

Handling Environmental Effects on a Triaxial Induction Tool

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ABSTRACT

A new fully triaxial induction tool is currently in field tests. This tool offers two significant technical advances. First, it features triaxial transmitter and receiver antenna modules. Each module includes an antenna with an axially oriented magnetic moment and a pair of orthogonal transverse antennas. The ability to collocate all orientations of the transmitter or receiver antennas greatly simplifies the analysis of the data and eliminates the problems of depth errors between the measurements. All nine couplings between transmitters and receivers are measured, giving the most complete data set possible.

Second, the tool is designed to minimize the borehole effect for the transverse couplings. For an induction tool with transverse coils enclosed in a nonconducting sleeve, the borehole effect in waterbase mud can be orders of magnitude larger than for a conventional induction array. In addition, the borehole effect depends in a complicated way upon the borehole geometry and formation resistivity far from the location of the tool, making it very difficult to correct. Understanding the physics of this effect has allowed us to develop a tool that provides a measurement with greatly reduced and simplified borehole effect. The remaining borehole effect is comparable in size to that of a conventional tool with axially oriented magnetic moments and it depends upon the borehole and formation only near the tool location. Experimental and modeling results show excellent agreement and demonstrate the effectiveness of the design.

This combination of collocated antennas and handling of borehole effects allows the tensor resistivity to be computed at any dip angle from all nine couplings of the triaxial arrays in most situations. Results from a very fast one-dimensional inversion show the ability of the tool to determine formation dip, bedding and tensor resistivity in typical formations with typical borehole complications.