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Three-dimensional Complex Resistivity Modelling and Inversion with Topography

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The characteristic of complex resistivity on rock and ore has been recognized by people for a long time. Generally we have used the Cole-Cole Model(CCM) to describe complex resistivity. It has been proved that the electrical anomaly of geologic bodies can be quantitative estimated by CCM parameters such as direct resistivity(ρ_0),chargeability(m),time constant(τ) and frequency dependence(c). Thus it is very important to obtain the complex parameters of geologic body. There are some drawbacks in traditional complex resistivity inversion methods. For example, most of these inversion methods are based on the hypothesis about apparent resistivity and true parameters. The hypothesis will lead to some obvious error for the result of inversion. In addition, the traditional methods can't inverse the geometry parameters. In order to enhance the veracity and reasonably of the complex resistivity data, the effect of topography should be taken into account. As a result, in this paper we study the methods on the frequency-domain electromagnetic three-dimensional(3D) modelling and inversion of complex resistivity with topography by volume integral equation.

First of all, on the basis of analysis about the complex resistivity mathematical models, the topography is regarded as anomalous bodies; and then, the CCM is introduced into the 3D electromagnetic modelling. The 3D electromagnetic responses of the surface electric dipole are computed by volume integral equation. In modelling, it is to separate the electromagnetic field into a primary and a secondary field to avoid a source singularity. In addition, the modelling uses the Gaussian quadrature and continued fraction to calculate the integral of Bessel function. The benchmark results of the modelling indicated that these methods are feasible and accurate.

As to the surface electric dipole source, the modelling results of 3D complex resistivity show that the values of secondary electric and magnetic field are not constant with complex resistivity parameters changes. In general, the absolute values of secondary electric and magnetic field increase with the rise of the complex resistivity parameters(m,τ,c), and the influence of m is more prominent among these parameters. In addition the topography can cause great influence on the horizontal component of secondary electric field, but it has little influence on the horizontal component of secondary magnetic field.

At last, in this paper we develop the sensitivity matrix that reflects the rate of real measurement field to the CCM parameters. It is achieved that the complex resistivity 3D electromagnetic inversion with topography using conjugate gradient algorithm based on electric dipole source. The conjugate gradient algorithm doesn't need to compute the sensitivity matrix but directly computes the sensitivity matrix or its transpose multiplying an arbitrary vector. Thus this algorithm efficiently reduces the computation of the inversion. The inversion results of complex resistivity parameters verify the validity and stability of conjugate gradient inversion algorithm.

The results of theoretical calculation examples indicate that the modelling and inversion of the 3D complex resistivity with topography are feasible.