地球物理学报 » 2010, Vol. 53 » Issue (8) :1940-1952 DOI: 10.3969/j.issn.0001-5733.2010.08.020
地球物理勘探★计算地球物理学

引用本文:
刘长胜, Mark E. Everett, 林 君, 周逢道.海底电性源频率域CSEM勘探建模及水深影响分析[J] 地球物理学报, 2010,V5

LIU Chang-Sheng, Mark E. Everett, LIN Jun, ZHOU Feng-Dao.Modeling of seafloor exploration using electr
analysis of water depth effect[J] Chinese Journal Geophysics, 2010,V53(8): 1940-1952

海底电性源频率域CSEM勘探建模及水深影响分析

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Modeling of seafloor exploration using electric-source frequency-domain CSEM and the an

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摘要 为了探索我国海域油气和水合物等高阻目标体CSEM勘探的可行性和方法技术,本文研究了在海水中水平电性源激励下
海洋地电模型的频率域电磁响应,为进一步的1D和3D仿真计算奠定了理论基础.在推导电磁响应公式时,首先给出了各层介质
势,然后根据Coulomb势与Lorentz势的关系,得到了各层介质的Coulomb势.各层介质中的电磁场均可以由Lorentz势或者C
计算得到,但在有限元计算时Coulomb势具有优势.长导线源的电磁场和势函数可以由电偶源的电磁场和势函数沿导线长度积
中具体给出了海水中水平电偶源和长导线源在海水层的电磁场公式,并根据该公式计算了不同水深环境下海底表面的电磁场
了海水深度对海底油气储层电磁异常的影响.结果表明,随着水深减小,异常幅度和形态特征发生明显变化.当水深很浅时(如5
同线方向的E_x和E_z两个电场分量存在明显异常.最后,以两个已知海底油田为例,计算了不同水深环境下可观测到的电场异常,
性源频率域CSEM在海底勘探中(包括浅海环境)的良好应用前景.对于该方法实用化过程中还需进一步解决的问题,文中结尾
了初步探讨.

关键词: 海底勘探 可控源电磁法 电性源 建模 仿真

Abstract: For the final goal of solving the problem about the feasibility and techniques of resistive targ
hydrocarbon) exploration in the environment of China sea using CSEM, this paper studies the frequency-
electromagnetic responses of a marine geological model with finite depth of seawater excited by a horizo
electric source, establishing theoretical base for 1D and 3D electromagnetic simulation. In the derivation
electric field formulas and magnetic field formulas, the Lorentz-gauged potential in each layer is solved fi
then the Coulomb-gauged potential in each layer is derived from the solution of Lorentz-gauged potentia
corresponding layer by the relationship between these two kinds of potentials. Although the electric field
magnetic fields in all layers can be computed from the Lorentz-gauged potentials or the Coulomb-gauged
potentials, the Coulomb-gauged potentials are advantageous in finite-element computation. The electror
fields and potentials for an electric source with finite length can be obtained by integrating those for an
dipole along the length of source. The electromagnetic field formulas in seawater both for a horizontal el
dipole and for an electric source with finite length are represented in this paper and they are used to sim
distribution of electric fields and magnetic fields over seafloor in different water-depth environments. Th
of water depth on the electromagnetic anomalies of hydrocarbon buried in seafloor is discussed in the er
results show that the intensity and shape of the electromagnetic anomalies markedly change with the de
water depth and only the E_x and E_z components reveal perceptible anomalies when seawater is very sha
example, 50 m. At last, the electric-field anomalies for two well known oil fields in different water depth a
calculated, which shows the good future of electric-source frequency-domain CSEM in seafloor explorati
in shallow sea. The problems that need further study in the practical application of this method are also
in the last part of this paper.

Keywords: Seafloor exploration CSEM Electric source Modeling Simulation

Received 2009-03-24; published 2010-08-20