

An Integrated Approach for Delineating Structural Trends Using Regional Gravity Enhancements and Borehole Imaging in the Michigan Basin

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Regional gravity data is often used in petroleum exploration to map large-scale tectonic elements within a basin. However, small-scale structural features are difficult to delineate mainly due to low-density contrasts within the sedimentary strata, dominance of basement signature in the gravity field, and data resolution limitations. Directional gravity enhancement is one of the methodologies that can be used for mapping fine tectonic trends. However, the pitfall is that arbitrary selection of enhancement direction while amplifying real features creates artifacts. High-resolution borehole image data, if available, as an independent source of subsurface information, provides the attitude of small-scale faults and fractures from direct borehole measurements.

A statistical approach is demonstrated here to analyze lineaments picked from a generated set of the directional horizontal gravity gradients. Utilizing acoustic borehole imaging techniques, the natural fractures and faults are identified, picked and statistically presented from a number of wells in the Michigan Basin. The directionality results for both gravity lineaments and fracture interpretations are compared. Two dominant structural trends are observed in both datasets. The fracture attitudes are then used to geologically bias selection of horizontal gradient directions to optimize the enhancement of structural features, thus delineating trends that were present but not obvious in the initial gravity field and its non-directional enhancements.

The results show a significant improvement in imaging geological features, the locations of which are also supported by other available geological information. The application of this approach can be potentially expanded to areas with no or limited surface structural information.

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