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基于电场矢量波动方程的三维可控源电磁法有限单元法数值模拟

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摘要 从可控源电磁法的基本原理出发，推导了基于电场矢量波动方程的三维边值问题，利用广义变分原理，把边值问题转换为变分问题，并引入散度条件，避免了伪解的出现，使有限元计算在理论上更加完备.在准静态近似条件下，把水平电偶极子在空中和大地的远区电场闭合表达式作为有限元计算中的区域外边界条件，解决了边界条件加载的困难；把应用于地震模拟中的伪delta函数引入到可控源电磁法中的三维有限元模拟中，消除了源点的奇异性，提高了方程组的稳定性.通过对均匀大地和层状介质模型的模拟，检验了程序的正确性，并对典型的地质体模型进行了数值模拟，分析了其变化规律.

关键词 可控源电磁法 有限元单元法 数值模拟 矢量波动方程

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Three dimensional controlled source electromagnetic numerical simulation based on electric field vector wave equation using finite element method

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Abstract From the basic principles of controlled source electromagnetic, boundary value problem based on electric field vector wave equation is derived, and then transformed into variational problem by generalized variational principle from which weak solutions form is obtained based on vector wave equation of the electric field, and the introduction of divergence conditions avoids a spurious solution and makes electromagnetic finite element method more complete in theory. In quasi-static conditions, the closed expressions of electric fields in the far zone in the air and the earth are taken as the outer boundary conditions of the finite element method, difficulties in loading the boundary conditions are solved. The pseudo delta function in seismic method is used to simulate three-dimensional electric dipole source in finite element simulation then the singularity at source is eliminated, and also the stability of the equation is improved remarkably. Through the numerical simulation for uniform media and layered media, the validity of the procedure is tested, and for typical geological models, numerical computing is performed and its electromagnetic response is analyzed.

Key words Controlled source electromagnetic method; Finite element method; Numerical simulation; Vector wave equation

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