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基于改进Krylov子空间算法的井中激电反演

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Inversion of IP logging based on improved Krylov subspace methods

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摘要

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摘要 井中激电是二次找矿重要的地球物理勘探手段,快速而稳定的正反演算法有助于方法的推广和应用.本文在正演模拟中,给出了考虑井眼影响下的网格剖分方式;用右端项校正技术减小边界效应和源点奇异性引起的模拟误差;并采用循环Krylov子空间算法提高多线性方程组的求解效率.反演用Gauss-Newton法结合Jacobian-free Krylov迭代求解技术,给出了Jacobian矩阵向量积的简化计算方法;用不精确预处理共轭梯度法对模型修正量方程近似求解以减少计算量;采用不同于正演的反演网格剖分降低不适定性.数值算例验证了相关算法的有效性和可靠性.

关键词 井中激电, 反演, Krylov子空间, Jacobian-free, 有限元

Abstract: IP logging is an important method for second mineral surveys. Fast and stable forward calculation and inversion are helpful to the practical application of the method. For the finite element forward simulation, a grid scheme was discussed upon the model complexity in 3D modeling of well logging. A correction to the right hand side of the finite element equation could reduce the effects of the source singularity and the influence of boundaries. Furthermore, this work used a recycling Krylov subspace algorithm to solve the multiple linear systems efficiently. The Gauss-Newton method and Jacobian-free Krylov techniques were employed for the inversion. We deduced the formula for a Jacobian-vector product. A linear search direction was solved approximately by an inexact PCG algorithm. Different grids for forward and inversion calculations were used to reduce the ill-posedness of calculations. Two synthetic examples were presented to demonstrate the effectiveness and reliability of these algorithms.

Keywords IP well logging, Inversion, Krylov subspace, Jacobian-free, Finite element

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