTIAL NEUTRON

GRSPN TECHNICAL SPECIFICATIONS

System Requirement	Logger 20 / ALT logger
Diameter	40 mm
Length	2.90 m
Weight	15 kg
Max. pressure	200 bars =2900psi
Max. temp.	70º C
Power supply	35 - 40 V
Detectors	**GR** - NaI(Tl) **Neutron** He3
Source (Neutron)	Am ^{241} Be 1 or 3 Currie
Logging speeds	6 m/min
Hole diameter	min. 60 mm

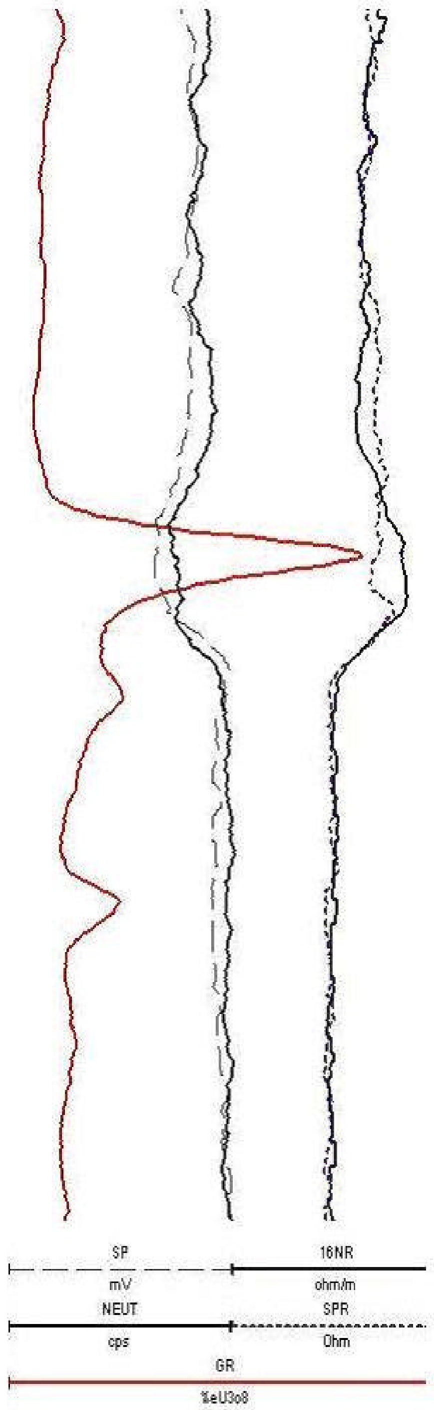
LOG PARAMETERS

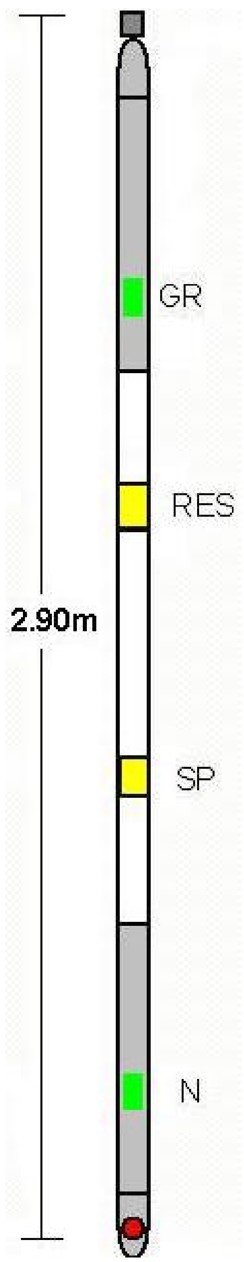
Natural Gamma Ray (GR)
Neutron (Neut) or (NPOR).
Self Potential (SP)
Single Point Resistance (SPR)
16 inch Normal (16NR)

APPLICATIONS

Gamma Ray logs measure the naturally occurring gamma emissions from the formation surrounding the borehole. These emissions are electromagnetic radiations that are released by a nucleus of an unstable element, decaying to a more stable state. In nature, the most significant of these elements occurring in abundance is potassium 40 (K40), uranium 238 (U238), uranium 235 (U235) and thorium 232 (TH232). The most plentiful of these elements is potassium 40.

As the unstable element decays, issuing electromagnetic radiation, the gamma ray probe detects the events by recording the number of particles or photon emissions. This detection is accomplished by use of a sodium iodide crystal optically coupled to a photo-multiplier. As the incident photon enters the crystal a release of energy takes place in the form of illumination that is detected by the photo-multiplier. A corresponding voltage is delivered to the surface where it is counted and averaged over a specific time period. Since radiation is of a statistical nature it is necessary to average the measurement of radiation over a selectable time period in order to derive a representative sample of the amount of radiation being emitted.





GAMMA RESISTIVITY SELF POTENTIAL NEUTRON

The greater the continuous rate the more events the gamma detector is measuring, which in turn corresponds to the greater amount of an unstable element present in the formation. As mentioned, potassium 40 is by far the most abundant of these elements found in rock strata. K40 is found in all potassium bearing minerals such as potassium feldspars, biotite, orthoclase and several clay minerals rendering detection of these minerals possible via the gamma ray log. Consequently, as the content of these minerals increases with the rock strata the response of the gamma ray probe increases. Inversely, as the content of the clay mineral decreases the response of the gamma ray probe decreases. Gamma ray logs show decreasing strengths from shales and clays, to siltstones, to sandy siltstones to clean sandstones- and gravels. Dependent on how clay is present within the quartz matrix, as dispersed particles structural grains, or as laminations, both porosity and permeability of the rock will be affected. To arrive at accurate porosity readings one must know the fraction of clay volume to total rock volume.

A word of caution with regards to calibrating the log response, when the area of interest is near a clay bed, is the assumption that the area of interest contains the same clay mineral. While potassium and thorium are considered good clay indicators, uranium may be present in the rock strata that contain no clay, causing a false indication. Montmorillonite has little or no gamma ray response.
When gamma active clays are present a gamma ray log can be useful in revealing stratigraphic development corresponding to changes in grain sizes.
When logging in metamorphic and igneous rocks of low porosity, the gamma ray response is dependent on the minerals within the rock. The one exception being along open water bearing fractures where high gamma activity is recorded. This response is derived normally from either uranium, which has become water soluble under acidic conditions, or the alteration of the host rock by water movement that has precipitated radioactive enriched minerals along the fracture wall.

Because the gamma ray log is a passive measurement of naturally occurring radioactive elements, and being lithologically dependent, it is an excellent correlation log. Gamma ray logs are normally run with all porosity tools and with an electric log when SP response lacks definition.
The vertical resolution of the gamma ray probe is a function of counting, time constant and logging speed. When all three are at optimum settings the vertical resolution is approximately one foot. Because of the statistical nature of radiation emission, repeatability of the log is not exact with respect to statistical variation of the counts. For this reason, the log will show repeatability in the shape of the curve but the individual curve peaks may be slightly different.
Since the energy of gamma emission is inversely proportional to distance, the greater the borehole diameter the less effective the gamma ray log response. Gamma ray logs can be run in gas filled holes of either open or cased wells.

NEUTRON LOG

The neutron log, like the gamma ray, measures radioactive- properties. Unlike the gamma ray, this log depends on the bombardment of the formation with neutrons from a source and measures secondary results brought on by this bombardment. As a comparison, the neutron log it like a resistivity log that measures the result of something being introduced into the formation, while the gamma ray and SP logs measure naturally occurring phenomena.
The heart of a neutron-logging tool is the radioactive source that emits epithermal neutrons. Characteristically, the source is made of Americium 241-Beryllium with a strength of from 3 to 5 curies, which generate 2.2 x l0~ neutrons per second. Americium 241 has a half-life of *458.1* years and a specific activity of *3.24* curies per gram.
Once a neutron is separated from the source, it begins its travel through matter, since it is neutral, it will lose energy upon collision with the nuclei of other atoms. After a sufficient number of collisions with nuclei and resulting loss of original kinetic energy, the neutron is slowed to a slow or thermal state. Although a formation's ability to slow down neutrons is considerably affected by its hydrogen content, this process is usually not free from the influence of other elements. An atom's comparative slowing down power to neutrons, in terms of the number of collisions required to thermalise fast neutrons, will decrease with increasing atomic number in proportion to the ratio of the two atomic numbers of the two

atoms being compared. The capture cross-section or probability that a neutron will interact with a nucleus depends upon neutron energy, size, mass and character of the atomic nuclei. Table 1 shows atomic numbers

Two different types of logging systems are employed in the running of neutron logs. These are the neutron-gamma log and neutron-neutron log. Early logging tools used the neutron-gamma method of logging whereby the secondary gamma rays emitted during neutron capture were measured by a fairly insensitive gamma detector located a short distance from the source. The detector was kept small and insensitive so that is would react to little influence from the natural gamma radiation from the formation while responding to the wealth of the secondary gamma rays. Most present day neutron logging tools are of the neutron-neutron type. This system uses a $Helium_3$ detector about six inches long that responds to thermal neutrons as they pass through the detector after being slowed by collision with nuclei in the formation. This passage ionises the detector

RESISTIVITY and SP

Resistivity logs may be usefully applied in a number of areas. In Ground-water studies, electrical resistivity logs have been regarded as vital for many years. Apart from general geological / stratigraphic information, resistivity values provide excellent information on two important hydro-geological aspects being aquifer location and water quality

In sedimentary sequences (consolidated or otherwise) aquifers are usually much more resistive than aquicludes such as clay layers and shale. In igneous and carbonate sequences, secondary aquifers formed by fracturing or dissolution are often less resistive than the adjacent massive rocks.

In Coal studies, electrical resistivity logs indicate that the seam has been coked by an igneous intrusion, or has been affected by oxidation.

PR (point resistance) measurements are used to ascertain depths and thicknesses of strata. These measurements will often clearly define the strata boundaries.

The **SP log** measures small, naturally occurring **spontaneous (self) potential** generated by electrochemical differences between differing rock types, water and drilling fluids.