

## A search for precursors to phreatic eruptions

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New Zealand has hosted several volcanic eruptions over the past decade which have provided an opportunity to examine the range of possible precursors to those events. A growing body of retrospective research is now available for the 2006-2007 Ruapehu eruptions, the 2012 Tongariro eruptions and the 2012-2016 White Island eruption sequence. This contribution will review the multi-parameter observations from seismic, deformation, gas geochemistry, and other observation parameters, to assess potentially useful contributions to volcano monitoring.

Precursors to the 2006-2007 Ruapehu eruptions included retrospective observation of anomalous *b*-values, shear wave splitting delay times and the direction of anisotropy beginning about 3 years before the September 2007 eruption (Keats et al., 2001). Just prior to the eruption, high frequency and very-long-period (VLP) seismicity were observed (Jolly et al, 2010). Several minutes of high frequency seismicity also preceded a separate eruption at Te Maari, located ~20 km north of Ruapehu, in August 2012 (Jolly et al., 2014) and were preceded by ~3 weeks of earthquake swarms (Hurst, et al., 2014) and anomalous magmatic degassing (Christenson et al., 2013).

At White Island, 6 phreatic or phreato-magmatic eruptions were detected over the 2012-2016 period. This unrest was marked by higher-level tremor documented in the real-time seismic amplitude measure (RSAM) which has proved valuable for hazards assessments of volcanic unrest. For example, a retrospective tremor analysis showed that 4 of the 5 White Island eruptions were related to the increased RSAM as part of a rigorous failure forecast (Chardot, 2015). In a separate analysis, the ratios of the low and high frequency tremor and the relative seismic velocity were shown to relate to eruption activity, possibly due to pressurization within the volcano hydrothermal system at Tongariro/Ruapehu (Caudron, et al., 2019) and White Island.

Numerous volcano-tectonic (VT), long-period (LP) and VLP earthquakes are recognized at White Island. While the local VT seismicity is not a recognized precursor, the LP activity does appear to be modulated by surface activity, including lake level changes and eruptions. VLP earthquakes are particularly useful because they are repetitious, are locatable, and related directly with 2 of the 6 eruptions. White Island eruptions are also linked to anomalies in the seismic ambient noise but the interpretation requires careful assessment, due to its modulation by external factors including tectonic stresses, seasonal climate and the effects of volcanic tremor (Yates et al., 2019).

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Together, these approaches offer great promise towards improved short to medium term hazards assessments at New Zealand's most active volcanoes.

### Main References

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