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2008年汶川8.0级地震前横跨龙门山断裂带的震间形变

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Interseismic deformation across the Longmenshan fault zone before the 2008 M8.0 Wenchuan earthquake

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摘要

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摘要 利用区域GPS和水准测量资料, 结合地震构造背景的分析, 本文研究2008年汶川8.0级地震前横跨龙门山断裂带地区的震间地壳形变, 探讨引起这种形变的活动构造与动力学模式, 并由此认识汶川地震的孕育与成因机制. 主要结果表明: 1997~2007年期间, 自龙门山断裂带中段朝北西约230 km的地带内存在垂直于断裂的水平缩短变形、以及平行于断裂的水平右旋剪切变形, 缩短率为 $1.3 \times 10^{-8}/a$ (即: $0.013 \text{ mm}/\text{km}/a$), 角变形速率为 $2.6 \times 10^{-8}/a$; 同一地带在1975~1997年期间还表现出垂直上隆变形, 上隆速率在龙门山前山断裂与中央断裂之间仅 $0.6 \text{ mm}/a$, 而至龙门山后山断裂及其以西达 $2 \sim 3 \text{ mm}/a$. 这些反映了在汶川地震之前至少 $10 \sim 30$ 余年, 龙门山断裂带中段的前山与中央断裂已闭锁、并伴有应变积累. 造成这种形变的主要原因是: 以壳内的低速层为“解耦”带, 巴颜喀拉地块上地壳朝南东的水平运动在四川盆地西缘受到华南地块的阻挡、转换成龙门山断裂带中段的逆冲运动; 由于该断裂段的震间闭锁, 致使西侧的巴颜喀拉地块的上地壳发生横向缩短以及平行断裂的右旋剪切变形. 然而, 龙门山断裂带北段在1997~2007年期间除了有大约 $0.9 \text{ mm}/a$ 的右旋剪切变形外, 横向的缩短变形极微弱, 这可能与该断裂段西侧的岷江、虎牙、龙日坝等断裂带吸收了巴颜喀拉地块朝东水平运动的大部分有关. 另外, 汶川地震前, 横跨龙门山断裂带中段与北段的地壳形变特征的差异, 与汶川地震时能量释放的空间分布吻合.

关键词 汶川地震, 震间形变, 断裂闭锁, 龙门山断裂带, 巴颜喀拉地块

Abstract: By using regional GPS and leveling data and through an analysis considering seismo-tectonic background, this paper studies interseismic crustal deformation in the region across the Longmenshan fault zone before the 2008 M8.0 Wenchuan earthquake, discusses the active tectonic and geodynamic model that caused the interseismic deformation, and, from these, analyzes the mechanism of brewing and producing the Wenchuan earthquake. The result mainly shows that, in the period from 1997 to 2007 horizontal shortening in the direction perpendicular to the fault zone and horizontal right-lateral shearing parallel to the fault zone occurred in the area from the middle segment of the fault zone to about 230 km away northwest. The shortening rate is estimated to be $1.3 \times 10^{-8}/a$ (that is $0.013 \text{ mm}/\text{km}/a$) and the distortion rate to be $2.6 \times 10^{-8}/a$. Vertical uplifting also happened in the same area during the period from 1975 to 1997, with uplifting rates changing from $0.6 \text{ mm}/a$ in between the frontal-range fault and the central fault of the fault zone to 2 to $3 \text{ mm}/a$ near and northwest of the back-range fault of the fault zone. All these reflect that at least in the last 10 to over 30 years before the Wenchuan earthquake the frontal-range and central faults of the middle segment of the Longmenshan fault zone had been locked with strain building up. The main reason to cause such deformation is believed to be that, taking a low-velocity zone in the crust as an “uncoupling layer”, the horizontal southeast-ward movement of the upper crust of the Bayan Har block was counterworked from the South China block at the western edge of the Sichuan

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basin and transformed into the thrust movement along the middle segment of the fault zone. The interseismic locking of this fault segment made both the horizontal shortening perpendicular to the fault and the right-lateral shearing parallel to the fault occur in the upper crust of the Bayan Har block. However, during the period from 1997 to 2007, horizontal shortening across the northern segment of the Longmenshan fault zone was very weak, but a right-lateral distortion deformation of 0.9 mm/a happened there. Such weak activity of the northern Longmenshan fault segment should apparently be attributed to that those fault zones of Minjiang, Huya and Longriba on the west of this fault segment have absorbed most of the horizontal east-ward movement of the Bayan Har block. In addition, the difference of the crustal deformation features between the middle and northern