

Perugia, Italy July 2-13, 2007



IAVCEI

**INTERNATIONAL ASSOCIATION OF VOLCANOLOGY
AND CHEMISTRY OF THE EARTH'S INTERIOR
INTER-ASSOCIATION SYMPOSIA AND WORKSHOPS**

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Compiled by Lucio Ubertini, Piergiorgio Manciola, Stefano Casadei, Salvatore Grimaldi

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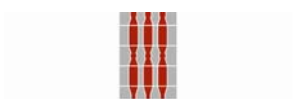
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Abbreviations

IAG	International Association of Geodesy
IAGA	International Association of Geomagnetism and Aeronomy
IAHS	International Association of Hydrological Sciences
IAMAS	International Association of Meteorology and Atmospheric Sciences
IAPSO	International Association for the Physical Sciences of the Oceans
IASPEI	International Association of Seismology and Physics of the Earth's Interior
IAVCEI	International Association of Volcanology and Chemistry of the Earth's Interior
CLiC	Climate and Cryosphere
Ev-K2-CNR	Everest-K2 CNR Committee
GEWEX	Global Energy and Water Experiment
HKH-FRIEND	Hindu Kush-Himalayan Flow Regimes from International Experimental and Network Data
IABO	International Association for Biological Oceanography
IACS	International Association of Cryospheric Sciences
ICACGP	International Commission on Atmospheric Chemistry and Global Pollution
ICASVR	International Commission on Atmosphere-Soil-Vegetation Relations
ICCE	International Commission on Continental Erosion
ICCL	International Commission on Climate
ICCLAS	International Commission on the Coupled Land-Atmosphere System
ICCP	International Commission on Clouds and Precipitation
ICDM	International Commission on Dynamic Meteorology
ICGW	International Commission on Groundwater
ICIMOD	International Center for Integrated Mountain Development
ICMA	International Commission on the Middle Atmosphere
ICRS	International Celestial Reference System
ICSIH	International Commission on Snow and Ice Hydrology
ICSW	International Commission on Surface Water
ICT	International Commission on Trac
ICWQ	International Commission on Water Quality
ICWRS	International Commission on Water Resources Systems
IGAC	International Global Atmospheric Chemistry
IGS	International Glaciological Society
ILP	International Lithosphere Program
INQUA	International Union for Quaternary Research
ION	International Ocean Network

IRC	International Radiation Commission
PUB	Prediction in Ungauged Basins
SCAR	Scientific Committee on Antarctic Research
SEDI	Study of the Earth's Deep Interior
SPARC	Stratospheric Processes and their Role in Climate
UCCS	Union Commission for the Cryospheric Sciences
UNESCO	United Nation Educational, Scientific and Cultural Organization
UNITAR	United Nations Institute for Training and Research
WMO	World Meteorological Organization

Session code naming

The first letter of the session codes indicates whether the session is a Union, a Joint Interassociation or a single Association sponsored event, the second letter indicates the type of event: Symposium (S) or Workshop (W). For Joint events, the second letter indicates the Lead Association (with the abbreviations listed below) and the third indicates whether a session is a Symposium (S) or a Workshop (W). In some cases (namely IAGA, IAHS) Association session codes have an extra codification referring to a specific Theme or Division.

U	UNION
J	JOINT
G	IAG
A	IAGA
H	IAHS
M	IAMAS
P	IAPSO
S	IASPEI
V	IAVCEI

Some examples:

US002

is a **Union Symposium**; **JGW001** is a **Joint IAG Workshop** with IAG as the Lead Association;

MS003

is an Association (IAMAS) **Symposium**. **AS III 020** is an Association (IAGA) **Symposium** sponsored by its **III** Division.

JVS001

Symposium

(2400 - 2414)

Convener : Prof. Stephen Self

Co-Convener : Dr. Roberto Isaia, Prof. Hans-F. Graf

Large-volume eruptions, including environmental effects

JVS003

Symposium

(2415 - 2431)

Convener : Dr. Ben Brock

Co-Convener : Dr. Andres Rivera

Ice Volcano Interactions

JVS004

Symposium

(2432 - 2477)

Convener : Prof. Jurgen Neuberg, Dr. Maurizio Ripepe

Volcano seismology

JVS005

Symposium

(2478 - 2480)

Convener : Dr. Dmitri Rouwet

The 25 Anniversary of the El Chichn Eruption



(V) - IAVCEI - *International Association of Volcanology and Chemistry***JVS001****2400 - 2414****Symposium****Large-volume eruptions, including environmental effects****Convener** : Prof. Stephen Self**Co-Convener** : Dr. Roberto Isaia, Prof. Hans-F. Graf

There has recently been a publicity focus on large-volume eruptions in Earth's history, particularly explosive "Supervolcanoes". We invite contributions that deal with -Factors that contribute to the accumulation of magma within arc and intraplate settings to form large magma chambers. (tectonics) - volcanology of large volume eruptions (effusive and explosive) -evolution and magma chamber dynamics -scaling problem of known small eruptions to super eruptions -climatic and environmental impacts -potential sites and eruption prediction

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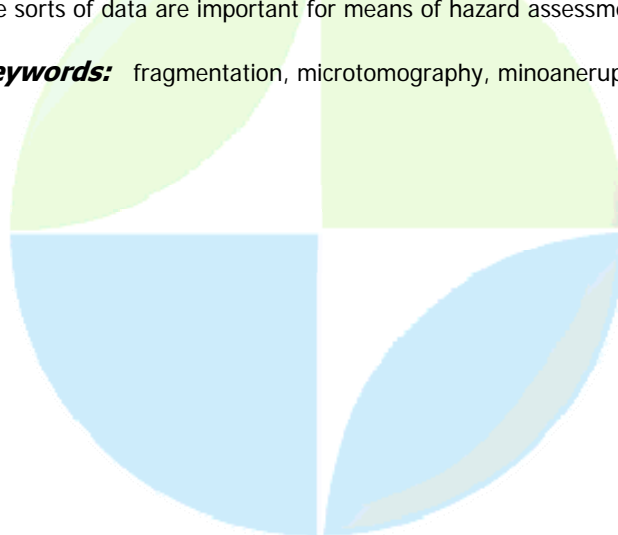
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I T A L Y



(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS001****Oral Presentation****2400****New insights into magma fragmentation during silicic explosive eruptions from X-ray computed microtomography****Mrs. Karen Fontijn***Geology and Soil Science Ghent University, Belgium IAVCEI****Bert Masschaele, Patric Jacobs, Luc Van Hoorebeke, Gerald Ernst***

Magma fragmentation during explosive eruptions remains incompletely understood. In our study, X-ray computed microtomography (CT) was used to analyze textures of pumices from the 3.6 ka rhyodacitic Minoan Santorini eruption (Greece). CT offers the opportunity to study the 3D structure of pumices in a non-destructive manner. Textural characteristics of pumices record their physical state during magma fragmentation, and thus can help constrain fragmentation models. Based on qualitative observations of the CT images, a conceptual magma fragmentation model for the Minoan eruption was developed. Study with CT reveals that outer surfaces (which possess an incomplete chill margin) of pumices are knobbly, indicating ductile fragmentation. The heterogeneous distribution of vesicle sizes and shapes in pumices, and the co-existence of regular pumice and tube pumice, suggest that gas concentration in the fragmenting foam is highly heterogeneous. In addition, CT images suggest that phenocrysts and microlites control vesicle shape (spherical vs. stretched) and density. Relatively large phenocrysts tend to be surrounded by large clusters of spherical vesicles, whereas microlites are also seen distributed randomly in between stretched vesicles. We propose a two-step fragmentation model with ductile fragmentation as the main mechanism to form pumices during silicic explosive eruptions, followed by brittle fragmentation to produce ash. The development of an incomplete chill margin on the knobbly outer surface of pumices is consistent with enhanced permeability development (possibly influenced by heterogeneous phenocryst/microlite contents) during ductile fragmentation. Enhanced permeability induces gas loss and rheological change bringing the locally more degassed melt at the pumice margins to the glass transition immediately after fragmentation. Thus whereas pumice production occurs in the ductile regime, any further fragmentation to produce the volumetrically dominant ash occurs in the brittle regime. If confirmed by further research, this model could be valuable in the understanding of the dynamics of silicic explosive eruptions, both moderate-size (e.g. the Minoan eruption) and large-size. Knowledge that is gained by studying the characteristics of deposits of well-known moderate-volume silicic eruptions can probably be applied to large-volume eruptions with similar characteristics (e.g. magma composition, crystal content, etc.), to understand their behaviour. Thorough models of magma fragmentation can provide necessary data regarding grain size distributions and the dispersal of pumice and ash. These sorts of data are important for means of hazard assessment.

Keywords: fragmentation, microtomography, minoan eruption

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS001****Oral Presentation****2401****The variation with latitude of ash clouds from large magnitude explosive eruptions****Prof. Peter Baines***Dept of Earth Sciences Bristol University IAMAS***Morgan T. Jones, Stephen J. Sparks**

Very large magnitude explosive volcanic eruptions can produce giant ash clouds hundreds to thousands of kilometres in diameter. The ash cloud form is controlled by gravity and rotational forces, leading to a more radially symmetric shape than clouds produced by smaller eruptions. Here we focus on the dynamics of giant ash clouds and the imbalances caused by latitudinal variations in the Coriolis force. Such imbalances lead to an equatorward distortion of the cloud, which may cause it to cross the equator if it becomes large enough. We develop a model incorporating source latitude, eruption type, magnitude and intensity and show that at sufficiently large distances from the equator, the cloud has the approximate shape of an ellipsoid of revolution. Closer to the equator, the structure of the cloud is determined by the parameter $Y_s = y_s(b/Nd_0)^{1/2}$, where y_s is the distance of the source from the equator, b is the north-south gradient of the Coriolis frequency, N is the buoyancy frequency of the stratosphere and d_0 is the cloud thickness. If $Y_s > 1.4$ the cloud shape is maintained but deformed toward the equator and the cloud moves to the west, but if $Y_s < 1.4$, this solution breaks down, and interhemispheric transport is possible. We apply this model to past large magnitude eruptions to assess whether mid- to high-latitude eruptions could affect both hemispheres. The results suggest that the fate of clouds formed from plinian phases with $M < 6.5$ depend strongly on eruption intensity, while for $M > 6.5$ clouds can achieve interhemispheric transport at most latitudes and intensities. A similar relationship exists for clouds from a co-ignimbrite source, with intensity controlling the cloud form for $M < 7.5$. Our model predicts that any co-ignimbrite cloud from a super-eruption ($M > 8$) can cross the equator at most latitudes and realistic intensities.

Keywords: ash clouds, volcanic eruptions

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS001****Oral Presentation****2402****Three-dimensional textural analysis of juvenile pyroclasts from the Kos plateau Tuff, South Aegean Arc, Greece****Mr. Wim Degruyter***Department of Mineralogy University of Geneva IAVCEI****Olivier Bachmann, Alain Burgisser, Veerle Cnudde, Bert Masschaele***

X-ray computed microtomography (CT) has become a widely-applied technique to obtain density maps of heterogeneous media; it allows gathering non-destructively qualitative observations as well as quantitative information on the 3D geometries of multi-phase samples. However, the limited resolution (volume-dependent) of the CT-scan should always be taken into consideration when interpreting the results. The aim of our study is to apply CT to vesicular volcanic rocks (pumices) from the largest explosive eruption of the active South Aegean Arc (the Kos Plateau Tuff; KPT) in order to quantitatively measure differences in bubble size distributions, bubble shapes, and the tortuosity of paths through connected bubbles. We selected for analysis pumices found in the same deposits (produced synchronously) to better understand bubble formation and deformation in a viscous magmatic foam. The rhyolitic KPT pumices are particularly prone to such an examination because (1) the high viscosity allows preserving information on the state of the magma in the conduit immediately prior to fragmentation (i.e., disruption of magma into pyroclastic fragments) and (2) they display variable macroscopic textures. Using existing software for analysis of the CT volumes, we observe a wide variety of textures at the microscopic level (from spherical, nearly undeformed bubbles to stretched, anisotropic bubbles forming tube pumice). Although results depend on the scanned volume, relative differences between pumices with different macroscopic textures are noticeable. Measurements of tortuosity values suggest a more convoluted path through the spherical bubble networks than the tubular bubble networks, which is consistent with the higher permeability of tube pumice (measured by gas permeametry). Current work involves numerical simulations of gas flow through the CT images to better tie macro- and microscopic textures.

Keywords: pumice, tomography

(V) - IAVCEI - *International Association of Volcanology and Chemistry***JVS001****Oral Presentation****2403****The role of fine ash in explosive eruptions****Prof. Pierfrancesco Dellino**
Geomineralogico Universit di Bari IAVCEI

h is one key ingredient of explosive volcanism. As demonstrated by experiments, stress-induced brittle magma fragmentation is the most likely cause of energetic eruptions. The mechanical energy release is proportional to the total surface area of the generated fine ash. The mechanical energy coupled to the mass of erupted material is decisive for determining the eruptive scenario in terms of a collapsing column (pyroclastic flow), plume (fallout) or transitional column (contemporaneous fallout + pyroclastic flow). Large-scale experiments demonstrate the significance of gas turbulence coupling of fine ash in increasing the transportation capabilities of the gas-particle mixture. Experimental and theoretical modelling allow to assess the increase of atmospheric residence time of fine ash. This is caused by the complex/irregular shape of particles, which increases the drag coefficient by several factors. This result reconciles with the evidence that distal fine ash deposits of large eruptions have size of tens of micrometers. By these new results, now we have scaling parameters that can be used to acknowledge the scale and intensity of explosive eruptions based on the particles characteristics of natural pyroclastic d

Keywords: fine ash, pyroclastic deposits, explosive eruptions

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(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS001****Oral Presentation****2404****2D Lattice Boltzmann conduction/advection model with phase-change: A new tool to assess melting/crystallization dynamics in magma chamber****Mr. Andrea Parmigiani***Department of Mineralogy University of Geneva IAVCEI***Christian Huber, Olivier Bachmann, Bastien Chopard, Jonas Latt**

As the crystallinity of erupted volcanic deposits never exceeds ~50 vol. %, a fundamental parameter for the prediction of volcanic risks is the evolution of the crystal fraction in a given magma reservoir. In magma chambers, crystallinity varies in a non-linear way as a function of (1) exchange of heat with its surrounding (both addition of heat by magma recharge and loss through wall rocks), (2) convection-advection dynamics (silicate melt and gas flow in the chamber) and (3) phase changes (melting/crystallization/exsolution/dissolution). In order to shed some light on these coupled physical processes, we have developed a new numerical tool, using the Lattice Boltzmann method, that can simulate 2D thermal magma flow in a natural porous medium subjected to possible phase transition (melting/crystallization). Preliminary results compare the rate of melting of a magmatic mush (≥50% vol. of crystals) in a conductive regime versus that in a conductive-convective situation. We also study the onset of self-mixing as a rheologically-locked mush remelts and becomes able to sustain bulk stirring by convective currents.

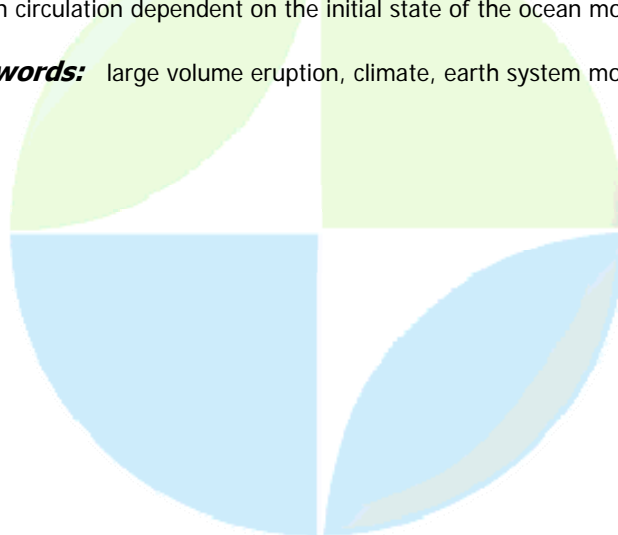
Keywords: magma chamber, lattice boltzmann method

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(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS001****Oral Presentation****2405****Climate response to a very large volcanic eruption: an Earth system model approach****Dr. Claudia Timmreck***Atmosphere in the Earth System Max Planck Institute for Meteorology IAVCEI***Monika Esch, Marco Giorgetta, Hans-F. Graf, Helmuth Haak, Johann Jungclaus,
Erich Roeckner, Reiner Schnur, Man Anna Thomas**

Very large volcanic eruptions constitute an extremely strong forcing to the Earth system that can have impacts for longer times than the pure residence time of the volcanic aerosol in the atmosphere. Depending on the location of the volcano these effects can be global or hemispheric. In the case of a very large eruption, volcanic sulphate aerosol can persist in the stratosphere for several years up to a decade, scattering incoming radiation back to space and absorbing outgoing longwave radiation. This will lead to large negative temperature anomalies at the surface and significant warming of the aerosol containing layers altering substantial atmospheric and ocean circulation and composition. Simulations of past historic eruptions show that the ocean heat content is reduced after large volcanic eruptions, and that these anomalies can persist for decades. Significantly cooler surface temperatures, as expected for a few years after a super eruption, might alter dramatically the terrestrial and marine biosphere, necessarily impact vegetation, especially tropical rain forests, and have at least a transient effect on the carbon and other biogeochemical cycles. In addition, large tephra deposits at the ground over huge areas will effect vegetation, surface albedo and snow cover for decades as well. Analyzing and understanding the climate effects of a super eruption is a quite difficult task due to the various complex interactions between chemical, microphysical, dynamical and biological processes affecting the whole suite of processes (ocean, atmosphere, chemistry, land surface, vegetation, cryosphere, carbon cycle etc.). Hence, the simulation of a super eruption requires the full complexity of an Earth system model. However, in order to understand the various feedback mechanisms it is important to investigate them step by step in specific model simulations. In particular, because many parameters of a very large eruption are highly uncertain, like eruption height, duration of an eruption, release of volatile gases (SO₂, H₂O, CO₂), atmospheric life time of the sulphate aerosols etc., there is a need to undertake sensitivity studies including the end members of the estimated parameters. Here we give an overview about ongoing activities at the MPI for Meteorology to study the climate impact of very large volcanic eruptions with a fully coupled Earth system model. We also present simulations of a very large volcanic eruption with a state of the art Atmosphere-Ocean GCM ECHAM5/MPIOM, analyzing changes in atmospheric and ocean circulation dependent on the initial state of the ocean model.

Keywords: large volume eruption, climate, earth system modelling

(V) - IAVCEI - *International Association of Volcanology and Chemistry***JVS001****Oral Presentation****2406****Mechanism of Climate Warming after Supervolcano Eruptions*****Dr. Georgiy Stenchikov****Environmental Sciences Rutgers University IAVCEI****Luke Oman, Alan Robock***

It has long been debated whether supervolcano eruptions could cause global cooling, ice ages, and mass extinctions. Here we find that, counter-intuitively, very large volcanic eruptions might cause climate warming. Supervolcano eruptions like the Toba eruption 74,000 years ago have injected into the atmosphere hundreds of times more SO₂ than the largest volcanic eruptions of the 20th century. The huge SO₂ mass from a Toba-size eruption could potentially produce a sulfate aerosol layer with optical depth of more than 40. However, the gas-to-particle conversion process might be effectively slowed down because SO₂ and an initially formed relatively thin aerosol layer will absorb and reflect UV radiation, reducing actinic fluxes and OH production to almost zero within and below the SO₂ layer. Therefore SO₂ would not be quickly converted to sulfate aerosols, but would stay in the stratosphere for years. Because SO₂, like ozone, is a strong greenhouse gas it would cause significant IR warming for an extended period until it will be converted to sulfate aerosols or removed. We have simulated Toba eruption using the NASA GISS ModelE, and find that coupled climate model results and available proxy data support this hypothesis.

Keywords: supervolcano, climate, modele

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(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS001****Oral Presentation****2407****Modeling Co-ignimbrite Plumes: or why a one dimensional plume model is not enough****Dr. Michael Herzog**

IAMAS

Hans-F. Graf

Big explosive volcanic eruptions of the caldera forming type are very probably characterized by the formation of secondary eruption columns, the co-ignimbrite plumes. Explosive volcanic eruptions form buoyant plumes after sufficient entrainment has taken place. If a (buoyant) Plinian eruption plume cannot be formed, the eruption column will collapse. A secondary, so called co-ignimbrite plume can be formed from the developing pyroclastic flow. In previous work the behavior of such co-ignimbrite eruptions has been studied by one-dimensional plume models based on the assumption that they can be regarded point sources. Here we use the plume model ATHAM in a two and three dimensional setup to investigate the impact of this assumption on the plume development. Clearly, Neutral Buoyancy Heights are overestimated when stationary top hat models are applied. Height and shape of the co-ignimbrite plume change significantly if a cylindrical geometry is imposed on the plume. Entrainment and wind shear have strong influence on the plume development. Co-ignimbrite plumes can be realistically represented only in a fully three dimensional model.

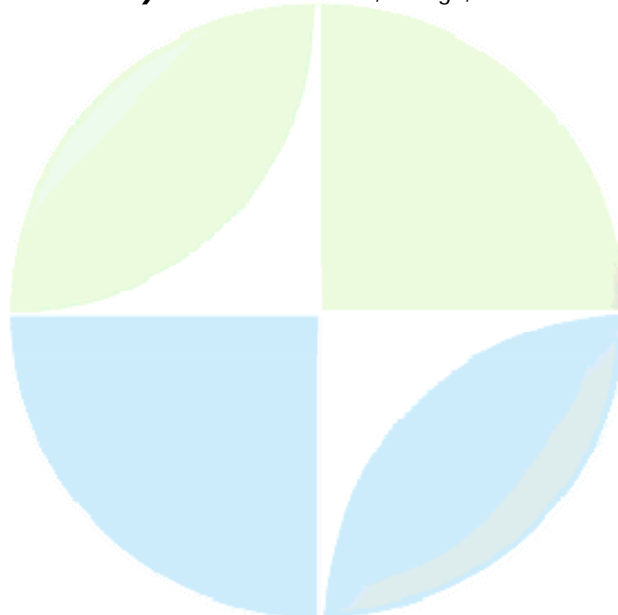
Keywords: co ignimbrite, simulation, volcano

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I T A L Y



(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS001****Oral Presentation****2408****Can volcanic eruptions produce ice ages or mass extinctions?****Mr. Alan Robock***Department of Environmental Sciences Rutgers University IAVCEI***Caspar Ammann, Luke Oman, Drew Shindell, Georgiy Stenchikov**

Volcanic eruptions are well known to be important causes of interannual and even interdecadal climate change. But can very large eruptions initiate ice ages, as has been suggested for the Toba eruption ~74,000 years ago? Could flood basalt eruptions, such as the Deccan Traps 65,000,000 years ago or the Siberian Traps 250,000,000 years ago, have produced climate change large enough and long-lasting enough, along with other atmospheric pollution, to have caused mass extinctions? Here we conduct climate model simulations of the effects of a volcanic eruption 100 times larger than the 1991 Pinatubo eruption as a test of the climatic effects of Toba. We use three different state-of-the-art climate models, CCSM 3.0 from the National Center for Atmospheric Research, which incorporated dynamic vegetation, and two versions of ModelE from the NASA Goddard Institute for Space Studies, to investigate the dependence of the results on the climate model used. We find that although the Toba eruption produces very large global cooling for a couple years, of up to 10C, the volcanic aerosols leave the atmosphere quickly and the climate largely recovers in 1-2 decades. We investigated the mechanism of vegetation response to the cold and dark, but this mechanism was not strong enough to prolong the response enough to allow ice sheets to grow. The ModelE version with explicit atmospheric chemistry does not produce a very different result. The stratospheric aerosol cloud lifetime is a little longer, but not enough to affect the conclusions. We find that the tropical tropopause is warmed and a large amount of water vapor is injected into the stratosphere, in contrast to previous suggestions of stratospheric dehydration. In contrast to the Toba results, continuous emissions from massive flood basalt eruptions lasting several decades could make it so cold and dark at the Earth's surface that many species would find it hard to survive. On longer time scales, however, continued large greenhouse gas emissions would have a significant warming effect. With good estimates of the amount and timing of gas and particle emissions into the atmosphere, we have the climate modeling tools to calculate their impact on climate.

Keywords: extinction, ice age, toba

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JVS001

Oral Presentation

2409

Environmental/cultural modifications at 40 ka BP in western Eurasia in the light of the potential impact of the Campanian Ignimbrite eruption (southern Italy)

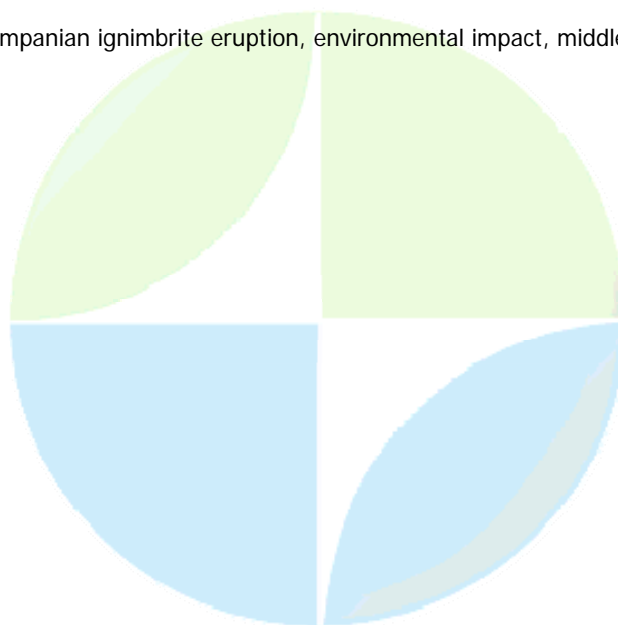
Prof. Francesco Fedele

Chair and Laboratory of Anthropology University of Naples Federico II

Biagio Giaccio, Roberto Isaia

Significant new information shows that the Campanian Ignimbrite (CI) eruption from the Phlegraean Fields, southern Italy, was much larger than hitherto supposed and in fact one of the largest Late Quaternary explosive events. The eruption can be dated to 40,000 calendar years ago, i.e. within the interval of the so-called Middle to Upper Palaeolithic transition. Its position can be precisely correlated with a number of other environmental events, including Heinrich Event 4 (HE4), the Laschamp Excursion, and a particular cosmogenic nuclide peak. In view of this unique combination of factors, the CI volcanic catastrophe was studied with particular attention for its impact on climate and human ecosystems, including potential interference with ongoing processes of cultural evolution (biological evolution is best left aside for the moment). We suggest that the contribution of this research is chronological and ecological. Concerning chronology, as resulting from tephrostratigraphy, the CI volcanic event provides unequalled means to correlate stratigraphic sequences across western Eurasia, either directly or indirectly, and affords a unique opportunity to establish age and climatic context of important archaeological sequences. Concerning ecology, the CI eruption inevitably interacted with the beginning of HE4 in terms of atmospheric feedback systems. Their combined forcing produced a sudden and at least hemispheric climatic deterioration; a volcanic winter scenario cannot be ruled out. Palaeolithic occupation was severely altered throughout the direct-impact zone of the eruption and likely along fringe areas in southern and southeastern Europe. The above observations call for a reconsideration of the processes and rhythms involved in the Middle to Upper Palaeolithic transition. A tentative model is suggested which links the exceptional environmental stress at 40,000 BP with processes already active in Palaeolithic societies, leading to a period of accelerated change in cultural configurations. That eventually evolved into an Upper Palaeolithic proper at a later date. The evidence to invoke allochthonous cultural input or invasionist scenarios is not considered compelling.

Keywords: campanian ignimbrite eruption, environmental impact, middle upper palaeolithic



(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS001****Oral Presentation****2410****Radiative forcing of fine ash and volcanic sulphate aerosol after a very large Northern hemisphere mid-latitude eruption****Dr. Ulrike Niemeier***Atmosphere in the Earth System Max Planck Institute for Meteorology***Claudia Timmreck, Sebastian Rast, Marco Giorgetta, Hans-F Graf, Sephen Self**

Super eruptions exert an extreme forcing on the Earth System. The life time of the emitted volcanic aerosol can probably be some years in the stratosphere, causing strong radiative effects with consequences for atmospheric processes. An interactive simulation of a super eruption in a global climate model requires a wide range of necessary processes in the model. Realistic volcanic emissions of fine ash and SO₂ should be considered, as well as the atmospheric life cycle including removal processes and the caused radiative forcing. We have interactively simulated atmospheric processes following a very large volcanic eruption. The simulations are carried out for a possible Northern Hemisphere mid-latitude super eruption located at Yellowstone National Park because it seems to be one of the most likely possible sites for such an event at higher latitudes. The simulations are performed with the middle atmosphere general circulation model MAECHAM5 including the global aerosol module HAM. HAM calculates the aerosol microphysics of sulfate and other species and their source and sink processes. In addition a fine volcanic ash module for MAECHAM5 has been developed, which contains the emission of volcanic ash, transport, sedimentation and deposition of the ash and its impact on radiative processes. The ash size distribution is described with one log-normal distribution. The model setup has been validated for the Pinatubo eruption, showing good agreement with satellite data. The discussion includes the formation and temporal development of the volcanic fine ash and sulphate aerosol, the radiative forcing and changes in atmospheric transport and circulation. A special focus is placed on the climate effect of fine ash in the first months after an eruption. An important effect which has not been paid much attention to before.

Keywords: supervolcano, simulation, climate

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS001****Oral Presentation****2411****Volcanic contributions to global atmospheric composition****Dr. Genevieve Millard***Earth Sciences University of Cambridge IAVCEI***Dr David M. Pyle, Dr Tamsin A. Mather**

New mechanisms have recently been diagnosed by which volcanic gas emissions can influence atmospheric composition. Chemical transport modelling has diagnosed unprecedented ozone destruction rates within Heklas volcanic plume, Iceland 2000, resulting from the activation of volcanic chlorine and bromine on the surface of volcanically induced polar stratospheric cloud particles (PSCs) within the stratosphere [Millard et al., 2006; Rose et al., 2006]. Previous studies have suggested that the volcanic flux of SO₂ dominates sulphate contributions in the upper troposphere/lower stratosphere compared to anthropogenic emissions. This is due to the increased lifetimes of volcanic gases due to their release from many elevated and remote settings. These features will also have an important role in the emission of other chemically active volcanic gases, enabling more efficient transport to the lower stratosphere and increasing the potential for ozone depletion. We present work on an updated and refined global volcanic SO₂ emissions inventory which is both temporally and spatially resolved for the period 1998-2005. We also present work on how a large volcanic eruption can perturb stratospheric ozone, potentially reducing surface UV-B shielding.

Keywords: volcano, emissions, ozone

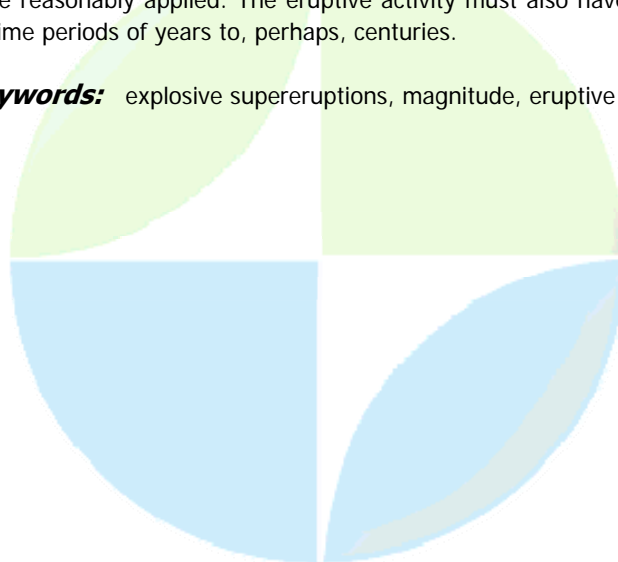
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(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS001****Oral Presentation****2412****Super-eruptions: present understanding of size, style, and gas release****Prof. Stephen Self***Earth Sciences The Open University IAVCEI*

If the term super-eruption is to be adopted, then it needs to be defined. Currently it has been applied to large-scale, caldera and ignimbrite-forming explosive eruptions that have occurred occasionally in the geological past. The present suggestion is that it is reserved for eruptions that released $> 1 \times 10^{15}$ kg of magma (roughly in excess of 500 cubic km of magma). An implication is that these eruptions also had a very high intensity (magma flux, $\sim > 1 \times 10^{10}$ kg/s) and thus fed widespread and/or voluminous pyroclastic flows and high eruptions columns, leading to the deposition of continent (or ocean basin)-wide co-ignimbrite ash fall deposits. A recent compilation of known very large eruptions suggests that such events have a poorly-defined average repeat period of ~ 0.1 to 1 million years. They are of magnitude (M) 8 on a scale where the largest known eruptions are M 9 ($> 1 \times 10^{16}$ kg). Such eruptions are truly rare and exceptional in size. They may also reach extremely high intensities at certain times during the eruptive event, yet some smaller eruptions occasionally appear to reach this intensity level (e.g., Taupo ignimbrite). All such eruptions produce ignimbrite and extensive ash-fall deposits, and form a caldera. We have, however, only an approximate idea of the true size of erupted magma batches in explosive super-eruptions due to complexities such as preservation of widespread and often ancient outflow ignimbrite deposits (O), the amount of inter-caldera deposits (I), deposition at sea, and the difficulty of recognizing co-ignimbrite ash fall deposits (A). The magnitude of large eruptions if $O=I=A$ is a general rule, as suggested by Mason et al. (2004), may be even greater than previously proposed. Moreover, the eruption of a 1×10^{15} kg magma-batch could release immense masses of gas such as SO_2 . For a range of sulfur-poor to sulfur-rich magmas, between 400 and 2000 Tg of SO_2 would be emitted to the atmosphere over a period from one day to, possibly, several weeks, compared to 17 Tg in a few hours for the 1991 Mount Pinatubo eruption. If eruptions are classed as super on the grounds of size alone, then another type of exceptional eruption from the geologic past also falls into this category. These are flood basalt lavas and we again have a poor idea of the true volume of individual eruptions. Reasonably well-established magnitudes up to $\sim 7 \times 10^{15}$ kg (M 8.8; 2500 cubic km of basalt magma) are known and there may have been many cases of eruptions $> M9$ during the formation of flood basalt provinces; some provinces also include prodigious volumes in individual silicic lava flows. One again, these eruptions are so unusual in size compared with the normal scales of volcanism that the term super may be reasonably applied. The eruptive activity must also have emitted vast amounts of SO_2 gas, but over time periods of years to, perhaps, centuries.

Keywords: explosive supereruptions, magnitude, eruptive style



(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS001****Oral Presentation****2413****Estimating the SO₂ degassing history of the Deccan Traps****Dr. Mike Widdowson***Dept. of Earth Sciences The Open University IAVCEI***Stephen Self**

Continental flood basalt (CFB) volcanism is characterised by the repeated effusion of huge batches of basaltic magma (~ 10²- >10³ km³ per eruption) over short periods of geologic time (<1 -5 Ma). CFB provinces, such as the Deccan, are constructed of thick stacks (0.5-3 km) of extensive pahoehoe-dominated lava fields generated during eruptive events that each lasted of the order of a decade or more (Self et al., 1997; Jerram and Widdowson, 2005). In turn, each CFB province contains hundreds of these huge eruptions, indicating that the process was cumulative both in terms of the development of the lava stack and, possibly, in terms of its effect upon the wider environment. Accordingly, CFB episodes are commonly cited as triggers for global biotic crisis and extinction (e.g. White and Saunders, 2005), and the most environmentally damaging aspects of these eruptions are likely to be derived from the accompanying magmatic degassing (Self et al. 2005). Atmospheric cooling associated with SO₂ emissions from just one CFB eruptive event (c.10⁴ Tg) are estimated to have been severe, and would have persisted for a decade or longer, whilst the repetition of such eruptive events can generate major climate change (Jolley and Widdowson, 2005). Degassing estimates exist for individual CFB eruptive events, or groups of events (Thordarson et al. 1996; Self et al. 2006), but the longer-term degassing histories of CFB provinces remains largely unknown. The current work combines high resolution ⁴⁰Ar/³⁹Ar dating, estimates of eruptive volumes of key stratigraphical units, together with geochemical proxies for SO₂ release, to provide a time-integrated degassing history for the Deccan Traps eruptions. Total gas release quantities, and a time-averaged SO₂ flux can thus be estimated, but the greater challenge lies in understanding the episodic nature of the gas release, the period of repose between eruptions, and how these might then affect climate and environment on biological rather than geological timescales.

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Keywords: deccan, degassing, climate



(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS001****Oral Presentation****2414****Solving the particle transport equations for elevation-dependent atmospheric flows*****Prof. Robert McKibbin***

Solid and liquid particles ejected into the atmosphere by volcanic eruptions, or dust and sand swept up by storms, are subsequently dispersed by atmospheric wind currents. The particles fall under gravity while being advected by the wind and dispersed by turbulence. Particle sizes are generally not uniform, and may change during flight, either by particle coalescence and/or fragmentation, or, in the case of fluids, by evaporation or condensation. The wind (speed, direction and dominant turbulence length scales) may also change with elevation and with time. A quantitative model that reflects these influences on particle dispersal is described. The elevation-dependent features listed above are included, as well as time-dependent settling speed. In particular, analytic solutions to the advection-dispersion equations that describe the motion of the particles are found. The variation of conditions with elevation are treated by using a piecewise-constant wind velocity, and dominant turbulence length scales and settling speeds which closely match actual profiles; this is the way that data are provided for most of the numerical schemes currently available. Results calculated directly from the derived analytical formulae are used to provide examples of the method. These are compared with some typical examples of field data, and with results calculated from some currently-available numerical schemes. The new formulae allow extremely fast direct computation of deposit distributions and size compositions.

Keywords: particle transport, ashfall deposit, mathematical modelling

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(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****2415 - 2431****Symposium
Ice Volcano Interactions****Convener :** Dr. Ben Brock**Co-Convener :** Dr. Andres Rivera

There are many important interactions between volcanism and glaciation, operating at different levels and over a wide range of timescales. In several regions of the world volcanoes generate the elevation necessary for glaciers and snow covers to form, while the deposition of pyroclastic material and eruptive and geothermal activity impact directly on glacier mass balance. On the other hand, expansion and contraction of glaciers over millennia and the release of meltwater during deglaciation can influence eruptive activity through the overburden pressure release and infiltration of water into the volcanic system. Catastrophic floods may be generated by subglacial eruptions and geothermal activity in the form of lahars and jkullhlaups, while landform evidence from moraines and flood and tephra deposits can provide important information on past glacier extent and the interactions between glacier fluctuations and eruptive activity. This session welcomes contributions on any aspect of ice-volcano interactions on Earth or on other bodies in the solar system, including results from field, remote sensing and modelling studies. The aim is to provide a forum for exchange of knowledge and ideas, particularly between scientists from different disciplines, and to encourage future collaborative research into these complex and challenging systems.


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(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****Oral Presentation****2415****Late Cenozoic glacier-volcano interaction on James Ross Island and adjacent areas, Antarctic Peninsula region*****Prof. Michael Hambrey****Institute of Geography & Earth Sciences University of Wales IAMAS****Prof. John Smellie, Dr. Anna Nelson, Dr. Jo Johnson***

The northern Antarctic Peninsula region has experienced approximately 10 m.y. of eruptive activity by basaltic volcanoes, mainly in subglacial settings. Spectacular exposures of lava-fed deltas, capped by basalt flows and commonly underlain by glacial sediments on top of a Cretaceous sedimentary basement characterize James Ross, Vega, and other islands and promontories in the region. Post-Cretaceous strata are collectively known as the James Ross Island Volcanic Group, and record a cryptic history of glaciation, with the timing of events determinable by argon-isotope dating. Focusing especially on the glacial sediments themselves, and their relationships with overlying or bounding volcanic rocks, we define facies associations related to (i) eruptions beneath thick ice (>200 m) that produced thick lava-fed deltas resting on, and intermingling with, diamictite, and (ii) eruptions under marine conditions that culminated in the development of several tuff-cone successions, some on top of presumably relict glacially-striated surfaces. A combination of provenance studies on clasts in the glacial sediments, some of which are derived from the Antarctic Peninsula, and geochronology, leads to the conclusion that an Antarctic Peninsula Ice Sheet extended over James Ross and Vega islands at around the time that the main volcanic edifices began to grow, i.e. prior to c. 6.2 Ma at least. Much of the subsequent development of the succession is attributed to the interaction between the growing volcanoes and local polythermal ice-caps. Full resolution of glacial/interglacial events in this region promises to inform the debate about the stability of the Antarctic Ice Sheet during the Pliocene Epoch, since these outer fringes of the continent are the most susceptible to climatic change.

Keywords: glacier, volcano, antarctica

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****Oral Presentation****2416****Relative Age dating of the Wahianoa moraines, Mt Ruapehu, New Zealand****Mrs. Erin Nolan***Geography Massey University***Martin Brook**

Mt Ruapehu is an active volcano situated in the central North Island of New Zealand. During the Last Glacial Maximum (LGM) in New Zealand, Mt Ruapehu was one of only a few locations in the North Island to have glaciers and is the only location to still have them. Although the glaciers are nowhere near as extensive as they once were, they are still present and have played an important role in the formation of Mt Ruapehu's current landscape. This paper will present findings from research conducted on the Wahianoa moraines, which are situated on the southeastern sector of Mt Ruapehu. Relative age dating methods are frequently used in glacial environments where there is a lack of datable materials. Lichenometry, schmidt hammer rebound and boulder roundness methods were used to try and determine an approximate age of the surface of the moraines and therefore identify which glacial event/s in New Zealand they formed during.

Keywords: wahianoa, ruapehu, lichenometry

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****Oral Presentation****2417****Monitoring ice capped active Volcan Villarrica in Southern Chile by means of terrestrial photography combined with Automatic weather stations and GPS****Dr. Andres Rivera***Centro de Estudios Científicos researcher IAHS***Ben Brock, Javier Corripio, Francisca Bown, Robert Koschitzki, Jens Wendt, Jorge Clavero**

Volcn Villarrica (392512 S / 715627W; 2847 ma.s.l.) is considered highly active and characterized in historical times mainly by mild strombolian activity, permanent degassing, periodic explosions, and being sensitivity to the magmatic conduit activity. Its eruptive history indicates a low frequency of large explosive eruptions (Volcanic Explosivity Index, VEI between 3 and 4) however, more than 50 eruptive events have been documented since 1558. The latest most violent eruption took place in 1971-72 when lava flows were generated, as well as 30 to 40 km hr⁻¹ laharcic flows descending towards Lagos Villarrica and Calafqun. Lahars produced by eruptions of Volcn Villarrica in 1948-1949, 1963-1964, and 1971-1972 have resulted in the death of more than 75 people, and constitute the main hazard factor of the volcano. The volcano is covered by a glacier of 30.3 km², mainly distributed toward the south and east where the main glacier basin (Glaciar Pichillancahue-Turbio, 17.3 km²), composed of partially ash/debris-covered ice is located, partially infilling a volcanic caldera depression. The main aim of this research is determining and distinguishing glacier responses to the volcanic activity and the atmospheric forcing. For that purpose, the glacier surface energy balance has been monitored close to the Equilibrium Line (~2000 m asl) since 2003 using a Campbell Automatic Weather Station. Surface topography have been monitored using Javad GPS receivers and snow/ice surface changes have been detected using an automatic Canon 300D digital camera, which was installed at a rock outcrop at 1997 masl, from where photographs of the glacier at daily basis have been collected. In spite of the robust installation setting of the camera, the acquisition process has been interrupted many times by extreme weather conditions. In spite of this, we have collected two consecutive periods of data in January 2006 and January-February 2007. The resulting photographs were georeferenced to a 10-m pixel size AirSAR digital elevation model acquired by JPL/NASA and CECS in 2004. The georeferencing technique consists of creating a virtual photography of the DEM that then can be scaled to the resolution of the photographic image to establish a mapping function between pixels in the photograph and grid cell points. Several points on the glacier which were visible from the camera were measured using geodetic quality GPS receivers allowing assignation of absolute co-ordinates to pixels in the oblique image. Once the photographs were georeferenced, the reflectance values were normalized according to several geometric and atmospheric parameters, some of them measured using the AWS installed on the glacier surface. The main result of this work was mapping the evolution of the snow cover, including changes in the extension of tephra-cover an important control on the glaciers mass balance, the variations in albedo and the dynamic of the glacier. These parameters are important monitoring the volcanic activity, especially determining potential risks associated to ice-volcano interaction during eruptive processes.

Keywords: chilean lake district, ice capped volcano, photography

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****Oral Presentation****2418****Modeling of the dynamics and heat transfer inside a crater glacier****Prof. Ralf Greve***Institute of Low Temperature Science Hokkaido University IAG***Thomas Zwinger, Evgeny Isenko, Erik Edelmann, Hakime Seddik, Olivier Gagliardini**

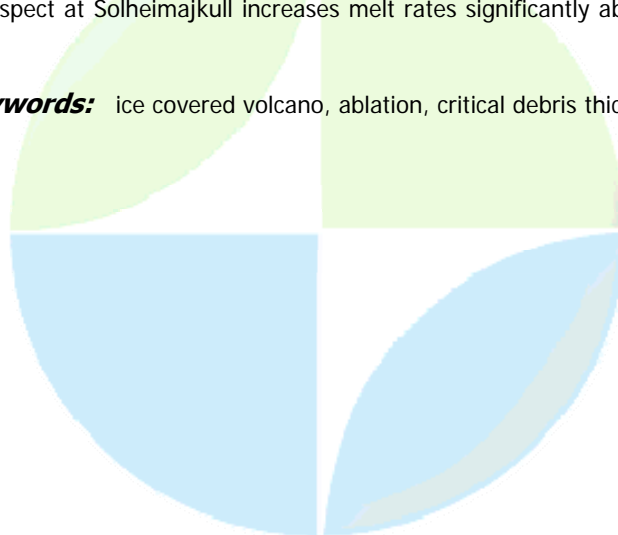
Earlier thermo-mechanically coupled simulations of the Gorshkov crater glacier at the Ushkovsky volcano, Kamchatka, Russia (Zwinger et al. 2007, Ann. Glaciol. 45, in press), revealed that the outflow condition northward down the mountain flank has an essential influence on the dynamics as well as heat transfer properties of the system. In order to improve the setup, an additional region extending the geometry beyond the crater into the caldera has been introduced. As - in contrary to the well resolved digital elevation model (DEM) inside the Gorshkov crater - no bedrock data for this region is available, a 500 meter long region of constant flow-depth and inclination has been added to the geometry obtained by the original DEM. The inclination of the outflow domain shall resemble the almost constant inclination that can be obtained from contours of the available maps. Due to the shallowness of this additional area, the formerly applied kinematic outflow condition can now be replaced with a dynamic condition based on shallow ice flow further away from the crater, making the choice of this condition less influential on the flow profile and the temperature distribution inside the glacier. The new geometry is meshed and imported into the open source finite element package Elmer, which solves the coupled problem of the ice/firn dynamics and heat transfer. In a second step, the still widely unknown distribution of the geothermal heat flux along the bedrock will be parameterized. An inverse method based on an optimization of this parameter set with respect to the measured temperature distribution along the bore-hole at K2 will be presented. The procedure utilizes the open source optimization library APPSPACK. Due the the size of the mesh as well as the quite large amount of needed runs it is computationally intensive and hence is run using parallel computing.

Keywords: crater glacier, ice flow, temperature

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****Oral Presentation****2419****Critical debris thickness, topography and ice ablation on active ice-covered volcanoes: a comparison of Chilean and Icelandic glaciers****Dr. Ben Brock***Geography, Social Sciences University of Dundee IAVCEI***Andrs Rivera, Martin Kirkbride**

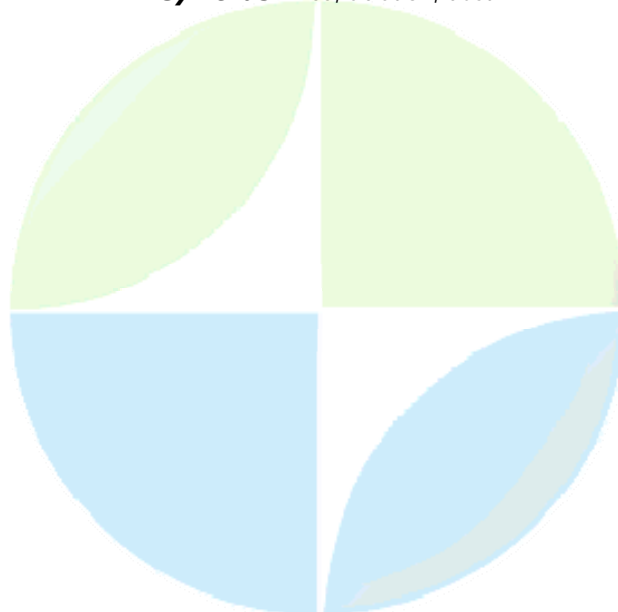
The net impact of supraglacial debris on glacier mass balance is usually assessed with respect to the critical debris thickness at which the buried ice melt rate equals the bare ice melt rate. Insulation provided by thick and continuous debris covers leads to a reduction in the surface melt rate and a net positive impact on mass balance, whereas albedo reduction under thin and patchy covers enhances melting, causing a negative mass balance impact. Many glaciers located on, or in proximity to, active volcanoes exhibit areas of supraglacial tephra cover varying above and below the critical thickness. Hence, it is important to assess the net impact of areas of reduced and enhanced melting on overall glacier mass balance. The impact of topography on surface melt rates must also be considered. Of particular importance are slopes, too steep to support thick debris cover, which develop in crevassed and marginal areas, where albedo reduction by thin veneers of dark and highly absorptive basaltic-andesitic tephra, combined with favourable slope aspect, can lead to exceptionally high local melt rates. In this study, an energy balance model is applied to calculate melt rates on ice slopes of varying steepness and aspect on glaciers located on active volcanoes in two contrasting environments: glacier Pichillancahue-Turbio, located on Volcn Villarrica in southern Chile (3925S, 7156W; vertical extent 1450-2847 m a.s.l., and Solheimajkull, an outlet from the Mrdalsjkull Ice Cap in southern Iceland (63 34 N, 19 18 W; vertical extent 200-1512 m a.s.l.) which is underlain by Katla Volcano. The ablation zone of glacier Pichillancahue-Turbio is covered by continuous mantle of ash and lapilli of several centimetres to metres thickness. An energy balance programme has been carried out at this site since January 2004 which revealed very low ice melt rates (~ 0.5 m w.e. a⁻¹) under tephra covered areas suggesting a net positive mass balance impact. In contrast, the supraglacial tephra cover at Solheimajkull, which mainly originates from the 1917 eruption of Katla, is thin and discontinuous, except in a narrow band where a thick (~ 1 m) layer is exhumed along a thrust plane in the ablation zone. Meteorological and surface melt measurements were conducted at this site in the late 1990s, revealing a net melt enhancement and overall negative mass balance impact. Experiments with an energy balance model on show that enhanced melting on steep slopes in relatively small areas of Glacier Pichillancahue-Turbio may offset the melt reduction provided by the much larger areas of continuous debris cover, while ablation on steep slopes of favourable aspect at Solheimajkull increases melt rates significantly above previous estimates for this site.

Keywords: ice covered volcano, ablation, critical debris thickness



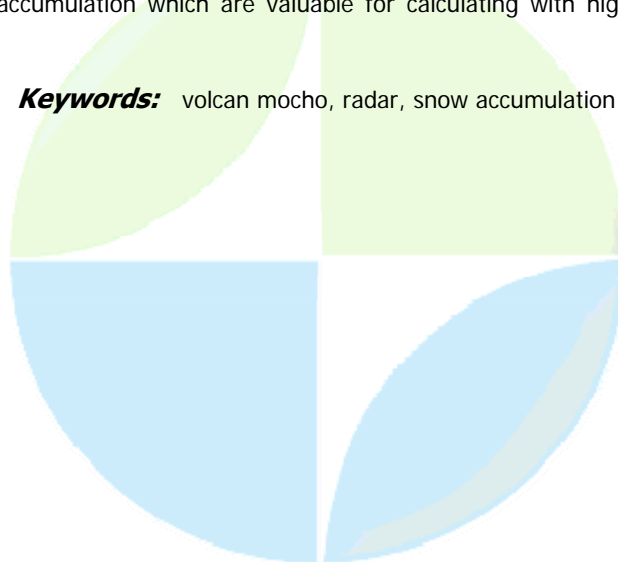
(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****Oral Presentation****2420****Effect of fine layers of dust on ice ablation: field experiments on BREIÐAmerkurjkull, Iceland, and laboratory simulations****Mrs. Cecile B. Menard***Centre for Glaciology University of Wales, Aberystwyth IAHS*

Many glaciers are characterised by the presence of debris covers in the lower parts of their ablation zones. Field experiments on Breiðamerkurjkull, Iceland, and laboratory simulations were performed over a range of partially and fully dust covered ice surfaces to establish the relationship between a thin debris layer (<10 mm) and ablation rates. Data corroborate prior findings on the two following accounts: (a) accelerated melting follows initial application of dust because the low albedo of tephra enhances absorption of shortwave radiation (b) ablation rates decrease as debris thickness increases and the layer acts as insulator. Whereas prior studies have suggested that (b) directly follows (a) as the debris cover increases, both field and laboratory data presented here show more complex ablation patterns. Under rainy and overcast conditions, ablation rates remain constant from when scattered tephra particles cover 10% of the ice surface until the ice first becomes entirely dust covered. This study suggests that filling of microtopographical hollows with water, aggregation of dust particles and light scattering by bubbles and cracks promote the stabilization of the ice albedo, and consequently of melt rates, following the initial dusting. Ablation rates decline as the thickness of the debris layer increases from 1 mm to 3 mm because the debris starts to act as insulator. Between 3 mm and 6 mm, melt rates stabilize a second time because the enhanced thermal conductivity of the wet tephra layer promotes the transfer of energy received at the atmosphere/debris interface to the ice. From 6 mm onwards, ablation again decreases following the mechanisms described in (b). In sunny conditions, ablation rates sharply decrease as the tephra cover increases from 20% to 85% because ice imperfections influence the albedo, latent heat lost to evaporation increases as the thickness of the tephra layers increases and more of the energy available at the top of the debris is used to heat up the dust rather than to melt the ice. Melt rates rise again when the ice surface becomes completely covered with dust because the high thermal conductivity of the warm wet debris promotes melting. The processes described in (b) then ensue for tephra layers of 6 mm and greater.

Keywords: ice, ablation, dust

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****Oral Presentation****2421****Glacier mass balance determination in Volcn Mocho, Southern Chile, using ground penetrating radar****Dr. Gino Casassa***Glaciology and Climate Change Centro de Estudios Cientificos***Gino Casassa, Rodrigo Zamora, Guisela Gacita, Fernando Ordenes, Francisca Bown, Ronald Mella, Andres Rivera, David Ulloa**

Glaciar Mocho (2422 m a.s.l., 3955'S, 7202'W) in the Chilean lake district has been regularly studied since 2003 and its eastern glacier of 5.1 km² is currently one of the two glaciers in Chile being monitored for mass balance by means of the traditional glaciological method using stakes. Volcn Mocho has not shown any eruptive activity since 1864 and therefore its glacier changes are expected to respond primarily to climate. In 2003 the total glacier cover on this volcano had an area of 16.9 km², having lost an average of 0.4 km²/y since 1976 (Rivera et al., 2005). The net mass balance in 2003/04 was 0.88 m w.e. (water equivalent), with an average net accumulation and ablation of 2.59 and 3.47 m w.e. per year, respectively (Rivera et al., 2005). In 2004/2005 the net mass balance was +0.36 w.e. with a winter balance of +4.04 m w.e. and a summer balance of -3.73 m w.e. (Bown et al., in press) Glacier shrinkage and negative mass balance is attributed to atmospheric temperature increase and precipitation decrease in recent decades (Rivera et al., 2005), while the positive mass balance of 2004/2005 is explained by precipitation variability. In November of 2005 a survey with a 400 MHz GSSI SIR 3000 ground penetrating radar was performed on Volcn Mocho glacier. The radar was towed behind a tractor, with a total survey length of 14.4 km, covering about 30% of the eastern glacier, between elevations of 1900 to 2000 m a.s.l. Each radar trace was composed of 512 samples, with a resolution of 16 bits, and a data capture rate of 16 scans per second. Near-surface snow and firn layers could be clearly detected in the radar records. A strong reflector was observed at the bed of the surface layers, below which no clear reflections were distinguished. The reflector was estimated to correspond to the snow surface at the end of the 2005/2006 summer. This interpretation was confirmed by means of an 8 m snow pit dug at an elevation of 1990 m a.s.l., where snow density and stratigraphy were measured. In total 160,000 radar data points were recorded, with a minimum thickness of winter snow accumulation of 5.4 m, and a maximum thickness of 14.7 m for 2005. Areas with increased snow cover are related to depositional sectors while decreased snow thicknesses correspond to erosional areas which in turn are related to the wind pattern on the volcano. Radar data provide thus a very detailed map of winter snow accumulation which are valuable for calculating with higher precision the mass balance of the glacier.

Keywords: volcan mocho, radar, snow accumulation

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****Oral Presentation****2422****Proximal tephra stratigraphy of the 2004 eruption of Grmsvtn volcano,
Iceland Evidence of oscillating eruptive conditions*****Mrs. Tanya Shavalia****University of Edinburgh School of Geosciences University of Edinburgh****Thorvaldur Thordarson, Magns Tumi Gudmundsson***

Grmsvtn central volcano, situated at the juxtaposition of the Icelandic axial rift and mantle plume, resides beneath ~200m thick ice within the Vatnajkull glacier. is dominated by basaltic volcanism, yet explosive basalt eruptions are far more common here than in other areas of comparable volcanism. Subglacial phreatomagmatic eruptions occur at Grmsvtn every 10-15 years on average. However, recent studies have shown that the activity is characterized by a long-term pattern featuring distinct 5080 year long periods of high eruption frequency alternating with equally long periods of low eruption frequency (Larsen et al., 1998). It is noteworthy that the volcano has erupted twice in the past 9 years (1998, 2004), which combined with continued inflation of the volcanic edifice strongly suggests that Grmsvtn has now entered a new high phase of activity. As illustrated by the 2004 event, explosive interaction of magma with external water and ice places important controls on the style of Grmsvtn eruptions and enhances the hazard potential of the activity. Although the erupted magma volumes are generally quite small (<0.1 km³) and the volcano is situated in a remote location, significant hazards may be posed in the event of an eruption by the generation of jkullhlaups as well as plume dispersal and tephra fallout. Consequently, characterization and anticipation of these events is a priority. The objectives of our study are to reconstruct the 2004 eruption from the proximal tephra stratigraphy and to characterize the conduit processes that drove the explosive activity. In this first phase of our work, we report on the initial results of our stratigraphic studies within the proximal sector of the 2004 tephra layer. The deposit comprises at least eight distinct lithofacies, each of which has distinct characteristics that are linked to fragmentation mechanisms and depositional processes. Furthermore, the vertical facies associations indicate that frequent changes from relatively dry to relatively wet vent conditions occurred during the course of the eruption - implying rapid oscillations in the availability of external water for explosive water-magma interactions. The reason for this oscillation in an environment inundated by water and ice is not immediately obvious, and requires investigation. Furthermore, it is not known whether vesiculation of the magma during ascent enhances or weakens the explosivity of the eruptions. The exsolution of magmatic gases plays a major role at shallow conduit levels because not only does it cause rapid expansion and acceleration of the magma column, but it also induces rapid changes in magma rheology (e.g. Hammer and Rutherford 2002). Processes such as the production of magmatic foam and microlite crystallisation make the magma stiffer, which may work to dampen the vigour of magma-external water interactions. Conversely, the formation of open-framework foam greatly increases the size of contact surfaces and reduces effective heat transfer distances which should enhance the explosive vigour of the interaction. Consequently, the interaction of degassing magma and external water needs further study.

Keywords: fragmentation, phreatomagmatic, stratigraphy

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****Oral Presentation****2423****Cooling of the hyaloclastite ridge at Gjalp, Iceland, 1996 - 2006****Mr. Alexander Jarosch***Institute of Earth Sciences University of Iceland***Magnus T. Gudmundsson, Thordis Hgnadottir**

In the subglacial eruption at Gjalp in October 1996, a 6 km long and 500 m high subglacial hyaloclastite ridge was formed. A large depression formed in the surface of the glacier as ice was melted and the meltwater drained away from the eruption site. Surface depression mapping and measurements of ice surface velocities have been done annually since the eruption, allowing detailed monitoring of volume changes of the depression and inflow of ice. Heat output from the subglacial ridge can be estimated using these data by taking surface mass balance into account. Inflow of ice to the depression, which occurs mainly from the north, is an important part of the overall ice mass budget. Estimates of this mass flux term are based on a combination of measurements of surface velocities and a 2D, full Stokes, ice flow model. Heat output values of several thousand megawatts were estimated for the first year after the eruption. By 1998, the heat output had decreased to 900 MW and remained of this magnitude until 2001/2002. However, in 2002 the heat output had dropped significantly, and has remained on the order of 10 MW since. This record reveals a rather stepwise cooling history of the Gjalp edifice. The total energy released since the start of the eruption is as follows: (1) During the eruption, 69%; (2) late 1996 - end of 1997, 23%; (3) 1998 - 2001, 7%, and (4) 200 - present, ~0.5%. This data may indicate that by 2002 the volcanic edifice had cooled down to a value close to background levels. Alternatively, the record may reflect drastic reduction in permeability caused by consolidation and alteration of the volcanic material. The most realistic explanation is probably some combination of these two processes.

Keywords: subglacial eruption, heat transfer, ice models

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(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****Oral Presentation****2424****Time scales and processes in subglacial eruptions, implications for Tuya formation****Prof. Magnus Gudmundsson***Institute of Earth Sciences University of Iceland IAVCEI*

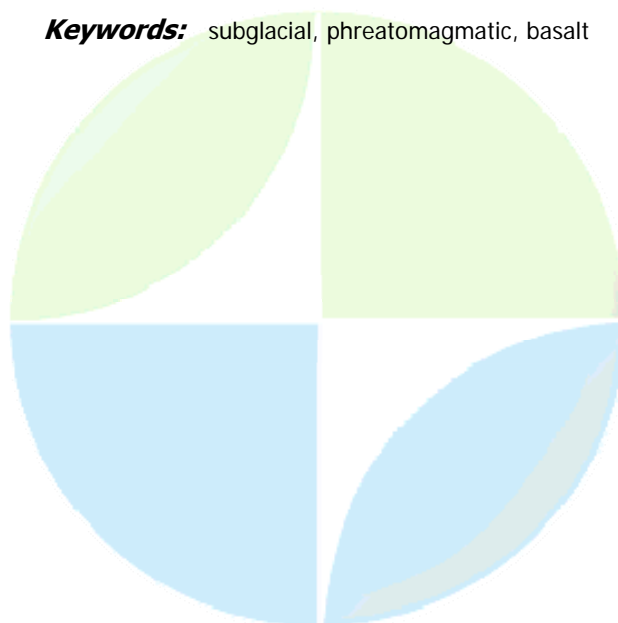
Tuyas are steep-sided, usually monogenetic basaltic volcanoes, formed in eruptions within large glaciers. These eruptions have broken through the ice and formed an englacial meltwater lake with the volcanic edifice growing as lava-fed deltas advanced into the lake. A common characteristic of tuyas is a well defined, largely horizontal passage zone indicating a stable meltwater lake level for extended periods during the eruption. In contrast, observations of recent subglacial eruptions suggest that fluctuations in lake level and unstable subglacial drainage of meltwater is the norm. Moreover, the volcanic edifices formed in observed eruptions have not resembled tuyas. It has recently been suggested that supraglacial drainage may provide an explanation for semi-stable meltwater lakes during tuya-forming eruptions (Smellie, 2006). However, the mechanism by which supraglacial drainage may be established and remain stable has not been resolved in a satisfactory manner. I propose that the differences between observed eruptions and past tuya-producing eruptions may lie in varying time scales and thermal regimes. It is likely that tuyas are mainly formed in long-lived low-discharge eruptions similar to the presently on-going eruption at Kilauea. However, as in most basaltic eruptions there may have been an initial high-discharge phase, leading to rapid subglacial drainage and surface cauldron formation. A feature seen in observed eruptions within large glaciers is a linear depression in the ice surface above the subglacial meltwater pathway. This depression is formed by basal melting as heat is released from the flowing meltwater. As an eruption progresses, magma discharge commonly drops. This should lead to a slowdown in ice melting and subglacial drainage, possibly resulting in temporal closure of the subglacial discharge tunnel. Water may then start to flow on the surface, along the linear depression above the former subglacial tunnel, before the water level has risen sufficiently to float the ice and re-establish subglacial drainage. In a temperate glacier, incision of a supraglacial channel should lead to a gradual drop in water level at the eruption site and hence a drop in passage zone elevation with time. However, in a polythermal glacier, surface ice temperatures well below zero will slow down or stop incision. This suggests that conditions for stable water level with supraglacial drainage can develop, providing an explanation for the horizontal passage zones in tuyas. This also indicates that tuyas not only confirm the existence of former ice sheets, but may also provide information on the thermal regime of these ice sheets. Smellie, J.L. 2006. The relative importance of supraglacial versus subglacial meltwater escape in basaltic tuya eruptions: An important unresolved conundrum.

Keywords: subglacial, basalt, tuyas

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****Oral Presentation****2425****Sulphur release from subglacial basalt eruptions in Iceland****Dr. Thor Thordarson***School of GeoSciences University of Edinburgh IAVCEI*

The basalt volcanism in is distinguished by unusually high proportions of explosive eruptions (e.g. Thordarson and Larsen, 2007). In historical time (i.e. last 1140 years), explosive basalt eruptions account for ~80% of recorded events (= 205) and ~30% of the total erupted magma volume (= 69 km³). They occur as fissure-fed phreatomagmatic and submarine eruption, although vast majority (>90%) has taken place at the ice-covered Katla, Grimsvotn and Bardabunga central volcanoes on the Katla, Grimsvotn, Bardarbunga-Veidivotn volcanic systems on the Eastern Volcanic Zone the three most active volcanic systems in Iceland. The Grimsvotn central volcano has the highest eruption frequency, with 7 to 10 eruptions per hundred years in historical time, followed by the Katla and Bardabunga volcanoes, each with ~2 eruptions per century. The size of individual eruptions is relatively small, where typical magma volume in the range of 0.01-1 km³ and the magma composition ranges from mildly alkalic (Katla volcanic system) to tholeiitic (Grimsvotn and Bardabunga-Veidivotn volcanic systems). The pre-eruption sulfur content of these magmas has determined by measurements of melt inclusions trapped in phenocrysts and give pre-eruption mean values of 1470185 ppm for typical Bardabunga compositions, 1660240 ppm for Grimsvotn and 2200165 ppm for Katla magmas (e.g. Thordarson et al., 2003). Similarly, the post-eruption mean sulfur values in degassed magmatic tephra are 45090 ppm (Bardabunga-Veidivotn), 49080 ppm (Grimsvotn) and 460125 ppm (Katla). However, the tephra produced by subglacial and subaerial phreatomagmatic eruptions has much more variable S contents, ranging from 255-1490 ppm for Bardabunga-Veidivotn, 460-1350 ppm for Grimsvotn 545-1890 ppm for Katla. These variable sulfur values are attributed to arresting of degassing as the magma is quenched upon contact with external water in the shallow levels of the volcano conduit. It is noteworthy that in each case, the sulfur concentrations in the phreatomagmatic tephra span the compositional gap between magmatic tephra and melt inclusions. Furthermore, the measured sulfur values exhibit a near Gaussian distribution imply that the amount of sulfur released into the atmosphere by subglacial and phreatomagmatic eruptions is only one half of what is released in comparable magmatic basalt eruptions.

Keywords: subglacial, phreatomagmatic, basalt



(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****Oral Presentation****2426****Temperature and circulation in a subglacial volcanic lake beneath Vatnajkull, Iceland*****Dr. Thorsteinn Thorsteinsson****Hydrological Service National Energy Authority****Tmas Jhannesson, Andri Stefnsson, Eric Gaidos, Bergur Einarsson***

At three locations in the western part of the Vatnajkull ice cap, interaction of geothermal heat with glacier ice leads to the collection of meltwater in subglacial lakes beneath 300-400 m thick ice cover. The largest of these, Lake Grmsvtn (40 km²), overlies one of the most active volcanoes in and has been the source of large jkulhlaups of varying sizes for centuries. Less known are the two Skaftkatlar subglacial lakes, which empty out in smaller jkulhlaups (0.1-0.3 km³) at 1-3 year intervals, leading to the formation of 2 km wide and up to 150 m-deep glacier-surface depressions, the Skaft cauldrons. The Western Skaft Cauldron was accessed with a hot water drill during a field campaign in June 2006. The design of the drilling system incorporates in-line sterilization of the drilling water, in order to minimize the risk of biological contamination of the subglacial water body. The ice shelf was 300 m thick and the lake depth was 115 m at the drilling site. A sample of the lake was obtained from a depth 2 m above the bottom using a specialized gas-tight bailer triggered by contact with the lake bottom. The temperature of the water was at the melting point in the borehole, rising rapidly to 4.7 C at the ice-water interface. A temperature of 4.5-4.7 C was recorded in most of the water column, with the exception of a cold tongue at 3.4 C in the bottom 10 m. We present evidence for circulation in the lake leading to the mixing of geothermal fluids (20%) with glacial meltwater (80%) originating by melting at the ice-water interface and as surface-derived meltwater entering the lake from the sides along the ice bed. Results from geochemical analyses of the sample from lake bottom combined with data on the rate of ice melting allow us to calculate a temperature of 310-320 C for the deep geothermal system and the power of the system is estimated to be 760 MW. The biological habitability of the Skaft cauldrons will be briefly discussed in the light of results obtained during the 2006 field campaign.

I T A L Y



(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****Poster presentation****2427****Reconstructing debris transport pathways on constructional ridges:
Wahianoa Glacier, Mt Ruapehu*****Mrs. Stephanie Mandolla******Dr Martin Brook***

It is generally accepted that Mt Ruapehu, Tongariro National Park, New Zealand, was heavily glaciated during the Pleistocene. Eight small glaciers can still be found on the summit of this active volcano. However, the glaciers have been retreating at a fast rate during the last few centuries. The scientific community has placed its main focus on the volcanic aspects of the region. Although most authors refer to the landforms that appear to be of glacial origin as moraines, no actual glacial studies have been undertaken so far to provide the necessary evidence that is needed to support this hypothesis. The aim of this study is to use established field techniques in glacial geomorphology to (1) identify the extent of glacial deposits using diagnostic criteria and (2) to reconstruct the transport pathways of the Wahianoa Glacier. Four main diagnostic criteria have been used: clast morphology, grain size distribution, macrofabrics and the surface texture of grains. The Wahianoa Valley has a very pronounced U-shape, and is likely to be of glacial origin. The valley consists of two elongate debris ridges that are made out of unconsolidated, poorly sorted diamict of varying lithologies. This study has identified that the activity and the composition of the volcano has lead to complex glacial processes. Glacial ice has advanced over a deformable bed and the glacier itself was probably extensively covered by supraglacial debris. The area has been identified as a pre-historic pathway for lahars and the volcano erupts frequently to produce fresh volcanic deposits. As the active vent has changed its position during the eruptive history of the volcano, the quantity and the location of the source rock that fed the glacier has varied greatly. This study is an initial attempt at unfolding the glacial history of Mt Ruapehu. This is based on field analysis of glacial sediments, rather than topographic and aerial photo analysis. The results show great complexity and the potential for further studies of other moraine systems on Mt Ruapehu.

Keywords: ice volcano interactions, deformable bed, post depositional processes



(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****Poster presentation****2428****1996-1998 Glacier surge at Northeastern active crater of Mutnovsky Volcano, Kamchatka: possible trigger factor of 17 March 2000 eruption****Dr. Georgy Gavrilenko***Far Eastern Branch Russian Academy of Sciences Institute of volcanology and seismology
IAVCEI***Polina Gavrilenko**

Mutnovsky Volcano is one of the biggest and most active volcanoes of South Kamchatka. Its height is 2323 m above the sea-level and it consists of 4 contiguous, successively forming strato-cones with apical calderas and daughter intracaldera structures. In present time the volcano has 3 active craters: North-Eastern (NE), South-Western (SW) and Active Funnel (AF). The most recent explosive eruption of Mutnovsky Volcano, prior to March 2000, occurred in 1960. However, the abnormally high evolution of heat in the period between paroxysms for volcanoes of this type (practically two orders greater) indicates that the volcano is in a stage of weak or passive eruption that has already been continuing for more than 40 years. The analysis of seismologic data and visual observations confirmed an eruption in 17 March 2000. Within several hours of the eruption a steam-gas outburst reaching 2500 m was observed. The eruption took place in the northern explosive funnel of the volcano's SW crater which was active until middle 1950s. What happened before the eruption? Near the end of 1996, after several weeks of long plentiful rain, the Mutnovsky perennial intra-crater glacier suddenly became active. Its front started to slide onto the northern part of the NE crater. By fall 1998, the glaciers mass reached the opposite side of the crater, damming the waters of the Vulkannaya River which drained it and clogging most of the volcanos gas and hydrothermal vents. Consequently, the following changed in the volcanos craters: (1) hydrological regime due to the increased level of ground waters (therefore, the water saturation level increased in the deposits inside of the crater); (2) regime of gas-hydrothermal activity; (3) heat balance of the active craters. The perennial hydrogeochemical monitoring of the Vulkannaya River which drains the active craters of Mutnovsky Volcano showed a regular increasing of SO₄/Cl and SO₄/F in the river water starting from 1997-1998 until the 2000 eruption. The old glaciers descent into the NE crater was very likely the eruption trigger as well as being one of the reasons for this geochemical effect. As a result of the above-mentioned changes, there was probably an increase in the amount of ground water that seeped through the bedrock of the volcanic edifice. Based on these observations in 1999 the authors made a mildly urgent forecast of the impending phreatic eruption on Mutnovsky Volcano which, indeed, occurred on March 17, 2000 (Gavrilenko, 2000; Gavrilenko, Gavrilenko, 2001; Gavrilenko et al., 2001). The acquired data showed that there is a correlation (which depends on dynamics and the old glaciers mass exchange inside the crater) between the changes in hydrological conditions in the Mutnovskys active craters on one hand and the increased activity on the other.

Keywords: volcano, glacier, eruption

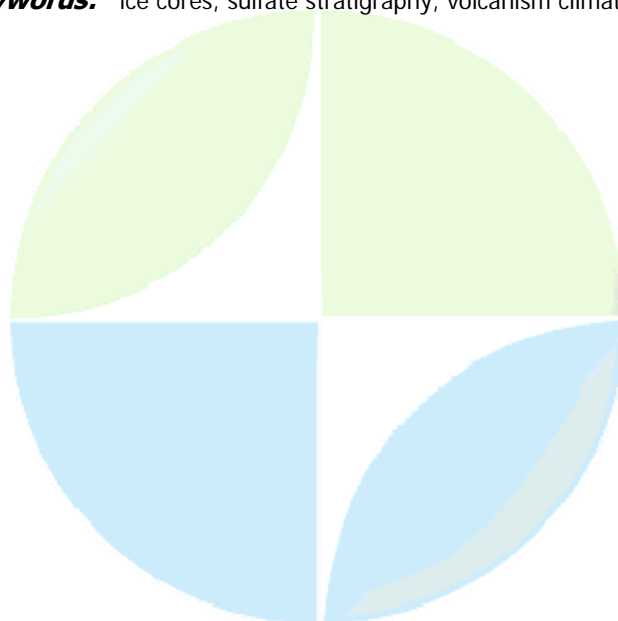
(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****Poster presentation****2429****Historical analysis and stratigraphy of the post-XII Century pyroclastic activity at Cotopaxi Volcano, Ecuador: implications for Lahar hazard assessment.****Dr. Marco Pistolesi***Earth Science Department University of Pisa***Mauro Rosi, Raffaello Cioni, Katharine V. Cashman, Eduardo Aguilera**

Cotopaxi, one of the highest and most dangerous volcanoes on Earth, is a perfect, ice-capped cone reaching an elevation of 5897 m. The volcano is located about 60 km south of Quito, capital of the Republic of Ecuador, and is surrounded by several villages and countrys rural infrastructures. During the past centuries volcanic eruptions and concurrent rapid snow/ice melting have resulted in large debris flows (lahars), which caused major devastation to the settlements around the volcano and traveled downstream for hundreds of km from the source. As a result, lahar hazard assessment is critical, as it represents the basis for effective mitigation actions in the fields of both civil protection and land-use planning. Assessment of the lahar impact along the main valleys has been addressed in previous works (Mothes et al., 1998, 2004; Pareschi et al., 2004) using numerical models that assume the last eruption (that of 1877) as the maximum expected event. The assumption of 1877 as the most probable maximum scenario derives from the belief that the release of water during this event was maximized by the effective interaction of pyroclastic flows with the glacier, whose surface was larger than the present ice cap extension. We have conducted a detailed mapping of the lahar deposits of Cotopaxi over the period 1150 to present, aimed at assessing the relative scale of different debris flow events based on thickness, maximum block size and extension of the related deposits. Precise and unequivocal identification and chronostratigraphic attribution of different lahars was made, within a radius of 17 km from the volcano, by identifying and tracing fallout beds interlayered with the lahar units. In a similar way, we also assessed the temporal relationships between pyroclastic flows and lahars. Tephra fallout architecture was assessed examining more than 400 stratigraphic sites. The study of the lahar deposits indicates that over the time interval under consideration, the volcano produced debris flows of widely variable scale, from moderate to large to very large. Within this scale, the 1877 event ranks as a moderate lahar, contrasting with other large (AD 1768, the largest for which eyewitnesses descriptions are available) or very large events (XII - XVI century). According to the description of the historical chronicles, during the 1877 eruption (and presumably during most of previous historical eruptions as well), the spilling out from the crater of pyroclastic flows (scoria flows) was the major cause of extensive and rapid melting of the ice cap and the formation of large scale debris flows. Our results suggest that all but one of the studied events were produced by this mechanism.

Keywords: lahar, tephrostratigraphy, hazard

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS003****Poster presentation****2430****Past modulations of global volcanic activity inferred from the EPICA Dome C (Antarctica) ice core sulfate record.*****Dr. Emiliano Castellano****Analytical Chemistry University of Florence****Mirko Severi, Silvia Becagli, Rita Traversi, Federica Marino, Ryan Bay, Mathias Bigler, Fabrice Lambert, Jorge-Peder Steffensen***

Ice cores from the inner areas of the Greenland and Antarctic ice sheets archive signals of past volcanic eruptions and can be so used for local-to-hemispheric paleo-volcanic reconstructions, spanning up to several hundred thousand years, depending on the annual snow accumulation rate. The possibility to infer at the same time different paleo-climatic information from the same ice samples allows to investigate the possible link between climatic change and volcanic activity, independently on age scale models. High resolution sulfate measurements performed along the EPICA (European Project for Ice Coring in Antarctica) EDC ice core (3190 m long corresponding to about 900 kyr, drilled at Dome C - 7506S; 12324 E; 3233 m a.s.l., in the East Antarctic Plateau) by FIC (Fast Ion Chromatography) are used here to reconstruct past volcanic activity recorded in the East Antarctic Plateau area for the last 400 kyr. The reconstruction of past volcanic history in the bottom part of the core is highly restricted by post-depositional processes of sulfate diffusion, so that this study is limited to the last 4 glacial/interglacial cycles only. The sulfate ice-core record consists on a almost constant background of mainly biogenic origin and sharp spikes of volcanic origin: volcanic events signatures were discriminated from the biogenic background by using a statistical approach. The comparison of the number of volcanic events per millennium with a climatic proxy for paleo-temperature (dD) points out the presence of increased volcanic activity during periods of fast changes of climatic conditions. The spectral analysis of the volcanic frequency (number of events recorded in the time) reveals significant periodicities, possibly linked to climatic change. The main periodicities are discussed by comparison with orbital frequencies and with results from tephra stratigraphies recorded in ocean sediments cores found in literature. Mechanisms of triggering of volcanic activity by climate changes should involve glaciers advance/retreat and sea level variations, therefore acting as crustal stresses on volcanic systems.

Keywords: ice cores, sulfate stratigraphy, volcanism climate link

(V) - IAVCEI - *International Association of Volcanology and Chemistry***JVS003****Poster presentation****2431****Can Persistent sustained Short Period Seismic Excitation Suppress the Eruptive Activity of a Strombolian Volcano?*****Prof. Douglas MacAyeal****Department of Geophysical Sciences University of Chicago IAHS****Richard C. Aster, Philip Kyle, Kyle R. Jones***

Mount Erebus, located on Ross Island Antarctica, has generally exhibited persistent Strombolian eruptive activity from its convecting phonolitic lava lake and associated inner crater vents for several decades. Many key features of the volcano's short-period and very-long-period seismic eruption-generated radiation show significant repeatability over this time period, indicating significant stability in its near-summit magmatic system configuration. Contrastingly, the volcano has also exhibited dramatic changes in eruptive frequency. The most recent such variation occurred when prolific (over 100 events per month) lava lake eruptions during 2000 nearly ceased for a period of approximately 1 year (2001-2002), moderately resumed (up to approximately 30 events per month) between February and August, 2002, and then essentially ceased again until weakly resuming in early 2004. Since late 2004, eruptive activity has gradually increased, and by late 2005 had resumed its previous vigor. This period of nearly absent eruptive activity between 2001 and 2004 coincided with the historic calving of megaicebergs from the Ross Ice Shelf in the immediate vicinity of Ross Island. These floating ice bodies (with masses up to approximately 10^{15} kg) repeatedly impacted with Ross Island and with each other between 2001 and 2004, generating repeated episodes of a novel type of short period (generally 1 - 10 Hz) iceberg tremor that is probably associated with stick-slip processes. Iceberg tremor on Ross Island was particularly intense, with the largest events producing ground motions equivalent to magnitude ~ 3 earthquakes persisting for several hours. We will statistically examine the eruptive record and the history of sustained short-period tremor on Ross Island in more detail to test the speculative but intriguing hypothesis that sustained shaking could correlate with suppression of the formation of the large gas slugs in the Erebus conduit system that drive characteristic lava lake eruptions.

Keywords: antarctica, eruption, iceberg

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****2432 - 2477****Symposium
Volcano seismology****Convener :** Prof. Jurgen Neuberg, Dr. Maurizio Ripepe

Seismic monitoring of active and dormant volcanoes remains the key element of any monitoring program undertaken by volcano observatories or research institutions. Major advances in volcano seismology have been made in the last years allowing us to identify several categories of volcanic seismic events, and interpret them in terms of different magmatic or tectonic processes encountered on a volcano. Attempts based on multi-disciplinary methodologies turned out to be particularly successful. This session is dedicated to latest developments in volcano seismological monitoring techniques, interpretation and modelling methodology in a wider volcanological context. We invite contributions for both oral and poster presentations that deal with any seismological aspects relevant to volcano monitoring, new methodologies as well as case studies from a wide variety of volcanic settings. This includes advances in seismic instrumentation, as well as theoretical approaches. Particularly welcome are studies that combine seismology with other monitoring or modelling techniques, such as ground deformation, gas monitoring, petrology and fluid dynamics of magmatic systems.


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I T A L Y

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2432****Geology and geophysics study in revealing subsurface condition of
Banjarpanji mud extrusion, Sidoarjo, East Java, Indonesia**

Dr. Prihadi Sumintadireja
Geology Institute Technology of Bandung

I. Purwaman, B. Istadi, A.B. Darmoyo

Adjacent to exploration well Banjarpanji (BJP-1), Sidoarjo, East Java, Indonesia at least on three separate locations, mud, water, and gas are ejected into the surface. The study of ejected material yields useful information about source of sedimentary deposits, and water at particular depths. The objective of the study is to figure out major cause of mud extrusion and source of ejected materials by establishing geological model for the area. Several cited references demonstrate possible triggering mechanism for mud extrusion. Not only drilling activities but also large earthquake may induce mud extrusion. The research results of field works consists of aerial photography, gravity, resistivity, and micro-earthquake monitoring. All field works were based on two premises. The first mud extrusion was set off either by large earthquake or drilling activities. The second, mud extrusion was triggered by both large earthquake or drilling activities. Late Pliocene shale sequence is a major source of the mud. It is composed of 45% clay mineral (smectite, illite, kaolinite and clorite), 45% quartz and 10 % others. Vitrinite reflectance data (Ro 0.64%) suggested the depth of mud source is equivalent to 4000-6000 ft. Log analyses of Banjarpanji-1 well, such as GR, Density and Sonic log, exhibit an anomaly within rock strata and indicated an under-compacted environment. This zone, located between 2800 and 6200 ft depth, is Late Pliocene in age and dominated by thick shale layer. Moreover, the under-compacted zone is segmented into three depth interval of overpressure zones, 3652-4400 ft (OP-1 interval), 4800-5400 ft (OP-2 interval) and 5800-6200 ft (OP-3 interval). Only two intervals (OP-1 and OP-2) have maximum water saturation, as indicated by resistivity in these zones. Resistivity of un-invaded zone is as high as resistivity of water (0.32 ohm-m). Two separated fault zones exist within the under-compacted zones. They are at 4400-4800 ft and 5500-5800 ft interval. OP-1 and OP-2 interval zones are separated by a fault zone that consists of cataclastic material. This fault zone is characterized by lower GR reading, lower density, and slower compressional velocity, compared to the other fault zone on adjacent strata. The first fault zone has the highest water saturation compared to other fault zone and it is acted as conduit and escape route for mud and water, from the over-pressured zone. The most probable logical explanation, corresponding to mud extrusion event in Banjarpanji area, are a failure to maintain the lithologic sealing capacity in the well bore and later on is worsen by an earthquake event.

Keywords: mudextrusion, banjarpanji, sidoarjo



(V) - IAVCEI - *International Association of Volcanology and Chemistry*

JVS004

Oral Presentation

2433

Quantification of volcanic explosions at Volcn de Colima, Mxico, from the broadband seismic records and tilts

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Carlos Navarro, Gabriel Reyes-Dvila, Justo Orozco, Hydyn Santiago, Juan Jos Ramrez, Mauricio Bretn, Armando Tellez

The methodology of quantification of volcanic explosions from the broadband seismic records and tilts and its application to the 2004-2005 sequence of explosions at Volcn de Colima, Mxico, are presented. The broadband seismic station situated at a distance of 4 km from the crater and the tiltmeter situated at a distance of 1.6 km from the crater are used. The energy of explosions E was estimated from the broadband seismic records. The amplitudes A of the tilt impulses generated by the same explosions were calibrated using the empirical equation $\text{Log } E \text{ (J)} = 3.89 \text{ Log } A \text{ (microrad)} + 5.96$. The importance of this methodology for quantification of volcanic explosions is discussed

Keywords: explosion, energy, colima



(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2434****The impact of the regional seismicity on the volcanic activities of Nyiragongo, Virunga volcanic region, Western Rift Valley, D.R. Congo****Mr. Wafula Mifundu Dieudonne***Department of Geophysics CRSN GOMA IAPSO***Franois Nyombo Lukaya, Hiroyuki Hamaguchi**

Nyiragongo is a stratovolcano, belonging to the Virunga volcanic region located at the northern end of lake Kivu (1460m) in the Western Rift Valley of the East African Rift System. The Western Rift is characterized by shallow seismic activity and volcanic activities just at the northern end of lake Kivu. The lava lake was seen in the crater of Nyiragongo since 1928 and its lava lake was progressively increasing with time. It was noticed that the earthquakes occurring in the Western Rift Valley have effects on the volcanic activities of Nyiragongo. Indeed, on January 6, 1977, an earthquake of magnitude $m_b = 5.2$ occurred about 130 km south of the volcano. After the occurrence of this event, the continuous volcanic tremors with high amplitude started recording at Lwiro station located about 90km south of the volcano until the occurrence of eruption on January 10, 1977 (Hamaguchi et al, 1992). The long-lived lava lake had completely disappeared. All the lava was drained through several fissures opened on the flanks of the volcano. It was observed, that very small amplitude tremors appeared in November 1990 after the occurrence of a 4.8 magnitude earthquake on November 20, 1990, on the south slope of the volcano. This activity was considered as precursor of the 1994 lava lake rejuvenation. The occurrence of moderate earthquakes $M_L = 4.5$, on October 7, 2001 about 250 km in the north of the volcano, triggered, volcanic tremors, vibrations and grumbling also felt by local population and occurrence of black smoke from the summit crater. The occurrence of another moderate earthquakes of $M_L = 4.8$, on January 4th, 2002 also 250 km in the north, triggered; volcanic tremors with large amplitude, vibrations and grumbling felt by local population, occurrence of black smoke from the summit crater and this time with the increase of temperature on the flank of the volcano. Nyiragongo flank fissure eruption occurred on January 17, 2002. All the contain of the lava were drained out through several fissures on the flanks of the volcano. After the eruption on January 2002, a period of quiescence was observed, no lava lake activity could be seen in the summit crater of the volcano. On October 24, 2002 an earthquake of magnitude $M_w = 6.2$ occurred about 50km south of the volcano, several days late, the bottom of Nyiragongo crater became active, fresh lava appeared in November 2002. Since than the lava lake is present in the Nyiragongo crater and its activity is gradually increasing with the volume of lava. These examples confirm the real impact of regional seismicity on the volcanic activities of Nyiragongo.

Keywords: earthquakes, volcano, nyiragongo

(V) - IAVCEI - *International Association of Volcanology and Chemistry***JVS004****Oral Presentation****2435****Spectral characteristics with respect to earthquake size; An analysis from Soufriere Hills Volcano, Montserrat, West Indies.*****Dr. Arthur Jolly****Wairakei Research Centre GNS Science IAVCEI****Philippe Jousset, Emma Doyle, Venus Bass, Raquel Syers***

At the Soufriere Hills Volcano, earthquakes are classified as volcano-tectonic, hybrid or long-period depending on the frequency characteristics of the waveforms. We have reprocessed earthquakes having these analyst designations by measuring local magnitudes (ML) and calculating spectral characteristics, for the period December 1, 1996 to June 25, 1997. Reprocessing produced over 1400 high quality events (good signal to noise ratios) with earthquake magnitudes ranging from 0.5-3.4 ML, located at the volcano summit and concentrated ~1.5 km below the surface. The data reveal a strong coincidence between earthquake size, and their spectral characteristics, with smaller earthquakes (< 2.5 ML) having broader spectra peaked in the 2-5 Hz range, while the largest earthquakes (2.5 -3.4 ML) have lower frequencies dominated by 0.8 Hz spectral energy. Coincidence between low frequency spectra and event size may be attributed to the earthquake duration, with smaller earthquakes having short event durations and broad spectral signatures while larger events have longer durations which preferentially excite lower frequencies. Observed spectral peaks in the earthquake data implies that 0.8 Hz resonance is established once an earthquake size threshold is exceeded. We have modelled the observed spectral characteristics using a visco-elastic 2D finite difference method by applying sources of different sizes within a strongly attenuating conduit section. Modelling confirms that source durations and event size play an important role in the highly variable waveform characteristics observed at Montserrat.

Keywords: earthquake, spectra, magnitude

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2436****Non-linear dynamics of singular long-period volcanic tremors observed at Mt. Asama****Prof. Minoru Takeo***Earthquake Research Institute University of Tokyo IAVCEI*

On September 1, 2004, a middle-scale eruption occurred at Mt. Asama. Before the eruption, long-period volcanic earthquakes were observed with the broadband seismographs located at the summit of Mt. Asama since October 17, 2003. The signals are so feeble that we can hardly recognize them even at the second nearest station from the summit crater. On June 24, we observed three long-period tremors with singular waveforms, which occurred at 4:25 (first tremor), 11:30 (second tremor), and 20:30 (third tremor). These tremors were estimated to lie just beneath the vent with very shallow depth. In this paper, the dynamical structure and characteristics of these tremors are investigated by employing some reliable and robust techniques in the estimation of geometrical and dynamical parameters. Embedding by the method of time delays has become the standard procedure in non-linear dynamical system analysis of a single time series. The first step for the nonlinear analysis of a single time series is to reconstruct a qualitatively similar dynamical attractor to the original in a relatively low-dimensional delay-coordinate space. The key questions are following. How can the minimum embedding dimension be determined for reconstructing the original dynamics? How do we select the delay time? An optimum time lag of delay-coordinate space is determined using high-order correlations up to sixth-order. A practical method for determining the minimum embedding dimension proposed by Cao is more objective than other methods. For the first tremor, the optimum time lag of 7 steps and the minimum embedding dimension of 7 were obtained by employing these methods. We succeed in reconstructing the attractors of tremors using these dimension and time lag. Then, we calculated a correlation integral curve of the reconstructed attractor, founding a certain degree of scaling region with the correlation dimension of 2.35 ± 0.16 . The optimum time lag and the minimum embedding dimension for the second tremor were 20 steps and 7, respectively. However, we could not found a certain degree of scaling range in the correlation integral curve in this case. The optimum time lag of 9 steps and the minimum embedding dimension of 7 were obtained for the third tremor. In this case, a correlation integral curve of the reconstructed attractor, represents a certain degree of scaling region with the correlation dimension of 1.48 ± 0.17 . The surrogate data analysis is a kind of statistical hypothesis testing. In order to check an non-linearity of the first tremor, we set several linearity null-hypotheses and applied the surrogate data analysis. This surrogate data analysis indicates that the null-hypotheses are rejected with the strong rejection level, suggesting there exists a deterministic non-linear dynamics in the tremor excitation that can be modeled with the system dimension ranging between 3 to 7.

Keywords: volcanic tremor, nonlinear dynamics

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2437****Systematic analysis of dike intrusions off the East Coast of Izu peninsula, Central Japan - geophysical evidence that tip cavity controls the size of dikes****Prof. Yuichi Morita***Earthquake Research Institute, University of Tokyo Associate Professor IASPEI***Shin-Ichi Sakai**

Earthquake swarms are frequently observed around volcanoes, and some of them are confirmedly related to the magma emplacement, because the stress is enlarged at the tip of the magma body and fractures (i.e. earthquakes) are generated easily. The earthquake swarms occurring at the east coast of Izu peninsula, central is known as one of the typical activities related to dike intrusions from previous studies. More than 30 earthquake swarms recur in this region since 1978 and all activities are followed by ground deformations, that reflects vertical tensile cracks opening. Therefore, this region is one of the best fields to study the physical process of dike intrusions from geophysical observations because the dikes intrude repeatedly under the same tectonic setting. We analyze seismic and geodetic data jointly for recent several activities and we evaluate the process quantitatively. We find out some common features in most swarm activities, and we also do some differences among them. We summarize them as follows. 1) Each earthquake swarm begins at the depth of 10km, and the hypocenters migrate linearly upward at first stage of each swarm activity. 2) After several upward migrations, seismicity increases rapidly and hypocenters migrate outward on a vertical aligned plane from the central depth just after distinct ground deformations, which can be represented by a dike opening, starts and continues until the activity concludes. 3) The central depths for the swarm activities are classified into two groups. One is around 5km, the other is 8km. 4) All swarm activities located on the same plane. Hypocentral areas of a swarm activity are partly overlapped on those of the other swarm in horizontal position but they are separated vertically. 5) The estimated excess pressure inside of the dike does not vary during a swarm activity, but it depends on the central depth of the dike. 6) The excess pressure in the dike whose central depth is 8km is around 50% larger than that of 5km. These results lead us the following conclusions. A series of dike intrusions in this region are composed of two kinds of magmas with different densities, because the vertical separation of the hypocentral area shows that the magma of dikes have two different buoyancy neutral depths. The higher excess pressure in deeper dikes is caused by lower pressure in the tip cavity, and it is likely realized in nature. We can demonstrate that the tip cavity control the size of dike in this region from geophysical observations. The quantitative analysis of dike intrusion mentioned above give us valuable information on the magma intrusion process that is still unsolved.

Keywords: dike intrusion, earthquake swarm, hypocentral migration

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JVS004

Oral Presentation

2438

Exploring the evolution of volcanic seismic swarms

Dr. Jacopo Selva

Sezione di Bologna Istituto Nazionale di Geofisica e Vulcanologia IAVCEI

Warner Marzocchi, Anna Maria Lombardi

We explore the temporal evolution of volcanic seismic swarms and their volcanic origin by means of nonstationary stochastic ETAS models of earthquakes occurrence. We analyze some historical swarms with different origins and outcomes. The variations through time of the models parameters, i.e., the background activity and the p-value, are interpreted in terms of nature and temporal evolution of the volcanic source of the swarm. The results obtained suggest that suitable nonstationary ETAS modeling could be used in almost real-time during future seismic swarms in volcanic areas to characterize the nature of their volcanic source and to help forecasting their evolution and outcome.

Keywords: seismic swarm, etas, volcanic source

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(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2439****The Explosion of March 2004 at Montserrat: Constraints From Borehole Strain Data****Dr. Alan Linde***Department of Terrestrial Magnetism Carnegie Institution of Washington IAVCEI****I. Selwyn Sacks, Dannie Hidayat, Barry Voight, Peter Malin, Eylon Shalev, Glen Mattioli, Simon Young, Derek Elsworth***

The dome-building volcano Soufriere Hills on Montserrat in the Caribbean has been active since about 1995. By the end of January 2003, the CALIPSO group had established a small network of 4 borehole sites with the instrumentation including Sacks-Evertson dilatometers. Major dome collapse in July 2003, reported elsewhere, was accompanied by increased pressure in a deep (~5km) reservoir. In March 2004 a well observed and recorded explosion took place (Green and Neuberg, 2005). This event resulted in clear, coherent signals (peak amplitudes up to ~100 nanostrain) on the 3 strainmeters then being recorded. The amplitudes and polarities of the strain signals from this event cannot be satisfied by a single Mogi-like source: two closer sites at similar distances (but different azimuths) record similar amplitudes but opposite polarities while the most distant site has amplitude less than one-fifth that of the nearer sites. The data are well satisfied by a small shallow dike striking N55W, consistent with geologic fabric, together with corresponding loss of pressure in the deep reservoir. Seismic activity accompanying the explosion does not commence until some minutes after the onset of the strain event, i.e. after the dike begins to form. Later, the magma chamber is re-pressurized. Analysis of strain changes taking place during dike growth but before any surface release allow an estimate of the bulk modulus of the magma reservoir and hence of gas phase content; this estimate is consistent with inferences from petrology.

Keywords: volcano explosion, strain, lava dome

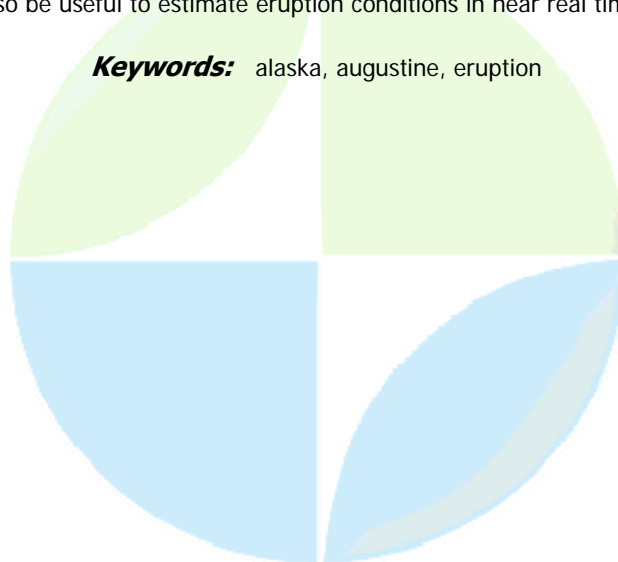
(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2440****Monitoring volcanoes in noisy urban areas: The Auckland Downhole Seismograph Experiment****Dr. Jan Lindsay***Geology Programme University of Auckland IAVCEI***Steve Sherburn, Peter Malin**

The Auckland Volcanic Field (AVF) is a small-volume, intraplate, monogenetic basaltic field located directly beneath New Zealand's largest city, Auckland (pop. 1.3 million). The Field is currently monitored by GNS Science/GeoNet via a network of five telemetered, vertical component short-period seismographs. Between 1995 and 2005, just 24 earthquakes were located in the Auckland region. The high level of surface noise in the AVF makes it difficult to record and locate small magnitude earthquakes; the existing network is only able to confidently locate earthquakes down to $c. ML \geq 2.5$. In an effort to overcome this problem, we have recently begun an experiment to compare the performance of downhole and traditional surface sensors at the same site. We have installed a downhole seismometer in a 250m-deep borehole located on the boundary of the AVF. Such a 250m-deep sensor may be able to detect earthquakes as small as $M 0.5$, which, following the Gutenberg-Richter law, could result in the detection of some 2,000 earthquakes over a 10 year period. This would represent a vast improvement on the number of recordable earthquakes, and has obvious implications for the early detection of any future AVF-related precursory seismicity. In the initial experiment phase, both downhole and surface seismometers were recording simultaneously for a period of 30 days between late November 2006 and late December 2006. During that time the borehole seismometer recorded six local events: five small ($< ML2$) earthquakes (or quarry blasts) and one $M 4.9$ earthquake originating 200 km southeast of Auckland, the latter being picked up by all GeoNet sites in the North Island. Of these six events, only two were recorded by the surface sensor: one of the small events and the $M 4.9$ earthquake. Borehole recordings were slightly higher frequency than the surface recordings and had shorter coda waves. Prominent on the borehole record from the $M 4.9$ earthquake was a wave reflected from the ground surface. The P-wave arrival at the borehole sensor was 0.10-0.12 s before the surface sensor, equating to a mean V_p over the top 250 m of 2-2.5 km/s. These preliminary results are very encouraging, and highlight the potential advantages of downhole sensors within a volcano monitoring network, particularly in a noisy, urban environment like Auckland. Further work will focus on maximizing the efficiency of the borehole seismometer (e.g. by sanding in the sensor) and ultimately installing more instruments, including in downtown Auckland, the heart of the AVF.

Keywords: downhole, seismograph, auckland

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2441****A geophysical study of the explosive eruptions of Augustine Volcano,
Alaska, January 11-28, 2006****Prof. Steve McNutt***Geophysical Institute University of Alaska Fairbanks IAVCEI***Steve Estes, Scott Stihler, Silvio De Angelis, Tanja Petersen, Guy Tytgat**

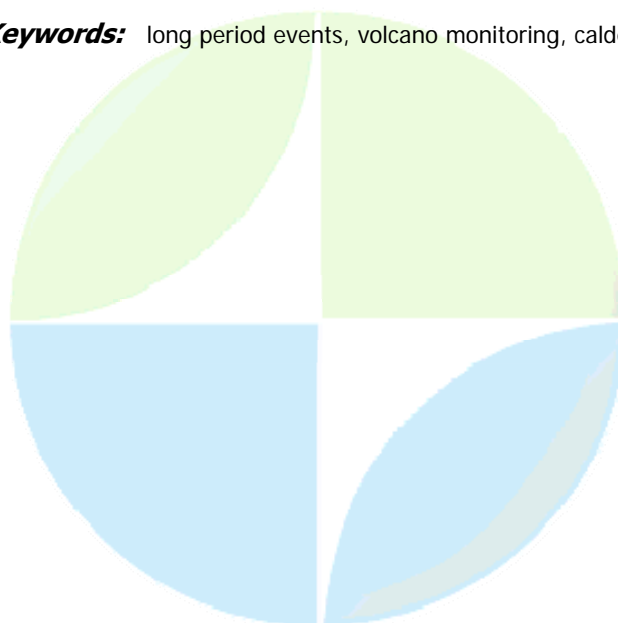
A series of 13 explosive eruptions occurred at Augustine Volcano, Alaska, from January 11-28, 2006. Each of these lasted 2.5 to 19 minutes and produced ash columns 3-14 km high. We investigated a number of geophysical parameters to determine systematic trends, including durations, seismic amplitudes, frequency contents, signal characteristics, peak acoustic pressures, ash column heights, and lengths of pre-event and post-event quiescence. Individual tephra volumes for the various eruptions are poorly known. In general, we find few strong correlations in the data set. However, several events stand out as being end members in their attributes. Two events (11 January 13:44 UT and 28 January 08:37 UT) are short (180 and 140 sec respectively) and have very impulsive and high acoustic peak pressures of 93 and 105 Pa, as well as high seismic amplitudes. We interpret these to be mainly gas releases, although some tephra was erupted. Two of the largest events followed quiescent intervals of 2 days or longer: 16 January 16:58 UT, and 28 January 05:24 UT. These two events had reduced displacements (DR) of 13.9 and 13.3 cm² respectively, larger than all others except the two gas release events cited above. While these DR values are typical for eruptions with ash columns to 9-14 km, most other DR values of 3.3 to 5.8 cm² are low for the 8-11 km ash column heights observed. The combination of short durations, small DR and high ash columns suggests that these events are more explosive than most other eruptions, in agreement with the Vulcanian eruption type. Several events had long durations and late bursts of energy on individual seismic stations but not on others; we interpret these to represent pyroclastic flows passing near the affected stations so that fallout of material from the cloud adds energy to the ground only near those stations. The eruption on 28 January 05:24 UT had abundant lightning, whereas two others that followed (28 January 11:04 UT and 16:42 UT) had very little lightning. The 05:24 UT eruption had a much longer duration (1180 sec compared to <460 sec for the others), a slightly higher ash column height (9 vs. 8 km) and higher acoustic peak pressure (83 vs. 66 and 24 Pa). The data suggest that the lightning-rich 05:24 UT eruption produced more tephra than the following eruptions, hence there were more charge carriers available. The parametric data outlined here are most useful when combined with other data to address specific research questions, and may also be useful to estimate eruption conditions in near real time.

Keywords: alaska, augustine, eruption

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2442****Seismicity associated with renewed ground uplift at Campi Flegrei Caldera, Italy.*****Dr. Gilberto Saccorotti****Sezione di Pisa Istituto Nazionale di Geofisica e Vulcanologia****Francesca Bianco, Mario Castellano, Maurizio Ciampi, Paola Cusano, Edoardo Del Pezzo, Danilo Galluzzo, Mario La Rocca, Simona Petrosino, Lucia Zaccarelli***

Following the huge ground uplift (1.8 m) of the 1982-1984 bradyseismic crises, the recent history of Campi Flegrei volcanic complex (Italy) has been dominated by a subsidence phase. Recent geodetic data demonstrate that such subsidence has terminated, and that ground uplift renewed in November 2004, with a low but increasing rate leading to about 4 cm of uplift by the end of October, 2006. As in the previous episodes, ground uplift has been accompanied by swarms of micro-earthquakes ($M < 1.4$) occurred during three distinct episodes on October 2005, October 2006 and December 2006. Hypocenters from these data are mainly located beneath the Solfatara Volcano, at depths ranging between 1 and 4 km b.s.l.. Inversion of S-wave spectra indicate source radius and stress drop on the order of 30-60 m and 10^4 to 10^5 Pa, respectively. Fault plane solutions indicate a dominance of normal mechanisms. Accompanying the October 2006 swarm, we detected intense Long-Period (LP) activity for about one week. These signals are represented by weak, monochromatic oscillations whose spectra depict a main peak at frequency ~ 0.8 Hz. This peak is common to all the station of the network, and not present in the noise spectra, thus suggesting that it mostly reflects a source effect. About 75% of the detected LPs are clustered into three groups of mutually-similar events. Least-Squares adjustment of differential times, obtained from Correlation Analysis, allows for precise alignment of waveforms, in turn permitting precise, absolute locations. Locations associated with the three different clusters are very similar, and appear to delineate the SE rim of the Solfatara Volcano at a depth of about 500 m b.s.l.. The most likely source process for the LP events involves the resonance of a fluid-filled, buried cavity. Quality factors of the resonator are clustered in a narrow interval around 4, which is consistent with the vibration of a buried cavity filled with a water-vapour mixture at poor gas-volume-fraction. A conceptual model is eventually proposed to interpret the temporal and spatial patterns of the observed seismicity.

Keywords: long period events, volcano monitoring, caldera



(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2443****Numerical Modeling of the Cyclic Pressure Change in the Magma Chamber of the Soufriere Hills during the Dome Collapse, July 2003****Dr. Taka'Aki Taira***Department of Geology and Geophysics University of Utah IASPEI****I. Selwyn Sacks, Alan T. Linde, Dannie Hidayat***

The lava dome collapse of the Soufriere Hill Volcano, Montserrat, occurred on July 2003. A network of borehole dilatometers observed a remarkable 20-minuted period oscillation. The strain amplitude ratios at sites at different distances indicated that the cyclic pressure change occurred in the magma chamber and lower conduit of the volcano. To examine the source mechanism of the oscillation, we adopted a simple magma chamber model (Ida, 1996) with a spherical magma chamber and a cylindrical conduit in an elastic medium. Magma is supplied into the conduit from below with a constant flux. We then derive an over pressure in the magma chamber when inflow exceeds outflow. For the numerical modeling of the pressure oscillation, the magma viscosity and the buoyancy (corresponding to difference in density between magma and host rock) were set to be 1 MPas (Voight et al., 1999) and 3000 Pa/m (Melnik and Sparks, 1999), respectively. Additionally the bulk modulus of magma and the rigidity of host rock were assumed to be 12.1 GPa (Sturton and Neuberg, 2006) and 4 GPa (Voight et al, 2006). To explain the observed oscillation period, the viscosity of host rock and radius of magma chamber ranges from 0.01 to 10 GPa s and from 40 to 700 m, respectively. Our numerical modeling suggests the over pressure in and constant flux into the magma chamber ranges from 0.02 to 16.0 MPa and 10 to 60 cubic meters/sec, respectively. Our estimation of these parameters is consistent with that of Voight et al. (2006).

Keywords: volcanic flow, volcano conduit, pressure oscillation

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2444****An amplitude battle: attenuation in bubbly magma versus conduit resonance****Mr. Patrick Smith***School of Earth and Environment University of Leeds IAVCEI***Jurgen Neuberg**

Quantifying the effects of attenuation in a gas-charged magma is critical in attempts to model the generation and propagation of low-frequency events, such as those on Montserrat, as a result of a resonating system triggered by brittle melt failure. In seismology, intrinsic attenuation is often quantified using the quality factor Q , and because of the nature of the material in a volcanic environment, values of Q may be much lower than elsewhere on earth. This study uses a finite-difference approach to model the seismic wave-field associated with low-frequency events in a viscoelastic medium. The attenuative behaviour of the magma (as function of frequency) is modelled by parameterising the material as an array of Standard Linear Solids (SLS). Synthetic signals are produced with a slowly decaying harmonic coda, comparing favourably with real examples of low-frequency events observed on Montserrat and elsewhere. Input values for the intrinsic attenuation of the magma within the conduit are compared to estimates of the attenuation calculated from the amplitude decay of the coda of the resultant harmonic signal. By considering the waveforms as a superposition of damped, reflected wavelets (including reflection and transmission coefficients at conduit ends) the Q values obtained from the codas were analysed. The results demonstrate that even with a highly viscous magma, with extremely low Q and hence high damping, a volcanic conduit can still support resonance. This provides further support for resonance following brittle melt failure as a plausible mechanism for low-frequency earthquake generation on Montserrat.

Keywords: volcano seismology, attenuation, resonance

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2445****Volcanic Activity Triggering due to Induced Pressure Changes in Magma Chambers****Dr. Selwyn Sacks***Department of Terrestrial Magnetism Carnegie Institution of Washington IASPEI***Dannie Hidayat, Alan T. Linde**

The observation that many volcanic eruptions occur on the same day as local or regional great earthquakes has been puzzling since the time of Darwin. Recent laboratory experiments and observations of magma chamber pressure changes during major dome collapses has given new insight into the possible mechanism for this eruption triggering. Magma ascending into a magma chamber from below is generally gas-saturated. As magma rises into the magma chamber, and the pressure is reduced, some gas may come out of solution but the remaining magma is super-saturated. Widely observed though not widely understood, is that shaking a super-saturated liquid causes gas to come out of solution, increasing the pressure. This effect is demonstrated in laboratory tests. This pressure increase has been observed during the July, 2003 major (210 million km³) dome collapse of the Souffriere Hills volcano in Montserrat. A small network of high sensitivity borehole strainmeters enabled the pressure in the magma chamber to be monitored. It was found that shortly (10 - 12 minutes) after vigorous vibration, observed by a seismic network, the magma chamber pressure increased. In May 2006, there was a 90 million km³ dome collapse which gave rise to a proportionally smaller pressure increase in the magma chamber, but with similar character and timing. If this is a general feature of super-saturated magmas beneath volcanoes, it would help explain the observed rapid triggering of volcanic eruptions due to earthquakes. In addition, the small earthquakes accompanying the pressure build up in magma chambers before eruptions, could cause further increased pressure leading to an eruption, i.e. a runaway situation develops.

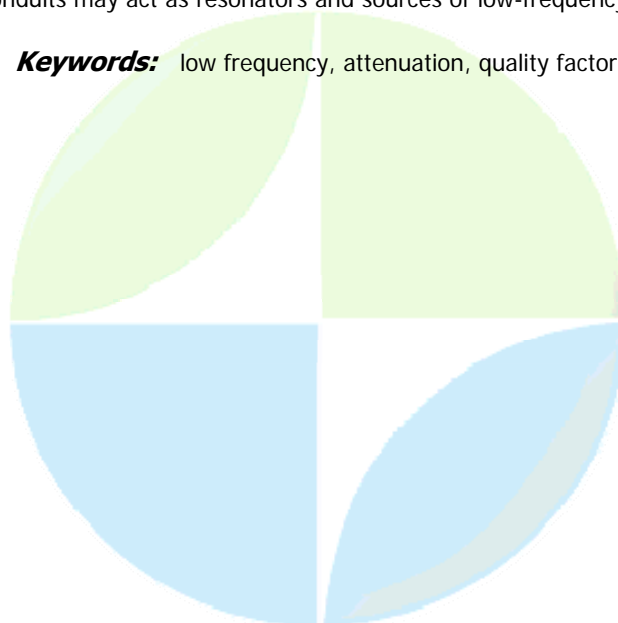
Keywords: eruption triggering, gas saturated, pressure increase



(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2446****Wave amplification in supersaturated bubbly magma****Mr. Ittai Kurzon***Geology, Institute of Earth Sciences Jerusalem, 91904, Israel IAVCEI***Vladimir Lyakhovsky, Nadav Lensky, Oded Navon**

A wave propagating through an ideal elastic medium maintains its initial energy and amplitude. The introduction of vesicles into the medium changes its acoustic properties, leading to two opposite effects: 1. Attenuation due to the inelastic properties of the vesicles; 2. Amplification due to the reduction in wave velocity. We examine two basic scenarios for wave propagation through visco-elastic bubbly magma: 1. saturated bubbly magma, where bubble radius oscillates around a constant value; 2. expanding supersaturated bubbly magma. In the first case, wave velocity is constant and waves are attenuated. We developed analytical asymptotic solutions and evaluated the role of volatile diffusion and melt compressibility on wave attenuation. In the second case, the magma is supersaturated and wave velocity decreases due to bubble growth, leading to an amplification effect. When the amplification effect overcomes damping, the amplitude of the waves increases. These two effects are examined analytically and numerically using a model that combines the theory of acoustic wave propagation in bubbly liquids (Commancher & Prosperetti, 1989) with the theory of bubble growth (Navon & Lyakhovsky, 1998). Wave attenuation is expressed in terms of quality factor, Q , which defines how well do propagating waves maintain their original amplitude, and is commonly calculated as the ratio between real and imaginary parts of the complex wave velocity. In supersaturated bubbly magma, the expression for the quality factor must include an additional term that accounts for the vesicularity-related reduction in wave velocity and the associated increase of wave amplitude. Our results indicate that amplification becomes significant when diffusion of volatiles from melt to bubbles is efficient enough, and when supersaturation and Deborah number are high (here, the Deborah number is the frequency times Maxwell relaxation time). In addition, it requires a narrow range of vesicularities. Very low vesicularity leads to insignificant effect and high vesicularity leads to strong attenuation that can be hardly overcome by the amplification effect. The amplification effect is important for modeling the interaction of seismic waves with magma-filled conduits and for the possibility that such conduits may act as resonators and sources of low-frequency earthquakes.

Keywords: low frequency, attenuation, quality factor



(V) - IAVCEI - *International Association of Volcanology and Chemistry***JVS004****Oral Presentation****2447****Numerical investigations of the seismic-acoustic coupling mechanism for long period events.****Mr. Robin Matoza***IGPP Scripps Institution of Oceanography IAVCEI***Milton Garces, Bernard Chouet, Luca D'Auria, Michael Hedlin**

The seismic long period (LP) event is commonly attributed to fluid oscillations in active volcanoes and is one of the most important signals in volcano seismology owing to its utility in short term eruption forecasting and its close relation to certain types of tremor. At Mount St. Helens, data from a portable array of broadband infrasound sensors collocated with a broadband seismometer at ~13 km range indicate that the process that generates LP seismic events intermittently generates infrasonic pressure signals that radiate away from the volcano through the atmosphere. Whenever present, the infrasonic LP events are shorter in duration and more impulsive than seismic LP events and lack a prominent long period coda. We summarize the observations and then present preliminary numerical investigations of the coupling mechanism between seismic and acoustic LP events using a 3D finite difference representation of the elastodynamic and acoustic wave equations, including the effects of topography and wind. We also consider the infrasonic wavefield generated by a pressure transient in a subsurface resonant steam-filled crack.

Keywords: infrasound, lp

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(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2448****Very-long-period signals observed immediately before a Vulcanian eruption accompanying pyroclastic flows at Tungurahua, Ecuador*****Dr. Hiroyuki Kumagai******Hugo Yepes, Masaru Nakano, Indira Molina***

Tungurahua, located near the center of the Ecuadorian Andes, is a large andesitic stratovolcano that has been erupting since 1999. In July-August 2006, Tungurahua reached the highest eruption activity, in which Vulcanian eruptions accompanying collapse-type pyroclastic flows repetitively occurred. The heightened eruption activity was observed by a permanent broadband seismic and infrasonic network deployed on the volcano. During the activity, three stations (BCUS, BMAS, BRUN) were in operation. A series of very-long-period (VLP) signals appeared about 20 minutes prior to the biggest Vulcanian eruption that occurred on August 17, 05:50 (UTC). This eruption and associated pyroclastic flows devastated the western flank of the volcano. The individual VLP signals are characterized by impulsive signatures with the characteristic period of 20-50 s. Since data from BCUS were contaminated by local noise originated from sustained eruptive activity before the biggest eruption, we used data from two stations (BMAS and BRUN) to estimate the source mechanism of the VLP signals. We performed waveform inversion in the frequency domain using an extended approach of Nakano and Kumagai [GRL, 32, L12302, 2005]. We assumed isotropic and horizontal and vertical crack point sources at each node point, where we performed a grid search in the azimuthal angle for a vertical crack. Greens functions were calculated by a finite-difference method with the topography of the volcano assuming a homogeneous medium with a compressional wave velocity of 3500 m/s, a shear wave velocity of 2000 m/s, and density of 2500 kg/m³. The computation of Greens functions was performed in the domain with lateral dimensions of 2000 x 2000 km and a vertical extent of 30 km to avoid the contamination of reflected waves generated at the domain boundaries. A uniform grid of 300 m was used in the calculation of Greens function and grid search in space. We used the observed displacement seismograms bandpassed between 20 and 50 s in our inversion. The inversion result indicates that an isotropic source at a depth of 3 km under the summit crater is the best-fit solution, although a vertical crack at a similar location also provides a small residual close to that of the best-fit solution. In any case, the inversion points to a volumetric source at a depth of 3 km under the crater. We interpret that the VLP signals were generated by a volumetric expansion caused by bubble growth in newly supplied magma at this depth. The magma containing bubbles further ascended along the conduit and resulted in the Vulcanian eruption accompanying pyroclastic flows. If we assume a closed conduit during the VLP event and accordingly lithostatic pressure at the VLP source, the magma beneath Tungurahua should initially contain the mass fraction of water at least 2.6-3.5 wt % for bubble formation to occur at the estimated VLP source depth. Here, we used Henry's constant of $9 \times 10^{-12} - 16 \times 10^{-11} \text{ Pa}^{-1}$ for an andesitic magma. The estimated water content is consistent with a petrologic estimation using Tungurahua's volcanic products.

Keywords: magma, degassing, eruption

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2449****Habits of a glacier covered volcano: Seismicity of the Katla volcano, South Iceland*****Mrs. Kristin Jonsdottir****Uppsala University, Geophysical department uu****Bjrn Lund, Roland Roberts***

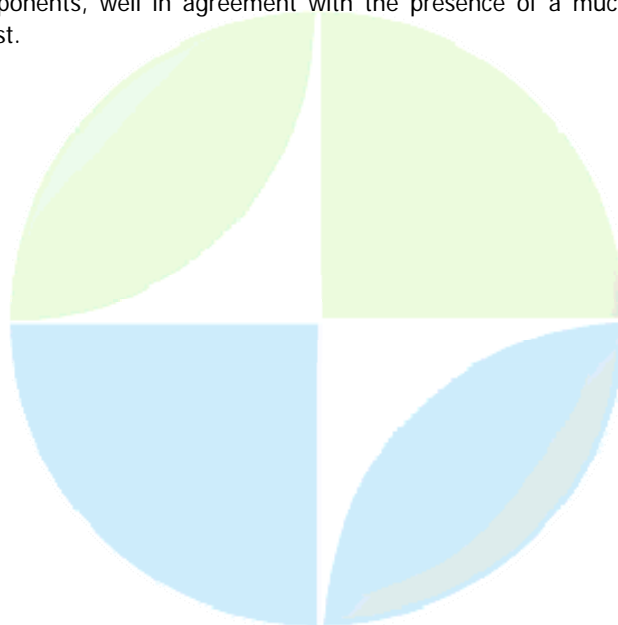
The Katla volcano, overlain by the Mrdalsjkull glacier, is one of the most active and hazardous volcanoes in . Earthquakes show anomalous magnitude-frequency behaviour and mainly occur in two distinct areas, within the oval caldera and around Goabunga, a bulge on its western flank. The seismicity differs between the areas. The caldera data show characteristics similar to many volcanic areas, but data from the Goabunga area is highly anomalous. The seismicity in both areas, but especially Goabunga, is clearly modulated by an outside factor, most likely the annual variations in the glacier. The seismicity increases in the autumn and reaches its maximum in July/August within the Katla caldera and in October at Goabunga, which is 2-3 months after the summer melt peak in July/August. This time delay, along with the temporal seismicity pattern (which resembles that of a homogeneous Poisson distribution), the low-frequency waveforms of the earthquakes at Goabunga and the inferred high permeability in the uppermost crust, suggest that neither hydraulic fracturing (from opening of new fractures) nor induced pore-fluid pressure (from melt-water, causing shear motion of existing fractures), is the mechanism causing the excess seismicity in the autumn. However the latter model might explain the induced seismicity within the caldera. Our results show a good correlation between the modelled snow loading/deloading but with a time lag since the minimum load occurs in September. The mechanism explaining the relationship between the annual variations in the Goabunga seismicity and the variations of the ice sheet remains unclear. Preliminary results of investigating the source mechanism of the low frequency Goabunga events suggest that they are very shallow and have a component of slow slip.

Keywords: low frequency earthquakes, seasonal seismicity, waiting time distribution



(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2450****Volcano seismology: shear-wave velocity models and complete earthquake source tensor in campanian volcanic areas (Vesuvio and Campi Flegrei)****Dr. Mariangela Guidarelli***Department of Earth Sciences University of Trieste***Gerardo De Nisco, Concettina Nunziata, Giuliano Francesco Panza**

We present a comparative study about the shear-wave velocity models and seismic sources in the Campanian volcanic areas of Vesuvio and Campi Flegrei. The velocity models for the Vesuvio and Campi Flegrei volcanic areas are obtained through the non-linear inversion of surface-wave tomography data, using as a priori constraints the relevant information in literature. Local group velocity data, obtained by means of Frequency-Time Analysis, in the period range 0.3-2s, are combined with group velocity data, in the period range 10-35s, obtained from regional events, located in the Italian peninsula and bordering areas, and two station phase velocity data in the period 25-100s. To invert Rayleigh wave dispersion curves we apply the non-linear inversion method, called hedgehog. In this way we retrieve average models for the first 30-35 km of the lithosphere, the lower part of the upper mantle being kept fixed on the base of existing regional models. At regional scale, i.e. for an area of 10 by 10, the inversion results indicate an average Moho depth of about 25 km, while the local scale inversion, in correspondence of the central parts of the two volcanic complexes (Vesuvio and Campi Flegrei), indicates the possible presence of a much shallower crust-mantle transition at about 15 km of depth. Another feature, common to the two volcanic areas, is a low V_s layer, centred at about 10 km of depth, while, outside of the cone, along a path in the north eastern Vesuvian area, this layer is absent. This low velocity can be reasonably associated to the presence of partial melting and therefore may represent a quite diffused crustal magma reservoir, which is fed by a deeper one, with regional character, located in the uppermost mantle. The obtained models are used to study earthquake source features by means of moment tensor analysis. The decomposition of the seismic moment tensor into double couple (DC), compensated linear vector dipole (CLVD), and volumetric (V) components is very suitable to investigate the physical processes within a volcano, related to magma or fluid movements. Although for many events the percentage of DC is high, our results show the presence of significant non-DC components for the events of the Vesuvio and Campi Flegrei area, the latter being characterized by the largest V components, well in agreement with the presence of a much higher percentage of fluids in the upper crust.



(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2451****Mechanics of dyke injection as resolved by seismicity (Piton de la Fournaise, Reunion Island)****Mrs. Paola Traversa***LGIT CNRS - UJF Grenoble - France IAVCEI***Jean Robert Grasso, Valrie Ferrazzini, Jari Rosti, Mikko Alava**

We discuss some hypothesis on the dynamics of dyke injections at volcanoes as imaged by Volcano Tectonic (VT) seismicity contemporary to dyke propagation at Piton de la Fournaise. High seismicity rates (~ 1000 events/hour) during the last few hours before an eruption are representative of the magma flow outward the storage system and towards the surface. By analogy with acoustic emissions (AE) produced by brittle damage during crack initiation and propagation in structural materials, we use the VT seismicity during the final stage before an eruption to constrain the mechanical response of the rock matrix to magma transfers. On these bases, we analyse seismicity patterns during seven dyke intrusions leading to eruptions at Piton de la Fournaise volcano (1988-1992). During the same period, ten days before eruptions, power law acceleration in seismicity rate was observed when stacking over all the eruptions (Collombet et al., 2003). In contrast, each of the dyke propagations is characterized by a constant seismicity rate in time, which argues for the intrusion of magma, and thus the fluid driven crack propagation within the volcanic edifice, to be a steady state process. Similarly seismic energy release, which follows the Gutenberg Richter law over three orders of magnitude, appears as constant in time with a possible slightly increasing trend when approaching eruption time. No correlation can be found between seismicity rates, seismic energy release, duration of the intrusion and erupted volumes respectively. Mechanical candidates able to reproduce these seismic patterns are creep process and quasi-static crack propagation.

Keywords: dyke, intrusion, seismicity

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2452****Time lapse seismic imaging of magma beneath Montserrat- a feasibility study****Prof. Larry Brown***Institute for the Study of the Continents Cornell University IASPEI***Melissa Stephenson, Rajat Maheshwari**

4D imaging of reservoir fluids, as developed in oil exploration, offers a potentially transformative tool for investigating deep magmatic systems. Deep seismic reflection profiling with surface sources, as well as analysis of reflected phases from microearthquake sources and converted phases from teleseismic sources, have revealed a number of deep crustal bright spots which have been interpreted as fluid, usually magma. Most of these examples are associated with magmatic systems or rift zones where magmatism is expected. The prominent nature of such fluids suggests that they not only should be mappable in 3D using exploration-type surveys, but that temporal changes might be detectable with time-lapse surveys. We have explored the feasibility of such detection using controlled sources by calculating the synthetic reflection response for both shallow (ca 5 km) and deep (ca 12 km) magma chambers suspected to exist beneath the active Soufriere Hills volcano on Montserrat, British West Indies. These reflection synthetics provide insight into the detectability of magma reservoirs of various shapes as well as variations in their shape due to inflation, deflation and cooling. Differencing synthetics (seismic interferometry) demonstrates that very subtle variations in magma chamber characteristics should be detectable if sufficient energy can be provided for illumination and sufficiently accurate source registration achieved. Both can be a challenge with high attenuation/scattering materials and difficult source/receiver coupling conditions. Integration of controlled source and earthquake source imaging may provide a practical strategy for quasi-continuous monitoring. Montserrat offers a number of particularly favorable factors for detection/modeling of deep magma. SEA-CALYPSO, an onshore/offshore experiment scheduled for late 2007 will provide a test of these methodologies.

Keywords: montserrat, reflection, magma

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2453****Towards a quantitative, seismic magma flow metre****Prof. Jurgen Neuberg***School of Earth and Environment The University of Leeds IAVCEI****Patrick Smith, Alix Poxon, Janet Key, Jess Johnson***

Low-frequency seismic swarms occur during periods of enhanced volcanic activity and have been related to the flow of magma at depth. Often they precede a dome collapse on volcanoes like Soufriere Hills, Montserrat, or Mt St Helens, however not each episode of swarm occurrence is followed by a collapse. This contribution is based on the conceptual model of magma rupture as a trigger mechanism but can also be applied to a model where low-frequency earthquake swarms are generated by a stick-slip motion in a shallow magmatic system. We discuss several source mechanisms and radiation patterns at the focus of a single event and model the energy partitioning between the low-frequency resonant part and the first motion observed at a seismometer. The seismic slip vector will be linked to magma flow parameters resulting in estimates of magma flux for a variety of flow models such as plug flow, parabolic- or friction controlled flow. In this way we try to relate conceptual models to quantitative estimations which might be helpful to assess magma flux at depth from seismic low-frequency signals.

Keywords: low frequency, magma flux

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I T A L Y

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2454****Fault plane orientations at Mt. Etna: inferences from the inversion of P polarities and rise times of small magnitude earthquakes**

Prof. Salvatore De Lorenzo
Geologia e Geofisica Universit IAVCEI

Domenico Patan, Marilena Filippucci, Elisabetta Giampiccolo, Carmen Martinez-Arevalo

A recently developed technique (Filippucci et al., 2006), aimed to infer the fault plane orientation of a small magnitude earthquake, has been applied to the seismicity recorded at Mt. Etna in the period 26 October 2002-5 December, 2002. The technique is based on numerically calibrated relationships among rise times of first P wave arrivals and model parameters (source radius, dip and strike fault, quality factor of the rocks). The relationships are based on a kinematical model of the source which assumes a circular crack rupturing at a constant rupture velocity. The inversion is performed in two steps. At the first step fault mechanisms are inferred from the inversion of P polarities using the classical FPFIT algorithm. At the second step rise times of first P wave arrivals are inverted by fixing dip and strike to the values of each nodal plane inferred at the first step. If a fault plane exists which gives rise to the best fit of data, independently on the noise affecting data, then this plane is considered the true fault plane. A statistically robust approach based on the use of the random deviates is used to evaluate how the noise on data affects the retrieved fault plane. Resolution of the inferred fault plane is evaluated by taking into account the coverage of the focal sphere, the data quality, the number of data and the increase in fitting when going from the auxiliary fault plane to the true fault plane. A grid-search method, based on both the assumption of Gaussian error on data and the use of a chi-square test, is used to a posteriori validate or reject the inferred solution. The studied events have been relocalized in the most recent 3D velocity model obtained from INGV (Patan et al., 2006). Ray-paths and take-off angles at the source have been computed using Simulps14 (e.g. Kissling et al., 2001). On each station, rise time and pulse width have been measured, together with their standard deviation, using a recently developed automated routine. Fault mechanisms for about 140 events of the dataset have been computed. The inferred solutions show a great variety of fault mechanisms. In some cases, owing to the limited number of P polarities and the scarce coverage of the focal sphere, multiple solutions have been found. After the inversion of rise times it was possible to image the fault plane orientation and the direction of motion at the source of 45 earthquakes. The obtained results are generally in a good agreement with the picture of the fault systems at Mt. Etna from previous studies. In particular there is a good correspondence with the surface fracturing occurred before and during the 2002 eruption, both in the northeastern sector (e.g. the NE Rift) and in the southeastern flank of the volcanic edifice (e.g. S. Venerina-S. Tecla Fault). In addition, the fault plane resolved for some events show orientations which are comparable with those inferred for the dikes. REFERENCES: Filippucci, M., de Lorenzo, S., & E. Boschi, (2006), Fault plane orientations of small earthquakes of the 1997 Umbria-Marche (Italy) seismic sequence from P-wave polarities and rise times. *Geophys. J. Int.* 166, 3223-38. Kissling, E., Husen, S., & F. Haslinger, (2001), Model parametrization in seismic tomography: a choice of consequence for the solution quality, *Physics of the Earth and Planetary Interior* 123, 89-101. Patan, D. De Gori, P. Chiarabba, C. & A. Bonaccorso, (2003), Magma Ascent and the Pressurization of Mount Etna Volcanic System, *Science*. 299. 2061-2063

Keywords: rise time, fault mechanism, mt etna fault systems

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Oral Presentation****2455****Premonitory seismicity patterns for moderate size earthquakes at Mt. Vesuvius****Dr. Antonella Peresan***Department of Earth Sciences University of Trieste IASPEI***Michela Rosso, Irina Rotwain, Igor Kuznetsov, Giuliano F. Panza**

A quantitative analysis of the precursory seismic activation preceding moderate size earthquakes at Mt. Vesuvius is investigated, based on the catalogue of the local earthquakes recorded at the station OVO, during the period 1972-2007. Although earthquakes occurring at Mt. Vesuvius are not particularly strong, due to their shallow depths and to the high urbanization of the area, they can cause significant concern and damages. Hence the possibility of intermediate-term prediction earthquakes with $M \geq 3.0$ at Mt. Vesuvius is explored by making use of the formally defined algorithm CN, as well as by considering the set of single premonitory seismicity patterns composed by CN functions of the seismic flow and by inter-event times distribution. The application of CN algorithm, that was originally designed to identify the Times of Increased Probability (TIPs) for the occurrence of strong tectonic earthquakes within a delimited region, shows that satisfactory and stable prediction results can be obtained, either by retrospective and forward analysis, when an appropriate time scaling is introduced. The prediction experiments based on individual functions of the seismic flow demonstrate that a certain predictability of moderate size earthquakes can be attained by means of some of the considered single seismicity patterns. Nevertheless CN algorithm, which is based on multiple seismicity patterns, outperforms individual functions, both in terms of total prediction error and of rate of false alarms. A similar analysis performed using a different catalogue of Vesuvian earthquakes, as recorded at the BKE station during the period 1992-2007, permitted to verify the significance of the obtained results. With these results acquired a system for the routine monitoring of the seismic flow by CN algorithm, aimed at forward diagnosis of TIPs for $M \geq 3.0$ earthquakes which may occur at Mt. Vesuvius, has been set up starting on March 2006.

Keywords: seismicity patterns, vesuvius, earthquake precursor

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2456****Seismic activity prior to the recent eruptions of volcano Nyamuragira,
Western Rift Valley of Africa****Mr. Mavonga Tuluka***Geophysics Centre de Recherches en Sciences Naturelles IASPEI***Sadaka K. Kavotha, Mifundu Wafula, Osodundu Etoy, Bizimana K. Rusangiza,
Jacques Durieux, Ndontoni Zana**

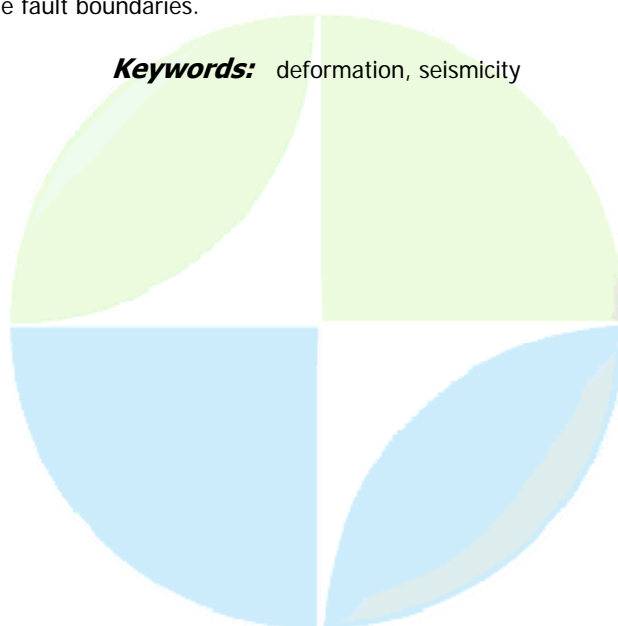
The spatial-temporal variation in the seismicity in the Nyamuragira area was examined for the period August 18, 2002 to May 7, 2004 and July 1, 2004 to November 27, 2006 prior to respectively the Nyamuragira eruptions of May 8, 2004 and November 27, 2006. It is found that seismicity exhibits similar tendencies. Swam-type seismicity composed mainly of long period earthquakes foreran by 2-4 months these eruption of Nyamuragira and were probably enhanced by tectonic seismicity related to rifting. Ten or eleven months before eruptions, a steady increase in seismicity at a constant rate from a deep magma feeder was observed. In the last stage (1 or 2 months) before the eruptions, the hypocenters of long-period earthquakes became shallower.

Keywords: seismicity, nyamuragira volcano, western rift valley of africa



(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2457****Volcanogenic deformations and related seismicity --- Pozzuoli, Rabaul and Usu ---****Prof. Izumi Yokoyama***Usu Volcano Observatory Hokkaido University IAVCEI***Dr. Giovanna Berrino**

Some volcanogenic deformations are closely related with volcanic seismicity in various ways. Such deformations are classified into two: One is caused by magmatic forces at depths and the other by displacements of magmatic bodies. In the present paper, volcanogenic deformations observed at Pozzuoli, Rabaul, and Usu are discussed mainly on published data. The first two are deformations at calderas which measure more than 10 km in diametral length, and are characterized by thick piles of caldera deposits, and the last is 1 km-1 km square and characterized by upward movements of dacitic magma. In all cases, their deformations are related with their seismicity, closely or moderately. In order to quantitatively compare the deformation with the seismicity, we treat the time-derivatives of both the deformation and the seismic energy release, which are interrelative in energetics. Actually the correlation between them are highly positive for Usu and Pozzuoli, and probably positive for Rabaul. Furthermore, to standardize the three cases, seismic energies released by unit volume of each area are compared. The necessary condition for such discussion is that the volume changes are accomodated only by seismic failure. It is verified by similarity between the trends of deformation and seismicity, and by the hypocenters directly related with the deformations, and by the focal mechanisms. We estimate the seismic energy releases accompanying an upheaval of unit volume in the three volcanic events: Pozzuoli (1983-1984): $1.5 \times 10^4 \text{ J/m}^3$, Rabaul (1981-1984): $3.3 \times 10^5 \text{ J/m}^3$, and Usu (1977-1979): $1.3 \times 10^6 \text{ J/m}^3$. The results vary in order of magnitude according to the tectonic conditions of the events. The caldera deposits of Campi Flegrei are easier to deform than those of Rabaul. This is compatible with that the secular subsidence of Serapeo in Pozzuoli is interpreted to be due to self-compaction of the caldera deposits which may behave rheologically. Rabaul caldera is not easy to deform by magmatic forces probably because of the existence of several post-caldera volcanoes within the caldera. The 1977 summit upheaval of Usu was accompanied with more releases of seismic energy than the two calderas because of strong resistance to the surrounding rocks. Actually it deformed in stick-slip motions at the fault boundaries.

Keywords: deformation, seismicity

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2458****Seismic activity of Ontake volcano, central Japan since December 2006*****Dr. Haruhisa Nakamichi****Graduate School of Environmental Studies Nagoya University IAVCEI****Fumiaki Kimata, Fumihito Yamazaki, Makoto Okubo, Mamoru Yamada, Toshiki Watanabe, Keiichi Tadokoro, Isao Yamada***

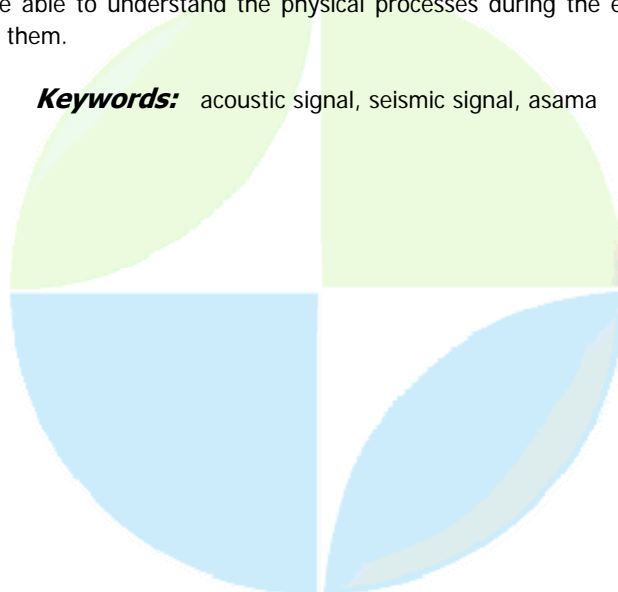
A dense seismic network has been operated around Ontake volcano, central Japan, by the Nagoya University, Nagano Prefecture, Gifu Prefecture, and the Japan Metrological Agency. Intense seismic activity just beneath the summit of the volcano started since the end of December 2006 and continued until now (February 2007). Volcano tectonic (VT) earthquake intensively occurred during the beginning to the middle of January 2007. Low-frequency earthquakes occurred and the daily number of VT earthquakes gradually decreased since the middle of January 2007. Volcanic tremors had been observed since the end of January 2007. The time history of the seismic activity consists with the generic volcanic earthquake swarm model [McNutt, 1996]. We applied the DD method [Waldhauser and Ellsworth, 2000] to obtain the detailed hypocenter distribution beneath the summit of Ontake volcano. The hypocenters distribute at the depths of 0-2 and 3-5 km just beneath the fumarole area (Jigokudani) near the summit of Ontake volcano. Several of the volcanic tremors associated with very long-period events (VLPEs). Waveforms of VLPEs consist of very long-period (20 s) signals. Seismic signals of the VLPE on January 25, 2007 observed at broad band stations of the Nagoya University and the F-net, some of which are 140 km far from the volcano. Particle motions of the broad band stations near the volcano consistent with the vertical crack source mechanism obtained by Kumagai et al. [this session]. Since January, we have gradually deployed the broad band stations near the volcano to capture VLPEs. A long-term data logging system [Okubo et al, 2006] has been operating at a broad band station.

Keywords: tremor, very long period event, low frequency earthquake



(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2459****Seismic and acoustic signals associated with the 2004 volcanic activity at Mt. Asama, central Japan*****Dr. Takao Ohminato****Volcano Research Center Earthquake Research Institute*

On September 1, 2004, Mt. Asama erupted for the first time in 21 years. Five summit eruptions occurred by the end of 2004. All the eruptions were moderate scale and were of the vulcanian type. Each event was accompanied by clear seismic and acoustic signals. We could record both seismic and acoustic signals for 4 of the 5 eruptions. Results of the waveform inversions of the seismic signals show that vertical single force components are dominant for all the events, indicating that the source processes are essentially the same for all the events. The excitation process of these vertical forces can be explained by the well-known model proposed by Kanamori et al. (1984). Although all the eruptions are of the vulcanian type, and the vertical single force components are dominant for all the events, the seismic and acoustic signals differ from event to event, not only in their amplitudes but also in their waveforms. The source time histories of the vertical single force component can roughly be divided into two types according to their characteristics. Seismic waveforms corresponding to these source time histories are also divided into two types. The waveforms of the acoustic signals also differ from event to event. However, the differences in the acoustic signals do not necessarily correspond to the differences in the seismic signals. Events whose seismic signals are classified into the same group are not necessarily accompanied by the similar acoustic signals. The differences seen in the seismic waveforms reflect the difference in the way the pressure that is accumulated just before the eruption at the top of the volcanic conduit is released. They also reflect the physical process following the pressure release, such as the linear momentum exchange associated with the mass movement in the conduit. On the other hand, the differences in the acoustic waveforms reflect the variation in the injection rates of the hot material into the atmosphere during eruptions. The observed differences in the waveforms of seismic and acoustic signals indicate that the physical processes, such as the pressure release rate from the conduit or the mass injection rates from the conduit to the atmosphere, are significantly different from eruption to eruption. From the source time histories obtained by the seismic waveform analyses, we infer the force system that is exerted on the conduit wall. From the acoustic signals, we infer the material injection rate from the conduit to the atmosphere. By combining these two different types of information, we will be able to understand the physical processes during the eruptions in detail more than using only one of them.

Keywords: acoustic signal, seismic signal, asama

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2460****Short time scale relationship between SO₂ flux and volcanic earthquake spectra: An example from Soufriere Hills Volcano, Montserrat, West Indies****Dr. Arthur Jolly***Wairakei Research Centre GNS Science IAVCEI***Steve Sherburn, Gillian Jolly, Philippe. Jousset, Venus Bass, Raquel Syers**

We examine the time relationship between SO₂ gas flux measurements collected by correlation spectrometer (COSPEC) and spectra from high resolution (broadband) earthquake data at Soufriere Hills volcano for the period 1 December 1996 to 25 June 1997, a period of full operation of a broadband seismic network on Montserrat. Over 1500 earthquakes used in the analysis were located beneath the volcanic edifice and had magnitudes ranging from 0.5-3.4 ML. These events were classified as either long-period, hybrid or volcano-tectonic with good signal to noise ratios in the frequency band 0.5-15 Hz. We calculate 1024 sample FFT (13.65 s) from the onset of these seismic events. The SO₂ data were collected by a ground based COSPEC using vehicular traverses under the plume at about 3 km distance from the vent. Measurements were made during daytime, usually between the hours of 10:00 and 16:00, but collection of good data were dependent on weather conditions. This results in an uneven sampling distribution with intervals between individual measurement times being as small as 15 minutes and as large as several weeks. Measurement errors for the SO₂ data are roughly 30% for each of the 251 independent SO₂ measurements collected. We compare the two data sets by subdivision of each dataset into equivalent time intervals and looking at the relationship between seismic spectra and the time associated SO₂ measurement. We will examine relationships for SO₂ data compared to both resonant (0.5-5 Hz) and non-resonant (>5 Hz) earthquake components by examining the correlation coefficient (R) of the individual seismic spectral bins from the FFT to the time associated SO₂ data. We also will examine time delays (phase lags) between the two time-series.

Keywords: earthquake, gas, volcano

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2461****Precise hypocenter determination of earthquakes beneath the summit caldera of Miyakejima Volcano, Japan****Dr. Hideki Ueda***Volcano Research Department NIED IAVCEI****Eisuke Fujita, Motoo Ukawa, Eiji Yamamoto, Tetsuya Jitsufuchi***

Hypocenter locations and focal mechanisms of volcanic earthquakes are important for monitoring a structure and stress state of magma feeding system under a volcano. However, difficulties of seismometer installation near an active vent sometimes prevent precise determination of hypocenters of the small volcanic earthquakes. We precisely determine hypocenters of high frequency earthquakes that occurred in Miyakejima Island, which is an active basaltic volcano about 170 km to the south of Tokyo, Japan. In the island, shallow earthquake activities ($M < 2$) have continued beneath the summit caldera, which is 1.6 km in diameter and 0.6 km in depth. Since a volcanic vent at the southern end of the caldera has been continuously emitting a large amount of volcanic gas since 2000, we cannot set up seismometers near the epicentral area. We extracted 27 groups of high frequency earthquakes that have similar waveform (multiplets) from 4702 earthquakes ($M > 0$) near the summit of Miyakejima during the period from June 2004 to December 2006. We used earthquake waveform records of 5 borehole seismometers and 6 seismometers established by National Research Institute for Earth Science and Disaster Prevention (NIED) and Japan Meteorological Agency, receptivity. Comparing the waveforms with high similarity and stacking the waveform, we can pick P and S phases more accurately than routine earthquake locations. Using the picked arrival times and phase differences obtained from cross-correlations of the waveforms, we relocated the 530 earthquake hypocenters by Double-Difference algorithm (Waldhauser and Ellsworth, 2000). The relocated hypocenters cluster 4 areas at the southwestern part of the caldera 0–3km deep. Focal mechanisms of the earthquakes show that the earthquakes are normal or strike-slip fault type and tensional axes seem to radiate from a point at the southwestern part of the caldera. The relocated epicenters are located around the high temperature area shown by the temperature image of VAM-90A (Airborne Multispectral Scanner) on November 4, 2004, and the tensional axes seem to radiate from the center of the high temperature area. GPS observations show a continuous contraction of the summit area explained by a contractive source at the southern part of the caldera about 3 km deep, suggesting a supply source of the volcanic gas and heat. We speculate that the crustal stress change by the contractive source probably causes the shallow earthquake activity. Acknowledgements: We thank the Japan Meteorological Agency for providing us with seismometer data.

Keywords: miyakejima, hypocenter, caldera

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2462****Long-period earthquakes in Bouillante hydrothermal system (Guadeloupe, French Antilles)****Dr. Philippe Jousset***Development Planning and Natural Risks division Researcher IAVCEI***Bernard Chouet**

We present evidence of sustained Long-Period (LP) seismicity at the Bouillante geothermal field, Guadeloupe, French Antilles. More than a year's worth of records from a permanent broadband seismometer reveal the existence of small repetitive superficial LP events (amplitudes, $1-5 \times 10^{-6} \text{ ms}^{-1}$); average repeat time, 15 - 40 s; frequencies, 0.5 - 10 Hz). To locate these earthquakes, we use the repetitive property of the source and sample ground motion with a second roving broadband seismometer recording for 20 minutes at each of 19 sites distributed within an area of $1 \times 1 \text{ km}^2$ near the permanent station. Using this approach we identify events recorded by the permanent station that are also recorded at some of the temporary stations. We locate these events by using four complementary techniques, namely, first-arrival phase picks, amplitude analyses (using both temporal and spectral amplitudes), polarity analyses using particle motions, and waveform inversion. The location of LP events coincides with an area where hydrothermal activity is manifested in anomalous He-gas emission on land, and sporadic 3-10 s-long submarine bursts of uncondensable gas at sea. This hydrothermal activity occurs along a major tectonic feature crossing southern Guadeloupe. These observations suggest that bubble cavitation may be the source of the LP events.

Keywords: hydrothermal fluids, long period seismicity, guadeloupe

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(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2463****Quantitative analysis of lp signals associated with recent activity of MT. Etna.****Dr. Bellina Di Lieto***Geophysics Department University of Salerno IASPEI***Saccorotti Gilberto, Lokmer Ivan, Bean Chris, Scarpa Roberto**

This work focuses on the study of Long-Period (LP) activity at Etna Volcano, Italy, during summer 2005. The ultimate goal is to retrieve the time-history of the moment tensor single-force components using a technique based on a search for the best fit between synthetic and observed waveforms for different source points within a volume encompassing the craters zone. Different intermediate steps are performed to achieve this goal. Data were recorded by a 16-element broad-band network composed by both permanent and temporary stations. LP spectra are characterised by several, unevenly-spaced narrow peaks spanning the 0.3-1.5 Hz frequency band. These peaks are common to all the recording sites of the network, and different from those associated with tremor signal. Polarisation analysis indicates a complicate pattern of particle motion orbits involving large amount of shear, which can be interpreted in terms of the radiation pattern from a non-isotropic source overprinted by propagation effects associated with the rough topography and shear-waves trapping in shallow soft layers. The waveform of LP is represented by weak pulses rapidly attenuating with distance, which maintain the same shape and spectral features noticed before the eruptive phase. Moreover, once band-pass filtered around the main frequency peak, LP signals show a common signature. These peculiarities point to the action of a non-destructive source process, stationary in time that we interpret in terms of the resonance of a fluid-filled, buried cavity. The waveform similarity is used to get consistent estimates of inter-event delay times, and to compute stacked waveforms. We first use correlation analyses to assess waveform similarity and high-precision differential times. For a cluster of similar events, we then use a weighted L2-norm adjustment of these time differences to obtain consistent alignment of waveforms. These times are then corrected for the visually-picked onset times of the stacked waveforms to obtain robust estimates of absolute P-wave arrival time. The location of the stacked waveforms and of individual LP events is made using a procedure which minimize the L1-norm between the observed and theoretical travel-times, using an homogeneous P-wave velocity structure. In order to define the confidence interval for such locations, we repeated the procedure adding random noise simulating errors in time readings and waveforms misalignment. All the hypocenters are clustered in a small volume located beneath the summit craters and extending between 400 m and 2000 m of depth. Concurrently with LP signals, recordings from the summit station ECPN also depict Very-Long-Period (VLP), radial and rectilinear pulses with characteristics period around 20 s. Using synthetic seismograms calculated for a 2D medium with topography, we evaluate the effects of the free surface on VLP particle motion trajectories, and use these data to correct the incidence angle of VLP polarisation vectors. The corrected VLP particle motions are consistent with a source located beneath the summit craters, at slightly greater depths than that inferred for the LP source. Following the resonating-source hypothesis, further investigations about the nature of the fluids sustaining the resonance process are possible with a detailed analysis of the dominant frequencies and decaying rate of LP waveforms. To this purpose we use the Sompi method, which is based on an auto-regressive equation. Due to its better resolution compared to Fourier-based spectral estimates, it becomes a good choice for the studies dealing with resonating sources. A signal is assumed to be a sum of a number of decaying (or growing) harmonic signals. Thus, in addition to the dominant frequencies of a signal we also obtain source Q-factors at those frequencies. They tell us about the time evolution of the physical properties of the fluid driving the source process. The most energetic part of signal consists of eigen-frequencies, spanning the

interval 0.4 0.8 Hz. Q factors take extremely low values, being lower than 5 at all the recording sites . These data indicate that a reduced impedance contrast between the resonating fluid and the hosting rocks hinders the efficient trapping of elastic waves at the fluid-rock interface. Following previous studies about the acoustic properties of magmatic-hydrothermal fluids, we infer that the LP-generating mechanism most likely involves water-steam or basalt-gas mixtures at very poor (<1-2%) gas-volume fractions. The knowledge of the source region make possible the implementation of the inversion procedure. We calculated the Greens functions at the different stations of the network for 16800 point sources spanning a ~ 1 km³ volume encompassing the LP source region. For these sources, we search for the model point and associated time histories which provide the minimum misfit between observed and predicted seismograms. The results indicate that the vibration of a rather shallow crack is the most likely source process generating the LP elastic waves.

Keywords: long period events, etna, volcano monitoring



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(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2464****Long Period Seismic Signals Observed before the Caldera Formation during the 2000 Miyake-jima Volcanic Activity****Dr. Tomokazu Kobayashi***Graduate School of Science ISV, Hokkaido University IAVCEI***Takao Ohminato, Yoshiaki Ida, Eisuke Fujita**

The 2000 Miyake-jima volcanic activity, which is characterized by a significant summit depression of the summit area, started on 26 June 2000. An intense earthquake swarm occurred initially beneath the southwest flank near the summit and gradually migrated west of the island. A few days later, a volcanic earthquake activity in the island was reactivated beneath the summit, leading to a summit eruption with a significant summit subsidence on 8 July. We detected unusual long period (LP) seismic signals with frequency peaks of 0.2, 0.4, and higher modes, suggesting an existence of a harmonic oscillatory, for several days before the caldera formation. In this study, their source locations and mechanisms were analyzed in a waveform inversion method. In the inversion, the source time functions of a single force and a moment solution were calculated at each of 3D grid points under the volcano and the optimal centroid position and mechanism of the source were determined so as to minimize the difference between the calculated and observed waveforms. Each waveform of the LP events consists of the two parts; initial impulsive signal with a period of about 2 s and the later oscillatory wave. According to the analysis, the initial impulsive pulse and the later oscillatory wave are well explained by a nearly horizontal single force and a moment solution, respectively. The single force for the initial pulse works firstly toward the north and then south at the depth of about 2 km beneath the summit. The moment source is located at the depth of about 5 km below a southern part of the island. We found a clear positive correlation of the amplitudes between the initial pulses and the later waves, strongly suggesting that single forces at shallow trigger the deeper moment sources in spite of several km distances between the two sources. The source time functions of the six moment tensor components do not always show the oscillations in phase. This source property requires us to develop a new analysis method in which three complex principal values that may represent the amplitudes and phases of oscillation are derived by the rotation of the coordinate axes for each spectral peak of the moment tensor in the frequency domain. According to the analysis, the two principal values have almost the same amplitude much greater than the third principal component, suggesting that the oscillation is axially symmetrical. One of the possible systems that meet the requirements for the moment solution may consist of two perpendicular cracks. We interpret that the single forces that triggered LP seismic events were generated when some magma mixed with rock blocks suddenly happened to move in a choked subsurface magma path below the summit, and the resulting pressure waves propagated and excited a resonance oscillation of the two cracks in the south region.

Keywords: long period seismic signals, miyake jima, source mechanism

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2465****b-Value spatial mapping at Mount Etna Volcano (Italy)****Dr. Maura Murru***Seismology and Tectonophysics Istituto Nazionale di Geofisica e Vulcanologia IAVCEI***Rodolfo Console, Giuseppe Falcone, Caterina Montuori, Tiziana Sgroi**

Mt. Etna is one of the largest and most active volcanoes on Earth. It is a composite strato-volcano located at the eastern margin of Sicily in southern Italy, where effects both of the slow convergence between Africa and Europe as well as Apennine tensional processes are observed. The evolution of the edifice is influenced by the regional tectonic setting and by local scale volcano-tectonic processes. The frequency-magnitude distribution was spatially mapped, in two and three dimensions, beneath Mt. Etna Volcano, Italy. We have used the gridding technique to investigate the heterogeneity of the crust up to 15 km depth. We analyzed a regional dataset of 2,900 well-located events with M_d (duration magnitude) ≥ 1.5 up to 15 km depth occurred between August 1999 and December 2005, recorded by the dense permanent seismic network on Mount Etna run by the Catania Section of the Istituto Nazionale di Geofisica e Vulcanologia. The dataset has been subdivided in five periods: 2001 pre-eruption (August 19, 1999-June 30, 2001), 2001 eruptive (July 1-30 August, 2001), 2002-2003 pre-eruption (September 1, 2001-October 24, 2002), 2002-2003 eruptive (October 25, 2002-January 31, 2003) and 2002-2003 post-eruption (February 1, 2003-December 31, 2005). The minimum magnitude of completeness and the b-value have been computed in each period. Two regions of anomalous high b-value have been found, one centered under the southern part of the "Valle del Bove", above the 6 km b.s.l. deep basement, and the other under the summit region at 2 km b.s.l. to the east of the Central Craters. The statistical differences between selected regions of low and high b-values are established at the 95% confidence level. We infer that these high b-values anomalies are regions of increased crack density, and/or high pore pressure, related to the presence of nearby magma reservoirs storages. All the available geophysical evidences (such as tomographic studies, geodetic deformation measurements) support this interpretation. This approach has allowed the detection of transient presence of magmatic intrusions during the period in analysis.

Keywords: b value, statistic, etna

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2466****Noise wavefield analysis in the Vesuvius area from array measurements****Dr. Rosalba Maresca***Dipartimento di Studi Geologici e Ambientali Universit del Sannio, Benevento, Italy IAVCEI***Lucia Nardone, Danilo Galluzzo, Mario La Rocca, Edoardo Del Pezzo**

Noise measurements were carried out in Terzigno, a small town that is located about 6 km from the Vesuvius crater, by a small aperture array. We applied the Spatial Autocorrelation (SPAC) method to the recorded noise, in order to calculate a surface velocity model of the area under investigation. This method is based on the hypotheses that the noise is a stochastic process, stationary both in time and space, and that the vertical component of motion is mostly composed of Rayleigh waves. Spatial averages of correlation coefficients calculated between the signals recorded at fixed distances and filtered in narrow-frequency bands were compared to the correlation coefficients evaluated over a long time interval for single station pairs, giving a good correspondence. This result appears to validate the hypothesis of a stochastic noise wave field in the area under investigation. The correlation functions estimated for the different distances as functions of frequency have allowed us to compute the Rayleigh waves dispersion function in the frequency band of 2-8 Hz, from which an S-wave velocity model was derived. The model obtained is consistent with previous results obtained at other sites on Mt. Vesuvius. To verify the hypothesis of a stochastic noise wave field we also applied polarization and f-k spectral analyses in selected frequency bands. The apparent velocities obtained from frequency-wavenumber analyses agree with results obtained from the dispersion analysis. The shallow nature of the noise wavefield is also confirmed by polarization analyses, which depict a dominance of horizontal components in the particle motion ellipsoid.

Keywords: seismic noise, array, vesuvius

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2467****Analysis of Erebus Volcano and its comparison with Stromboli****Dr. Mariarosaria Falanga***Physics Department-Salerno University Physics Department-Salerno University***De Lauro Enza, De Martino Salvatore, Palo Mauro**

We analyze long time series of Erebus volcano recorded by Mount Erebus Volcano Observatory (MEVO). In particular, we focus our attention on the data relative to broadband digital seismic network working since 1997. We investigate the velocity seismograms related to the explosions at the high frequency, i.e. [0.5-10] Hz. The analyses are performed looking at properties of the wavefield and the dynamic process underlying the volcano activity. We have two main goals: understanding the Erebus behaviour and comparing its activity with the standard Strombolian one. The wavefield analysis reveals a very inhomogeneous structure of Erebus volcano as already underlined by previous analysis (see e.g. Rowe et al., 2000). Though the apparent behaviour is very different from Stromboli, namely the two volcanoes show a different thermodynamic state and Erebus persistent tremor appears rarely, the presence of repeating exploding bubbles at the lava lake surface reveals a Strombolian-like behaviour. The analysis of inter-times between successive explosions shows that the underlying dynamic process is Poissonian, with a characteristic rate of about 6 hours. We remark that a Poissonian process is also responsible of the observed explosions at Stromboli volcano, characterized by a specific rate of about 3 minutes during 1997, indicating a more intensive activity (Bottiglieri et al., 2005). Moreover, it is possible to associate a dynamic map generating intermittency that well fits Erebus macroscopic dynamic evolution (De Lauro et al., 2007). M. Bottiglieri, S. De Martino, M. Falanga, C. Godano, M. Palo, Statistics of inter-time of Strombolian explosion-quakes, *Europhys. Lett.*, 72, 3, 492-498, 2005. doi: 10.1209/epl/i2005-10258-0; Research Highlights, *Nature Physics*, 1, December, 2005. Rowe, C. A., R. C. Aster, P. R. Kyle, J. W. Schlue, and R. R. Dibble, Broadband recording Seismic and acoustic observations at Mount Erebus Volcano, Ross Island, Antarctica, 1994-1998, *J. Volcanol. and Geoth. Res.*, 101, 105128, 2000. E. De Lauro, S. De Martino, M. Falanga, M. Palo, High frequency Strombolian-like activity at Erebus volcano, preprint 2007.

Keywords: erebus volcano, strombolian activity, poissonian process



(V) - IAVCEI - *International Association of Volcanology and Chemistry***JVS004****Poster presentation****2468****Hidden Dykes detected on Ultra Long Period seismic signals****Mr. Nicolas Houlie***Berkeley Seismological Lab. Berkeley Seismological Lab. IAG***Jean-Paul Montagner**

Broadband seismic data enable us to test whether Ultra Long Period (ULP) signals can be used to investigate magma chamber pressure state and to monitor volcanic eruptions. By systematically investigating seismic signals at GEOSCOPE station RER, we find ULP signals associated with volcanic events, during the last 2 decades. These events highlight the activity of the upper magma feeding system of the Piton de la Fournaise volcano and its relationship with the deep magma chamber. They are detected using STS1 seismometers sensitive in the bandwidth 10^{-3} to 10^{-2} Hz. Each event is quantified in terms of a pressure drop in the upper magma reservoir of the volcano. Two types of fracturing events are described in this study. The first one is related to the fast rise of a magma batch coming from the deep magma chamber and the second is the result of a slow rise in pressure inside shallow reservoirs. In both cases, we are able to detect these events on very long period seismic data. The interpretation of these signals supports the idea of a single magma source at the sea level. Thus, we propose to classify all the eruptions occurring during the last two decades into two groups, corresponding to the two primary pressure states of the magma chamber.

Keywords: volcanology, gps, seismology

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(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2469****Submarine volcanic activity in French Polynesia detected by the BBOBS array****Mrs. Aki Ito***Institute For Research on Earth Evolution JAMSTEC IASPEI***Hiroko Sugioka, Daisuke Suetsugu, Hajime Shiobara, Toshihiko Kanazawa, Yoshio Fukao**

T-waves associated with submarine volcanic activities were observed for the first time by broadband ocean bottom seismographs (BBOBSs) in the French Polynesia area. Along with the Japan-France cooperative project we deployed 10 BBOBSs in the French Polynesia area in a period from 2003 to 2005. All the BBOBSs were installed on the seafloor at depths of 4000-5000m with an average spacing of 500km. Each BBOBS was equipped with the Guralp CMG-3T broadband sensor that could record ground motions at periods from 0.02 to 360s. Swarms of T-wave events from submarine volcanic activities, as well as T-waves associated with local and global seismic activities, were recorded. In the northern part of our study area, typical T-waves were recorded at a BBOBS station near the Marquesas hot spot. They are accompanied by no obvious P or S waves. They have shorter durations and higher prominent frequencies than those of tectonic earthquakes. All of these characteristics are similar to those of volcanic T-waves reported by previous studies. Each of the repeated T-wave events has duration of 20-30s with an intermission of also 20-30s. Another type of T-wave events were also observed at several BBOBS stations in the southern part of the studied area around the Macdonald hot spot which is located in Austral islands. Each of the repeated T-wave events has duration of 60s or longer with an irregular intermission. In the presentation, we will report locations of the events in the southern part of the studied area in detail and discuss submarine volcanic activities in the French Polynesia area.

Keywords: t waves, submarine volcano, french polynesia

(V) - IAVCEI - *International Association of Volcanology and Chemistry***JVS004****Poster presentation****2470****Nature of low frequency earthquakes observed at Asama volcano: Time variation of wave parameters and hypocenter distribution*****Dr. Jun Oikawa****Earthquake Research Institute University of Tokyo IAVCEI****Yoshiaki Ida***

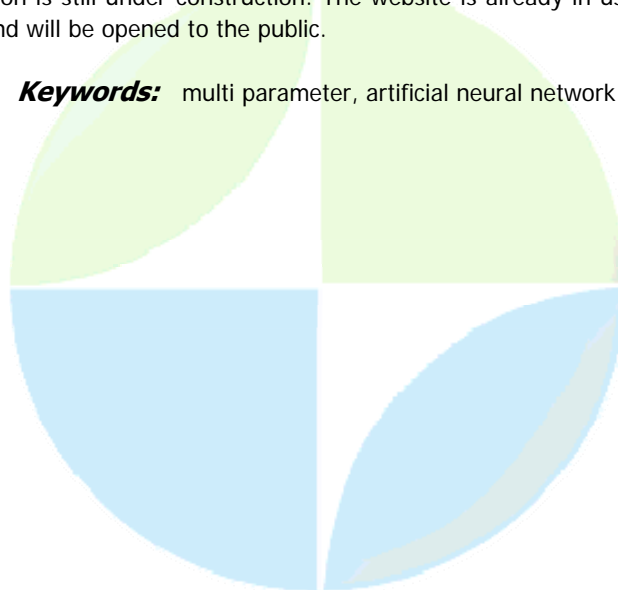
Long period (LP) events called N-type earthquakes are typical phenomena observed at many active volcanoes, such as Kusatsu-Shirane, Asama and Tokachi-dake volcanoes, which is probably related to activities of magma, ground water or volcanic gas and many source mechanisms such as resonance of fluid cracks or spheres and so on are proposed. In this study, we analyze the data of LP events observed at Asama volcano in Dec. 1-10, 1996 and show the features of the LP events revealing their source process by using the high quality data obtained by the seismic network close to the summit crater of the volcano. During the period, 112 N-type earthquakes were observed. The waveforms of these events seem to be a quasi-monochromatic oscillation whose amplitude is gradually decreasing. The spectrum has a dominant peak at 1.6-7Hz. Most of the events make a group in which the dominant peaks changes from 2.0 Hz to 1.6 Hz gradually. This means that the scale or the physical properties of the LP source changes gradually if we accept the resonance model. Attenuation factors have a positive correlation with dominant peaks, but the coefficient of correlation was small. Hypocenters of the events determined by the travel time of the first motion are concentrated into a shallow range within the depth of 300 m underneath the summit crater and are distributed in the upper part of the region B-type earthquakes occur.

Keywords: long period event, asama volcano, time variation



(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2471****The Krakatau volcano monitoring system (Indonesia)*****Dr. Malte Ibs-von Seht****Applied Airbourne and Ground Geophysica BGR****Rudolf Kniess, Claudia Khler, Arne Hoffmann-Rothe, Klaus Klinge, Eckhard Faber,
Christian Reichert, Mas Atje Purbawinata, Hendra Gunawan***

The joint Indonesian-German Krakmon project was developed to improve early warning procedures for volcano-induced risks in the Sunda Strait and the adjacent densely populated coasts of Sumatra and Java. In the scope of the project, BGR is running a multi-parameter monitoring system at Krakatau volcano (Indonesia) since 2005. The system is designed for long-term continuous monitoring of various geophysical and environmental parameters such as seismic signals, electromagnetic field, deformation, ground temperature, meteorological parameters, sea-level and chemical and physical parameters of fumarolic gases. Installations on the edifice of Anak Krakatau itself consist of three sites in a triangular setting around the volcanic cone. Each site is equipped with a short-period or broad-band seismometer and a differential GPS sensor, forming the backbone of the system. All measuring sites are connected by WLAN. The data acquisition centre is located on Java and receives the data streams via radio telemetry from the island. The observatory is integrated into the German Indonesian Tsunami Early Warning System by VSAT link, which allows for a near real-time access of the data via internet. Additional to the permanent installations on Krakatau, a network of nine temporary seismic stations in the Sunda Strait region had been operated for eight months in 2005/2006. Processing and analysis of the various data-streams is automated to a great extent. All data processed can be accessed through a web interface. One section of the interface displays the current data of the different sensors. Seismic data are automatically processed by an event detector and a subsequent artificial-neural-network based event type identification. This way, event statistics showing the current present-day counts for the different event types such as VT, LP, Tremor are updated and displayed every ten minutes. Events detected are indicated in seismogram dayplots, and they are also converted to audio files, which is an instructive means to demonstrate the varying spectral and amplitude properties of different signal types recorded at the volcano. Besides the online part, the web interface also allows to access archived data plots. These plots show the time series of the different sensors and event statistics in various time scales. This enables to study developments in the volcano's activity state easily. The data processing and web interface implementation is still under construction. The website is already in use in the laboratories of the project partners and will be opened to the public.

Keywords: multi parameter, artificial neural network

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2472****P- and S-wave velocity structure on Sao Miguel Island, Azores****Mrs. Dina Silveira***Centro de Vulcanologia e Aval. Riscos Geologicos Universidade dos Acores IASPEI***Carsten Riedel, Ari Tryggvason, Nicolau Wallenstein, Jess Ibez**

Located on the eastern segment of the Terceira Rift, the So Miguel Island (Azores) displays a high diversity of volcanic and tectonic structures, including three active trachytic central volcanoes with calderas emplaced in the intersection of the NW-SE to WNW-ESE regional faults with an E-W deep fault system. Owing to its tectonic setting and volcanic structures, seismic activity on So Miguel Island is high, with occurrences of numerous seismic swarms in the Fogo-Congro region, at the central part of Island. A local seismic network installed in the early 80s that has gradually been upgraded in terms of number of stations, the quality of location routines and detection capacity, especially during the last decade, is today operating in the area. From the period 1998 2005, 15,399 events in a 1,536Km² area circumscribing the So Miguel Island have been located. From this catalogue, a subset of 2,443 high-quality events has been selected for a P- and S-wave LE-tomography study using the PStomo_eq algorithm. Three initial 1D velocity models were tested and compared, including the one currently used in location routines by the local seismic network (SIVISA). A checkerboard test was performed showing that the resolution is good for the central and western part of the island. Due to the distribution of the events, the best resolution is obtained in the depth range of 3-10 km. Preliminary results show that high P- and S-wave velocities exist within Mosteiros Graben and Ribeira Grande Graben, intersecting Sete Cidades and Fogo central volcanoes, respectively. This could be interpreted as solidified magma bodies bellow those central volcanoes.

Keywords: le tomography, vp/vs ratio, azores



(V) - IAVCEI - *International Association of Volcanology and Chemistry***JVS004****Poster presentation****2473****Relations between volcanoseismicity and geoelectric signal variations in the Timanfaya Volcanic Zone (Lanzarote Island, Canary Islands, Spain) and the island hydrological system****Mr. Javier Carmona***Volcanology National Research Council IAVCEI***Ramn Ortiz**

Studies developed in the Timanfaya National Park (Lanzarote Island, Canary Islands) have shown a relationship between volcanoseismicity and geoelectric signals variations. These variations are the consequence of subsuperficial fluid circulation related with a geothermal anomaly area, located along fractures of the 1730-36 fissural eruption. The recorded seismic events are preceded by geoelectric signals variations with a good correlation degree, and when strong precipitations occur variations in the boreholes pressure are detected as well, demonstrating therefore, that seismic activity of Timanfaya is a consequence of subsuperficial gasses circulation mechanism. If isotopic analysis of the emanating steam from the detected zones of anomalies is taken into account, which indicates an important deep oceanic water contribution, the resultant geothermal anomaly area would be the consequence of two hydrologic systems of the island. In one hand, oceanic waters reach warm areas under the island, which presumably correspond to the supposed residual conduits of the mentioned eruption, and be heated ascending therefore along the fractures. More oceanic waters are supplied upwards where the system permeability allows it, until a level of influence of the subsuperficial hydrological system. This subsuperficial circulation system is strongly related with the rainfall conditions due to the aquifer inexistence, being responsible of the volcanoseismicity and the geoelectric signals variations.

Keywords: geoelectric signals, volcanoseismicity, geothermics



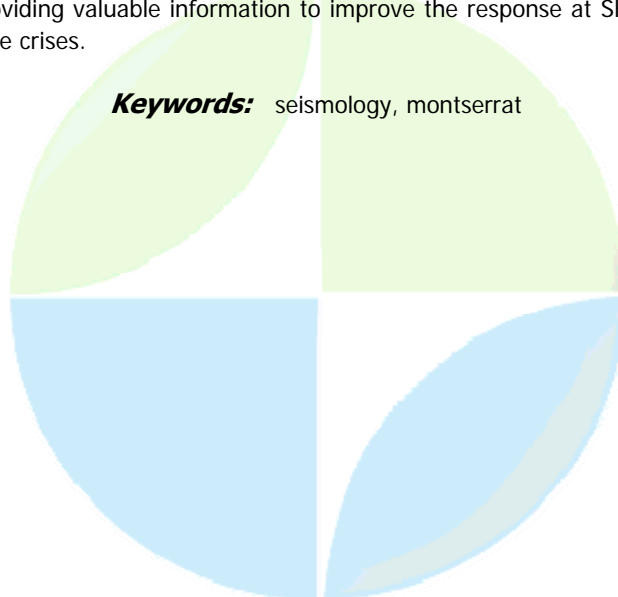
(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2474****Changes in seismic activity at Soufriere Hills Volcano, Montserrat and the increasing importance of rockfall seismicity for eruption monitoring*****Dr. Silvio De Angelis****Montserrat Volcano Observatory IAVCEI****Richard Luckett, Vicky Hards***

Soufriere Hills Volcano (SHV), Montserrat, is an andesitic dome building volcano. The current eruption started in 1995 and since then intermittent dome growth has taken place in the crater at top of the edifice. The entire eruption can be divided into three main episodes of lava dome extrusion and collapse. The first two phases took place between September 1995 and March 1998 and between November 1999 and July 2003. The third and ongoing phase started in August 2005. There are marked differences in the seismicity accompanying phases of dome extrusion and seismicity during the repose periods between them. The three phases of dome growth are also characterized by different levels of earthquake activity. Earthquake types recognised at SHV can be classified according to the following scheme: 1) volcano-tectonic (VT) earthquakes that have impulsive P-wave and S-wave arrivals and energy concentrated between 5 Hz and 10 Hz, 2) long-period (LP) events which are monochromatic, emergent signals with frequencies between 1 Hz and 2.5 Hz and are considered to be related to pressurization of the volcanic plumbing system, 3) hybrid earthquakes which exhibit features of both VT and LP having impulsive high frequency onset with a clear P-wave arrival followed by a monochromatic coda at lower frequencies, 4) rockfall events which are emergent broadband signals longer in duration than any of the other types and are often visually correlated with rockfalls or pyroclastic flows activity from the dome. Before the start and during the eruption at SHV in September 1995 many thousands of volcano-tectonic and hybrid events were recorded. After the first dome collapse there was very little seismicity. The start of renewed dome growth was preceded by increased earthquake activity but the overall level of seismicity was lower than during the whole of the first dome growth episode. Similar low levels of seismic activity have characterized the third and ongoing phase of the eruption. The seismicity associated with the movement of magma beneath the dome at SHV has decreased over the length of the eruption and is presently dominated by rockfall signals. Rockfalls are the effect of the dome growth rather than related directly to the movement of magma beneath the volcano. They currently provide the most efficient seismic monitoring tool for dome extrusion activity at SHV. The analyses of cumulative rockfall energy release has proven to be useful in detecting changes in dome growth and extrusion rates. It has been observed that higher extrusion rates make a collapse or explosive event more likely and that the extrusion rate often increases when the direction of dome growth changes. Monitoring rockfall activity can give the first indication of a possible new focus of dome growth, potentially to a more dangerous area.

Keywords: seismology, montserrat

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2475****Seismic characterization of pyroclastic flow activity at Soufriere Hills Volcano, Montserrat on January 08, 2007****Dr. Silvio De Angelis***Montserrat Volcano Observatory IAVCEI***Vicky Hards**

A moderated-size dome collapse episode with concurrent pyroclastic flow (PF) activity occurred at Soufriere Hills Volcano (SHV), Montserrat at about 10:00 a.m. UTC on January 8th, 2007. Pyroclastic density currents were observed to propagate from the Northwest and West sector of the summit dome into Tyres Ghaut and Gages Valley on the Northwest and West slopes of the edifice. Between 10:00 a.m. and 10:15 a.m. UTC the largest pyroclastic flow, was observed reaching a distance of about 5 km from the dome. At 10:25 a.m. UTC an ash cloud was reported to have reached 30,000 ft above the volcano by aviation authorities. Pyroclastic flow activity on the Northwest and West side of the edifice continued at high levels over the following 1.5 hours with run-out distances of individual flows limited to 1-1.5 km. Subsequent observations showed that material had been removed from the lower Northwest side of the dome in the area above the head of Tyres Ghaut leaving an amphitheatre-like structure cutting through the crater rim. The seismic waves excited by the propagation of pyroclastic flows were recorded by a network of broadband seismometers maintained by the Montserrat Volcano Observatory at SHV. The seismic records show the onset of a continuous signal, gradually increasing in amplitude as early as 09:30 a.m. UTC with energy in the 1-8 Hz band. This is believed to represent the progressive failure of slip zones along the boundaries of an unstable portion of the dome. As the slip became larger, the signal increased in amplitude until the collapse of the unstable front generated pyroclastic flows that descended along the slopes of the volcano. Large amplitude waves with broadband energy (1-25 Hz) were recorded from 10:00 a.m. UTC for about 15 minutes. The later stages of activity comprise a sequence of individual pulses well correlated with visual observations of PF and mild explosive activity seen in the images from a web camera installed in the proximity of the volcano. Each pulse has emergent character with no clearly defined seismic phases. PF are a major hazard at SHV and pose significant risk for the population living in the proximity of the volcano. They can occur with little or no warning and have the potential to reach inhabited areas. The study of the seismic activity associated with the generation and propagation of pyroclastic flows can help to identify characteristic precursory seismic sequences providing valuable information to improve the response at SHV and to mitigate flow hazards during eruptive crises.

Keywords: seismology, montserrat

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS004****Poster presentation****2476****Wavelet analysis related to eruptions of Colima Volcano, Mexico*****Mrs. Dulce Vargas-Bracamontes****School of Earth and Environment University of Leeds****F. Alejandro Nava, Gabriel A. Reyes-Davila***

To study the evolution in time of energy content at different scales of seismic signals preceding eruptive episodes, we analyzed by means of the wavelet transform, the seismic activity from one of the most active periods of the Colima volcano, from October 1998 to July 1999. During this analyzed period four significant volcanic events took place. An effusive stage began on November 20, 1998 and ceased about 80 days later changing to a period of intermittent explosions and continuous degassing. Significant large explosions occurred on February 10, May 10 and July 17, 1999 with eruptive columns as high as 10 km and incandescent blocks reaching distances about 5 km from the crater. Time-scale analysis performed for this period showed significant seismic energy concentrations at certain scales preceding significant eruptions, relative to non-eruptive stages. We present their implications for determining the impending occurrence of significant effusive or explosive eruptions, based on a quantification of the observed wavelet patterns. After 1999, small to moderate explosions have been presented at Colima volcano. During March to July, 2005 a sequence of relatively large explosions occurred, some having the largest amplitudes on their seismic signals since the seismic network was deployed. Further time-scale analysis of some of the large explosions occurred after those of 1999 will be presented as well.

Keywords: volcanic seismicity, wavelet transform, colima volcano

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JVS004

Poster presentation

2477

Assessing the factors that impact on the generation of volcano-tectonic earthquakes

Mrs. Dulce Vargas-Bracamontes

School of Earth and Environment University of Leeds

Jurgen Neuberg

Volcano-tectonic earthquakes are probably the earliest precursors of volcanic eruptions. To understand their relationship with magma emplacement can provide light to the mechanisms of magma transport at depth and help in the ultimate goal of forecasting eruptions. Volcano-tectonic events have been observed to occur on faults that experience increases in Coulomb stress changes as the result of magma intrusions. To simulate stress changes associated with magmatic injections, we test different models of volcanic sources in an elastic half-space. For each source model, we look at several aspects that influence the stress conditions of the magmatic system such as regional tectonic setting and the volume and rheology of the ascending magma, as well as the evolution of the magma with time.

Keywords: volcano tectonic, stress

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(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS005****2478 - 2480****Symposium
The 25 Anniversary of the El Chichn Eruption****Convener :** Dr. Dmitri Rouwet

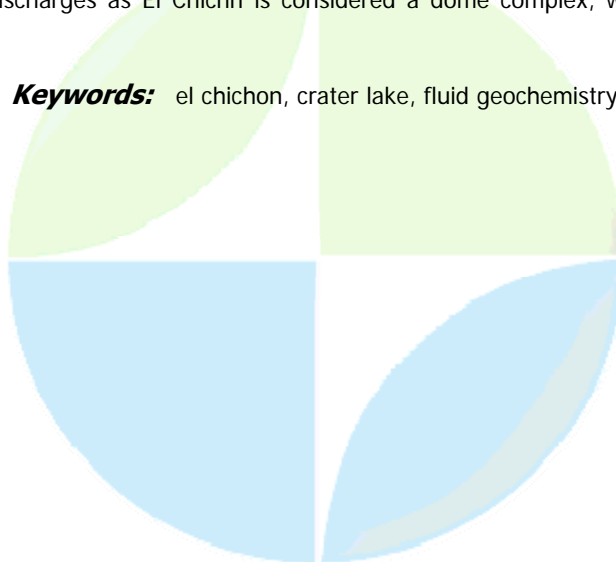
A dome-destroying explosion of a small dormant volcano named El Chichn occurred on March 1982 in Mexico. More than 1.5 km³ of the pyroclastics has covered a large area of jungle with many small settlements in the northern Chiapas State. More than 2000 people were killed. A 1-km wide, 250 m deep crater was formed, almost immediately filled with an acid hot lake. A special volume of JVGR has been issued in 1984, where papers were published on different topics related to the eruption, its impact and products. During a quarter of century after the eruption, volcanology has done a remarkable step forward, armed with new lab and field powerful tools. New techniques and computer codes have been developed for modeling volcanic plumes and pyroclastic columns and flows, magma generation and differentiation, volcano-hydrothermal systems, volcanic explosions and magma dynamics. Many new experimental works have been done on physical and chemical properties of magmatic rock and volatiles. A spectacular set of the high-resolution seismic tomography images obtained in the last couple of decades is available for demonstration of deep structures of convergent and divergent plate boundaries. The most of the mentioned new techniques were applied during the last 25 years for studying El Chichon volcano, its historical eruptions and other similar events occurred after 1982 like the 1991 eruption of Mt. Pinatubo and a decade of the eruptive activity of Montserrat. The theme of this session are new studies on the past, present and future of El Chichon volcano. We invite also works on volcanic hazard and impact, explosive volcanism, volcano-atmosphere interaction, volcano-hydrothermal systems, volcanic lakes, volcano tectonics, volcanic seismology and geophysics within environments close to that of El Chichon volcano. Contributions on the petrology and geochemistry of the alkaline subduction-type magmas are particularly welcome.

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(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS005****Oral Presentation****2478****Geochemistry of the El Chichn Volcano-Hydrothermal system****Dr. Dmitri Rouwet**
IAVCEI**Salvatore Inguaggiato, Yuri Taran**

The March-April 1982 Plinian events of El Chichn volcano breached through an active volcano-hydrothermal system, leaving a 1 km wide-200 m deep crater. A crater lake was formed shortly after the eruptions. This lake was highly acidic (pH ~0.5), saline (Cl ~24,000 mg/l) and hot (T ~55C), so a lake dominated by magmatic degassing. The lake evolved to a less acidic (pH ~2.5), less saline (TDS) and less hot (T ~30C) lake during the past 25 years. El Chichn crater lake is extremely shallow (max. 4.5 m) and variable in volume (from ~104 to >105 m³) and chemistry (Cl content from ~0 to 3,000 mg/l). These variations are due to the geyser-like behaviour of near-neutral boiling springs periodically feeding the lake with Cl-rich waters (Soap Pools). Chemical, isotopical and energy budget models give insight into seepage, evaporation, fumarolic steam condensation and meteoric precipitation processes of the El Chichn crater lake for the period 1995-2007. The residence time of crater lake water is extremely short (< 2 months). A dilution trend of Cl in time suggests the absence of new Cl-input into the shallow boiling aquifer below the crater floor, tapped by the geysers. The total heat power from the crater is estimated to be between 35 and 60 MW and the CO₂ flux is not higher than 50 t/day or 140 g/m²day. Additionally, ~100 MW heat is liberated from four groups of ~70C thermal springs on the S-SW flanks of the edifice. These thermal waters are of a Cl-SO₄ type and the pH ranges from near-neutral to ~2.2. At present, the recently discovered (June 2004) Agua Salada spring group discharges the most saline (Cl content up to >10,000 mg/l) and acidic waters of the entire El Chichn volcano-hydrothermal system. These extreme conditions might be due to an enhanced degassing below the western dome, outside the main crater. We suggest a direct connection between some of the spring groups and the crater lake. Despite the apparent transition to hydrothermal conditions for the El Chichn volcano-hydrothermal system, the fumarolic and crater lake and spring bubbling gases clearly have a magmatic isotopic composition for He ($^3\text{He}/^4\text{He}$ 7.40.7 Ra) and C ($\delta^{13}\text{C}_{\text{CO}_2}$ ~ -4). According to the crater lake and thermal spring chemistry, we believe the highly soluble species HCl and SO₂ are condensed in the deeper thermal aquifer feeding the springs, converting the crater lake into a Cl-free SO₄-enriched steam-heated pool in future. We still expect a dome to grow in the 1982-crater, which should be anticipated by changes in crater lake chemistry and dynamics. Nevertheless, monitoring should also focus on the spring discharges as El Chichn is considered a dome complex, with possibly one active dome at present.

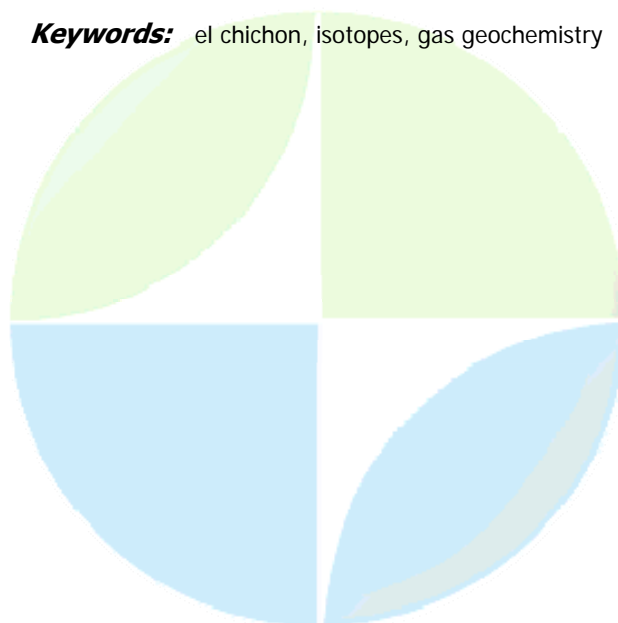
Keywords: el chichon, crater lake, fluid geochemistry

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS005****Oral Presentation****2479****El Chichn, the hinge between two large volcanic arcs: constraints from He-C-N Isotopic systematics****Dr. Dmitri Rouwet**

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El Chichn is the only active volcano of the Chiapanecan Volcanic Chain (CVC), a short (150 km) volcanic chain situated in Northern Chiapas (Mexico) in between the Transmexican Volcanic Belt (TMVB) and the Central American Volcanic Arc (CAVA). The He-C-N isotopic systematics of fluids from the El Chichn volcano-hydrothermal system can be related its geotectonic setting. At El Chichn, the He-C isotopic data were collected during the period 1995-2007; the d15N data were collected since 2006. The $^3\text{He}/^4\text{He}$ ratios of fumarolic and crater lake bubble gases are in the range or slightly higher (7.40.7 Ra, with Ra the $^3\text{He}/^4\text{He}$ ratio in air of 1.40×10^{-6}) than the ratios for both the TMVB (6.80.6 Ra) and CAVA (5.971.44 Ra; Hilton et al., 2002), suggesting the presence of a ^3He -enriched mantle wedge below El Chichn. The d13CCO₂ of El Chichn gases shows typical values for CO₂ of mantle origin: ~ -4 vs. PDB. The d15N values for crater gases range from +1.8 to +5.1 vs. air. The bubble gases at Agua Caliente thermal spring (SE flank of El Chichn) show slightly lower values for $^3\text{He}/^4\text{He}$ (5.30.3 Ra) and d15N (+0.7 vs. air), indicating a stronger atmospheric contribution for these peripheral gases. Confronting these data with regional tectonics (Manea et al., 2005), we think the ^3He -enrichment originates from the change in subduction angle of the Cocos Plate beneath the Isthmus area (Oaxaca-Chiapas) and beneath El Chichn volcano; magma is probably generated at higher depths for El Chichn. North of the Tehuantepec Ridge (TR), the Cocos Plate subducts at low angles affecting the volcanism of the TMVB. On the other hand, south of the TR, the Cocos Plate subducts at higher angles beneath the Northamerican and Caribbean Plates, the driving agent of CAVA volcanism. At first sight, the d15N values for El Chichn gases seem to correspond with subduction type gases in volcanic arcs, but, similar high d15N values for gas-oil strata in the El Chichn area are found. Something like adakites were suggested beneath El Chichn and slab melting might affect melt generation (De Ignacio et al., 2003). Further geochemical (rocks and fluids) and geophysical research is necessary to detail the exceptional tectonics and melt formation processes beneath El Chichn.

Keywords: el chichon, isotopes, gas geochemistry

(V) - IAVCEI - International Association of Volcanology and Chemistry**JVS005****Oral Presentation****2480****Geochemical monitoring of the Solfatara of Pozzuoli hydrothermal system (Campi Flegrei, Naples, Italy): what it is happening?*****Prof. Giovanni Chiodini****INGV-Napoli, Osservatorio Vesuviano INGV-Napoli, Osservatorio Vesuviano IAVCEI****Avino Rosario, Caliro Stefano, Cardellini Carlo, Frondini Francesco, Granieri Domenico***

Recurrent crisis characterized by seismic activity and ground deformation episodes (bradyseism) occurred over the last 30 years at Campi Flegrei (CF), a very dangerous volcanic system located in a densely inhabited area. A multi-parametric geochemical monitoring of the volcanic activity at Solfatara crater, the most active zone of CF, has been performed in the last ten years. The monitoring system includes: periodical sampling of the 3 main fumaroles; repeated campaigns of soil CO₂ flux measurements; continuous recording by two automated stations of CO₂ flux from soil, ambient parameters, heat flux and thermal gradient in soil; daily acquisition of thermal images by an automatic infrared camera. The interpretation of chemical and isotopic compositions of the fumaroles reveals that fluids result from a mixing of hydrothermal and magmatic components. Chemical-isotopic compositional variations since early 1980s can be explained by the increase of the input rate of CO₂ rich magmatic gases during the bradyseismic crises, causing a peak of the XCO₂/XH₂O ratio, which is observed at the surface some months after the injection. Three clear XCO₂/XH₂O peaks were observed in concomitance with the bradyseismic crisis of 1982-84, 1990 and 1996. After 2000, the fumarolic XCO₂/XH₂O ratios shows a slow increasing trend which suggests a progressive increase of the magmatic component of the fumaroles. This slow compositional change is accompanied by a large expansion of the area interested by anomalous CO₂ degassing (DDS). In particular, since July 2000 the DDS expanded from about 450,000 m² up to about 1,000,000 m² of April 2004, with a main increase in the eastern outside-cone area, in correspondence of a main fault NE-SW oriented. In this areas the background soil CO₂ flux population passed from 20 up to 80 gm-2d-1. A detailed investigation on the isotopic composition of the CO₂ emitted by soil proved that this increase in the soil CO₂ mean values of the background is caused by the new arriving of hydrothermal-volcanic CO₂ in areas previously not affected by the deep source. Other geochemical anomalies were detected more recently by an automatic soil CO₂ station located in the same NE-SW which showed a strong and sudden increase in the CO₂ fluxes the 1st November 2006, few days after the occurrence at shallow depth of a swarm of LP events. The role of the hydrothermal vs magmatic systems in the genesis of these signals detected by the monitoring system and the implication on the surveillance of the volcanic activity at Campi Flegrei will be finally discussed.

Keywords: volcano, degassing, geochemistry

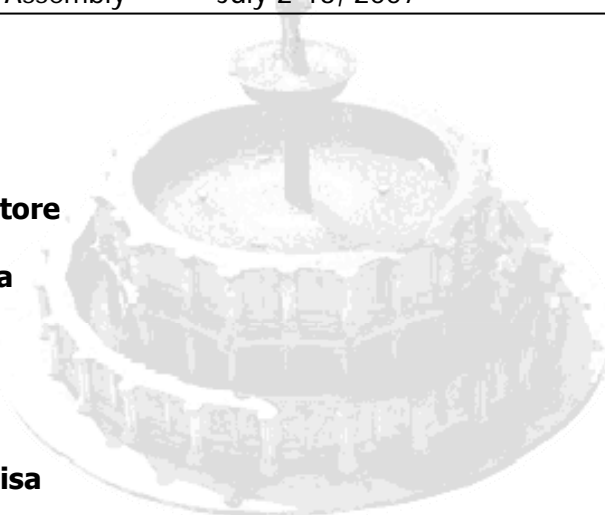
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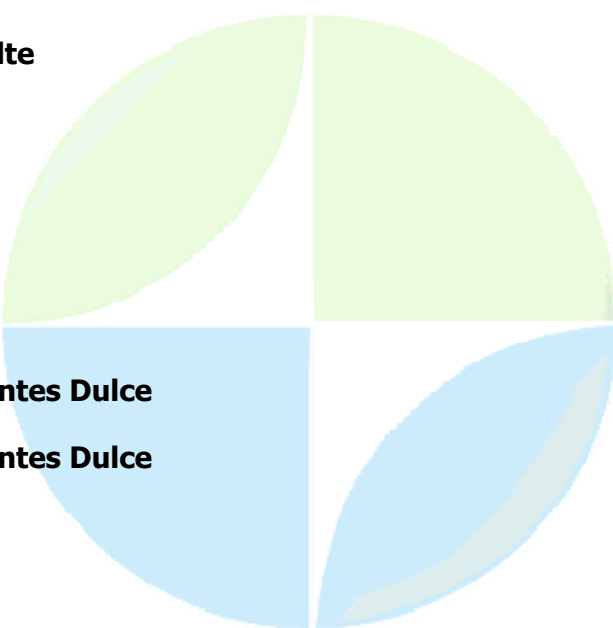
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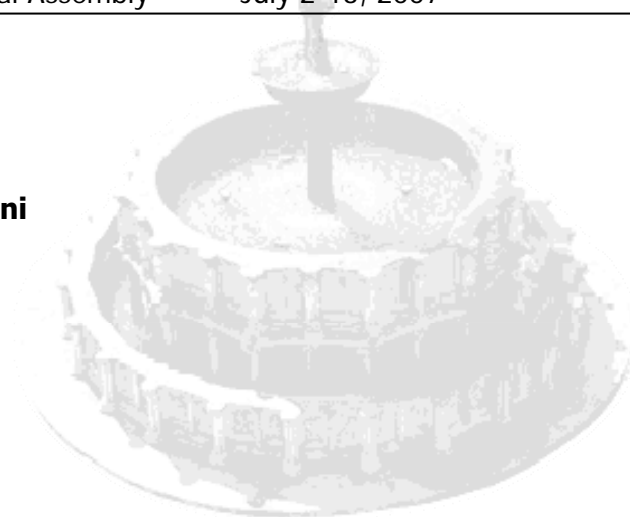
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