fluorescence causing Ge-detector to saturate in energy dispersive x-ray diffraction was not an issue in the present angular dispersive experiments. With energy of 30.4912keV (0.040663 nm) x-ray, $NaMgF3$ was studied to 30 GPa. Exposure time was 1 to 6 minutes for different pressures. No phase transition was found in the pressure range. The P-V data fitting to a third order Birch- Murnahgan equation yields a bulk modulus Ko=68.9 1.7 GPa and Ko'=6.3. [1] Z. Zhong, et. al., Acta. Cryst. A 59 (2003) 1-6 [2] Z. Zhong, et. al. J. Appl. Cryst., 34 (2001) 646-653

V42A-0335 1330h POSTER

Neighborite Under High Pressure: *In Situ* Angle Dispersive X-ray Diffraction Study Using Synchrotron Radiation

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The neighborite ($NaMgF_3$) is an ideal analogue model for silicate perovskite ($MgSiO_3$) due to the similarities between their crystal and electronic structures. The advantage of the analogue study is that the weaker bonding feature of neighborite grants us the opportunity to simulate behavior of silicate perovskite at lower mantlei. e.high pressure and high temperature condition, at relatively lower P-T conditions. The previous high pressure studies for neighborite were reported by Zhao et al [1, 2]. Energy dispersive x-ray diffraction data were achieved within 10GPa and 1000^{o}C, while angle dispersive x-ray diffraction data were obtained only at 4.9GPa and room temperature.More information of atomic position change is required to reveal the role of MgF_6 octahedral framework tilting during its phase transition process responding to heating andcompressing. Thus the high-resolution monochromatic x-ray powder diffraction studies on $NaMgF_3$ perovskite at high pressure were carried out using diamond anvil cell at X17C of National Synchrotron Light Source (Brookhaven) and HPCAT of Advance Photon Source (Argonne). The orthorhombic structure keeps stable under pressure up to 30 GPa, and the crystal structure is refined using Rietveld method. The result indicates that tilting angle of the MgF_6 octahedral framework increases continually while the octahedral Mg-F bond length decreases slightly with increasing pressure.Difference between the tilting angles derived from macro-structure (lattice parameters) and from microstructure (atomic positions), as well as the trend of change in the tilting angle with temperature and pressureare discussed. [1]. Zhao YS, Weidner DJ, Ko JD, Leinenweber K, Liu X, Li BS, Meng Y,Pacalo REG, Vaughan MT, Wang YB, Yeganehhaeri A,J.Geophys. Res. Solid Earth, 99 (1994) 2871. [2]. Zhao YS, Parise JB, Wang YB, Kusaba K, Vaughan MT, Weidner DJ, Kikegawa T, Chen J, Shimomura O,Am.Miner., 79 (1994) 615.

V42A-0336 1330h POSTER

A High Pressure X-Ray Diffraction Study of CaCO3-Aragonite: Implications for the Post-Aragonite Phase Transition

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The volume and lattice parameters of CaCO3-aragonite have been measured as a function of pressure to 50 GPa using angle-dispersive synchrotron x-ray diffraction at 300 K. The Birch-Murnaghan equation of state of aragonite yields a best-fit bulk modulus (K0) of 83 (+/- 3) GPa, assuming a value of dK/dP of 4. A progressive pressure-induced change takes place in the diffraction patterns, with the (021) and (111) diffraction lines converging on one another with compression. This change is accompanied by a significant (85 percent) loss in relative intensity of the (202) and (041) peaks. This convergence and shift in intensity of diffraction lines implies that CaCO3-aragonite is approaching a transition to a trigonal structure, such as occurs within BaCO3 at pressures of 7 GPa. Indeed, the b/a ratio of aragonite at 50 GPa approaches the square root of 3: the critical value for producing a transition to a trigonal structure, and close to that of BaCO3 at low pressure. A short extrapolation of our results indicates that a phase transition, with minimal volume change, is expected in CaCO3-aragonite at pressures exceeding 60 GPa. This result is in general accord with the systematics of phase transitions in aragonite-structured divalent cation carbonates. If free CaCO3 exists in the deep mantle, we anticipate that it will occur in a trigonal structure.

V42A-0337 1330h POSTER

A High Pressure Infrared Spectroscopic Study of PbCO3-Cerussite: Constraints on the Structure of the Post-Aragonite Phase

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We have measured the infrared spectrum of aragonite-structured PbCO3-cerussite to 42 GPa at 300 K in the diamond anvil cell. The in-plane bending, symmetric stretching, and asymmetric stretching vibrations of the carbonate group each shift to higher frequencies to pressures of 17 GPa at rates between 1.1 and 4.0 cm-1/GPa, while the out-of-plane bending vibration shifts to lower frequency by -1.3 cm-1/GPa. This softening is likely due to pressure-induced strengthening of the Pb-O bond. A phase transition is observed beginning at 17 GPa: this is in accord with previous Raman spectroscopic and x-ray crystallographic work on PbCO3 under pressure. The phase transition is manifested by a splitting of the out-of-plane bending vibration, and a broadening and dramatic decrease in amplitude of the symmetric stretching vibration: the absolute positions of the remaining bands are essentially identical between the low- and high-pressure phases, implying that the bonding environments of the carbonate unit in the two phases are similar. However, the pressure shifts of the vibrational bands are lower in the high pressure phase, with shifts between 0 and 0.3 cm-1/GPa: these smaller rates suggest that the carbonate group in the high pressure phase is less compressible than within the aragonite-structured phase. No further phase transitions were observed to 42 GPa. The high pressure phase has been proposed to crystallize in the orthorhombic space group P2sub122 with 16 formula units in the unit cell by Lin and Liu (1997). Yet, the band splittings and disappearance of the symmetric stretching vibration in the spectra of the high pressure phase are instead consistent with a substantially smaller trigonal unit cell, with space group P-31c: this is the same as that of the high pressure phase of BaCO3 (Holl et al., 2000), and our spectra strongly resemble those of this phase. Our results thus indicate that the post-aragonite high pressure phase in carbonates may generally be a comparatively high symmetry trigonal structure. Such a structure thus represents the most likely candidate for the ultra-high pressure structure of CaCO3-aragonite.

V42A-0338 1330h POSTER

Cation Order-Disorder of Dolomite at High Pressure and Temperature

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The structure of dolomite, $CaMg(CO_3)_2$, was determined at a constant pressure of about 4 GPa and from 25 to 1345^{o}C by *in-situ* synchrotron X-ray diffraction ($\lambda = 0.91997$ Å) at ID30 of the ESRF, France. The sample (packed into a Au capsule) was first compressed and data were then collected at different temperatures. Previous studies on the ordering in dolomite were done on quenched samples, but the kinetics of reordering upon quenching were too rapid to preserve the high-temperature disorder state. In fully ordered dolomite, the fraction of Ca cations on the $3a$ site is $x_{Ca} = 1$, whereas in a disordered dolomite, $x_{Ca} = 0.5$. Alternatively an order parameter $S = 2x_{Ca}$-1, varies from $S = 1$ (where $x_{Ca} = 1$) for a completely ordered dolomite to $S = 0$ (where $x_{Ca} = 0.5$) for a completely disordered dolomite. The ratio of intensities of reflections sensitive and insensitive (ratio = $I_{(105)}/I_{(006)}$) to ordering was also used to test the disorder in dolomite, and this ratio shows that dolomite disorders with temperature. These methods for characterizing the order-disorder reaction is compared to the results obtained from Rietveld refinement methods. Initially, $S = 1.0$ ideally for ordered dolomite. On heating, there is no change in cation ordering until the temperature is high enough to cause exchange of Ca and Mg between the two octahedral sites to occur. This activation barrier is overcome beyond about 1000^{o}C, where the sample starts to disorder. On further heating the sample continuously disorders along a smooth pathway to the maximum temperature studied ($T_{max.} = 1345^{o}$C, $S = 0.2(2)$). Trace amounts of CaO and MgO were observed in diffraction patterns at and beyond 1135^{o}C. This would indicate either decomposition or partial melting, but dolomite was still the dominant phase. This reaction may cause a slight deviation from the ideal stoichiometry for the remaining dolomite.

V42B MCC: Level 1 Thursday 1330h

Eruptive Behavior of Hazardous Volcanoes II Posters

Presiding: **C A Neal,** U.S. Geological Survey**; P Stelling,** University of Alaska, Anchorage

V42B-0339 1330h POSTER

Flow-Package Emplacement of the Valley of Ten Thousand Smokes Ignimbrite During the 1912 Novarupta, Alaska, Eruption

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The Valley of Ten Thousand Smokes (VTTS) ignimbrite was emplaced by 9 sequential flow packages, each with distinct compositional proportions of rhyolite (R), dacite (D) and andesite (A) pumice clasts that permit us to map their boundaries and flow paths from vent to distal extents. Changing R:D:A proportions link ignimbrite formation to contemporaneous fall deposition during the first ~16 hours (Episode I) of the eruption. Documentation of pumice compositional proportions in the ignimbrite was accomplished by counts on at least 100 lapilli-sized pumice clasts at multiple levels in vertical sections wherever accessible, and more widely over most of the ignimbrite surface in the VTTS. An initial 100% rhyolite flow package (time-equivalent to regional fall Layer A) was followed by packages with increasing proportions of andesite then dacite (time-equivalent to regional fall Layers B1-B3). The coeval regional fall deposits are locally intercalated with the ignimbrite and show parallel changes in R:D proportions, but lack significant amounts of andesite. Andesite is thus inferred to represent only a low-fountaining component in the eruption column, and is preferentially represented in packages filling the VTTS north of vent. Maps of the packages show that the most-extensive deposits occur midway through the sequence (B1 and early-B2 times) where flow mobility and volume were optimised; the earlier all-rhyolite flows were highly energetic but less voluminous, while later packages were less voluminous. Boundaries between flow packages are expressed as one or more of: sharp color changes corresponding to compositional variations, persistent finer-grained basal parts of flow units, compaction swales filled by later packages, erosional channels cut by the flows that fill them, lobate accumulations of material of one composition, and (particularly south of vent) intercalated fall deposit layers. Emplacement of the VTTS ignimbrite involved accumulation of successive, largely overlapping packages of material, with breaks in deposition only locally apparent, typically between the products of non-successive packages.

V42B-0340 1330h POSTER

Dacite Dome Growth and Disruption During the 1912 Novarupta Eruption: The Missing Episode

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The eruption of Novarupta on June 6-8, 1912 was the largest eruption of the 20th century, producing c. 11 km^3 of ignimbrite and c. 17 km^3 of Plinian fall deposits in ~60 hrs. Three episodes of Plinian activity were followed by dome extrusion ultimately responsible for the rhyolitic dome currently occupying the Novarupta vent New mapping shows a dacite block bed overlies the fine ash deposited at the close of Episode III and underlies the Episode V rhyolite dome. In places the blocks also underlie thin deposits of fluvially and slope-reworked Episode III pumice implying a short time break after the close of the main explosive phase of the 1912 eruption. This dacite block bed covers an elliptical area of at least 5 km^2 and extends to at least 2 km south of Novarupta. The blocks appear to have mostly followed ballistic trajectories; the largest clasts are up to 8 m^3 in volume or 10^4 kg in mass. We have mapped the size, lithology, and distribution of 700 blocks, including reconstruction of broken clasts. The blocks are of four types: 1) pumiceous dacite often with breadcrust exteriors, 2) dense glassy dacite that may be flow-banded and/or breadcrusted, 3) monolithic slightly to moderately welded dacite breccias, and 4) moderately to densely welded vitrophyres. The vitrophyres represent wall rock fragments derived from the vent-filling tuffs of principally Episode I; the dacite breccias are juvenile in origin. Point counting of 200 blocks suggests that 54% of the deposit is pumiceous dacite, 25% dense dacite, 12% juvenile breccia and 9% vitrophyres. The block bed seemingly formed in a series of Vulcanian explosions that followed the close of Plinian volcanism and disrupted a body of dacitic magma which had undergone a very heterogeneous pattern of degassing and, to a much lesser extent, wall rock.. Block morphology and textures strongly suggest that this dacitic magma was first erupted as a relatively gas-rich lava dome (Episode IV) but incomplete outgassing led to explosive disruption of this precursor to the present day (rhyolitic) dome (Episode V).

V42B-0341 1330h POSTER

Complex Proximal Geometry of Fall Deposits From a Plinian Eruption: Implications for Eruption Dynamics

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The 1886 eruption of Tarawera, New Zealand, is unusual for a Plinian eruption because (1) it involved entirely basaltic magma and (2) it produced abundant proximal deposits with a complex geometry not predicted by standard models of Plinian eruption columns. The eruption occurred along a 17 km fissure that extended from Mt Tarawera to Rotomahana. The Plinian activity is interpreted to be restricted to the 8 km segment on Mt Tarawera. During the 5 hour eruption, over 50 point source vents were active along this segment with a variety of styles and dispersals. These vents primarily produced localized, cone-building tephra fall, while at the same time some vents contributed to the Plinian plume in a random and spasmodic fashion. The proximal deposits that resulted comprise a series of lensoid packages that can be mapped along continuous exposures on both sides of the 1886 fissure. We map package thicknesses on cross sections using a combination of field observations, photographs, and detailed stratigraphic logs. The cross sections allow us to determine which vents contributed to the proximal deposits at any instant in time, and thus to contrast style and intensity among vents. There is clear evidence for rapid and localized accumulation of bombs and lapilli coeval with the Plinian plume. Clasts from both low fountains and high plume were deposited simultaneously, thus a range of explosive styles is represented by the particles in each sample. The 1886 dispersal data require much more complex models for the velocity distribution in the lower portion of the plume than are afforded by existing numerical models.

V42B-0342 1330h POSTER

Black Peak Caldera, Alaska: Preliminary Investigations of the ~4600 BP Caldera-forming Eruption and Subsequent Post-caldera Activity

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Black Peak Caldera is a 4-km-diameter, circular crater located on the Alaska Peninsula midway between Aniakchak and Veniaminof Volcanoes, approximately 45 km south-southwest of the community of Port Heiden and 730 km southwest of Anchorage. The caldera truncates a highly altered volcanic edifice that consists largely of lava domes, minor lava flows, and volcaniclastics. New radiocarbon dating of soils beneath the ash-flow deposit confirm earlier dating and place the age of the caldera-forming event at approximately 4600 14C yrs BP. Climactic fall deposits from this eruption form a prominent, crystal-rich, regional tephra horizon informally referred to as the 'salt and pepper ash.' Coeval pyroclastic flow deposits fill the two major drainages around the caldera to a depth of up to 100 m, and extend at least 10 km from the caldera rim. Deposits consist of a lower, highly pumiceous, crystal-rich dacite flow unit capped by a conspicuously oxidized, lithic-rich unit that is less aerially extensive. We estimate the bulk volume of the eruption to be less than 10-20 km3. Post-caldera eruptions at Black Peak have largely consisted of viscous, crystal-rich, hornblende-bearing dacite lavas forming a coalescing field of steep-sided, blocky domes and at least one coulee that fill much of the caldera. No coarse tephra fall deposits related to these eruptions have been found. Fine-grained, highly altered ash fall deposits, possibly related to dome emplacement, form a thick, monotonous sequence on the caldera rim and immediately overlying the ash flow in exposures near the caldera. This suggests that the dome eruptions closely followed caldera formation. Several domes collapsed over the eastern rim of the caldera to form coarse block and ash avalanche fans that extend 1.5 km down Red Bluff Creek. Radiocarbon dating of an overlying soil indicates an age of >500 14C yrs BP for these avalanches. There are no reports of eruptive activity at Black Peak in historic time (approximately 1750-present). A USGS report from 1926 noted both carbon dioxide and hydrogen sulfide springs within the caldera. With the exception of a few areas of diffuse bubbling, we were unable to relocate significant sites of degassing. An area of pervasive sulfur deposition against the west inner caldera wall is not thermally active at present. Radiometer measurements of Purple Lake showed rapid fluctuations due to possible overturning. Terraces, dry channels, and lake-clay exposures indicate that at least two of the several small lakes presently inside the caldera once formed a larger body of water.

V42B-0343 1330h POSTER

Analysis of Silicate Melt Inclusions in Plagioclase Phenocrysts in Prehistoric Tephra ~1400 Years B.P. From Augustine Volcano, Alaska.

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Augustine volcano, located in southern Cook Inlet, Alaska, has been historically active, erupting 6 times in the last 200 years. Eruptions first began prior to 40,000 years B.P. (Begét and Kienle, 1992). There are a minimum of 6 prehistoric tephra layers, G (oldest), I, H, C, M and B (youngest), present on Augustine Island (Waitt et al, 1996). In this study, we analyzed glassy silicate melt inclusions in plagioclase phenocrysts from tephra layer H (~1400 years B.P.) for major and minor and some trace elements (Cl, F, S, Ba, and Sr) by electron microprobe. We use the data to determine the chemical variation of melt inclusions in specific locations within zoned plagioclase phenocrysts. Plagioclase phenocrysts (0.5 to 4 mm long) exhibit unzoned, oscillatory or patchy zoned regions. Unzoned phenocryst cores lack melt inclusions. Patchy zonation occurs in cores and is sometimes found in intermediate zones between the core and rim. Planar oscillatory zones are distinguished in BSE images by light (An_{56-90}) and dark (An_{46-55}) bands. In some phenocrysts light and dark layers differ only by 1% An. Most phenocrysts show 2-3 repeated oscillating pairs of light and dark plagioclase compositional layers. Normal and reverse zoning are apparent in phenocrysts. Rims tend to be more calcic than the cores, varying from 1-5% An. Large melt inclusions (60 to 70 μm long) are located in patchy zoned cores. Small melt inclusions (2 to 10 μm long) are located at the contact of high calcic and low calcic oscillatory layers. All melt inclusions are trapped along compositional boundaries and occur in the more calcic plagioclase. Petrography suggests that melt inclusions may have been formed by partial dissolution of a less calcic plagioclase layer. The composition of the melt inclusions are rhyolitic (71 to 75% SiO_2). The chlorine concentrations range from 3020 to 6100 ppm with the more chlorine enriched concentrations occurring in the outer rims of the phenocryst. Sr and Ba vary from 0 to 887 ppm and 0 to 1280 ppm respectively. Dissolved fluorine concentrations range from 0 to 510 ppm and show a positive correlation with Ba. S ranges from 75 to 395 ppm and shows a positive correlation with Cl. Negative correlations of SiO_2 with Cl for all melt inclusions may suggest mixing with a primitive magma and/or degassing before eruption. The chemistry of some melt inclusions in the same oscillatory zone varies dramatically. SiO_2, Na_2O, Al_2O_3, K_2O, Ba and Sr show the widest discrepancy. This may be attributed to post-entrapment diffusive reequilibration between the melt inclusion and phenocryst.

(J.E. Begét and J. Kienle, 1992, Nature 356: 701-704)
(Waitt, et al.,1996, U.S.G.S. Open File Report 96-516, 44 p.)

V42B-0344 1330h POSTER

Late Quaternary Tephrochronology From Three Lakes, Kenai Peninsula, Alaska

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Tustumena, Paradox, and Jigsaw Lakes, located 60-120 km southwest of Anchorage, Alaska, on the Kenai Peninsula, were cored to evaluate the conditions best suited for the preservation of tephra, and to determine the ages and frequency of ash fall associated with regional volcanic eruptions. The lakes are located downwind of the eastern Aleutian Arc, where they are likely to receive tephra fallout, especially from Augustine, Iliamna, Redoubt, Spurr and Hayes Volcanoes. The lakes are close together (<60 km), so differences among their tephra records should primarily reflect lake-dependent processes and features, although variations in individual tephra plumes may preclude deposition in all the lakes. Multiple cores from each lake were analyzed to locate tephra using magnetic susceptibility (MS) and petrographic techniques (all tephra were found to have high MS). Tephra beds are typically light-gray ash, 1-2 mm thick, and are composed of glass shards and pumice (commonly 0.06-0.3 mm diameter), and varying proportions of glass-coated phenocrysts. Most are relatively pure, suggesting primary deposition with minor subsequent reworking. Core depth-age models were derived based on 28 radiocarbon ages on plant macrofossils preserved in the stratigraphy. Of the three lakes, sediment from Paradox Lake recorded the greatest frequency of tephra-fall events: 6.1 tephra/ka (81 over the 13,200-cal-yr record). Sediment from Jigsaw and Tustumena Lakes contains only 1.1 and 1.9 tephra/ka over their 9700-cal-yr records. Paradox Lake is better suited for tephra preservation compared to Tustumena and Jigsaw Lakes because, (1) it is small (0.11 km^2) yet has a relatively large drainage-basin-to-lake area ratio of more that 5 times the other lakes for accumulating tephra; (2) it is situated in a narrow (ca. 0.6 km), steep-sided (10-18^o) valley that focuses tephra deposition and shelters the lake from wind-driven mixing (the other lakes are more exposed and susceptible to wind-driven mixing); (3) it is deep enough (16 m) to maintain an anoxic bottom layer to inhibit bioturbation, compared to Jigsaw Lake, with its better-oxygenated, shallower subbasins (most <12m); (4) it has a higher sedimentation rate (0.7 mm/yr; compared to $\leq$0.5 mm/yr

at the other lakes) to resolve tephra layers. At Paradox Lake, the frequency of tephra fall ranges from 0 to 17 tephra/ka, and the number of tephra dating to the last 1000 yr (7) is about average for the last 13 millennia. No tephra layers are preserved during the intervals between 1000-2000 and 4000-5000 cal yr B.P., despite continuously laminated lacustrine sediment. In contrast, between 5000-9000 cal yr B.P., the frequency averages 11.8 tephra/ka. This may reflect changes in the predominant wind direction, or more likely the increased eruptive activity of the Cook Inlet volcanoes. Because the upper several centimeters of all cores were disturbed during coring, evidence of historical eruptions (last ca. 70 yr) was not preserved. Excluding this recent portion of the record, clusters of 3-5 tephra deposited within a 100-year interval occur nine times, most recently during the century leading to the 1912 A.D. eruption of Mount Katmai. The different number of tephra preserved in the three lakes demonstrates the importance of careful lake selection for obtaining the most complete record of tephra fall.

V42B-0345 1330h POSTER

Timing of Volcanism on Yunaska Island, Central Aleutian arc, Alaska: an Investigation Applying Multi-temporal Synthetic Aperture Radar

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The volcanoes of the central Aleutian arc remain largely uninstrumented and unstudied despite numerous eruptions within the last century. Many of these eruptions are not documented and others may not have been observed. Previous synthetic aperture radar (SAR) studies at Westdahl volcano show that radar can be used to relatively date a'a lava flows and to suggest whether some flows are "historic" though not recorded. This is accomplished through comparison of semi-quantitative measurements of surface roughness for young, unvegetated lavas. Because a'a lavas typically become smoother as they weather, they produce less radar backscatter. Thus, lavas that exhibit higher radar backscatter intensities are younger than those with lower backscatter intensities for regions of similar relief and aspect. Located 305 km west of Dutch Harbor, Yunaska has six volcanic centers, of which three have probably been active in the Quaternary. Based on field observations, recent volcanism on Yunaska is associated with the younger of two nested calderas and several smaller vents and cones on the eastern half of the island. Although there is a reported 1937 eruption, it is not clear if this came from fissures north of the caldera or created the intracaldera cinder cone and lava flows. Using a twenty-year composite of SAR data, we establish relative ages for five basaltic andesite lavas from these fissures and from within the young caldera. Clear stratigraphic relationships among three lavas within the caldera provide a check on the accuracy of this technique. The use of SAR to differentiate between young lavas allows us to better document the eruption history of remote volcanoes and to mitigate their hazards.

V42B-0346 1330h POSTER

The 1817 Eruption of Okmok Caldera, Umnak Island, Alaska: New Insights Into a Complex Historical Eruption in the Eastern Aleutians

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Okmok is a 10-km-diameter, late-Holocene caldera on Umnak Island in the eastern Aleutians, 1400 km southwest of Anchorage. The most recent eruption in 1997 was strombolian in character, producing a basaltic-andesite lava flow within the caldera and localized ash fall. Since caldera-formation approximately 2050 14C yrs BP, however, more violent eruptions from vents within the caldera have impacted all flanks of the volcano with tephra fall, ballistics, pyroclastic surges and flows, and lahars. An example of these more violent intracaldera events is the 1817 eruption. Reevaluation of historical accounts of activity at Okmok combined with new geologic mapping and tephra studies suggest that an 1817 eruption included (1) early, largely hydrovolcanic, explosive activity and the production of significant pyroclastic fall and surge deposits extending down the north and east flanks of the volcano; (2) generation of a flood that reached the Bering Sea; (3) late-stage strombolian fountaining and lava flow production. Vents from the 1817 eruption form a 4-km-long arc that parallels the base of the north caldera wall and include a 50-70-m-deep, elongate maar crater erupted through pre-existing tuff cone deposits. Terrace morphology and flood deposits less than 200 14C yrs BP indicate a flooding event down Crater Creek consistent with historical accounts of Aleut village inundation at the coastline in 1817. The later part of the eruption produced a 120-m high cinder and spatter cone and a blocky a'a lava flow field that fills a shallow basin near the outlet of Crater Creek. These preliminary results indicate that Okmok is capable of eruptions far more violent than the largely effusive events of the last century.

V42B-0347 1330h POSTER

Petrology of Holocene Caldera-Forming Eruptions at Ksudach, Kamchatka

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Ksudach caldera complex, Kamchatka, appears to represent a case where the mechanism of recurrent caldera-forming eruptions can be inferred using petrological and experimental studies. A sequence of three caldera-forming eruptions occurred at Ksudach during the Holocene: KS-4 (8800 yr. BP), KS-2/KS-3 ($\sim$6000 yr. BP), and KS-1 (1800 yr. BP). This sequence produced a complex of nested calderas, each of which is 2-km to 2x5-km in size. Erupted magmas range from andesite (62.5 wt.% SiO_2) to rhyolite (72.1 wt.% SiO_2), though compositional variations within each caldera-forming eruption are smaller. For all erupted magmas the main mineral assemblage is plagioclase, orthopyroxene, clinopyroxene, and Fe-Ti-oxides. We focused first on mineral and glass compositions of the most evolved magmas erupted during each caldera-forming event: the dacite of KS-4 initial fall deposit (67.4 wt.% SiO_2), the KS-3 rhyolite (70.3 wt.% SiO_2), and the KS-1 rhyolites (71.5-72.1 wt.% SiO_2). Magnetite-ilmenite thermometry indicates that the dacite of KS-4 was last equilibrated at 914-924°C and f_{O2} of NNO+0.4, KS-3 rhyolite at 894-927°C and f_{O2} of NNO+0.1, KS-1 rhyolite at 870-907°C and NNO+0.6. It appears that there is a weak overall cooling trend from older to younger magmas. Plagioclase is a dominant phenocryst phase in the studied KS-1, KS-3, and KS-4 products. Oscillatory-zoned plagioclases are most common. Their compositions range from $An_{52.3\pm3}$ in KS-4 to $An_{43\pm6}$ in KS-1, with KS-3 plagioclase compositions being intermediate.In addition to oscillatory-zoned plagioclases, KS-3 magmas contain "dusty-zoned" plagioclases, which resorbed An_{46-49} cores are mantled by An_{72-75} inclusion-rich rims, as well as rare anorthite xenocrysts (An_{93-96}). The ongoing petrological experiments and the study of erupted products will be used 1) to investigate whether the erupted magmas represent snapshots of an evolving long-lived magma body, 2) to determine the final storage conditions for the magmas, and 3) to explore possible mechanisms of the recurrent caldera-forming eruptions.

V42B-0348 1330h POSTER

2003 Eruption of Chikurachki Volcano, Paramushir Island, Northern Kuriles, Russia

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Chikurachki Volcano in the northern Kurile Islands erupted for the second time in two years in mid-April 2003. Although the Kamchatka Volcanic Eruptions Response Team (KVERT) received word of a possible eruption from residents of Paramushir Island on April 17, poor weather precluded confirmation of volcanic activity, and the exact start date is uncertain. On April 18, during routine satellite image analysis, the Alaska Volcano Observatory (AVO) detected an ash cloud from Chikurachki in GMS data and immediately notified the Federal Aviation Administration (FAA), National Weather Service, and other agencies. Subsequent formal alerts were issued through aviation and meteorological channels as outlined in the Alaska Interagency Operating Plan for Volcanic Ash Episodes. Thermal infrared imagery and trajectory models suggested the initial cloud was relatively low-level (below 25,000 ft ASL), however this height was not well constrained. Over the next several months, activity at Chikurachki consisted largely of strombolian bursts producing intermittent ash clouds reaching heights of generally less than 10-13,000 ft. ASL. Ash fall was noted as far as 60 km downwind. The last confirmed eruptive activity was June 16, 2003. During the eruption, AVHRR, MODIS, and GMS satellites captured images of the ash cloud as far as 300 km generally east and southeast of the volcano in the region heavily traveled North Pacific air routes. The propagation of volcanic clouds was monitored using visual and infrared channels and included a routine split-window analysis. Weak thermal anomalies were detected in AVHRR images suggesting minimal effusive activity near the central vent. Over the course of the eruption, aviation and meteorological authorities in Russia, the U.S., and Japan issued official notices regarding the eruption and the position and estimated height of the ash plume. Impacts to aviation were minor due to the low-level and intermittent nature of the eruption. Chikurachki is a young, basaltic 1816-m-tall stratovolcano on the northern coast of Paramushir Island, 370 km southwest of Petropavlovsk-Kamchatsky. No seismic or other instrumentation exists near the volcano, however satellite imagery is examined at least twice daily to look for evidence of volcanic unrest. The nearest community is Severo-Kurilsk (population 3,000), 60 km to the northeast. Previous historical eruptions have primarily consisted of VEI 1-2 strombolian eruptions, however, plinian eruptions with significant local fall deposits were recorded in 1986 and 1853. Its most recent eruption from January 25 - March 16, 2002 was similar in character to the 2003 event.

V42B-0349 1330h POSTER

Remotely Induced Eruptions: the Caldera-Forming Eruption of Fisher Volcano

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The caldera-forming eruption (CFE) of Fisher Volcano, Alaska, occurred in three major phases: a Plinian eruption of dacitic pumice from a northern vent, followed by a compositionally diverse pyroclastic flow from the same northern vent, and finally another Plinian eruption of a different dacite from a separate southern vent. Juvenile material within the pyroclastic flow consists of the northern dacite (67 wt.% SiO_2), basaltic andesite (54 wt.% SiO_2), and banded clasts showing liquid-liquid mingling of these two magmas. The southern dacite (63 wt.% SiO_2) shows no indication of contact with the northern dacite or basaltic andesite, and is compositionally and genetically distinct from these magmas. The physical, chemical and textural separation of the southern dacite from the northern CFE magmas indicates that these magmas occupied separate magma reservoirs prior to eruption. Temporal relationships deduced from field exposures indicate that the eruption of the southern dacite was the final component of the CFE sequence and was contemporaneous with piecemeal caldera collapse. Combined, these data suggest that the violent northern eruption stimulated the unconnected southern magma system and induced an eruption. This marks one of few (if not the only) descriptions of one eruption provoking the eruption of an unrelated system, and may call for the re-interpretation of other significant volcanic sequences.

V42B-0350 1330h POSTER

Present Stage Of Activity At Colima Volcano, México

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Colima volcano (19.51 N, 103.62 W, 3,950 m) is one of the most active volcanoes in México. It is located at the oriental end of the Mexican volcanic belt and with Nevado de Colima it forms a volcanic complex. The Colima seismic network (RESCO), has been monitoring the seismic activity since 1989 so we have records from the last three eruptions (1991, 1998-1999 and 2001-2003). During the 1998 eruption we also could measure deformation and SO2 . At the present time we are also monitoring activity with a tiltmeter network and two cameras which are continuously recording the outside activity. We also take periodically simples from springs and measures of distances. We are planning to include the measurement of three more geophysical paramenters: gravimetry, magnetometry and radon gas. The 2001-2003 eruption lasted for 15 months and it is considered the largest eruption of the last fifty years. Each eruption recorded from Colima volcano is different from the previous. The 2001-2003 eruption for example, was characterized by a very low seismic activity previous to the eruption. We also observed tremors of large amplitudes never seen before during an effusive stage. For the last seven months it has been in an explosive stage with three major explosions which have alarmed to the comunities around the volcan. The explosion of August 29th, was heard at Colima city, 32 kilometers away from the volcano. Geophysical parameters indicate that the explosive activity is due to de degassing of the residual magma trapped in the conduit and not to a new magma coming from depth.

V42B-0351 1330h POSTER

Monitoring Morphological Changes at Colima Volcano Crater and Explosive Activity in 2003

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The Colima Volcano is located in the West of the Volcanic Mexican Belt, since February 10 1999 has presented an alternated efusive and explosive activity, which has generated constant morphological changes at the summit. As result of the several explosions occurred in 1999, 2000 and at the beginning of the year 2001, a new crater was formed with dimensions of 260 for 225 meters, and an average depth of 40 m. This crater began to be filled by the end of October 31, 2001 by a extrusion dome that reach an approximate volume 2 x 106 m3. In the first week of February 2002 this dome reach the edge of the crater, beginning to form lava flows by the western, northeastern, and south flanks. This effusive activity continued in 2002, and small gas emission and explosions were observed. In April 2003 the number of explosions and degassings became more frequent in the dome, this activity was registred by the seismic networks (RESCO and RESJAL) and recorded by video cameras located at Jalisco Civil Defense Nevado Base, 5 km away of the volcano. Aerial reconnaissance carried out in May 16 showed a complete change in the morphology of the dome as was observed in February 2002, identifying a new crater with a elipsoidal concave shape with approximate dimensions of 140 x 110 m and a depth in its central part of 15 mts. In the SE flank we observed another crater with similar form to the previous one whose dimensions are of 30 x 20 m with depth of 15 m, where continuous explosions have been appraised. At dawn of June 17, August 2 and 28, 2003 explosions happened that reached an altitude between 2000 and 3000 m, which were of smaller magnitude than happened the 22 of February of the 2000. These explosions were preceded of prolonged periods of tremor reported by RESCO. This explosive activity also present gas emission gas in form of jets, with duration from some seconds until more a than minute and altitude of approximate 500 meters, like the occurred on June 7, its point of emission was located in the crater of the SE sector. The eruptive columns begin to reach greater heights, since the conduit offers less resistance to the outgoing of material and gas, since the seismic energy released is smaller each time, most of the energy is concentrating in the exhalation. As a result of this explosive activity, we observed in the last aerial reconnaissance an important change in the morphology in the summit in relation to the observed in the month of May. The crater reaches approximate dimensions of 160 x 120 m, and a depth of approximately 30 m. The edges of the dome present an irregular morphology and a series of heterometrics blocks launched by the constant explosions.

V42B-0352 1330h POSTER

Volcan de Fuego de Colima, review of the 2003 explosion activity and its morfological changes

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Volcan de Fuego de Colima, Mexico, (19° 30'44 " N and 103° 37'02 " W) is an stratovolcano located in the western front of the Trans Mexican volcanic belt. It shows 3 explosive events at least during the last 500 years (VEI=4), being the nearest those happened in 1818 and 1913. In the year 2002, after a stage of dome growth and later collapses of incandescent material on the volcanic edifice, its activity suffered changes during the first months of the year 2003. The volcanic activity during this period is characterized by the occurrence of lava collapses concentrated at west and south-west flanks of the edifice. During this period, a lava emission rate of 0.15 m3/s is taking place. The material collapses occurred from the summit reaches an average 250 per day. After this behavior the lava movement decrease and obstruct the lava conduct changing the volcanic activity during this period to an explosive scenario. During the months of May, June, July and August of 2003 several explosive events have been presented, being the most significant those happened the days July 17th (05:27) August 2 (15:41) and August 28th (11:52). These three events in particular, have been those that bigger changes have caused in the morphology of the summit. A description of the eruptive development of this stage is presented in the one that the main explosions and their reaches can be identified.

V42B-0353 1330h POSTER

Experimental Constraints on the Magma Chamber Conditions and Degassing of Arenal Volcano, Costa Rica

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Continuously erupting since 1968, Arenal Volcano's frequent activity displays differing styles, from highly explosive events to passive lava flows. The erupted products are geochemically similar, yet show a complex history of magma chamber processes that are not fully understood. Given the temporal records and geophysical data collected from Arenal, a comparison with petrologic data and carefully controlled experiments may enable us to better understand the processes occurring at this highly active volcano. We performed phase equilibria experiments on sample AR99-1, from a 1999 eruption of Arenal, at water-saturated conditions with fO_2 buffered at NNO, in TZM pressure vessels. The purpose of these experiments is to determine the pre-eruptive P and T conditions of the Arenal magma as a starting point for decompression experiments, which will be used to help determine magmatic ascent rates. Most samples from Arenal contain plagioclase, pyroxene, and magnetite in a matrix of variably crystallized microlite-rich groundmass. Because ilmenite is absent, we first had to iterate in P and T until we obtained the correct assemblage that matches the starting material. Water content has not been obtained due to the lack of appropriate samples (mostly degassed lavas and degassed glass inclusions). Preliminary results indicate that the magma was stored at between 950°C and 1000°C and at a depth of 3-5 km prior to eruption, assuming water saturation. These experiments will continue, including those that are water under saturated. In order to determine magmatic ascent rates, we plan to perform a series of decompression experiments at various rates, starting from our determined pre-eruptive conditions. Our goal is to match the microlite textures observed in rapidly quenched Arenal samples, such as those from explosively produced pyroclastic flows, as a way to resolve the ascent rates. This information can be compared to geophysical data collected in the 1990's in order to link pre-cursory geophysical signals with magmatic ascent rates and petrologic observations.

V42B-0354 1330h POSTER

Plinian Newberry Pumice and Related Eruptions of Newberry Volcano, Central Oregon, USA

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The Newberry Pumice deposit forms a highly elliptical, eastward-extending lobe, and distal deposits are known from as much as 550 km downwind in Idaho. The 25 cm isopach has an aspect ratio of 7.5:1. Pumice and lithic isopleths also have a strongly elliptical pattern for smaller clasts. Larger clasts (e.g. lithic fragments greater than about 10 cm in longest diameter) have a more nearly circular distribution. The maximum crosswind range for a 3.2 cm lithic fragment is 7 km, and the maximum downwind range is 27 km. These data indicate a maximum column height of about 25 km and a tropopause wind velocity far in excess of 30 m/s. The three largest ballistic lithic fragments at a site on the south rim of Newberry caldera have 1.0, 1.12, and 1.3 m median diameters. The maximum observed thickness of 7-8 m is known from the same locality. The vent location is probably about 1.2 km from this location but could be as close as 0.5 km. Initial velocities of about 130 m/s and 95 m/s are needed for the measured blocks to reach distances of 1.2 and 0.5 km respectively. Particle size and lithic content vary significantly with stratigraphic height. As many as seven ash layers may be observed in the upper part of the deposit. In general, the upper part of the deposit has smaller clasts and a greater lithic content. It also has a different distribution direction with an azimuth of 75-78° versus 82° for the lower portion. This change in trajectory indicates that wind directions shifted during the eruption and/or that lower altitude winds had a different direction than higher altitude winds. The Newberry Pumice was preceded by at least one small precursory eruption and followed by the Paulina Lake ashflow and Big Obsidian flow. On the south rim of Newberry caldera, the Paulina Lake ashflow deposit includes pyroclastic surge beds overlain by a nonstratified deposit of one or more pyroclastic flows. The basal contact is irregular and suggests erosion. Seven radiocarbon dates for the ashflow deposit span 1,270+/-60 to 2,054+/-230 ^{14}C years BP. The mean limiting age is 1320+/-30 ^{14}C years BP (1,260+/-40 2σ calibrated age). Nineteen dates on wood and charcoal found at or near the base of the Newberry Pumice span 1,510+/-80 to 2,210+/-140 ^{14}C years BP. The mean limiting age is 1,525+/-40 ^{14}C years BP (1425+/-95 2σ calibrated age). A sequence of deposits at the south shore of Paulina Lake records at least two eruptions prior to the ashflow with significant time elapsed between eruptions. Either could be the Newberry Pumice.

V42B-0355 1330h POSTER

Origin of orange scoria from Omuroyama volcano, Japan

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Origin of color variation of scoria from Omuroyama volcano, Izu peninsula, Shizuoka, Japan, was investigated. In the fresh glass domains, the compositions are homogeneous whereas the color of the scoria widely varies from black to orange. In fall units, the orange scoria clasts are homogeneously mixed with the black scoria clasts, and gray scoria clasts are included in some units. Continuous spectra of chemical (bulk clast) compositions correspond to the systematic variation of the scoria color from black to orange. Gray scoria has intermediate composition between orange and black scoria. The orange scoria is richer in Al, Fe^{3+}, Si, and Ti and poorer in Ca, Mg, Na, and K than the black scoria. Back-scattered electron image observations of the orange scoria exhibit that the volcanic glass includes altered domains in which iron content is higher than the other area of the glass. Electron microprobe analyses, visible diffuse reflectance spectroscopy, and X-ray diffraction indicate the presence of goethite-like ferric iron hydroxide in volcanic glass. On possible explanation for the formation of ferric iron hydroxide is a leaching of iron by acid water including contributions from volcanic gasses and a precipitation-crystallization of iron hydroxides under near neutral pH conditions.

V42B-0356 1330h POSTER

The Significance of Cross-Bedded Surge Deposits

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We characterized cross-beds in surge deposits to distinguish between features that indicate large-scale motions and those controlled by small-scale depositional processes in order to determine the modes of transport (suspended load, traction-dominated) shaping the cross-beds. Surge deposits in the Upper Toluca Pumice at Toluca Volcano, Mexico, were selected because of their well-preserved dune forms and exceptional exposure. We measured the grain size distribution and componentry of representative individual layers as well as the occurrence and shape of the dune forms. Individual surge beds have variable amounts of size sorting, with well-sorted units occurring at all grain sizes. Density sorting is poor, except for the coarse-grain layers. No density sorting of the coarse layers occurs, however, where sub-horizontal bedding merges with poorly sorted, massive deposit. The shape of dune forms is self-similar, as shown by the power law relating their height to their length, and large dunes are frequently followed by a string of smaller dunes immediately downstream, the sizes of which decrease rapidly down current. Both prograde or retrograde dune crests can be present within the same dune form. Previous work has shown that large-scale turbulent structures sort clasts as a function of both size and density, because the viscous force needed to suspend clasts varies linearly with density and with the square of the clast diameter. Thus, the transport system produces clasts sorted in both size and density. On the other hand, processes occurring in the traction-dominated depositional system are little known. Our observations suggest clast transport in the boundary layer was more likely by rotation rather than either sliding, owing to the roughness of the substrate and the angular nature of the clasts, or gravity-induced grain flowage, as the beds dip significantly below the angle of repose of the clasts. We thus propose that rolling causes size sorting to occur regardless of density because the force needed to rotate a clast at rest varies linearly with density but with the fourth power of the diameter. As a result, traction-dominated transport sorts clasts only by size, reinforcing the coarser end of the density sorting of the transport system by remobilizing and mixing finer grains while leaving the coarse fraction. Coarse-grain layers well sorted in density are thus composed of clasts traveling successively through the transport system and the traction bed. Those coarse layers retain a memory of the large-scale transport system, whereas boundary layer processes control the sorting of the finer grain sizes. The general absence of density sorting within zones in transition with massive deposit is consistent with an increasing control of traction-dominated transport across the transition. Dunes appear to form around a nucleus of clasts creating a small protrusion and grow layer by layer via accretion. This feedback growth indifferently produces prograde or retrograde dune crests. The cascading distribution of dunes suggests that the smaller dunes are built in response to the emplacement of a large dune. Consequently, dunes originate from local disturbances of the boundary layer that is rapidly attenuated downstream. If this cascading process is repeated, the original dune string is likely to be reworked into a complex array of dune forms. The shapes and sizes of dunes thus record little information on the large-scale dynamics of the surge.

V42B-0357 1330h POSTER

Real-time Differentiation Processes at Arenal Volcano, Costa Rica, 1968-2003

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The current eruption of Arenal volcano, Costa Rica (1968-present) provides opportunity to study magma differentiation in real-time. Fifty lavas were analyzed by XRF and ICPMS for major and trace element concentrations. The data are consistent with previous work and suggest that the current eruption has three stages. During the first stage (1968-early 1970), a zoned magma chamber was emptied after being intruded by an unseen new magma. The most differentiated magma was erupted first as the zoned chamber erupted from the top down. Mixing of the two magmas occurred in the second stage (1970-early 1974). The minimum concentration of incompatible elements (e.g. K) occurs earlier in the eruption than the maximum concentration of compatible elements (e.g. Ni, Cr, V). The third stage (early 1974-present) is characterized by fractionation and recharge of mafic magma. Two different differentiation processes have caused the geochemical variations observed during this eruption. The first operated pre-1968, and the second has been operating since 1974. During the first differentiation, compatible elements decreased by up to 75% and incompatible elements rose by 25%. During the second differentiation, compatible element concentrations remained constant within 10-30%, and incompatible elements (Ba, Zr, and Sr) increased by 30% while others remained constant. Lavas erupted at Arenal now are more differentiated in some respects than in 1968. For example, Ba, Rb, and Sr concentrations are higher now than they were at the beginning. Since 1974, rare earth element patterns are steeper, lavas are richer in incompatible elements (Ba, Rb, Sr, and Zr), U/Th ratio is higher, and Fe_2O_3, CaO, MgO, TiO_2, Ni, Cr, Sc, and V concentrations have remained constant, whereas they decreased with differentiation initially. Sr, Nd, Pb, and Hf isotopic ratios will be presented.

V42B-0358 1330h POSTER

Volatile Release and Eruption Dynamics of a Basaltic Plinian Eruption From Masaya Caldera, Nicaragua

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Our project is part of SFB 574 "Volatiles and Fluids in subduction zones", and focusses on degassing dynamics of highly-explosive arc volcanoes. Masaya Caldera in west-central Nicaragua is part of the Central American volcanic arc at the convergent boundary of the Cocos and Carribean plates. A basaltic plinian eruption of VEI 6 occurred at Masaya Caldera in the Late-Pleistocene, depositing a widespread fan of scoria lapilli, named Fontana Tephra. We have constrained parameters of the Fontana eruption by extensive isopach and isopleth mapping. Total erupted tephra volume is >0.83 km^3 (about 10^{12} kg DRE). The eruption columns reached 30 to 35 km height at an average discharge rate of $1.3*10^8$ kg/s. This violent eruption was not continuous but proceeded in distinct pulses evident by the well-bedded deposit. An initial sequence of numerous highly explosive but short pulses formed a well-bedded layer of very highly vesicular, hawaiian-type lapilli, possibly representing a gas-enriched top zone of the magma reservoir. The following series of longer-duration plinian events, interupted by weak phases of ash emission, formed beds of highly vesicular scoria lapilli. The eruption ceased with abundant short-lived pulses of lower-energy subplinian activity. We estimate volatile emissions during the eruption from the differences in volatile concentration between matrix glass and glass inclusions in minerals, considered to represent degassed and undegassed melt, respectively. Concentrations of fluorine of about 7000 ppm are about equal in matrix glass and glass inclusions, indicating little degassing of fluorine during eruption. Chlorine contents amount to 1200 ppm in the inclusions, and to about 1000 ppm in matrix glass. The concentration difference, multiplied by erupted magma mass, suggests a total chlorine emission of 16 Mt. Apparently only little chlorine exsolved in the initial eruption phase, but degassing strongly increased during the plinian phase. Sulphur concentrations in glass inclusions range between 220 ppm and 680 ppm while reaching values as low as 20 ppm in matrix glass. Sulphur emission totals at least 24 Mt, of which the largest portion had been released during late stages of the eruption. This is a minimum estimate of sulphur emission since it is not known if a sulphurous fluid phase already existed in the magma reservoir. The Fontana eruption provides an impressive example of a highly-explosive, large-magnitude plinian eruption of basaltic composition. The eruption was driven by degassing of magmatic volatiles and evolved through numerous eruptive pulses, of which high-frequency short-duration phases bracket low-frequency long-lasting episodes.

V42B-0359 1330h POSTER

Deposits from the 12 July Dome Collapse and Explosive Activity at Soufriere Hills Volcano, 12-15 July 2003

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A large dome collapse took place on 12-13 July 2003 at Soufriere Hills Volcano. This event was the largest in magnitude during the 1995-2003 eruption and involved over 120 million m^3 andesite dome and talus material. The collapse took place over 18 hours and culminated in an explosive phase that continued intermittently until 15 July 2003. Prior to the collapse, the total volume of the dome was 230 million m^3 and was made up of remnants of lava erupted 1997-2001, talus material and fresh andesite dome lava erupted during the last two years. Talus made up around 50% of the total dome volume. This paper describes and interprets the pyroclastic flow and airfall deposits from this event, using other monitoring data and empirical evidence to reconstruct the dome collapse. The airfall and pyroclastic flow deposits were studied in detail over the weeks following the collapse. Airfall deposits were studied at 45 locations around the island and 75 samples were collected for analysis. The surge deposit stretched over 10 km^2 on land and 35 pits were dug at intervals through it. The sections were described and sampled, yielding a further 60 samples for grain size analysis. Further sampling was carried out on the block and ash deposits in the Tar River Valley and on the Tar River Fan. Pumices from the post-collapse explosion sequence were collected and their densities measured and mass coverage estimated. Deposit maps for airfall, lithics and pumices were constructed for all of the individual events and a map to show the distribution of the main surge unit was generated. The collapse was monitored in real-time using the MVO seismic network and observations from the field. The sequence of events was as follows. From 09:00 to 18:00, low-energy pyroclastic flows took place, confined to the Tar River Valley, which reached the sea at the mouth of Tar River. These flows gradually increased in energy throughout the day but were not associated with energetic, large surges. By 18:00 the pyroclastic flows had increased in volume and were causing phreatic explosions as large, hot blocks hit the sea on the Tar River Fan. By 20:00 the pyroclastic flows had changed in character and were associated with a larger seismic signal and powerful surges that traveled up to 3 km off the coast over the surface of the sea. The most energetic phase of the eruption took place between 22:30 12 July and 01:30 13 July. The dome collapse of 12-13 July culminated in several very large individual pyroclastic flows, representing the collapse of the massive, hot, gas-rich interior of the lava dome. One very large flow was associated with a destructive and energetic surge that swept over topography to the north of the Tar River, killed 40-50 cows, removed trees at their bases and caused large clasts to become embedded in trees at a height of 1.5 m above the ground surface north of Irish Ghaut. The unloading of such large masses of lava dome from over the vent area caused large and powerful explosions. The mapping of the deposits from this event has shed light on the origins of the surge and the timing of large phreatic and magmatic explosions and has led to a new understanding of the hazard potential of large surges derived from the Tar River Valley during large dome collapses at Soufriere Hills Volcano.

V42B-0360 1330h POSTER

The Collapse of the Lava Dome at Soufriere Hills Volcano, 12-13 July 2003

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A large dome collapse took place at the Soufriere Hills Volcano, Montserrat, on 12 July 2003. Around 120 million m^3 of lava dome and talus collapsed to the east, generating large pyroclastic flows in the Tar River Valley. The collapse took place after a three-day-long hybrid earthquake swarm, which merged into a continuous tremor in the early morning of 12 July 2003. A period of brief but intense period of rainfall occurred between 6:30 and 9:30 am, which coincided with the onset of pyroclastic flow activity. Pyroclastic flows continued throughout the day, slowly increasing in volume and energy as the hotter interior of the talus and dome were exposed, this stage being similar to the evolution of dome collapses on 20 March 2000 and 29 July 2001. At 18:00 phreatic explosions began to take place where the block and ash flows were hitting sea on the Tar River Fan, sending black jets 50-100 metres vertically above the Fan. By 20:00 the pyroclastic flows were associated with energetic surges that were observed to be traveling 2-3 km over the surface of the sea at the mouth of the Tar River Valley. From 22:30 to 01:30 13 July the most energetic sequence of events took place, with one very large vulcanian explosion from the exposed upper conduit and dome remnants and 3-4 smaller explosive events. These explosions took place shortly after large volumes of dome material slumped into the sea down the Tar River Valley, the largest occurring at 23:34. This event caused a 1 metre high tsunami in Guadeloupe. The subsequent explosions were recorded by pressure sensors both on Montserrat and on the island of Martinique, 260 km to the south. This large single flow in the Tar River was associated with a block and ash flow that was confined to the Tar River valley and a powerful surge component derived from the lower reaches of the Tar River valley, which spread northwards, covering 10 km^2 and reaching as far as Spanish Point, Bethel Village and White's Yard. This surge was immensely destructive and its deposit reached over 1 m thick in places. Animals were killed 4 km northwards of the Tar River Valley and a GPS receiver and remote camera at White's Yard were destroyed (the last data recorded at 23:35 12 July). An explosion occurred shortly after 01:00 13 July and thereafter the seismic signal decreased in amplitude over the next three hours, reaching background levels by 06:00 13 July. At 09:12 13 July a vulcanian explosion occurred, with a vertical eruption column 12 km high. This event deposited highly vesiculated pumice up to 6.5 cm in dimension in inhabited areas and up to 30 cm on the southwestern flanks of the volcano. Two more vulcanian explosions took place thereafter, the first at 01:10 14 July and the second at 01:15 15 July. On 16 July 2003 at 09:10 a strong SO_2 degassing event took place, reaching 70 kg/s before decaying exponentially throughout the rest of the day. A new dome began to grow in the scar 22-25 July, but then stagnated. On 1 August 2003 a sustained water degassing and ash venting event took place throughout the day, from 06:00 to 17:00, sending a thick plume of steam and ash to the west of the volcano. Seismicity decreased dramatically after 1 August and up to 3 September, there was no eruptive activity at Soufriere Hills Volcano.

V42B-0361 1330h POSTER

Pyroclastic Flows, Rockfalls, and Heightened Magma Flux Associated With the Merapi Volcano Eruption of 1992-1998, Central Java, Indonesia

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An elevated phase of magma production with respect to the long-term rate for the 20th century characterizes the activity at Merapi volcano, Central Java/Yogyakarta, Indonesia, for the period 1992-1998. During this time, 224,810 recorded seismic events were identified as rockfalls and pyroclastic flows between January 1992 and December 1998. Of these, 820 pyroclastic flows specifically were reported, mainly from field observatory posts. Most of nine large (0.2 - 3.4 x 10^6 m^3) dome collapses or dome collapse episodes began to occur during elevated short-term extrusion rates typically 0.2 m^3 s^{-1} or greater. Large collapses were often preceded by variable inflationary tilt of the crater rim, increasing numbers of rockfalls and their associated seismicity, and intensifying multiphase earthquake activity. In such cycles, a gas-rich volume of magma extruded onto or intruded into preexisting dome lava, leading to rockfalls and eventual dome collapses from the headwalls of developing lava flow fronts. While gas pressure build-up within the dome may have played some role, similar effects may have been generated by intense monsoon rainfall on still hot lava. Multiphase earthquakes, rockfall counts, and amplitude-duration data established from seismic records show varying positive correlations with extrusion rate. Pyroclastic flow and rockfall seismic amplitude-duration data have been calibrated as proxies for collapse volume. When combined with calculations of dome volume estimates over time and deposit volumes from major dome collapses, an overall magma flux of 0.1 m^3 s^{-1} between 1992 and the end of 1998 has been obtained. This rate is significantly greater compared to the long-term 0.04 m^3 s^{-1} magma flux calculated for Merapi over the first nine decades of the 20th century (Siswowidjoyo et al., 1995). For the 20th century as a whole, observed magma production rates continue to suggest long-term cycles of ca. 30 years that begin with heightened magma flux over two to eight years with greater potential for explosive eruptive activity, followed by much-diminished mean magma flux in the concluding ca. 25 years of the cycle. If similar cycles continue into the 21st century, activity at Merapi will experience lower magma production compared to the most recent eruptive phase during the next 20-25 years, followed by significantly heightened magma flux over several years to begin the next cycle, accompanied by a greater likelihood of major explosive events.

V42B-0362 1330h POSTER

Santiaguito Volcano, Guatemala: A Study of Vent Dynamics Over the Past 50 Years

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October 1902 marked one of the Earth's largest historic eruptions at Santa Maria volcano, Guatemala. Since 1922, volcanic dome extrusion has been occurring on the southwest flank of Santa Maria from the continuously active Santiaguito vent system. Dangerous activity including vertical ash eruptions, avalanches, lava flows, and pyroclastic flows has been persistent from Santiaguito, requiring observations of the volcano to be carried out from a distance. Consequently, our understanding of subsurface processes, such as the shape, size, and position of the magma body and conduit systems must be inferred by remote measurements. There may be a correlation at Santiaguito between the effects of subsurface conduit dynamics on summit vent morphology and subsequent volcanic activity. Our recent observations have identified the presence of a ring-shaped vent, approximately 150m wide, within the Santiaguito summit dome, which is thought to represent the surface expression of a series of fractures generated from the conduit at depth. Thus, a time series of surface observations of vent geometry and observations of volcanic activity could help constrain the near surface conduit evolution. An archive of aerial photos from 1947 to 2000, photographs of vent activity from 1969 to present, and 11 hours of digital video from 2002 and 2003 volcanic activity at Santiaguito will be analyzed to discover how these observations are related. The objective of this project will be to better understand the conduit evolution at Santiaguito volcano by documenting changes in vent morphology over the last 50 years and to correlate these findings with eruptive history. These results can be further correlated with gas, thermal, seismic, and other geophysical studies, calculations of dome volume and dome dimensions, and predictive modeling of Santiaguito's volcanic activity.

V42B-0363 1330h POSTER

South Hachijyo Volcano - Initial Stage of Submarine Caldera Activity

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South Hachijyo Volcano (SHV), a part of Northern Izu-Bonin Arc, is located between Hachijyojima Is. and Aogashima Is. SHV is composed of four blocks (somma) surrounding a bathymetric low. Each block is flat-topped and has a scarp with a gentle slope. The bathymetric low, encircled by the -400m contour line, extends vertically 160m to the top of the SHV. At the bottom of the bathymetric low lies a small depressional structure (caldera floor), which is approximately 2 km in diameter. At the middle of this structure lies a N-S trending central cone that is 1.3*0.9km in diameter and 100m high. We collected many dredge samples of pumice, basaltic fragments, and Q-diorite. Based on observations from a submersible, the sediments on the caldera floor consist of sorted pumice, unsorted pumice and coarse sand. Huge pumice blocks were observed near the slope of the central cone. Angular M-type pumice block and rhyolitic breccias were observed on the top of the central cone. Several rhyolitic volcanic cones (knolls) were observed around the central cone in the caldera floor. Therefore these rhyolitic fragments are associated with dome activities. The result of total geomagnetic analysis indicates that non-magnetic layer (about 600-900m thick) exists at the Hachijyo insular shelf (HIS). Non-magnetic layer in SHV covers magnetic basement, and the south part of it is shallower than the north part. Single-channel seismic records indicate that well-stratified layers (with a total thickness of 700m) exist at the HIS. These layers are corresponds to non-magnetic layer, and the thickness of these layers (interpreted as volcanic products from Hachijyojima Is.) decreases from Hachijyojima toward SHV. Therefore, the production of volcanic material from SHV has been small. Some crypt dome structures are observed under each block (somma). The seismic profiles show knolls atop the stratified somma and the caldera floor. From the geological and geophysical data, we interpret the following regarding the evolution of the SHV. Despite the fact that this volcanic structure is young, we observe morphology that suggests the existence of a caldera that is characterized by gentle slopes that are not well stratified. We interpret the relief between the caldera floor and the somma tops as having been caused by crypt dome intrusion that elevates the somma, rather than by depression of caldera floor after huge eruption. This interpretation is supported by the lack of voluminous volcanic product around the somma. In conclusion, we consider SHV to be in an initial stage of submarine caldera volcanism that is characterized by dike (knoll) complex activity without large volcanic eruptions.

V42B-0364 1330h POSTER

Variations in Cross-Stratification within the Tuff Deposits at Sinker Butte, a Western Snake River Plain Hydrovolcano

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Sinker Butte is the remnant of an emergent basaltic hydrovolcano that erupted about 1 Ma beneath the surface of Plio-Pleistocene Lake Idaho, near the southern margin of the Western Snake River Plain. The Snake River has eroded through the deposits, creating an unusual opportunity to study the entire eruptive sequence. One of the most interesting aspects of this volcano is the many different types of cross-stratification and dune bedding which can be found in the fragmental rocks. The first stage of this eruption created a series of subaqueous tuff deposits which formed a volcanic-sedimentary platform that grew towards the surface of the lake. The platform would have been growing at inconsistent rates around the vent causing the resulting deposits to vary around the platform. Cross-stratification in these deposits include channel scour and fill, dune bedding, trough cross bedding, and bouma-turbidite sequences. As the eruption progressed, this platform built above the water level, which represents the subaerial stage of the eruption. At this time the magma/water interaction was still significant, causing a pulsatory type of eruption creating many thin interbedded pyroclastic surge and airfall deposits. Near the vent large-scale regressive low-angle dunes (wavelength 1-2 m) are found interbedded with

thin planar beds. The crests of regressive dunes migrate upstream, with the coarser fragments dropped on the upstream side of the crest. These are thought to form as a result of wet surges due to the presence of accretionary and/or armored lapilli as well as vesicles due to trapped volatiles in wet ash. Dunes in deposits further from the vent are generally thinly bedded and have gentler dip angles and shorter wavelengths. Other types of cross-stratification found at Sinker are wavy-planar beds, which are a mixture of airfall and surge, and deformed low angle dune beds (.5-1 m wavelength) containing abundant soft sediment deformation and sag structures. Found high in some sections are large-scale progressive dune-forms (1-2 m wavelength). These may be attributed to a late dry surge towards the end of eruption, just before the volcano isolated itself from all external water. The low angle cross-stratification and irregular truncations reflect the highly pulsatory nature of surges during deposition. The dune bed thicknesses and average wavelength appear to decrease away from the vent. This finer cross-stratification may be result of the same type of surges that formed the larger regressive dunes, but may represent a loss in momentum, density and turbulence as the surge travels further from its source.

V42B-0365 1330h POSTER

Facies analysis of Hlodufell basaltic subglacial to emergent volcano, SW Iceland: insights into sub-ice growth mechanisms and meltwater drainage

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Hlodufell is a subglacial to emergent basaltic volcano located 9km south of the Langjokull ice-cap in SW Iceland. This study is the first detailed facies analysis of this well-known volcano. The vertical facies architecture of the basal half of the volcano is typical of many basaltic subaqueous (including submarine) to emergent volcanoes, comprising basal pillow mounds overlain by Surtseyan eruption-fed subaqueously-deposited sediment gravity flows. However, facies in the upper part of the edifice demonstrate the influence of variable water levels more typical of englacial lakes. The Surtseyan sequence is overlain by two subaerial lava flow and cogenetic lava-fed delta sequences, separated by a second Surtseyan sequence. In addition, the uppermost lava flows are also draped by a thin veneer of Surtseyan tephra. Both lava-fed delta sequences are unusually dominated by subaerial lava breccias. This may be due to a number of factors that influence steep slope stability but the possibility of retreating ice walls should be considered. Detailed facies analysis also revealed evidence of the influence of ice on eruptive and depositional products throughout the history of the edifice. Some of the basal pillow mounds preserve metre-sized cavities with partial hyaloclastite fills, interpreted as meltout structures formed during sub-ice growth by ice-block stoping. Some mounds also have steep chill surfaces where pillows have been compressed against a rigid wall (now absent) interpreted as ice. The peripheral pillow mounds, particularly those to the immediate south of Hlodufell (Rani area) are draped by Surtseyan eruption-fed tephra deposited by erosive meltwater streamflows. The draping tephra was derived from both the first and second Surtseyan sequences. These observations illustrate that direct ice-contact and ice-block stoping was important during initial construction of the volcano and that meltwater drainage (particularly to the south) was important throughout its history.

V42B-0366 1330h POSTER

First Recorded Eruption of Mount Belinda Volcano, South Sandwich Islands

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The MODVOLC satellite monitoring system at the University of Hawaii Manoa has revealed the first recorded eruption of Mount Belinda volcano, on Montagu Island in the remote South Sandwich Islands. Here we present some initial qualitative observations gleaned from the relatively limited amount of satellite imagery available throughout the eruption, including MODIS, Landsat 7 ETM+ and ASTER data. The eruption started some time between September 12 and October 20, 2001, with low-level ash effusion. In January 2002 a Landsat 7 ETM+ image indicated possible collapse structures in the surface of the continuous ice cover within the caldera, suggesting some degree of subglacial volcanism. By May 2002, a broad area of lava or ash was observed close to the subaerial erupting centre, and activity subsequently increased to its highest observed levels in August 2002. Observations in February and March 2003, from a British Antarctic Survey ship and an aircraft of the British Royal Navy, provided the first visual confirmation of the eruption. Minor thermal anomalies continued to be observed in MODIS imagery throughout August 2003, indicating a prolonged low-level eruption or the establishment of a persistent summit lake possibly similar to that believed to occupy the summit crater (Mount Michael) on nearby Saunders Island. A dynamic lava lake on Saunders Island was first reported in 2001 and remains active.

V42B-0367 1330h POSTER

Degassing at Basaltic Tuyas in northern British Columbia: Insights from the Hydrogen Isotopic Composition of Glasses and Whole Rocks

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Interest in subglacial volcanism was rekindled by the spectacular 1996 Gjalp eruption in Iceland. Northern British Columbia, Canada, hosts numerous flat-topped subglacial volcanoes called tuyas. Ash Mountain, South Tuya, and Three Caribou Tuya are three examples of basaltic volcanoes that began eruptive activity under glacial ice during the Fraser glaciation (25 to 10 ka). Sections of the three superbly exposed tuyas reveal a consistent stratigraphic progression from pillow lavas to hyaloclastite deposits from the base upward. Locally the sections are capped by subaerial basaltic lava flows. Based on classic eruptive models, the glassy pillow basalts and overlying hyaloclastite deposits indicate eruption of basalt within melt water caverns of increasingly shallow depths. Capping subaerial flows record the emergence of lava above the ice sheet. Large thicknesses of ice and melt water overlying the basaltic volcanoes would significantly impede the release of volatiles from the ascending magma. Degassing and ascent rates of magma are thought to exert control on eruptive style. Despite hydrogen isotopes being sensitive measures of degassing, to our knowledge no hydrogen isotope data has been collected on glassy subglacial basaltic rocks. H_2O contents and hydrogen isotopic analyses of glasses from the pillow basalts and hyaloclastite deposits should improve our understanding of degassing processes at these classic tuyas and help refine current models of subglacial basaltic eruptions. Consequently, samples of glassy pillow basalts and hyaloclastites along with crystalline basalt flows were collected at Ash Mountain, South Tuya, and Three Caribou Tuya in northern British Columbia. XRF major and trace element analyses of glassy and crystalline basalts reveal relatively primitive compositions with MgO values ranging from 5.52-10.07 wt%. Whereas Ash Mountain samples are largely tholeiitic, South Tuya and Three Caribou Tuya basalts show more alkalic affinities. In order to definitively track degassing at these subglacial volcanoes, glasses and whole rock basalts were analyzed for their H_2O concentration and hydrogen isotopic composition. At Ash Mountain, glasses from pillow basalts have higher water contents (0.54-0.66 wt%) and less depleted δD values (-87.2 to -102.0$^o/_{oo}$) than associated hyaloclastite deposits (0.43-0.48 wt% H_2O and δD from -112.5 to -122.6$^o/_{oo}$). Hyaloclastite glasses from South Tuya have H_2O contents similar to the Ash Mountain pillow glasses, but δD values resembling Ash Mountain hyaloclastites. Bulk rock basalts have even lower H_2O contents than either the pillow glasses or hyaloclastite deposits and exhibit extreme depletions in δD (i.e., less than -140$^o/_{oo}$). These preliminary data support eruptive models that propose pillow basalts erupted in deeper water than hyaloclastite deposits. Moreover, the H_2O data can be used to constrain the thickness of ice overlying the basalts at the time of the eruption.

V42B-0368 1330h POSTER

Spatial Analysis of the Landbrotsholar Rootless Cone Group, South-Central Iceland: Preliminary Results

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Here, we examine the spatial distribution of the Landbrotsholar rootless cone group in South-Central Iceland. Rootless cones (or pseudo-craters) are hydrovolcanic cones of spatter and scoria that rest directly on tube-fed pahoehoe lava flows. They are formed by explosive interaction between the host lava and underlying water-saturated sediments; they do not represent primary volcanic constructs. Within a given rootless cone group, cones generally appear to be randomly distributed, lacking any obvious association with linear features such as eruptive fissures. However, in the Landbrotsholar group, some cones appear to be linearly aligned. The significance of this apparent alignment is unclear, but it might be related to sequential eruptions along preferred internal pathways (e.g., lava tubes) within the flow field and/or changes in the water content and density of the waterlogged substrate. The spatial distribution of rootless cones may therefore have important implications for the dynamics of these hydrovolcanic explosions and the mechanisms of cone formation. We employ various spatial analysis techniques to examine the Landbrotsholar rootless cone group in detail, including both global and local techniques. These methods provide a means for assessing the degrees of spatial randomness in the cone field and evaluating the statistical confidence in this assessment. Our work entails: (1) developing a filter to automatically identify rootless cones from digital images; (2) identifying spatial trends (such as linear alignments) within the cone group by applying a Hough Transform and identifying peaks in the transformed image; (3) quantifying the characteristic spacing among cones using nearest-neighbor analyses; and (4) relating these results to the underlying processes governing cone formation. Specifically, we aim to elucidate the relative roles of lava tube distribution and substrate hydrology in determining rootless cone distribution. This work may also lead to the development of a remote sensing tool to differentiate rootless cone groups from primary cone groups in digital images.

V42C MCC: Level 1 Thursday 1330h

Noble Metal Geochemistry Posters

Presiding: **J C Lassiter,**
Max-Planck-Institut für Chemie

V42C-0369 1330h POSTER

Os and Sr Isotope Signatures in Kamchatka Adakites, Nb-Rich Arc Basalts and Mantle Pyroxenites: Inferences on Mantle and Crustal Processes

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A suite of adakites, Nb-enriched arc basalts (NEABs), and mantle pyroxenites from Kamchatka have been analyzed for Os and Sr isotopes in order to investigate the relationship between the lavas and their respective veined-mantle source regions, and the extent to which crustal contamination has contributed to the enriched isotopic signatures in the lavas. The mantle pyroxenites range in $^{187}Os/^{188}Os$ from 0.1280 to 0.4138, and in $^{87}Sr/^{86}Sr$ from 0.70305 to 0.70339. The adakites and NEABs for which both Sr and Os data are available fall within the compositional range of the pyroxenites for $^{187}Os/^{188}Os$, varying from 0.1384 to 0.2983, and have $^{87}Sr/^{86}Sr$ ranging from 0.70294 to 0.70320. Os abundances in these lavas range from 12 to 112 ppt. Two distinct positive Os-Sr isotope correlations are observed amongst these samples, including a shallower trend that comprises pyroxenites and lavas from the northern arc front, and a steeper trend that comprises pyroxenites and lavas from behind the arc

V