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储层岩石流动电位频散特性的数学模拟

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Mathematical simulation on the frequency dispersion characteristics of the streaming potential in reservoir rocks

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摘要

利用储层岩石流动电位的频散特性评价复杂储层已经成为勘探地球物理领域关注的热点,但是目前还没有形成基于储层岩石储渗特性及电化学性质的具有普遍指导意义的理论方法和数学模型.本文利用微观毛管理论,通过随时间谐变条件下渗流场和电流场的耦合模型,建立了描述储层岩石流动电位频散特性的数学方法,定量分析了频率域储层岩石动态渗透率、动电耦合系数和流动电位耦合系数随储层岩石孔隙度、溶液浓度和阳离子交换量的变化规律.研究结果表明:储层岩石流动电位频散特性是储层流体惯性力与流体黏滞力相互作用的结果.储层岩石孔隙度越大,储层维持流体原有运动状态的能力越大,临界频率越小;储层岩石的溶液浓度和阳离子交换量对临界频率没有影响.储层岩石的孔隙度越大,流体流动能力越强,流动电位各耦合系数的数值越大;溶液浓度越小或阳离子交换量越大,孔隙固液界面的双电层作用越强,各耦合系数的数值越大.

关键词　储层岩石, 毛管模型, 流动电位, 频散特性, 数学模拟

Abstract：

It is difficult to describe mathematically the microscopic mechanisms of the frequency-dependent streaming potential in reservoir rocks by now.In this paper,a mathematical method to describe the time-periodic oscillating streaming potential was established from the coupling model of the flowing filed in porous media and the electrical current field by the capillary tubes model of the porous media.The frequency response of the dynamic permeability,electrokinetic coupling coefficient and the streaming potential coupling coefficient are shown to be dependent on the porosity and electrochemical properties in the reservoir rock.The results show that the frequency dispersion characteristics of the streaming potential are dependent on the interaction between the inertial effects and the viscous effects of fluid.The critical frequency decreases when the porosity increases,And there is no influence of the concentration and cation exchange capacity of the fluid on the critical frequency.The coupling coefficient of the streaming potential increases with the increasing of the porosity.The effect of the electric double-layer on the solid-liquid interface in the pore decreases with the increasing of the concentration of the fluid,and the coupling coefficient decreases with the increasing of the concentration of fluid.The coupling coefficient increases with the increasing of the cation exchange capacity.

Keywords Reservoir rock, Capillary model, Streaming potential, Frequency dispersion characteristics, Mathematical simulation

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