Kinematics and Crustal Deformation of the Yellowstone Hotspot from GPS Measurements: 1987-2006

C. M. Puskas » Dept of Geology and Geophysics, University of Utah
R. B. Smith » Dept of Geology and Geophysics, University of Utah
W. L. Chang » Dept of Geology and Geophysics, University of Utah
D. Drobeck » Dept of Geology and Geophysics, University of Utah
C. M. Meertens » UNAVCO, Boulder, CO

Campaign and continuous GPS data were acquired from 1987 to 2005 to measure deformation of the Yellowstone-Snake River Plain volcano-tectonic province [Puskas et al., 2006]. The University of Utah, supported by UNAVCO and with collaborators, conducted seven campaigns between 1987 and 2003, occupying 140 stations and installing and operating 15 permanent GPS stations. The University of Utah permanent stations will be incorporated into an expanded EarthScope PBO network, improving coverage of Yellowstone. The GPS data revealed large and unexpected episodes of vertical deformation of the Yellowstone caldera. The caldera subsided at a maximum rate of 14 ± 3 mm/yr in 1987-1995. Vertical deformation shifted to the NW caldera boundary uplift at 5 ± 4 mm/yr for 1995-2000. For 2000-2003, caldera deformation switched to subsidence of up to 9 ± 6 mm/yr, yielding direct evidence of a restless caldera. Continuous GPS observations revealed a reversal to rapid caldera-wide uplift up to ~6 cm/yr from 2004 to 2006.

These deformation episodes have been modeled [Vasco et al., 2007] by volumetric strain inversion revealing a mid-crustal source (6-10 km deep) of compression and expansion that coincides with the top of the tomographically imaged crustal magma body. Deformation is likely a result of accumulation and/or migration of hydrothermal fluids or magmatic crystallization.

Thirty kilometers west of the Yellowstone caldera, fault-normal extension continued across the Hebgen Lake fault at 3.1 to 5.3 mm/yr during the period 30 to 46 years following the 1959 M7.5 earthquake. Baseline data for 16 years of GPS observations combined with USGS trilateration data were used to model crustal rheology from the viscoelastic relaxation following this large event [Chang and Smith, 2006]. This model predicted post-seismic horizontal motion of 1 mm/yr within 40 km of the fault and uplift up to 2 mm/yr to the north of the fault. Using the rheology model, all of our data were corrected for time-dependent deformation caused by the M7.5 earthquake.

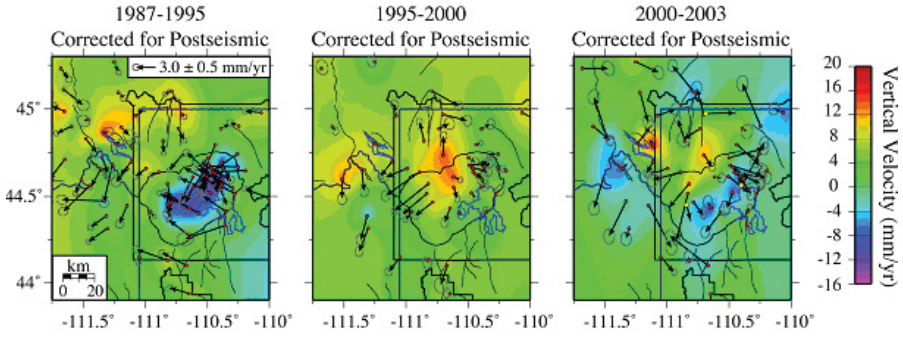

Figure 1. Vertical velocities in the Yellowstone caldera (a) 1987-1995, (b) 1995-2000, and (c) 2000-2003.

References

Chang, W. L. and R. B. Smith, (2007), Lithospheric rheology from post-seismic deformation of a M=7.5 normal-faulting earthquake with implications for continental kinematics, J. Geophys. Res., (in revision).

Meertens, C. M., R. B. Smith, C. M. Puskas, (2000), Crustal Deformation of the Yellowstone Caldera from Campaign and Continuous GPS surveys, 1987 – 2000, Eos Trans. AGU, 81(48), Fall Meet. Suppl. Abstract V22F-19.

Puskas, C. M., R. B. Smith, C. M. Meertens, W. L. Chang, (2007), Crustal Deformation of the Yellowstone-Snake River Plain volcanic system: campaign and continuous GPS observations, 1987-2004, J. Geophys. Res., 112 doi:10.1029/2006JB004325, in press.

Puskas, C. M., R. B. Smith, G. Waite, L. Flesch, (2004), Kinematic Deformation of the Interior Western U.S. Extensional Regime with Mantle Flow, Eos Trans. AGU, 85(47), Fall Meet. Suppl. Abstract T31A-1247.

Vasco, D. W., C. M. Puskas, R. B. Smith, and C. M. Meertens, (2006), Crustal deformation and source models of the Yellowstone volcanic field from geodetic data, J. Geophys. Res., (in revision).

The research was supported by NSF Grants 0314298, 9725431, and 9316289.