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2001年8.1级昆仑山大震破裂过程及对2008年汶川8.0级大震孕育发生影响的研究

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A study on the rupture process of the 2001 M_S8.1 Kunlunshan earthquake and its influence on pregnant process and occurrence of the M_S8.0 Wenchuan earthquake in 2008

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摘要 本文用三维流变非连续变形(块体边界)与有限元(块体内)相结合(DDA+FEM)的方法,在青藏高原及其东侧四川盆地,鄂尔多斯块体地区三维构造块体相互制约的大环境中,考虑了龙门山断裂带东西两侧地势、地壳厚度和分层的明显变化,及断裂带东侧四川盆地及鄂尔多斯块体坚硬地壳阻挡的影响,通过用GPS资料做位移速率边界约束和震源机制约束,计算得到研究区的速度场和应力场与该地区GPS测量结果和震源机制分布结果基本相似.在此基础上,数值模拟2001年昆仑山大震的破裂过程;研究大震引起各构造块体边界断层应力状态变化特征,特别是对2008年汶川大震发震断层的影响.结果表明:(1)数值模拟昆仑山大震发震断层发生左旋走滑错动,最大水平错距约4.5 m,最大应力降约18 MPa.计算获得大震释放的主压应力场图像,最大剪应力变化等值线图,大震发震断层垂直面上位错等值线图及大震引起垂直位移变化三维图分别与大震的震源机制,地表破裂带同震位移分布,GPS同震位移图及地震波反演和GPS反演的结果总体上均比较相近.(2)计算获得的最大剪应力变化等值线图分布具有不对称特点,大震发震断层南侧变化梯度明显大于北侧.(3)模拟计算得到大震引起汶川大震发震断层库仑破裂应力增加约0.016 MPa(上地壳层).昆仑山大震破裂过程是在东昆仑断裂带其发震断层上发生的左旋走滑错动,引起东昆仑断裂带南侧巴彦喀拉块体进一步东扩和一定规模的变形,并受到该块体东侧四川盆地较硬地壳的阻挡,使得块体东边界断层中低倾角的汶川大震发震断层库仑破裂应力增大,应变能积累增强.可以认为这一破裂过程对汶川大震发震断层发生逆冲型失稳起了促进作用.

关键词: 昆仑山大震 汶川大震 构造块体 数值模拟 破裂过程

Abstract: In this paper, 3D Finite Element Method combined with Discontinuous Deformation Analysis is used to firstly calculate velocity and stress fields of the Qingzang Plateau in the framework of northward compression of the Indian Plate and obstruction of the strong crust of Sichuan basin, with constraints from GPS data and focal mechanism. Then we simulated the rupture process of the Kunlunshan M_S8.1 earthquake in 2001, and studied the characteristics of stress change on the boundary faults of tectonic blocks caused by the earthquake, especially the influence on the seismogenic fault of the Wenchuan earthquake in 2008. The results show that (1) the Kunlunshan earthquake undergoes sinistral strike-slip movement, the calculated maximum horizontal dislocation of the seismogenic fault is 4.5 m, and the calculated maximum stress drop is 18 MPa. The distribution of principal compressive stress change, the contour map of maximum shear stress change before and after Kunlunshan earthquake, the 3D distribution of the vertical displacement caused by the earthquake acquired via calculation are totally in agreement with the focal mechanism solution, the coseismic displacement distribution on the rupture zone of the earthquake. (2) The maximum shear stress variation on the north and south sides of the seismogenic fault is asymmetrical, with the stress change gradient on the south side much greater than that on the north side. (3) We find that the Kunlunshan earthquake caused the coulomb failure stress increase 0.016 MPa (upper crust) on the seismogenic fault of the 2008 Wenchuan earthquake. The rupture process of Kunlunshan earthquake, a sinistral strike-slip movement on the seismic fault of eastern Kunlun fracture zone, caused

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Bayankala block at southern side of eastern Kunlun fracture zone to extend further to east and deform to a certain extent. Meanwhile, the obstruction of stronger crust in Sichuan basin at eastern side of Bayankala block made the Coulomb failure stress increase and strain energy accumulation strengthen, on seismic fault of Wenchuan earthquake with low dip angle at eastern boundary of the block. Therefore, the occurrence of the Kunlunshan earthquake has played a role of promoting the generation and instability of the seismogenic fault of the Wenchuan earthquake.

Keywords: Kunlunshan earthquake Wenchuan earthquake Tectonic block Numerical simulation Rupture process

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