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 respectibly. There is no critical differences between FTVC and SPVCin their bulk chemistry. For example rocks from FTCV are almost identical to the SPCV in SiO2 contents in the same site. Total AK concentration of rocks from FTCV is lower than those of SPVC in K203, but FTVC is higher than SPCV 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 FTCV. 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 $^{40}Ar/^{39}Ar$ 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 km^2), 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 $^{40}Ar/^{39}Ar$ 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 km^3 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 km^3, 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% SiO_2, 3-5.5 wt% MgO, and relatively high TiO_2 concentrations (0.9-1.8 wt%). The total volume of the cinder cones is 0.83 km^3. No lavas with < 51 wt% SiO_2 have erupted in the past 1 Myr. Peripheral andesites to dacite domes, totaling about 14 km^3, 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 m^3 per km^2 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 de facto 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 ^{230}Th, 1622 a for ^{226}Ra), so it seems logical that any disruption in the U-series decay chain should correct itself relatively quickly. We have developed a model whereby $^{226}Ra/^{230}Th$ disequilibrium can be maintained indefinitely between coexisting clinopyroxene and phlogopite. The steady-state $^{226}Ra/^{230}Th$ 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 ($\sim 10^{-5}$), while that for Th is neutral (~ 1). Therefore, when ^{230}Th in cpx decays to ^{226}Ra, 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 ^{230}Th excess in cpx, with a complementary steady-state ^{226}Ra 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 ^{226}Ra loss is given by $(D_{Ra}/\lambda_{Ra})^{1/2}$. 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 ^{226}Ra excess in the melt itself, with the extent of the ^{226}Ra excess dependent on the degree of partial melting. Small degree melts of metasomatised mantle can develop very high ^{226}Ra excesses ($^{226}Ra/^{230}Th$ > 60 in a 0.1% melt), consistent with observations of high activity ratios in island arc lavas. Furthermore, the high $^{226}Ra/^{230}Th$ 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, $^{226}Ra/^{230}Th$ 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.

V12C-04 1415h

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

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Aniakchak 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 fO_2 between NNO and NNO + ~0.5 log units using both René-style cold seal and TZM 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

the rhyodacite equilibrated at 1.2 to 1.3 kbars (4.5 to 5.5 km) and approximately 840 °C. However, Fe-Ti oxide geothermometry indicates that the rhyodacite last experienced a temperature of 880 (± 10) °C. Preliminary data on the andesite indicate that it may have last equilibrated at greater temperatures and pressures than the rhyodacite. Thin sections of the rhyodacite pumice contain plagioclase phenocrysts with rounding and re-entrant features that indicate late-stage dissolution. These resorption features and the high temperatures estimated from Fe-Ti oxide thermometry indicate that the rhyodacite was heated shortly before the eruption from ~840 to 880 °C. Thus, the Fe-Ti oxides may have rapidly re-equilibrated with the heated melt prior to eruption. Our results lead to a model where the andesite magma heated and destabilized a shallower chamber containing the rhyodacite prior to the eruption, resulting in the mixing and mingling seen in the 3400 yBP deposits.

V12C-05 1430h

Multiple Parent Magmas at Shishaldin Volcano, Alaska, Imply Multiple Protoliths

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Recent petrographic and compositional investigations of Shishaldin volcano, Alaska has revealed two distinct, simultaneously active magmatic series. For convenience, these series have been termed high Rb (HRB; relatively Al-poor, Fe-, Ti-, incompatible-rich) and low Rb (LRB; relatively Al-rich, Fe-, incompatible-poor), although differences between the series extend beyond Rb concentration. The LRB series ranges from 48-57 wt.% SiO_2 and is distinguished by higher crystallinity, smaller ranges in major element concentrations, lower degrees of Fe enrichment, steep drops in Al_2O_3, lower incompatible trace element concentrations and less scatter in trace element variation plots. The HRB series ranges from 49-68 wt.% SiO_2 and is comparatively less crystalline, Fe-Ti and incompatible-trace-element enriched, with wider ranges in major element compositions and greater scatter in trace element variation plots. Although products from the LRB series dominate the younger Shishaldin deposits, both magmatic series have been active throughout the history of the volcano, and on one occasion erupted simultaneously. Only the LRB series rocks preferentially erupt from flank vents rather than the summit.

Compositional differences between the LRB and HRB series suggest these magmas have undergone separate developmental paths, likely as a result of different crustal storage conditions. Incompatible trace element concentrations in HRB basalts are significantly greater than basalts of the LRB, indicating these magmas are not related by fractionation of a common parent. Major and trace element modeling suggests these magma series have not been generated through a single magma experiencing differing degrees of crustal assimilation. Two different parental magmas must therefore be present. Initial analyses do not indicate these magmas have resulted from differential degrees of partial melting of the mantle wedge, and suggest a separate protolith for each magma series.

V12C-06 1445h

Magmatism in the Denali Volcanic Gap, Southern Alaska

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Volcanism accompanying subduction of the Pacific plate beneath the North American plate forms the Aleutian volcanic arc, which extends eastward from the western Aleutian Islands to the Alaska Peninsula and mainland Alaska. Long-lived volcanoes are absent from the easternmost 320 km of the seismically defined subduction zone, which we call the Denali Volcanic Gap. The arc-trench gap widens to 500 km in this region, and the shallow portion of the subducted slab becomes sub-horizontal, resulting in hundreds of kilometers of "flat-slab" subduction. Does the lack of volcanism arise from lack of magmatism? There are lines of evidence that suggest not - that magmatism is robust, but that the magmas don't erupt: (1) Anomalously low b-values on the surface of the subducting slab are more robust in the non-volcanic part than in the area underlying the active eastern stratovolcanoes. These b-values reflect high fluid pressures associated with slab dewatering and magmatism. (2) 3,000 yr old small-volume monogenetic volcanism above the very easternmost end of the W-B zone (320 km from the nearest long-lived volcano) erupted primitive basalt which has the unique and unmistakable trace-element signature of arc volcanism. This signature arises by fluxing of the mantle source region by fluids derived from the subducted slab. The presence of these tiny volcanoes signifies that slab fluids can be carried through the flat-slab region without being lost, which further suggests that models of the volcanic gap that call on off-scraping or dewatering of slab-top lithologies during flat-slab subduction causing a "sterile" asthenosphere are incorrect. Ongoing accretion of the Yakutat Block to the southern Alaska margin compresses southern Alaska, and forces the crust northwestward, and then counterclockwise. This compression may prevent magmas from rising and forming long-lived volcanoes. A persistent knot of deep- and sub-crustal seismicity in the Denali Gap may reflect large-scale magmatism. If, true, and if this system grows big enough to achieve sufficient buoyancy to rise through the crust, then an eruption far larger than anything in historic time worldwide may occur.

V12C-07 1500h

Compositional Variation and Magma Mixing With Respect to Time and Space at Volcán Aucanquilcha, Northern Chile

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Volcán Aucanquilcha is located at 21°16S in the Andes of northern Chile and consists of an 8-km long ridge made up of least 5 vents that are successively younger to the east. Later eruptions vented from the northwestern flank of the volcano. Aucanquilcha has erupted an estimated 150 km^3 of material over past 1 Ma based on Ar age dates of the oldest lavas. Lavas range from 62.3 to 67.5 wt% SiO_2 and have abundant andesitic inclusions (59.0 to 60.2 wt% SiO_2). $^{87}Sr/^{86}Sr$ values (0.70614 and 0.70679) generally increase with decreasing $^{143}Nd/^{144}Nd$ (0.51234 and 0.51228) but do not covary with SiO_2. The eastern summit lavas and NW flank lavas are more evolved (SiO_2 > 66 wt%) compared to the main edifice. The easternmost summit lavas, however, are distinct from the rest of the volcano in that they have elevated K_2O (> 2.9 wt%), Zr (> 168 ppm) and Rb/Sr (> 0.154) as well as higher $^{87}Sr/^{86}Sr$ and lower $^{143}Nd/^{144}Nd$, suggesting more of an upper crustal history. The eastward increase in K_2O is consistent with regional trends across the arc. Electron microprobe data for the early and late series lavas indicate two distinct populations of amphibole are present in both: one wholly pargasite and another spanning to tschermakite and hornblende. These amphibole populations indicate mixing of two batches of magma of different temperatures. The lack of disequilibrium reaction rims on amphibole indicates that eruption quickly followed the mixing events.

V12C-08 1535h

Geochemical and Tectonic Evidence for the Role of Crustal Thickening and Forearc Subduction Erosion in Miocene to Recent Andean Southern Volcanic Zone Magmas

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Key to understanding temporal and spatial variations in Andean-type margin magmas is identifying their mantle and crustal sources in well constrained tectonic settings. A study of Andean Southern Volcanic Zone (SVZ) Early Miocene to Recent magmas in an west to east transect near 34°S points to a linked role for crustal thickening and forearc subduction erosion. The whole rock and isotopic chemistry of these magmas show a trend from Early Miocene tholeiitic sequences with low pressure pyroxene-bearing residual mineral assemblages and more depleted isotopic signatures ($^{87}Sr/^{86}Sr \sim$ 0.7036; $\epsilon Nd \sim$ +6 to +4; $^{206}Pb/^{204}Pb \sim$ 18.5) to Pliocene/Recent high-K calc-alkaline sequences with high pressure garnet-bearing residual mineral assemblages and enriched isotopic signatures ($^{87}Sr/^{86}Sr \sim$ 0.7042; ϵNd + $1 to 0; ^{206}Pb/^{204}Pb \sim$ 18.6). Relatively abrupt breaks in this sequence at ~ 19 to 15 Ma and ~ 7 to 4 Ma coincide with an early Miocene extensional to compressional deformational switch and major Late Miocene out-of-sequence thrusting that accompany eastward shifts of ~ 35 and ~ 50 km of the arc front and peaks in uplift history. These changes are consistent with peaks in forearc subduction erosion that introduce continental crust into subcrustal magma sources and in backarc shortening that enhance MASH processes in a thickening crust. Shifts to higher pressure chemical signatures and isotopic enrichment as frontal arc magmatism wanes in the west and migrates eastward fit with continental crust entering subcrustal magma sources. The projections of extinct arc fronts near 34°S into chemically equivalent units to the south indicate an ~ 35 km shift of the arc front north of 36.5°S at ~ 19 to 15 Ma and another ~ 50 km shift north of 34.5°S between ~ 7 to 4 Ma. These SVZ shifts coincide with major tectonic changes along the Andean margin that are best related to variations in plate convergence parameters.

V12C-09 1550h

Generation of Continental Crust in Central America: New Field and Geochemical Observations on Silicic Magmatism in Costa Rica

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Explaining the occurrence of high-silica arc magmatism in the absence of continental crust remains a fundamental problem in igneous petrology. Recent work in the southern portion of the Central American volcanic arc has expanded the database for the abundant high-silica ash-flow tuffs erupted on top of thick oceanic basement in Costa Rica and southern Nicaragua. Regional differences in geochemistry are observed in data from central and northern Costa Rica. In addition, local heterogeneities among units are demonstrated in plots of both major and trace elements.

High-silica ash-flow tuffs in central Costa Rica include the Tiribi Tuff (~0.33 Ma) and Alto Palomo formation (~0.56 Ma). In northern Costa Rica, numerous large silicic ash-flow sheets are found in the Guanacaste province, ranging from late Miocene (<10 Ma) to Pleistocene (~0.6 Ma) in age. A frequency histogram of normalized silica content for all analyses to date from these units (n=222) produces a left-skewed curve with a mode occurring at approximately 70 wt.% SiO_2. Samples from the northern region (n=107) demonstrate a tighter distribution of silica content (60.1-78.7 wt.% SiO_2 with a median of 72.2 wt.% SiO_2) compared to samples from the central region (n=115, 55.4-74.2 wt.% SiO_2 with a median of 67.1 wt.% SiO_2). The least evolved samples come from the Tiribi Formation in the Valle Central and are chemically distinct from rocks in the Guanacaste region. In both chemistry and geographical position, the Alto Palomo formation appears to represent a transition between tuffs in the Valle Central and those in Guanacaste. Incompatible trace element ratios for these units are nearly identical to regional trends observed in basaltic to andesitic lavas of the modern Costa Rican arc (e.g. Ba/Nb).

The Papagayo sequence is an example of chemical variation within one vertical section. The sequence is a ~21 m section of well-exposed tuff that represents an essentially continuous sampling of an evolving magma body. Major-element analyses from a systematic vertical sampling of the section support a model of crystal fractionation, eruption, and mafic replenishment of the magma chamber. Samples range from 60.1 to 70.2 wt.% SiO_2, with the most mafic sample occurring at the top of sequence as a visibly mafic-silicic mingled pumice.

The Rio Liberia (~1.47 Ma) and Salitral (~1.3 Ma) formations in the Guanacaste region form a series of tuffs, related by the same inferred vent. Despite overlapping silica content, the units have distinct mineral compositions. The Salitral formation includes plagioclase- and amphibole-rich units that appear very similar in the field, while the Rio Liberia contains biotite. Chemically, the units are distinct, forming several separate trends in trace element plots. These heterogeneities most likely reflect differences in both source and/or processes of magma evolution.

V12C-10 1605h

Origin of Enriched Geochemical Signatures in Continental Arc Rocks by Antithetic Subduction of Continental Lithosphere

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The source materials for magmas in continental arcs are not well known. Magmas are typically assumed to be derived from the subducted slab, subducted sediment, and mantle wedge, but some continental arcs have isotopic signatures that are inconsistent with these sources. For example, a large volume of the Sierra Nevada batholith consists of rocks that have initial Sr ratios of about 0.706-0.708 and ϵ_{Nd} values ranging from -3 to -8. Late Cenozoic volcanic rocks erupted through the batholith, and their entrained xenoliths, have similar isotopic compositions. These characteristics are inconsistent with derivation from only the sources above and are most easily explained by derivation from enriched continental lithospheric mantle. However, there was never enough lithospheric mantle under the arc to produce the observed volume of enriched arc rocks; mass balance fails by one or two orders of magnitude, and lithosphere cannot flow by viscous processes to provide material to the arc.

A possible solution to this problem lies in kinematic mass balance of the arc system. In many continental arcs (e.g., Cenozoic Andes, Mesozoic northern Cordillera and Sierra Nevada), thrust faults have carried the arc at least 100-200 km toward the craton. This motion requires moving a comparable amount of sub-detachment lower crust and mantle toward the arc and produces a tremendous cross-sectional balance problem. Geologic field studies and geodynamic modeling indicate that this antithetic subduction feeds continental lithosphere into the convecting mantle wedge where it can contribute to magma genesis. This process provides a large volume of enriched and probably fertile continental lithospheric mantle to the arc system and may account for the unusual geochemical signatures of some arc rocks.

V12C-11 1620h

Growth and Evolution of the Accreted Talkeetna Arc, South-Central Alaska: Solutions to the "Arc Paradox"

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The accreted Talkeetna arc, exposed in the Chugach Mountains of south-central Alaska, represents a cross section from the Moho to surficial volcanic deposits of a Jurassic intra-oceanic arc. We are using SIMS and partial dissolution-TIMS U/Pb zircon analyses of plutonic rocks in the Talkeetna arc to study how island arcs grow, evolve, and morph into continental crust.

Our partial dissolution analyses (PDA), following the chemical abrasion technique developed by Mattinson (2000, 2001a, 2001b), used high-T (800°C) annealing of radiation damage, followed by successive acid digestions of grain populations, to generate reproducible high precision ages. Low-T (160-170°C) "clean-up" digestions typically showed signs of Pb loss, consistent with removal of discordant zircon, whereas high-T (>170°C) and residue steps gave concordant age plateaus. Repeat analyses of samples showed similar dissolution patterns and ages agreed within two sigma errors.

The SIMS and TIMS U/Pb zircon analyses from the Talkeetna arc yielded ages of 184.3 ± 0.4 Ma, 185.0 ± 0.4 Ma, 186.6 ± 0.4 Ma, 192.4 ± 2.9 Ma, 193.2 ± 0.4 Ma, and 198.6 ± 0.4 Ma, indicating that the arc was active from ~184-199 Ma. Previous $^{40}Ar/^{39}Ar$ hornblende cooling ages for the arc range from ~175-182 Ma, suggesting a total arc lifespan of ~20 My. This is consonant with fossil ages within arc volcanic rocks that range from early Sinemurian to upper Toarcian (~180-202 Ma) and biochronology that bounds arc growth between Late Triassic and early Bajocian (~169-206 Ma). Intermediate to felsic plutonic rocks in the Talkeetna Mountains intrude the volcanic carapace of the arc, but were not previously considered to be part of the Talkeetna arc. Our new SIMS and TIMS ages of 163.9 ± 3.6 Ma, 170.0 ± 4.2 Ma, 171.3 ± 5.1 Ma, 175.6 ± 0.4 Ma, 180.8 ± 2.7 Ma, and 183.8 ± 2.1 Ma, overlap the ages reported above for the Chugach Mountains, suggesting that portions of the intermediate plutonism could be related to the Talkeetna arc.

Our new age data from the Talkeetna and Chugach Mountains may explain the apparent paradox of intermediate continental crust being produced by the accretion of mafic intra-oceanic arcs. The lifespan of the Talkeetna arc, combined with Raleigh-Taylor instability modeling by Jull and Kelemen (2001) and thermobarometry on lower crustal garnet gabbronorites (Mehl et al., 2001), suggests that the lower crust of the Talkeetna arc could have become convectively unstable, and sunk into the asthenosphere prior to accretion. The removal of mafic lower crust would drive the bulk arc composition toward more continental values. Additionally, previously unrecognized intermediate arc plutonic rocks in the Talkeetna Mountains would lead to a more intermediate composition for the Talkeetna arc and also help solve the arc paradox.

V12C-12 1635h

Zircon U-Pb And Biotite 40Ar/39Ar Ages Of Kohistan Lower Crustal Tonalite And Their Implications For The History Of Continental Collision

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The Kohistan block in northern Pakistan exposes a crustal cross section through an ancient oceanic island arc, comprising garnet pyroxenite, garnet granulite, banded amphibolite, norite gabbro, metasediment and metavolcanics. The Dasu Tonalite intrudes the lower crustal Kamila Amphibolite. The tonalite is foliated and folded concordantly with the host amphibolite, indicating syn-tectonic intrusion, and contains abundant magmatic epidotes, indicating high-P crystallization.

The Dasu Tonalite is extremely poor in K2O (0.6-0.9 wt.% for SiO2 64-70%) and has a low initial 87Sr/86Sr (0.7037-0.7038, similar to the associated lower crustal amphibolite and granulite), consistent with juvenile granitic magma free of contamination by recycled upper crust.

The Dasu Tonalite gave SHRIMP zircon U-Pb ages of 97.6+/-1.0 Ma and 98.0+/-1.1 Ma on two samples, and biotite 40Ar/39Ar ages of 69.7+/-0.7 Ma and 69.7+/-0.9 Ma. The euhedral shape and lack of overgrowth or resorption features in CL images of the zircons suggest a simple magmatic history starting at ca. 98 Ma with no evidence for a later major thermal event.

The large discrepancy between the U-Pb and Ar-Ar ages might record the deep crustal residence time of the Dasu Tonalite. The tonalite magma was probably generated and crystallized at ca. 98 Ma, then remained in the lower crust at a temperature of about 700C (which is given by geothermometry of the intercalating Kamila amphibolite), cooling down to ca.300C at 69.7Ma. 69.7Ma is a cooling age during the process of exhumation of the Kohistan arc caused by the Indian collision.

V12C-13 1650h

^{238}U-^{230}Th Disequilibrium in Zircon and $^{87}Sr/^{86}Sr$ Variations in Plagioclase as Recorders of Magmatic Processes in a High-Silica Rhyolite: Taupo Volcano, New Zealand

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The processes involved in, and the timescales over which large bodies of silicic magma are generated and stored in the crust are addressed here by studies of the Oruanui eruption (530 km^3 magma), the latest caldera-forming event (26.5 ka) at Taupo volcano (Taupo Volcanic Zone, New Zealand). The eruption was mildly zoned, dominantly 73-76% SiO_2, but was non-systematically tapped. Here we report (^{238}U-^{230}Th) disequilibrium data on whole rocks and zircon by TIMS on bulk samples and SHRIMP-RG on single crystals and show that the Oruanui magma contained a suite of zircons with a bimodal age distribution. The dominant population yields a weighted mean age of 35.4±3.6 ka (10 ka in excess of the eruption age, which includes zircons actively crystallising in the Oruanui magma at the time of eruption), versus a smaller age population yielding a weighted mean age of 91.5±8.8 ka (65 ka in excess of eruption age). We believe that these data indicate that accessory phases such as zircon record episodic growth histories, where the older age population represents crystals relating to an earlier magmatic episode(s).

In addition, we present preliminary $^{87}Sr/^{86}Sr$ microanalysis data for feldspar crystals separated from the Oruanui rhyolite. High resolution electron microprobe traverses and Normarski imaging reveal a growth history punctuated by magmatic events that are manifested as unconformities and inclusion rich zones within the crystals. The opaque feldspar cores have $^{87}Sr/^{86}Sr$ of 0.70550, whereas rims are 0.70562, the latter being compatible with the whole-pumice values for Oruanui rhyolite. These variations are accompanied by changes from ~An30 at the rim (in equilibrium with the host pumice) to ~An65 in the core. However, some feldspars show a much more complex crystallisation history, where Sr isotope variations within the grains are far outside values seen in the whole-pumices. We interpret these variations and the age spectrum of the zircons to represent open system processes in the generation of the Oruanui rhyolite.

V21A MCC: Hall C Tuesday 0830h

Statistical Analysis of Data Recorded on Active Volcanoes: Advancements and New Perspectives I Posters *(joint with S)*

Presiding: s **Falsaperla,** Istituto Nazionale di Geofisica e Vulcanologia**; S Malone,** University of Washington

V21A-1163 0830h POSTER

Search for a Possible Triggering Effect Between Tectonic Earthquakes and Swarms at Volcanoes

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We searched for possible relationships between earthquake swarms at volcanoes and tectonic earthquakes nearby, using the Global Volcanic Earthquake Swarm Database (GVESD). From the GVESD we extracted a sample of 358 swarms with reported start dates. The durations of these swarms are in the range 15 minutes to 4.6 years and they occurred at 93 volcanoes around the world. Then we used the NEIC earthquake database to search systematically for earthquakes with magnitude >6 and distance <1000 km from the volcano, occurring in the ten years before the swarm start date. The relation between tectonic earthquakes and swarm start dates was analyzed by plotting the number of earthquakes, their magnitudes, and their distances to the volcano versus delta T, the time difference between earthquake occurrence and swarm start date. The time distribution of precursor earthquakes was divided into bins of 6 months and 1 month and all distributions were tested for significance of peaks in the number of earthquakes, magnitudes, or distances. For 50 randomly selected swarms with durations less than 120 days we found only one peak in the number of precursor earthquakes that appears to be statistically