V31B-08 0945h

On the Trail of Missing Heat: Forward Gravity Modeling of the San Francisco Volcanic Field, Northern Arizona

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The San Francisco volcanic field is a Quaternary field in northern Arizona, the age and size of which suggests there is a high possibility for an associated exploitable high temperature geothermal resource. Sunset Crater, the youngest dated feature in the field, erupted less than 1000 years ago. The youngest felsic volcanism in the area, located near Strawberry Crater, has been dated at about 51,000 years b.p. Felsic magmas are viscous, and therefore felsic magmatism is generally associated with upper crustal plutons, whereas mafic magmas commonly form surface flows. Heat from felsic magmatism tends to remain near subsurface ponds of the magma. Felsic magmatic systems can sustain substantial geothermal heat for tens to hundreds of thousands of years after emplacement. Knowledge of the quantity and distribution of felsic magmatism is therefore paramount to understanding the geothermal potential of the field. Surface heat flow in the study area ranges from ~20 to ~50 mW/m^2, anomalously low for the region. Hydrological characteristics of the San Francisco volcanic field are thought to mask increased surface heat flow from the magmatic system. The deep water table (>300m) and a 2-level hydraulic system prevent characteristic surface manifestations of hydrothermal potential, such as hot springs and elevated surface heat flow. Lack of these thermal features at the surface precludes analysis of the resource based solely on surficial mapping and measurements. Forward modeling of the gravity field of a 50 km x 45 km area covering the eastern San Francisco volcanic field has been completed. Results suggest that a large felsic body (~-0.15 g/cc contrast) trends northeastward under the Sugarloaf Mountain-O'Leary Peak-Strawberry Crater magmatic trend. This trend parallels a regional basement fabric, likely of early- to middle-Proterozoic origin. These results are being correlated with new surface geologic mapping and radiometric dating of young felsic volcanic rocks to guide an exploratory drilling program.

V31C MCC: Level 2 Wednesday 0830h

Birth, Growth, and Death of Magmatic Arcs: Comparisons Among Arcs in Different Settings I Posters

(joint with T)

Presiding: **M Rioux,** University of California, Santa Barbara**; R Flowers,** Massachusetts Institute of Technology

V31C-0938 0830h POSTER

Evidence of Magma Mingling in the Tiribí Tuff, Valle Central Costa Rica

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This study is part of a larger oxygen isotope investigation to sort out the role of assimilation and crustal melting in the formation of abundant, large-volume silicic ignimbrites in Central America. The 0.33 Ma Tiribí Tuff of Valle Central Costa Rica is a large-volume, compositionally heterogeneous ash flow sheet (25 km^3 dense rock equivalent) that did not form in the presence of evolved continental crust. Glassy pumices, from the dominant ash flow sheet within the Tiribí, have been sub-divided into three groups based on their textures and whole rock compositions: a low-silica group (55.1-65.6 wt% SiO_2), a mingled group (58.6-67.7 wt% SiO_2), and a silicic group (66.2-69.2 wt% SiO_2). Variations in major and trace elements within the low-silica group are best explained by fractional crystallization. However, differences in trace element data between the low and silicic groups cannot be explained by this same process. The mingled group has been interpreted as mingling of the low-silica and silicic magmas based on petrographic evidence and trace element data. Oxygen isotopes can provide an excellent test for the proposed origin of the magma groups in the Tiribí Tuff. If crustal material has been incorporated into a primitive magma, the $\delta^{18}O$ (WR) of the whole rock will typically vary with increasing SiO_2(WR). The $\delta^{18}O$ of 10 Tiribí samples range from 3.27$^o/_{oo}$ to 3.90$^o/_{oo}$ for magnetite and 5.15$^o/_{oo}$ to 5.63$^o/_{oo}$ for clinopyroxene. These data suggest $\delta^{18}O$ (WR) values consistent with derivation from mantle melts or melting of primitive crustal rocks. Likewise, fractional crystallization in the absence of contamination causes a predictable correlation of $\delta^{18}O$ to wt% SiO_2. Oxygen isotope thermometry of magnetite and clinopyroxene demonstrates that these phenocrysts have preserved magmatic $\delta^{18}O$ values and further divides the low-silica from the silicic group, suggesting formation of these magmas at 1200^{o}C and below 1100^{o}C, respectively. These $\delta^{18}O$ data of magnetite and clinopyroxene are not consistent with fractional crystallization of the low-silica magma to produce the silicic magma. The $\delta^{18}O$ data better support a model where the low-silica and silicic magmas were two separately generated magma batches that, in part, mingled shortly before or during eruption.

V31C-0939 0830h POSTER

The Geochemical Evolution of Arenal Volcano, Costa Rica

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Arenal is a small stratovolcano located in northwestern Costa Rica, along the Central American volcanic front. It is the youngest and most active volcano in Costa Rica. Field studies by Soto et al. (1996) have discovered over twenty distinct tephra layers and several lavas. This sequence spans approximately 7000 years. The geochemistry of these tephras and lavas show many variations in La/Yb, Zr/Hf, and Nb/Ta indicating changes in percent melting over time. Specifically, the percent of melting appears to increase for the first 4000 years, then decrease for the last 3000 years. Trace element ratios that track the subducted slab signal, such as Ba/La, U/Th and Pb/Ce correlate positively with the apparent percent of melting. These slab signal indicators increase during the first 4000 years of Arenal's history and then decrease for the last 3000 years. Because of Arenal's high rate of eruption and the comprehensive sampling of major units, it is possible to show small temporal changes in the amount of flux melting in the mantle wedge beneath Arenal.

V31C-0940 0830h POSTER

Systematic Variations in the Trace Element and Isotopic Compositions of High-K_2O, Medium-K_2O, and High-TiO_2 Volcanic Rocks From the Zitácuaro-Valle de Bravo Region of Central Mexico

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Within the Zitácuaro-Valle de Bravo region of the central Mexican Volcanic Belt, three series of lava have erupted during the Quaternary period. These lava series are defined based on their major and trace element compositions to be: 1.) Shoshonitic (high-K_2O), 2.) Medium potassium (med-K_2O) basaltic andesites through dacites, and 3.) High-TiO_2 basalts and basaltic andesites. The distribution of these distinct compositions is systematic; with the high-K_2O volcanism at the arc front, the med-K_2O volcanism concentrated along the central axis of the arc, and the high-TiO_2 volcanism at the middle to back portion of the arc. The high-K_2O compositions are extremely enriched in large ion lithophile elements (LILE's) and light rare earth elements (LREE's), with a narrow range of distinctly enriched $^{87}Sr/^{86}Sr$ values from 0.704245 to 0.704507 and ϵ_{Nd} values ranging from 4.27 to 5.63. The med-K_2O compositions are only moderately enriched in the LILE's and LREE's and have the largest range of $^{87}Sr/^{86}Sr$ values from 0.703227 to 0.704287 and ϵ_{Nd} values ranging from 3.39 to 6.03. In contrast, the high-TiO_2 compositions have no enrichments in LILE's or LREE's and instead are enriched in the high field strength elements (HFSE's). The high-TiO_2 lavas have $^{87}Sr/^{86}Sr$ values ranging from 0.703549 to 0.704095 and a narrow range of ϵ_{Nd} values from 2.98 to 3.47. The isotopic compositions of the Zitácuaro-Valle de Bravo lavas correlate with their major and trace element characteristics, as well as the spatial distribution of the lavas within the arc. The systematic spatial distribution of these distinct lava types is similar to that of the Quaternary lavas in the Michoacan-Guanajuato Volcanic Field, directly to the west. However, in distinct contrast, the Quaternary lavas in the Sierra Chichinautzin Volcanic Field, to the east, are not spatially distributed according to composition. Instead, their distribution appears to be predominantly controlled by several conspicuous faults.

V31C-0941 0830h POSTER

Magmatic processes at Popocatepetl volcano, Mexico: petrology, geochemistry and Sr-Nd-Pb isotopes

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Popocatepetl volcano is one of the most famous and most active stratovolcanoes of the Trans-Mexican Volcanic Belt (TMVB). It is located 60 km south-east of Mexico-City and 40 km west of the city of Puebla, both cities have more than 30 million inhabitants. In this contribution we present a study of Late Pleistocene to Recent products of Popocatépetl (Popo) volcano and surrounding scoria cones to better establish their genetic relationship and magmatic history. Popo and flanking vents are located within the central portion of the Trans Mexican Volcanic Belt, which is related to oblique subduction of young oceanic lithosphere. Current activity of Popo can be understood in the context of its past eruptions and those from surrounding scoria cones. The latest cycle of eruption began Dec. 21, 1994 with continuous to pulsating emission of phreatic ash. The last important event happened on July 19, 2003, covering Mexico-City with a thin ash-layer. Both Popo and surrounding scoria cones produced moderate-K, calc-alkaline rocks, with the two groups differing mainly in degree of differentiation, water content, and oxidation state. Some vent samples on the immediate flanks of Popo and have phenocryst assemblages and compositions transitional between typical flanking vent and stratovolcano samples. Monogenetic vents produced mainly basaltic andesites to andesites, primarily by crystal fractionation of Ol (Fo80-90)+chromite, 2Pyx±Ol, and 2Pyx±Plag±Hb assemblages, with minor assimilation of crustal debris. The andesitic to dacitic rocks of Popo are dominated by Plag-2Pyx-2Oxide±Hbl assemblages, with variable amounts of Ol (Fo70-90)+chromite xenocrysts. A few Popo samples contain locally abundant xenolithic debris of cognate-granitoid intrusions and their metasedimentary wall-rocks. The two suites share parental Mg-rich basaltic andesite magmas, with the Popo magmas reflecting longer residence in the crust, and enhanced hydration and oxidation due to the resulting processes of crystallization, recycling, assimilation, and degassing in relatively evolved magma chambers. The 1996 and 1997 dome eruptions confirm that dacitic magma currently resides beneath Popo and is episodically recharged by more mafic magma, fostering eruption and excess degassing. Two-oxide thermometry and the presence of FeCu sulfide globules confirm that these magmas erupted at T = 930^{o}C and fO2 = -10.2 log, below anhydrite stability. 87Sr/86Sr, e-Nd and 206Pb/204Pb ratios are between 0.70365 and 0.70463, +6.4 and +3.0, and 18.618 and 18.781, respectively. Andesitic to dacitic rocks of Popo formed by mafic recharge, fractionation, and mixing of dacitic to basaltic magmas in mature crustal chambers. Plagioclase accumulation and recycling related to protracted fractionation and assimilation of earlier emplaced magmas and their wall-rocks was also important.

V31C-0942 0830h POSTER

Chemical Variation and Origin of Pleistocene Silicic Pyroclastic Flows from Central American Volcanic Arc

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Silicic pyroclastic flows have occurred along the Central American volcanic arc during the Pleistocene. The volcanic products from these eruptions range in composition have SiO2 mode of 70 wt.%. In the latest part of the Pleistocene (<100 Ky), ash-flow tuffs are common in Guatemala, El Salvador and Nicaragua, but absent from Costa Rica. Phenocryst phases of the silicic pyroclastic flows along Central America are generally very similar. Plagioclase dominates as phenocryst and in the groundmass. Sub-calcic augite, hypersthene are common in dacites. Amphibole as well as biotite are common in the rhyolites and rhyodacites in Guatemala and El Salvador, but these minerals are absent from all units in Nicaragua, and from the youngest unit in Costa Rica. In addition, Ti-oxides, apatite, quartz, are common. It is worth noting that the silicic rocks from Central America contain very little alkali feldspar. There are some chemical variations in the composition of ash-flow tuffs along the arc. The most primitive materials in ignimbrites from Guatemala and Costa Rica are basaltic andesites and andesites; but in Nicaragua and El Salvador, basaltic scorias are present. The ignimbrites from Central Costa Rica have higher alkali content, than the rest of the Pleistocene ash-flow tuffs from Central America, a pattern similar to that observed in lavas. Furthermore, some trace element and trace element ratios also vary along the arc in a pattern similar to that observed in the lavas. The ignimbrites from Nicaragua tend to have the lowest concentrations of Zr (<100 ppm) and the highest concentration of Rb (>200 ppm); Ba/Th, U/Th are highest and La/Yb is the lowest in Nicaragua.Fractional crystallization has played a role in the evolution of ash-flow sheets in the Central American volcanic arc. Some samples from Guatemala and El Salvador have Eu/Eu*<0.7 and Sr<200 ppm. These compositions can be interpreted as the result of plagioclase fractionation. However, this process alone does not explain the wide range of compositions observed in the ignimbrites. We argue that variations in the composition of the parent material and in the conditions of melt generation played an important role in the generation of the diverse compositions of Pleistocene ash-flow tuffs. Furthermore, we propose that that the basement rocks along the arc, Paleozoic continental crust in the north and Caribbean large igneous province in the south, are not possible sources for the Pleistocene silicic pyroclastic flows. Based on the similar key trace-element ratios of the ignimbrites and the arc lavas, we concluded that remelting of the calc-alkaline plutons, emplaced at depth, are the likely source of the ash-flow tuffs.

V31C-0943 0830h POSTER

High Field Strength Element Evolution of Telica and Izalco Volcanoes, Central America

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Telica and Izalco are well sampled Central American volcanoes in Nicaragua and El Salvador, respectively. Telica is a complex volcano with a history of at least several tens of thousands of years. Izalco is a parasitic cone that first erupted on the flank of Santa Ana volcano in 1770. These two volcanoes provide stratigraphic sections on long and short times scales. Furthermore, Telica has one of the highest slab signals in Central America, whereas Izalco has a smaller slab signal. These two volcanoes were selected for detailed measurement of Nb, Ta and other HFS elements. Nb (and Ta) depletions relative to other similarly incompatible elements are a prevalent characteristic of island arc basalts. Nb (and Ta) may be depleted because of a residual Ti-bearing phase, such as rutile or Ti-amphibole, which preferentially retain these elements. All the Izalco samples and the majority of the Telica samples display significant Nb (and Ta) depletions. There are a few high-TiO2 samples (>1wt% TiO2) at Telica that do not have a negative Nb anomaly. At Telica, Nb/Ta decreases and Zr/Hf increases with age (youngest to oldest). Zr/Nb decreases then increases with age. Ratios that are proxies for total slab signal, such as Ba/La and U/Th, fluctuate with age in the same manner as Zr/Nb. U/La, which is used to track the hemipelagic sediment signal, increases with age whereas Ba/Th, which tracks the carbonate sediment signal, decreases then increases. Zr/Hf positively correlates with U/La (hemipelagic signal). Neither Nb/Ta nor Zr/Hf correlates with La/Yb hence the variations in these ratios are not the result of different degrees of melt. A variation in the HFSE might not be expected in Izalco, which is very young, however Nb/Ta does vary, whereas Ba/La, U/Th, Ba/Th, U/La do not. Nb/Ta is also not correlated with La/Yb; therefore, degree of melt is not responsible for the range in Nb/Ta values. However, the degree of melt is lower in the older Izalco samples, shown in La/Yb and Zr/Hf. The lack of a Nb anomaly in some Telica samples implies that these originated from a source with no residual rutile or Ti-amphibole to retain these elements. Overall, the HFS element abundances do not significantly vary compared to the rest of Central America.

V31C-0944 0830h POSTER

Helium Variations in Mineral Separates from Cerro Negro Volcano, Nicaragua: Assessing Short Time-Scale Variations

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Cerro Negro volcano is a young basaltic volcano located in northwestern Nicaragua. It has undergone at least 23 eruptive phases over its 150-year history. We report new He abundance and isotope results in phenocryst phases from recent volcanic ashes and lavas. Analyses were carried out on both olivine and pyroxene phases for the 1992, 1995 and 1999 eruptions, allowing He variations over relatively short time scales to be assessed. He abundance and isotope ratios results show the following: 1) co-genetic olivine-pyroxene pairs show a consistent trend of higher $^3He/^4He$ ratios in the olivine phase (6.1-6.6 R_A) relative to the pyroxenes (4.6-5.5 R_A), 2) He concentrations are lower in the olivine phase (0.59-2.2 x 10^{-9} cm^3/g) than the pyroxene phase, (2.2-5.4 x 10^{-9} cm^3/g), 3) the $^3He/^4He$ ratios in the olivines are similar, yet slightly lower than values measured in geothermal fluid samples (6.99 +/- 0.07 R_A), and 4) no significant difference is found in values measured in the three eruptive phases. The first two observations are consistent with a scenario where the olivines crystallized out of a magma before the pyroxenes, preserving a more pristine He isotope signature. The lower $^3He/^4He$ ratios and higher concentrations found in the pyroxenes indicate radiogenic He additions, likely due to crustal assimilation occurring after olivine crystallization. This hypothesis will be tested by electron microprobe analyses of co-genetic pairs, evaluating whether olivines are in fact more primitive (higher Mg values). The third observation shows that although both phenocryst and geothermal fluids preserve magmatic volatiles, geothermal fluids may be less influenced by contamination effects, which act to lower $^3He/^4He$ ratios. The final observation suggests that the volatile composition of the magma chamber feeding the eruptions has been relatively homogeneous over decadal time scales.

V31C-0945 0830h POSTER

Evolution of mantle-crust thermal structures in the late Cenozoic NE Honshu arc, Japan

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NE Honshu is an island arc associated with the back-arc Japan Sea basin, and three prominent stages of the volcanic activity in the late Cenozoic have been recognized. These are continental margin volcanism (66-21 Ma), back-arc basin volcanism (21-13 Ma), and island-arc volcanism (13-0 Ma). In the continental margin stage, the volcanic front was located deeper in the back-arc side compared to the present. The volcanic front expanded toward the trench side, and volcanic arc was at its widest between 25 and 21 Ma. After the back-arc opening event ended, the volcanic front began to migrate to the rear-arc, and settled at its present position. Geological and petrological approaches combined with seismological images enable examination of deep structures beneath island arcs. Across-arc profiles of source mantle temperatures and heterogeneity of mantle compositions inferred from petrological data are compared with the seismic velocity structures. Volcanic products in each stage have unique patterns of across-arc chemical variations that should be closely related with the thermal structure of the wedge mantle. The spatial heterogeneity in the basalt source regions of the NE Honshu arc mantle wedge may be formed by injection of depleted asthenospheric mantle into enriched continental lithosphere during the back-arc basin opening stage. This was related to three rifting episodes in the arc, firstly at 21 Ma in the back arc Yamato Basin, secondly at the rear-arc edge of the present island arc at 16 Ma, and finally at 14 Ma in the imediately inside of the Backbone Range of NE Honshu. In the back-arc basin volcanic stage, the inferred head structure of the 1320?O'C mantle isotherm was very flat. This temperature increase in the back-arc mantle region may be related to upwelling of asthenosphere, resulting in eruption of tholeiite from shallower mantle depth. Slow subsidence of the rear-arc edge area began at 14.5Ma, perhaps due to cooling of the injected hot mantle and sub-arc lithosphere. In the island arc volcanic stage, alkali contents of erupted lavas increase toward the rear-arc. This suggests that the 1320 ?O'C isotherm was inclined toward the rear-arc, and hence magma segregation depths gradually increased westward. This inclination would result from the cooling of back-arc mantle after back-arc basin opening. The present day mantle wedge has a low velocity zone in the middle of the mantle wedge, and this zone is inclined toward the rear-arc. The coincidence of these features provides evidence for the thermal structure of the arc mantle wedge. The geothermal gradient in the fore-arc and the Backbone Range of the NE Honshu arc appears to have fallen through the late Miocene to the Quaternary (Ban et al., 1992; Yamaji, 1994). The westward retreat of the volcanic front (Ohguchi et al., 1989) is also in accord with the regional cooling which has occurred in the NE Honshu arc since the late Miocene.

V31C-0946 0830h POSTER

Episodes of Middle to Late Jurassic Arc Development in the Klamath Mountains, California and Oregon

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The sequence of tectonostratigraphic terranes in the Klamath Mountains provides a rich history of arc magmatism that spans at least 400 m.y. The Middle to Late Jurassic record can be organized into episodes that consist of arc formation and development, contractional deformation (thrusting), plutonism that lacks significant crustal influence, and younger plutonism (with accompanying extension?) with widespread crustal assimilation and/or anatexis. The first episode began with formation of the Middle Jurassic western Hayfork arc (WH; 179 to 171 Ma). It is characterized by water-rich calc-alkaline andesite, but ranges from basalt to dacite. WH magmatism ended with a regional thrusting event. Following thrusting, within uncertainty of dating, plutons of the Ironside Mountain suite (IM) were emplaced. They show a distinctive decrease in Mg/(Mg+Fe), a paucity of early hydrous phases, and increases in LILE. Neither the WH nor IM rocks show

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evidence for significant crustal contribution. The period 169 to 162 Ma was characterized by regional metamorphism and emplacement of small calc-alkaline plutons. Then from 162 to 159 Ma, large calc-alkaline to calcic plutons were emplaced (Wooley Creek suite). All plutons of this age show isotopic evidence for crustal anatexis and/or assimilation. Scarce 159 Ma garnet-bearing andesitic dikes suggest equilibration at circa 800 MPa, with a crustal thickness of at least 30 km. Wooley Creek magmatism was coeval with outboard growth of the supra-subduction zone Josephine ophiolite (166 to 159 Ma). Extension associated with ophiolite formation may have increased the flux of mafic magma necessary for crustal melting in the Wooley Creek suite. The next episode began with development of the Rogue/Chetco arc along the outboard margin of the Josephine ophiolite (155 to 160 Ma). This arc was generally similar to the WH arc, with water-rich, calc-alkaline magmatism. Collapse and underthrusting of the Josephine ophiolite-Rogue arc assemblage beneath inboard terranes occurred from 155 to 150 Ma; this contractional deformation was the Nevadan orogeny. Thrusting was followed by renewed calcic and calc-alkaline plutonism from 150 to 146 Ma, some of which was similar to the dry, LILE-rich IM suite. These plutons are also similar to the IM in that they show little evidence for interaction with crustal rocks. In contrast, tonalitic to granodioritic plutonism from 145 to 136 Ma requires primarily crustal sources, specifically the underthrust rocks of the Josephine-Rogue assemblage. Each episode began with arc magmatism that ended in contractional deformation. Contraction was followed by localized emplacement of mantle-derived plutons. Later magmatism was partly crustal in origin and, at least in the case of the Wooley Creek suite, associated with extension. This suggests that the time lag between post-arc contraction and emplacement of crustally-derived magmas reflects the time necessary for fresh, mantle-derived magma to heat the lower crust to its solidus.

V31C-0947 0830h POSTER

The western Idaho shear zone: a transpressional self-exhuming, intra-arc shear zone

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The mid-Cretaceous Salmon River suture zone of west-central Idaho marks the boundary between the North American craton and the accreted terranes to the west. The arc-craton boundary in this part of the Cordillera is defined by sharp gradients in the Sr and O isotope ratios, indicating that oceanic lithosphere is juxtaposed directly against continental lithosphere. The granitic units that carry this isotopic gradient span a 10 km wide zone. This is in contrast to other Cordilleran arcs, such as the Sierra Nevada, where the isotopic gradient occurs over a much wider zone (40-50 km). Additionally, this narrow band of arc rocks is characterized by mid-crustal mineral assemblages, suggesting an origin at depths greater than 20 km. To the west, the accreted terranes have volcanics and volcaniclastic sediments that display lower greenschist facies assemblages. Thus the Salmon River suture zone exposes a much deeper level of crust than is observed on the arc side of the boundary. The isotropic gradient, the width of the arc, and the level of exposure in west-central Idaho may reflect a tranpsressional self-exhuming, intra-arc shear zone. The western Idaho shear zone (WISZ) is a dextral transpressional feature that reactivated the Salmon River suture zone in the Late Cretaceous. U-Pb zircon ages from a syn-deformational tonalitic pluton indicate that deformation was active by 92.2 +/- 1.3 Ma. The solid-state fabric of the WISZ is cut by several low-angle, mesoscale shear zones. 40Ar-39Ar ages on recrystallized biotite and hornblende from these shear zones suggests that deformation ceased 80 Ma. Biotite and hornblende thermochronology indicates that these rocks were initially rapidly exhumed between 90 and 80 Ma, however they did not pass thought the apatite fission track closure temperature until much later (44-28 Ma). Thus exhumation was rapid during transpressional deformation and slowed significantly afterwards. We hypothesize that transpression involved a significant contractional component, resulting in shortening across the WISZ and a steepening of the isotropic gradient across the arc-craton transition. This narrowing of the arc was accommodated by vertical extrusion, causing the exhumation of mid-crustal level rocks in the shear zone. Since exhumation was driven by deformation the exposure of rocks from deeper in the crust is centered on the WISZ.

V31C-0948 0830h POSTER

Sr-Pb isotopic studies of primitive and near-primitive basaltic magmas, Garibaldi volcanic belt, northern Cascadia subduction system

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The northern Cascadia subduction system is intimately associated with aseismic subduction of extremely young and presumably hot' oceanic lithosphere beneath northwestern Washington and southwestern British Columbia. Sr and Pb isotopic analyses are presented for primitive and near-primitive (>6.0 wt. % MgO) basalts from a southeast-northwest transect along the Garibaldi volcanic belt (GVB), which overlies subducted oceanic lithosphere that decreases in age from ca. 22 m.y. below Glacier Peak at its southern end to about 13 m.y. beneath the northernmost eruptive centers in the Mosaic (Meager Mountain) and Salal Glacier-Bridge River areas. The basaltic rocks have initial $^{87}Sr/^{86}Sr$ ratios of 0.70317-0.70426, with minimum observed values in individual lava suites decreasing northward. Values of Pb isotopic ratios for GVB basaltic suites range from 18.22 to 18.97 for $^{206}Pb/^{204}Pb$, from 15.51 to 15.59 for $^{207}Pb/^{204}Pb$, and from 37.73 to 38.49 for $^{208}Pb/^{204}Pb$. Sr isotopic compositions, unsupported by lava Rb contents, show positive correlations with Cs/Rb, La/Nb, Ba/La, Ba/Nb, Ba/Ta, B/La, B/Zr, Sr/Nd, and primitive mantle normalized Sr/P; and negative correlations with high field strength elements (HFSE: Nb, and Ta), FeO and other transition metals (Co and Zn), Ce/Pb,Cr/Ni, Sm/Yb, Ta/Yb, Hf/Yb, K/Ba, K/Sr, and La/Yb. Moderate to strong correlations between $^{87}Sr/^{86}Sr$ and ratios involving fluid-mobile and less-fluid-mobile elements are compatible with decreased slab input northward along the volcanic front as the subducted plate becomes hotter. The Pb isotopic compositions exhibit only limited variations when examined against position along the volcanic arc, but show uniform to extremely weak positive correlations of $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ with $^{87}Sr/^{86}Sr$, Ba/La, Sr/Nd, Ba/Nb, Zr/Nb, Mg-Number and SiO2; and similarly weak negative correlation of Ce/Pb with $^{206}Pb/^{204}Pb$ and $^{207}Pb/^{204}Pb$. The isotopic data suggest that GVB basaltic magmas have experienced with little or no involvement of old continental material, but may be consistent with the combined effects of melting of mantle and subordinate anatexis of isotopically juvenile terranes (e.g., Wrangellia). When plotted against corresponding $^{206}Pb/^{204}Pb$, the $^{207}Pb/^{204}Pb$ values of GVB basalts plot above whereas $^{208}Pb/^{204}Pb$ values plot below the Northern Hemisphere Reference Line (Hart, 1984); similar variations apparently characterize plutonic rocks of the underlying Coast Plutonic Complex. The basalt values therefore may reflect either similar extents of crustal input or possibly a long-lived U-enriched, Th-depleted character of mantle sources above the northern Cascadia subduction system.

V31C-0949 0830h POSTER

The Evolution of Silicic Magmatism in the Accreted Talkeetna Arc, South-Central Alaska: Implications for the Growth of Continents

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The accreted Talkeetna arc, south-central Alaska, presents a rare opportunity to study both the intrusive and extrusive record of an intraoceanic arc. The exposed arc section includes residual mantle harzburgites, mafic to ultramafic cumulates, mafic to felsic plutonic rocks, and related volcanic units. The plutonic section of the Talkeetna arc consists of ~20-30%, km-scale, intermediate to felsic plutons. Evolved Talkeetna arc plutons have 57-77 wt% SiO_2 0-1.4 wt% K_2O, and flat to slightly LREE-enriched REE patterns (Ce/Yb = 5-12). Our TIMS and SIMS U/Pb zircon analyses from arc plutonic rocks indicate crystallization ages of 181.3 ± 0.3 Ma, 181.4 ± 0.2 Ma, 184.0 ± 0.3 Ma, 184.9 ± 0.3 Ma, 186.0 ± 0.2 Ma, 186.1 ± 0.2 Ma, 190.4 ± 2.3 Ma, 192.4 ± 2.9 Ma, 193.2 ± 0.2 Ma, 193.8 ± 0.2 Ma, 198.6 ± 0.4 Ma, and 201.4 ± 0.3 Ma. The new ages suggest a relatively short arc lifespan of 20 Myr, similar to many modern arcs. New and existing $^{40}Ar/^{39}Ar$ hornblende ages from the arc range from 181-175 Ma and five new replicated single-grain zircon U-Th/He analyses (T_c ~180°C) yielded cooling ages of 59 ± 5 Ma, 98 ± 8 Ma, 103 ± 8 Ma, 107 ± 9 Ma, and 137 ± 11 Ma. The $^{40}Ar/^{39}Ar$ and He ages suggest that rapid post-magmatic cooling was followed by slow final exhumation through depths of 6-9 km between 137-60 Ma. In combination, the U/Pb zircon data and the geochemical analyses show that silicic plutons were intruded throughout the life of the arc and that there was no change in K_2O content with arc maturity. Several factors thus indicate that intraoceanic arcs have a more felsic bulk composition than commonly considered and may help explain the apparent discrepancy between bulk arc compositions and average continental crust: i) intermediate to felsic plutons comprise a significant fraction of the Talkeetna arc and were intruded throughout its history; ii) these plutons are similar in composition to the Tanzawa complex, Japan, which has been interpreted to be exhumed middle crust from the Izu-Bonin-Mariana arc (Kawate and Arima, 1998); and iii) we calculate P-wave speeds of 6.0-6.3 km/s for the intermediate to felsic Talkeetna arc plutons, similar to mid-crustal P-wave speeds measured in the active Izu-Bonin-Mariana arc (Suyehiro et al., 1996).

V31C-0950 0830h POSTER

Tertiary Magmatism in the Lake Clark Region of Southern Alaska: A Comparison of Coeval(?)Plutonic and Volcanic Rocks Adjacent to the Tlikakila Complex

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The Cretaceous-Tertiary phase of magmatism in the Lake Clark region is related to the subduction of the Kula plate beneath southern Alaska. Rock types in the Lake Clark region include calc-alkaline intermediate to felsic volcanic rocks, and granitic plutons. These rocks are cut by the Tlikakila shear zone complex, which is a linear belt of metamorphosed volcanic and sedimentary rocks with an unknown displacement history. Exhumation of the plutonic rocks may have occurred along this shear zone. Existing geochronology from Lake Clark Tertiary igneous rocks is sparse. A few K/Ar whole rock dates on volcanic rocks range from 74-39 Ma and K/Ar biotite dates range from 63-59 Ma, and plutonic rocks in the same area yield biotite K/Ar dates between 72-56 Ma (Thrupp, 1987; Eakins et. al., 1978). These ages indicate that at least some of the plutonic and volcanic rocks are coeval. Determining the genetic relationships between the volcanic and plutonic rocks and the implications for exhumation of the plutonic rocks along the Tlikakila complex will be investigated using geochemistry and $^{40}Ar/^{39}Ar$ geochronology. Preliminary geochemical data from eight samples analyzed thus far suggest that the volcanic and plutonic rocks are not necessarily comagmatic. The SiO_2 values of plutonic rocks range between 63%-77%. The SiO_2 values of the volcanic rocks range between 58%-69% indicating andesitic to dacitic compositions. Both rock types are calc-alkaline. K_2O in the plutonic rocks range from 2.0%-4.7%. The K_2O values for the volcanic rocks range from 1.8%-3.1%. The Na_2O values for the plutonic rocks range from 3.1%-5.3%. Na_2O values for the volcanic rocks range 3.7%-4.2%. The MgO values for the plutonic rocks range from 0%-2.6%. The MgO values for volcanic rocks range from 1.3%-2.5%. The trace element data indicate relatively low levels of incompatible elements. For the plutonic rocks Zr ranges from 134-222 ppm. The volcanic Zr range is 92-191 ppm. The Nb levels in the plutonic rocks range from 12-17 ppm. The Nb levels in the volcanic rocks range from 3-10 ppm. The Y levels in the plutonic rocks range from 25-70 ppm. The Y levels for the volcanic rocks range from 10-29 ppm. These rocks are enriched in the large ion lithophile group elements. The plutonic levels of Ba range from 888-1036 ppm. The volcanic levels of Ba range from 729-1259 ppm. Further work on geochronology is pending.

V31C-0951 0830h POSTER

Explosive and Effusive Silicic Magmatism in the Macolod Corridor, Luzon Islands, Philippines

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Silicic magmatism occurs in the Macolod Corridor, Luzon Island, Philippines. Luzon Island is an oceanic arc related to the subduction of the South China Sea plate eastward under the Philippine. Several silicic domes and voluminous pyroclastic deposits occur in the Macolod Corridor, which is a pull-apart rift zone that cuts across Central Luzon. The Laguna de Bay caldera occurs on the northern margin of the Corridor and has been the source of several pyroclastic flows that contain abundant silicic pumice fragments. Dating the different types of volcanic deposits reveals similar ages for the domes and some of the ash-flows sheets. Ar/Ar dates of three of the domes, Trapiche, Mt. Bulalo and Mt. Bijang has yielded ages of 43±17 ka, 15±7 ka, and 66±14 ka, respectively. ^{14}C dates of the pyroclastic samples from Laguna de Bay area used in this study are 42-47 ka (unpublished PHIVOLCS report, 1999). The silica concentrations for the high-silica portion for the domes and ignimbrites are also similar, averaging 66 wt.% SiO_2 (normalized anhydrous) for Laguna de Bay, and 68 wt.% for the domes. The chemical compositions of both the domes and Laguna de Bay samples put them outside the field of adakites. Thus, it is unlikely that the silicic magmas represent subducting slab melts. Despite the similar ages, SiO_2 concentrations, and proximity of the domes and caldera, they are chemically distinct with respect to both major and trace element concentrations. The Laguna de Bay samples have higher REE, Th concentrations and lower CaO and Na_2O concentrations than the dome samples. Negative Eu anomalies are present in the Laguna de Bay samples and not in the dome samples. These data are consistent with plagioclase fractionating from the dome magmas producing the Laguna de Bay magmas.

V31C-0952 0830h POSTER

Structural, Geochemical, and Isotopic Studies on Magmatic Dyke Swarms of the South Shetland Islands Volcanic Arc, West Antarctica - Revealing the Geodynamic History

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Between 2000 and 2002 areas of up to 100,000 m^2 have been mapped at several locations of the South Shetland Islands, mainly on King George and Livingston Islands. A structural analysis of the dykes and the host rocks was undertaken, and about 250 dykes were sampled for geochemical studies.
On Livingston Island six different strike directions were identified, yielding a reliable relative time sequence as deduced from field-relationships. Geochemically, these dykes can be separated into five different groups, correlating with the different strike directions, one of those groups comprising two directions. Analysis of the structural data shows, that at least on Livingston Island only minor changes of the tensional situation occurred.
Geochemical data reveal that all dykes of the South Shetland Islands belong to a calc-alkaline, arc-related suite, ranging from primitive basalts to highly differentiated rhyolites.
Interpretation of Sr isotopic data of the dykes proves difficult, as there are indications for sea-water induced Sr-alteration.
Nd isotopic analysis yield better results, revealing a three-stage development from the oldest dykes (ϵNd -0.2 to 0.6) on Livingston Island towards a second, younger group (ϵNd 2.8 to 4.2, also Livingston), terminating with a third one (ϵNd 5.2 to 7.6), which includes the youngest dykes on Livingston and all dykes on King George and also Penguin Island. Either two mantle sources were involved, or the amount of crustal contamination changed considerately with time. It may have been high during initial arc volcanism, because of a still unstretched crust, then decreasing continually with progressing volcanism. In any case, the pattern reflects a chronological sequence corresponding with other authors' hypothesis of a migrating arc volcanism from SW to NE, i.e. from Livingston (older dykes) towards King George Island (younger dykes).
Pb isotopic data, plottet together with MORB- and sediment-samples dredged from the Drake Passage, indicate a three-component mixture of the arc magma. Mixing of MORB- and sediment-sources alone cannot explain the observed pattern. An additional source, maybe the crust underlying the South Shetland block, was involved.

V31C-0953 0830h POSTER

Fast Orogenic to Anorogenic Magmatic Transition in Central Tyrrhenian Basin at Pontine Islands

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The location of the Pontine Archipelago makes it a key area to describe the initial Neogene volcanism in the Tyrrhenian basin. This archipelago is indeed at the connection between the Northern and the Southern Tyrrhenian basin. A new geochronological and geochemical survey of the two northernmost islands of Ponza and Palmarola permits a detailed examination of the complex tectonic and volcanologic evolution of this area. Previous studies suggested that volcanic activity began before 5 Ma on Ponza. Twenty-five new K-Ar ages, obtained by the Cassignol-Gillot technique, constrain the volcanic activity (mainly rhyolites) of Ponza to the last 4.2 Ma, with two episodes of quiescence between 3.7 and 3.2 Ma and between 2.9 to 1.0 Ma. At 1.0 Ma, a trachytic episode ended the volcanic activity in Ponza. A new volcanic episode dated at 3.2-2.9 Ma has been identified on the central and southern portion of the island, with emplacement of pyroclastic units. Palmarola has rhyolitic products with K-Ar ages from 1.6 to 1.5 Ma. Although only 6-8 km apart, the two islands show significantly different geochemical signatures. Trace element ternary diagrams and Y/Nb and Yb/Ta ratios show that Ponza Pliocene rhyolites are representative of magmas emplaced in a syncollisional orogenic context, while Pleistocene products (Palmarola rhyolites and Ponza trachytes) are characteristic of a late- to post-collisional context. The source of these Pleistocene products is chemically close to OIB. The transition between orogenic to anorogenic magmatism in this portion of the archipelago has been estimated to last less than 1.3 Ma. Such a fast transition could be related either to a process of slab breakoff starting during the Pliocene, or to a slab window in the subducted plate. This window could have channeled plume-type magmas from the lower mantle into Italian volcanic provinces. This would explain the progressive magmatic evolution we observe in Pontine Islands, from a calc-alkaline volcanic-arc type to an alkaline within-plate type volcanism

V31C-0954 0830h POSTER

Back-Arc Extension in Continental Lithosphere: Reflections From a Buoyant Mantle and Thin Crust.

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Back-arc extension within the continental lithosphere of New Zealand has produced a zone of thin crust and mantle of unusual geophysical properties. The Central volcanic region (CVR), central North Island, New Zealand is the apparent extension of the Havre Trough back-arc basin, which has opened since 5ma. The area has ∼ 12 times the continental heat flow and numerous geothermal systems and volcanic complexes. Seismic data shot in 2001 as part of the NIGHT (North Island GeopHysical Transect) project show low crust and upper mantle velocities and two unusual reflectors beneath the volcanic area. The first is interpreted as a crust-mantle transition zone or "Moho" reflector that shallows to ∼ 16 km beneath the area of highest extension and volcanic activity. The second is a strong reflection at 35 km depth, which for the CVR is in the mantle. The three defining attributes of this reflector are: it has an apparent lateral extent equivalent to the surface expression of the CVR, it is of low frequency and it is of high amplitude compared to the crust-mantle reflection and Pg arrivals. AVO analysis of the mantle reflection indicates it is likely to be produced by a layer of negative impedance contrast equivalent to at least 80% drop in S-wave velocity. Laboratory studies on naturally organised, realistically orientated melt inclusions indicates such an S-wave drop could be produced by 11 - 15% partial melt. We therefore interpret the reflector to be a body of melt pooled at a viscosity boundary in the mantle. Despite the thin crust of the CVR, the topography of the area defines a broad dome with average elevation ∼ 300m above sea level. The low Pn wave speed measured in the area and the presence of melt in the mantle beneath the region of thinnest crust and highest extension indicates a possible contribution from decompression melting and the support for the thin crust being supplied by a mantle of increased buoyancy.

V31C-0955 0830h POSTER

Constraints on the Mechanism and Timing of Sediment Recycling Beneath the Tonga-Kermadec arc From Be isotopes

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The fate of sediment subducted beneath island arcs and where and how portions of this becomes returned to the surface in arc lavas has profound implications for the thermo-mechanical nature of the mantle wedge and crustal evolution. Here we compare the $^{10}Be/^{9}Be$ isotope ratios in Tonga-Kermadec arc lavas with a $^{10}Be/^{9}Be$ profile from the subducting sediments which confirms previous evidence that the sediment component takes several Myr longer than the subducting plate to reach the magma source region beneath Tonga. We also show that the arc lavas trend towards Th/Be and Li/Be ratios which are much lower than either the bulk sediment or the mantle wedge. This cannot be explained by bulk sediment addition and so requires addition of a sediment partial melt. Experimental data on these sediments constrain this to occur at approximately 775 degrees C between 0.5 and 2 GPa. The data require a hotter thermal structure and a more complex pattern of convection in the mantle wedge than has previously been inferred in models assuming a simple mechanical coupling between the wedge and the subducting plate. This may be linked to evidence for southward flow of the mantle parallel to the trench axis.

V31D MCC: Level 2 Wednesday 0830h

Frontiers in High-Pressure Research Posters I *(joint with GP, MR, DI)*

Presiding: **S R Shieh,** National Cheng Kung University

V31D-0956 0830h POSTER

Electron Channelling Spectroscopy of Iron in Majorite and Silicate Perovskite

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