

IPTC 12183-PP

Using Open And Cased Hole Sonic Anisotropy And Geomechanics Modeling For Hydraulic Fracturing Evaluation: A Case Study - Carmópolis Field, Northeast Brazil

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This paper was prepared for presentation at the International Petroleum Technology Conference held in Kuala Lumpur, Malaysia, 3–5 December 2008.

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Abstract

Hydraulic fracturing plays a very important role in these mature and complex geology fields located onshore northeast Brazil – Carmópolis and Sirizinho Fields – on the revitalization of the oil production. The purpose of this work is to demonstrate the benefits of applying an integrated analysis for a hydraulic fracturing evaluation, that is performed using a workflow including time-lapse Sonic Anisotropy and Flexural Waveform Dispersion Analysis (open hole and cased hole) which main objectives consisted on the generation of a horizontal stress map for the studied area and an accurate measurement of the hydraulic fracture heights on the borehole wells together with a representative Mechanical Earth Model (MEM). In these mature fields, an accurate evaluation of the hydraulic fracturing operations is vital to enhance the effectiveness of the fracturing treatments and improve the production results. Multiple hydraulic fracturing operations were evaluated in five different boreholes providing a diagnosis of the expected versus the measured fracture heights. It was observed that the geomechanical modeling predictions for some possible natural barriers due to higher values of minimum horizontal stress (S_h) are in concordance with the fracture height measurements. This paper describes the applied methodology for one of these evaluated boreholes (Carmópolis Field) where the data evidences suggest a singular fracturing propagation for two different and unexpected cases: (i) a preferential down going fracture propagation for one of the fracturing operations apparently induced by two joined factors - a fault acting as a barrier to the hydraulic fracture up going dissemination and a rock formation weakness caused by open natural fractures and induced fractures in the zone below this fault – resulting in almost 25 m of reservoir missed, and (ii) the propagation of the hydraulic fracturing through a 10 m thick shale bed resulting in an unique hydraulic fracture covering two different reservoirs. Also, the minimal horizontal stress directions were evaluated on these five wells. Surprisingly, a not unique stress direction was obtained.

Introduction

Carmópolis and Sirizinho oil fields are located in Sergipe-Alagoas Basin, in Northeast Brazil (**Figure 1**). Discovered in the sixties and quickly put in primary production, at the beginning of the seventies the waterflooding began trying to restore reservoir pressure and well productivity. In the nineties the production profile of those fields showed a steep decline and reservoir pressure presented a significant depletion. In 1993, PETROBRAS started a strategic IOR project (named PRAVAP) where strategies like increasing water injection rates, improvement in the selectivity of water injection profile, reducing of wells spacing in fields borders, and specially a massive campaign of hydraulic fracturing in all producing wells, resulted not only on the attenuation but also on the total reversion and increase of the oil production that was declining for over ten years (Dória et al, 2005).

Until 2000 the results of the hydraulic fracturing operations in the Carmópolis field were below the expectancy. The low reservoir pressure associated with the high costs of the fracturing operations and the low oil prices turned these operations uneconomical during the nineties. After 2000, the increase in water injection rate has restored the reservoir pressure and become one of the main factors to restart the hydraulic fracturing operations.

New technologies both in equipment and fluids associated with the utilization of pseudo-3D hydraulic fracturing simulators increased the effectiveness of the fracturing treatments and improved the production results. At the same time the