Th SP2 05

Interpretation and Modeling of Fractured Zones Using Seismic Attributes and Image Log Data - Teapot Dome, Wyoming

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SUMMARY

Fractures are discontinuities in a rock and can significantly influence the fluid behaviour of a reservoir. The aim of this study is to create a Discrete Fracture Network (DFN), for a naturally fractured reservoir at Teapot Dome, Wyoming. The input for the DFN are well log information (FMI) and seismic attributes.
Introduction

Fractures are discontinuities in a rock and can significantly influence the fluid behaviour of a reservoir. The aim of this study is to create a Discrete Fracture Network (DFN), for a naturally fractured reservoir at Teapot Dome, Wyoming. The input for the DFN are well log information (FMI) and seismic attributes.

Method

Figure 1 reflects the main steps of the workflow, applied in this study. The available data includes well and seismic data from the Teapot Dome dataset and geological information from literature research.

Prior to seismic interpretation, well tops must be time converted to be integrated in the interpretation process. To link seismic data and well data, synthetic seismograms are generated. Therefore, 12 wells with available sonic and density logs are chosen. From these 12 wells a general time-depth relationship is determined, which is then applied to 12 further wells. After the identification of the reflectors, the horizons as well as geological structures like faults are interpreted. The structural interpretation is used to construct a structural model in time domain. To establish a DFN seismic attributes, in this case coherence, curvature, spectral decomposition, and acoustic impedance are used. Directional grey level co-occurrence (GLCM) matrix-based attributes can help to determine the strike and dip of fractures. Combining all results and available information from geology, well data (FMI data), the structural model and the seismic attribute calculations, a DFN can be generated.

Teapot Dome

Teapot Dome is a basement-involved, thrust-generated anticline (Laramide-age), located in the southwest edge of the Powder River Basin of Wyoming. Most fractures, deformation bands, and faults at Teapot Dome are formed during contemporaneous longitudinal and transverse stretching of sedimentary cover over a basement-involved thrust (Cooper et al. 2006). To highlight such structural features seismic attributes are calculated. Among the calculated attributes coherence is the most prominent attribute for fracture detection. Coherence measures the similarity between seismic waveforms or neighbouring traces. Incoherent data, like rapidly changing waveforms, result in low coherence events and can be related with the occurrence of fractures, faults or channel edges (Bahorich and Farmer, 1995). In general, there are several methods to calculate coherence, but this
study focuses on the semblance based coherence by Marfurt et al. (1998).

To calculate coherence cubes the software package OpendTect (dGB Earth Sciences) is used. In order to generate dip guided coherence cubes, dip and azimuth cubes (steering cubes) are necessary. In OpendTect volumetric dip estimations can be calculated using complex trace analysis (FFT steering), discrete scan method (Event steering) or gradient structure tensor-based method (BG Fast steering). To improve the quality of the coherence cubes, a prior filtering of the raw steering cubes can reduce the noise (Eichkitz et al., 2012). With each steering cube and filtering technique a coherence cube is calculated and results are compared to each other to determine the optimum workflow (see examples in Fig. 2).

![Coherence cubes](image)

**Figure 2** Coherence cubes. (a) Coherence cube calculated without a steering cube. (b) Coherence cube calculated with a filtered BG Fast-steering cube. (c) Coherence cube calculated with a filtered FFT (Standard)-steering cube. (d) Coherence cube calculated with a filtered Event-steering cube.

### Conclusions

Seismic attribute interpretation is a helpful tool for the extraction of fractures. Coherence, curvature, spectral decomposition, and acoustic impedance can clearly highlight fractured zones. Additionally, directional grey level co-occurrence matrix-based attributes can help to identify strike and dip of fractures. The next step in the workflow will be the structural modeling part and the construction of a DFN.

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### References


