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地面可控源频率测深三维非线性共轭梯度反演

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Three-dimensional controlled source electromagnetic inversion using non-linear conjugate gradients

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摘要 讨论了地面可控源电磁勘探三维非线性共轭梯度反演的可行性以及反演过程中考虑场源的必要性.反演采用非线性共轭梯度反演方法.反演过程中,模型响应利用交错网格有限差分技术计算.反演数据采用与发射源平行的电场x分量E_x.利用层状导电模型作为背景,设计了两个理论模型进行数值试验:第一个模型中包含两个电阻率异常,以检验反演的有效性;第二个模型中,在测区外设置了一个低阻异常,以考察源的信息在反演中的作用.两个模型的反演分别从层状背景模型开始,迭代120次后终止.数值试验结果表明,(1)非线性共轭梯度反演所获得的电阻率分布和理论模型吻合较好;(2)非线性共轭梯度算法收敛速度较慢,需要较多的迭代次数完成反演;(3)对于可控源频率电磁勘探,必须考虑源位置信息.因此,本文采用考虑场源信息的地面可控源非线性共轭梯度反演方法能完成真正意义上的可控源频率电磁测深数据的反演.

关键词 可控源电磁法, 非线性共轭梯度法, 三维, 反演

Abstract: There are two objects concerned in this paper: (1) to verify the feasibility of nonlinear conjugate gradients inversion (NLCG) applied to three dimensional (3D) data from controlled source electromagnetic method (CSFEM); (2) to study the necessity and effect of source information on the inversion of 3D CSFEM data. NLCG inversion with heuristic approach to find optimal step length is used. During inversion, Helmholtz equation based on secondary electric field governed by primary filed as source is first computed by using staggered grid finite difference scheme. The x-component of electric fields E_x with random noises of Gaussian type are put into the inversion. Two theoretical models are designed to prove the feasibility of the inversion method. One has two anomalies in the top layer of the background and the other contains a conductive body out of survey area where no resistivity anomaly exists. Both inversions start from background model, and terminate after 120 iterations. Numerical results show that (1) the three-dimensional resistivity distributions from NLCG inversion coincide with the theoretical models, validating that NLCG can be applied to three-dimensional controlled source electromagnetic inversion; (2) NLCG inversion needs a relatively large number of iterations to achieve error threshold, revealing the inherent slow convergence of NLCG inversion method; (3) in order to suppress the effect of the conductivity abnormal out of survey area on the target conductivity distribution, information of controlled source must be considered during 3D CSFEM inversion.

Keywords Controlled source electromagnetic method, Non-linear conjugate gradient, Three dimension, Inversion