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Visualization of subsurface resistivity anomalies in VLF-EM method

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Electromagnetic waves of narrow-band frequencies generated by VLF transmitters induce electrical currents in the subsurface due to localized electrical conductivity anomalies. Secondary induced components of magnetic field would be observed above the surface due to the induced electrical currents. Therefore, the secondary induced magnetic field could be used to detect the induced currents in the subsurface. This method, so-called VLF-EM, has been recognized as a powerful tool for mapping subsurface conductivity anomalies because of its low cost and short survey terms. Conductivity anomalies are in general mapped on the surface but have not been estimated as a vertical pseudo-resistivity section nor in a 3D cube. We hypothesized that both the apparent resistivity and the depth of conductive anomalies could be estimated using the measured magnetic components with a single frequency. In this study, the Normalized Full Gradient (NFG) method, generally used for the downward continuation of the potential filed data, is applied to the observed magnetic data on the surface in order to estimate the 3D distribution of conductivity anomalies in the subsurface. A synthetic VLF-EM data set was created numerically to test our hypothesis. The cross section of NFG values derived from the horizontal component of magnetic field clearly peaks at the edges of a low resistivity anomaly zone buried below the surface, while the value of the NFG from the vertical component at the centre of the anomaly. Finally, we estimate a pseudo-section of apparent resistivity from the VLF-EM data weighted with the NFG values at each depth. We confirm that the weighted apparent resistivity values are lower in the vicinity of low resistivity anomaly than in the surrounding area, although the estimated value is a little higher than the original value. We conclude that our simple technique gives approximate subsurface resistivity structures quickly, which is useful for geological interpretations and also for building an initial model of three-dimensional inversion.

Keywords: VLF-EM, downwardcontinuation, NFG, apparent resistivity