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New evidence of magma intrusion beneath Long Valley caldera from InSAR and gravity measurements

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Our study provides new, compelling evidence that magma has been forcing Long Valley caldera resurgent dome upward for the past 30 years. Since 1975, Long Valley caldera, located in the eastern side of the Sierra Nevada in Central California, is the site of major geologic unrest, characterized by 75 cm of uplift of the resurgent dome and earthquake activity followed by periods of relative quiescence. We investigate the cause of unrest by a joint inversion of surface deformation measurements and micro-gravity data.

To measure the deformation of the entire caldera floor and its surroundings, we analyze a data set composed by 21 descending orbit SAR images (Track 485, Frame 2845), acquired by the European Space Agency ERS-1/2 satellites spanning the time interval from June 1992 to August 2000. The ERS 1/2 satellite data are processed using the SBAS-InSAR algorithm.

In addition to the InSAR measurement, we consider in our analysis levelling data from 1982 to 1999, horizontal deformation EDM data from 1992 to 2000 and gravity data from 1982 to 1999. Given the constraints on the available geodetic and gravity data sets and the need to have the largest possible signal-to-noise ratio, our modelling strategy follows a two-step approach: first we invert EDM and InSAR data from 1992 to 1999 to bound the geometry of the source, then we use uplift and gravity changes between 1982 to 1999 to determine its density.

To evaluate the source of deformation beneath the resurgent dome, we jointly invert the EDM and InSAR data for the geometry and expansion of a finite prolate spheroid in a homogeneous elastic half-space. We use a non-linear inversion algorithm to determine the best-fit parameters for the spheroid.

Because of the critical convergence of geodetic and microgravity data we are, for the first time, able to unambiguously determine that the source of unrest is magma. In particular the source driving the resurgent dome uplift involves a mass intrusion with a density of 2192 to 3564 kg/m3 (95% bounds) centered at a depth between 6.6 and 8.7 km (95% bounds), representing the emplacement of about 0.13 – 0.17 km3 (95% bounds) of rhyolitic or basaltic magma.