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地震发生过程的有限单元法模拟——以苏门答腊俯冲带上的大地震为例

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摘要 地震预报由目前的经验预报走向物理预报，数值模拟地震过程是其中的关键.文中应用统一的数学公式表述了速率相关的摩擦接触中黏着（sticking）和滑移(sliding)这两种不同的运动状态；有限元计算中采用静力显示的时间积分方法，基于*R*最小策略，控制时间步长以保持力学状态变化稳定，从而保证有限元计算过程平稳、收敛.以2004年发生过M_m=9.3特大地震的苏门答腊俯冲带为例，模拟了俯冲带上俯冲板片与上伏板块之间的闭锁、解锁、滑动到再闭锁这一准周期性过程，即地震的孕育、发生过程.计算结果表明，俯冲带上具有较大尺度、介质均匀、摩擦系数相同的区域是产生大规模、大幅度整体突然滑动（即大地震）的条件；模拟的苏门答腊俯冲带上的大地震在时间上有准周期性，空间上有迁移特征，破裂由深部向浅部进行；此外，俯冲带的几何特征对大地震的震源位置有很大的影响.

关键词 有限单元, 摩擦接触, 地震, 苏门答腊俯冲带

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Simulation of earthquake processes by finite element method:The case of megathrust earthquakes on the Sumatra subduction zone

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Abstract Numerical simulation of the earthquake processes is a key method to carry out physical accurate earthquake forecast in the future，but today empirical method is used in earthquake prediction，which is seldom successful. In this paper，we use a unified rate-dependent frictional law to formulate two different frictional states，one is sticking，and the other is sliding. Based on R-minimum，time integration method with static explicit is adopted in finite element analysis in order to make the result convergent in calculation. Take the Sumatra subduction zone as an example，where the major earthquake with M_m 9.3 occurred in 2004，the process of locking，unlocking，and sliding between the subduction plate and the overriding plate is simulated. The result shows that a large space of homogeneous media with the same frictional coefficient is a prerequisite for forming large-scale sudden sliding，which is regarded as an event. The earthquakes simulated by the model on the Sumatra subduction zone have characteristics of quasi-cycle in time and migration in space. The earthquake ruptures propagate upward from bottom. Moreover，the geometry of the subduction zone has much influence on the location of the large event.

Key words Finite element Frictional contact Earthquakes Sumatra subduction zone

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