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断层黏滑动动态变形过程的实验研究

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Experimental study on the dynamic displacement evolution of fault in stick-slip process

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摘要

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摘要 实验研究断层黏滑过程的变形演化,尤其是失稳黏滑瞬间的断层位移演化特征,对于了解地震从孕育到发生的全过程具有重要意义. 本文基于数字散斑相关方法(digital speckle correlation method, DSCM),用三套图像采集系统(两套低速和一套高速图像采集系统)搭建了断层黏滑过程的多观测区域、多时间尺度的变形场测量系统,并用此系统对一种花岗岩双剪滑动模型的黏滑过程进行了实验研究. 对间黏滑期和黏滑期断层位移演化特征进行深入分析的结果表明:间黏滑期断层位移演化体现出空间上的非均匀性和时间上的“趋同化”特征,断层滑动趋同化也许是断层错动匀阻化的一种宏观表现形式;断层黏滑动态过程持续时间非常短(本文300 mm断层黏滑过程持续时间约在1 ms量级),黏滑失稳前会出现预滑,预滑出现到黏滑失稳发生所经历的时间与黏滑失稳过程所用时间相差一个量级;断层的一次黏滑由若干个滑动速度不同的、小的失稳滑动组成,黏滑失稳过程中断层的滑动速度呈现出波动性,整个滑动过程中断层经历了多个高速滑动和低速滑动的交错.

关键词 断层黏滑, 数字散斑相关方法, 动态变形, 间黏滑期, 黏滑期

Abstract: Observation of the deformation evolution of a stick-slipping fault, especially the dynamic fault displacement evolution characteristics during the very short period of unstable stick-slip, is of great importance to the understanding of initialization and occurrence of earthquakes. Based on the digital speckle correlation method (DSCM), a deformation observation system with multi measurement areas and multi data acquisition speeds is constructed by combining 3 different (2 low speed and 1 high speed) CCD cameras. The stick-slip of a double-shearing slipping rock specimen made of Fangshan granodiorite is experimentally studied, and the fault displacements in the locked stage and the unstable slipping stage are measured using DSCM. The experimental results show that the fault displacements on different locations are different and spatially heterogeneous in the locked stage, however the displacements tend to be uniform at the end of the stage. The uniformization of the fault displacements could probably be considered as a macro form of expression of the uniformization of fault friction resistance. The dynamic displacement results show that the duration of the unstable stick-slip of the fault is very short (about 1 ms for the 300 mm long fault in the experiment in this paper). Pre-slip, i.e., an obvious acceleration of the slipping speed just before the unstable slip is found in the experiment. The duration of the pre-slip is about one order of magnitude longer than that of the stick-slip. The slipping speed of the fault varies during the stick-slip. The whole stick-slip is composed of several unstable slips with different slipping speeds.

Keywords Stick-slip of fault, Digital speckle correlation methods, Dynamic deformation, Locked stage, Unstable slipping stage

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