

Seismogenesis structure and mechanism of the 2008 Wenchuan earthquake, Sichuan, China

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The 2008 Wenchuan earthquake occurred on the Longmen Shan fault, eastern margin of the Tibetan Plateau. The Longmen Shan fault zone deforms very slowly and had been assigned a modest to low seismic hazard rating. How such a slowly deforming fault could host such a large earthquake? We argue that earthquake cycles in the Longmen Shan are characterized by long recurrence intervals and slow speed of interseismic deformation because of the relatively high rock strength in the source area of the earthquake, combined with unusually tight interseismic locking of the fault and a very gradual loading of stress. The Longmen Shan is composed of ancient Precambrian crystalline rocks that appear to be stronger than those in eastern Tibet. Indeed, seismic waves move faster through the crust beneath the Longmen Shan, compared to the eastern Tibetan Plateau, indicating that strong, cold rocks make up the seismic source region deep beneath the Longmen Shan. Such strong rocks will prohibit rapid strain accumulation and deformation. The geometry of the seismogenic fault, the Yingxiu-Beichuan fault, has a listric shape. Deep in the crust, below about 15 km in depth, the fault is only gently inclined downward at an angle of about 30° from the horizontal. However, at shallower depths, the fault curves upwards into a steep shape with an angle of about 70° to the surface. Compression on such a steep fault would increase the frictional resistance of the fault, causing it to lock tightly and to deform slowly. Although growth of the Tibetan Plateau causes eastern Tibet to deform, only a small amount of strain is transferred to the Longmen Shan fault zone. Faults in the Longmen Shan are therefore loaded gradually and slip very slowly. The recurrence of great earthquakes in the fault zone should therefore be as long as a few thousand years and, indeed, palaeoseismic investigations show that large earthquakes occur on the Longmen Shan fault zone with a recurrence interval of about 3,000 years. Why such a great Wenchuan earthquake occurred on the fault that is disfavorable for earthquake rupture? The high-angle listric nature of earthquake faulting and the associated stress state would reduce normal stress perpendicular to the fault, and hence the friction on the fault surface, to facilitate earthquake rupture initiation and propagation to generate a great earthquake.