Interpreting Array Induction Log Data in Deviated Boreholes

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Array induction instruments deliver a set of conductivity measurements with varying depths of investigation. Conventional processing through focusing algorithms can then provide resistivity profiles looking along a radial direction from the borehole into the formation. However, these focusing algorithms typically assume the presence of vertical boreholes and require "correction" terms if the well deviates.

In this work we present two different methods to derive such corrections. The first method, or geometric factor (GF) based dip correction uses the skin-effect and borehole corrected input curves from the different arrays to provide dip-effect-corrected logging curves, which then are used as input into the existing focusing or inversion algorithm. The algorithm uses newly developed geometrical factors, which generalize Doll's geometrical factor to be applied in dipping beds. In the second approach, or inhomogeneous background-based focusing (IBF) the array measurements are separated into a background response and a perturbation response, which allows us to treat each term differently. The background focusing result can be determined precisely, with the dip effect removed, while the perturbation focusing result can still be obtained through the standard focusing process. Combining the two results delivers the dip-corrected final focused and resolution matched results.

After describing the two methods and demonstrating the validity with some synthetic examples we present a field example from the Gulf of Mexico: 3,000 ft of HDIL data in a 45 degree well were corrected for dip effect using both techniques. The IBF showed significant improvement in the final vertical resolution matched curves, i.e., a reduction of curve separation in resistive sands, higher resistivity of the deep curves and elimination of other dip-effect artifacts. 2D inversion processing following the GF based dip effect correction resulted in a final resistivity model, which correlates well with mineralogical and petrofacial analysis. The excellent fit of corrected and synthetic data validates the approach of correcting for dip.