A Multi-Azimuth VSP Experiment for Fracture Orientation Detection in HMD Field, Algeria

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Natural micro-fractures are very important in the control of production in the hydrocarbon reservoirs. The presence of the vertical fractures in the rock mass causes the split of the incident shear wave into two approximately orthogonal components with different velocities. Splitting shear wave analysis permits the estimation of fracture orientation.

In the offset VSP experiment, converted SV waves are generated with varying strengths at particularly all depths. Consequently, the converted Sv waveforms partially overlap with direct P waveforms makes the separate event analysis difficult and inaccurate.

In this paper, an automatic picking technique was used to accurately compute travel time of P and Sv down-wave. The polarization angles are determined from particles motion analysis. The interval velocities Vp and Vs were than computed using the travel time inversion technique.

In this study, an attempt was made to determine the orientation of natural fractures by two analysis methods; shear wave splitting and P wave velocity anisotropy based on an anisotropic ratio computed from four offset VSP data acquired with different azimuths in the same well using the following formula:

Tau = (Vmax - Vmin) / Vmax

Where Tau is the anisotropy ratio, Vmax is the maximum velocity assuming equal to oblique velocity and Vmin is the vertical velocity calculated from zero offset VSP.

In the results, we have found that offsets B, C and D are practically equal (similar angles of incidence), but the corresponding anisotropy ratio are different.

Consequently, the velocity variations are rather related to the azimuth and the fracture orientation direction which corresponds to the smallest anisotropy ratio is about 78°.