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Crustal controls on eruptions at large calderas

Christopher Kilburn, Alexander Steele, Robert Robertson, Danielle Charlton, and Lara Smale
University College London, UCL Hazard Centre, Earth Sciences, London, United Kingdom (c.kilburn@ucl.ac.uk)

After centuries or more of repose, large calderas can enter extended intervals of episodic unrest. Most episodes do not end in eruption, encouraging vulnerable communities to perceive emergency warnings of volcanic activity as false alarms. Using data from Rabaul, in Papua New Guinea, and Campi Flegrei, in Italy, we argue that non-eruptive episodes are an essential feature of a longer-term approach to eruption and that the probability of eruption increases with each episode. The episodes are characterised by elevated rates of ground movement and of local micro-seismicity. They may continue for ∼1 year and be separated by intervals about ten times longer. The lengths of the intervals have encouraged the view that each episode can be treated independently when evaluating eruptive potential. Such an approach implicitly assumes that the crust relaxes accumulated stress after each episode. A new model for elastic-brittle deformation instead indicates that successive episodes promote a long-term accumulation of stress in the crust. A full pre-eruptive sequence may thus consist of several episodes over ∼10-100 years before major crustal failure. Preferred locations for failure are the margins of a pressurized magma body and the vicinity of major faults in the crust. In the first case, the potential for eruption is governed by the direction of tensile stresses caused by the geometry of the magma body; in the second, it is controlled by the ability of magma to enter an opening fault. The probability of eruption can therefore be quantified by modulating the elastic-brittle model of crustal failure with statistical models of structural controls on magma ascent.