Application of new Quality Indicators (QIs) in Association with Novel Vertical 1D Inversion of Multi-component Induction Data: Case Study

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Abstract

Formation electrical anisotropy has been recognized for many years. In the laminated shale-sand sequences, the horizontal resistivity that is parallel to the formation bedding plane is much smaller than vertical resistivity that is perpendicular to the formation bedding. Triaxial induction logging is currently used for delivering formation resistivity anisotropy (horizontal and vertical resistivities), dip magnitude, and dip azimuth, but it cannot directly measure these formation properties. They are obtained by inverting the multi-component induction apparent conductivity tensor measurements. The new quality indicators flags and helps to identify the uncertainty of the inverted results, so it can be used cautiously for the interpretation. Triaxial or multi-component induction borehole correction algorithms are based on an eight-variable borehole formation model, namely horizontal resistivity (*Rh*), vertical resistivity (*Rv*), relative dip angle, relative dip azimuth angle, borehole diameter, tool standoff, tool eccentricity azimuthal angle, and borehole mud resistivity (*Rm*). Actual data, however, do not always conform to the model; the most important inverted results, such as *Rh, Rv*, relative dip angle, and relative dip azimuth angle, could be highly affected by these model nonconformities. The quality of the fit of the data to the model is generally characterized with a single misfit function constructed by summing the difference squared of all measured and reconstructed conductivity tensors. These QIs address the effects of borehole rugosity, whether the formation conforms to the assumptions of being a transversely isotropic (TI) formation and the validity of the inverted *Rh, Rv*, relative dip, and relative dip azimuth angle. This study demonstrates results of conventional inversion and the new improved vertical inversion on actual data and to show how QI aid in explaining the multi-component induction responses of formation. The results shows more details in the source of anisotropy; steeply dipping beds, biaxial anisotropy (BA) or non TI and invasion, which helps the user in making use of this information to their best advantage. The results were then examined with the borehole image logs and they show good agreement in various scenarios, and where they do not, inferences were attempted to explain the observation based on the triaxial resistivity and high resolution micro resistivity image logs

Present QI indicators demonstrates an integrated assestment of the inverted properties where it can be used in confidence to explain geological-petrophysical insight, and also where it has to be used with cautions. The new QI equations explicitly incorporate all the additional information compared to conventional triaxial applications to explain source of anisotropy.