ABSTRACT

The orientation of crustal anisotropy changed by ∼80 degrees in association with the 1995/96 eruption of Mt. Ruapehu volcano, New Zealand. This change occurred with a confidence level of more than 99.9%, and affects an area with a radius of at least 5 km around the summit. It provides the basis for a new monitoring technique and possibly for future mid-term eruption forecasting at volcanoes.

Three deployments of seismometers were conducted on Mt. Ruapehu in 1994, 1998 and 2002. The fast anisotropic direction was measured by a semi-automatic algorithm, using the method of shear wave splitting. Prior to the eruption, a strong trend for the fast anisotropic direction was found to be around NW-SE, which is approximately perpendicular to the regional main stress direction. This deployment was followed by a moderate phreatomagmatic eruption in 1995/96, which ejected material with an overall volume of around 0.02–0.05 km^3. Splitting results from a deployment after the eruption (1998) suggested that the fast anisotropic direction for deep earthquakes (>55 km) has changed by around 80 degrees, becoming parallel to the regional stress field. Shallow earthquakes (<35 km) also show this behaviour, but with more scatter of the fast directions. Another deployment (2002) covered the exact station locations of both the 1994 and the 1998 deployments and indicates further changes. Fast directions of deep events remain rotated by 80 degrees compared to the pre-eruption direction, whereas a realignment of the shallow events towards the pre-eruption direction is observed.

The interpretation is that prior to the eruption, a pressurised magma dike system overprinted the regional stress field, generating a local stress field and therefore altering the fast anisotropic direction via preferred crack alignment. Numerical modelling suggests that the stress drop during the eruption was sufficient to change the local stress direction back to the regional trend, which was then observed in the 1998 experiment. A refilling and pressurising magma dike system is responsible for the newly observed realignment of the fast directions for the shallow events, but is not yet strong enough to rotate the deeper events with their longer delay times and lower frequencies. These effects provide a new method for volcano monitoring at Mt. Ruapehu and possibly at other volcanoes on Earth. They might, after further work, serve as a tool for eruption forecasting at Mt. Ruapehu or elsewhere. It is therefore proposed that changes in anisotropy around other volcanoes be investigated.