MODELLING OF SEISMO-VOLCANIC SOURCES

by

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Submitted in accordance with the requirements for the degree of Doctor of Philosophy

The University of Leeds

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August 1999

The candidate confirms that the work is his own and that appropriate credit has been given where reference has been made to the work of others.

Abstract

In 1995 Leeds University deployed a 5 station broadband seismic array around the active vents at Stromboli volcano. Cross-checking these data with a video record revealed that eruptions at vents 1 and 3 correspond to characteristic very-long period (VLP) seismic phases (periods 2-20 s) which show that the volcano inflates rapidly immediately prior to each eruption. These VLP phases are the key to unlocking the physical processes that give rise to eruptions at each of the vents. The problem is to relate these seismic signals to the underlying physical processes since no work exists that discusses the seismic signatures of different flow-related processes. The main purpose of this thesis is to start to bridge that gap.

Two modelling methods are derived in order to estimate the pressure change needed to generate the very-long period phases recorded at vent 1. The first method works by extrapolating the displacement and stress at the conduit wall from that recorded at a seismometer, and then by assuming continuity of stress the pressure inside the conduit can be estimated. Separate models are developed for point sources and line sources. The second method is based on solving the wave equation in cylindrical coordinates and applying a set of boundary conditions at the conduit wall and is used to calculate synthetic seismograms for some simple volcanic processes. Line sources and moving sources are represented by the perturbations in pressure and shear stress they produce at the conduit wall. The main example of a moving source used is rising magma. Both of these methods incorporate near field (in addition to far field) effects, which are particularly important for these VLP signals since they are recorded at distances much less than 1 seismic wavelength from the source.

The VLP signals are consistent with a stationary (rather than moving) non-destructive source, which can be modelled as a point source at a depth of 350 m. This source is thought to represent a pressure variation of no more than 0.5 MPa in a magma chamber with a radius of at least 100 m, centred on a depth of 350 m. This corresponds to a volume change of about 600 m^3. The Bernoulli effect can be rejected as a source of these VLP phases because the largest seismic signals it could generate are several orders of magnitude too small.

Although these methods were only applied to VLP signals at Stromboli volcano they can be generally applied to isotropic, near-field seismic signals at any volcano.

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Acknowledgements

Balancing a full-time job with writing a thesis was as difficult as everyone told me it would be. However, it paid off, for my job at the Alaska Volcano Observatory (AVO) restored my motivation to complete my thesis and continue my career in volcano-seismology. I therefore wish to thank Steve McNutt for taking a gamble on me, and for his patience.

Thanks to my advisor, Jurgen Neuberg for giving me the opportunity to study volcanoes. I hope we will continue to work together, and bring volcano seismology and the underlying fluid dynamics closer together.

Without doubt the best part about studying volcanoes has been the travel. People are always asking me '*Why are you studying volcanoes when there are no volcanoes in Britain?*' which is exactly the point! In the first year I did fieldwork in New Zealand and Indonesia, and also visited Stromboli, Etna and Vesuvius. Without doubt though the best experience was working in Montserrat in the summer of 1996, which was at the time the world's most dangerous volcano. The interaction between scientists, government, media and local population was a tremendous learning experience. I was surprised to find that monitoring can be personally very rewarding, because of clearly defined goals and teamwork. I wish to thank Richard Luckett for suggesting to the British Geological Survey (BGS) that they hire me, and to Gill Norton (BGS) who made it happen.

Thanks to the Natural Environment Research Council who supported my Ph.D. studentship, fieldwork trips to New Zealand and Indonesia and a conference in The Hague. Needless to say I couldn't have done this project without their financial support.

Most of all I wish to thank those people who made life in Leeds so much fun. My best memories are hanging out with Rachel, Ruth and Susan at Hessle View, watching B5, Friends and the X-files, weekend lunches at McCoys, and salsa dancing at every opportunity.

I also wish to thank my best friend Andy, who has been a constant inspiration, and who will one day, I'm sure, discover the Higgs boson in a box of Weetabix.

Finally I wish to thank Mum, Dad and Jared, who will be as relieved as I am that this thesis is finished at last!