地球物理学报
CHINESE JOURNAL OF GEOPHYSICS

地球物理学报 » 2009, Vol. 52 » Issue (3) :833-841 doi:

引用本文(Citation):

杨守文;汪宏年;陈桂波;姚东华.倾斜各向异性地层中多分量电磁波测井响应三维时域有限差分（FDTD）算法. 地球物理学报, 2009,52(3): 833-841,doi:

YANG Shou-Wen;WANG Hong-Nian;CHEN Gui-Bo;YAO Dong-Hua.The 3-D finite difference time domain（FDTD）algorithm of response of multi-component electromagnetic well logging tool in a deviated and layered anisotropic formation.Chinese J.Geophys. (in Chinese),2009,52(3): 833-841,doi:

倾斜各向异性地层中多分量电磁波测井响应三维时域有限差分（FDTD）算法

杨守文;汪宏年; 陈桂波;姚东华*

吉林大学物理学院，长春 130023

The 3-D finite difference time domain（FDTD）algorithm of response of multi-component electromagnetic well logging tool deviated and layered anisotropic formation

YANG Shou-Wen; WANG Hong-Nian; CHEN Gui-Bo; YAO Dong-Hua*

School of Physics, Jinlin University, Changchun 130023,China

摘要 利用三维时域有限差分技术（FDTD）研究建立倾斜各向异性地层中多分量电磁测井响应的数值模拟算法.首先，利用Yee氏交错差分格式和线性内插公式对各向异性介质中时域Maxwell方程进行离散化，得到各向异性介质中各个交错节点上电磁场的时域递推公式，同时将面积加权平均与旋转矩阵技术相结合确定各个网格节点的等效电导率张量，此外，单轴各向异性吸收边界条件（UPML）被用于降低求解区域外边界反射.在此基础上，利用单频正弦磁偶源计算时域电磁场空间分布以及特殊的双方程算法（2E2U）从数值结果中快速提取电磁场幅度和相位，确定多分量电磁测井仪器的三维响应.最后，通过数值结果证明该算法的有效性，并系统考察不同层厚、地层倾角以及侵入带半径等变化对多分量电磁测井响应的影响.

关键词 各向异性地层, 3-D时域有限差分, 多分量电磁波测井, 时频变换

Abstract： In this paper, we advance an algorithm of numerical modeling of responses of multicomponent electromagnetic well logging in a deviated and layered anisotropic formation through the 3-D finite difference time domain approach (FDTD). First, we use Yee′s staggered grids and linear interpolation formula to discretize the Maxwell equation in time domain in an anisotropic medium and determine the non-defined components of electromagnetic (EM) field in the staggered grids in order to obtain the time recursive equation of EM field on all staggered grids in an arbitrary anisotropic media. At the same time, area weighted average and transformation matrix are utilized to calculate the effective conductivity tensors on the grids, and an absorbing boundary condition is executed to reduce the reflection of outer-boundary on the base of uniaxial anisotropic perfectly matched layer (UPML). Then, we apply three mutually orthogonal transmitter coils with a single-frequency sinusoidal current to excite EM fields in time domain and extract the amplitude and phase of EM from the EM field through a special two-equation and two-unknown (2E2U) approach to obtain the responses of multicomponent EM propagation logging tool. Finally, numerical calculations are used to validate the algorithm and investigate systematically the influence of changes in bed thickness, formation dipping angle and radius of invasion zone on the response of the tool.

Keywords Anisotropic formation, 3-D finite difference time domain approach(3-D FDTD), Multicomponent EM propagation logging, Time-frequency conversion