Present-Day 3D Crustal Movement in the Qinghai-Tibetan Plateau from GPS Data

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3D displacement rates of GPS monitoring sites in Qinghai-Tibetan Plateau are inferred from seven repeated GPS observation data, which were collected in 1993, 1995, 1997, 2000, 2002, 2007 and 2009 separately. GPS monitoring sites cross the Kunlun faults, the Karakorum-Jiali faults, the Yarlung-Zangbo suture and Yadong-Gulu rift. The movement of sub-blocks within the Plateau is analyzed according to the location of these sites, and the tectonic background of the Plateau.

Adopting previous divisions of the Plateau into sub-blocks, we have sites 0001 (Golmud), 0002 (Budongquan), 0003 (Erdaogou), 0004 (Yanshiping), 0005 (Wenquan), 0006 (Anduo), 0014 (Soxian), 0007 (Naqu) and 0008 (Lhasa) in the Tibetan sub-block, and sites 0009 (Ganzi), 0010 (Lhaze), 0011 (Nyalam), 0012 (Saga), 0013 (Xigaze) and 0015 (Yadong) in the Himalayan sub-block (Liu and others, 2000; Zhang and others, 2004). With reference to the Eurasia plate, the horizontal velocity of site 0008 is 23.3±0.4 mm/a, significantly less than the result of Liu and others (2000) (29.8±1.5 mm/a), but consistent with the result of Zhang and others (2004) (25.1±1.8 mm/a). The reason for the difference may be that only three periods of repeated surveying were processed, with less accurate orbits in early years. Provided that the velocity of the IGS site IISC (Bangalore) represents the subduction velocity of the India plate, the convergence rate of India-Asia collision is 19.0±0.5 mm/a, which is consistent with the results of Liu and others (2000) (19.5±1.7 mm/a) and Zhang and others (2004) (17±3 mm/a) (Zhang and others, 2004), and a result (18±7 mm/a) based on seismic and geological data (Armijo and others, 1986). Similarly, the shortening rate of the Tibetan sub-block in NS direction, represented by the velocity difference of site 0001 and 0008 in NS direction, is 9.1±0.6 mm/a, in agreement with the result of Liu and others (2000) (9.3±4.6 mm/a).

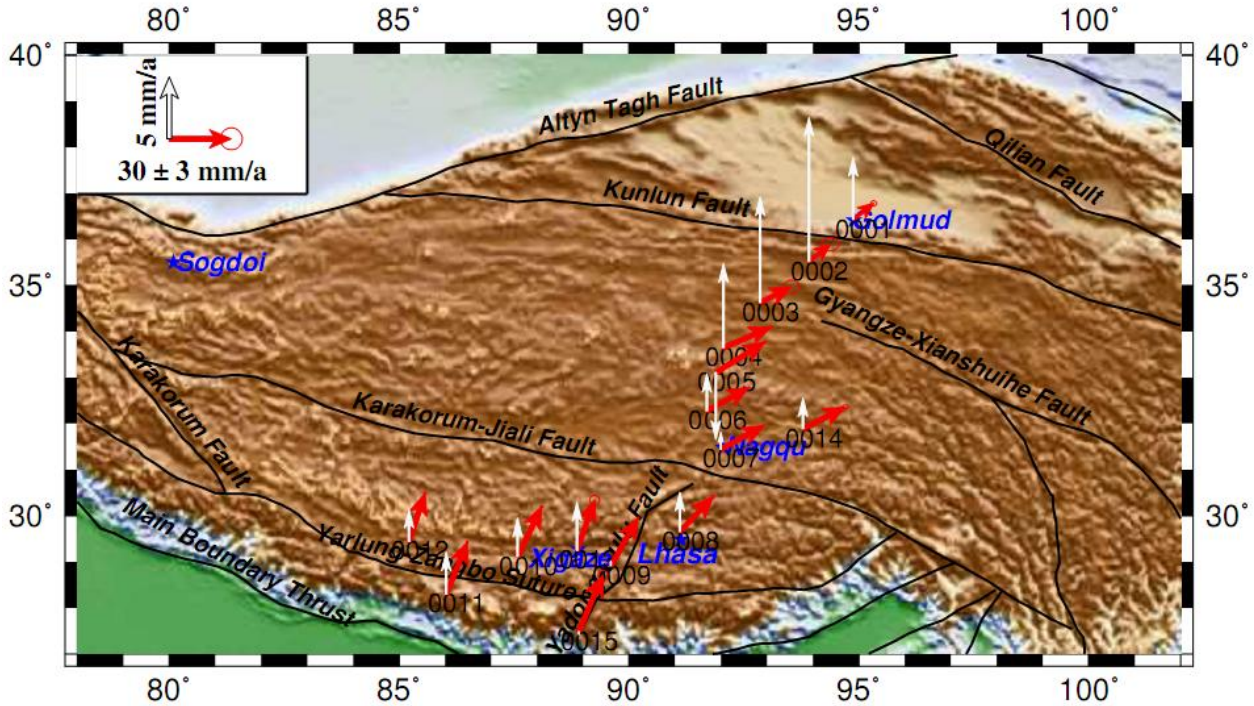

Figure 1. Present-day 3D velocity of GPS monitoring sites in Qinghai-Tibet Plateau. Red and white arrows represent the horizontal and vertical velocity of the sites, respectively.

We also calculated strain rates. The extension and contraction rates of the Himalayan sub-block are 9.4±0.9 nanostrain/yr and 26.6±3.8 nanostrain/yr respectively, less than the results of Chen and others (2004) (11.9±5.4 nanostrain/yr and 41.3±11.6 nanostrain/yr). The difference may be caused by the number and location of the sites. Our extension and contraction rates of the Tibet sub-block are 6.2±1.0 nanostrain/yr and 11.4±2.9 nanostrain/yr respectively, also less than the results of Chen and others (2004) (7.8±2.5 nanostrain/yr and 20.5±2.2 nanostrain/yr), and presumably for the same reason.

The EW extension of the plateau mainly occurs in the central part of the Tibetan sub-block. Relative to site 0001, the average EW extension rate of the other sites in the sub-block is 8.5±0.7 mm/a, consistent with the results of Liu and others (2000) (8.7±6.4 mm/a), Jiang and others (2008) (11.2±0.2 mm/a), and Armijo and others (1986) (10±5 mm/a) that was inferred from the secular average velocity of active faults. The opening rate of the Yadong-Gulu rift, inferred from the velocity difference between sites 0008 and 0009 in the direction $N20^0E$ is 4.9±0.4 mm/a, similar to the result of Chen and others (2004) (5.9±0.7 mm/a), and the dextral strike-slip rate of the Yarlung-Zangbo suture, inferred from the velocity difference between sites 0015 and 0009 in the direction $N20^0E$, is 2.8±0.9 mm/a, consistent with the result of Gan and others (2007) (2.5±1.1 mm/a).

Except for sites 0005 and 0015, the vertical velocities of our sites show ongoing uplift of the Tibetan Plateau. Site 0005 is very close to the Qinghai-Tibet Highway, and may be subsiding with the settlement of the highway. As for 0015, it has been surveyed only three times, and those measurements were early on, so the vertical velocity for this site is not considered reliable. Sites 0002, 0003 and 0013 have similar problems. Except for these sites, the average vertical velocity is 3.2 mm/a, which is less than previously estimated (4-5 mm/a) (Jiang and others, 2008).

In general, the present 3D crustal movement in the Qinghai-Tibet Plateau is characterized by compression in the NS direction, extension in the EW direction, and vertical uplift.

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