

V12A-1415 1330h POSTER

Complex Proximal Deposition During the Plinian Eruptions of 1912 at Novarupta, Alaska

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Proximal (<3 km from vent) deposits of the 60-hour-long Novarupta 1912 eruption exhibit a very complex stratigraphy and diverse depositional mechanisms. They contrast as such with relatively simple stratigraphy and emplacement mechanisms inferred for the medial-distal fall deposits and the accompanying Valley of Ten Thousand Smokes ignimbrite. The proximal products include alternations and mixtures of locally and regionally dispersed fall ejecta, and numerous thin complex deposits of pyroclastic density currents (PDCs) with no regional analogs. The locally dispersed fall deposits form sector-confined wedges of material whose thicknesses halve radially from and concentrically about the vent over distances of 100-300m (cf. several km for the medial-distal fall deposits). This locally dispersed fall material (and many of the associated PDC deposits) is rich in andesitic and banded pumices and richer in shallow-derived wall-rock lithics in comparison to the widespread fall units. Associated PDC deposits form a spectrum of facies from fines-poor avalanched beds through thin-bedded landscape mantling beds to lobes of block-rich ignimbrite.

The origins of the Novarupta proximal deposits are considered within a spectrum of four transport regimes: (1) sustained buoyant plume, (2) fountain with counter flow, (3) fountain with counter current flow and (4) direct lateral ejection. The Novarupta deposits suggest a model where stable regime-1 plumes were accompanied by transient and variable partitioning of clasts into all three remaining regimes. During Plinian activity, margins of the jet and perhaps lower plume were strongly affected by short-lived instabilities, inferred to be associated with heterogeneities in the emerging mixture of gas and pyroclasts. Of the parameters that control explosive eruptive behavior, only such sudden and asymmetrical changes in the particle concentration could operate on time scales sufficiently short to explain the rapid changes in the proximal 1912 products.

V12A-1416 1330h POSTER

Multiple generations of tuffsite veins record repetitive ductile-brittle deformation of rhyolitic magma rising within an effusive vent: a source of flow banding in silicic lavas and repetitive seismic signals?

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Multiple generations of tuffsite veins within the obsidian margins of a 10 m-wide effusive rhyolite vent at Torfajkull, Iceland record episodic ductile-brittle deformation of rising magma[1]. The vent is dissected 30 m beneath the 10⁶ m³ subaerial lava flow that it fed, contains vesicle-free obsidian and devitrified rhyolite, and intrudes poorly-consolidated pumiceous rhyolite breccia. The youngest veins are anastomosing, irregular and filled with annealed fragments of obsidian and broken crystals ripped from their walls. These cut through earlier veins, which have undergone ductile shear parallel to the vent margins and are identifiable by their pale colour and abundance of crystal fragments. Axial strain (delta L/L) in earlier veins ranges from <2 close to the outer margin of the vent to >1000 towards the centre, where sheared veins resemble the flow bands seen in the overlying lava flow. The orientation of each tuffsite vein is unrelated to that of previous veins, indicating that the magma annealed sufficiently between

brittle events to recover mechanical isotropy. ICP-MS and FTIR analyses of the youngest veins and surrounding obsidian show that major element compositions are homogeneous, but vein material is relatively degassed (0.14 vs. 0.21 wt % H₂O). This suggests that vein formation briefly increased the vent wall permeability, and allowed escape of magmatic volatiles into the country rock[2].

We argue that such repetitive ductile-brittle deformation reflects the strain rate dependent behaviour of viscous magma[3] and is likely to be restricted to silicic compositions. Parameters such as the magma flow rate, the gradient of viscosity and pressure across the vent, strength of magma and country rock, and the annealing rate may control the depth and frequency of brittle events. This process is important because it is a primary mechanism for the formation of flow banding in compositionally homogeneous silicic magmas, through the introduction of bands with different volatile contents and thermal histories. Furthermore, it is potentially a non-destructive, repetitive source of shallow seismicity during effusive silicic eruptions, which does not depend upon the mechanical coupling of a pressured fluid phase with a solid[4], but instead reflects the deformation of material capable of solid-like and fluid-like behaviour on different timescales.

[1] Tuffen H (2001) Unpub. PhD thesis, Open Univ., UK [2] Jaupart C (1998) J Geol Soc London Spec Publ 145:73-90 [3] Dingwell DB (1997) J Petrol 38:1635-1644 [4] Chouet B (1996) Nature 380:309-316

V12A-1417 1330h POSTER

Integrating TOMS and TOVS retrievals of sulfur dioxide in volcanic clouds

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Ultraviolet backscatter data from the series of Total Ozone Mapping Spectrometer (TOMS) instruments have been used to construct a time series of volcanic sulfur dioxide (SO₂) emissions covering the past ~24 years, except for an 18-month data gap in 1995-96. Recently a new technique for retrieving SO₂ from infrared data collected by the High-Resolution Infrared Sounder (HIRS) on the TIROS Operational Vertical Sounder (TOVS) platform has been developed, based on a strong SO₂ absorption band centered around 7.3 μm. The TOVS data are global, cover almost 22 years, have a spatial resolution of 18 km at nadir (compared to 25-50 km for TOMS) and can be used by day or night (TOMS requires sunlight), and therefore provide a unique opportunity to independently cross-validate and evaluate the TOMS SO₂ retrievals. The nighttime capability of TOVS and the uninterrupted dataset also permit extension of the TOMS volcanic SO₂ record (e.g. to include eruptions at high latitudes in the winter months) and coverage of the TOMS data gap in 1995-96.

As a case study of the relative merits of the UV TOMS and IR TOVS methods, we will present retrievals of SO₂ in the stratospheric volcanic cloud produced by the August 1980 eruption of Hekla volcano, Iceland. This was a relatively modest eruption, producing ~470 kilotons of SO₂ (measured by TOMS), but the resulting volcanic cloud was unusually long-lived and could be tracked by TOMS and TOVS for ~5 days as it circumnavigated the North Pole. Detailed inter-comparison of SO₂ retrievals from TOMS and TOVS, taking into account the different sensitivities and biases of the two methods, allows a thorough examination of the evolution of this SO₂ cloud. Merging of the TOMS and TOVS datasets may also provide sufficient information on the movement of the volcanic cloud to permit validation of trajectory models (e.g. CANERM, HYSPLIT).

URL: <http://skye.gsfc.nasa.gov>

V12A-1418 1330h POSTER

FLYSPEC: A new Ultraviolet Correlation Spectrometer for the Detection of Volcanic SO₂

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A new miniature, lightweight and low cost ultraviolet Correlation Spectrometer, the FLYSPEC, has been developed as a replacement for the COSPEC, which has previously been the mainstay for the monitoring of volcanic SO₂ emissions. The total mass of this battery operated prototype system, including computer/PDA, power, cabling, and GPS is less than 2 kg and can be mounted in a 25 x 15 x 10-cm protective case. The FLYSPEC can be used in a similar fashion to the COSPEC (e.g., mounted on a ground vehicle or stationary tripod - a similar instrument, the mini-DOAS, is now being routinely used by the Montserrat Volcano Observatory for near-continuous stationary measurements). Field experiments were conducted at Masaya (Nicaragua), Poás (Costa Rica), Kilaua (USA), Vulcano, Mt Etna, and Stromboli (Italy) volcanoes as well as at industrial stacks in Hawaii. A number of these measurements were made simultaneously with COSPEC and showed statistically identical results. Unlike the COSPEC, the FLYSPEC also has the ability to simultaneously measure and perform real-time analyses of a number of UV-absorbing gas species (e.g., NO₂) making it a valuable instrument for environmental monitoring of industrial plumes. Furthermore, the small size and low cost lend the FLYSPEC to novel deployment modes such as hand-held, multi-instrument continuously recording networks, or flown on small Unmanned Aerial Vehicles. This instrument has the potential to revolutionise the manner in which volcanic, industrial, and environmental monitoring is performed.

V12B MCC: Hall C Monday 1330h

Volcanology Posters

Presiding: C E Gregg, University of Hawaii

V12B-1419 1330h POSTER

Pressure changes of volcanic systems derived from seismic signals

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Seismic low-frequency events from Soufriere Hills volcano in Montserrat are a superposition of single interface waves travelling along the conduit and leaking into the volcanic edifice at the upper end of a conduit section where magma properties change rapidly. These low-frequency signals are largely characterised by the intermittency of the interface waves, as well as by the dispersion effects they encounter.

Using finite difference modelling of the seismic wavefield together with simultaneous modelling of magma properties in time and at depth, allows us to link the seismic signature directly to magma and conduit parameters.

We retrieve a relationship between frequency content of seismic signals and governing pressure in the magma which enables us to determine the pressure changes in the magma from spectral characteristics and their temporal changes.

V12B-1420 1330h POSTER

Microgravity Changes Associated With the July-August 2001 Etna Eruption

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On the 17th of July, 2001 a new flank eruption (the first in nearly 10 years) started at Mt. Etna. It lasted 24 days (until the 9th of August) producing about 48*10⁶ m³ of lava. For about 5 months before the eruption, a progressive gravity decrease was evidenced by measurements along a profile of 19 stations running from the town of Zafferana (at the eastern edge of the profile; 450 m a.s.l.) to the town of Adrano (at the western edge of the profile; 600 m a.s.l.) through the Rifugio Sapienza (1890 m a.s.l.). The gravity decrease, with a wavelength of about 15 km, reached its maximum amplitude (80 mGal) at a station very close to

the dry fracture which opened during the 1989 eruption. A 3D calculation showed the gravity decrease to be the effect of a 2.3×10^{11} kg mass decrease within a source 2-3 km b.s.l. deep. This mass decrease is likely to be due to a magma uprise from the inferred deep source to shallower portions of the Etna plumbing system. Some of the magma lost from the deep source could have supplied the 2001 eruption. Between July and the beginning of August 2001 the above gravity anomaly partially reversed as a consequence of either new magma entering the deep source zone or collapse of voids left during the previous period when magma escaped from the inferred source. At some gravity stations in the upper Northeastern zone of the volcano (elevation ranging between 2800 and 3100 m a.s.l.) a gravity increase of up to 80 mGal was observed before the start of the 2001 eruption. A 3D calculation showed that this anomaly is due to a 2×10^{10} kg mass increase below the summit craters zone, at about 1800 m a.s.l. The above increase reversed i) partially 9 days after the start of the 2001 eruption and ii) totally after its end, indicating that the inferred mass increase reflects a magma accumulation which fed the eruption. Also, between June 2001 and October 2001, a strong gravity increase (up to 210 mGal) was observed at some stations on the upper Southeastern zone of the volcano and is attributable to the nearby emplacement of the lava flow field.

V12B-1421 1330h POSTER

DC-Resistivity Imaging and Self-Potential Measurements: a Tool to Investigate the Present State of the Long Valley Caldera/California

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A large-scale Direct-Current (DC) imaging investigation of the Long Valley Caldera included both an active 21 km DC-survey line across the caldera and the mapping of natural self-potential (SP) anomalies in the western and central part (200 m spacing over 35 km). For the detection of the potential differences special stand alone transient recorders were applied. This kind of signal recording offers the possibility of statistical methods for signal enhancement. The recorded time series yield information not only about the DC-resistivity than special effects like induced polarization and self-potentials. The geoelectrical methods make sense to apply in volcanic areas since porosity, permeability, ionic mobility, ionic concentration in rock fluids, and cation exchange capability are modified by volcanic-magmatic activity directly and processes generated by volcanism (geothermal systems). The feasibility study of tomographic resistivity deep sounding in Long Valley, a combination of measurement of a multitude of transmitter-receiver configurations and numerical reconstruction, was very successfully. The most important result is a contemporary 2-D model of resistivity distribution of the Long Valley Caldera. The model of the caldera (Inyo Craters to Cashbough Ranch) up to a depth of 5-6 km was constructed by means of 2-D tomographic inversion. Although a geological model was not incorporated in the inversion process, the final image reflects the major geological units and faults in the area under study. The investigations contribute e.g. to the answer of the question what fault presently control the hydrothermal system beneath the west moat. Structures with deep extension outlined in the resistivity image and in strong SP variations indicate the western part of the caldera as the recent active part driving the present-day hydrothermal system. Data argue for the conceptual hydrothermal model that the heat source for the hydrothermal system lies beneath the west moat, causing deeply circulation recharge water and heat water rise along nearly vertical faults to depth of about 1 km in the western part of the caldera and flows laterally to south moat and discharge areas in the eastern part east of the resurgent dome and prove the importance of the fracture systems and especially its intersections.

V12B-1422 1330h POSTER

The Alignment and Spacing of Volcanoes on Earth: Are Oceanic and Continental Settings Really That Different?

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The origin of the alignment and spacing of volcanoes has traditionally been treated from two fundamentally different perspectives: continental and oceanic.

With the overwhelming evidence from the Hawaiian-Emperor chain, where a robust plume has generated a simple time-transgressive chain of volcanic islands, many oceanic alignments worldwide have been ascribed to plate motion above a fixed source of melting. Conversely, alignments of volcanoes in continental settings are primarily ascribed to some structural or tectonic pathway that serves to guide rising magmas. This fundamental difference of cause and effect, with respect to these two settings, has led to misinterpretations regarding the age and evolution of some island chains. In the Hawaiian Islands attributes like volcano age, elevation, morphology, and lava composition change systematically in the direction of plate motion away from the most recent activity on the island of Hawaii. However, some other plume-related volcanic archipelagoes have more diffuse volcanic activity and the relative ages among some the islands are not so clear. In the Galapagos Islands, although the maximum measured ages of the lava flows increase systematically eastward from Fernandina to San Cristobal, the large western volcanoes are essentially coeval. Similar ages imply that morphological and geochemical differences among these volcanoes are due to differences in melt generation and magma supply imposed by variations in plume strength and lithospheric structure rather than an evolutionary model like that predicted for Hawaiian systems. Comparisons of other volcanic chains and fields less voluminous than Hawaii indicate that although oceanic and continental magmas are chemically quite different, the controls governing their emplacement are not. The emplacement of smaller volume oceanic systems like the Galapagos, Canaries, Reunion, and many seamounts may share more aspects with continental volcanic fields than they do with large volume systems like Hawaii. Magma transport in small volume systems is strongly influenced by lithospheric/crustal thickness, tectonic stresses, and preexisting weaknesses which ultimately provide the dominant control on the location, alignment, geochemical variation, and eruptive volume of volcanoes.

V12B-1423 1330h POSTER

Channel Development and Evolution on the 1942 Mauna Loa Lava Flow

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Detailed mapping of the 1942 Mauna Loa flow allows quantification of structures such as branches, pressure ridges, incipient channels, and well-developed channels. In the (distal) zone of dispersed flow [Lipman & Banks, 1987, USGS Prof. Pap. 1350], shear planes accommodated velocity differences. Pressure ridges are common on lava that was flowing between pairs of shear planes, termed here an incipient channel. A few hundred meters upflow, incipient channels are more common whereas pressure ridges are less so. Numerous lens-shaped islands of lava occur between adjacent incipient channels. Some shear planes are asymmetric in that they have no opposite mate.

A well-developed channel becomes distinct ~5 km upflow from the distal end. It is sinuous in map view but contains few very sharp bends. It is comprised of portions of many incipient channels connected end-to-end and utilizes the portions that produce a relatively straight overall path. Those portions of incipient channels diverging at sharp angles from the average flow direction did not become part of, and are now truncated by, the trace of the main channel. Obviously, the direction in which a lava flow develops is controlled by gravity. Small variations in the path of a developing lava channel result from the interplay between gravity pulling the lava downslope and lava pushing from upslope. A channel will be relatively straight if these two forces are of approximately equal strength and direction. If they differ by more than $\sim 30^\circ$ and/or the upslope push is considerably stronger, the downslope pulling direction is commonly abandoned. If the directions differ but the forces are of equal strength, the flow branches.

These controls on flow direction are important considerations for numerical models of lava flow emplacement and their use for determining inundation hazards.

V12B-1424 1330h POSTER

PEG Simulation Insight Into the Construction and Cross-Sectional Morphology of Levees

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Polyethylene glycol (PEG) was extruded at constant rates and temperatures into a 75-cm-long tank filled with cold sucrose solution in a series of low-volume (<

2000 mL), short-duration (< 240 s) simulations conducted on underlying slopes ranging from $4 \times 10^\circ$ degrees with effusion rates of 6-10 mL/s to constrain the development of levees in channeled flows. Upon extrusion, thin slabs of PEG solidify on the surface of the flow. The PEG slabs drift to the lateral flow margins, stall, and accrete, establishing a foundation for a levee system. Distinguishable levees in the PEG channel flows do not form until almost 30-50 s into the simulation. Levee length grows as liquid PEG oozes around the solid down-slope levee end, stalls, and solidifies. After initial emplacement, the levees remain stable entities regardless of their width, and the outer levee margins do not grow laterally through overflow or underflow of PEG. Although minuscule, partially solidified, morsels of PEG do accrete to the inner margin of the levees, total levee width remains relatively constant until effusion at the vent stops and the entire flow surface solidifies. Initial results suggest that levee width is not a linear function of distance from the vent, effusion rate, or underlying slope, although levees are slightly wider, on average, on lower underlying slopes than they are on steeper slopes. Wider levees (> 1 cm) usually comprise a hollow, internal conduit system that PEG can continue to flow through. The most striking feature of the cross-sectional morphology is the concave shape to the inner wall of the levees, regardless of eruption parameters. This concavity conceals a volume of moving liquid wax in the channel, so that the true channel is actually wider than what is observed at the flow surface. General observations of the concave inner walls reveal that height, thickness, and concavity for an individual levee remain fairly constant from the vent to the flow front. Field observations on a selection of channeled flows on the north side of Mauna Ulu, Kilauea volcano, Hawaii, display cross-sections similar to those found in lab simulations, particularly in the concavity of the inner levee walls. Extension of true channel width into hollow levee systems that parallel the main channel beneath the crust of the flow was observed, and in one case, tripled the observed channel width. Additional simulations over a spectrum of conditions will further levee construction and morphology analysis.

V12B-1425 1330h POSTER

The Evolving Morphology of an Open Channel Lava Flow on Mt. Etna, Italy

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From mid-May to mid-July 2001 a small eruption from the southeast cone on Mt. Etna into the Valle del Leone persistently fed a classic example of a compound aa flow field. The flow field developed by multiple channel bifurcations to eventually extend 1km across and 2km down the volcano.

This flow field provided the opportunity to study changes in the thermal structure and morphology of the uppermost part of open lava channel over a period of days. This was done using temperature-calibrated digital images from a FLIR (Forward-Looking Infrared) camera and continuous recordings from a radiometer, which provided an integrated radiance value over the area of the channel in the field of view.

The images and patterns of change in these data showed many features occurring over a 100m length of channel. Features observed included different types of tube formation, channel blockages, overflows, diverted flows, crust formation and destruction and "surges" in the volume of lava flowing in the channel. There were small surges or "pulses", and large surges that totally over-filled the channel. The pulses resulted from lava build up behind channel blockages, which then partly broke-up allowing the rapid lowering of the channel fill level, before blockages formed again. The larger surge events however, completely overwhelmed the channel and were attributed to a change in supply volume. Changes in the integrated thermal output (of the lava channel surface) lag behind when compared to changes in the surface velocity of the flowing lava, which would be consistent with the hypothesis of a changing supply volume.

This study represents one of the first uses of a FLIR to study active lava flows and suggests it has great potential for helping understand eruption dynamics.

V12B-1426 1330h POSTER

Basaltic Shield Volcanoes: A Quantitative Tool for Characterizing Flow Field Morphometry

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Young basaltic shields display morphologies unique from older shields that have undergone magmatic evolution. We have tested the validity of differentiating basaltic shields at different stages of magmatic evolution through analysis of their slope frequency distributions. Slopes are the irregular surface expressions of the processes that have formed the landscape. Therefore, unique slope distributions can be used to identify regions that have undergone unique formational processes. Young shields form a broad, gently sloping structure composed of long, overlapping lava flows. These flows are often erupted from a central source vent region. Throughout the magmatic evolution of a shield volcano, the erupted lavas gradually become more silicic. As the erupted lavas become more viscous, flow lengths decrease causing slopes to increase near the summit. Late stage shield volcanism is typified by eruption of lavas from numerous vents producing steep sided cones that are superimposed on the shield's flanks. As a shield volcano ages, its morphometry evolves due to the changing lava flow emplacement conditions. Slope analyses should detect the differing emplacement conditions that exist between young and old shields as unique slope frequency distributions. We have conducted slope frequency studies on the USGS, 10 m Digital Elevation Models (DEMs) for the Hawaiian shields Mauna Kea and Mauna Loa. Slopes were calculated from a complete Hawaiian DEM, mosaiced in ArcView GIS 3.2 by ESRI (Environmental Systems Research Institute, Inc.).

A slope frequency plot, or histogram, is produced for each shield. Mauna Loa displays a gaussian distribution of slopes centered at 15 degrees while the older shield, Mauna Kea, displays a gaussian distribution that is skewed towards higher slopes centered at 21 degrees. The unique slope signatures of the two volcanoes highlight the unique flow emplacement conditions for shields at different stages of magmatic evolution. Slope frequency distribution analyses could also be capable of identifying the unique flow field emplacement processes that form Flood- and Plains-style basaltic provinces. If so, these studies can be used to further characterize basaltic provinces on any planetary surface for which reliable topographic data exists.

V12B-1427 1330h POSTER

Tectonic Control on the Eruptive Dynamics at Mt. Etna Volcano (Eastern Sicily) During the July-August 2001 eruption

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The eruptive dynamics of July-August 2001 at Mt. Etna (eastern Sicily) has provided new insights for modelling the development of magma feeding systems and its relationships with regional tectonics. The eruption took place mainly on the upper southern sector of Mt. Etna with eruptive vents at the South-East crater, Piano del Lago, Montagnola area. The eruption was preceded by a large earthquake swarm few days before its onset and accompanied by a relevant ground deformation and fracture opening. Erupted lavas are K-trachybasalts which, considering their petrographic features, may be considered as two distinct types. The development of surface cracking along with the seismic pattern has allowed to recognize three distinct eruptive systems (the NE-SW, NNW-SSE and N-S systems) which have been simultaneously active. Such eruptive systems are only the upper portions of an articulated feeding system which was fed at the same time by two distinct magmas. The NE-SW and NNW-SSE systems, connected with the SE crater conduit, were fed by a magma coming from depth. The N-S system served instead as ascending pathway for a an amphibole-bearing magma residing in a shallow reservoir, whose uprising

and eruption was, very likely, triggered by an input increase of deep coming magma. The eruption of July-August 2001 confirms that at Mt Etna volcano the conditions of ascent of magmas are strongly dominated by extensional structures, which are connected to a larger scale regional regime.

V12B-1428 1330h POSTER

Using Lava Inflation Structures to Estimate Eruption Duration in Fossil Lava Fields: the Helgafell Eruption 5900 BP

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Lava inflation structures, such as tumuli and pressure ridges, are common features in subarctic pahoehoe flow fields but has also been reported from submarine lava flows. Tumuli form by clogging of individual lava tubes inside a flow field or when the lava supply rate exceeds the flow front displacement, which causes inflation of previously formed crust and formation of the characteristic whale-back shape of tumuli. Axial and radial clefts cut the tumuli ("inflation-clefts"). Measurements on active lava flows has shown that the time (during which inflation occur) correlates positively with the square of the measured inflation-cleft depth, and can therefore be used to calculating active time of inflation by measuring cleft depths in fossil flows.

Over threehundred measurements of inflation cleft depths were collected from tumuli and pressure ridges located in the Helgafell lava field, Vestmannaeyjar, South Iceland. The Helgafell eruption occurred approximately 5900 BP, and emplaced the largest lava flow on the island covering 6.5 km² (~ 0.6 km³ DRE). The erupted lava are plagioclase-phyric alkali basalt, exhibiting considerable variation (7.0 wt% MgO to 4.4 wt% MgO) due to flow fractionation and incorporation of large (< 7 cm) plagioclase xenocrysts. Measurements of inflation cleft depths show that a minimum crustal thickness of 0.3 m is required to initiate tumulus growth. The deepest clefts are located furthest away from the vent, which coincides with the largest elevation difference between tumuli and source (e.g. uppermost point of lava tube). The cleft measurements were combined with careful stratigraphic mapping in order to estimate the total duration of the Helgafell eruption. It is important to keep in mind that tumuli are surface features and only reflect inflation of the uppermost flows. The maximum time calculated for active inflation must therefore correspond to a minimum eruption duration. By doing these calculations, and adding measurements of tumuli from various stratigraphic levels in the exposed coastal sections, the total duration of the Helgafell eruption can be estimated to a minimum value of nine months. The ratio of erupted volume/duration (km³/month) for Helgafell (0.06) is well in range of both the 1973 Eldfell eruption (0.04) and the 1963-1967 Surtsey eruption (0.02), considering that this estimate of minimum duration and any increase in time will lower the volume-time ratio.

V12B-1429 1330h POSTER

Hazard Zonation at Mount Adams, Washington based on Edifice and Flank Stability Modeling

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Collapse of the edifice [summit] and flanks of volcanoes is common worldwide, including the Cascade Range. Many of these failures have transformed into devastating debris flows that may travel hundreds of miles from their source area and have killed or injured hundreds of thousands of people. Despite the danger posed by these failures and the incipient debris flows, limited geotechnical data exists to quantify hazards from edifice and flank failure.

Recent field work and investigation at Mount Adams, Washington focused on developing and refining a methodology for characterizing volcanic stability for geologic hazard analysis. This methodology may be applied at other volcanoes worldwide. Geotechnical data, including discontinuity and strength characteristics, Rock Mass Rating (RMR), point load index, direct shear, unconfined compression, and triaxial data were used to identify sectors based upon common geotechnical and geologic characteristics. The geotechnical information collected at Mount Adams adds to the limited

data available worldwide and provides general strength ranges for use in initial stability studies at other volcanoes. In addition, a new point load index device was developed for use at high elevation and remote locations.

Stability of each identified sector was analyzed using limit equilibrium methods, based upon collected geotechnical and geologic data. Three previous failures were backanalysed to determine strength characteristics at the time of failure. Areas of immediate instability include The Castle and the Avalanche Glacier Headwall. Backanalysis of the Trout Lake Mudflow, which formed the Avalanche Glacier Headwall, suggests a seismic or eruption triggering mechanism.

Stability analysis resulted in a failure hazard map quantifying the hazard in each sector from slope failure. This hazard map in combination with other data may be used by agencies and organizations involved in land-use planning in the Mount Adams area to protect lives and property.

V12B-1430 1330h POSTER

Eruption Warning System for Active Volcanoes in Japan: Present Situation, Problems and a Proposal

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How to inform the public about unrest and eruptions of volcanoes is an important problem to reduce impending volcanic hazards. Japan Meteorological Agency issues four types of warning depending on how serious the condition is. For instance, the highest level of warning called "volcanic alert" is issued when human lives have been lost or will likely be lost due to eruptive activities. Precautions to take responding to this warning are ambiguous, however, because the loss may be simply accidental near the crater or caused by such dangerous phenomena as pyroclastic flows. The Coordinating Committee for the Prediction of Volcanic Eruptions in Japan has proposed another scheme that represents recommendable precautions more explicitly in terms of alert levels. For instance, the alert levels 3 and 4 recommend the officials to prohibit people from entering the volcano and to evacuate residents from dangerous zones, respectively.

Recently, the public has some concern about possible future eruptions of Mount Fuji after many low-frequency earthquakes were observed below this volcano in 2000 to 2001. Fuji may erupt effusively or explosively at various part of the volcano and the eruption may influence wide areas including the Metropolitan area of Tokyo. Taking these special conditions of Fuji into account, I propose the alert levels that clearly show the type of precaution and the associated location. The alert levels are based on zoning of the volcanic and ambient region into the central part containing all possible vents, the flank zone, the residential areas divided by the flow directions, and the outside merely subjected to ash falls.

V12B-1431 1330h POSTER

The Perception of Volcanic Risk in Kona Communities from Mauna Loa and Hualalai Volcanoes, Hawaii

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Hawaii coastal communities are becoming increasingly vulnerable to natural hazards as a consequence of increasing population and infrastructure. Volcanic hazards in Kona (i.e., western side of the island) stem primarily from Mauna Loa and Hualalai volcanoes. The former has erupted thirty-nine times since 1832. Lava flows were emplaced in Kona during six of these, but last impacted Kona in 1950. Hualalai last erupted in c. 1800. The most recent eruptions at each volcano were damaging to society, but future eruptions would exact much greater impacts. The second largest city on the island, several resort complexes, and an international airport are located within 15 km of vents. Societies proximity to potential eruptive sources, a potential for relatively fast moving lavas, and the relatively

long time intervals since the last eruptions in Kona, are the stimuli for this study of risk perception. Target populations were high school students and their parents, and the greater adult public (n=462). Using this data, we discuss threat knowledge as an influence on risk perception and perceptions as a driving mechanism for preparedness. Threat knowledge and perception of risk were found to be low to moderate. On average less than two-thirds of residents were aware of the most recent eruptions that impacted Kona and a minority felt that Mauna Loa and Hualalai could erupt again. Furthermore, only about one-third were aware that lava flows could reach the coast in Kona in under three hours. Lava flows and ash fall were perceived to be among the least likely hazards to affect the respondents community. Not unexpectedly, individual preparedness measures were found to be limited to simple tasks, while measures specific to infrequent hazard events such as volcanic eruptions and earthquakes were seldom adopted. Respondents exhibit an unrealistic optimism bias and infer that responsibility for community preparedness for future eruptions rests primarily with officials. Hazard awareness and risk perception varies between subpopulations defined by age, geography, and ethnicity. Long time intervals since damaging lava flows have occurred in Kona has contributed to lower levels of awareness and perception of the threat. The on-going eruptions at Kilauaea has facilitated greater awareness and perception of risk from vog but not of other volcanic hazards. Low levels of preparedness may be explained by this and perhaps by the lack of motivation to seek new modes of adjustment.

V12B-1432 1330h POSTER

Tephrochronology and Paleomagnetism in the Northwest Wall of Kilauaea Caldera, Hawai'i, Reveal the Age of the Observatory Shield

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Chemical analysis of tephra in the northwest wall of Kilauaea's caldera, and paleomagnetism of associated lava flows, allow correlation to more distal tephra and flows of known C-14 age. This correlation shows that the Observatory shield-the shield that existed before the modern caldera formed about 500 ka-must be considerably younger than previously considered. We dug a pit through a mantle of scree to exhume a 2.2-m-thick section of tephra about one-third of the way up the caldera wall. A distinct color change divides the tephra section into upper and lower parts. Glassy ash and lapilli from just below the color change have unusually high TiO₂ and K₂O contents (3.1 and 0.75 wt. percent, respectively) recognized at more than 30 localities in the 1.3 to 1.1 ka Kulanaokuaiki tephra south, west, and north of the summit. The paleomagnetism of lava flows beneath the exhumed tephra is equivalent to that of the Kipuka Nene flows, which underlie complete sections of Kulanaokuaiki tephra southeast of the caldera. Tephra in another exposure, at the base of the caldera wall several hundred meters northeast of the pit, consists only of beds above the high Ti-K ash. That ash, and tephra below, are apparently buried beneath a flow that is interlayered with the tephra. The exposed upper part of this flow has the same paleomagnetic direction as the Hope'o (Hornet kipuka) flow, which occurs between the upper and lower Kulanaokuaiki tephra 6 km south of the summit. The flow immediately overlying the upper part of the tephra correlates magnetically with the 1.0 ka Old Kalue flows, which directly overlie complete sections of Kulanaokuaiki tephra on Kilauaea's south flank. Flows making up the upper ~30 m of the caldera wall correlate magnetically with the 0.6-0.8 ka Young Kalu'e, Ahua, Lua Manu, and Observatory lava flows that blanket wide areas around the caldera, in the Koa'e fault system, and on the south flank. We conclude that the tephra in the caldera wall, considered by some as the type locality of the 2.1-2.8 ka Uwekahuna Ash, is the Kulanaokuaiki tephra. The lava flows exposed in the caldera wall above the Kulanaokuaiki were erupted during growth of the Observatory shield from 1.0 to 0.6 ka.

V12B-1433 1330h POSTER

Accretionary lapilli beds in the Keanakako'i Ash: footprint-bearing beds not 1790 in age

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The Keanakako'i Ash is the product of explosive volcanic activity at Kilauaea volcano between about A.D. 1500 and 1790. The explosive eruption of 1790 killed 80-800 members of a war party near the caldera and earned a place in Hawaiian history. The deposits of this eruption consist mainly of coarse pyroclastic beds and finely laminated base surge strata that form dunes in proximal areas and thin with distance away from the vent. Accompanying these deposits are thin, massive, fine ash layers a few centimeters thick containing accretionary lapilli. Human footprints are preserved in two fine ash layers abundant in accretionary lapilli at many places within 10 km southwest of Halemaumau Crater. Early researchers put these layers high in the stratigraphic section and attributed them to the 1790 eruption. The rationale behind this assumption was that the footprints were left by the war party fleeing from the eruption.

Erosional gullies cut through the deposit at Sand Hill, about 1 km southwest of Halemaumau Crater, and expose an almost complete proximal section. McPhie and coworkers in 1990 recognized three major unconformities in the section, each relating to a hiatus in deposition. Early investigations concluded that the Keanakako'i Ash was deposited by a series of explosive events separated by breaks in time. More recent studies suggested that the formation was deposited more quickly, with unconformities produced through erosion by pyroclastic surges. We find, however, that this hypothesis is inconsistent with field observations.

Accretionary lapilli beds were identified in proximal sections, separated by lithic surge deposits. These beds can be traced away from Sand Hill and identified by unique characteristics and small-scale stratigraphic relationships. More distally, the deposit is eroded in most places, but stratigraphic correlation is possible using small depressions that protect the ash layers from erosion. Samples were taken and individual accretionary lapilli beds were characterized in terms of the constituent ash particles and of the aggregates themselves.

We conclude from the correlation data that the two footprint-bearing accretionary lapilli beds are separated by an unconformity, and at least the lower of these beds was produced by an eruption earlier than 1790, possibly decades or more. The footprint-bearing layers have important implications not only for stratigraphic correlation, but also for the understanding of activity of ancient Hawaiians in this area and how these people viewed Pele, their volcano goddess.

V12B-1434 1330h POSTER

TEPHRASTRATIGRAPHY AND ANALYSIS OF TECTONIC SETTING OF TRIASSIC INTERMEDIATE VOLCANIC STRATA: NANPANJIANG BASIN, SOUTH CHINA

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The Nanpanjiang is a deep-marine basin in the southern margin of the Yangtze microcontinent of South China. The basin contains several shallow-marine carbonate platforms developed in Triassic time. Differential carbonate platform development and subsidence analysis suggests that the Nanpanjiang basin developed into a foreland basin resulting from an arc collision in the southern part of the basin in the Triassic. The tectonics of this area, however, received little previous study.

Ash Tuff horizons extend across the basin for 500 km near the Permian-Triassic boundary (PTB) and the Lower to Middle Triassic boundary (LMT). Thin-section analysis of the ash tuff horizons revealed the units are pyroclastic composed primarily of carbonate altered rhyolites and rhyodacite vitric ash tuffs (Schmid, 1981). PTB horizons are most abundant and the LMT volcanic horizons are thickest in the southern part of the basin. Petrographic analyses of samples from the LMT volcanic horizon indicate that coeval, geochemically similar lavas that are 150 m thick

in the southern part of the basin may represent volcanic products proximal to the eruptive center, become coarse grained pyroclastics northward, and grade into bentonite clay in the northern part of the basin where it is less than 20 cm thick.

Immobilized trace elements (Zr/TiO₂)/(Nb/Y) indicate that the PTB and LMT volcanics are rhyolites and rhyodacites in composition (Winchester 1977). Major element discrimination of tectonic setting indicates a convergent margin in an intra-oceanic or continental volcanic arc; however, the relative mobility of the major elements affects the overall usefulness of this analysis. Immobilized trace and REE elements (Th, Ta, Y, Rb, Yb) also support the interpretation of a convergent arc setting. Trace element fingerprinting of the volcanic horizons indicate basin wide distribution of volcanic units that erupted from a similar magmatic source throughout Late Permian and Early Triassic time. Petrographic and geochemical studies of the volcanic horizons associated with the end-Permian mass extinction and the Early Triassic indicate eruption from southerly volcanic arc that collided with the southern margin of the Yangtze microcontinent in the Triassic.

V12B-1435 1330h POSTER

Tectonic Setting of the Big Pine Volcanic Field, Eastern California

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The Big Pine Volcanic Field (BPVF) is situated in the northern part of the Owens Valley, a fault-controlled basin that has evolved between the Sierra Nevada and the White-Inyo Mountains during the last 7 m.y. The Owens Valley is part of the Eastern California Shear Zone (ECSZ), which is a broad transensional zone of right-lateral shear that defines an oblique rift zone in the wake of the NW-moving Sierra Nevada-Great Valley block. The BPVF occupies 400 square miles of the basin straddling the dextral Owens Valley Fault Zone and consists of scattered centers of volcanism dominated by cinder cones, lava flows, and domes associated with normal faults near the valley walls and with cross-basin oblique fault systems. The lavas consist of moderately potassic olivine basalt, hawaiite and trachyandesite. One dome west of Poverty Hills consists of rhyolite. Most basaltic samples contain 1-4 mol% normative nepheline but a few have small amounts of normative hypersthene. All analysed samples have similar chondrite-normalized rare-earth element patterns with strong light rare-earth enrichment. La is up to 200 times chondrite and Lan/Smn ratios average 3.5. Two hawaiites from the Red Hill cone west of Bishop are distinct from the other samples. They have relatively high K₂O (3.5 wt%), low Na₂O (2.5 wt%), high FeO_t (9.8 wt%) and very high Zr (350-400 ppm). The distinct geochemistry of the hawaiites suggest that they originated from a separate parental magma. Likewise, the geochemistry of the Poverty Hills rhyolite and the lack of intermediate samples between it and the basalts suggests that it too was derived from a separate parental magma. The Big Pine volcanic rocks are the youngest of the eastern Sierra Nevada potassic province. They have undergone relatively little fractionation and thus were probably erupted shortly after formation of the parental liquids. Development of the BPVF corresponds to the evolution of the Owens Valley Fault Zone (OVFZ) as a major transensional dextral fault system during the Pleistocene-Holocene, as this fault system migrated westward within the basin in response to changes in local fault kinematics. We predict that volcanism in the BPVF became progressively younger both westward and northward as the OVFZ established itself as the most recently active fault system in this part of the ECSZ.

V12B-1436 1330h POSTER

Origin of steep-pointed and flat-topped volcanic cones in Southwest volcanic field

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KR01-12 cruise of Japan Marine Science and Technology Center using ROV KAIKO and its mother ship

R/V KAIREI were carried out around Hawaii islands in the early fall of 2001. During this cruise, two dives of ROV KAIKO were made on southwest Oahu volcanic field (K203 and K206). The new Seabeam bathymetry revealed that there are remarkable topographic features: flat-topped volcanic cone, ca. 2.5 in diameter and 200m in height; steep pointed cone, ellipsoidal in plain: major axis 2km, minor axis 0.5km; 200-400 m in height. This volcanic topographies are similar to those described in elsewhere e.g., Clague et al., 2001. Flat-topped cones distributed in this area are different from other area in their occurrence. They are accompanied with steep-pointed cone. In order to study the geological and petrological relationship between flat-topped cone and steep-pointed cone, both K203 and K206 have been analyzed by video image, thin sections and bulk rock chemistry.

The rocks recovered from K206 and K203 are trachybasalt and basanite respectively. There is no critical differences between FTVC and SPVC in their bulk chemistry. For example rocks from FTVC are almost identical to the SPVC in SiO₂ contents in the same site. Total AK concentration of rocks from FTVC is lower than those of SPVC in K203, but FTVC is higher than SPVC in K206. This result implies that topographical characters are not correlated with bulk chemistry. Both in K206 or K203, rocks collected from SPVC have higher vesicularity, ranging from 20 to 40%, and higher crystallinity in groundmass than those from FTVC. It is suggest that differences in topographical characteristics between FTVC and SPVC are controlled by physical property of the groundmass. That is, the viscosity of magma lead to rise due to exsolution of gas phase from melt.

V12C MCC: 106 Monday 1330h
Arc Magmatism II (joint with T)

Presiding: J F Larsen, University of Alaska, Fairbanks; **A F Glazner**, University of North Carolina

V12C-01 1330h

Eruptive Productivity of the Ceboruco-San Pedro Volcanic Field, Nayarit, Mexico

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High-precision ⁴⁰Ar/³⁹Ar geochronology coupled with GIS spatial analysis provides constraints on magma eruption rates over the past 1 Myr of the Ceboruco-San Pedro volcanic field (1870 km²), located in the Tepic-Zacoalco rift in western Mexico. The volcanic field is part of the Trans Mexican Volcanic arc and is dominated by the andesitic-dacitic stratocone of Volcan Ceboruco and includes peripheral fissure-fed flows, domes, and monogenetic cinder cones. The ages of these volcanic features were determined using ⁴⁰Ar/³⁹Ar laser step-heating techniques on groundmass or mineral separates, with 78% of the 52 analyses yielding plateau ages with a 2 sigma error < 50 kyrs. The volumes were determined using high resolution (1:50,000) digital elevation models, orthophotos, and GIS software, which allowed for the delineation of individual volcanic features, reconstruction of the pre-eruptive topography, and volume calculations by linear interpolation. The relative proportions of the 80 km³ erupted over the past 1 Myr are 14.5% basaltic andesite, 64.5% andesite, 20% dacite, and 1% rhyolite, demonstrating the dominance of intermediate magma types (in terms of silica content). Overall, there appears to be no systematic progression in the eruption of different magma types (e.g., basalt, andesite, dacite, etc.) with time. However, more than 75% of the total volume of lava within the Ceboruco-San Pedro volcanic field erupted in the last 100 kyrs. This reflects the youthfulness of Volcan Ceboruco, which was constructed during the last 50 kyrs and has a present day volume of 50 ± 2.5 km³, accounting for 81% of the andesite and 50% of the dacite within the volcanic field. Eleven cinder cones, ranging from the Holocene to 0.37 Ma, display a narrow compositional range, with 52-58 wt% SiO₂, 3-5.5 wt% MgO, and relatively high TiO₂ concentrations (0.9-1.8 wt%). The total volume of the cinder cones is 0.83 km³. No lavas with < 51 wt% SiO₂ have erupted in the past 1 Myr. Peripheral andesites to dacite domes, totaling about 14 km³, were dated

from 0.4 to 0.6 Ma. The eruptive productivity of the Ceboruco-San Pedro volcanic field over the past 1 Myr is 43 m³ per km² per year, which corresponds to a lava accumulation rate of 43 m/Myr. This rate is less than 1/6 of the lava accumulation rate of 268 ± 71 m/Myr at the Mt. Adams volcanic field in the Cascade arc (Hildreth and Lanphere, 1994). However, if only the last 100 kyrs are considered (which includes the Ceboruco cone-building episode), the resulting eruptive rate of 323 m/kyr is comparable to the 160-500 m/kyr cited for cone-building episodes at Mt. Adams. The non-focal or peripheral magmatism in the Ceboruco-San Pedro volcanic field is predominantly comprised of phenocryst-poor andesites and dacites that erupted in a 200 kyr interval. This is in marked contrast to the Mt. Adams volcanic field, in which non-focal eruptions are dominantly basaltic. Given that the continental crust is 30-35 km thick beneath Ceboruco and 40-45 km thick beneath Mt. Adams, there is not a positive correlation between crustal thickness and more evolved magma types. These results underscore the importance of studying multiple volcanic fields to better understand the interaction of arc volcanoes and peripheral lavas and their evolution through time.

V12C-02 1345h

A diffusion-decay model for steady-state U-series disequilibrium in the mantle with implications for island arc lavas

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Mantle equilibrium has long been considered the default starting point for U-series modeling. The half-lives of most U-series elements are considerably shorter than the timescales for major mantle differentiation processes (e.g. 75 Ka for ²³⁰Th, 1622 a for ²²⁶Ra), so it seems logical that any disruption in the U-series decay chain should correct itself relatively quickly. We have developed a model whereby ²²⁶Ra/²³⁰Th disequilibrium can be maintained indefinitely between co-existing clinopyroxene and phlogopite. The steady-state ²²⁶Ra/²³⁰Th ratio is determined by competing effects of diffusion and radioactive decay. Partition coefficients have been calculated (Ra) or experimentally determined (Th) for diopside and phlogopite. The cpx/phlogopite distribution coefficient for Ra is very low (~10⁻⁵), while that for Th is neutral (~1). Therefore, when ²³⁰Th in cpx decays to ²²⁶Ra, the incompatible Ra tends to diffuse out of the cpx and into neighboring phlogopite, while the Th remains in place. The result is a steady-state ²³⁰Th excess in cpx, with a complementary steady-state ²²⁶Ra excess in phlogopite. The extent of the disequilibrium is determined by the rate of diffusion (a function of temperature), the size of the grains, and the ratio of phlogopite to cpx. In order for disequilibrium to develop, the Ra must diffuse out of the cpx grain faster than it decays. The lengthscale for ²²⁶Ra loss is given by (DRa/λRa)^{1/2}. At 1000°C, Ra is lost from only the outer 35 μm of the cpx grain, whereas at 1300°C, loss occurs from the outer 1.7 mm of the grain, effectively draining it of Ra.

Preferential sampling of phlogopite during melting leads to ²²⁶Ra excess in the melt itself, with the extent of the ²²⁶Ra excess dependent on the degree of partial melting. Small degree melts of metasomatised mantle can develop very high ²²⁶Ra excesses (²²⁶Ra/²³⁰Th > 60 in a 0.1% melt), consistent with observations of high activity ratios in island arc lavas. Furthermore, the high ²²⁶Ra/²³⁰Th in island arc lavas is correlated with high Ba/Th, also consistent with a preferential phlogopite contribution. Phlogopite contamination of the melt is possible in the source region, by incipient melting of conduit walls during transport, or from the partial re-melting of cumulates in the magma chamber. Therefore, ²²⁶Ra/²³⁰Th may not be a reliable tracer of source-to-surface magma travel time at island arcs.

V12C-03 1400h

238U-230Th-226Ra disequilibria at Cotopaxi volcano, NVZ, Ecuador

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True rhyolites are scarce in volcanoes of the Northern Volcanic Zone of the S. American Andes but they have been intermittently produced at Cotopaxi volcano since at least 10 ka ago. Lava flows and airfalls of Cotopaxi volcano comprise andesite and rhyolite, and isotopic data for both compositions are similar to the mantle-like values typical of island arcs, despite a 50 km thick crust. Rhyolite also erupted from nearby Chalupas Caldera at approximately 230 ka; Cotopaxi is constructed near the rim of the Chalupas Caldera.

By studying the differences in the amount of ²³⁸U-²³⁰Th-²²⁶Ra disequilibria between the rhyolite and andesite at Cotopaxi, we hope to gain a better understanding of the timing of rhyolite differentiation as well as to learn about the general nature of the fractionation event (i.e. relative roles of fluid addition, mineral fractionation, melting etc). Also of interest is the timescale of andesite generation.

Cotopaxi whole rocks and associated mineral separates were analyzed for ²³⁸U-²³⁰Th-²²⁶Ra disequilibria using PIMMS (U, Th) and TIMS (Ra). Zircon grains were separated from the rhyolite and analyzed for U-series isotopes using SIMS. The Cotopaxi andesites have (²³⁸U/²³⁰Th) from 0.96-0.99, and (²³⁰Th/²³²Th) from 1.11-1.18. Mineral separates indicate an age of ca 28 ka. Rhyolite samples have (²³⁰Th/²³²Th) of 1.22-1.31, and (²³⁸U/²³⁰Th) of 1.03-1.18. Isochron ages from the rhyolite mineral separates range from ca. 90-130 ka. Andesites have ²²⁶Ra-excesses, and an isochron through the data gives an age range of ca. 0-500 years.

Three notable observations based on the U-Th-Ra data are: 1) The majority of Cotopaxi andesite have (²³⁸U/²³⁰Th) < 1, which is in contrast to the rhyolite samples which have (²³⁸U/²³⁰Th) > 1. 2) The ²²⁶Ra data show that an event happened within the last 500 years to fractionate Ra from Th in the andesite. 3) The ages inferred from Ra-Th and U-Th systematics respectively are different. If the Ra-Th and U-Th fractionations correspond to specific petrogenetic events, then these are not the same.

The high ²³⁰Th/²³²Th and U-excesses of the rhyolites show that in order for them to be related to the andesite through fractional crystallization, they must have evolved for >90 k.y. from U-enriched andesites unlike any currently erupted. An alternative model involving assimilation of continental crust is not likely based on the consistent mantle-like isotopic ratios for both the rhyolite and andesite. Based on the similarity of the zircon ages to the eruption age of the Chalupas ignimbrite, it is possible that andesite mixed with residual Chalupas caldera magma to form the Cotopaxi rhyolite. If, as seems likely, the ²³⁰Th enrichments that characterize the andesites are the result of a melting process, then the andesite isochron suggests that melting and ascent occurred on a timescale of ca. 40 ka. The ²²⁶Ra excesses in the andesite and the (²²⁶Ra/²³⁰Th) isochron age suggest that perhaps a second magmatic event happened recently (<500 yrs); the lack of associated U-enrichment suggest that interaction with a fluid or volatile phase is not involved. It may be more likely that the ²²⁶Ra excesses are the result of crystallization, in which case the ²²⁶Ra data may help us to constrain the timescales of crystallization in the andesite prior to eruption.

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Pre-eruptive dynamics of the 3400 yBP Aniakhak Caldera forming eruption: A phase equilibria study.

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Aniakhak caldera is located on the Alaska Peninsula, and has a 10 km wide present-day caldera. The 3400 yBP eruption that produced the caldera resulted in voluminous rhyodacitic and andesitic pyroclastic deposits that show marked evidence for mixing and mingling of the two magmas involved. The 3400 yBP deposits generally consist of basal rhyodacite Plinian pumice beds, capped by mixed rhyodacite and andesite ash flows, with purely andesitic ash flows at the top of the sequence. This study focuses on phase equilibria experiments performed on samples of the 3400 yBP rhyodacite and andesite in order to constrain the conditions of pre-eruptive magma storage, and elucidate the magma dynamics prior to the eruption. Approximately 35 experiments have been run on the rhyodacite and andesite at fO₂ between NNO and NNO + ~0.5 log units using both René-style cold seal and TQM pressure vessels at appropriate crustal P and T conditions. We collected BSE images, x-ray maps, and quantitative chemical analyses using a Cameca SX-50 electron microprobe in order to determine stable phases and quantify the compositions of minerals and glasses resulting in the charges. Compared to the mineralogy and glass chemistry of the rhyodacite pumice, experimental plagioclase and glass compositions indicate that