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Integrated interpretation of microseismic data with seismic attributes from Hoadley field, central Alberta

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Summary

Microseismic event mapping provides valuable information about stimulation of unconventional reservoirs. More advanced information can be extracted using an integrated approach where the microseismic data are correlated with surface seismic attributes. These attributes have long been used for the interpretation of data from unconventional plays such as tight gas and shale. Integrated studies using advance techniques help unveil the potential of unconventional resources and aid in further development. This article describes a methodology for integrated interpretation of microseismicity recorded during simulation of two horizontal wells and 3D surface seismic attributes, from a case study in central Alberta. Curvature and coherence are two attributes that show promising correlation with microseismicity.

Introduction

The increasing confidence on seismic data entails that we gain the most information possible from seismic reflection data. Seismic attributes provide interpreters with additional information from seismic data. Although there are numerous seismic attribute studies that focus on unconventional shale plays, relatively little attention has been given to seismic attribute analysis in a tight sand environment. In this study we have used 3D post stack time migrated data with spectral whitening applied to enhance data resolution. Microseismicity was recorded using downhole seismic monitoring array during simulation of two horizontal wells in Lower Cretaceous Glauconitic tight sand of the Mannville Group. Our area of study lies in Hoadley field in south - central Alberta basin. Over 1650 microseismic events were recorded and located during this 12 stage treatment (Eaton et al, 2013).

Volumetric seismic attributes allow interpreters to map subtle stratigraphic details and structural deformation that are not readily observable on seismic data (Chopra and Marfurt, 2007). In this study, we have computed numerous volumetric attributes, using post stack time migrated 3D seismic data and compared these attributes with microseismicity. Curvature and coherence are two attributes that have shown promising correlation.

Geological background

Lower Cretaceous base glauconitic sandstone of the Mannville Group comprises a 7.5-24m thick pay zone. In central Alberta this Glauconitic sandstone member contains shallow marine sandstone deposits interpreted to have formed as an extensive barrier bar complex trending SW-NE. The middle and southwestern portion of the barrier bar is entirely saturated with gas and natural gas liquids, trapped laterally by impermeable shale and up-dip by shale-filled tidal channels (Chiang, 1981). The field is estimated to contain an ultimate potential recoverable reserve of 6 to 7 tcf of gas and 350 to 400 million barrels of associated natural gas liquids.

Method

The key process in post stack seismic attribute analysis is to examine and analyze different seismic attributes and narrow them down to interpretable seismic attributes (Wang, 2012). The process is divided into three main steps: **1)** seismic attribute computation and analysis using stacked seismic amplitude data; **2)** rock property attribute computation and combining azimuthal impedance anisotropy with curvature; **3)** visualization techniques and integration with microseismicity.

After correlating different attributes with microseismic data, we found curvature and coherence to provide the best correlation with the microseismic event distribution. Here we work with most-positive and most-negative curvature attributes co-rendered with amplitude horizon time slice.

Seismic attribute computation and interpretation

Seismic data offer valuable information for all the stages of exploration and or exploitation of unconventional resources. They carry certain signatures associated with lithology, rock property, fluid and in-situ stress (Wang and Dopkin, 2012). Certain properties can be extracted form well data, such as formation thickness, depth, fluid properties and seismic signature from synthetic. After calibration of surface seismic with well data, we are able to interpret horizons and compute various surface and volume based attributes, which further help in extracting various information to delineate resource play.

Rock property attribute computation

Existence of fractures and anisotropic stress fields result in velocity variations with azimuth and hence acoustic impedance (Chopra and Marfurt, 2012). Impedance volume can be extracted by removing seismic wavelet from reflectivity through seismic inversion. This then enables the estimation of anisotropy over the zone of interest (Zhang et al., 2010). Impedance is a layer property, which is directly related to rock properties like Poisson's ratio and Young's modulus from which tight sand brittleness can be estimated. The impedance volume then can be co-rendered with curvature volume for further correlation.

Visualization techniques and integration with microseismicity

Visualization techniques such as opacity, co-rendering and directional illumination are mandatory in understanding seismic attributes. The angle at which data is viewed, adds value in identifying certain features (Chopra and Marfurt, 2009).

Examples

The microseismic events from two treatment wells are shown in Figure 1a. The majority of events exhibit a linear fracture geometry which lie consistently NE-SW in the direction of the regional maximum

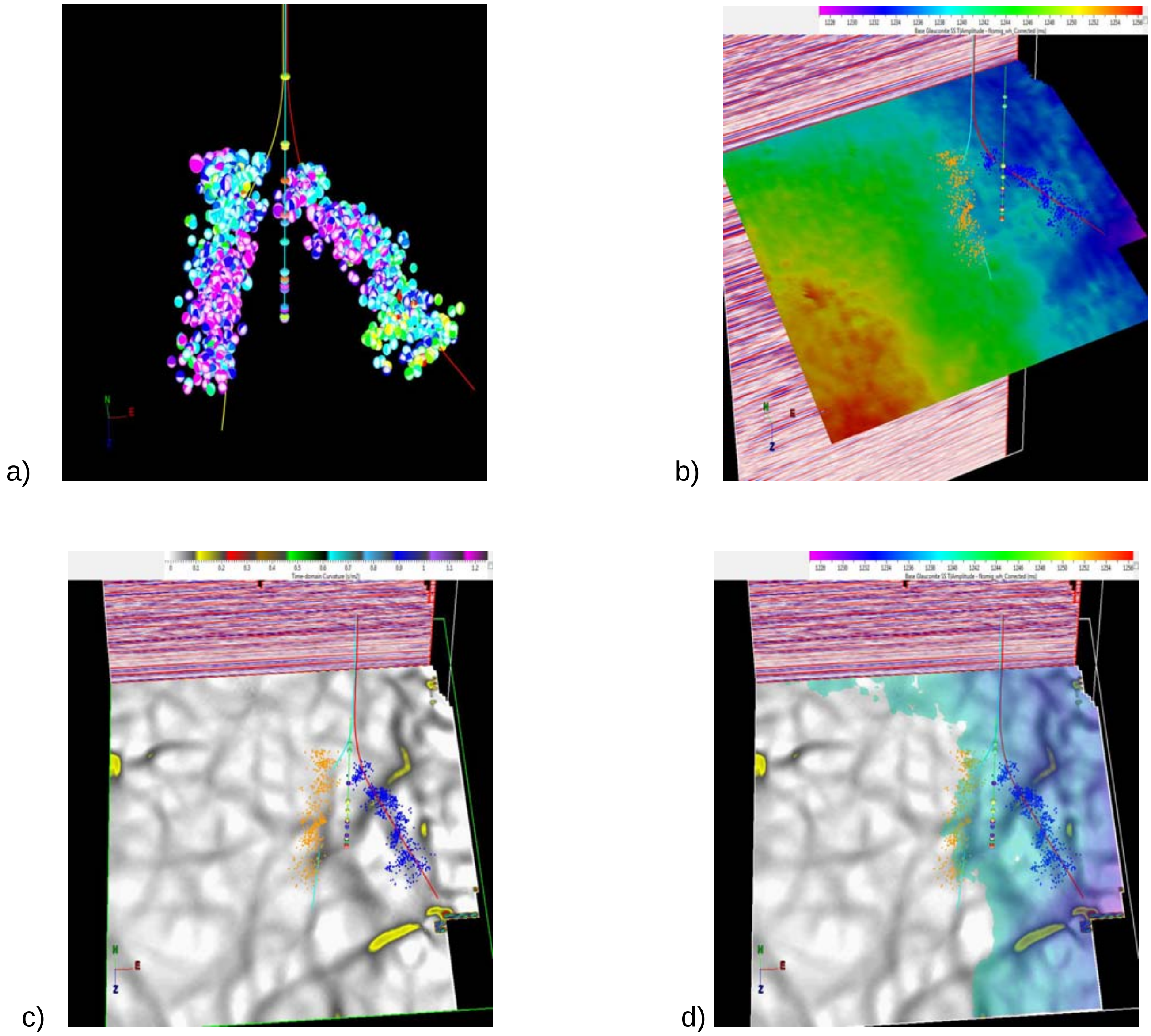

Figure 1: 1a) Three-dimensional view of the microseismic data recorded for two horizontal treatment wells, 1b) Time horizon slice, 1c) Most positive curvature k1 and 1d) Most positive curvature co-rendered with amplitude time horizon.

horizontal stress. The size of the symbols corresponds to the magnitude of each event. Time horizon is displayed with vertical slice through seismic amplitude in Figure 1b. A chair view of most positive curvature k1 through vertical slice of seismic is shown in Figure 1c and most positive curvature is co-rendered with amplitude horizon slice using opacity as in Figure 1d.

Conclusions

Integration of curvature (kpos and kneg) attributes with microseismicity indicates very good correlation, particularly when co-rendered with other attributes such as amplitude horizon slice in Figure 1d. Computation of rock property attributes further improves the integrated interpretation.

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