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三维地形直流电阻率有限元法模拟

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摘要　基于稳定电流场的基本方程、三维区域满足的边值问题以及相应的变分问题，研究了三维起伏地形条件下电阻率的有限单元数值模拟算法. 离散积分区域时，以三棱柱为最小研究单元，推导了含有地形特征信息的三线性插值型函数以及单元刚度矩阵. 采用变带宽、一维数组方式只存储稀疏刚度矩阵中非零元素，能够节约内存. 利用Cholesky分解法只分解一次大型稀疏矩阵，通过回代可以求出方程组的全部解，当求解有多个供电点的测深问题时可以缩短计算时间. 模型计算表明，在水平层状介质模型上，三维计算结果与解析解或二维数值解十分吻合，计算精度满足误差要求. 在二维山脊上的二极剖面或三维山谷上的中间梯度剖面上，其三维计算结果与相应模型的土槽实验结果或边界元法计算结果也非常接近.

关键词　电阻率法,有限单元法,三维数值模拟,起伏地形

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The resistivity FEM numerical modeling on 3-D undulating topography

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Abstract Based on stable electricity flow field equation, three-dimension boundary question and its corresponding variation question, the algorithm of resistivity FEM numerical modeling on a 3-D topography is studied. The integral area is divided into many tri-prism units with anomalous shapes and landform characteristics. The function of tri-linear interpolation and the matrix of tri-prism unit are then deduced. Using varied band matrix and one-dimension array to collect the large sparse matrix, the integral coefficient of all the nodes, we could save memory space. Before solving the system of linear equations, the Cholesky algorithm was adopted to decompose the large sparse matrix only once, and then we obtained the potentials of all nodes of hundreds of different current electrodes by backward substitutions. This is an important step to improve the speed of forward modeling when there are more sounding-points. The results of this modeling show that the 3-D numerical solution is in agreement with the analytic solution on level stratified medium, on 2-D mountain ridge with pole to pole array, or on 3-D mountain valley with central gradient array. The 3-D numerical solution is also in agreement with the results from physical experiment or boundary element method.

Key words Resistivity method Finite element method (FEM) 3-D numerical modeling Undulating topography

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