Delineating Compressional Structures Through Refined Geosteering Methods

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ABSTRACT

Horizontal gas development wells drilled in the Marcellus Formation in Susquehanna County, Pennsylvania encountered tight fold structures, as detected through geosteering. However, compared to fold analogues in outcrop and in laboratory settings, the geosteering interpretations generated from existing methods depicted these sub-surface structures with varying accuracy. To more acutely determine the cross-sectional profile of these geologic structures, I developed a method whereby an algorithm is used to project and extrapolate the existing geosteering data into a valid 2-dimensional cross-section. Using this new method, I have determined that Devonian strata in the Appalachian Basin have an overlying detachment in the Upper Marcellus Member and an underlying detachment in the Esopus Formation. These detachments are bedding-parallel faults that periodically cut up-section to form fault propagation folds. 3rd and 4th order folds (wavelengths and amplitudes of tens of feet) are disharmonically contained within 1st and 2nd order folds (wavelengths of ½-mile or greater). In each case, conjugate chevron folds dominate the structures observed, indicating that shortening did not exceed 30%, in any case. 3-dimensional formation surface maps were constructed from the projected and extrapolated 2-dimensional cross-sections. These surface maps reveal, in more detail, the structural complexity that is not resolvable through basic seismic imaging. This enhanced view of the subsurface will greatly increase the effectiveness of horizontal drilling programs by being able to construct more accurate directional drilling plans, as well as anticipate changes in geologic structure in order to keep each horizontal wellbore within the optimal zone of production.