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Title: Deep Crustal Deformation Constrained From

Co-seismic Ruptures Associated with the 2008

Wenchuan Earthquake, Sichuan, China

龍門山的深部地殼構造變形:來自2008年汶

川地震破裂的制約

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Language: Putonghua

張院士 1987 年在美國麻省理工學院獲博士學位;1987-1991 年在美國內華達大學新構造研究中心從事博士後研究;1991-2015 年任職中國地震局地質研究所·地震動力學國家重點實驗室主任·現任中山大學地球科學學院教授。1992、2003 和 2006 年三次獲國家科技進步二等獎。先後發表論文 122 篇·其中 SCI 收錄 51 篇·被 SCI 他引 2189 次。2001 年以第一作者發表在 Nature 的 Article 被列為該期的 "亮點" 論文;2001 年還以通訊作者在 Science 發表論文一篇;2010 年又以第三作者在 Nature Geoscience 上發表論文一篇。長期從事地震地質和新生代構造地質研究,在中國大陸現今構造變形、青藏高原生長與動力學、活動斷裂習性與強震復發規律、新構造與氣候變化、利用 GPS 技術研究構造變形與地震活動等方面開展了大量的工作,在國際有關領域形成了較大影響。

龍門山的深部地殼構造變形:來自2008年汶川地震破裂的制約

龍門山和四川盆地構成了地球陸地表面最陡峻的地貌之一,不到 50 千米的水準距離的垂直高差達到 4000 米以上,但是龍門山卻並不對四川盆地載荷壓彎而使 其成為前陸盆地。什麼樣的地質作用形成了龍門山?龍門山的深部地球動力過程是什麼?這些問題一直引起全球地球科學家的關注。2008 年汶川地震的同震變 形為回答這些問題提供了重要的線索。2008 年汶川地震同震破裂有兩個最基本的特徵:一是狹長分佈的同震變形,地震破裂的長度達 350 千米左右,而破裂寬 度只有 30 千米左右,長寬比大於 10:1; 二是同震變形以垂直位移為主,幾乎是同震水準位移的 2 倍。這種最基本的特徵只能用高角度鏟型逆沖斷裂產生的錯 動來解釋。橫跨龍門山的深地震反射揭示汶川地震的發震斷裂在上部地殼以向北西傾斜的高角度鏟型逆沖斷裂為特徵,在下部地殼則以向南東傾斜的韌性剪切 帶為特徵。利用粘彈性有限單元方法類比了汶川地震的同震位移場,發現高角度鏟型逆沖斷裂將青藏高原向東擴展的水準擠壓轉換成沿龍門山斷裂帶的垂直隆 升,產生的水準擠壓分量很小,很好地解釋了汶川地震狹長的同震變形和巨大的同震位移。龍門山的形成和演化也許可以很好地用分解的岩石圈純剪切增厚模型來理解,也就是,上地殼的高角度鏟型逆沖作用通過下地殼的韌性剪切作用與增厚的粘性岩石圈地幔相互耦合。

Deep Crustal Deformation Constrained From Co-seismic Ruptures Associated with the 2008 Wenchuan Earthquake, Sichuan, China Rivaling the Himalaya in relief, the Longmen Shan is probably one of the most enigmatic mountain ranges in the world: high mountains reach more than 4000 m relief but without adjacent foreland subsidence and with only slow active convergence. What are geological and geodynamic processes that built the Longmen Shan? Co-seismic deformation associated with the 2008 Wenchuan earthquake could hold clues to answer these questions. The primary features associated with the 2008 Wenchuan earthquake could hold clues to answer these questions. The primary features associated with the 2008 Wenchuan earthquake could hold clues to answer these questions. The primary features associated with the 2008 Wenchuan earthquake could hold clues to answer these questions. The primary features associated with the 2008 Wenchuan earthquake could hold clues to answer these questions. The primary features associated with the 2008 Wenchuan earthquake could hold clues to answer these questions. The primary features associated with the 2008 Wenchuan earthquake could hold clues to answer these questions. The primary features associated with the properties as the result of slips on high-angle listric reverse faulting in the brittle upper crust and east-dipping reflectors that we interpret as ductile shearing, in the viscous lower crust. In conjunction with a visco-elastic finite element modeling of coseismic displacements associated with the Wenchuan earthquake, we show that the high-angle listric nature of earthquake faults produces insignificant horizontal shortening across the fault and facilitates upward slips along the fault that both explain the localized coseismic deformation and vertical displacement, as well as the presence of high mountains without adjacent foreland flexure. We suggest that the formation of the Longmen Shan may be better understood in terms of partitioned lithospheric pure-shear thickening in the

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