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Title **Seismic Facies Analysis for Fracture Detection : a Powerful Technique**

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Preview

Summary

Fractured reservoir analysis requires an accurate delineation of fracture corridors, as well as an estimate of the fracture density. Fracture corridors are often closely associated with faults, large and small. 3D seismic data is of great help for minor "sub-seismic" fault detection and characterization, small faults being often expressed as very subtle zones of deformation (discontinuities), with no obvious offset of seismic reflections.

A large number of seismic attributes are known to highlight discontinuities. They can be horizon-based, such as curvature, dip, edge, azimuth or based on the 3D seismic trace variability in a given neighborhood such as "coherence-type" attributes or computed after Fourier or Hilbert transform as instantaneous phase or frequency.

This paper proposes, in a large Upper Cretaceous carbonate reservoir onshore UAE, to use jointly a set of selected "fracture relevant" attributes in a multi-variable statistical process called Seismic Facies Analysis (SFA). The resulting seismic facies map delineates areas spatially oriented towards two directions that are consistent with the general structural knowledge of the field. Analyzing seismic attribute distributions within each seismic facies gives a preliminary interpretation of these seismic facies in terms of fracture density. The validation of this interpretation with well data (BHI, core and dynamic data) delivers an accurate map of fracture occurrence. This map is then used to interpret structural lineaments and constrain stochastic realizations of the fracture model.

Introduction

An update of the fracture model of an Upper Cretaceous reservoir was planned in 2002 by Abu Dhabi Onshore Oil Operations Company (ADCO). The objective of the study was to compute the equivalent fracture parameters (fracture porosity, fracture permeability and block sizes) required for the reservoir simulation. A close integration of geological, geophysical and dynamic data was carried out using the methodology and workflows implemented in the FRACA software.

The 3D seismic data set (reflectivity) used in the study described in this paper has been acquired and processed in 1994 by ADCO (bin size 25m×25m, 32 fold). Reprocessing took place in 1998, followed by a powerful post-processing noise reduction step (Shell's software SOF, "Surface Oriented Filter") was applied in 1999. This technique enhances the signal to noise ratio of the data whilst preserving the subtle discontinuities (edge preservation algorithm). The quality of the seismic data has been significantly improved and different type of fracture-related information can be extracted from the 3D seismic data set with different algorithms.

A Seismic Facies Analysis (SFA) was performed in order to integrate fracture relevant seismic attributes and delineate areas characterized by their degree of fracturation.

Methodologies

Seismic Facies Analysis (SFA) analyzes automatically the character of the seismic traces to generate “Seismic Facies” maps (2D analysis) or cubes (3D analysis). These maps or cubes highlight the variation of the seismic pattern throughout the 3D seismic survey. The subsequent interpretation step allows to relate these variations to geological properties variations of the reservoir.

The methodology (2D analysis) consists in characterizing each trace over the reservoir interval by a series of seismic attributes (Déquirez et al., 1995). In this framework, traces are characterized as a series of seismic attributes that can be represented as points in a multidimensional space. In the attribute space, statistical cluster analyses are carried out for grouping similar traces (ie traces that are sharing similar attribute responses). Each group of traces corresponds to a particular “seismic facies”.

Two complementary approaches are possible. Firstly, the supervised analysis consists in the use of geological information, through training traces around well locations, for guiding the facies determination. This approach allows a straightforward interpretation of the resulting seismic facies maps, but requires a sufficient number of wells to be carried out. Conversely, the non-supervised analysis does not use the geological a-priori and is based on cluster analysis, carried out in the attribute space. In this case, well information is used for a-posteriori interpretation of the obtained seismic facies maps.

In this study, we focus on the non-supervised scheme.