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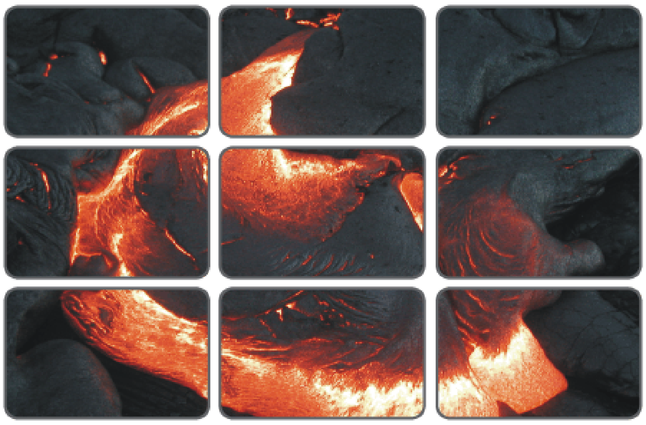
VOLCANIC RISK SOLUTIONS



North Island Volcanic Risk Symposium

9 am - 4 pm: 4 August 2006
Te Manawa, 396 Main Street, Palmerston North

Convenor: Dr Shane Cronin

After two years of research progress on our FRST-PGST funded project this is an opportunity to discuss our latest research results. It will also be a meeting to develop an effective work-plan for the next two years and identify new areas of collaboration with other researchers and organisations in New Zealand. Since we are experiencing an influx of new PhD and MSc students for 2007-08, it is important to coordinate their studies with other universities and the present gaps in our knowledge of volcanic hazards.

Agenda

0900-0915	Welcome and introduction
0920-1020	Volcanic group Research presentations
1020-1040	Morning tea – provided
1040-1240	Volcanic group Research presentations
1240-1320	Lunch – provided
1320-1420	Contributions/presentations from other researchers/participants
1420-1450	Discussion of research results
1450-1500	Afternoon tea – provided
1500-1550	Future research aims and collaborations – a 2-year plan
1550-1600	Closing

Presentation schedule

Prof Russell Tillman	Welcome
Dr Shane Cronin	Learning to live with volcanic risk and Massey Volcanic Risk Solutions

Technical presentations - AM

Magmatic/eruption processes	
Dr Bob Stewart	The tale of Xenoliths from the sub-volcanic lithosphere of Mt Taranaki
Prof Richard Price	Processes and timescales in andesite volcanoes
Mr Thomas Platz	Reconstructing eruption mechanisms of Mt. Taranaki
Mr Michael Turner	Eruption types and triggers at Mt Taranaki – mineral chemistry evidence
Ms Anja Moebis	Pyroclastic eruptions from the Tongariro Volcanic Centre
Volcanic mass flows	
Ms Anke Zernack	A history of growth and collapse of Mt Taranaki
Ms Suzy Cole	Understanding the internal dynamics of lahars using geophysical techniques
Mr Matt Irwin	Remote-sensing classification of unstable areas on Mt Tongariro
Dr Shane Cronin	Pyroclastic-flows and hazard mapping at Ngauruhoe
Hazard mapping and forecasting	
Mr Jon Procter	Numerical modelling tools for volcanic hazard assessment
Dr Mark Bebbington	Probabilistic eruption forecasts for Mt Taranaki
Industry volcanic risk implications	
Prof Vince Neall	Ascertaining Volcanic Risk to Infrastructure in Taranaki
Mr Ian Chapman	Assessing the volcanic risk to the Taranaki energy distribution sector
Mr Tom Wilson	Volcanic hazard implications for the Dairy Industry
Ms Coral Aldridge	Economic loss estimations for volcanism at Mt Taranaki
Volcanic emergency management	
Dr Jerome Lecointre	TARANAKI AWAKENS! - An emergency management eruption scenario
Dr Karoly Nemeth	Lessons for volcanic emergency management from the 2005 Ambae caldera-lake eruption

Other North Island volcanic risk presentations - PM

Assoc Prof David Lowe	Micro-tephras/cryptotephras in New Zealand lake cores
Dr David Johnston	Joint GNS-Massey Disaster Management Centre
Dr Richard Smith	Volcanic hazards research at University of Waikato
Dr Martha Savage	Changes in seismic wave propagation related to eruptions of Mt. Ruapehu Volcano: Anisotropy and attenuation
Dr Vern Manville	Instrumenting the Whangaehu channel in preparation for a lahar
Mr Colin Lawrence	GIS applications in the Tongariro National Park and ERLAWS

Abstracts

The tale of Xenoliths from the sub-volcanic lithosphere of Mt Taranaki

Bob Stewart

Mount Taranaki is located 140 km west of the Taupo Volcanic Zone, lies 180 km above the Wadati-Benioff-Zone and represents the most westerly expression of subduction-related volcanism on the North Island of New Zealand. It is a high-K arc volcano and is compositionally predominantly basaltic andesite to andesite with minor dacite and basalt. The sub-volcanic basement under Taranaki is thought to comprise calc-alkaline plutonic and metamorphic rocks of the Median Tectonic Zone (MTZ), overlain by a sequence of Cretaceous and Tertiary Sediments. There is geophysical evidence of a change to lower velocities at 10 km depth across a narrow zone beneath the volcanic edifice. A xenolith suite from Taranaki has been initially grouped into six categories based on petrography, geochemistry and inferred genetic relationships; sedimentary rocks (1), mafic hornfels (2), garnet gneiss (3), granite and granodiorite (4), finely banded amphibolitic gneiss (5) and gabbros and ultramafic rocks (6). Groups 1, 3 and 4 are exotic lithologies derived from the MTZ basement and Cretaceous-Tertiary sediments of the Taranaki Basin while Groups 2, 5 and some fine grained gabbros from Group 6 could either be derived from the MTZ or be cognate xenoliths. Group 6 gabbros and ultramafic rocks are dominated by clinopyroxene, amphibole and plagioclase and are predominantly cognate in origin. Rare dunite and wehrlite xenoliths are only found in basaltic andesites and may represent cumulates from more primitive basalts. Some xenoliths contain glass of rhyolitic to trachyitic compositions with up to 6 % K2O that may represent partial melts of the sub-volcanic lithosphere.

Processes and timescales of volcanism at North Island andesite volcanoes

Richard Price

The past 3000 years of eruptive history at Ruapehu is recorded in ash deposits of the ring plain surrounding the volcano and these indicate repeated relatively small eruptive events, similar to those of 1995/96 every 50-100 years. The 200-300 thousand year prehistoric record is contained in thick lava flow sequences that make up the present day cone. Detailed geochemical studies of these deposits can be interpreted to show that the sub-volcanic plumbing system feeding eruptions is a complex of small dyke and sill-like storages, not a simple large magma chamber. The 1995 – 1996 eruptions of Ruapehu were the largest and best sampled events since the dome – forming eruptions of 1945. Nonetheless, the eruptions were small in global terms (< 0.02 km3) and entirely pyroclastic. Collectively, samples from the eruptions over the past 60 years display a spectrum of chemical compositions covering much of the range shown by the prehistoric record, extending back 150 ka. The temporal variations in isotopic and trace element variation for lavas erupted between 1945 and 1996 are systematic and, in comparison with prehistoric eruptives, they provide the basis of a model for predicting future eruption patterns

Reconstructing eruption mechanisms of Mt Taranaki

Thomas Platz

The last 1000 years of volcanic activity of Mt. Taranaki is characterised by predominantly extrusive, lava-dome building and collapsing episodes. However these low-violence eruptions have concluded in one instance with a major explosive, sub-plinian eruption and in another case a highly explosive “blast”. A sudden shift from effusive to explosive eruptive styles is a major consideration for hazard assessment for the Taranaki peninsula as well as the entire North Island. Results presented outline reconstructions of representative eruptions of Mt. Taranaki over the last 1000 years, demonstrating variations in high-level magmatic processes as potential causes of the sudden changes in eruptive violence. Another outcome of the studies has been the development of an overall petrogenetic model for the Taranaki rock suite that constrains key data such as magma storage levels, magma ascent rates and changes of magmas during ascent.

Eruption types and triggers at Mt Taranaki – mineral chemistry evidence

Michael Turner

Much of the current edifice of Mt Taranaki was constructed during approximately 7000 years of eruptions. The main objective of this research is to compile a complete eruption record for this time period and to use this record to shed some light on Taranaki's magma system. A record of open-vent and closed-vent eruptions (events) has been determined by both identifying the different deposits at proximal, on-mountain sites and using glass shard and titanomagnetite features to distinguish each type from distal ash-fall deposits. Initial analysis of this record shows that individual events can be grouped by geochemistry and time into 'eruption episodes'. Mineral chemistry evidence indicates that each episode was initiated by the influx of new and more mafic magma to the base of the magma system. Detailed trace element geochemistry and the completion of the eruption database within the next few months will help elucidate overall trends and cycles within the volcanic magma system during the past 7000 years of Taranaki eruptions.

Pyroclastic eruptions from the Tongariro Volcanic Centre

Anja Möbis

From previous studies we have inherited a comprehensive record of the history of large volcanic events from the main eruptive centres of the Tongariro Volcanic Centre, along with basic geochemical information. There has been a large range in eruption types and scales from this centre, but normally the smaller eruptions have been grouped together as single stratigraphic "formations". The two main thrusts of this study are to (1) provide more detail of the frequency and nature of the poorly studied small eruptions, and (2) elucidate the physical processes/column heights and tephra distributions of the range in eruptions possible at this centre. Initial work has focused on sampling tephra layers within the Mangatawai and Tufa Trig Formations and analysing their grain-size distribution, mineralogy, and particle shapes. The Mangatawai Formation, originally defined in 1974 and effectively ignored since, actually contains >30 layers, each of which represent individual eruptions over a c. 500 year period. Also, the Mangatawai Fm was long thought to represent the eruption history of Mt Ngauruhoe, but grain-size data show that between 20-50% of the units were probably erupted from Ruapehu.

A history of growth and collapse of Mt Taranaki

Anke Zernack

The last 150,000 years of volcanic activity from Mt. Taranaki are marked by alternating phases of edifice construction and collapse. These events are recorded in distal ring-plain successions exposed along the southern and northern coast of Taranaki. The main aims of this project are to (1) reconstruct the early history of Mt. Taranaki, (2) characterise the evolution of the magmatic system from its beginning to now, in order to (3) better understand the processes and driving forces behind the volcano's cyclic behaviour. Detailed mapping of the coastal sections involved the correlation of mass flow deposits and their sedimentological classification to interpret their diverse origins, varying emplacement mechanisms and depositional conditions. Accumulation during constructional phases seems to be marked by massive sequences of lahar and hyperconcentrated flow deposits rich in pyroclastic fragments. Intervals of quiescence separating these eruptive periods are represented by paleosols and complex channels of reworked volcaniclastic sediments formed by intense fluvial erosion. By contrast, destruction/degradation episodes are represented by coarse polylithologic debris flow and debris avalanche deposits which form due to partial or complete failure of the edifice. The study reveals a higher frequency of cycles of growth and destruction than previously thought, with at least 10 catastrophic collapse events occurring during the last 130 ka. But although large sector collapses and the generation of debris avalanches represent the greatest hazard at this stratovolcano, they are far less frequent than other, similarly long-runout mass-flows produced during construction phases. In order to forecast future hazards from these types of volcanoes, it is extremely important to understand their cyclic nature as well as the point of the cycle which we are currently in.

Understanding the internal dynamics of lahars using geophysical techniques

Suzy Cole

Lahars, or water-containing mass flows, pose a great threat to communities that live near river channels on volcanoes. The internal dynamics of these lahars are not well known, neither are the sediment-concentrations or sediment-distribution gradients within them. This is mostly because it is impossible to “see” inside a moving lahar. New monitoring or “imaging” systems to fill this knowledge gap were tested earlier this year at Semeru, Indonesia, which is prone to semi-daily lahars during the rainy season. Equipment used to measure the flows as they passed included: a three-component broadband seismometer, a water conductivity probe, a load-pressure plate, and two acoustic flow monitors (AFMs). Along with the aim of measuring moving flows, the field work also allowed for the experimentation of the effectiveness and reliability of the equipment; variants of which are to be installed in the Whangaehu River, Ruapehu. Several problems were highlighted with equipment installation, which help us to prepare more confidently for the anticipated lahar at Ruapehu.

Mapping hydrothermal alteration products on Mt Tongariro using Hyperion data

Matt Irwin

The threat of a major collapse/landslide from a volcanic cone is a primary hazard of concern in the Tongariro National Park. The geologic record at Ruapehu and Tongariro volcanoes shows that past debris flows (lahars) have often contained a high proportion of alteration products. The present flanks of both volcanoes have several hydrothermally altered zones that could be sources of future collapses. The purpose of this study is to interpret Hyperion data using field spectra collected from a portable spectro-radiometer to assess the overall extent of alteration products and map altered zones on Mount Tongariro. A Hyperion image of the study area will be corrected for atmospheric and topographic effects prior to analysis. Various alteration-product zones have been identified visually on the image and accessible zones were visited, samples were collected and reflectance spectra recorded using a portable spectro-radiometer with GPS locations stored. X-Ray diffraction analysis of the field samples will identify the alteration products and the field spectra will provide the ground truth for the Hyperion image. This will allow selection of accurate end-members that will be used to perform a supervised classification of the image in the study area. The alteration products form some of the least stable zones on the volcano. Identifying these zones provides crucial information in the production of a new lahar hazard map for the Tongariro National Park.

Pyroclastic flows and hazard mapping at Ngauruhoe

Shane Cronin

Pyroclastic flows, from syn-eruptive collapse of agglutinate and scoria piles and eruption column collapse have been a feature of several past Ngauruhoe eruptions. A two-pronged study has been completed into the internal flow dynamics and properties of the Ngauruhoe-type pyroclastic flows. Firstly sedimentological evidence reveals that the flows are a granular-flow phenomena, with little or no gas-fluidisation. Granular sorting processes are strong within flow which constrains flow margins, runout and changes in downstream properties. Secondly a numerical code, titan2D, designed to simulate dry flows of granular material, was used to model scoria-and-ash flows from the 1975 eruption of Mount Ngauruhoe. A run-out map was constructed in order to assess the risk to users of a proposed change in the location of the Mangatepopo Track segment of the Tongariro Crossing. Three deposits were precisely surveyed and model input-parameters such as flow volume and bed-friction plus internal-friction angles were constrained from these deposits. Using the interpolated parameters, scaled-up flow volumes were modelled in order to evaluate the inundation from larger events. Continuing work is now progressing on the slightly longer-runout flows generated from collapsing columns, here the uncertainties in the starting parameters are greater and a bracketing approach needs to be taken

Numerical modelling for volcanic hazard assessment

Jonathan Procter

Volcanic mass flows and lahars from stratovolcanoes in New Zealand are one of the greatest risks surrounding communities are exposed to. Traditional volcanic hazard identification and mapping has strongly relied on understanding and unravelling ancient and historic deposits and related volcanic events. Numerical modelling of hydrologic and mass flows allows us to simulate various volcanic flow hazard scenarios on the present day terrain providing a more realistic representation of future hazards. The Titan-2D program is a depth averaged, “shallow water” granular flow and two-phase (water and granular) model. The computer simulation attempts to solve the movement of a granular or two phase flow over a terrain by using a parallel adaptive grid. This 2-D model has been tested and correlated against recent 1995-96 Ruapehu Volcano lahars to calibrate the model to this type of rheology as well as determine future hazards and risks to current mitigation measures. The model has also been applied to model various mass flow scenarios on Mt. Taranaki such as dome collapse, block- and ash-flows, debris flows and debris avalanches. The outputs from these scenarios can be analysed in Geographic Information Systems (GIS) further to produce hazard areas. The representation and combination of these hazard layers still require refinement and an appropriate method of display as well as an acceptable and trouble-free method of incorporation into current risk analyses.

Probabilistic eruption forecasts for Mt Taranaki
Or: Short and long intervals? And which are we in?

Mark Bebbington

A core taken from Lake Umutekai near New Plymouth shows evidence of 100+ eruption events in the last c. 10000 years BP. Ten of these events were dated and the remaining dates interpolated using a spline fitted to the known dates and depths. The resulting record is combined with individually dated recent events to cover the top portion of the core which was uncompacted and not recovered. The ash fall event data was then analysed as a renewal process. Evidence of preferred “short” and “long” intervals was observed and further examined using a hidden Markov model. Probabilistic forecasts of the time to the next eruption will be presented.

Ascertaining volcanic risk to infrastructure in Taranaki

Vince Neall

The main events in the history of Egmont Volcano are published in a 1:100,000 map. We are now trying to relate this information to understand the volcanic risk to infrastructure in Taranaki. We began by gathering infrastructure data in a wide variety of digital formats. These were combined into a GIS database which was cross-referenced to a volcanic hazards map. This analysis was made available to participating local government authorities and key industries in a web-based GIS viewer on a CD ROM. This included GIS datasets containing multiple attributes of each vulnerability point, together with an image and other relevant spatially referenced information. One result of this analysis was the recognition of a very large number of vulnerability points and the need to create a priority order for mitigation purposes. We are now in the next phase of this development. Of all the potential volcanic hazards in the region, it is the combined lahar, debris avalanche, and pyroclastic flow hazard which have the greatest potential to impact on the economy. This led us to concentrate on the ground-hugging hazards impacting on local infrastructure. The risk to some infrastructure has already been lowered by emplacing it underground and beneath rivers. This is in marked contrast to bridges with attached pipelines and cables. We have analysed the vulnerability of these bridges and their attached infrastructure in the highest volcanic risk zone in South Taranaki. Maximum flows that can be accommodated in the channels beneath have been calculated and rated in conjunction with importance of attached infrastructure. This information can then be used not only for emergency management purposes but also for mitigation strategies.

Assessing the volcanic risk to the Taranaki energy distribution sector

Ian Chapman

The Taranaki Region is unique in New Zealand because it is the current locus for petroleum exploration as well as being the distribution hub for residential and commercial natural gas products. Overshadowing this is the threat of volcanism from Mt. Taranaki; latest research shows that there has been an ashfall-producing eruption from Mt Taranaki on average every c. 90 years and lahars would also probably accompany most events. Given our society's reliance on electricity and natural gas, what impacts would a typical eruption have on the Taranaki energy distribution sector, including the network of Powerco? What practical steps could be taken to mitigate this risk, so that effective post eruption recovery can be achieved? The eruptions of Mount Ruapehu in 1995-1996 gave an indication of the disruption caused by a small volcanic event. Information from this event along with experience in snow-fall conditions can be applied to Taranaki to predict eruption consequences. This analysis will go beyond damage to the Powerco electrical network, to include the wider implications resulting from interdependencies of downstream users; i.e. Hospitals, critical industry, cell phone towers, gas gates and other essential infrastructure.

Volcanic hazard implications for the Dairy Industry

Tom Wilson

The central North Island of New Zealand faces one of the largest volcanic hazards in the world. At particular risk within this region is the dairy industry; which makes up a significant portion of New Zealand's economy. This risk extends from the production of milk at individual farms, to the distribution of milk to and from milk-processing plants, to wider economic implications for Fonterra's (and thus New Zealand's) global supply of milk to the world market. This doctoral research aims to complete an integrated and comprehensive study of the volcanic hazards faced by the dairy industry in the central North Island of New Zealand. International examples and experience will be drawn on to help quantify the risks faced. Once the risks are identified, this knowledge can be used to develop workable, effective and sustainable mitigation strategies that will increase the resilience of the New Zealand dairy industry to volcanic eruptions. These recommendations will be forwarded to the Ministry of Agriculture and Fonterra (key stakeholder partnerships have been developed with both organisations to ensure industry participation), allowing better organisational response/planning within key dairy industry organisations. Ultimately this will improve the resilience of New Zealand's dairy industry to volcanic eruption.

Economic loss estimations for volcanism at Mt Taranaki

Coral Aldridge

While the expected scale of any disaster is frequently assessed on historical evidence for planning purposes, social or economic studies tend to consider vulnerable sectors during evacuation and recovery as opposed to an economic impact. If precursors to volcanic activity extend for a long period of time the threat of economic stagnation, reduced investment, emotional stress and permanent relocation from the region will increase. Input-output analysis used three eruption scenarios, all skewed towards a "most likely" smaller eruption, in an analysis of the Taranaki region. The results of the single period input-output scenario analyses show an immediate value-added decline in the regional economy of between 5% and 40% ($519.09 - $2,505.21 million) due to volcanic eruption. Input-output captures the overall regional impact of an eruption and the immediate reduction in output as a result of evacuation and physical influences. However an eruption of any magnitude will also have long-term and national impacts on the economy. Assessment of iconic industries enabled the identification of more long term, widespread and national effects of an eruption which are not captured in input-output assessments. The largest of which is Taranaki's gas monopoly and the significant downstream impact any regional disruption in supply could have on the national economy and social wellbeing. Oil and gas is vital to many aspects of New Zealand business not just within Taranaki, but day to day business operations, manufacturing processes and power generation capacity.

TARANAKI AWAKENS! - An emergency management eruption scenario

Jérôme Lecointre

An eruptive scenario for Mt Egmont has been developed specifically for Taranaki Regional Council Civil Defence authorities. The objective was to provide a practical and up-to-date emergency management tool that can be easily used for training purposes during a table-top exercise. The scenario is based on the incremental development of an eruptive crisis, over a period of +69 days. Suggested volcanic phenomena are coherent with geological data covering the last 1,000 yrs of eruptive activity at Mt Egmont. Multiple volcanic hazards (tephra falls, lahars, debris avalanches, pyroclastic flows) and chain-reaction effects are progressively introduced along the build-up phase, as reported by field observers and and/or detected by the TV-SN recording instruments. Alert level changes are suggested at periods of critical changes. An application of the scenario, once integrated into a GIS-based emergency management system, is to help decision makers to focus on areas of increased vulnerability and key infrastructure in sectors directly affected by the eruption (dairy plants; pipe lines; petrochemical production facilities; roads and bridges). Our plan is to apply the scenario directly to a critical, high-value Taranaki industrial site in order to explore structural mitigation options adapted to ground-hugging hazards.

Lessons for volcanic emergency management from the 2005 Ambae caldera-lake eruption

Károly Németh

Ambae began erupting on 28 November 2005 after disrupting the lives of ~ 10 000 inhabitants after at least 90 years of quiet. Surtseyan-style eruptions formed a tephra cone in the summit caldera lake (which is 5 times the size of Ruapehu's), threatening to form lahars due to displacement of water and mud. Eruptions never reached a size to be able to triggering lahars during this eruption, which only ever reached volcanic alert level 2 (confirmation of eruption threat). Despite this low level of scientific concern, local authorities organised themselves rapidly and managed a 4-week evacuation of 3500 people. This was driven by public and local authority fear, along with a lack of recent experience in volcanism and perhaps also a strong and overbearing interest from international media wanting to sensationalise the events. On the plus side, this eruption sequence showed the effectiveness of locally developed plans for volcanic crisis response and the ability of the Province to manage a full evacuation without external help. On the negative side, the event demonstrated a strong disconnect between scientific advice/warning levels and the magnitude of community response. According to the highest level of alert reached and official national Disaster Office advice, only readiness activities should have been undertaken. Local political forces dictated, however, a much stronger reaction.

Participants:

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