IAVCEI Commission on Volcanic Lakes

SECOND CIRCULAR

CVL 10 Workshop, New Zealand
17-25 March 2019

Ruaumoko – Atua of volcanoes
Artist: Te maari Gardiner

INVITATION

On behalf of the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI), its Commission on Volcanic Lakes and GNS Science, we are pleased to invite you to the 10^{th} Workshop on Volcanic Lakes (CVL10) to be held in Taupo and Rotorua, New Zealand over the period March 17-25, 2019.

The meeting aims to bring together volcano scientists from a wide range of sub-disciplines, including physical volcanology, hydrology, limnology, biochemistry, geochemistry and geophysics, all with a view toward establishing broad communication amongst the disciplines and development of holistic models of volcanic lake environments. The goals of the workshop are to provide ample opportunity for exchange of ideas around data collection and monitoring methodologies in volcanic lake environments, hazard recognition and mitigation, and copious discussion of conceptual models for so-called "wet volcanic systems".

As for previous workshops, CVL10 is designed around both formal scientific sessions and field visits to well-studied magmatic-hydrothermal environments. The CVL10 workshop includes visits to Mt. Ruapehu, Waimangu, and Lake Rotomahana, with an optional, post-conference visit to Whaakari (White Island). Water column sampling will be possible from Lake Rotomahana, the site of ancillary activity to the 1886 eruption of Mt Tarawera. The lake has a sustained discharge of ~ 300 T/day of CO_2.

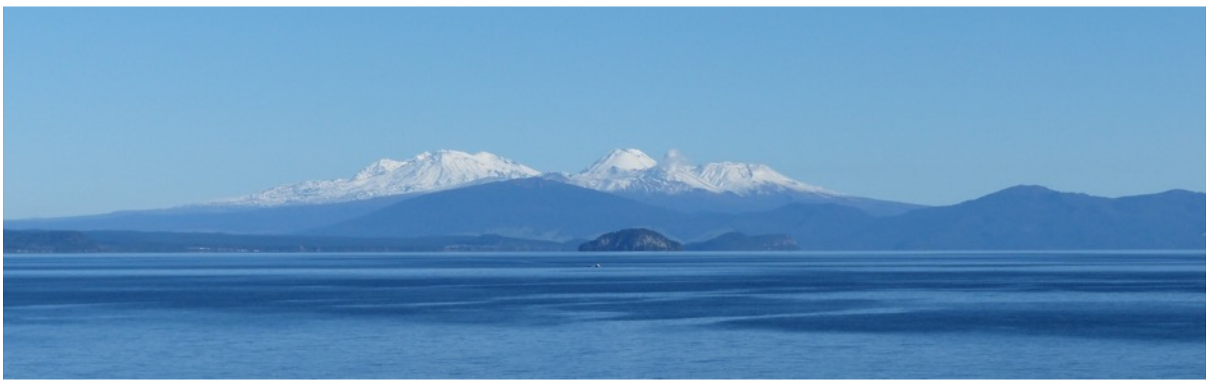


Photo across Lake Taupo to the volcanoes of Tongariro National Park. Mt Ruapehu is the broad cone on the left, Mt. Ngauruhoe the equant, snow covered cone in the centre, and Mt Tongariro the flat-topped cone on the right in the image.

SCIENTIFIC SYMPOSIA

1. Tracking lake water chemistry: the future of direct sampling of volcanic lakes

Conveners: *Dmitri Rouwet & Joop Varekamp*

The water chemistry of the infamous crater lakes of Kawah Ijen, Poás, Ruapehu and Kusatsu-Shirane volcanoes has been reported on a monthly basis for over four decades. The most indicative anionic species, such as SO_4 and Cl, and enigmatic ratios between species (e.g. Mg/Cl, SO_4/Cl) have been directly related to the state of activity of the underlying magmatic-hydrothermal system (i.e. state of unrest), yet they did not result unambiguous precursory signals for single phreatic eruptions, as most lakes are “too slow” to detect a change in chemistry in a timely fashion. In this session we aim to discuss the role of temporal variations in water chemistry in relation to eruptive activity. Has, in the era of high-tech real-time monitoring setups, the direct sampling method become an obsolete? Or, do the acidic environments of active crater lakes that lead to technical challenges, make water chemistry still a must-do at active crater lakes? Are there any neglected (e.g. polythionates) or overlooked species (e.g. REE and trace constituents) that need a second look?

2. Gas emissions from acidic crater lakes

Conveners: *Takeshi Ohba & Franco Tassi*

It has long been recognized that non-reactive gases such as CO_2 are released from many volcanic lakes. However, it has only recently been more deeply appreciated that ultra-acid volcanic lakes directly release significant quantities of acid gas species such as SO_2 and HCl, opening a host of new avenues for monitoring and investigation of these systems, as well as presenting new challenges to our understanding of magmatic-hydrothermal systems. We invite abstracts on topics ranging from observations and measurements of lake degassing, to experimental and modeling results of gas-water-rock interactions, to implications for monitoring, hazards, and understanding magmatic-hydrothermal systems and their behaviors.

3. No black sheep in the Commission of Volcanic Lakes: what can geophysical techniques reveal about volcanic lakes?

Conveners: *Corentin Caudron & Nico Fournier*

Volcanic lakes are nowadays studied by an increasingly wide spectrum of scientific techniques and methodologies. Although historically dominated by geochemistry, the Commission on Volcanic Lakes has recently welcomed geophysical and numerical modeling approaches providing a more comprehensive understanding of these systems. Fluids circulation generates continuous volcanic tremor that can be tracked and located using various seismological approaches. Acoustic techniques are sensitive to subaqueous gas emanations or jetting produced by fumaroles. Numerical modeling can explore the parameters controlling the absence/presence of hot crater lakes or the seepage; a key parameter to constrain heat budget of volcanic lakes. Electrical tomography could even be deployed on volcanic lakes to study stratification events. Multi-disciplinary approaches are particularly interesting as they tend to integrate complementary observables altogether to reach an improved understanding of volcanic lake systems. The emergence of geochemical data at high sampling rate, such as provided by Multi-GAS (Session 2), allows more direct comparison with geophysical data.

This session aims at gathering all these previously underrepresented methodologies from imaging to monitoring approaches, from in situ deployment and sampling to drone or satellite inspection of volcanic lakes, from the most conventional seismic techniques to the emerging disciplines such as muons from numerical or analog modeling efforts to mining of historical records. We particularly welcome multi-disciplinary studies combining different approaches.

4. Sub-lacustrine hydrothermal systems: insights from surveys, analogue experiments and numerical modeling

Conveners: *Shaul Hurwitz & Jennifer Lewicki*

In active sub-lacustrine hydrothermal systems significant heat and mass transfer between magma and lake waters take place at a range of spatial and temporal scales. The non-linear processes involve flow of multi-component aqueous-rich fluids and gases ranging from supercritical brines and low-salinity vapors, to meteoric waters in systems that are characterized by highly transient temperature and pressure conditions with heterogeneous permeability structures. Detection and quantification of hydrothermal processes and their signals has improved significantly with the advent of geophysical and geochemical methods, analogue experiments, and numerical models. This improved detection and quantification allows for a better understanding of the complex multi-phase thermo- and fluid-dynamics of these systems and could provide quantitative information that has implications for the mitigation of hazards. Contributions from studies that integrate geological, geophysical and/or geochemical data, and/or with numerical modeling to elucidate processes in volcanic lake hydrothermal systems are invited to contribute.

5. Phreatic eruptions from Wet Volcanoes

Conveners: *Bruce Christenson & Akihiko Terada*

Phreatic and/or gas-driven eruptions remain one of the least predictable hazards on active volcanoes, particularly those where the magmatic-hydrothermal environments intersect the Earth's hydrosphere. They often occur with little or no precursory signals – or is it just that we are just not listening closely enough? This session seeks studies from all disciplines (chemistry, physics, physical volcanology, and others) which characterise discrete eruption events, as well as theoretical approaches (e.g., numerical simulation), with the overall goal of identifying the key processes which lead to phreatic and gas-driven events. From this, we propose to have a panel discussion that will focus on techniques that we can employ to specifically monitor processes leading to these events.

6. The impact of volcanic lakes on society: from mythology to risk mitigation

Conveners: *Hollei Gabrielsen & Dmitri Rouwet*

The presence of water-filled craters at active volcanoes can impact the surrounding populations in both positive and negative ways. Overflow or lake expulsion during eruptions increases lahar hazard, whereas the presence of water in maar or caldera lakes can also be a source of livelihood. In some ethnic groups, local knowledge embedded within oral histories has the ability to provide insight into historical behaviours of certain lakes and can potentially inform likely future behaviours. Within New Zealand, there is an evolving recognition for indigenous knowledge systems that derive from an intense and historical relationship with specific landscapes and natural features. This indigenous knowledge system can contribute to and inform risk assessment and management of natural hazards alongside science. This session welcomes historical and cultural reporting, hazard and risk evaluations (e.g. maps, communication protocols), as well as probabilistic hazard assessment approaches on lake-hosting volcanoes.

7. Carbon dioxide degassing at volcanic lakes: theory and practice

<u>Conveners:</u> *Artur Ionescu & Agnes Mazot*

It is now well stablished that active volcanoes emit very large amounts of carbon dioxide to the atmosphere, not only through volcanic plumes and fumaroles, but also from soil diffuse degassing areas, and from the degassing of crater lakes. Furthermore, diffuse emissions occur both during quiescent periods and during volcanic eruptions. The mapping of the CO_2 diffuse degassing structures is of crucial importance in the study of a volcanic-hydrothermal system, as it allows to estimate the amount of energy released by the system. In addition, the shape of the diffuse degassing structures can reveal information about the structural or lithological controls on fluid up-flow from deep sources.

In the case of volcanic lakes, degassing occurs through the lake surface by convective or advective degassing and/or by diffusion through the water-air interface. At the present time, the physics and chemistry of CO_2 degassing through lakes is not well constrained. The session aims at a better understanding (1) of the degassing process of the lakes, (2) on which is “best practice” for measuring degassing on the surface of the lake and crater shores, and (3) if the wind and pH of the lake water affect degassing.

8. Limnology of Lake Nyos and its nephews: searching for strata

<u>Conveners:</u> *Minoru Kusakabe, Bill Evans & Greg Tanyileke*

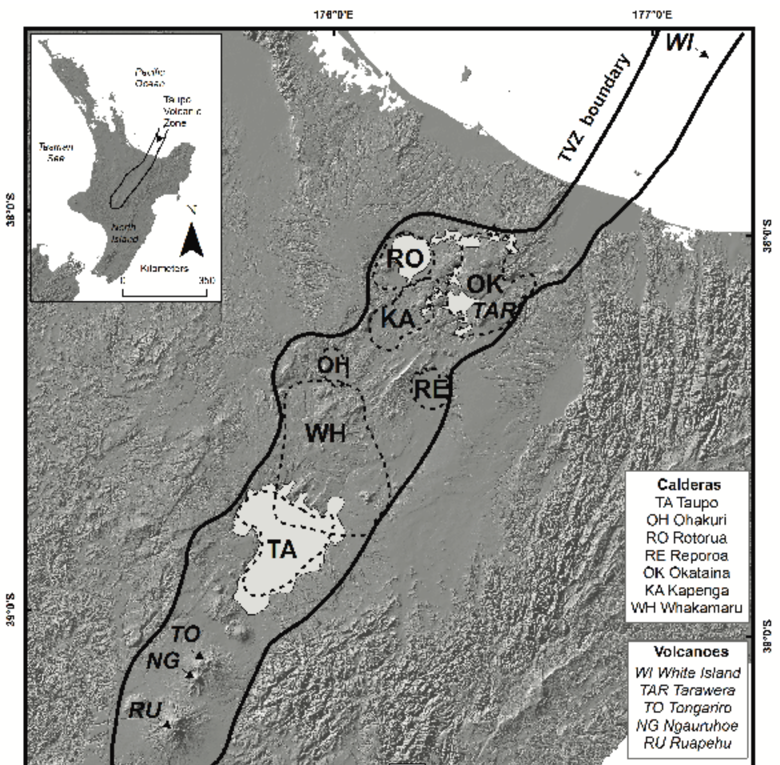
The 1986 Lake Nyos gas disaster and a similar event in August 1984 at Lake Monoun, both in Cameroon, were so unusual that no one had even envisioned the hazard associated with huge amounts of magmatic CO_2 in the bottom layers of the lakes. This unusuality attracted a lot of attention from world geoscientists, boosting studies of basic science of lake-related volcanology. They included not only monitoring Lakes Nyos and Monoun but also surveys of other maar lakes and active crater lakes of the world. The Nyos event even accelerated the studies of geochemistry of rocks from the Cameroon Volcanic Line, mantle petrology and mantle evolution. Such studies are good examples to show how different disciplines are inter-related. They have been published in journals and books such as "Crater Lakes" (2000, Varekamp, J.C. and Rowe, G.L., eds, Elsevier), "Volcanic Lakes" (2015, Rouwet, D., Christenson, B., Tassi, F. and Vandemeulebrouck, J., eds, Springer), and more recently a special volume "30 years of volcanic lake studies after the Lake Nyos gas disaster in Cameroon" is being published in Journal of African Earth Sciences.

In the session "Limnology of Lake Nyos and its nephews: searching for strata", we welcome papers that address cross-cutting issues of geology, physics, chemistry, limnology and microbiology of volcanic lakes. They are microcosms, and should, therefore, be studied multidisciplinarily. Target lakes of the studies may be of Nyos-type or anti-Nyos type, active crater lakes, man-made gas-rich lakes, etc., each of which is a microcosm. A majority of researchers study the present situation of the lakes, but since the past is a key for the future, the studies of lake sediments and of old documents, if available, would give us valuable information such as eruptive history and environmental changes in the past. The information may be helpful in interpretation of the current situation of the lakes. We welcome presentation of papers describing "integrated" research of the lake(s) you are studying.

VOLCANISM IN NEW ZEALAND

Tectonically, the Taupo Volcanic Zone (TVZ) is described as an extensional arc (Wilson et al., 1995; Wilson and Rowland, 2016), where the Pacific Plate is actively subducting beneath the Indo-Australian Plate. This gives rise to both NE trending andesitic arc magmatism which currently occurs along the eastern margin of the volcanic region, but also crustal extension along the arc which is responsible for some 2 km of subsidence along the axis of the volcanic region. No fewer than 7 centres of silicic volcanism and associated calderas have been identified in the region (Houghton et al., 1995; Wilson et al., 1995; Leonard et al., 2010), most notably that of Taupo some which is regarded as the world’s most violent eruption in the last 5000 years (Wilson, 1993).

New Zealand has a lot to offer those who study the intersection between active volcanoes and the Earth’s hydrosphere. Although just two volcanoes (White Island and Mt Ruapehu) are currently active, with a total estimated energy output exceeding 4000 MW (Bibby et al., 1995), the TVZ hosts more than 20 geothermal systems, all having magmatic heat sources of varying age and depth, and all pointing to the vast extent of this magmatic province. In short, it is an ideal place to host CVL10!



Location map of the principal volcanoes and calderas of the Taupo Volcanic Zone.

References

Bibby, H.M., Caldwell, T.G., Davey, F.J., Webb, T.H., 1995. Geophysical evidence on the structure of the Taupo Volcanic Zone and its hydrothermal circulation. J. Volcanol. Geotherm. Res. 68: 29-58.

Houghton, B.F., Wilson, C.J.N., McWilliams, M., Lanphere, M.A., Weaver, S.D., Briggs, R.M. and Pringle, M.S., 1995. Chronology and dynamics of a large silicic magmatic system: Central Taupo Volcanic Zone, New Zealand. Geology 23: 13-16.

Leonard, G.S., Begg, J.G., Wilson, C.J.N. (comps), 2010. Geology of the Rotorua area : scale 1:250,000. Lower Hutt: GNS Science. *Institute of Geological & Nuclear Sciences 1:250,000 geological map 5.* 102 p. + 1 folded map

Nairn, I.A., 1979. Rotomahana-Waimangu eruption, 1886: base surge and basalt magma: NZ Jour. Geology and Geophysics 22: 363-378.

Nairn, I.A., 2002. Geology of the Okataina Volcanic Centre, Institute of Geological and Nuclear Sciences Geological Map 25: 156p + map.

Scott, B.J., McLeod, J.T., Luketina, K.M., Barber, J., Harvey, M.C., Keam, R.F., 2017. May 2016 Mud Rift hydrothermal eruption : data and observations. Lower Hutt, N.Z.: GNS Science. *GNS Science report 2016/59.* 26 p.; doi: 10.21420/G2W88Z

Scott, B.J., 1994. Cyclic activity in the crater lakes of Waimangu hydrothermal system, New Zealand. *Geothermics 23(5/6):* 555-572

Wilson, C.J.N., 1993. Stratigraphy, chronology, styles and dynamics of late Quaternary eruptions from Taupo volcano, New Zealand. *Philosophical transactions. Physical sciences and engineering 343:* 205-306

Wilson, C.J.N., Houghton, B.F., McWilliams, M.O., Lanphere, M.A., Weaver, S.D., Briggs, R.M., 1995. Volcanic and structural evolution of Taupo Volcanic Zone, New Zealand: A review. J. Volcanol. Geotherm. Res. 68: 1-28.

Wilson, C.J.N., Rowland, J.V., 2016. The volcanic, magmatic and tectonic setting of the Taupo Volcanic Zone, New Zealand, reviewed from a geothermal perspective. *Geothermics, 59B:* 168-187; doi: 10.1016/j.geothermics.2015.06.013

Areas to be visited during CVL10

Mt. Ruapehu

The crater lake on Ruapehu is one of the more extensively studied volcanic lake systems on Earth. The lake is currently 110 m deep, and holds ca. 9 million m^3 of hyper-acidic water. A most interesting feature of the lake is its thermal cycling behaviour, with temperatures ranging from 9 °C to greater than 40 °C. The cycles correspond directly to varying gas emissions through the vent-lake system, with CO_2 and SO_2 emissions ranging from < 100 to 2400 T/d and < 5 to 550 T/d respectively.

The volcano has had two historic lake expulsion events in 1945 and 1995, with the latter providing the first ever opportunities to sample and characterise gases from the magmatic system. The lake took some 10 years to refill after the 1995/96 eruptions, and today stands at overflow.

Depending on the state of unrest and weather, the group will climb the northern flank of the volcano to the Dome on the northern margin of the crater (approximately 1.5 hours from the upper gondola/chairlift station). The outlet is approachable from the western side of the crater basin, a pathway which crosses snow and ice fields, replete with crevasses – this takes an additional ca. 30-45 minutes. Whereas remote sensing measurements around the lake shore will be possible (e.g., multigas or spectroscopic methods), owing to cultural sensitivities of the local Iwi (the lake is a sacred burial site for past Chiefs) and stringent rules concerning removal of materials from NZ national parks, obtaining a permit for group sampling of the lake is not possible. Those wishing to conduct sampling-based studies are, however, welcome to apply for individual research permits (application forms are available from the NZ Department of Conservation (DOC); all proposals are assessed as to their scientific merit). As weather is often unsuitable for climbing the volcano, we have allocated two days for this, with the second day being free for other pursuits in the Taupo area.

Note: Ruapehu is an alpine environment, and weather can be changeable and unpredictable. Although the climb and descent are not technically difficult, participants should have at least some mountaineering experience (including skills in the use of ice axe and crampons) and a reasonable level of fitness. Snowpack will be at a minimum by mid-March, but there will be snow/ice fields to traverse in the summit area. The summit is not extraordinarily high (~ 2800 m), but conditions under foot (e.g., soft snow) can be aerobically challenging at times. Warm alpine clothing, suitable footwear and alpine equipment (ice axe and crampons) are absolute necessities.

Waimangu and Lake Rotomahana

Lake Rotomahana is part of the Tarawera Volcanic Complex located in the southern part of the Okataina Volcanic Centre, the most recently active of the 8 major rhyolite eruptive centres in the Taupo Volcanic Zone (Nairn, 2002). Over the past 26,000 years, rhyolitic and basaltic eruptions formed the Tarawera volcanic complex in the southern part of Haroharo Caldera. Prior to the 1886 Tarawera eruption, the Rotomahana area was a site of numerous phreatic and magmatic eruptions and was host to an intensely active hydrothermal field with hot springs, geysers, fumaroles and two famous sinter terraces known as the Pink and White Terraces. Two small lakes occupied part of the site of present day Lake Rotomahana: Lake Rotomahana (hot) and Lake Rotomakariri (cold). The most destructive manifestations of the 1886 Tarawera basaltic eruption occurred in the Rotomahana area during large scale phreato-magmatic events (Nairn, 1979).

Phreatomagmatic and hydrothermal explosions ejected both hydrothermally altered and juvenile rocks, forming large explosion craters. Shortly after the 1886 eruption, the Rotomahana crater began filling with cold water. Today, surface hydrothermal activity in Lake Rotomahana is focused in the western part of the lake with numerous fumaroles, hot springs and geysers (known as Steaming Cliffs) occurring along the shoreline, and a number of bubbling areas clearly visible offshore (Stucker et. al., 2016).

Eruptive activity occurred also to the southwest of Lake Rotomahana in the Waimangu area in 1886 (Nairn, 1979). Since then, surficial hydrothermal features have established themselves (Scott, 1994), and there have been numerous hydrothermal eruptions in the area, as recently as 2016 (Scott et al., 2017). Today, surface activity consists of hot springs, fumaroles and the large Inferno and Frying Pan hot crater lakes.

Steaming Cliffs on the western shore of Lake Rotomahana (2013).

Workshop activities at Waimangu and Rotomahana will be spread over two days. The afternoon of the first day (**Saturday, March 23rd**) will be spent walking through the Waimangu Valley looking at the various hydrothermal features, and discussing the events which took place in 1886. Sampling of springs/pools and chemical remote sensing will be possible under our current permitting arrangements (***Note: Biological sampling will require additional permitting, through the aforementioned process with the Department of Conservation)***.

Sunday, March 24th, will be spent on the water at Lake Rotomahana. We have organised for the Waimangu Valley launch to serve as the “mother ship” for the day, providing a home base for sampling activities that will be conducted from inflatable boats belonging to a professional rafting company from Rotorua. We will have two sampling stations in the lake, where participants will be able to conduct water column sampling and/or diffuse degassing (water-borne), or other (e.g., geophysical) measurements that are capable of being made from small inflatable boats. The lake has numerous CO_2 emissions through the lake floor, thus providing an excellent opportunity to characterize chemical and physical processes related to gas transfer into and through lacustrine environments.

In keeping with the general philosophy behind the CVL, we would like to propose that ideas be promulgated around possible multi-disciplinary, multi-parameter studies that could be done on this day, with a view toward generating a collaborative publication from the effort. The CVL is, after all, a group of world leading experts on volcanic lake systematics, and here we have a brilliant opportunity to advance understanding about this extremely interesting natural lacustrine environment as a team pursuit. The challenge will be to achieve something meaningful with just one day of field work, but with a little planning, anything is possible. We suggest that the following references are used as starting points for generating ideas around this goal:

- Mazot, A., Schwandner, F. M., Christenson, B., de Ronde, C. E. J., Inguaggiato, S., Scott, B., Graham, D., Britten, K., Keeman, J., Tan, K., 2014. CO_2 discharge from the bottom of volcanic Lake Rotomahana, New Zealand, Geochem. Geophys. Geosyst. 15: 577–588, doi:10.1002/2013GC004945
- Stucker,V.K., de Ronde, C.E.J, Scott, B.J., Wilson, N.J., Walker, S.L., Lupton, J.E., 2016. Subaerial and sublacustrine hydrothermal activity at Lake Rotomahana, J. Volcanol. Geotherm. Res. 314: 156-168, ISSN 0377-0273
- Walker, S.L., LeBlanc, C., Davy, B.W., Fornari, D.J., Caratori Tontini, F., Scott, B.J., Seebeck, H., Stewart, T.J., Mazot, A., Nicol, A., Tivey, M.A., 2016. Reconstruction of the geology and structure of Lake Rotomahana and its hydrothermal systems from high-resolution multibeam mapping and seismic surveys: Effects of the 1886 Tarawera Rift eruption. J. Volcanol. Geotherm. Res. 314: 57-83. ISSN 0377-0273
- Tivey, M.A., de Ronde, C.E.J, Caratori Tontini, F., Walker, S.L., Fornari, D.J., 2016. A novel heat flux study of a geothermally active lake — Lake Rotomahana, New Zealand. J. Volcanol. Geotherm. Res. 314: 95-109. ISSN 0377-0273

We will circulate the list of registrants to the group after registration closes to facilitate planning/coordination of possible collaborative studies that might be undertaken.

Lake Rotomahana and Mount Tarawera in the background. Waimangu valley and Inferno Crater Lake in the foreground (2005).

Post-conference field trip: ***White Island (optional, independent)***

Aerial view looking west to the main crater floor of White Island (Whakaari).

White Island, situated 48 km off of the Bay of Plenty coast, is New Zealand's most active volcano. The 1976-2000 volcanically active period consisted of phreatic, phreato-magmatic and magmatic events, and the formation of the 1978-90 Eruption Crater complex in the western sub-crater. A quiescent period between 2000-2012 fostered 3 crater lake cycles, and the re-establishment of acid spring discharges on the Main Crater floor. Activity recommenced in mid-2012, and since then there have been numerous phreatic and phreatomagmatic eruptions, and the extrusion of a dome in the 1978/90 Crater Complex. All the while, fumarolic emissions on the Main Crater floor have reflected, through their compositions, the changing state of the magmatic-hydrothermal system. In essence, this is a classic "wet" oceanic island volcano.

We have organised with the main tour company providing transport out to White Island (White Island Tours) a 10 % discount to Workshop participants for a day excursion to the island by launch. Participants will need to get themselves to Whakatane on the Bay of Plenty coast to meet up with the boat after the conference.

There is a regular bus service between Rotorua and Whakatane, and there are of course rental car agencies in Rotorua. Please visit the White Island Tours website for details concerning departure times and programme (https://www.whiteisland.co.nz).
A discount code will be supplied to those wishing to do this trip; please request this from Bruce Christenson (email address is below).

White Island crater lake early 2014. The lake was growing at this time, and was close to overtopping the dome which was extruded in late 2012.

Costs

Full conference fees are set at NZD $1050 per person covering the Science Sessions and field costs described below. A “Sessions Only” option is available for NZD $350.

Both options cover:

- Hire of the conference facilities and amenities (icebreaker, morning and afternoon teas and lunches) for 3.5 days in Taupo
- Transport, entry and barbeque at Debrett’s Thermal Spa, Taupo

Full conference option includes:

- Bus transport to all field areas (Ruapehu, Waimangu/Rotomahana, and Rotorua)
- Two night’s accommodation in Rotorua (Holiday Inn)
- Entry fees to the Waimangu Valley (2 days)
- Launch, inflatable hire and lunch for the Lake Rotomahana sampling
- Conference dinner and cultural evening at the Tamaki Village, Rotorua

Not included in the conference fees are:

- Transport to Taupo from Auckland (17 March)
- Six nights accommodation and food costs in Taupo (17-23 March) – we assume that everyone would wish to choose suitable accommodation from the very broad range available in Taupo. As a guide, average cost for six night’s accommodation in Taupo will be around NZD $840 single, NZD $480 shared twin for reasonably comfortable rooms (of course, cheaper and more expensive accommodation may be found). We suggest using website services such as Trivago or Air B&B to peruse/organize accommodation.
- Costs of any tourist activities for the free day in Taupo
- Breakfasts at Holiday Inn (Rotorua)
- Lunch at Waimangu (there is a café on site)

Abstract Submission

The deadline for abstract submission is **December 20, 2018**. Please provide an abstract no longer than 1 A4 page (1.5 spacing), including figures (if any), and nominate your preferred session (by number). Please centre-justify the title in bold, list the authors and their affiliations, followed by the text. Please email these to a.mazot@gns.cri.nz.

A Poster Session will be convened at the end of the second day, and there will be an opportunity for very brief presentations to introduce these posters to the group prior (2 minutes max.).

Registration

Please follow the links below for registration and payment details. Credit card payment is the preferred method of payment, and fees must be paid by **January 31, 2019**. All fees are listed in NZ dollars.

If you wish to attend only the sessions, proceed to this site:

http://shop.gns.cri.nz/iavcei-sessions/

If you are intending to attend the full workshop, go to this site:

http://shop.gns.cri.nz/iavcei-full/

FOR FURTHER INFORMATION

Contact: Bruce Christenson: b.christenson@gns.cri.nz

Local Organising Committee

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Agnes Mazot (GNS, New Zealand)
Nico Fournier (GNS, New Zealand)
Takeshi Ohba (Tokai University, Japan)
Bruce Christenson (GNS, New Zealand)

CVL-10 Itinerary

Day 1: Arrive Taupo, Sunday March 17

- 1400-1700 Registration for Conference at Great Lake Centre (GLC)
- Check in to accommodation
- 1700-1900 Official Welcome, Ice Breaker, Maori Welcome, finger food
- Evening free in Taupo (lots of local restaurants)

Day 2: Sessions at Taupo GLC, Monday March 18

- 0830 Official Opening of Conference, local welcome (Iwi, Local govt., Sponsors, etc.) at GLC
- 0930 Science Sessions
- 1730 Finish
- Evening free in Taupo

Day 3: Sessions at Taupo GLC, Tuesday March 19

- 0830 Science sessions at GLC
- 1530 Finish oral session
- 1545 Poster Session (with beer!)
- 1730 Finish
- Evening free in Taupo

Day 4: Sessions at Taupo GLC, Wednesday March 20

- 0830 Science sessions at GLC
- 1500 Finish oral sessions
- 1530 CVL Business Meeting
- 1730 Conclusion of Formal Sessions
- 1800 Excursion to Debrett's Thermal Spa, barbeque
- 2100 Return to GLC

Day 5: Mt Ruapehu (or free day if bad weather), Thursday March 21

- 0630 Pickup from motels
- 0900 Arrive "Top of the Bruce" (TOB), board chairlift to top of ski area
- 1645 Return to TOB
- 1700 Depart TOB
- 1800 Evening free in Taupo

NB If weather precludes Ruapehu on 21 March, the climb to Ruapehu Crater Lake will shift to 22 March. In this case, the 21st will become a free day.

Day 6: Free day (or back-up day for Ruapehu), Friday March 22

- There are numerous tourist activities available in the Taupo area (from mountain biking to skydiving to simply sitting on the beach, mountain biking, boat excursions on Lake Taupo, fly fishing, …) – the list of things to do in the Taupo area is endless!.

- **Tongariro Crossing (optional)**
    - 0700 Pick-up motels and drive to Mangatepopo
    - 1700 Pick-up at Ketetahi car park
    - 1830 Return to Taupo

Day 7: Transfer to Rotorua, Waimangu walk-through, Saturday, March 23

- 0900 Depart Taupo
    - Stops at Huka Falls, Wairakei bore field,
- 1100 Arrive Waimangu
    - Tour and purchase lunch at site
- 1430 Depart Waimangu to Rotorua
- 1500 Arrive Rotorua
    - Check into Holiday Inn
    - Shopping and/or cultural opportunities in the late afternoon
    - Evening is free

Day 8: Lake Rotomahana, Sunday, March 24

- 0700 Breakfast at hotel
- 0800 Depart for Waimangu/Rotomahana
- 0845 Depart wharf
    - water column sampling
    - fumarole sampling (if interest arises)
    - water-borne diffuse degassing group measurements
- 1730 Depart Waimangu/Rotomahana for Rotorua
- 1815 Arrive Holiday Inn
- 1930 Assemble for Conference Dinner
- 2130 Close of conference, and return to Holiday Inn

Day 9: Checkout of Holiday Inn.

- Participants make their way from Rotorua to points beyond on their own arrangements.