

Incorporating electromagnetic measurements into drilling systems with a relay station

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Electromagnetic measurement while drilling (EM-MWD) systems transmit downhole data by emitting electromagnetic waves into the formation, thereby carrying the emitted data to a surface antenna; however, these electromagnetic waves are attenuated when transmitted into the formation. To further extend depth capabilities, Extended-Range EM-MWD systems have been developed. Expanding on this approach, this paper introduces an EM-MWD system that incorporates a relay station within ultra-deep wells; our proposed system consists of a downhole instrument assembly, a relay station and a ground receiver assembly. After decoding a received signal, the relay station amplifies, filters and recodes the signal; then the relay station emits the augmented signal. Through numerical simulations, as presented in this paper, propagation characteristics of electromagnetic waves in heterogeneous and stratified strata show that when the resistivity of the upper formation and the lower formation is kept constant, the voltage of the ground receiving signal first increases and then decreases with the increased resistivity of the interlayer. Similarly, when the resistivity of the upper stratum and interlayer is kept constant, the voltage of the ground receiving signal first increases and then decreases with the increased resistivity of the lower stratum. This paper also presents the design schemes, the technology used to process the insulation gap, and the power-saving technology to increase the lifetime of the downhole instruments. Furthermore, the working principle of the relay station is described. Moreover, by analysing the electric and magnetic excitation methods under the same conditions, signal attenuation is fast and the signal strength obtained on the ground is low when magnetic excitation is used. Therefore, an electric excitation method is adopted for implementing the relay station. To conclude, suggestions as to reasonable locations of the relay station and reception and decoding of the ground signal are provided.