# Coupled long- and short-term eruption precursors during caldera unrest

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Short-term forecasts rely on accelerations in precursory signals. Although the strategy has proved suitable at stratovolcanoes reawakening after centuries of repose, it has been less successful at large calderas, where unrest may continue for decades or more. Here we argue that patterns of short- and long-term unrest are strongly coupled at large calderas, so that reliable interpretations of short-term precursors require knowledge of preceding episodes of long-term unrest.

During unrest, potential precursors may show significant variations in their rates of change with time. More than one episode of increased rate may decay without eruption. Associated warnings of eruption can be viewed as false alarms by local communities, who may then be reluctant to respond during future alarms. A classic example is the 21 years of unrest before the 1994 eruption in Papua New Guinea. An uplift of c. 2.3 m was recorded across the north of the caldera. Nearly 40% of the uplift occurred in 1982-84, accompanied by elevated rates of volcano-tectonic (VT) seismicity. The uplift rate of c. 0.45 m/yr was a magnitude larger than typical values over the 21-year interval. The 1982-84 crisis ended without an eruption. When an eruption finally occurred in 1994, it began without a significant increase in uplift rate and with an elevated VT event rate only 24 hours beforehand. An apparent contradiction thus exists in which significant precursory changes occurred without eruption, whereas an eruption occurred without significant precursory changes.

The contradiction is resolved by comparing changes of precursors with each other, rather than with time. The results yield an exponential dependence of VT event number on uplift. The trend is consistent with a single precursory sequence, during which damage accumulates in the crust until a new pathway is formed to feed an eruption. The amount of damage increases as the crust is stretched under a combination of (1) a build-up of pressure in an underlying magma reservoir and (2) movement of magma through the crust. Thus, the 1973-94 sequence can be related to a long-term increase in magma pressure, coupled with the shallow intrusion of a small batch of magma during 1982-84. At the time of intrusion, the amount of accumulated damage was too small to propagate a new pathway to the surface and so the event culminated in a non-eruptive crisis. By 1994, however, the amount of damage accumulated since the early 1970s had reached a critical amount, such that another episode of magma movement triggered the opening of a new pathway and led to an eruption after a very short interval of elevated precursory signals.