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Seismic imaging along the Longmen-Shan fault zone: Implications for the 2008 Wenchuan earthquake (Ms 8.0) generation

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The Longmen-Shan range front, characterized by convergent mountain building with a greater topographic gradient than anywhere else on the Tibetan Plateau, lies in a conjunctional area between the northwestern Songpan-Ganze terrane and the Sichuan foreland basin. The Songpan-Ganze fold system has obliquely collided with the Sichuan foreland basin, resulting in three large reverse-thrust and strike-slip faults along the Longmen mountain region with 250–300 km extents, including the Guanxian-Jiangyou fault (fore fault), the Yingxiu-Beichuan fault (central, principal fault), and the Wenchuan-Maowen fault (rear fault), oriented from southwest to northeast across the fault zone (Figure 1). The Longmen-Shan fault zone is one of the most extensively studied areas in the world, yet its deformation model and seismic generating mechanism remain subjects of vigorous debate. This paper presents a new three-dimensional (3-D) velocity model determined using 136,795 P and Pn phases and 121,292 S and Sn phases from 16,142 local earthquakes, together with two-dimensional (2-D) magnetotelluric (MT) profiles from previous studies, to investigate the nuclei of crustal deformation and earthquake generation along the reverse-thrust and strike-slip fault zone. It has been observed that anomalously low velocity, with low resistivity relative to the Sichuan foreland basin, is in sharp contrast to high-velocity and high-resistivity anomalies in the Songpan-Ganze block in the upper crust. The tomographic model presented here reveals two crustal bodies with anomalously low velocity and high conductivity underneath the Longmen-Shan fault zone, which is separated into three contrasting segments by the bodies. These low-velocity and low-resistivity bodies have been interpreted as being associated with extrusion of either fluids or products of partial melting from the lower crust, the upper mantle, or both. This suggests strong variations in the rheological strength of the rock along the fault zone. This finding implies that the coupling between these presumably fluid-bearing bodies and earthquake generation could be extremely complex and that there is dramatic variation from the southwestern portion to the northeastern segment along the fault belt. It is suggested here that this complex and variable deformation system along the fault zone played a principal role in controlling seismic generation and rupturing during the 2008 Wenchuan earthquake (Ms 8.0) and that it will do so again during possible future earthquakes in the region.