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汶川地震断裂带科学钻探1号井(WFSD-1)非弹性应变恢复法(ASR法)三维地应力测试与"5.12"汶川地震的形成机制

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摘要:

汶川地震断裂带科学钻探1号井(WFSD-1)的ASR三维地应力测试结果表明,龙门山前陆逆冲带与其下伏的龙门山前陆盆地和上覆的松潘-甘孜地块的构造及地应力状态存在有重大差异. 从整体上看,在汶川地震中,龙门山前陆逆冲带表现为在强烈的区域性挤压背景下,深部物质沿壳内拆离层自SW向NE方向的"层状"流动,在地壳上部转化为沿映秀-北川断裂(YBF)的快速垂向挤出,而其西侧的松潘-甘孜地块作自SE往NW方向的重力滑覆,东侧的龙门山前陆盆地则表现为自NE往SW方向的走滑或右行旋转. 晚新生代以来,扬子地块相对于青藏高原东缘的龙门山造山带并无明显的或大尺度的陆内俯冲作用发生. 龙门山前陆逆冲带深部高温低粘度物质垂直向上的、快速的流动和挤出,直接导致了"5.12"汶川地震的发生,而松潘-甘孜地块E向扩展导致龙门山前陆带的强烈挤压和陆壳增厚及深部应力和地震能量的积聚则是诱导深部位移场发生突变和物质快速垂向挤出的主因,E向扩展是深部地震能量积聚和快速垂向挤出作用的必要条件,而非地震发生的直接原因. ASR地应力测试得出的主压应力方向完全平行于GPS同震速度场的位移方向,似乎表明ASR测试获得的原地应力场或许真实地反映了或最接近于地震过程中的构造应力状态.

英文摘要:

The stress existing in the crustal rock mass is called in-situ stress. The ASR (short for anelastic strain recovery) technique is widely used in deep 3-D stress measurements of rocks in crustal drilling, especially in seismic fracture zones with complex geologic conditions and broken formations. The 3-D ASR measurement results of the well WFSD-1 show that there are major differences between the Longmenshan foreland obduction zone and its underlying Longmenshan foreland basin and overlying Songpan-Garzê block in terms of structure and stress state. On the whole, during the Wenchuan Earthquake, the Longmenshan foreland obduction zone displayed SW to NE "laminar" flow of deep materials along the inter-crustal detached layer, and then turned into rapid vertical extrusion along the Yingxiu-Beichuan fault in the upper crust; while the Songpan-Garzê block on its west side showed SE to NW gravitational slipping, and the Longmenshan foreland basin on its east side showed NE to SW strike-slip or dextral rotation. There has not occurred apparent or large-scale intracontinental subduction of the Yangtze block toward the Longmenshan orogenic zone on the eastern margin of the Qinghai-Tibet Plateau since the Late Cenozoic. The rapid and vertical up-going flow and extrusion of deep high-temperature low-viscosity materials in the Longmenshan foreland obduction zone is the direct cause for the occurrence of the May-12 Wenchuan Earthquake, while the intensive compression and crustal thickening of the Longmenshan foreland area as well as accumulation of deep stress and seismic energy as a result of E-trending expansion of the Songpan-Garzê block are the main cause inducing abrupt change of the deep-seated shift field and rapid vertical extrusion of materials. The latter is the necessary condition for the former and not the direct result. The orientation of the principal compressive stress obtained by the ASR stress measurement is exactly parallel to the shift direction of the GPS coseismic velocity field, which indicates that the in-situ stress measured with the ASR technique may actually reflect or most approach the tectonic stress state during the earthquake.

关键词: [汶川地震断裂带科学钻探1号井\(WFSD-1\)](#) [非弹性应变恢复法\(ASR法\)](#) [地应力测试](#) [地震形成机制](#) [逆冲作用](#) [右行走滑作用\(或右行旋转\)](#) [正滑作用](#) [垂向挤出](#)

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