Tornillos modeled as self-oscillations of fluid filling a cavity: implications for the 1992-1993 activity at Galeras volcano, Colombia

Kostas I. Konstantinou

National Central University, Dept of Earth Sciences, Taiwan

E-mail: kkonst@ncu.edu.tw

Tornillos represent an enigmatic class of quasi-monochromatic seismic signals with a slowly decaying coda that are observed near active volcanoes and geothermal areas worldwide. In this work, a model describing the tornillo source process is investigated that is based on the self-oscillations of fluid filling a cavity. A nonlinear ordinary differential equation is derived that governs the behavior of the model taking into account viscous damping, nonlinear damping and the reaction force of the fluid inside the cavity. This equation is numerically integrated both for different cavity sizes and different fluids of volcanological interest, such as gas (H2O+CO2, H2O+SO2) and gas-particle mixtures (ash-SO2, water droplets-H2O). A cavity with a smaller radius compared to its vertical extent produces synthetic tornillos with broader frequency range (1-20 Hz) that may also exhibit amplitude modulation effects. On the contrary, a cavity with a radius much larger than its vertical dimension generates signals with lower frequencies (1-7 Hz). When the fluid filling the cavity is a gas-particle mixture the total duration of the synthetic signals attains values of tens of seconds and quality factors of several hundred. The tornillo activity preceding five of the six vulcanian eruptions during 1992-1993 at Galeras volcano is consistent with the self-oscillations of a mixture of ash-SO2 filling a cavity that is gradually enriched in ash particles. Additionally, the model predicts a progressive increase of the tornillo signal duration followed by a small decrease as was observed at Galeras. It can be inferred that the time dependent rheology of the andesitic dome that was emplaced earlier at Galeras may have played a very important role in the formation of these cavities and the seismic phenomena observed during each eruptive cycle.