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Fast Shear Azimuths in the Marcellus Shale From VSP and Dipole Sonic Data

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ABSTRACT

The Marcellus Shale is a commercially important unconventional shale gas play. It has been suggested that a contributing factor to the success of the Marcellus Shale is the presence of natural fracture systems. At least two sets of joints are commonly reported to exist in the Marcellus shale commonly referred to as the J1 and J2 systems. The earlier J1 system is reported to be confined to the lower Marcellus black shales and coincidentally aligned with the contemporary stress direction in an ENE-SSW direction. The later J2 fracture system occurs in the upper section of the Marcellus Shale and is described to result from gas expulsion from the underlying organic shales. If such fracture systems are present in the Marcellus Shale it is likely that they will need to be taken into account for optimal well planning and stimulation. For this reason it would be useful to remotely map any fracture systems for exploration and production purposes. To investigate whether seismic techniques could be used to characterize any fracture systems in the Marcellus shale walkaround VSP surveys were acquired to determine if fracture induced azimuthal anisotropy could be detected. A robust statistical approach was developed to process walkaround VSP data to measure shear-wave splitting resulting from fracture-induced anisotropy. We found a low degree of fracture induced anisotropy aligned in an ESE direction. This direction was surprising as the expectation was to find a fast shear azimuth aligned with the contemporary ENE stress direction. Based on this finding we expanded our analysis to review the fast shear azimuth measured over the Marcellus Shale interval from high quality crossed dipole logs. We found that in the majority of cases the fast shear azimuth appeared to be tracking the J2 fracture system rather than the J1 fracture. A second observation from this study is that the degree of azimuthal anisotropy observed in the seismic data is greater than that observed in the sonic data. This observation supports the idea that fracture induced anisotropy is frequency dependent and suggests that upscaling observed azimuthal anisotropy from sonic logs make lead to underestimating lower frequency wave propagation effects as observed in borehole and surface seismic data.