Seismic Monitoring

As magma migrates towards the surface beneath volcanoes, stress changes in the crust can cause volcanic earthquakes. Hence monitoring of precursory seismicity at active, or potentially active, volcanoes is one of the most reliable and widely used volcano monitoring techniques.

Recording and analysing volcanic earthquakes has been a critical monitoring tool throughout the eruption of the Soufriere Hills Volcano. Seismic Monitoring at MVO relies on a network of seismic stations, which use seismometers to measure the ground motion at different sites around the volcano. This network has been continuously improved during the course of the eruption. A network of three stations operated by the Seismic Research Unit (now Seismic Research Centre) was in place prior to the eruption. This was expanded during the first few weeks of the eruption with equipment and assistance from the USGS/VDAP program.

The network was upgraded by the British Geological Survey (BGS) in October 1996 and again in early 2005, by which time it included ten broadband, high dynamic range instruments with digital telemetry, located all over the southern half of Montserrat. The network has remained broadly similar since, and has been supplemented since 2014 by several “Spiders” (portable instruments designed for short-term, remote deployment), provided by the USGS. A further major upgrade of the seismic network is planned as part of the MVO/SRC management contract, and is due to take place in the coming months.

As the stations are not easily accessible, they use solar power and the signals are transmitted to MVO in real-time using spread-spectrum radios. The signals are recorded and analysed using a computer-based data acquisition system at MVO. Like the seismic network, this has been upgraded several times during the course of the eruption and currently uses a combination of Scream! and Earthworm software for data acquisition and Seisan for data analysis. MVO records both continuous and triggered event data which are then analysed by specialists. MVO also uses real-time automatic processing of the seismic data to provide immediate information to staff on duty and, if seismic activity increases significantly, alerts to staff cell-phones. All data are archived.

Figure 1. Map showing the locations of the stations in the MVO seismic network as of May 2017

Figure 2. Panoramic view of the MVO Operations Room. From here MVO’s scientific and technical staff continually monitor the volcano's seismic activity.
There are a number of distinct types of seismic signals recorded on the seismic network at the Soufriere Hills Volcano, and most are too small to be felt by people on Montserrat. The most important types are volcano-tectonic earthquakes, long period earthquakes, hybrid earthquakes and rockfall or pyroclastic flow signals:

The signals from volcano-tectonic (VT) earthquakes have a sudden or impulsive start and last for a short time. They are predominantly high frequency signals (>5 Hz) and can occur in swarms lasting from a few minutes to several days in duration. VT earthquakes are caused by the fracturing of the rock under the volcano as the magma forces its way to the surface. They were common at the start of the eruption but now occur much more sporadically, and in recent years sometimes occur in short bursts or swarms termed “VT strings”. VT earthquakes can be located using the MVO seismic network and generally occur a few km beneath the summit of the SHV. Early in the eruption, some VT swarms were located under St. George’s Hill and to the northeast under Long Ground.

Long period (LP) earthquakes have a more emergent start and a lower, narrow-band frequency content (0.5 – 5Hz). These are thought to be caused by resonance in the gas or magma inside the volcanic conduit. It is normally not possible to locate LP earthquakes.

A hybrid earthquake is, as the name suggests, somewhat a mixture between a VT and an LP. They tend to have impulsive starts but also contain a significant amount of low frequency signal. They are thought to represent magma making its way to the surface at shallow depths, and are often associated with periods of rapid dome growth. They have also sometimes been precursors to major dome collapses, or switches in the direction of lava extrusion. These signals can often merge together into continuous tremor, which sometimes occurs in bands several hours apart.

Rockfall or pyroclastic flow signals have often been the dominant type of seismic signal, particularly during periods of lava extrusion. They have an emergent start and a wide frequency range and are interpreted as material falling off the dome and travelling down its flanks. Signals from pyroclastic flows are similar to rockfalls, but are generally of longer duration and higher amplitude.

Lahars or mudflows can also create seismic signals that may be confused with pyroclastic flow signals, although they are usually of lower amplitude and longer duration. These signals usually build-up gradually and are stronger at stations close to ghauts (valleys).
recorded at SHV by the MVO seismic network. Note the much longer timescale of the lahar signal.