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Fractured Basement Characterization from Multi-Attributes Guided Integrated Continuous Fracture Modeling

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Abstract

This paper demonstrates an integrated approach to conditioning models for fractured basement reservoirs (granite) through application of Continuous Fracture Modelling (CFM). The approach is built on two main steps: 1) the interpretation and analysis of FMI, log and core data which provide high vertical resolution information for a limited number of locations and, 2) the prediction of the fracture intensity in the inter-well space.

The process involves identifying and analyzing the underlying mechanisms that control the presence and distributions of fractures that contribute to flow by intervals using detailed and robust analysis of FMI data. The current work is based on a semi-automated fracture trace extraction module. The results show that this new method improves the quality and the consistency of fracture detection.

The robustness of the method is based on both qualitative and quantitative analysis of the data at each step of the workflow. The optimized fracture intensity curve is evaluated as a fracture indicator against attributes to establish a short list of fracture drivers from seismic data.

Fracture intensity models are then constructed using expert system based on neural network artificial intelligence methods. The fracture intensity probability models are finally evaluated by multiple realizations.

Introduction

The characterization and modeling using discrete fracture network (DFN) relies heavily on quality interpretation and analysis of image logs (FMI-Formation MicroImager) and core data at discrete well locations. These data provide high vertical resolution information, but quickly becomes challenging to use and propagate away from the borehole.

In addition, classical FMI interpretation of fracture types into open fractures and healed fractures or more detailed

classification is not sufficient to identify and predict with confidence hydrocarbon flowing zones within the basement. To palliate that inconsistency, traditional drilling data such as mud losses, ROP (Rate of Penetration), temperature log data have been considered more reliable to spot the contributing zones in absence of production logging data. While this traditional approach provides qualitative information, it does not provide the necessary quantitative data that can be translated into a reservoir model.

Our approach to Continuous Fracture Modeling (CFM) is a method of 3D fracture modeling that maximizes the geosciences controls on predicting fracture intensity in the inter-well space. The detailed and robust analysis of FMI data will be presented in a first part. Then the quantitative approach to select the fracture drivers from seismic data will be presented and finally the methodology to extend this information to the whole volume will be explained.

This workflow has been tested on the Vietnam fractured basement rocks. These basement reservoirs correspond to type I reservoirs (Nelson, 2001) where the matrix has little porosity or permeability, the fractures providing the essential storage capacity and permeability. These rocks date from Late Jurassic to Early Cretaceous are mainly granodiorites to granites and diorites.

Fracture classification and interpretation

A lot of examples of fracture classification in basement reservoirs exist in the literature. Each of them advocates a different classification based on either descriptive morphologic criteria such as Continuous, Discontinuous, Solution Enhanced fractures (vuggy), Brecciated, etc. (Li et al., 2003), or subjective aperture criteria such as Mega, Major and Minor and fracture density distribution function analysis (Tamagawa & Tezuka, 2004) or even both morphologic and aperture criteria (Tandom et al., 1999). Even if the fracture classes are the same or overlap largely, the definition varies from one author to the next. Moreover, the difference between different fracture classes is sometimes difficult to establish on the image log. For example, the same image log interpreter will not generate a consistent and objective interpretation along the same borehole and the differences will be more pronounced between two wells. This issue will be even more accentuated over a field study where image interpretation spans over the years as a function of drilling campaigns unless fully revisited. The reliability and consistency of fracture classification and interpretation will have significant impact on the fracture density curves used to base further analysis