Geochemical precursors for eruption repose length

Rebecca M Green[1], Mark S Bebbington[2], Shane J Cronin[2], Geoff Jones[1]

[1]Institute of Fundamental Sciences, Massey University, Palmerston North, New Zealand, [2]Volcanic Risk Solutions, Massey University, Palmerston North, New Zealand

E-mail: r.green@massey.ac.nz

Volcanic eruptions are inevitable but the ability to accurately forecast their occurrence can lead to considerable reductions in risk through incorporation in land-use planning and emergency management scenarios. Volcanic hazard forecasting is based around the idea that a volcano's future activity is best predicted by its prior history. Thus, models are usually assembled using point processes techniques and renewal theory. A point process assumes that events occur in a period of time $(t+\Delta)$ with probability $\lambda(t)\Delta t$. One special case is the Poisson point process which assumes that events occur at a constant average rate $\lambda(t)=\lambda$, exhibiting no trend over time. This is extended to form a renewal process by allowing the elapsed time since the previous eruption to solely control the timing of the next eruption. Most of these models are purely temporal in the sense that they only consider the distribution of onset times as predictors of future volcanic activity. It has been hypothesized, however, that there are underlying cycles in geochemistry data that could be linked to the eruption rate.

We illustrate through the use of a high-resolution Holocene eruption record from Mt Taranaki (New Zealand) that by incorporating geochemical data using a proportional hazards type approach the current renewal-type models can be improved on. The use of a proportional hazards model incorporates geochemical influences into the eruption process by attaching a vector of covariates to the inter-onset hazard. These covariates act multiplicatively on the hazard and as a result the timing of the next eruption becomes dependent on both the magnetite geochemistry of the previous eruption and the time since the last event.

Mt Taranaki is an andesitic stratovolcano that has an activity record that includes long periods of quiescence and subsequent re-awakening. Thus the distribution of inter-onset times is bimodal, with the possibility of anomalously long reposes. Using magnetite major-element chemistry as a proxy for the state of the magmatic system, the concentrations of TiO_2 and Al_2O_3 (or MgO) are useful predictors of repose length. In particular, they provide a better explanation than a bimodal renewal distribution, with the important feature that this predictive information is available at the beginning of the repose to be forecast.