Detection and interpretation of stress changes at restless volcanoes through analysis of VT earthquake fault-plane solutions

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Systematic changes in the orientations of double-couple fault-plane solutions (FPS) for volcano-tectonic (VT) earthquakes have been observed to accompany episodes of volcanic unrest. In some cases, the observed FPS reorientations are consistent with changes in stress induced by magma pressurization or ascent. For example, long-term increases in VT seismicity preceding eruptions at Mt. Spurr, Alaska, in 1992, and Soufriere Hills, Montserrat, in 1995-2007 were accompanied by sustained 90°horizontal FPS rotations consistent with dike inflation. In both cases, the rotated FPS were no longer observed once the eruption began, suggesting that pressure in the conduit driving dike inflation had been relieved. Short-duration precursory VT sequences, such as those preceding the 2004 eruption of Mt. St. Helens, Washington, and the 2009 eruption of Redoubt Volcano, Alaska, included short-lived but distinct changes in FPS orientation similar to those observed during longer-duration precursory sequences. 90°horizontal rotations are also observed during some, but not all, VT earthquake swarms that do not culminate in eruption, including a strong post-eruptive VT swarm at Crater Peak, Alaska, in late 1992, and a weak VT swarm at Mt. Martin, Alaska, in 2006. In other cases, for example at Iliamna Volcano, Alaska, in 1996, non-eruptive swarms may be accompanied by no evident change in FPS orientation, suggesting that the mechanism of seismicity in these cases is not directly related to magma ascent, or that conduit pressurization was too weak to overcome background tectonic stresses. In sum, careful analysis of VT FPS in the context of other available geophysical and geochemical data provides a powerful means for assessing the volcanic and/or tectonic processes causing increased seismic unrest at potentially active volcanoes.