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Identification of Bypassed Pays in Low-Resistivity, Thinly-Bedded, Sand-Shale Sequences in the Ghdames Basin of North Africa Through Use of the Wireline Formation Tester

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Abstract

This paper presents a discussion on the use of the Wireline Formation Tester (WFT) to identify oil-bearing intervals in a reservoir section that contains thinly-laminated, low-resistivity pay sections in the Ghadames Basin of southern Tunisia. Pay zones previously bypassed by conventional log analysis have been conclusively determined as oil-bearing through use of the tool.

Three field examples are discussed on the use of the Downhole Fluid Analyzer (DFA) to determine hydrocarbon type and in-situ GOR for three different hydrocarbon phase environments.

The paper also discusses, again through use of field examples, how analysis of the post-DFA pressure response could be used to determine zonal producibility. This zonal producibility from the WFT is then compared to conventional well-test productivity. A close agreement exists between the WFT and conventional well-test productivity estimates. Thus, it eliminates the need for zones to be conventionally tested to determine productivity.

Finally, the paper provides a method to significantly reduce the time necessary to collect representative fluid samples through proper monitoring of the DFA data stream.

Introduction

Oil production has been established from several sand bodies within the Silurian Acacus formation in the Ghadames Basin of southern Tunisia (Figure 1). This production comes from a thinly-laminated, sand-shale section with highly variable quality and petrophysical response, including sandstones with very low values of resistivity and induction from the open-hole logs. As a result, most hydrocarbon-bearing intervals appear to be water-bearing by conventional log analysis and in the past bypassed and considered wet.

This phenomenon exists in these Acacus sandstones, due to the presence of large amounts of capillary bound water and conductive minerals such as chlorite. To conclusively determine which intervals are hydrocarbon-bearing, a modular wireline formation tester (WFT) equipped with a single-probe module is used during open-hole logging. The WFT identifies in-situ reservoir fluid types using a downhole fluid analyzer (DFA) and determines the GOR by measuring the methane content of the fluid. A multiple sampling module or large sample chamber is then used to collect downhole fluid samples to confirm fluid types and GORs.

After identifying hydrocarbon-bearing intervals using the DFA, without the guidance of conventional log analysis, producibility of each potential pay section is calculated from a single pressure buildup following a controlled pumping period. By monitoring both fluid optical density (Crombie et al, 1998) and GOR in pay intervals of these laminated Acacus sandstones, a completion program is designed to group intervals according to GOR and water-oil ratio behind separate sliding sleeves to control production.

Data Acquisition Process

The WFT tool string (Figure 2), used in these operations, consists of 7 modules (1) a single-probe, (2) hydraulic power, (3) DFA, (4) multisample chambers, (5) large sample chambers, (6) pump-out, and (7) electric power. A typical pre-test sequence includes a fluid withdrawal (drawdown) of varying volume (5-20 cc) followed by a shut-in (buildup) period. Results from a pre-test are a lost-seal (unable to create a seal between pad and formation wall through the probe), a dry test, a tight test or a permeable test. If the pre-test is tight or permeable, a reservoir pressure is measured from the shut-in and drawdown (DD) mobility is calculated at the probe point using

$$\left(\frac{k}{\mu}\right)_{DD} = C\,\frac{q}{\Delta p_{ss}},$$