

# 地层裂缝动态变形对堵漏效果的影响研究

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**摘 要:** 钻井过程中井筒压力的波动易导致地层裂缝动态变形, 影响堵漏效果。为了找到消除该影响的技术措施, 模拟分析了裂缝闭合变形的特征, 通过室内试验评价了裂缝动态变形对堵漏效果的具体影响。模拟发现, 裂缝闭合分为初始阶段、局部变形阶段和最后阶段3个阶段, 随着闭合裂缝面的接触应力不断增大, 接触面积与位移呈幂函数关系; 在裂缝动态变形情况下, 使用非弹性堵漏剂堵漏会出现反复漏失的情况, 使用弹性堵漏剂则能使之趋于稳定, 不再发生漏失。研究结果表明, 裂缝变形会对封堵层产生破坏, 裂缝变形程度越大对封堵层的破坏越强, 弹性堵漏剂能够更好地适应裂缝变形。因此, 在裂缝性地层堵漏时, 建议在堵漏浆中加入一定比例的弹性堵漏材料, 在堵漏的后续作业中尽量降低井筒压力波动, 以减小裂缝动态变形带来的不利影响。

**关键词:** 压力波动; 裂缝变形; 几何模型; 堵漏; 模拟试验

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## The Influence of Dynamic Deformation of Formation Fractures on the Plugging Effect

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**Abstract:** The pressure fluctuation of wellbore during drilling can easily lead to dynamic deformation of formation fractures and affect the plugging effect. In order to solve the problem, the characteristics of fracture closure deformation has been simulated and analyzed. It evaluated the influence of fracture dynamic deformation on leakage plugging by indoor simulation test. The simulation found that fracture closure could be divided into the three stages, i. e. the initial stage, the local deformation stage and the final stage. With the increase of the contact stress on the closed surface of the fracture, the relationship between the contact area and the displacement is a power function. In the case of fracture dynamic deformation, leakage plugging with a non-elastic plugging agent will result in repeated leakage, but the elastic plugging agent can work in a stable manner, and leakage will no longer occur. The research results showed that fracture deformation would damage the sealing layer, and the larger the degree of fracture deformation, the the more intense the damage on the sealing layer. Thus, the elastic plugging agent could better adapt to fracture deformation. Therefore, it is recommended to add elastic plugging agent at certain proportion into the slurry for plugging the fractured formation. In the follow-up plugging operations, the pressure fluctuation of wellbore should be reduced as far as possible, so as to minimize the adverse impacts caused by the dynamic deformation of fractures.

**Key words:** pressure fluctuation; fracture deformation; geometric model; leakage plugging; simulation test

裂缝性地层在钻进时经常会发生钻井液大量漏失的问题, 导致发生井下复杂情况, 增大施工风险和难度, 延长钻井周期<sup>[1]</sup>。由裂缝导致的井漏问题是钻井中的一大难题<sup>[2]</sup>。国内外学者针对裂缝和堵漏进行了大量研究: 练章华等人<sup>[3-4]</sup>利用有限元数值模拟方法建立了裂缝宽度预测模型, 研究了影响裂缝宽度变化的因素, 并对一定条件下的缝宽进行了预

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