P-wave Azimuthal Variation in Amplitude and Attenuation and Velocity in 3D Field Data: Implications for Mapping Horizontal Permeability Anisotropy

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3D P-wave data processed as limited-azimuth volumes through pre-stack time migration document an area in which the east-west travelpaths have greatly diminished amplitudes, slower interval velocities, and a limited bandwidth, while the north-south travelpaths display mappable seismic events, faster velocities and a broad signal frequency bandwidth. If the effective horizontal permeability is significantly different by azimuth, at the reservoir scale (the inter-well sfcale) and seismic wavelength scale, then azimuthal variation in the attenuation should be considered as a potential contributing cause of this anomaly. With these field data observations, the possibiltiy to use 3D P-wave multi-azimuth data to map directly the connectivity, or permeability anisotropy, associated with vertical aligned fractures is established. Akbar et al., (1994) predicted the slow velocity direction to correspond to the high attenuation direction, when a permeability anisotropy exists due to a preferred alignment of flow conduits (fractures). Our field data is in accord with his theory. Disputation as to the theoretically more attenuated direction exists (Gelinsky and Shapiro, 1997). Other attenuation mechanisms than the squirt flow mechanism do exist: when these other mechanisms control the seismic response in a laterally variant fashion, then our ability to map information about the horizontal permeability might decrease. To calculate the attenuation using P-wave seismic is often a daunting task: however, to calculate an azimuthal variation in the apparent attenuation may be more tractable (Thomsen, personal communication, 1997).

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