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2008年汶川地震中断坡-滑脱断层破裂: 龙门山挤压隆升的大地测量证据

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Rupture of ramp-décollement faults in the 2008 Wenchuan earthquake-Geodetic evidence for the uplift of the Longmen Shan driven by convergent deformation

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摘要

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摘要

青藏高原东缘龙门山构造隆升一直存在挤压造山模式和下地壳层流模式之争。下地壳层流模型认为, 龙门山隆升与水平缩短关系不大, 山前断层只是高原、盆地间差异性垂直运动的结果, 高原之下无需挤压模式中的大规模水平滑脱层。本文利用近场密集的同震形变数据, 约束汶川地震破裂几何特征及同震滑动分布。反演结果显示汶川地震撕裂龙门山中南段近水平滑脱层, 宽度达到60~80 km, 释放能量约占总标量地震矩的12%。在16~21 km深度出现两三个滑动量高达6~7 m的破裂区。深部低角度破裂往上转为高角度逆冲, 沿龙门山中央断裂以约55° 倾角出露地表。汶川地震破裂的几何产状和滑移幅度表明龙门山冲断带发育大规模的近水平滑脱层, 是青藏高原东缘地壳缩短增厚、龙门山挤压隆升的重要证据。

关键词 汶川地震, 同震形变, 滑动分布, 破裂特征

Abstract:

The mechanism for the build-up of the Longmen Shan on the eastern margin of Tibet is controversial with two end-member models of crustal thickening -mid-crustal channel flow vs crustal shortening. The former states that the uplift of the Longmen Shan results from an eastward flowing of mid-lower crust from the interior of the Tibetan Plateau driven by the collision between India and Tibet. As a result, the thrust fault system on the foothill of the Longmen Shan was produced to accommodate differential vertical motions between eastern Tibet and Sichuan Basin, requiring no large-scale ramp-décollement structure associated with crustal shortening. In this study, we use dense near-field geodetic measurements of coseismic deformation to constrain rupture geometry and slip distribution of the Wenchuan earthquake. Our modelling shows a sub-horizontal décollement fault at depths of 16~21 km with a 60~80 km downdip width, on which there are several high-slip patches with peak values of 6~7 meters, altogether corresponding to 12% of total scalar geodetic moment. Deep slip with a dipping angle of 7° extends updip with rupturing on two high-angle ramp faults, one of which emerges at the surface as the Beichuan fault dipping about 55° to west. The great rupture on the ramp and décollement faults under the Longmen Shan provide evidence of the existence of a large-scale faulting system characterized with substantial crustal shearing at depth along a transition zone located between the upper brittle and the underlying ductile layers, suggesting that the crustal shortening across the eastern margin of the Tibetan Plateau gives rise to the growth of the Longmen Shan.

Keywords Wenchuan earthquake, Coseismic deformation, Distribution of slip, Fault geometry

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