Continuous Carbon/Oxygen Log Interpretation Techniques

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Summary

A relatively modern nuclear logging survey provides methods to evaluate the production potential of both old and new wells through casing, even in formations containing fresh water. Several interpretation techniques are developed that apply test pit data to field applications in determining possible production. Applications and limitations are discussed of the techniques that offer the user independent alternatives and complements to other log analysis methods.

Introduction

A need long has existed for a method to determine hydrocarbon saturations of zones behind casing. To make such determinations, an instrument was introduced in 1963 to measure the lifetime of pulsed neutrons.[1] Since interpretation of this type of survey requires zones of higher formation-water salinity, another process was needed for lithologies consisting of fresher waters. When introduced in 1973, the carbon/oxygen (C/O) log was limited to static measurements of preselected zones. Since it was reintroduced commercially in 1977 as the continuous C/O log, its ability to evaluate potential zones has been improved because the continuous measurements help prevent productive zones from being overlooked.[2]

Theory of Measurement

The continuous C/O log is made possible by known reactions that occur when elements are bombarded by high-energy neutrons.[3] Whenever neutrons of 14.2-MeV (million electron volts) energy collide with the nuclei of different elements, those elements react in predictable ways, which have been detailed in previous publications.[4-6] Basically, different elements usually can be identified from characteristic gamma ray energy levels released as a result of the neutron bombardment. The number of gamma rays at each energy level is proportional to the quantity of each element.

The C/O ratio effectively can indicate the presence or absence of hydrocarbons.[5] Since the formation rock also may contain carbon (e.g., calcium carbonate), a comparison of the relative amounts of silicon and calcium is used to differentiate between carbon in the fluid and in the lithology.

The silicon and calcium measurements are performed using two different methods. A Si/Ca ratio is measured using capture gamma rays, while a Ca/Si ratio is obtained using inelastic (prompt) gamma rays. Each mode has certain advantages as described here. The carbon and oxygen measurements, of necessity, are measured only in the inelastic mode.[4] (The ratios, as measured by the C/O instrument, are proportional to the actual atomic ratios but should be considered as indices for comparative purposes rather than as absolute atomic ratio values.)

Instrumentation, Calibration, and Presentation

With a maximum outside diameter of 3⅞ in., the subsurface instrument has a length of 15.75 ft. The maximum temperature rating is 300°F, and 15,000 psi is the maximum pressure rating. The instrument source consists of a high-voltage power supply used to accelerate deuterium ions (deuterons) into a tritium target, thereby generating a large number (about 10^8) of 14.2-MeV neutrons per second at a repetition rate of 20,000 bursts per second. The subsequent gamma radiation is detected by a high-resolution sodium iodide (thallium-activated)

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0149-2136/81/0007-8366$00.25