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Elastic Flexural Simulations under the Structural Load Triggered by Wenchuan Earthquake and Its Geological Significance

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The Wenchuan earthquake on May 12, 2008 triggered a large number of collapses and landslides in Longmen Shan area, and also caused the coseismic surface deformation on Longmen Shan and Sichuan basin. The Longmen Shan tectonic belt in the east margin of Qinghai-Tibet Plateau is a mutation belt of geology, landform and climate in the western China. Now, the popular uplift mechanism of Longmen Shan and focal mechanism of Wenchuan earthquake include the lower crustal flow mechanism(Wang Chunyong et al., 2008; Lou Hai, et al., 2008; Weiwei, 2010; Li Dewei, 2008), the crustal shortening mechanism due to squeezing action(Yao Qi Xu & Xiwei et al., 2012) and the crust rebound mechanism due to isostasy(Li Yong et al., 2006; Zhang Yongqian, et al., 2010). These three mechanisms could induce different ground response, so the coseismic surface deformation triggered by Wenchuan earthquake would certainly show us the most straightforward and powerful testimony, which could explain the uplift mechanism of Longmen Shan.

Based on the coseismic surface deformation date revealed by GPS measurements, SAR images, we found the area located on the west side of Beichuan-Yingxiu fault uplifted in the earthquake, and the area located on the east side of Beichuan-Yingxiu fault subsided in earthquake, and the higher coseismic uplift of Longmen Shan was well corresponding to the stronger coseismic subsidence of Sichuan basin. This corresponding relation is in accordance with the flexural model of lithosphere due to structural load. The flexural model of lithosphere includes elastic flexural model (Fleming & Jordan, 1981, 1990) and viscoelastic flexural model (Beaumont & Quinlan, 1984, 1988). The structural load triggered by Wenchuan earthquake was finished within 120 second, which is very short relative to the tectonic

evolution of Longmen Shan. Therefore, on the one hand, the structural load triggered by Wenchuan earthquake and the flexural subsidence accorded with the elastic flexural model, because the initial response of viscoelastic lithosphere under structural load is elastic; on the other hand, only the structural load would have to be addressed and the sediment load could be ignored, because the large number of collapse and landslide triggered by Wenchuan earthquake had been not transported to the basin within 120 second. We could simulate the elastic deformation process triggered by Wenchuan earthquake with the conventional elastic equation ① (Hetenyi, 1974) and equation ②, which could figure out the deflection under the line load.

(where ω is the deflection; H is the load(the force bear on unit length); ρ_m is the density of mantle, 3300 kg/m³; ρ_a is the density of air, 1 kg/m³; g is the acceleration of gravity, 9.8 m/s²; x is the horizontal scale from load(the

$$\omega = \frac{H}{2\alpha(\rho_m - \rho_a)g} \exp\left(-\frac{x}{\alpha}\right) \left[\cos \frac{x}{\alpha} + \sin \frac{x}{\alpha} \right]$$

load in this case is the Longmen shan); α is the flexural parameter)

$$H = V \cdot \rho \cdot g / L$$

(where H in this case is the force bear on unit length triggered by Wenchuan earthquake; V is the volume of load, 3.8 km³ (de Michele, M., 2010); ρ is the density of rocks on the Longmen Shan's surface 2680 kg/m³ (Liu Beili, 1994); L is the length of load, 200 km (de Michele, M., 2010))

The simulation curves could be drawn according to the data gotten from the formula ① and ②, where the value range of α is 20-80 km. We found that the simulation curve is in good agreement with the GPS data when α is 70 km. The simulation curve ($\alpha=70$) and the GPS data show the

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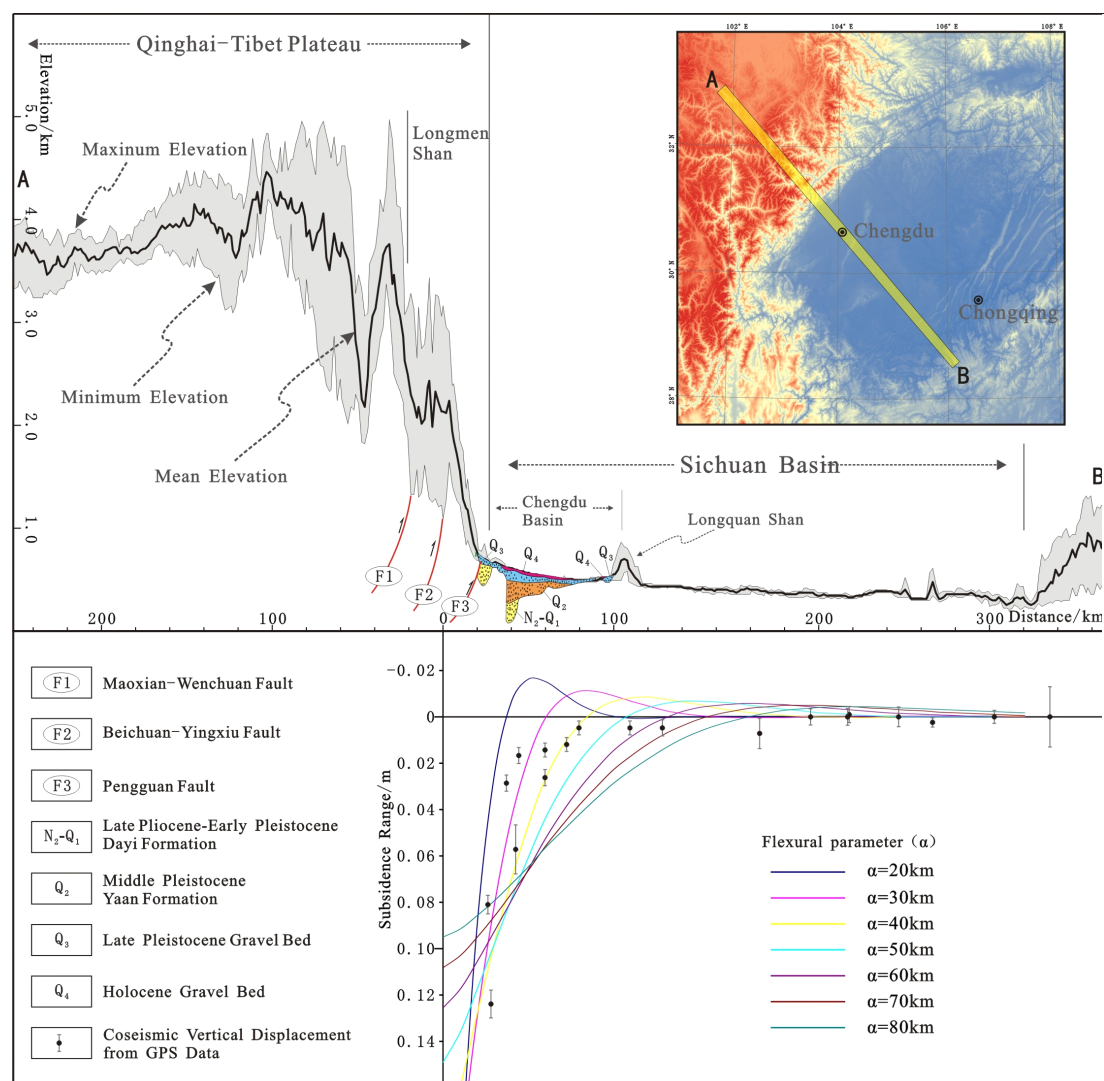


Fig.1 Longmen Shan-Sichuan basin digital elevation profile and the elastic flexural simulations under the structural load triggered by Wenchuan earthquake

coseismic subsidence at the area between 0-140km. The simulation curve($\alpha=70$) show the coseismic uplift at the area near 200km, and the area lie in southern Chongqing also uplifted a few millimeters in the earthquake(Qu Chunyan, 2008)

According to making the analysis of elastic flexural simulations under the structural load triggered by Wenchuan earthquake, we found that there should be a 140-kilometer-wide foreland basin at the front of Longmen Shan because of the strong structural load triggered by the high-steep mountain. But the wide of the late Cenozoic basin (the Chengdu basin)between Longmen Shan and Longquan Shan is just about 80km(fig.1). Such huge variations invites more careful consideration of the nature of the lithosphere, which may be in accordance with the viscoelastic flexural model(for example, the elastic flexural simulations under the structural load triggered by Wenchuan earthquake). Because the initial

response of viscoelastic lithosphere under structural load is elastic, but as time goes on, the stress of lithosphere will be slack, and the equivalent elastic thickness of lithosphere will be reduced, then the foreland basin become deep and narrow(Beaumont, 1988). Thereby we think that the present lithosphere of Sichuan basin is in accordance with the viscoelastic flexural model, which maybe controlled the forming of the Chengdu basin.

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Key words: Elastic Flexure; Viscoelastic Flexure; Longmen Shan; Wenchuan Earthquake; Coseismic Surface Deformation; Chengdu Basin