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## Repeated 4D Monitoring of the Girassol Field (Angola): Impact on Reservoir Understanding and Economics

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### Abstract

4D-seismic is regarded with increasing interest as a strategic source of dynamic information, and as an added value monitoring tool to optimise reservoir management decisions.

The actual value of the 4D-seismic information relies on the possibility to bring it early enough in the project life to impact the development plan, and to participate in the construction of a reliable Reservoir Model.

Two seismic monitors have been acquired on Girassol-Jasmim, as part of a seismic monitoring project. The 4D processing and interpretation workflow we have developed has allowed us to start exploiting the essential of 4D information very early after the monitor acquisition. This key dynamic information has been used to constrain the reservoir model history match. The integration of 4D information has impacted fundamental decisions, like the drilling of a development well on a poorly drained area identified on 4D data.

Girassol-Jasmim 4D experience proves that time-lapse seismic brings added-value information all along the project life. 4D can effectively help optimising the development wells locations. The additional reserves associated to wells targeting undrained panels, the optimisation of development well locations and the increase in reliability of the Reservoir Model (basis for the reservoir management decisions) largely justify 4D expenses.

Our next ambition is to deconvolve, at least partially, pressure and saturation changes from 4D data. To advance in this direction, we are currently trying to extract reliable P and S time-lapse impedance changes through 4D-seismic multi-offset simultaneous inversion.

### Introduction

The 4D Seismic Monitoring Program on Girassol-Jasmim fields started end 2002 (1 year after 1st oil; 6 months after the beginning of water injection & gas re-injection in Girassol), with the acquisition of a first monitor seismic survey on Girassol field. It was followed by a second monitor, acquired end 2004 on Girassol and Jasmim fields (1 year after Jasmim 1st oil).

The purpose of this project is to integrate 4D-seismic information in the reservoir management decisions, as an instrument to improve the oil recovery. Seismic becomes an instrument for the integration of the different views on the reservoir monitoring, opening the way towards a geodynamically consistent vision that constrains the Reservoir Model.

This paper presents some fundamental results of the integration of 4D information in the reservoir management.

### Geologic Context

Girassol and Jasmim fields are located in the Girassol Development Area of Block 17, Angola deep offshore, within the Lower Congo Basin in the South Atlantic passive margin. Girassol field was discovered in early 1996, and Jasmim field in March 2000, by 1200-1400 meters of water.

The reservoirs are made of highly permeable unconsolidated sands, and correspond to the distal deposits of an Upper Oligocene turbiditic system linked to the paleo-Congo river, with a NE-SW orientation. They consist of several meandering channel-levee and sheet complexes separated by mud turbidites, deposited by syn-sedimentary compensation.

The fields are located on a turtle back structure created by the migration of the Aptian salt deposits right after the turbidites deposition (late Oligocene-early Miocene). They extend over an area 18 km long and 10 km wide.

### Field Development Context

Development of Girassol has been decided in 1998. Excellent reservoir properties and good communication have been inferred through DST, MDT and interference testing, while PVT analysis have shown good oil quality with 32°API. Desulfated seawater injection started 6 months after first oil for reservoir pressure maintenance and sweep efficiency.