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中地壳断层带内微裂隙愈合与高压流体形成条件的模拟实验研究

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A simulating experimental study on crack healing and the formation of high pore fluid pressure in faults of middle crust

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摘要

中地壳断层带内发现的接近静岩压力的高压流体能够合理解释汶川M_S8.0级地震断层的高角度逆冲滑动, 而高压流体的产生与断层带的微裂隙愈合紧密相关.利用熔融盐固体介质三轴高温高压实验系统,我们采用含水和烘干的Carrara大理岩样品开展了微裂隙愈合实验,研究中地壳断层带内高压流体的形成条件.实验分为三类:A类、A+B类和A+B+C类,其中A阶段实验在室温条件下将样品压裂,形成一系列共轭破裂面,B阶段实验在600℃、围压700 MPa和应变速率$10^{-6}s^{-1}$条件下愈合了A阶段破碎的样品,实验样品从以碎裂变形为主向以韧性变形为主转变,C阶段实验通过快速降低轴压模拟一个扩容过程,再以相同实验条件重新加载样品,通过比较实验样品强度来检验样品的愈合程度.样品显微结构和实验样品强度表明,动态重结晶作用能够愈合微裂隙和孔隙,水能促进矿物的动态重结晶作用,较高的水含量和较大的应变有利于微裂隙和孔隙的愈合,从而有利于高压流体的形成.

关键词 中地壳断层带, 汶川M_S8.0级地震, 高压流体, 熔融盐固体介质三轴实验设备, 裂隙愈合, 动态重结晶作用, 傅里叶变换红外光谱仪(FTIR)

Abstract:

Sublithostatic pore fluid pressure in faults cutting the middle crust is considered to trigger slip on the high-angle reverse fault slip for the Wenchuan M_s8.0 earthquake,the mechanism of which is suggested to be related to crack healing. We conducted microcrack healing experiments on Carrara marble samples with different water contents to reveal the formation conditions of high pore fluid pressure using a molten-cell solid medium triaxial apparatus under high temperature and pressure. The experiments were designed to be three types as A, A+B and A+B+C, respectively. All the samples were fractured at room temperature in phase A, leading to conjugate fractures as the result of brittle deformation, and then healed at a constant temperature of 600℃, confining pressure of 700 MPa and a strain rate of $10^{-6}s^{-1}$ in phase B, causing a transition from cataclastic flow to plastic deformation. Finally, we simulated a dilatation by reducing the axial stress instantaneously, and then loading again with the same strain rate to examine the degree of crack-healing by comparing the ultimate strength of stress-strain curves in phase C. The microstructures of samples after deformation and the stress-strain curves show that the dynamic recrystallization can heal the micro-cracks and pore, and the presence of water can enhance the process of the dynamic recrystallization. Our experiments suggest that higher water content and the larger strain are favorable to form high pore fluid pressure in a fault.

Keywords Middle crustal fault, Wenchuan M_S8.0 earthquake, High pore fluid pressure, Molten-cell solid medium triaxial apparatus, Crack healing, Dynamic recrystallization, Fourier transform infrared spectrum (FTIR)

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