Magma Movement at Galápagos Shield Volcanoes

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Campaign GPS measurements at Fernandina and Sierra Negra calderas from 2000-2002 revealed extraordinary extents of deformation of the caldera floors and flanks of the volcanoes, undoubtedly due to the intrusion of magma into shallow reservoirs between eruptions (Geist et al., 2006). Regular expansion of Fernandina is modeled as pressurization of a subcaldera sill that lies about 2 km beneath the caldera floor. This inflation culminated in an eruption in May 2005. We reoccupied the Fernandina network in June 2005 and found that the eruptive fissure serendipitously intruded directly between 2 benchmarks only 500 m apart; those data are currently being processed.

Sierra Negra displayed more complicated behavior before its latest eruption, which began on 22 October 2005. From 2001-2002, the caldera floor subsided, although there was no eruption. From 2002 onward, the deformation of the volcano has been captured in great detail by a six-station continuous GPS network. Subsidence continued until 2003, when the caldera floor began uplifting. The caldera floor then inflated at accelerating rates up until the time of the eruption. The results of this geodetic monitoring show that the filling and pressurization of an ~2-km-deep sill eventually led to an eruption that began on 22 October 2005. The continuous GPS monitoring measured >2 m of accelerating inflation leading up to the eruption and contributed to nearly 5 m of total uplift since 1992, the largest precursory inflation ever recorded at a basaltic caldera. This extraordinary uplift was accommodated in part by repeated trapdoor faulting, and coseismic CGPS data provide strong constraints for improved deformation models. These results highlight the feedbacks between inflation, faulting, and eruption at a basaltic volcano, and demonstrate that faulting above an intruding magma body can relieve accumulated strain and effectively postpone eruption.

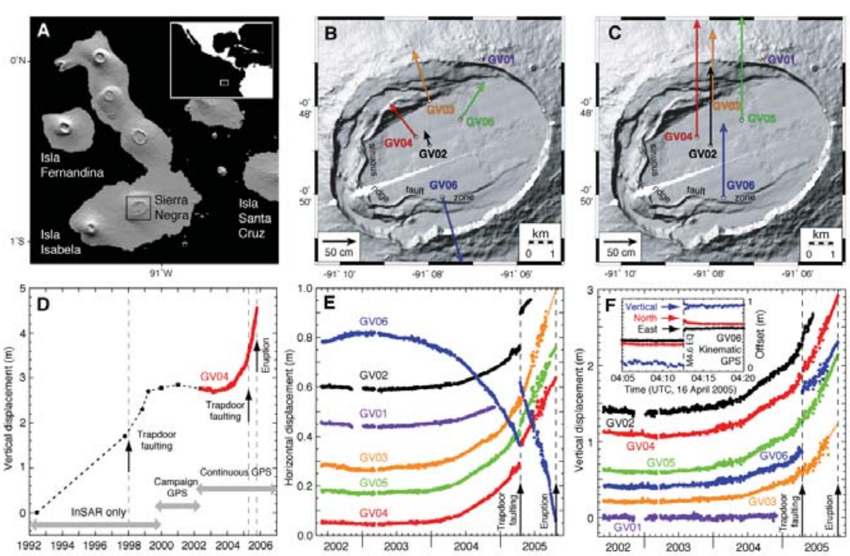

Figure 1. Continuous global positioning system (CGPS) results showing pre-eruption deformation at Sierra Negra volcano. A: Location map after Yun el al. (2006). B: Summit of Sierra Negra, showing sinuous ridge fault system, location of CGPS stations, and horizontal displacements during inflation from 1 April 2003 to 21 October 2005 (GV01 only to 3 December 2004; GV02 only to 10 June 2005). Fault-related displacements on 16 April 2005 are not included (see Figure 2). C: Vertical displacements during inflation, as in B. D: Uplift history of the center of the caldera at Sierra Negra from 1992 to 2006 amounting to nearly 5 m. Times of major trapdoor faulting events and 2005 eruption are indicated. E: Horizontal displacements (north component only) at CGPS stations from 2002 to 2006, relative to stations GALA and GLPS on Isla Santa Cruz. Noise level increases after 10 June 2005, when both dual frequency receivers had failed (GV01 and GV02). After 1 September 2005, GALA and GLPS were also down; thereafter movement at GV03 is extrapolated (dashed line) and GV04, GV05, and GV06 are shown relative to GV03. F: Vertical displacement time series, as in E. Inset shows kinematic solution for displacements at GV06 during 16 April 2005 trapdoor faulting event, relative to GV03. Vertical dashed lines in E and F show times of 16 April 2005 trapdoor faulting event and eruption on 22 October 2005. InSAR—inferometric synthetic aperture radar; GPS—global positioning system.

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References

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