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## 随钻核磁共振测井的地层界面响应特征

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Nuclear Magnetic Resonance Logging-While-Drilling response at formation boundary

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摘要

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摘要

随钻核磁共振测井的地层界面响应特征对地质导向和原状地层评价具有重要意义,但钻井轨迹的复杂性决定其响应特征是多重因素综合作用的结果,且较难直接给出统一显式表达式.本文根据仪器在地层内的运动特征,建立了基于敏感区域体积元的随钻核磁共振测井响应方程和离散化计算方法;通过正演、反演结合的数值模拟,研究了单、双界面水平层状地层中,不同井斜角度、天线长度和目标地层厚度等条件下的随钻核磁共振测井响应特征,对关键结果给出了成立条件和定量关系.随钻核磁共振测井在斜井段中的 $T_2$ 分布和孔隙度响应与直井中差异明显;井斜角越大,视地层厚度越大,地层界面在 $T_2$ 分布和孔隙度曲线上的过渡段越长, $T_2$ 分布过渡起始位置已不能确定界面深度;仪器的最高纵向分辨率与天线长度、井眼条件和仪器参数有关;受围岩作用影响,较薄目的层的测井响应特征上可能出现异常“夹层”.基于分析结果,对随钻核磁共振测井资料解释提出了建议.

关键词 随钻核磁共振测井, 地层界面, 响应特征, 大斜度与水平井

Abstract:

It is of significance to identify properties and boundaries of formation for NMR geosteering and in-situ reservoir evaluation. In this paper, a discretization method and NMR LWD response function are proposed based on drilling trajectory and sensitive-volume-unit contribution concept. Forward numerical modeling and inversion are employed to simulate NMR LWD logging response in different formation cases and factors, such as well deviation angles, formation boundary types, antenna apertures and target formation thicknesses. Quantitative relationships of these factors in certain condition are given here. Significant differences of  $T_2$  distributions and porosities can be found in comparison of NMR logging response between vertical wells and deviated wells. It shows that the bigger the deviated angle, the longer the apparent formation thickness and the longer the transitional interval in NMR response of formation boundary. Therefore, the depth of formation boundary cannot be extracted from initial point of transitional part of  $T_2$  distribution anymore. Vertical resolution is related to the length of antenna, borehole and tool's parameters. Besides that, an abnormal 'sandwich' may be reflected in thin target formation of logging response because of the existence of surroundings effects. These results provide suggestion to NMR LWD applications to improve real time formation identification.

Keywords NMR LWD, Formation boundary, Response, Horizontal and high-deviated well

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