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In-loop TEM for fast investigation of subsurface water-filled zones in coal mines

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The central-loop TEM configuration is now increasingly being used to detect subsurface water-filled coal mines in China. This survey layout is sensitive to anomalous geological structures with low resistivity and relatively easy to implement within a complex working environment (Taylor et al. 1992; Baumgartner 1996; Danielsen et al. 2003). However, in practical applications of central-loop TEM, it is neither convenient nor efficient to continuously move the transmitting loop from one place to another so as to observe central TEM signals. To overcome this problem and partially reduce the effect of local heterogeneities close to the receiver, the TEM values around the central position and within a fixed range inside the loop could be measured.

However, no such simple formula does exist for in-loop off-center TEM sounding. For this type of acquisition, the field response is recorded at several points surrounding the loop's center. In-loop TEM surveys are frequently employed to obtain high spatial resolution in engineering geophysical investigations. Although, the apparent resistivity formula for a fixed-loop TEM system is also applicable to the non-central receiver points used in an in-loop TEM system, the apparent resistivity values need to be extracted using an iterative method which requires complex integrations. Thus, at the moment there is no fast method that can give access to the apparent resistivity values in a direct manner.

Therefore, the main objective of this paper is to present a possible solution to this computational problem. Hence, a new solution is presented, which takes a circular transmitter loop, where an analytical solution exists, as a starting point for non-central receiver points. This analytical solution is further approximated through the combined use of least-mean square (LSQR) determined polynomial coefficients and an equivalent circular loop, to represent the rectangular loop.

The proposed approach was applied to the field data acquired in the Shanxi Province of China. The results obtained were then confirmed via actual drilling, thus, demonstrating that the proposed method of calculating the apparent resistivity can be used to rapidly delineate water-filled areas in coal mines.

References

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