MONTSERRAT VOLCANO OBSERVATORY

GOVERNMENT OF MONTSERRAT

Investigation of the low-frequency seismic wavefield:
Justification for a broadband network?

Glenn Thompson

MVO Open File Report 96/29

MONTSERRAT VOLCANO OBSERVATORY

GOVERNMENT OF MONTSERRAT

Investigation of the low-frequency seismic wavefield: Justification for a broadband network?

Glenn Thompson

MVO Open File Report 96/29

Montserrat Volcano Observatory
PO Box 292
Montserrat
West Indies

Tel: 1 664 491 5647
Fax: 1 664 491 2423
Email: mvo@candw.ag

* Affiliation inside cover

Affiliation of author

Glenn Thompson
Department of Earth Sciences
University of Leeds
LS2 9JT
UK

Executive Summary

In the period May – August 1996 investigations were conducted into the broadband seismic wavefield on Montserrat using two portable Guralp broadband seismometers and Reftek data loggers on loan from the University of Puerto Rico.

The idea was to detect if any frequency components of volcanic origin were present below 0.5 Hz, to increase the justification for a proposal to purchase and install a digital seismic network on Montserrat containing broadband seismometers. During May and June 1996, these investigations were performed by Richard Luckett who concluded there was some evidence of a signal of volcanic origin around 0.4 Hz.

Temporary deployments were made at various locations including Long Ground, Whites Yard, Plymouth, Cork Hill, St Georges Hill, Lees Yard and various locations in Old Towne, Olveston and Salem. The download and analysis procedure was convoluted, but in all 150 hours of data were analysed. However, no evidence of a volcanic signal below 0.5 Hz was found.

This suggests that the main advantage gained by the installation of a network of permanent broadband stations on Montserrat would be the far better dynamic range these instruments provide over short period seismometers, so long as digital telemetry is also used.

1. Introduction

Very-long period (VLP) signals with frequencies in the range of 0.01 – 1 Hz have been found on many volcanoes including Stromboli [Neuberg et al., 1994] and are interpreted as being elastic deformation caused by the movement of magma and gases related to explosive activity observed at the surface [Neuberg and Thompson, 1995; Neuberg et al., 1996]. It would be of great interest if such signals were recorded on Montserrat.

Between May and August 1996 an experiment was performed to investigate the broadband seismic wavefield emanating from the activity at the Soufriere Hills Volcano. The main aim of the broadband project was to look for significant spectral peaks of volcanic origin that cannot be detected by the short-period network. This was a kind of pilot study to investigate the potential for broadband seismology at Soufriere Hills, to seek justification for the deployment a permanent broadband seismic network on the island. Jurgen Neuberg and John Shepherd had proposed the installation of a broadband seismic network in 1995. Its important to point out the results presented here were not influential, as a decision to fund a broadband network was made during this study and before this report was completed.

2. Data collection

2.1 Equipment

The University of Puerto Rico loaned MVO two portable broadband seismic stations each consisting of a Guralp seismometers with a corner frequency 20s, a Reftek datalogger with an in built hard drive, a 12 V power supply and a Guralp breakout box for centering the sensor. For starting or stopping acquisition in the field, it is necessary to use a laptop PC with the FSC software on it, connected to the datalogger by modem, to configure the station.

2.2 Data recorded

Temporary deployments were made at various locations including Long Ground, Whites Yard, Harris, Plymouth, Cork Hill, St Georges Hill, Lees Yard and various locations in Old Towne, Olveston and Salem. The signal to noise ratio was generally poor as it was only possible to bury the seismometers to a shallow depth in loose soil. This left them very sensitive to wind induced noise, and the temporary nature of the deployment also caused temperature noise.

Infrequent access to a laptop and a jeep, along with along duties, meant that data could only be recorded two or three days a week, simulataneously at two sites. In total about 1800 hours of data were recorded (900 hours on each datalogger).

2.3 Starting acquisition in the field

1. Recorder on -- it should beep annoyingly. If it does not beep, check power.
2. Run FSC.EXE.
3. Check Status F7,0. If status window blank check modem connection.
4. Reformat Hard Disk F5,5.
5. Clear RAM F4,7.
6. Reset time F4,1 (if necessary).
7. Receive Parameters (from DAS) F4,3. Edit them (if necessary) using F3. If edited, send to DAS, F4,2.
8. Start acquisition F4,4.
9. Check status F7,0 -- should say ‘Acquisition start on’. Annoying beeping should stop too.
10. Press <ESC> and then F10 to exit from FSC.EXE.

2.4 Ending data acquisition

1. Run FSC.EXE.
2. Check status F7,0 -- should say ‘Acquisition start on’.
3. Dump RAM to Hard drive F4,5.
4. Check status F7,0 -- should say ‘Acquisition stop off’
5. Press <ESC> and then F10 to exit from FSC.EXE.
6. Swap HDDs or remove equipment from field.

2.5 Downloading data to a laptop

1. Put Artex in DOS mode: (From Windows 95 -- Start, Shut Down, Reboot in DOS mode).
2. Type ‘C:\START’.
3. Type ‘cd dat’. Should now be in C:\REFTEK\DAT.
4. Connect DAS to modem/printer port on Artex computer.
5. Power up DAS -- it should beep annoyingly.
6. Run FSC.EXE.
7. F8,2 to change to COM port 2 (press ‘+’).
8. Check status F7,0 -- should say ‘Acquisition stop off’.
9. F5,2,9.
10. Press any key to remove ‘Waiting on SCSI’.
11. F5,2,5.
12. Enter filename (such as ZJB236.dat; ZJB is station id, 236 is Julian day when data collection began).
13. If downloading is working, ‘Pkts Acked’ at bottom of screen will increase.
14. Press <ESC> and then F10 to exit from FSC.EXE.
15. Type ‘EXIT’ to get back to Windows 95.
16. Disconnect equipment and store away.

Two sampling rates have been used, 40 Hz and 2 Hz. Twenty-four hours of data recorded at 40 Hz will take 7 hours to download. Twenty-four hours of data recorded at 2 Hz will take 20 minutes to download. All data not yet downloaded is at 2 Hz.

3. Data analysis

Data analysis was performed on an Operations Room PC which had Windows 3.1 and the PITSA seismic data analysis software [Scherbaum and Johnson, 1992] installed. Data were downloaded from the laptop onto a Zip drive, and then from the Zip drive to the PC. Initially analysis was very time consuming and so DOS batch files and PITSA macros were written that sped up analysis by a factor of 10. Continuous data from each deployment were divided into 3 minute windows. Velocity and acceleration spectra were then computed, with the instrument response removed, and attempts were made to identify stable peaks in the data.

4. Results

About 1800 hours of data were recorded, but only about one-third of these were downloaded. About 150 hours of data were analyzed in total.

Low-frequency tremor is an obvious signal to investigate since spectral peaks can be interpreted as resonance phenomena that yield information about the dimensions of seismo-volcanic sources. Motivation for this kind of study increased when John Stix observed a 4 s oscillation using a Lacoste and Romberg gravimeter. From his experiments, Luckett concluded that a peak around 0.25 Hz is related to ocean microseism. He also recommended simultaneous deployments in the North and South of the volcano to discern whether a 0.4 Hz peak he identified has a volcanic origin.

While much energy existed in the frequency range 0.05-1 Hz, no evidence was found of spectral peaks strong, or stable enough, to be of interest. If low-frequency volcanic tremor occured it was masked by wind generated noise and/or ocean microseism. In particular, no evidence for a stable 0.4 Hz peak was found. My conclusions do not support those of my valued colleague Richard Luckett who in working here in May & June 1996 felt he had found evidence of a very-long period wavefield [pers. comm.], but it is possible that he found his evidence in data I did not analyze, as much remains unanalyzed. I particularly regret that I could not deploy the broadband equipment on 22 July (no vehicle was available) when Mark Davies observed a very strong 17 s oscillation with a Lacoste and Romberg gravimeter.

A secondary aim was to look for low frequency components of events (rockfalls, hybrids, VTs, LPs) but none were found. These components may have been obscured by noise; it proved quite difficult to distinguish events from the background signal. If low frequency components of events do exist, then a broadband seismic network will show them.

Though a large amount of unprocessed data remain, it is unlikely these will ever be analyzed since in August 1996, a team from BGS Seismology visited Montserrat to make plans to install a broadband seismic network. The broadband network will be a very valuable tool for investigating tremor.

5. Conclusions and recommendations

Data collected using two portable broadband stations on loan from the University of Puerto Rico were temporarily deployed at various sites around Montserrat, at differing azimuths and distances from the dome. Approximately 1800 hours of data were recorded of which 150 hours were spectrally analysed. No evidence of a stable spectral peaks indicative of a VLP seismic wavefield (frequencies much below 1 Hz) of volcanic origin were observed.

It is entirely possible that a continuous multi-station broadband seismic network will reveal VLP components of the volcano-seismic wavefield that this limited study did not find. Its also possible that there are volcanic processes which occur occasionally and other processes that will appear as the volcanic eruption evolves which have therefore been outside the time window analysed in this study. Moreover, even if a VLP wavefield is never observed, this will be an important observation. A null result is still valuable. While VLP signals have been observed on many volcanoes, it is also important to learn which volcanoes do not show them, in order to help understand the mechanism of these signals.

In any case, there are other reasons benefits to installing a new network. There will be a considerable improvement in dynamic range provided by a broadband network with 16 or 24 bit digital telemetry. This will be of enormous benefit for being able to calculate signal amplitudes and magnitudes reliably without the signal clipping. In this capacity, it will score heavily over the current analog short-period network, though the latter will probably remain an excellent tool for real-time monitoring with its helicorders and real-time seismic amplitude measurement (RSAM) tool. Another important benefit of installing the broadband network will be the failover capability provided by having two networks with separate telemetry and acquisition systems.

It is vital that with a new broadband network there is automated data transfer to an efficient data analysis system, and there are tools for monitoring changes in spectra, and for archiving the data, to support the sort of studies attempted here.

References

Neuberg, J., Luckett, R., Ripepe., M., Braun., T., Highlights from a broadband seismic array on Stromboli volcano, Geophysical Research Letters, 21, 9, 749-752, 1994.

Neuberg, J. and Thompson, G., 1995, A model of Strombolian eruptions inferred from seismic broadband data, EOS, Transactions, AGU, 76, 46, 658, 1995.

Neuberg, J., Thompson, G., Luckett, R., Models for Strombolian eruptions inferred from broadband data, Annales Geophysicae Supplement 1 to Vol 14, C281, 1996.

Scherbaum, F., and Johnson, J., PITSA, Programmable Interactive Toolbox for Seismological Analysis, IASPEI Software Library, 5, 1992.