Identifying Stress-Induced Anisotropy and Stress Orientation Using Cross-Dipole Acoustic Logging

Zheng, Yibing [1]; Tang, Xiaoming [1]; Patterson, Douglas [1] (1) Baker Hughes, Houston, TX.

A formation's stress condition greatly impacts oilfield operations. For example, the stress information can help in planning well paths and maintaining borehole stability. In this paper we present an effective and reliable method to determine the formation's stress field using the shear-wave anisotropy measurements from cross-dipole borehole acoustic logging.

A challenge in cross-dipole anisotropy measurements is distinguishing the stress-induced anisotropy from intrinsic anisotropy. Our unique method calculates the azimuthal directions of fast waves from cross-dipole data at both low and high frequencies. Because low- and high-frequency waves have different depths of penetration, they measure anisotropy in the far and near regions of the formation around a borehole, respectively. Fast-wave angles are calculated directly using a global optimization algorithm by exploiting redundancy of array waveforms from all available receiver combinations. This algorithm is stable and accurate even at high frequencies where traditional methods have difficulties. If the angle difference of the fast waves at low and high frequencies is small, the anisotropy is dominantly intrinsic. A large difference close to 90 degrees indicates the dominance of stress-induced anisotropy. When both types of anisotropy are present and their principal orientations are not aligned, the angle difference varies between 0 and 90 degrees. In the latest scenario, the crossover of the fast- and slow-wave dispersion curves might not be valid because it assumes this angle difference to be either 0 or 90 degrees.

The successful application of this method is demonstrated by several field data sets from vertical and deviated wells. One example of a well near a salt dome shows clear intrinsic anisotropy in shale and stress-induced anisotropy in sand caused by the compressive stress from the pushing of the salt body. The direction of the stress agrees well with the local geological conditions.