The Soufrière Hills volcano in Montserrat is one of several volcanoes worldwide that show marked cyclic behaviour. **Sue Loughlin** and team explain how cycles on timescales of years to hours can be used to forecast hazardous volcanic activity.

A volcano's pulse

Before the 1995 Soufrière Hills eruption began, there had been seismic crises approximately every 30 years since the late 1890s; each crisis lasted months to years and involved thousands of small earthquakes. In 1935, some earthquakes were large enough to cause damage to buildings in the capital Plymouth and there was real concern that an eruption was imminent. These seismic crises were later interpreted as pulses of magma trying, but failing, to reach the surface. A final seismic crisis began in 1992, and by November 1995 fresh lava had reached the surface and began to form a dome in the volcano's summit crater. The eruption has since been characterised by pulsatory activity on a range of different timescales.

MVO staff watch an explosion on 28 June 2005.

At this type of volcano, viscous lava is piled up in a dome which can collapse at any time generating devastating hot and fast-moving pyroclastic flows and surges. These are the main volcanic hazards but others include explosions, lateral blasts and, following heavy rainfall, lahars (mudflows). In March 1998, the lava dome stopped growing but volcanic activity such as explosions and fast-moving pyroclastic flows of debris from the still-hot dome continued. In November 1999, the lava dome began to grow again. It was clear then that this is one of relatively few eruptions in the world that is long-lived and could continue in this manner for decades. Between 1995 and 2008, lava was discharged in three distinct episodes each lasting 21 to 44 months separated by periods of repose lasting 16–24 months.

BGS staff sample fresh pyroclastic flow deposits in Tar River valley, November 2005.

The BGS are now engaged in volcano research, this includes investigation of the cyclic nature of volcanic activity at this and other similar volcanoes. The 30-year seismic cycles are well recognised, as are the dome growth cycles on a two- to three-yearly scale. There are also cycles lasting about six weeks that may represent pulses of magma released from a shallow magma chamber. The onset of these cycles typically leads to instability of the lava dome. There are also cycles on timescales of days that are linked to the release of volcanic gases and rockfalls

Thomas Christopher (BGS) inspects the deposits and impacts of the 20 May 2006 total dome collapse including trees bent and scorched by pyroclastic surges.

Mick Strutt (BGS) fixes the time-lapse camera at Perches Mountain on the crater rim, January 2008.

on the sides of the lava dome. The most impressive cycles though have been on a scale of hours and these are linked to degassing of magma in the conduit just below the lava dome. These various cycles have, on occasions, allowed staff at the MVO to forecast hazardous volcanic activity quite well. Better understanding of the processes driving the cycles should facilitate improved cycle recognition and hazard forecasting.

To better understand the processes causing these cycles, we need to know more about the magma chamber and conduit supplying magma to the volcano. The BGS has contributed to a unique seismic tomography experiment (SeaCALIPSO) with UK and international partners that is giving new insights into the crustal structure and magma supply system under the volcano. The combination of our vast datasets of instrumental and observational evidence with new constraints from the SeaCALIPSO experiment, and ongoing petrological work, will facilitate a new generation of models aimed at understanding how these dangerous volcanoes work.

The social and economic management of this ongoing volcanic eruption has been very challenging due to its long duration, the changing hazards and risks and the fact that Montserrat is a relatively small island. Nevertheless, despite the challenges Montserrat remains a beautiful island and vibrant community. The MVO is now run by the Seismic Research Centre (University of the West Indies), based in Trinidad.

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Dome-collapse pyroclastic flows enter the deserted capital Plymouth on 4 January 2007.