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井中磁源瞬变电磁响应特征研究

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Research on transient electromagnetic response of magnetic source in borehole

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摘要

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摘要 井中瞬变电磁波勘探是一个全空间地球物理场问题. 采用Gaver-Stehfest逆拉氏变换方法, 正演计算了瞬变信号激励下接收线圈上的电磁场响应. 分析了包含井眼泥浆、套管、水泥环和地层的轴对称多层介质模型的电磁场响应特征, 考察了各层介质参数对井中瞬变电磁响应的影响. 不同电导率井眼泥浆的电磁场响应衰减曲线表明, 井眼泥浆电导率的变化对井中瞬变电磁响应的影响极小, 不同套管几何参数的电磁响应数值模拟结果显示, 套管内径变化对电磁响应有较大影响; 在套管厚度变化的端点处, 电磁响应存在明显异常. 通过对不同套管磁导率电磁响应特征的讨论, 认为套管磁导率参数对电磁响应有重要影响, 套管相对磁导率越高, 电磁波信号越难穿过套管, 响应信号幅度越低. 最后, 对不同水泥环参数的电磁场响应进行了数值模拟, 发现对于低导地层, 低阻水泥环会产生较大的测量误差; 而对高导地层, 水泥环厚度参数对响应信号影响可忽略不计.

关键词: 井中 瞬变电磁法 磁偶极子 瞬变响应 电磁波场

Abstract: The transient electromagnetic exploration in borehole is a full space geophysical problem. The Gaver-Stehfest inverse Laplace transform is used to theoretically calculate the transient electromagnetic response in the receiver loop. And the effects of the parameters of the borehole mud, metal casing, the cement sheath and the formation on electromagnetic logging responses are analyzed. The response curves of different electrical conductivity of the borehole mud indicate that the borehole mud has little effect on the electromagnetic responses. The numerical results of different geometry of the casing pipe show that the inner radius and the thickness of casing have an obvious effect on the logging responses, moreover, the abnormality of transient response appears where the casing thickness suddenly increases or decreases. The simulation results of different magnetic permeability of the casing pipe show that it has an important effect on transient response in borehole and the higher the magnetic permeability, the more difficult the electromagnetic signals through the casing. The results of different parameters of the cement sheath indicate that the high conductive cement sheath can generate large measurement error for low conductive formation. It is also found that the effect of the thickness of the cement sheath can be ignored for high conductive formation.

Keywords: Borehole Transient electromagnetic method Magnetic dipole Transient response Electromagnetic field

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