The Use of 3-component Seismic Data to Identify Sweet Spots in Fractured Bakken Reservoirs

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Differences in the seismic image of shear waves over producing wells vs. dry holes in the Bakken Formation are a key for drilling success in the Bakken. The Middle Bakken Formation in the Williston Basin has eluded detailed imaging from conventional surface-seismic methods for two reasons: 1. Its thickness, typically between 15 and 60 ft., at 8,000 ft., is well below resolution of conventional seismic methods, and 2. The P-wave response of seismic energy in the fractured vs. non-fractured rock is virtually identical. Prevailing wisdom on drilling successful Bakken tests has been locating wells near subtle structural flexures where expectations that higher density natural tectonic fractures exist. The Middle Bakken Formation in Mountrail Co., ND is a tight, brittle, dolomitic siltstone with little or no native porosity or permeability. Fractures are required for reservoir to exist. Two types of fractures exist: Tectonic fractures resulting in HTI anisotropy. Difficult to see on seismic images, tectonic fracturing, manifested on tonal and landform lineaments is correlative with better Bakken production. Another fracture mechanism in the Middle Bakken, proposed by Meissner, Price, and others is hydraulic. The Bakken Petroleum System is self-sourced, and the combination of a uniquely closed petroleum system, a high thermal gradient and volumetric expansion of the Upper and Lower Bakken kerogen into oil has resulted in high potential for creating in situ fractures parallel to bedding planes. This mechanism causes horizontal fractures resulting in VTI anisotropy. The edge of the natural secondary porosity in the Middle Bakken is geographically coincident with the thermal maturity boundary. In early 2009, Vector Seismic formed a consortium to evaluate the seismic signature of fractured reservoirs in the Middle Bakken. A high-resolution converted-wave (3C) seismic profile was acquired through the Behm Energy Edwards 1-34BH Well in T154N, R88W, in Mountrail County. The line tied the dry Behm Well with Bakken producing wells in Parshall Field. The seismic signature of the waveform on the converted-wave, (P-Sr) image shows marked differences that can be correlated to natural fractures in the Bakken Formation and better production. The strong relationship between the converted-wave seismic signature and Bakken productivity suggests that polarized surface seismic data can play an important role in the successful exploitation of this play.