

Surface-To-Borehole TFEM Data Acquisition System Development and Field Test

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ABSTRACT

A surface-to-borehole time-frequency domain EM (TFEM) data acquisition system has been developed and a successful field test was conducted in the Liaohe Oilfield of North China early this year. The field test has successfully acquired downhole 3-component magnetic field and vertical electrical field surface-to-borehole TFEM data the first time using a 3 km long surface dipole current source at two source locations. The first long dipole current source was placed in the radial direction of the borehole and 3 km away from the wellhead, and the second dipole current source was placed in the radial direction of the borehole and 3.5 km away from the wellhead. The long dipole current source injected more than 50A square wave current into the subsurface to generate the underground TFEM signal. The source square wave with a total of 11 frequencies (0.03125Hz, 0.04Hz, 0.0625Hz, 0.1Hz, 0.12207Hz, 0.24414Hz, 0.48828Hz, 0.97256Hz, 1.95312Hz, 3.90625Hz, 7.8125Hz) was transmitted at each receiver array location. A newly developed 4-level borehole TFEM receiver array was used to record surface-to-borehole TFEM data from the depth of 1,000 m to 1,800 m in the borehole. Each level of borehole TFEM receiver contains a 3-component time domain induction coil package installed in the center of the receiver tool and two electrodes are located at each end of the receiver tool with a spacing of 10 m. Each receiver array acquires the vertical electrical field TFEM data and 3-C magnetic field TFEM data. The recorded surface-to-borehole TFEM data were used to conduct unconstrained inversion, interface inversion and constrained inversion. The surface-to-borehole TFEM data show the characteristics of subsurface formation electromagnetic properties and their changes at different depth. The first field test proved the correct design of the surface-to-borehole TFEM data acquisition system and its ability to acquire high quality borehole TFEM data than that of the borehole-to-surface TFEM system.