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Volcanic Unrest of Fogo Volcano in 2011-2012, S.Miguel Island, Azores, Observed by Continuous and Campaign GPS Analysis

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Volcanic eruptions can occur after long time of dormancy as has been seen from the recent examples: Mount St. Helens 1980, Pinatubo 1991, Unzen 1991, Soufrière Hills volcano 1995, Chaitén 2008, and Eyjafjallajökull 2010. By utilizing space geodesy techniques, namely GNSS and InSAR, it has been reported that the inflation-deflation processes exist at several dormant volcanoes in the world, but the mechanism responsible for this phenomena is still controversial. Fundamental questions such as magma vs. hydrothermal fluids and volcanic vs. tectonic process remain unanswered in many cases.

In this study, we analyze both continuous and campaign GPS data from Fogo volcano, S. Miguel Island, Azores. Although no geochemical and hydrothermal evidences for a magmatic intrusion were reported during the past seismic swarm episodes (1989, 2003-2006, and 2011-2012), geophysical data, both seismic and ground deformation, indicate possible volcanic sources.

GPS time series spanned 2008-2013 period characterize tectonic plate divergence between Eurasian and Nubian, and reveal two different types of ground deformation associated with the 2011-2012 volcanic unrest of Fogo. One is the permanent edifice-scale inflation centered at NE summit which corresponds to the increase of volcano-tectonic events. Another is the subsequent minor-scale inflation-deflation reversals between Congro, a trachyte maar, east of Fogo and Furnas volcano. Calculated strain rates and GPS campaign results indicate that the 2011-2012 deformation is one order smaller than the previous unrest episode.

A strong similarity exists to Matsushiro earthquake swarm (1965-1966) and Campi Flegrei volcanic unrests (1969–1972 and 1982–1984), which is the coexistence of an edifice-scale main inflation associated with intense volcano-tectonic earthquakes with inflation to deflation reversal that coincided with a sharp drop of seismicity. High recovery rate of inflation-deflation may be an indicator for the existence of hydrothermal fluids in the highly heterogeneous/porous media.

We propose the following hypothesis for the 2011-2012 volcanic unrest of Fogo - (1) a minor magmatic intrusion beneath Fogo which acts as a heat source encourages lateral diffusion of fluids, (2) the fluids are transported through the existing cracks/fissures which are sustained by regional extension due to plate divergence, (3) influx of fluids increases pressure in cracks/fissures and generates lower-frequency earthquakes, and (4) discharge of fluids causes sudden pressure decrease and dilatancy recovery which leads seismic quiescence.

Fogo volcano represents 450 years of dormancy since 1563-1564 when the last eruptions took place at the summit caldera. However, we show that the volcano has been experiencing intermittent magma ascents (i.e. repeating “failed eruptions”) even its dormant period. Further researches are needed in order to understand the eruption triggering conditions. Nevertheless, we have a continuous GPS network that can detect small changes in the volcano roots and provide important contribution to evaluate future unrest episodes at Azores.