Response simulation of 3-D resistivity structure using Time Domain Vertical Electric field Gradient (TDVEG) method

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Gradient of the vertical electric field is measured using borehole. This method is conducted simultaneously with the usual time domain electromagnetic (TDEM) method which utilizes horizontal current dipole, however, it is especially suitable for monitoring the variation of resistivity.

Time variation of the gradient will be equal to the gradient of the current density if the resistivity of the layer where electrode is installed does not change. This quantity is very sensitive to resistivity change below. Since the vertical component of current in the surface is zero, if there is an insulator at the depth below the measurement point, the current density is also zero. On the other hand, if conductor exists, the value of the current density will be large.

Numerical modeling to calculate gradient of the vertical electric field component for a borehole observation system is conducted. In this case, it is necessary to install

electrodes in three or more different depths for one single borehole. This method is conducted simultaneously with the usual time domain electromagnetic (TDEM) method, which utilizes horizontal current dipole, however, it is especially suitable for monitoring the time variation of resistivity at depth.Time variation of the gradient will be equal to the gradient of current density if resistivity of the layer where electrode is installed does not change. This quantity is very sensitive to resistivity change below the measurement point. Since the vertical component of current in the surface is zero, if there is an isolator at the depth below the measurement point, the current density gradient is also zero. On the other hand, if conductor exists at that depth, the value of current density gradient. To get the value of vertical electric field gradient first we have to solve the coupled Maxwell's equations in the modeling domain in which performed in this case by using the finite-difference scheme on a staggered grid.

The 3-D earth model comprises a prismatic anomalous body, which is embedded in a layered resistivity structure. After finite differencing, the system of equations for field responses generated by a horizontal electric dipole which provides a turn-off step function current located at the earth's surface are solved numerically in the Laplace s-domain using the quasi-minimum residual (QMR) method with symmetric successive-over relaxation (SSOR) preconditioning. Transformation from Laplace domain to time domain is conducted by using the digital filtering technique called the Gaver-Stehfest method.