地球物理学报 2008 51 (5): 1608～1619 ISSN: 0001-5733 CN: 11-2074/P

各向异性层状介质中视电阻率与磁场响应研究

沈金松[1，2，3]，郭乃川[2]

1 中国石油大学资源与信息学院，北京 102249
2 油气资源与探测国家重点实验室，北京 102249
3 中国石油天然气集团公司物探重点实验室，北京 102249

收稿日期 2007-3-26 修回日期 2008-6-18 网络版发布日期 2008-9-17 接受日期

摘要 针对任意各向异性地层，利用极向型和环向型标量位函数，导出相应的直流电视电阻率和磁电阻率的磁场响应关系.计算了各向异性地层的直流电视电阻率和磁电阻率响应特征，重点分析了电阻率测深方法与磁电阻率探测方法对地下各向异性介质的探测能力.文中采用状态矩阵的分析方法，首先采用极向型和环向型标量位构造了各向异性层状介质电场与磁场的通解，利用各层界面电场、磁场的连续性及地面激励源的耦合条件，推导了不同层之间电磁场的状态矩阵，建立了空间电场与磁场的递归计算关系.其次，针对递归计算中指数项数值计算的不稳定性，借用状态矩阵的性质，导出了将不稳定指数计算项转化为稳定的指数项的转换关系.针对横向各向同性(TI)介质中极向位与环向位解耦的特点，导出了电磁场的直接积分解.最后，采用解析解验证了算法的正确性，给出了多层各向异性地层模型的视电阻率和磁场响应曲线，分析了直流电法探测裂缝性地层、估计裂缝分布性状的可能性.

关键词 状态矩阵 各向异性层状介质 极向型与环向型位函数 裂缝性地层
分类号 P631
DOI:

Study on the apparent resistivity and magnetic field responses of a layered earth with arbitrary anisotropy

HEN Jin-Song[1,2,3], GUO Nai-Chuan[1]

1 Geophysical Department, China Petroleum University，Beijing 102249，China
2 State Key Laboratory of Petroleum Resource and Prospecting,China University of Petroleum, Beijing 102249,China
3 CNPC Key Lab of Geophysical Exploration, Beijing 102249，China

Received 2007-3-26 Revised 2008-6-18 Online 2008-9-17 Accepted

Abstract The electric and magnetic responses to an arbitrary anisotropic formation have been checked through the direct current apparent resistivity and the magnetometric resistivity by using the potential of poloidal and toroidal scalars. The direct current apparent resistivity and the magnetometric resistivity responses to a multi-layer model have been calculated and applied to the analysis of the sensitivity of the apparent resistivity and the magnetometric resistivity methods to the anisotropic formation. In this study, the method of the state matrix analysis has been adopted. First of all, we construct the general solutions of the electric and magnetic fields by using of the poloidal and toroidal scalars. The current density and magnetic field are represented by potential of poloidal and toroidal scalars, and direct current (D.C.) apparent resistivity response due to point current sources in the layered half space with general anisotropy has been analyzed. The state matrix which propagates the electric and magnetic fields from upper layer to lower layers has been derived by adoption of the continuity of the electric and magnetic fields and the coupling of the source on the earth, and the fields are calculated recursively from the bottom layer to the top layer. Secondly, with regard to the unstable computation of the exponential term, a stable formulation has been deduced from the state matrix through the conversion to the stable exponential relationship. For the TI medium, an integral of the Green′ s function is used because of the decoupling of the poloidal and toroidal functions. Finally, the validity of the numerical method has been tested against an analytic solution of a simple half space anisotropic model. Results of multi-layer models have been shown to assess the feasibility of discerning the fractured formation and predicting the distribution of the fractures by using the D.C. current survey and magnetometric resisitity method.

Key words State matrix Layered medium with arbitrary anisotropy Poloidal and toroidal potential function Fractured formation

通讯作者:
沈金松 shenjinsong@cup.edu.cn

作者个人主页: 沈金松[1;2;3]; 郭乃川[2]