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Similarities in Eruption Dynamics: A Seismo-Acoustic Analysis of Explosion Sequences at Tungurahua Volcano in May-July 2010 & December 2012

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We analyze a continuous seismo-acoustic dataset of explosions at Tungurahua volcano, Ecuador, from July 2006 to the present. Reduced amplitudes and energies are calculated for discrete events using four collocated broadband seismic and infrasound sensors. Of the 19 explosive episodes identified, we highlight eruptive activity in May-July 2010 and December 2012 because of their similar characteristics and temporal evolution.

During both periods of unrest, the following sequence is observed: Stage 1 – Activity commences after more than 3 months of quiescence. Stage 2 – Inflation and increasing VTs lead to the initiation of one high-energy explosion. Stage 3 – After approximately 48 hours of relative repose, a few high-energy explosions are followed by strong tremor, column generation and pyroclastic flows. Stage 4 - Hundreds of daily explosions are accompanied by chugging signals lasting about one week. Stage 5 - A sudden end to chugging coincides with a rapid decline in explosion numbers and seismo-acoustic energy radiated.

We quantify the volcano acoustic-seismic ratio (VASR: acoustic energy/seismic energy) from discrete explosion sequences during the early stages of activity in May-July 2010 and December 2012 and find relatively low values (VASR = 0.1-10) when compared with other episodes of activity at Tungurahua (where VASR = 10-1000). These periods of low VASR are related to explosions accompanied by the strong chugging of Stage 4, between days 3 and 10 of the eruption cycle. We suggest that the first high-energy explosions during Stages 2 & 3 were unable to completely clear the old viscous magma plugging the vent. Subsequent explosions through a blocked, or constricted conduit (during Stage 4), are likely to exhibit low VASR due to strong seismic coupling with the surrounding plug and conduit walls. Following continuing explosive activity, we envision that the plug is eventually cleared, as chugging events rapidly disappear and an increase in explosion VASR is observed (Stage 5), suggesting a period of more efficient acoustic radiation during explosive degassing.

A transition between low explosion VASR (constricted conduit system) to high explosion VASR (open conduit system) across an eruption cycle is consistent with eruptive behavior at andesitic stratovolcanoes worldwide. This research shows that seismo-acoustic energy partitioning provides a quantitative measure for tracking such alterations in the eruptive mechanism of the degassing system in near real time.