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Review Article

A review on active tectonics and deep crustal processes of the Western Sichuan region, eastern margin of the Tibetan Plateau

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ABSTRACT

One of remarkable geological and geomorphological features in continental China is the presence of a north–south trending tectonic zone which separates the seismically active Tibetan Plateau to the west from the tectonically stable South China and Ordos blocks to the east. The zone also owns a name of "north–south seismic belt" as a large number of great historical earthquakes occur on it. The most recent one, the 2008 Wenchuan earthquake, attests its recent tectonic activity. In this review I take the Western Sichuan region as an example to probe the structural styles and kinematic pattern as well as deep geological process associated with tectonic deformation of the north–south trending zone. Through integrated studies on active faults, GPS crustal deformation, and geophysical structure, we show that deformation in the Western Sichuan is governed by interactions among three crustal blocks (Songpan, Chuandian, and South China) of distinctive rheological properties under the tectonic framework that eastward growth of the "soft" Eastern Tibet is blocked by the "hard" lithosphere of the South China block. The left-lateral Xianshuihe Fault continues to the north–south trending fault system without crustal shortening to form a bounding fault to limit the northern extend of the magnificent clockwise rotation of crustal material around the Eastern Himalaya Syntax. Upper crust of the three blocks is dominated by brittle deformation, whereas the ductile flow of lower crust would drag the brittle upper crustal blocks to move with respect to each other. The relative motions among the brittle upper crustal blocks cause strain accumulations among their bounding faults to generate large earthquakes. Deformation of the Western Sichuan region can thus be described in terms of combined model of rigid block movement and continuous deformation. We suggest this combined model can be applied to entire continental China.

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1. Introduction

A prominent seismotectonic feature in continental China is the presence of a north–south trending tectonic zone (NS-trending Zone), which extends southward from the Helan Shan in northern Ningxia, crosses the Western Qinling Mountain, follows the traces of Longmen Shan and Xiaojiang faults, strides over the Red River Fault, and enters territory of Burma (Fig. 1). As an important boundary, the NS-trending Zone separates seismically active Tibetan Plateau from the tectonically stable Ordos block, Sichuan basin, and South China block (Deng et al., 2003; Zhang et al., 2003). West of the zone, the average elevation reaches more than 4000 m above sea level, the crustal thickness is more than 60 km, and wide-spread active faults testify tectonic activity. East of the zone, however, the elevation decreases to about 1000 m above sea level, the crustal thickness reduces to 40–45 km, and the presence of fewer active fault suggest weak if any tectonic activity.

The structural architecture of the NS-trending Zone itself consists of interactions among faults of different trends and structural style (Fig. 1). Normal faulting with right-lateral strike–slip component is the main tectonic process in the northernmost part of the zone, where the eastern dipping normal faults control formation of westward titling, several hundred kilometer long grabens. To the south in the Haiyuan and Liupan Shan region, tectonic deformation is characterized by a transition of left-lateral strike–slip along the west northwest trending faults into reverse faulting and folding of north–south trending (Burchfiel et al., 1991; Zhang et al., 1991) (Fig. 1). Active tectonic pattern in the western Qinling is very complex involving interactions among the east–west trending, northwest trending and northeast trending structures. The kinematics and mechanics of tectonic deformation have not been adequately understood yet and further studies are urgently needed. Active tectonic deformation in Longmen Shan and Songpan blocks has been studied before and after the 2008 Wechuan earthquake (e.g. Burchfiel et al., 1995, 2008; Densmore et al., 2007; Hubbard and Show, 2009; Zhang et al., 2010). Distributed crustal shortening and right-lateral shear widely spread over the vast region of Songpan block northwest of the Longmen Shan, and listric high-angle reverse faulting control deformation in the Longmen Shan itself (Zhang et al., 2010). Structures in the NS-trending Zone south of the Longmen Shan are also manifested by

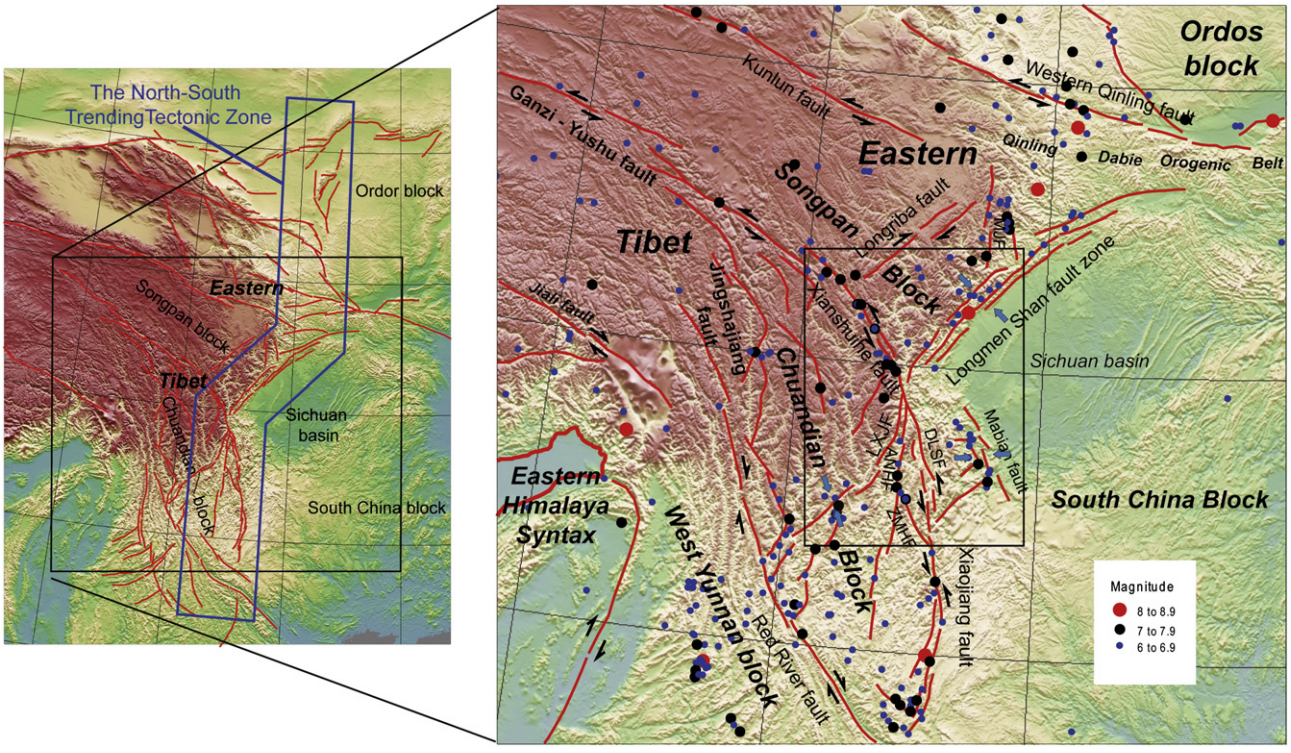

Fig. 1. Major active faults and historical earthquake distribution of the Western Sichuan region. Different background colors denote different blocks. Red lines are major active faults. Black arrows mark the sense of motion along the strike–slip faults. Double cyan arrows indicate major convergent component. LXJF denotes Lijiang–Xiaojinhe Fault, ANHF is Anninghe Fault, ZMHF is Zemuhe Fault, DLSF is Daliang Shan Fault, and MJF is Minjiang Fault. Black rectangle marks the region of Fig. 2. Blue polygon in left panel marks the North–South Trending Tectonic Zone. Black rectangle in left panel marks approximation of Fig. 2, the Western Sichuan region.

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