

Repetitive hybrid earthquakes at regular intervals as a precursor of the 6 August 2012 eruption of Tongariro volcano, New Zealand.

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New Zealand's Tongariro volcano had been dormant for over a century in July 2012, when there were three episodes of seismic activity beneath its northern slopes. Small tectonic earthquakes are not uncommon in this area. However, most of the small ($ML < 2.5$) events in July 2012 were hybrids and had very similar waveforms, indicating they probably had the same source mechanism and location. There were also monochromatic tornillo earthquakes, some in the coda of hybrid events and others occurring separately.

GNS Science responded to this unusual seismicity by raising the alert level for Tongariro, and increasing its seismic, deformation and chemical monitoring. Less than a month after the first events, there was a small ash and steam eruption from the upper Te Maari crater on the northern slopes of Tongariro. The eruption was phreato-magmatic, with any magmatic component being very small.

Further analysis of the pre-eruption seismicity found that it was dominated by events of similar size at regular intervals; 80% of the events had local magnitudes 1.8 ± 0.3 , and the inter-event intervals in the first swarm were all between 63 and 79 minutes. The similar waveforms of these events displayed a pulsatory beating pattern. Such repetitive hybrid earthquakes, but closer-spaced and in much larger numbers, have been seen during dome-building at Soufrière Hills, Montserrat, and interpreted as being the result of repeated magmatic injections into a dome.

The repeating waveforms, consistent beating pattern and clockwork nature points to a stationary and mostly non-evolving source geometry located about 2 km beneath the 6 August eruption vent. The source of events of this type might be due to a near constant flux process through a constricted pressurised cavity. If we had recognised these features of the seismicity closer to real-time we would have been more confident of its unusual nature, and perhaps had sufficient confidence to make an eruption forecast. This activity reinforces the value of looking at all the characteristics of seismic activity on a volcano when considering whether it might be an eruption precursor.