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Special Section:
Creep on continental faults and subduction zones: Geophysics, geology, and mechanics

Key Points:
- InSAR analysis provides evidence for laterally and vertically complex volcanic plumbing system at Sabancaya
- High fluid pressure at Sabancaya promotes strong seismicity during 2012–2019 eruptive period
- High fluid pressure and static stress transfer from deep inflation promote long-lived fault creep

Supporting Information:
- Supporting Information S1

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Volcano-Tectonic Interactions at Sabancaya Volcano, Peru: Eruptions, Magmatic Inflation, Moderate Earthquakes, and Fault Creep

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Abstract We present evidence of volcano-tectonic interactions at Sabancaya volcano that we relate to episodic magma injection and high regional fluid pore pressures. We present a surface deformation time series at Sabancaya including observations from ERS-1/2, Envisat, Sentinel-1, COSMO-SkyMed, and TerraSAR-X that spans June 1992 to February 2019. These data show deep-seated inflation northwest of Sabancaya from 1992–1997 and 2013–2019, as well as creep and rupture on multiple faults. Afterslip on the Mojopampa fault following a 2013 M_W 5.9 earthquake is anomalously long lived, continuing for at least 6 years. The best fit fault plane for the afterslip is right-lateral motion on an EW striking fault at 1 km depth. We also model surface deformation from two 2017 earthquakes (M_W 4.4 and M_W 5.2) on unnamed faults, for which the best fit models are NW striking normal faults at 1–2 km depth. Our best fit model for a magmatic inflation source (13 km depth, volume change of 0.04 to 0.05 km^3 yr^{-1}) induces positive Coulomb static stress changes on these modeled fault planes. Comparing these deformation results with evidence from satellite thermal and degassing data, field observations, and seismic records, we interpret strong pre-eruptive seismicity at Sabancaya as a consequence of magmatic intrusions destabilizing tectonic faults critically stressed by regionally high fluid pressures. High fluid pressure likely also promotes fault creep driven by static stress transfer from the inflation source. We speculate that combining high pore fluid pressures with sufficiently large, offset magmatic inflation can promote strong earthquakes during volcanic unrest.

1. Introduction

Volcano-tectonic (VT) seismicity often occurs with volcanic eruption and unrest (e.g., Ebmeier et al., 2016) and frequently reveals significant volcano-tectonic interactions. Large ($M_W > 4$) tectonic earthquakes can promote eruption via static stress changes (e.g., King et al., 1994) over smaller distances (e.g., <5 km at Cerro Negro, Nicaragua, La Femina et al., 2004) or via dynamic stress changes over larger distances (e.g., >50 km at Merapi, Indonesia, Walter et al., 2007). Conversely, intrusions can trigger strong seismicity, as inferred from InSAR (Interferometric Synthetic Aperture Radar) at Peulik and Akutan in Alaska (Lu & Dzurisin, 2014) and static stress calculations at Iwatesan Volcano in Japan (Nishimura et al., 2001). Two-way interactions are also possible. Static stress changes from volcanic inflation promoted large earthquakes at Chiles-Cerro Negro Volcanoes (Ecuador-Colombian border, Ebmeier et al., 2016) and Karymsky Volcano Group (Russia, Walter, 2007). At Chiles-Cerro Negro, the earthquake stress change inhibited further inflation (Ebmeier et al., 2016), while the earthquake at Karymsky instead promoted eruption (Walter, 2007).

In several volcanic crises, tectonic activity on regional faults kilometers away from the volcanic edifice preceded renewed magmatic activity (White & McCausland, 2016). White and McCausland (2016) summarize several such cases of precursory distal volcano-tectonic earthquakes (“distal VTs” or “dVTs”) around the globe. These dVTs are often the earliest precursor to eruptive activity at volcanoes that have been dormant