Chapter 13: Volcano Seismology (Joachim Wassermann, Jürgen Neuberg)

(Note: New contributions/topics are marked in red)

13.1 Introduction

13.1.1 Why a different chapter

13.1.2 Why using seismology when forecasting volcanic eruptions

13.2 Classification and source models of volcano-seismic signals

13.2.1 Transient volcano-seismic signals

13.2.1.1 Volcanic-Tectonic events (deep and shallow)

13.2.1.2 Low-Frequency events

13.2.1.3 Swarms of seismic events

13.2.1.4 Explosion quakes, ultra-low-frequency events

13.2.2 Continuous volcanic-seismic signals

13.2.2.1 Volcanic tremor (low-viscous two-phase flow and eruption tremor)

13.2.2.2 Volcanic tremor (high-viscous)

13.2.2.3 Surface events

13.2.3 Special note on noise

13.3 Design of a monitoring network

13.3.1 Station site selection

13.3.2 Station distribution

13.3.3 Seismic arrays in volcano monitoring

13.3.4 Network of seismic arrays

13.3.5 Communication Lines

13.4 Analysis and methodology

13.4.1 One-component single station

13.4.1.1 Spectral analysis

13.4.1.2 Envelope, RSAM and cumulative amplitude measurements

13.4.1.3 Material Failure Forecast Method (FFM)

13.4.2 Three-component single station

13.4.2.1 Polarization

13.4.2.2 Polarization filters

13.4.3 Network

13.4.3.1 Hypocenter determination by travel-time differences

13.4.3.2 Cross correlation of diffusive wavefield

- (Campillo)

13.4.3.3 Moment Tensor Inversion (Method)

13.4.4 Seismic arrays

13.4.4.1 f-k beamforming

13.4.4.2 Array polarization

13.4.4.3 Array analysis of non-planar wavefronts

13.4.4.3 Hypocenter determination using seismic arrays

13.4.5 Automatic analysis

- List of possible software packages with applications for volcano seismology

Annex 1
13.4.5.1 Automatic Classification/Detection
- Self Organized Maps, Neuronal Networks, Hidden Markov Models, Template Based Pattern recognition
13.4.5.2 Automatic Source Location
- pick based, waveform or coherency based, amplitude-distance modules etc.
13.4.5.3 Automatic Standard Tools
- SSAM, RSAM etc.

13.5 Interpretations and Source Models
13.5.1 Volcano seismicity and magma flow models
13.5.2 Volcano-Tectonic events and the associated stress field
- regional stress field
- magma induced stress
13.5.2. Low frequency events and swarms
- resonance models: dykes, conduits and cracks
- trigger: stick slip, magma rupture
13.5.3 Constraints through seismic moment tensor inversions
13.5.4 Volcano seismicity as a forecasting tool

13.5 Other monitoring techniques..................................................................................36
13.5.1 Infra Sound
(New important field for validation of surface activity and estimation of eruption strength; closely related to seismology)
13.5.2 Ground deformation.............................................................................................36
(tilt, strainmeter measurements, GPS, InSAR, ground base InSAR (see 13.5.5))
13.5.3 Micro-Gravimetry...............................................................................................37
13.5.4 Geochemical gas-monitoring.................................................................................38
(CoSPEC, DOAS, FTIR - ground based and remote)
13.5.5 Thermal and video surveillance
13.5.6 Laboratory studies
List of possible parameter estimated out of these studies
13.5.5 Meteorological parameters ..................................................................................39

13.6 Technical Considerations.......................................................................................39
13.6.1 Site and Vault .......................................................................................................39
13.6.2 Sensors and digitizers ..........................................................................................41
13.6.3 Analog versus digital telemetry ..........................................................................41
13.6.4 Power considerations ...........................................................................................42
13.6.5 Data center ..........................................................................................................43

13.7 References..............................................................................................................43