FIRST LWD FULLY TRIAXIAL CO-LOCATED ANTENNA SENSORS FOR REAL-TIME ANISOTROPY AND DIP ANGLE DETERMINATION, YIELDING BETTER LOOK-AHEAD DETECTION

Paper Ref : **SPWLA-5078**

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Abstract:

Electromagnetic (EM) resistivity tools measure the electrical properties of downhole formations that are critical in determining the hydrocarbon saturation of a reservoir. In complex and heterogeneous reservoirs, both horizontal and vertical formation resistivities are required to obtain an accurate hydrocarbon saturation. For decades, wireline multi-component induction type measurements have provided reliable determination of formation anisotropy, structural dip, and dip azimuth in wells with any orientation relative to the bedding planes. Logging-while-drilling (LWD) multi-array propagation resistivity tools have also demonstrated similar capability in deviated wells where the relative dip angle is between 45 and 90 degrees. However, measuring anisotropy and dip in wells with low relative dip angle still poses difficulties for LWD propagation resistivity systems because of the simple antenna structures employed.

This paper describes the development of a new LWD EM sensor equipped with an innovative, fully triaxial, colocated, tilted antenna structure. The tool, along with a unique processing scheme, enables the determination of horizontal and vertical resistivity as well as the dip angle and the azimuth of the formation while drilling in real time. The co-located sensor design is capable of acquiring multi-component signals that are sensitive to formation anisotropy and structural dip in wells at any orientation. Modeling studies and several field trials have proven that the design concept can detect these formation properties at any arbitrary wellbore deviation. This paper presents test results from the new technology, together with reference measurements from azimuthally compensated LWD and fully triaxial wireline resistivity measurements. Very good comparison is observed in these trials, providing an independent verification of the tool performance. The azimuthal responses of the tool enable measurement of all EM field components, as well as providing 360-degree azimuthal resistivity and geosignals, and allowing a three-dimensional (3D) resistivity mapping technique for real-time decisions at any wellbore deviation. The collocated antennas are further integrated with deep-reading antennas to enhance look-ahead detection ranges for LWD applications.

Bio:

Hsu-Hsiang (Mark) Wu is a senior scientific advisor in the electromagnetic sensor-physics research group in Halliburton in Houston. He joined Halliburton in 2008 and has since improved the LWD resistivity logging tools and developed several new electromagnetic tools. Wu has been working on LWD related projects for more than 10 years and has helped to develop the new ranging system and ultradeep resistivity tool in the last five years. He received his MS and PhD degrees in electrical engineering from the University of Houston in 2007 and in 2017, respectively. Wu has proposed various innovations related to downhole formation evaluation, look-ahead look-around determination, and magnetic ranging detection since 2009.