V52C-05 1440h

Volcanic Activity Evaluation by the Mean of Soil Temperature Continuous Monitoring During the 2002-2003 Eruption at Stromboli Volcano (Eolian Islands, Italy)

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Stromboli volcano is characterised by both strombolian activity and periodic isolated paroxysmal events of mayor intensity, the more recent of which started on December 27th, 2002 and terminated on August, 2003. The eruptive event may be subdivided into two major phases, separated by a big explosion that took place in April 5th, 2003. During the first phase we observed a lack of activity at the top craters, due to the opening of some eruptive fractures at altitudes between 500 and 600 m a.s.l., along the so called “Sciara del fuoco”, on the northern flank of the edifice. The April 5th explosion, from crater #1, occurred under condition of partial obstruction of the vent, caused launching and fall-down of lava fragments and rock blocks of several hundreds of kilograms in an area of about 1 km around the mountain top. After the explosion the eruption evolved towards a progressive renewal of activity at top craters, accompanied with a diminution of the lava flow rates from the fractures, until their complete closure occurred during August, 2003. These different phases were well detected by a network of soil temperature monitoring stations, composed of two multi-parametric (CO_2 fluxes-soil temperature-meteorological parameters) stations, located in the top area (STR02) and at sea level (STR01), with continuous operations from January 2003, and other 3 provisory temperature-only dataloggers, placed at different altitudes between the two previous cited stations, that operated in a time range of 1 to 3 months. In particular, during the first phase we observed several cycles of cooling-warming of the soil at STR02, with frequencies of few days. The April explosion occurred just after a thermal anomaly of 3-4°C, that interrupted the seasonal soil warming, well detected at STR01. The final phase of the eruption was characterized by stable temperatures at STR02 and little well-defined thermal anomalies detected either at STR01 either at the other temperature dataloggers. The acquired thermal data seem to represent a useful tool in volcanic activity monitoring but, on the other hand, they need to be validated also under different seasonal conditions. The major detected anomalies, in fact, did not occurred during the warmest months (June-July), when the strong soil warming, due to high solar irradiance, may mask the volcanic-induced effects.

V52C-06 1455h

The 2002-2003 Mt. Etna Eruption: Insights From Volcanic Tremor Analysis

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The unrest of Mt. Etna in Fall 2002 marked a renewal of effusive activity shortly after the previous eruptive episode, which occurred between July and August 2001. The brief time span between the two eruptions and the similarities in the composition of the volcanic products erupted have led to surmise their strict link, which is supported by several geophysical evidence as well. Seismic swarms and remarkable changes in volcanic tremor at the beginning of both eruptions characterized seismic activity recorded at the permanent seismic network. We analyze the main features of volcanic tremor between the 2002-2003 eruption, providing a characterization of this signal in the time and frequency domains. We discuss the amplitude and frequency variations at several seismic stations, which are located at different distances with respect to the volcanic source. Besides, we propose a comparison with the previous eruptive episode, during which remarkable changes in the amplitude of volcanic tremor accompanied and marked different styles of eruptive activity.

V52C-07 1510h

Analyses of Etna Eruptive Activity From 18th Century and Characterization of Flank Eruptions

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Etna explosive activity has usually been considered subordinate with respect to the effusive eruptions. Nevertheless, in the last decade and overall after the 2001 and 2002 flank eruptions, explosive activity has drawn the attention of the scientific and politic communities owing to the damages that the long-lasting ash fall caused to Sicily’s economy. We analyzed the eruptions from the 18th century to find some analogous behavior of Etna in the past. A study of the Etna historical record (Branca and Del Carlo, 2003) evidenced that after the 1727 eruption, there are no more errors in the attribution of the year of the eruption. Furthermore from this time on, the scientific quality of the chronicles allowed us to obtain volcanological information and to estimate the magnitude of the major explosive events. The main goal of this work was to characterize the different typologies of Etna eruptions in the last three centuries. Meanwhile, we have tried to find the possible relationship between the two kinds of activity (explosive and effusive) in order to understand the complexity of the eruptive phenomena and define the short-term behavior of Etna. On the base of the predominance of the eruptive typology (effusive or explosive) we have classified the flank eruptions in three classes: i) Type 1: almost purely effusive; ii) Type 2: the intensity of explosive activity comparable with the effusive; iii) Type 3: almost purely explosive with minor lava effusion (only the 1763 La Montagnola and 2002 eruptions belong to this class). Long-lasting explosive activity is produced by flank eruptions with continuous ash emission and prolonged fallout on the flanks (e.g. 1763, 1811, 1852-53, 1886, 1892, 2001 and 2002 eruptions). At summit craters continuous activity is weaker, whereas the strongest explosive eruptions are short-lived events. Furthermore, from the 18th to 20th century there were several years of intense and discontinuous summit explosive activity, from high strombolian to fire fountain. This activity produced abundant ash fall in the whole volcano area reaching the Calabria region and Malta Island. Generally, some of these periods preceded important flank eruptions. Concerning the occurrence of the higher magnitude explosive events, we observe that at least one subplinian eruption occurred both in the 18th and 19th centuries. In the 20th century the increased quality of the scientific reports has allowed to recognize 6 subplinian eruptions from summit craters.

V52D MCC: 3008 Friday 1340h

Mantle Geochemistry

Presiding: **K Cooper,** University of Washington**; F Frey,** Massachusetts Institute of Technology

V52D-01 1340h

Nb-U-Th-La Tracers of Basalt Sources Revisited

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Oceanic basalts from mantle upwellings (MORB, OIB) have typically much higher Nb abundances relative to other highly incompatible elements than do island arc and continental rocks, and this serves as one of the chief geochemical discriminants between the two tectonic environments. Hofmann et al. (1986) quantified this and claimed, on the basis of 28 MORB and 41 OIB analyses (from 11 oceanic islands), that Nb/U ratios are surprisingly uniform at 47 $\pm$ 10 (=$\pm$ 21%) in MORB and OIB. They further argued that mantle melting in the MORB-OIB environment does not change Nb/U, so that this ratio also characterizes the mantle source(s) of these rocks, in contrast with a much lower average Nb/U =10 of the continental crust. Finally, they concluded that this rules out recycling of continental crust as an explanation for the trace element enrichment of OIB sources. Subsequently, local correlations between Nb/U and 87Sr/86Sr in EM-type OIBs indicated at least some admixture of recycled continental material to those sources (Chauvel et al., 1992, Hofmann, 1997), so that specific source contributions of OIBs can be identified. Sims & DePaolo (1997) reanalyzed the 1986 database and concluded that the Nb-U relationships (as well as Ce-Pb, not discussed here) are consistent with recycling of continental material to explain the entire isotopic heterogeneity of OIB sources. Seventeen years later, the amount of relevant data has increased dramatically, and their assessment is facilitated by the GEOROC and PetDB databases (http://www.earthchem.org/). Even now, a major difficulty lies in filtering out data of poor quality, due to either alteration or analytical errors. This can be done using criteria of analytical technique and data scatter, but a subjective judgment is unavoidable. I present a survey of about 450 OIB analyses from 20 (non-EM-2 type) hotspots and 170 MORB analyses from the three major oceans. Elements forming a globally uniform concentration ratio should be linearly correlated on a logA-logB plot with a slope of 1.0. Thorium, U, and La in MORBs form tightly linear correlations with Nb, with slopes changing systematically from 1.06 through 0.99 to 0.71, respectively. For OIBs, the respective slopes are 1.11, 1.06, and 0.93. Thus, for both MORBs and (non-EM-2) OIBs, the logNb-logU correlations have slopes closest to unity, with mean values of Nb/U = 47$\pm$24% (MORB) and 52$\pm$25% (OIB). R.S.D. values of Nb concentrations are 100 % (MORB) and 123% (OIB). Although no attempt has so far been made to weight the data, e.g. by location, this evaluation of a greatly expanded dataset provides remarkable confirmation of the original conclusions, with the important modification that most EM-2 (and at least some EM-1) type OIBs have significantly lower Nb/U ratios, which correlate with 87Sr/86Sr ratios, consistent with significant input of recycled sediment or other continental material in their sources. Other OIB sources contain little or no recycled continental source components.

Chauvel, C. et al. (1992) Earth Planet. Sci. Lett. 110, 99-119. Hofmann, A.W. et al. (1986) Earth Planet. Sci. Lett. 79, 33-45. Hofmann, A.W. (1997) Nature 385, 219-229. Sims, K.W.W. & DePaolo, D.J. (1997) Geochim. Cosmochim. Acta 61, 765-784.

V52D-02 1355h

Trace Element Composition of the Depleted Upper Mantle

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The trace element composition of the depleted upper mantle (DMM) is a crucial parameter in modelling the generation of mid-ocean ridge basalts (MORBs), calculating the crust-mantle mass balance, and establishing the chemical and thermal evolution of the stratified Earth. Although MORBs have some degree of heterogeneity in radiogenic isotope ratios (Sr-Nd-Pb-Hf), they are focused within a small range of values relative to ocean island basalts and are, with few exceptions, depleted from bulk earth values in ^{87}Sr/^{86}Sr, ^{143}Nd/^{144}Nd and ^{176}Hf/^{177}Hf. We interpret DMM to be a reservoir residual to variable degrees of melt depletion from a primitive mantle, and offer a method of estimating the trace element composition of a depleted mantle given any degree of depletion at any time. This method is based on the following: (1) Trace element compositions of clinopyroxenes from a global suite of abyssal peridotites with known modal abundances (compiled from the literature), (2) Parent/daughter ratios needed to evolve to today’s average isotopic ratios of DMM based on segregation from bulk silicate Earth (BSE) at 1.8 Ga and (3) Canonical trace element ratios of MORBs. Trace element compositions (Sr, Zr, Ce, Nd, Sm, Eu, Dy, Er and Yb) of cpx grains in abyssal peridotites have been converted into bulk rock compositions using modal abundances and mineral/mineral partition coefficients. We have excluded samples containing more than 1% modal plagioclase. The relationship between the concentrations of two elements, A and B, in the residue of fractional melting can be linearized as follows:

$$\ln(C_s^A) = R\ln(C_s^B) + \ln\left(\frac{C_o^A}{(C_o^B)^R}\right)$$

Where R is a function of the bulk partition coefficients:

$$R = \frac{D_B(1-D_A)}{D_A(1-D_B)}$$

Calculated bulk rock compositions were plotted as ln([A]) vs. ln([B]) and fit with a two-error regression. Most regressions involving two REE intersect the primitive upper mantle (PUM) coordinates of McDonough and Sun (1995) within error of the regression, reinforcing the assumption that the starting composition for DMM was PUM, and suggesting that bulk partition coefficients have been very nearly the same throughout the melt depletion process. Since this regression scheme only provides relationships between elements, the absolute concentration of one or more elements must be determined from an additional constraint. For

this, the time-integrated Sm/Nd ratio is determined for DMM based on its isotopic evolution from BSE. The Sm/Nd ratio has a unique intersection with the Sm-Nd abyssal peridotite regression line, defining unique Sm and Nd concentrations. This intersection sets the absolute Sm and Nd concentrations of DMM equal to 0.27 and 0.64 ppm, respectively. With these absolute concentrations of Sm and Nd, estimates of the absolute concentration of all other measured trace elements are made. The same is done in turn with each of the other elements. With the abyssal peridotite regressions, constraints from radiogenic isotopes, interpolations between the REE, and canonical trace element ratios (i.e. U/Nb, Ce/Pb, Nb/Ta, Ba/Rb), a complete trace element pattern has been calculated for DMM and is shown at http://www.whoi.edu/pclift/whAGU03. This pattern represents ~3% melt depletion with calculated partition coefficients matching those of spinel-field peridotite melting. Depletions relative to PUM are 0.04 (Rb), 0.16 (Th), 0.21 (U), 0.28 (La), 0.28 (Sr), 0.70 (Eu), and 0.85 (Yb).

URL: http://www/whoi.edu/pclift/whAGU03

V52D-03 1410h

Depleted Components Within the Hawaiian Plume

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The rejuvenated-stage (post-erosional) lavas of volcanoes forming Hawaiian islands are alkalic and rich in incompatible elements, but among Hawaiian lavas they have the lowest $^{87}Sr/^{86}Sr$ and highest $^{143}Nd/^{144}Nd$. The submarine North Arch lavas north of Oahu have similar geochemical characteristics. Although MORB-related lithosphere or asthenosphere has been inferred to be an important source component for these lavas, in detail their isotopic systematics deviate from the fields defined by most MORB. Specifically, at a given $^{143}Nd/^{144}Nd$ these Hawaiian lavas are offset to high $^{87}Sr/^{86}Sr$ relative to the field for MORB. They also have high ϵ_{Hf} relative to the $\epsilon_{Hf} - \epsilon_{Nd}$ trend of Hawaiian shield lavas, and they trend to lower $^{206}Pb/^{204}Pb$ (less than 18) than most MORB. Surprisingly, tholeiitic lavas at Detroit Seamount, a 75-81 My volcanic edifice in the Emperor Seamount Chain, also have these isotopic characteristics. Unaltered glasses from Detroit Seamount and rejuvenated-stage lavas also have the distinctive high Ba/Th that distinguishes all Hawaiian lavas from MORB. We suggest that these geochemical similarities are not a coincidence. Although we cannot conclusively dismiss the hypothesis that the depleted component in these lavas originates from MORB-related lithosphere or asthenosphere, we propose the alternative hypothesis that the same depleted plume component has contributed to relatively young rejuvenated-stage alkalic lavas and old tholeiitic basalt from Detroit Seamount. How can this depleted component be expressed in such compositionally different lavas? Detroit Seamount formed on young and thin oceanic crust lithosphere thereby enabling sampling of a depleted plume component by relatively high extents of melting in a long melting column (Regelous et al., 2003). In contrast this depleted component is expressed in rejuvenated-stage lavas because these magmas may form from second-stage melting of a double-melting zone (Ribe and Christensen, 1999).

V52D-04 1425h

The Deep Mantle Subduction Flux and its Implications for Mantle Th/U and Pb/Ce Ratios

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Subduction of oceanic crust and sediment is thought to have profoundly influenced the chemical evolution of the mantle. In particular, it has been argued that crustal recycling through subduction is responsible for the incompatible-element-enriched nature of mantle plumes; the addition of crustal material to the mantle has also been suggested as a solution to the 'kappa conundrum', i.e., the discrepancy between time-integrated mantle Th/U ratios (~3-4, as recorded by radiogenic Pb isotopes) and the present-day mantle Th/U (~2.55). These hypotheses can be tested if the composition of material subducted into the deep mantle is known. However, before oceanic crust and sediment is carried into the deep mantle, its composition is modified through extraction of fluids and/or melts that are incorporated into island arc magmas. We have attempted to account for these processes using a simple mass-balance approach to calculating deep mantle subduction fluxes. Our calculations allow us to estimate residual slab (i.e., slab material carried into the mantle) compositions for trace elements other than Th, U, Pb, and Ce. In general, the residual slabs are enriched relative to primitive mantle in all elements except Ba and Zr. The slabs themselves lose large fractions of their initial budgets of fluid-mobile elements, particularly Pb and Ba, within the subduction zone. On the other hand, less than 10% of the less fluid mobile, moderately incompatible elements, such as the intermediate and heavy rare earths, is lost from the slab in the subduction zone. Our results indicate an important role for slab-derived fluids in subduction zones, and suggest that enriched mantle sources may contain a recycled crustal component. In the six subduction systems we have examined to date (Marianas, Izu-Bonin, Tonga, Kurile, and the Southern and Northern Lesser Antilles), generally high Th/U subducting sediments (2.0-8.9) are combined with low Th/U altered oceanic crust (~0.23), and bulk subducting slabs generally have Th/U ratios similar to modern depleted mantle (~2.6 vs. ~2.55). Furthermore, the similarities between the Th/U ratio of the slab component of island arc volcanics and the depleted mantle indicate that Th and U are not strongly fractionated beneath island arcs. Consequently, the average Th/U ratio of the deep mantle subduction flux (2.57 +/- 0.71) is similar to the Th/U ratio of depleted mantle. If this is true, then incorporation of altered crust into the mantle cannot be solely responsible for the low Th/U ratio of the modern mantle, i.e., it cannot be the solution to the kappa conundrum. The Pb/Ce ratio has been used as a sensitive indicator of recycled material in the mantle because of the large contrast in crust and mantle values (0.30 vs. 0.035). Most oceanic island basalts have Pb/Ce ratios similar to those of MORB (roughly 0.04). This observation is apparently inconsistent with the idea that mantle plumes, which are thought to produce oceanic island basalts, contain recycled crustal material. We find, however, that the processes occurring beneath island arcs strongly fractionate Pb from Ce. In three of the six arcs examined so far, the Pb/Ce ratio in the residual slab lies in the range 0.03-0.05 (i.e., identical to the mantle value), while in the other three it is in the range of 0.1 to 0.26. Thus, low Pb/Ce ratios in oceanic island basalts do not preclude the presence of subducted sediment in their sources. Higher Pb/Ce ratios in some slabs might explain why some oceanic islands (e.g., the Society Islands) do have elevated Pb/Ce ratios.

V52D-05 1440h

He, Sr, Nd, and Pb isotopic variations in basaltic lavas from Marquesas Archipelago, south-central Pacific

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The Marquesas Archipelago is one of the proposed hotspot volcanic chains in French Polynesia. Previous studies have suggested that the volcanic chain is being built by melts from two plume end-components originating from deep thermal boundary layers (EM2 and HIMU), and interacting with the oceanic lithospheric mantle (DMM) and/or crust (e.g., Dupuy et al., ESPSL 82, 1987; Desonie et al., JGR 98, 1993; Caroff et al., Lithos 46, 1999). Effects on plume melts of shallow lithosphere and crustal contamination through melting, magma mixing and wall-rock assimilation coupled with AFC processes are most apparent in intermediate lavas. To minimize the signature of the lithosphere mantle and crust on the purported plume-generated lavas, we analyze only high magnesian (MgO = 7 to 37 wt%) basalts, picrites and a gabbro for Sr, Nd and Pb isotopes. Olivine separates from these samples have been previously analyzed for He isotopes by Scarsi & Scarsi (Nuovo Cimento Della S.I.F. 23, 2000). The basaltic lavas show significant isotopic variations. Although plots of Sr, Nd and Pb isotopic ratios show simple binary relationships, plots of 3He/4He vs. 87Sr/86Sr and 3He/4He vs. 207Pb/204Pb suggest three possible plume end-components. In addition to EM2 and HIMU, which are believed to be recycled crustal materials, there is a trace of a component with high 3He/4He (up to 14.4 R/RA), near bulk-earth 87Sr/86Sr (0.7047) and 143Nd/144Nd (0.51284, e = 3.9) and radiogenic 206Pb/204Pb (19.01). This component points toward the PHEM (FOZO or "C") region in some of the permutations of isotope plots, and thus may provide evidence for the existence of a common, near-primitive mantle source for some hotspot lavas.

V52D-06 1455h

CO2 Well Gas, Noble Gases and the Origin of Volatiles in the Earth's Mantle

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Neon isotopes provide a unique opportunity to distinguish between volatiles introduced into the mantle during the accretion of the Earth by equilibration between a magma ocean with a massive early atmosphere, or as a component trapped within accreting material. A massive early atmosphere would have a Solar Ne isotopic composition (20Ne/22Ne=13.8) while accreting material that has been irradiated by solar wind preserves a distinct composite mix, often called Ne-B (20Ne/22Ne=12.5). To date the highest reliable Ne isotopic values measured in mid ocean ridge basalt (MORB) samples reach a maximum at values of about 12.5. It is not possible to rule out using the MORB sample suite the possibility that ubiquitous air contamination (20Ne/22Ne=9.8) found in this sample type suppresses the maximum Ne value measured. We present noble gas data from 14 CO2 well gases collected from Harding County, New Mexico. With 3He/4He ranging from 0.76 to 3.7Ra (Ra= atmospheric ratio) and correlated 40Ar/36Ar ratios that vary from 4660 to 22600, these samples represent a mixture of crustal and mantle-derived noble gases with only a small groundwater-derived air component. The precision with which we can analyse these gases combined with a systematic and well-mixed crust/groundwater component allows us to resolve crustal, mantle and air components for He, Ne and Ar. The resolved elemental ratios of the mantle He/Ne and He/Ar components are similar to those resolved in volatile rich mid ocean ridge popping rocks. A near constant crust+air end-member component defines a Ne isotope mixing line that intersects with the MORB-air mixing line at 20Ne/22Ne=12.20 plus or minus 0.05. The small difference between the 20Ne/22Ne upper-limit resolved in the well gases compared to that observed in MORB can be accounted for by slightly different mantle He/Ne ratios. While this result provides the first unambiguous evidence for the upper mantle 20Ne/22Ne limit, sources other than Ne-B must also be considered. These include lowering the mantle Ne isotopic composition from Solar by the recycling of air-derived volatiles into the mantle and by enhanced nucleogenic production of 22Ne caused by the co-siting of F with U+Th in the mantle.

V52D-07 1510h

Global similarity in oxygen-isotope composition of MORB

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Primitive lavas from volcanic arcs and ocean islands vary in $\delta^{18}O$. In some instances, these variations can be attributed to the presence of recycled crustal materials in their mantle source. In these cases, oxygen isotope data provide unique constraints on amounts and

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origins of those components. Radiogenic isotope data suggest mid-ocean-ridge basalts (MORBs) also contain variable amounts of recycled crustal materials within their mantle sources, suggesting that oxygen isotope data might be similarly useful in constraining their abundances and origins. We present new high-precision laser-fluorination analyses of fresh MORB glasses for the Australian-Antarctic discordance (AAD; n=11) and the 9-10^{o} N region of the East Pacific Rise (EPR; n=23). When combined with previous measurements in the same lab, we now have a dataset of 130 geographically and geochemically diverse MORBs, representative of much of the global range of physical and chemical properties of mid ocean ridge spreading centers. Within a given geographically (e.g., mid-Atlantic ridge) or compositionally (e.g., NMORB) restricted subset, there are relationships between δ^{18}O and other geochemical properties that can be attributed to the varying influence of recycled crustal materials. However, as a whole, MORB from all different areas spans a restricted range in δ^{18}O (5.2-5.8$^{o}/_{oo}$), and subsets of the data each have a similar range and similar mean composition (of 5.45-5.54 $^{o}/_{oo}$). This low variance in δ^{18}O places upper bounds on the influence of recycled crust in producing the other geochemical distinctions among MORBs. For example, there is no systematic difference in the amount of recycled crust sampled during different degrees of partial melting (e.g., low-degree melting of anomalously cold mantle beneath the AAD compared to other locations), different spreading rates, or within the different ocean basins (Indian vs. Pacific vs. Atlantic). These observations suggest that 1) at the scale sampled by MORB melting, all MORB source regions preserve oxygen-isotope heterogeneity, and 2) this heterogeneity is due to the presence of similar and small (<10%) percentages of recycled crustal material. In particular, the fact that δ^{18}O across the AAD shows no difference between Indian and Pacific MORB suggests that the MORB source in both ocean basins contains a similar average amount of recycled crust, and if the distinction in radiogenic-isotope composition (e.g., Sr, Pb) is due to the presence of pelagic sediment in the Indian mantle, it cannot be present in abundances greater than 1-2%

V52D-08 1525h

High Precision Osmium Isotope Evidence From Chondrites for Late Accretion and Evolution of the Earth's Mantle

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Prevailing models for early differentiation in terrestrial planets call for magma oceans generally concurrent with core formation. Consequently, extraction of a metal-rich core must have resulted in strong depletion of the silicate portion of Earth in highly siderophile elements (HSE), including Re, Os, and Pt. Efficient degassing of a magma ocean could leave the interior of the Earth depleted in volatiles. A result of such processes is that subsequent late accretion may be necessary to replenish both volatiles and HSE to their estimated and measured bulk silicate Earth concentrations. If one type of material was the supplier, then late accretion material should be volatile-rich, and have Os isotope compositions and HSE concentration ratios similar to the Earth's mantle. At present, such type of material is not known. Alternatively, if different types of materials led to volatile and HSE replenishment, then volatile-poor material could supply HSE during late accretion. The Os isotopic compositions of the Earth's mantle can provide a fingerprint for the type of material accreted. Thus, tracing mantle evolution over Earth's history is critical to constraining the Os isotopic composition of the earliest terrestrial mantles, and hence the types of materials present during late accretion. To address the issues surrounding late accretion and terrestrial mantle evolution, volatile-rich carbonaceous, and volatile-poor enstatite and ordinary chondrites, were measured for high-precision Os isotopic compositions. These data combined with those from previously published data for abyssal peridotites, new data for 2.7 Ga Pyke Hill komatiites, show the following. The Earth's primitive upper mantle has evolved with Pt/Os and Re/Os ratios similar to those in enstatite and ordinary chondrites, suggesting that late accretion materials that replenished HSE in terrestrial mantles were volatile-poor. Different materials are therefore required to re-seed the interiors of terrestrial planets with volatiles. These volatile-rich materials must essentially be depleted in HSE.

V52E MCC: 2010 Friday 1340h

The Changing Shapes of Active Volcanoes: Volcano Geodesy II *(joint with G)*

Presiding: **M P Poland,** U.S. Geological Survey**; A V Newman,** Los Alamos National Laboratory

V52E-01 1340h

2002 and 2003 Gravity and GPS observations in Yellowstone's Upper Geyser Basin

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Here we present 10 days of continuous relative gravity and global positioning system [GPS] campaign data from 2002 and 5 days of GPS campaign data from 2003 collected in Yellowstone's Upper Geyser Basin. These data confirm the persistence of the crustal deformation first detected in absolute gravity measurements from 2000 and 2001 and GPS observations from 2001 in the Upper Geyser Basin. The magnitude of the oscillatory microgravity fluctuations is on the order of +/- 4-6 microGals, on the timescales of hours to tens of hours. The crustal deformation inferred from the GPS is on the order several cm of vertical motion and is corroborative of the apparent inflation and deflation interpreted from the gravity measurements. The 2002 continuous gravity data provides a higher resolution of the temporal gravity signal with 1 minute averages versus the 1 hour and 15 minute sets from the 2000 and 2001 absolute gravity data. In the 2002 and 2003 campaigns we tried to test the breadth of the crustal deformation signal with spatially broadly distributed GPS campaign measurements. The 2003 GPS campaign sites span the length and the width of the 3.2 km x 0.8 km Upper Geyser Basin.

V52E-02 1355h

Co-eruptive deformation of Nyiragongo and Nyamulagira volcanoes, Africa, from radar interferometry

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Nyiragongo and Nyamulagira volcanoes are located in the western branch of the East African Rift in the Democratic Republic of Congo. On January 17, 2002, an eruption at Nyiragongo stratovolcano sent lava flows into the city of Goma (population 500,000), 18 km south of the summit. About 13% (4.5 km^2) of the city was destroyed and several dozen people were killed. Although the extrusion of lava on the flanks ended by January 18, intermittent volcanic activity at the summit of Nyiragongo continued through 2002 and 2003. The region experienced a second major eruption of lava on July 25, 2002, from the Nyamulagira shield, 14 km northwest of Nyiragongo. Radar interferometry results derived from RADARSAT-1, ERS-1, and ERS-2 data do not indicate significant deformation in the area between early 1997 and January 14, 2002, except for subsidence of a lava flow that erupted on the north flank of Nyamulagira in 1989-1991. Interferograms spanning January 14 to February 13, 2002, show a broad pattern of fringes across the rift valley in addition to closely spaced fringes in the vicinity of Goma. After February 13, 2002, little deformation is apparent until the July-August 2002 time period, when fringes suggesting uplift characterize the summit of Nyamulagira. From August 2002 until February 2003 no noteworthy deformation is evident, despite the occurrence of several large (M > 5) tectonic earthquakes. We believe that radar interferograms covering the January 2002 eruption of Nyiragongo volcano reveal a broad rifting event accompanied by shallow dike intrusion. The temporal characteristics of the displacement field indicate the event occurred in a relatively brief period of time with little precursory or post-eruptive deformation. Inflation of Nyamulagira volcano in July-August 2002 may be the result of dike intrusion from a shallow reservoir that fed the July 25, 2002, eruption. The results suggest that the eruption of Nyiragongo on January 17, 2002, may have been driven by an episodic rifting event, while the subsequent eruption of Nyamulagira occurred without accompanying tectonism. Since 1997, minor eruptive activity at Nyiragongo, including the reemergence of a lava lake, has not been associated with significant deformation.

V52E-03 1410h

Anelastic Deformation on Montserrat

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GPS measurements at Soufriere Hills volcano on Montserrat show that displacements that occurred since 1995 are irreversible. Displacements measured between June 1996 and June 1997 (Shepherd et al., 1998) are re-interpreted using a three-dimensional Boundary Element Method (3D BEM) for elastic medium. Using a spherical source model, it is shown that the source of the displacements is located at the base of the dome (350 meters below the dome summit in 1997), therefore these displacements could be created by the dome weight. Further models show that the weight of the dome on the crater floor only accounts for 14 percent of the measured displacements. We have then assumed that the dome was fed by a vertical cylindrical conduit so that increase in the dome volume increases pressure in the conduit. We find that this pressure could explain the GPS observations if the conduit radius was 350 meters in diameter. In 1996 and 1997, tiltmeters recorded cyclic deformations of the edifice (Voight et al, 1999). Two tiltmeters operated simultaneously at different distances from the summit allowing determination of the source depth. Assuming these deformations are created by the pressurization of a portion of a cylindrical conduit in an elastic medium and using again a 3D BEM, we show that this source is located at 900 meters depth below the dome summit. Scaling the conduit diameter so that the elastic rock matrix does not fail, the measured tilt amplitudes are explained by a conduit diameter larger than 100 meters. These interpretations of Montserrat deformations lead us to estimate a conduit diameter much larger than the 30 meter-diameter estimated from geological and petrological interpretations (Devine et al., 1998). This paradox can be explained if the conduit size estimated from the deformations corresponds to a "pseudo-pressurized-conduit" made of a central cylindrical conduit where magma is flowing, embedded in a visco-plastic cylindrical medium where stresses are close to hydrostatic so that magma pressures are transmitted to the surrounding elastic rock matrix. This explanation is compatible with the geological and petrological interpretations as these methods provided the conduit diameter required to transport magma to the surface. This anelastic rheology is particularly relevant to studies of the stability of the edifice and further risk assessments.

V52E-04 1425h

Interpretation of Gravity Gradients Produced by Magmatic Intrusions Using Elastic- and Viscoelastic-Gravitational Deformation Models

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A method for the computation and interpretation of time-dependent potential and gravity changes and gravity gradients produced by magmatic intrusions in a layered elastic- and viscoelastic-gravitational medium is presented. The model assumes a plane medium geometry, which consists of welded layers overlying a half-space. Every layer or the bottom half-space can be