Low-frequency events on Montserrat

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Introduction

Swarm earthquakes are composed of low-frequency events. A suggested mechanism for these events consists of a source inside the conduit that generates a P-wave and interface waves along the sides of the conduit. The interface waves are converted into weak secondary P phases and surface waves at the top and bottom of the conduit. In this mechanism only the first low-frequency event shows a clear P-wave onset. The consecutive events are formed by the weak secondary P phases and surface waves. This research investigates the applicability of conventional seismic tools on the low-frequency events of Montserrat focusing on hypocenter location analysis and particle motion analysis.

Data

This research uses the data of June 25th 1997 recorded at the seismic network on Montserrat at five broadband stations and three short-period stations. The data shows in the beginning separate low-frequency events that gradually merge into swarms preceding a dome collapse. The synthetic model (figure 1) consists of a homogeneous halfspace with receivers positioned at the surface and a magma conduit extending from 100 to 1000m in depth (Jousset et al., 2002).
The synthetic dataset produced by this model is shown in figure 2.
Figure 3 shows three consecutive events recorded on Montserrat similar to the synthetic low-frequency events.

Hypocenter location analysis

The hypocenter locations are obtained with a location program (HYPOELLIPSE) using the arrival times of the first P-wave onsets. The hypocenter locations for the Montserrat data (figure 4) are divided into two groups. One group is situated below sea-level at a depth between 500m and 1000m with relatively small error bars. The second group is located above sea-level with larger error bars. For the synthetic data only the hypocenter location for the first low-frequency event (figure 4, number 1) of the dataset is well constrained. The consecutive events (number 2 and 3) are unconstrained.

Particle motion analysis

The first P-wave onset of the events is used to get the particle motion directions. For the Montserrat data the particle motion directions point towards the dome but they do not agree in depth. The particle motion directions for the synthetic data (figure 5) only point to a reliable hypocenter location for the first low-frequency event. The second and third event do not point to any hypocenter location in particular.

Conclusions

Conventional seismological tools can be successfully applied to low-frequency events as long as these are single events with identifiable P-wave onsets. The single primary event is triggered by a point source and shows a clear P-wave. This primary event corresponds to the first synthetic event and to the events with a clear hypocenter location for the Montserrat data. Consecutive events of the same swarm consist of weak secondary P-waves and surface waves. These consecutive events correspond to the second and third of the synthetic events and to the hypocenter locations above sea-level with large uncertainties of the Montserrat data.

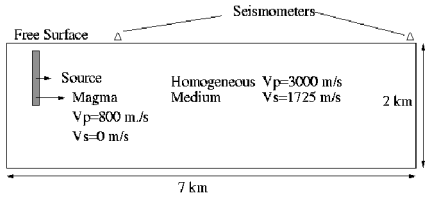

Figure 1. Synthetic model

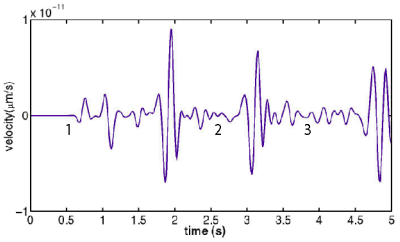

Figure 2. Synthetic seismogram. Vertical component of a receiver at a horizontal distance of 1961m from the conduit. Numbers 1, 2 and 3 correspond to the first, second and third onset of the three synthetic events.

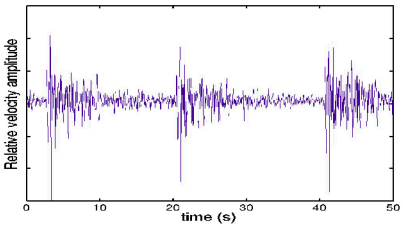

Figure 3. Seismogram of the vertical component of station MBGA on Montserrat. The distance to the dome is 1961m.

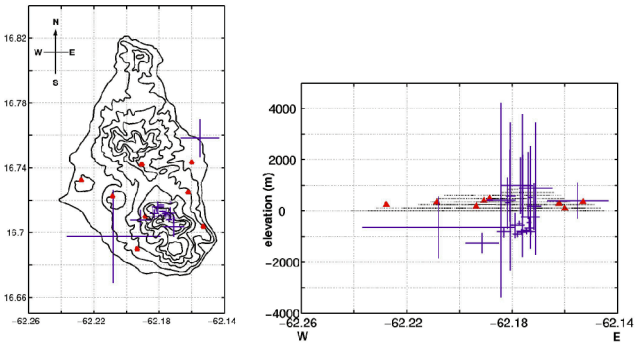

Figure 4. Epicenter and hypocenter(W-E section) locations and their error bars with respect to the island of Montserrat. The red triangles represent the seismometer stations and the blue lines show the error bars.

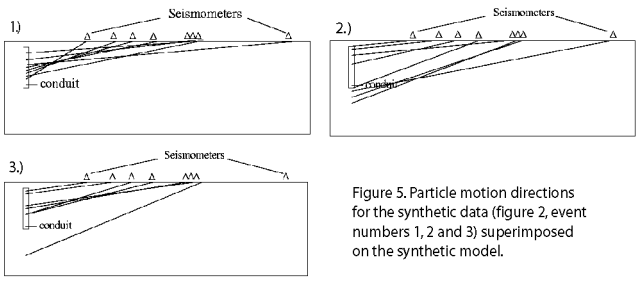

Figure 5. Particle motion directions for the synthetic data (figure 2, event numbers 1, 2 and 3) superimposed on the synthetic model.

References

Jousset, P., Neuberg J. and Sturton, S.(2002) Modelling the time-dependent frequency content of low-frequency volcanic earthquakes. *J. Volc. and Geoth. Res.*, in press.