



Forecasting the fate of caldera unrest through statistical analysis of monitoring data

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Calderas are among the most spectacular, dangerous and active volcanoes on the Earth. Seismicity, surface deformation and degassing are commonly observed at many calderas, denoting unrest. The unrest can be intermittent, lasting for months to years, or persistent, over decades to centuries. Although most caldera unrest episodes do not lead to an eruption, the possibility of an impending eruption warrants detailed monitoring and study. To better understand caldera unrest and forecast any possible eruption, we built a database from all available publications and reports on the recent unrest episodes at calderas in the world and then carried out a statistical analysis. We focused on the unrest episodes from the last 25 years, being complementary to Newhall and Dzurisin (1988). We considered the monitoring data from 42 unresting calderas, totaling 166 unrest episodes, of which 110 eruptive and 56 failed (unrest without eruption). Attention has been given to unrest duration, seismicity, deformation and gas variations, along with their possible interaction.

First, we analyzed the unrest duration through the Kolmogorov-Smirnov two-sample test to find any significant variation between different classes of unrest: unrest duration of the eruptive vs failed unrest episodes, unrest duration at mafic vs felsic calderas, unrest duration at mafic calderas with eruptive vs failed unrest and unrest duration at felsic calderas with eruptive vs failed unrest. Subsequently, we analyzed the inter-event time between two eruptions, searching any relationship between time and the VEI of the preceding or following eruption, according to time and size predictable models. We then used the Fisher Discriminant Analysis to find any linear combination of features which maximizes the separation between two (or more) classes of objects. Finally, we used the binary decision tree to classify the unrest through several input variables.

The statistical analysis of the database confirms that all eruptions are preceded by an unrest episode, but not all unrest episodes culminate in an eruption; Eruptive unrest episodes are typically shorter than failed unrest episodes, as confirmed by different independent algorithms (KS test and Fisher analysis). The binary decision tree shows that 79% of the eruptive unrest episodes show high seismicity, degassing and last less than 9 months; without considering the unrest duration, virtually all the several tens of eruptive unrest episodes in closed (non recently erupting) magmatic systems show high seismicity and degassing over periods longer than a few days; This has potential implications for the ongoing, currently aseismic unrest at Campi Flegrei caldera.

This statistical analysis will be improved including also the Newhall and Dzurisin 1988 data and performing the time series analysis of the measured parameters, in order to better constrain caldera unrest and its possible culmination in eruptions.