Recent Deep Seismic Refraction/Wide-angle Reflection Profiles in Western China

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The deep crustal structure of western China has been investigated in the past several decades with multiple geophysical techniques, including gravity, magnetic, magnetotellurics, seismic surface waves and receiver functions, seismic reflection profiles, and seismic refraction/wide-angle reflection profiles. Here we review new results obtained by the last technique, compare them with previous results, and discuss the implications for the tectonic evolution of western China (Liu and others, 2006; Li and others, 2006; Mooney, 2007; Zhang and others, 2009; Wang and others, 2009).

Northern Margin of the Tibetan Plateau

We examined the northern margin of the plateau with a seismic refraction/wide-angle reflection profile across the Altyn Tagh Range and its adjacent basins and found that the crustal velocity structure and compositional interpretation sharply change beneath the Cherchen Fault, that is, ~100 km north of the northern margin of the Tibetan Plateau. North of the Cherchen Fault, beneath the Tarim Basin, a platform-type crust is evident. South of the Cherchen Fault, the crust is characterized by a missing high-velocity, lower-crustal layer. The high topography (~3 km) of the Altyn Tagh Range is supported by a wedge-shaped region of 7.6-7.8 km/s that we interpret as a zone of crust-mantle mix. Our seismic velocity structure supports the viscous sheet model for the origin of the Altyn Tagh Range (England and McKenzie, 2007). The Altyn Tagh Range formed by crustal-scale strike-slip motion along the North Altyn Tagh Fault and by northeastward extrusion. Contraction across the Altyn Tagh Range is accommodated by (1) crustal thickening via upper-crustal thrusting and lower-crustal flow and (2) slip-parallel (SW-directed) underthrusting of only the lower crust and mantle of the eastern Tarim Basin.

The central Qaidam Basin, the largest basin within the Qinghai-Tibetan plateau, was investigated with a detailed seismic wide-angle reflection/refraction profile. The 350-km-long profile extends from the northern margin of the East-Kunlun Shan to the southern margin of the Qilian Shan. The P- and S-wave velocity structure and Poisson’s ratio data provide constraints on composition. The crust here consists of a near-surface sedimentary layer and a four-layered crystalline crust having several significant features: (1) The sedimentary fill of the Qaidam Basin reaches a maximum thickness of 8 km, and the basin shape mirrors the uplifted Moho. (2) Within the four layers of the crystalline crust, P- (S-) wave velocities increase with depth and fall within the following velocity ranges: 5.9-6.3 km/s (3.45-3.65 km/s), 6.45-6.55 km/s (3.7 km/s), 6.65 km/s (3.8 km/s), and 6.7-6.9 km/s (3.8-3.9 km/s), respectively. (3) Low-velocity zones with a 3 to 5 percent reduction in seismic velocity are detected in the lower half of the crust beneath the Qaidam Basin and its transition to the Qilian Shan. (4) The crystalline crust is thickest beneath the northern margin of the basin towards the Qilian Shan (58-62 km) and thinnest beneath the center of the basin (52 km). Variations in crustal thickness are mostly due to thickness variations in the lowermost layer of the crust. (5) Poisson’s ratio and P-wave velocity values suggest that the Qaidam crust has an essentially felsic composition with an intermediate layer at its base. Based on the crustal structure reported here, we suggest that late Cenozoic convergence is accommodated by thick-skinned tectonic deformation with thickening involving the entire crust across the Kunlun-Qaidam-Qilian system.

The Northeastern Tibetan Plateau (Tarim Basin to Sichuan Basin)

We obtained a deep crustal section across the northeastern Tibetan Plateau based on active-source seismic data. Our profile was recorded along a 1,600-km-long profile crossing the southern Tarim Basin, the western flank of the South-Qilian Shan, the northeastern margin of Qaidam basin, East-Kunlun Shan, Songpan-Ganzi terrane, and Sichuan Basin. The crustal P- and S-wave velocity structure and Poisson’s ratio outline the seismic characteristics of the crust and provide constraints on the crustal composition. The resultant crustal cross-section shows several significant features: (1) The crustal thickness varies considerably along this profile. North of the Kunlun Fault, variations in crustal thickness and topography correlate well. The crust thickens from 48 km below the Tarim Basin to 70 km beneath the northeastern

margin of the Qaidam Basin, and then thins to 56 km beneath the eastern flank of the Qaidam Basin. The crust thickens to 70 km beneath the East-Kunlun Shan. Across the Songpan-Ganzi terrane, the crust steadily thins from 70 km just south of the Kunlun Fault to 48 km beneath the Sichuan Basin, despite the fact the topography remains constant across the Songpan-Ganzi terrane and then abruptly drops by 3.5 km from the elevated Longmen Shan into the low-lying Sichuan Basin. (2) North of the Kunlun Fault, variations in crustal thickness are mainly caused by variations in lower-crustal thickness, whereas south of the Kunlun Fault they are caused by variations in upper-, middle- and lower-crustal thickness.
(3) North of the Kunlun Fault we detect a mid-crustal low-velocity zone that is not apparent south of the fault. (4) Across the NE Tibetan Plateau, Poisson's ratio has a nearly constant value of 0.24-0.25 in the upper and middle crust, indicating a felsic bulk composition. However, the Kunlun Fault seems to act as a compositional boundary for the lower crust, with a Poisson's ratio of 0.29 north of the fault (Kunlun-Qaidam terranes) and 0.26 south of the fault (Songpan-Ganzi terranes). Measured Poisson's ratio and P-wave velocity values suggest that the lower crust throughout the Tibetan Plateau (South-Qilian Shan, margins of the Qaidam Basin, East-Kunlun Shan, Songpan-Ganzi terrane) is of intermediate composition. Thus the NE Tibetan Plateau along our profile is missing a mafic lower crustal layer. The Tarim Basin, which borders the Tibetan Plateau to the north, shows a typical platform-like crustal structure with a felsic upper and middle, and a mafic lower crust. The Sichuan Basin, which borders the Tibetan Plateau to the east, also has a felsic upper and middle crust, and an intermediate or mafic lower crust.

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