Phreatic & hydrothermal eruptions: Insights into energy budget and eruption dynamics based on laboratory experiments.

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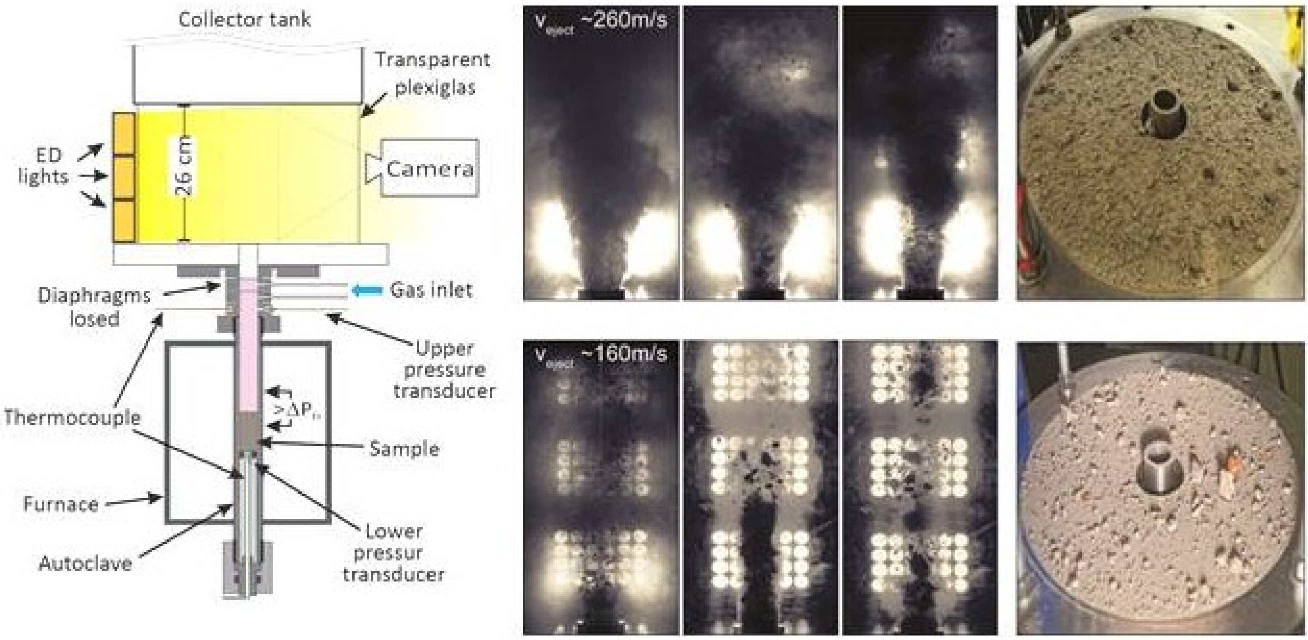
Phreatic and hydrothermal eruptions are amongst the most common and most diverse eruption types on earth. Heating and/or decompression leads groundwater or hydrothermal fluids to rapidly flash to steam triggering these types of eruptions. Their diversity arises from the variety of (1) rock types and host rocks that can be involved, (2) ways to seal possible degassing pathways, (3) alteration type and degree of depending on the composition of volcanic gases and the hydrothermal fluids, and finally (4) P-T conditions possible. In addition phreatic and hydrothermal eruptions are very difficult to predict in terms of timing and magnitude bearing important consequences, especially in densely populated regions or popular hiking / recreation destinations. Despite of their hazard potential, phreatic and hydrothermal eruptions have been understudied in volcanology compared to their magmatic counterparts. Recent violent eruptions as for instance the 2012 Upper TeMaari eruption (NZ) and especially the 2014 Ontake eruption (Japan) spotlighted this eruption type and triggered various studies, combining for instance field and experimental approaches.
Here we present conclusions from several case-studies, representing weak and violent eruption behavior. Further we give insights into the effect of host rock lithology and alteration on the eruption likelihood and dynamics.
Field studies revealed insights into the eruption dynamics, for instance based on detailed mapping of the deposits and or the ballistic strew field of a hydrothermal eruption. The main lithology types identified for an eruption were characterized for their petrophysical properties and degree of alteration. Then these lithology types were used for rapid decompression experiments mimicking hydrothermal explosions under realistic P-T conditions (from 110 °C & 0.3 MPa up to 400°C & 25 MPa). Experimental studies of this kind facilitate better constraints on the eruption dynamics as for instance the ejection of ballistics or amount of ash produced and their associated hazard. Furthermore they shed light on the energy conversion and partitioning during hydrothermal explosions.

Keywords: phreatic , hydrothermal , energy budget, eruption dynamics, experimental volcanology



Left: Experimental Setup used to investigate phreatic eruptions under controlled laboratory conditions.
Right: Still frames showing the plume and ejection created in the lab. Fragmentation and ejection behavior is different comparing energetic steam-flashing (above) to pure steam expansion (below).

Automated seismic event location combining waveform stacking and relative location techniques: An application to geothermal and volcanic environments

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Microseismic monitoring became a common operation in many applications, including monitoring of volcanic areas and underground industrial operations (i.e. induced seismicity). The analysis of microseismicity is challenging, because of the large number of recorded events often characterized by low signal-to-noise ratio. Such seismic datasets are often characterized by multiple events with short inter-event times or overlapping events; in this case, correct phase identification and event association are challenging, and errors can lead to missed detections and/or reduced location resolution. In the last years, to improve the performance of the current data analysis procedure various waveform-based methods for the detection and location of microseismicity have been proposed. These methods exploits the coherence of the waveforms recorded at different stations and do not require the automated picking and phase association procedures. When the recorded waveforms are very noisy, waveform based methods appear to be more robust than the traditional ones (based on phase picking). However, like any other absolute location method, the accuracy of locations strongly depends on the knowledge of the velocity model. Volcanic areas are generally characterized by complex 3D velocity and by a pronounced topography, for these reasons the use of simplified 1D velocity models may strongly affect the locations accuracy. In general, the largest source of error in the seismic event location process is related with the use of inaccurate velocity models (a condition which often occurs in volcanic areas). In this work we apply a location method which combines some features of relative location techniques (such as the source specific station correction term [Richards-Dinger and Shearer 2000]) with the waveform based location methods [Grigoli et al 2016]. This location approach inherits all the advantages of the full waveform location methods without the main drawback which characterizes all the absolute location procedures. In fact, this method is less dependent on the knowledge of the velocity model and presents several benefits, which improve the location accuracy: 1) it accounts for phase delays due to local site effects, e.g. surface topography or variable sediment thickness 2) theoretical velocity model are only used to estimate travel time within the source volume, and not along the entire source-sensor path. We tested this location approach with different datasets, including: a seismic swarm associated with magmatic fluid migrations in NW-Bohemia (Czech Republic) and to seismic swarms in volcanic environments (Piton de la Fournaise Volcano (La Reunion) and Masaya Volcano (Nicaragua)).

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6, 25744; doi: 10.1038/srep25744 (2016).

Keywords: Fluid Induced Seismicity, Microseismic data analysis, Earthquake location

Trapped bubbles keep pumice afloat and gas diffusion makes pumice sink

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Pumice can float on water for months to years –long enough for pumice to travel across oceans and facilitate the spread of species. Long-lived pumice floatation is unexpected, however, because pumice pores are highly connected and water wets volcanic glass. As a result, observations of long floating times have not been reconciled with predictions of rapid sinking. We propose a mechanism to resolve this paradox - the trapping of gas bubbles by water within the pumice. Gas trapping refers to the isolation of gas by water within pore throats such that the gas becomes disconnected from the atmosphere and unable to escape. We use X-ray microtomography to image partially saturated pumice and demonstrate that non-condensable gas trapping occurs in both ambient temperature and hot (500˚C) pumice. Furthermore, we show that the size distribution of trapped gas clusters matches predictions of percolation theory. Finally, we propose that diffusion of trapped gas determines pumice floatation time. Experimental measurements of pumice floatation support a diffusion control on pumice buoyancy and we find that floatation time scales as L^2/DF^2 where L is the characteristic length of the pumice, D is the gas-water diffusion coefficient, and F is pumice water saturation. A mechanistic understanding of pumice floatation is a step towards understanding how pumice is partitioned into floating and sinking components and provides an upper bound on the lifetime of pumice rafts in the ocean.

Shallow submarine silicic eruptions at Oomurodashi Volcano, northern Izu-Bonin Arc, and their potential hazards

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Oomurodashi is a large bathymetric high located at the northern end of the Izu-Bonin Arc. Using the 200 m bathymetric contour to define its summit dimensions, the diameter of Oomurodashi is ~20 km, making it one of the biggest edifices among the Izu-Bonin Arc volcanoes. Oomurodashi has been regarded as inactive, largely because it has a vast flat-topped summit at ~100 meters below sea level (mbsl).
During cruise NT07-15 of R/V Natsushima in 2007, we conducted a dive survey in a small crater, Oomuro Hole, located in the center of the flat-topped summit, using a remotely-operated vehicle (ROV). The heat flow measurement conducted on the floor of Oomuro Hole during this dive recorded an anomalously high value of 4,200 mW/m^2. Furthermore, ROV observations revealed that the southwestern wall of Oomuro Hole consists of fresh rhyolitic lavas.
These findings suggest that Oomurodashi is an active silicic submarine volcano. To confirm this hypothesis, we conducted detailed ROV and geophysical surveys of Oomurodashi in 2012 and 2016 (cruises NT12-19 of R/V Natsushima and KS-16-6 of R/V Shinseimaru).
The ROV surveys revealed numerous active hydrothermal vents on the floor of Oomuro Hole, at ~200 mbsl, with maximum water temperature measured at the hydrothermal vents reaching 202°C. We also conducted a much more detailed set of heat flow measurements across the floor of Oomuro Hole, detecting very high heat flows of up to 29,000 mW/m^2. ROV observations revealed that the area surrounding Oomuro Hole on the flat-topped summit of Oomurodashi is covered by extensive fresh rhyolitic lava and pumice clasts with minimal biogenetic or manganese cover, suggesting recent explosive eruption(s) from the Hole. Furthermore, several small (~50 m in diameter) domes were discovered on the flat-topped summit of Oomurodashi, and an ROV survey recovered fresh rhyolite lava from one of these domes, suggesting that more effusive, lava dome-building eruptions also occurred recently.
These findings strongly indicate that Oomurodashi is an active silicic submarine volcano, with recent eruption(s) occurring from Oomuro Hole. Since the summit of Oomurodashi is in shallow water, it is possible that eruption columns are likely to breach the sea surface and generate subaerial plumes. A ~10 ka pumiceous tephra layer with identical geochemical characteristics to the rhyolites recovered during the dives has been discovered in the subaerial outcrops of the neighboring islands of Izu-Oshima and Toshima, strongly suggesting that these tephra deposits originated from Oomuro Hole.
The deeper slopes of Oomurodashi are composed of effusive and intrusive rocks that are bimodal in composition, with basaltic dikes and lavas on the northern flank and dacite volcaniclastics on the eastern flank. This suggests that Oomurodashi is a complex of smaller edifices of various magma types, similar to what has been observed at silicic submarine calderas in the southern part of the Izu-Bonin Arc (e.g. Sumisu Caldera; Tani et al., 2008, Bull. Vol.).
We will provide a geological overview of Oomurodashi Volcano and edifice growth history based on the ROV observations, and discuss its potential hazards from shallow submarine silicic eruptions.

Keywords: Shallow submarine silicic eruption, Oomurodashi, Izu-Bonin Arc

Investigating submarine eruptions using H_2O contents of volcanic glasses: application of a new FTIR spectroscopy method

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Volatile degassing during magma ascent plays a fundamental role in determining eruption style and pyroclast formation, and the analysis of the dissolved volatile contents preserved in volcanic glasses (both melt inclusions and matrix glasses) is therefore an important tool for investigating eruption processes. Given its strong control on parameters such as melt viscosity, H_2O is one of the most important magmatic volatiles, especially for felsic magmas where it is often the most volumetrically abundant volatile. In addition, the well-constrained pressure-dependence of H_2O solubility means that the H_2O contents of pyroclast glasses can provide a record of the pressure at which pyroclasts quenched. For submarine eruptions, where vent depth and pyroclast formation are rarely observed directly, this is particularly valuable information. Unfortunately, silicate glasses are vulnerable to secondary hydration (i.e. the addition of H_2O from the surrounding environment at low temperature in the time following deposition), and thus volcanic glasses deposited in the submarine environment are often hydrated. To obtain meaningful H_2O data from these hydrated glasses it is therefore necessary to distinguish between the original final dissolved H_2O content and the H_2O added subsequently during hydration. Since H_2O added during hydration is added as molecular H_2O (H_2O_m), and the species interconversion between H_2O_m and hydroxyl (OH) species is negligible at ambient temperature, the final OH content of the glass remains unaltered during hydration. By using H_2O speciation models to find the original H_2O_m content that would correspond to the measured OH content of the glass, the original total H_2O (H_2O_t) content of the glass prior to hydration can be reconstructed. These H_2O speciation data are obtained using Fourier Transform Infra-red (FTIR) spectroscopy. In many cases OH cannot be measured directly and instead is calculated indirectly as $OH = H_2O_t - H_2O_m$. Here we demonstrate the importance of using a species-dependent H_2O_t molar absorptivity coefficient to obtain accurate H_2O_t and H_2O speciation data and outline a methodology for calculating such a coefficient for both hydrated and unhydrated rhyolite and andesite glasses. Using this method we present reconstructed final H_2O_t contents of hydrated felsic pyroclasts from submarine volcanoes in the Japanese Izu-Bonin Arc and use these data to investigate submarine felsic eruptions and the processes that produce submarine pyroclasts, in order to understand their associated hazards.

Keywords: FTIR spectroscopy, hydration, submarine volcanology

Rootless cones as Martian cone analogues and miniature volcanoes

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Rootless cones are a type of volcanic pyroclastic cones formed through lava-water interaction. When hot lava flows onto a region of waterlogged sediments secondary explosion is induced triggered by intense vesiculation of water and forms a pyroclastic cone. They are peculiar in that they are formed at remote places from lava emanation site. On Mars even at distal part of long lava flow such as 1000 km from the source rootless cones are found. Until recently much attentions have not been paid on rootless cones and they have been regarded as a minor existence so that even the basic information such as the morphology of the cones and the pyroclastic constituents is lacking. But in the recent 10 years significant meanings have been gradually recognized in planetology and terrestrial volcanology.
Although the formation of terrestrial rootless cones is regionally restricted to several areas such as Iceland and Hawaii high-resolution imaging has revealed the pervasive existence on Mars (e.g., Greeley and Fagents, 2001). Martian rootless cones are located in very young volcanic regions which were thought to be active in 2 Ma at the latest (e.g., Burr *et al.*, 2002). The existence of these young rootless cones is an evidence of 1) the distribution of subsurface water ice on recent Mars and 2) hot interior of recent Mars enough to generate amount of flood lava (e.g., 5000-7500 km^3 in Athabasca Valles; Jaeger *et al.*, 2010). Thus, rootless cones show recent environment and thermal state of Mars, and terrestrial ones should contribute to this field.
Rootless cones would be nature analogues of huge terrestrial volcanoes. There are several good points to focusing rootless cones in point of volcanology; 1) they are formed as groups (more than 1000 cones), i.e., they can be a target of statistical analysis which is difficult for limited numbers of huge volcanoes, 2) they help simple understanding of volcanic explosions because of their simpler formation system, and 3) easier field working thanks to their small edifices.
In the presentation at first we show typical examples of rootless cones in Iceland and on Mars; their distributions and the cone morphometry in comparison with other pyroclastic cones based on our surveys of 5 years. Then we will discuss the relative position of the rootless eruption among cone-forming eruptions by magmatic and phreatomagmatic.

Keywords: rootless cone, Mars, miniature volcano

