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Variations of the state of stress and dike propagation at Fernandina volcano, Galápagos.

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Fernandina volcano forms the youngest and westernmost island of the Galapagos Archipelago, a group of volcanic islands located near the equator and 1000 km west of Ecuador. Twenty-five eruptions in the last two hundred years make Fernandina the most active volcano in the archipelago and one of the most active volcanoes in the world. Most eruptions occur along fissures fed by dikes that propagate from the central magmatic system and from reservoirs centered under the summit caldera. Eruptive fissures in the subaerial portion of the volcano form two distinct sets: (1) arcuate or circumferential fissures characterize the upper portion of the volcano around the caldera while (2) radial fissures are present on the lower flanks. The subaerial portion of the volcano lacks of well-developed rift zones, while the submarine part of Fernandina shows three rifting zones that extend from the western side of the island.

Using Interferometric Synthetic Aperture Radar (InSAR) measurements of the surface displacement at Fernandina acquired from 1992 to 2010, and in particular the ones spanning the last three eruptions (1995 – radial, 2005 – circumferential and 2009 – radial) we infer the geometry of the shallow magmatic system and of the dikes that fed these eruptions.

A shallow dipping radial dike on the southwestern flank has been inferred by Jónnson et al. (1999) for the 1995 eruption. This event shows a pattern of deformation strikingly similar to the one associated with the April 2009 eruption for which we infer a similar geometry. Co-eruptive deformation for the 2005 event has been modeled by Chadwick et al. (2010) using three planar dikes, connected along hinge lines, in the attempt to simulate a curve-concave shell, steeply dipping toward the caldera at the surface and more gently dipping at depth.

Dike propagation in a volcano is not a random process but it is controlled by the orientation of the principal stresses, with the dike orthogonal to the least compressive stress. We calculate stress changes within the volcanic edifice generated by the active geophysical processes (e.g., pressure changes in reservoir, dike emplacement, . . .) and we investigate what phenomena can produce a stress field compatible with the inferred dike geometries and the observed pattern of eruptive fissures.

Stress models are generated in a three-dimensional linear elastic medium, using a 3D boundary element code based on the analytical solutions for triangular dislocations in isotropic elastic half and full space.