MONITORING TIME-DEPENDENT VOLCANIC DYNAMICS AT LONG VALLEY CALDERA USING INSAR AND GPS MEASUREMENTS

Zhen Liu, Danan Dong, Paul Lundgren

Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, USA

The Long Valley area situated at the eastern edge of the Sierra Nevada block has been active for the past several million years. Continuous monitoring since the late 1970s, including data from seismic and geodetic networks has shown renewed unrest activity at Long Valley Caldera. This activity has been episodic, with accelerated uplift separated by reduced uplift, no activity or slow deflation. Despite considerable progress in understanding this complex system in prior uplift events, i.e., 1997-1998, and more recently 2002-2003, a thorough understanding of its time-dependent dynamics remains elusive. The important questions regarding this active volcano are: Do the recent unrest episodes (recurrent uplift and subsidence) at Long Valley Caldera have similar source mechanism? What is their implication for the volcanic eruption hazard in the region?

Here we examine the time-dependent behaviors at Long Valley Caldera by integrating InSAR and continuous GPS measurements. We processed ERS-1/2 radar data between 1992 and 2008 using JPL/Caltech ROI-PAC software. We revisit the inflation event prior to 2000 by applying SBAS-InSAR approach [Berardino et al., 2002] to solve for the mean LOS deformation rate. We used reprocessed three-component continuous GPS (CGPS) data from Long Valley GPS network in 1996-2009 to estimate seasonal variations and remove common mode error by principal component analysis [Dong et al., 2006]. Non-secular deformation rate during 97-98 uplift, 02-03 uplift, 04-07 slow subsidence, and 07-09 slow uplift are estimated from CGPS with uncertainty estimates from CATS [Williams et al., 2004]. The CGPS and suitable InSAR measurements are combined to invert for the source morphology and dynamics during these deformation episodes. We examine a suite of models including spherical and finite source (prolate spheroid) and employ a non-linear Monte-Carlo random cost approach [Berg, 1993] to estimate source and volume change.

We find that the post-2000 events (i.e., 02-03, 07-09 inflation and 04-07 deflation) have similar source geometries. They both locate at depths of ~8-9 km and have near horizontal source configuration. These suggest that these events are caused by the same mid-crustal source, possibly due to magma partial melt. In contrast, the 97-98 event has a much steeper source geometry and much larger volume change, possibly driven by the magma intrusion beneath the resurgent dome It is likely driven by the magma intrusion beneath the resurgent dome from deeper source. If we regard post-2000 events as proxies for future eruption hazard, the source geometries, small volume changes, and mid-crustal locations for these events suggest that the probability for near-term eruption is low. Our study indicates that CGPS, along with InSAR, are important tools for monitoring time-dependent source process in active volcano regions.

References

1. Berg, B., 1993, Locating global minima in optimization problems by a random-cost approach, *Nature,* 361, 708-710.
2. Berardino, P., G. Fornaro, R. Lanari, and E. Sansosti, 2002, A new algorithm for surface deformation monitoring based on small baseline differential SAR interferograms, *IEEE Trans. Geosci. Remote Sens.,* 40, 2375-2383.
3. Dong, D., P. Fang, Y. Bock, F. Webb, L. Prawirodirdjo, S. Kedar, and P. Jamason, 2006, Spatiotemporal filtering using principal component analysis and Karhunen-Loeve expansion approaches for regional GPS network analysis, *J. Geophys. Res.,* 111, B03405, doi: 10.1029/2005JB003806.
4. Williams, S. D. P., Y. Bock, P. Fang, P. Jamason, R. M. Nikolaidis, L. Prawirodirdjo, M. Millier, D. J. Johnson, 2004, Error analysis of continuous GPS position time series, *J. Geophys. Res.,* 109, B03412, doi:10.1029/2003JB002741.