Many microstructural observations of minerals in meteorites show evidences of shock effect, but rarely give data about the parent body. However, the microstructures of minerals in achondrites may retain the important information about the parent body which gives a basic idea about the formation of internal structural of the Earth. We carried out microstructural and microfabric analyses of olivine grains in the Divnoe meteorite by optical microscopy, electron probe microanalysis, electron back-scattered diffraction (EBSD) analysis, and transmission electron microscopy (TEM) with the selected area electron diffraction, in order to search the microstructures produced in the parent body. The Divnoe meteorite is a granoblastic, olivine-rich primitive achondrite. Neither black shock veins nor pockets of silicate melt typical of heavily shocked meteorites were found. Most olivine grains exhibit weak undulose extinction. Some grains show mosaic extinction though this is not as pronounced as in heavily shocked meteorites, and lamellar Fe-Mg zoning (2 to 4 mole percent Fa). The weak shock metamorphism experienced by Divnoe is consistent with the shock stage S3. The EBSD analysis of the Divnoe olivine grains reveals a distinct crystallographic preferred orientation (CPO) characterized by a [001] density maximum and girdle distributions of [100] and [010] around the [001] maximum. This type of fabric is not known in crystal-plastically deformed Earths mantle rocks, and can be explained by rigid body rotation of olivines in matrix flow. It suggests that this CPO was formed by rotation of olivine grains in strong melt flows on the meteorite parent bodies, so that their longest [001] axes were aligned parallel to the flow direction. Therefore, Divnoe should preserve an initial CPO of olivine formed during crystallization in the parent body that has not been significantly disturbed by later processes such as thermal and shock metamorphism. Now, the microstructures such as dislocations and inclusions within the single crystal olivines showing the CPO which should retain the important information about the parent body are examining by TEM.

V31E MCC: Level 2 Wednesday 0830h

Arc and Continental Magmatism I Posters

Presiding: **R Conrey,** Washington State University

V31E-0973 0830h POSTER

Geochemical Characteristics of Volcanic Rocks from the Southern Okinawa Trough and its Implications for Tectono-magmatic Evolution

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The Okinawa Trough is a site of ongoing backarc rifting behind the Ryukyu arc-trench system. Recent intensive surveys, including submersible dives, at the southern Okinawa Trough (SOT) have revealed details of bathymetric, geological, and geophysical features. Here, we present the petrological and geochemical characteristics of volcanic rocks collected during these cruises, and discuss its relation to the evolutionary stage of rifting. Based on bathymetirc and magmatic features, SOT can be divided into two (i.e., eastern and western) segments with non-transform offset at $\sim 123.5^{\circ}$ E. The eastern segment represents a well-developed rift system with E-W-trending central graben and separated NE-SW-trending volcanic front; these two features merge at $\sim 125^{\circ}$ E. In contrast, the western segment is in the incipient rifting stage; rift axis exists close to 100 km contour of the Wadati-Benioff zone. The most notable feature is the presence of 'abnormal' volcanic chain (Cross Backarc Volcanic Trail, CBVT), which trends NE-SW and is obviously oblique to the axial trend. All rocks are subalkaline, but range from basalt to rhyolite; dacite-rhyolite are dominant in the eastern volcanic front and CBVT. Basalts from both segments are low-K tholeiites; they have high abundance of LILEs relative to HFSEs, negative Nb anomalies on MORB-normalized diagrams, and range of $^{143}Nd/^{144}Nd$ (0.5128-0.5129) and $^{87}Sr/^{86}Sr$ (0.7034-0.7048). Pb isotope systematics indicate $^{206}Pb/^{204}Pb$=18.398-18.582, $^{207}Pb/^{204}Pb$=15.594-15.652 and $^{208}Pb/^{204}Pb$=38.570-38.912, clearly above the Northern Hemisphere Reference Line. These elemental and isotopic variations are compatible with derivation from Indian Ocean MORB-like mantle with strong overprint of subduction components from the slab. There is clear difference among more felsic rocks between two segments. At similar silica contents, most of felsic rocks from the western segment, including CBVT rhyolites, have higher LILE contents, $^{87}Sr/^{86}Sr$ and $^{208}Pb/^{204}Pb$ and lower $^{143}Nd/^{144}Nd$; these feature can be explained by significant crustal contamination of mantle-derived magmas. On the other hand, the eastern segment felsic rocks have a similar range of Sr-Nd-Pb isotopes for basalts. We suggest that the marked spatial differences in geochemical characteristics of felsic rocks reflects different stage of the backarc rifting. Geophysical surveys provided evidence that crustal thickness is relatively thin ($\sim$ 20km) under the eastern segment, whereas thick continental crust ($\sim$ 25-30km) without significant thinning have been proposed in the western segment. Sibuet et al. (1998) proposed the linkage of subducted Gagua Ridge for CBVT rhyolites, because of a sharp change in subduction angle (slab tear?) near 123° E. The CBVT rhyolites are, however, not adakitic. Instead, we suggest mantle flow originated from the magmatism at the Northern Taiwan Volcanic Zone, which commenced since $\sim$ 3 Ma and was resulted from post-collisional extensional collapse, have important implications for required heat source and comparatively depleted mantle source inferred from mafic inclusion in CBVT rhyolites.

V31E-0974 0830h POSTER

Continued Magmatic Unrest: Geochemical Evolution of Recent Eruptions from Mt. Cleveland, Aleutian arc, AK

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Mt. Cleveland, a previously unstudied composite volcano (1730 m) in the central Aleutians, last erupted in 1994 and 2001. Mt. Cleveland occupies an unusual tectonic setting, near the transition from sub-arc continental crust to oceanic crust further west. It and the other Islands of Four Mountains are closer to the forearc trench than any other Aleutian volcanoes, and the close configuration of five Quaternary volcanoes is unusual and not understood. To constrain the magmatic evolution and hazard potential of Cleveland and to better understand this unstudied region of the arc, we present new mapping and geochemical results related to field seasons in 2001-2003. The edifice is mainly constructed of lava flows, lahars and isolated domes. Collapse of the summit sometime between September 2002 and August 2003 indicates active magma withdrawal, perhaps temporary, at the agitated volcano. Lava and tephra from both recent eruptions are basaltic andesite (56.7-58.3 wt. % SiO_2; 3.9-4.3 wt. % MgO), and these more mafic compositions compared to most, older Cleveland lavas (58-70.7 % SiO_2, 1.8-3.7 wt. % MgO, n=20 samples) substantiates that influx of new magma preceded the recent eruptions. Disequilibrium mineral textures and zoned plagioclase compositions (An_{90-58}) confirm that open system processes, including recharge and mixing, have been a dominant characteristic of the magmatic system. Correlation between major elements and trace elements (e.g., Sr, Cr) indicate that some lavas were influenced by fractionation of olivine and plagioclase. Mantle-normalized REE concentrations are not strongly light-element enriched (La_N/Lu_N=1.9-2.3), and the relatively flat, similar patterns corroborate limited olivine and plagioclase fractionation (Eu_N/Eu_N*= 0.8-1.0). New Sr, Nd, Pb and Hf isotopic analyses will demonstrate the extent of source variability and allow comparison to the regionally radiogenic Sr and Pb isotopic compositions found at Yunaska and Seguam Islands $\sim$300 km to the west.

V31E-0975 0830h POSTER

Magmatic Evolution of the Skye Igneous Center, Western Scotland

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Geochemically complex igneous suites are the result of interplay between deep and crustal-level processes. Quantitatively modeling the contribution that crustal-level processes such as magma recharge, crustal assimilation, and fractional crystallization have is critical for developing realistic models of how magma transport/storage systems evolve. The Energy-Constrained Recharge, Assimilation, and Fractional Crystallization simulator (EC-RAFC, Spera & Bohrson, 2001, 2002; Bohrson & Spera, 2001, 2003) provides a means to model thermal, compositional, and magma volume data for complex magmatic systems. The Skye igneous center, western Scotland, spanning the period 60.53 $\pm$ 0.08 Ma - 53.5 $\pm$ 0.8 Ma and characterized by a well-documented suite of lavas and intrusive rocks of picritic to granitic composition, is the first natural data set to which the EC-RAFC model has been applied in detail. Based on analysis of published field, stratigraphic, petrographic, and chemical data, we propose that the Skye Tertiary magmatic sequence be divided into four petrogenetically related lineages. EC-RAFC results indicate that each lineage is characterized by a unique parental magma that has undergone distinct episodes of RAFC. Model results, constrained by published data on the nature of the crust beneath Skye, indicate that the character of the assimilant changes upsection, suggesting that the associated magma reservoirs migrated to shallower levels as the magmatic system matured. The magmatic products of each group also record the fingerprint of multiple episodes of magma recharge, where the character of the recharge magma also evolves with time. The image of the magma transport system that emerges is one in which magma is initially intruded at lower crustal levels and undergoes a distinct RAFC episode. Residual magma from this event then migrates to shallower levels, where mid-crustal wallrock is assimilated; recharge magma is characterized by increasingly crustal chemical and thermal signatures. For some of the stratigraphically youngest rocks, results also suggest that magma reservoirs ascended into and interacted with upper crustal sediments. While the quantitative details provided by the Skye simulations support the hypothesis that the Skye igneous center can be characterized by a relatively small number of compositionally similar parental magmas to which complex RAFC processes occur, they also allow detailed predictions to be made about the geochemical, thermal and magma volume characteristics of the magmatic system. Further study that builds on these predictions at locations such as Skye promise to enhance our understanding of the evolution of complex magmatic systems on Earth.

URL: http://magma.geol.ucsb.edu/

V31E-0976 0830h POSTER

Olivines in the Egersund Dikes (SW Norway): Evidence for the Evolutionary History of Neoproterozoic Tholeiitic Magmas.

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The Neoproterozoic Egersund dikes in Sw Norway intruded at 650-600 Ma, and the majority formed by intrusion of olivine tholeiites and tholeiites that are geochemically similar to modern OIB. The olivine tholeiites are remarkably well preserved, with glassy chilled margins that contain olivine and plagioclase. Olivines show a range of textural and compositional characteristics that potentially provide information about the evolutionary history of the magmas. Olivine microphenocrysts in the chilled margins are euhedral, and sometimes skeletal indicating rapid cooling. Their compositions (Fo_{80-82}) are appropriate for equilibrium with the host melt at oxygen fugacities 0-1 log unit below QFM. Resorbed macrocrysts are more magnesian

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($Fo_{0.82-0.84}$) than the microphenocrysts and are similar in composition to olivines in the centers of the dikes. The latter include skeletal crystals (mostly less than 1mm), strained crystals, and crystals intergrown with plagioclase. Skeletal crystals with compositions of about Fo_{84} could have been in equilibrium with magmas corresponding in composition to the nearly aphyric centers of some dikes at 0-1 log unit below FMQ. These crystals are interpreted as high-pressure phenocrysts that formed in magma chambers near the base of the crust (about 30km). The centers and chilled margins of the dikes have compositions consistent with evolution along the Ol-Cpx-Plag cotectic at 0.8-1 Gpa. The compositions of larger, strained olivines (up to 3mm) and olivines intergrown with plagioclase are interpreted to be xenocrysts derived from the wall rocks through which the magma ascended. This interpretation is supported by the presence of reverse-zoned olivines with relatively Fe-rich ($Fo_{0.76}$) cores that are strained or are intergrown with plagioclase. The overall compositional similarity between the majority of the xenocrystal olivines and the skeletal olivines (high-pressure phenocrysts) suggests that the former might have formed by crystallization of earlier batches of olivine tholeiite magma. It is clear that olivines in the Neoproterozoic Egersund dikes provide evidence for a complex evolutionary history similar to that proposed for recent Kilauean olivine tholeiites.

V31E-0977 0830h POSTER

The 780 Gunbarrel Magmatic Event: U-Pb Documentation of Widespread Mafic Magmatism Along the Neoproterozoic Western of Laurentia

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Precise U-Pb baddeleyite dating of mafic igneous rocks provide evidence for a widespread and synchronous magmatic event that extended for >2400 km along the western margin of the Neoproterozoic Laurentian craton. The gabbros dated in this study include three mafic sheets that intrude crystalline basement rocks of the Northwest Territories (the Gunbarrel, Calder and Faber Lake gabbros), a mafic sill exposed in the Mackenzie Mountains (Concajou Canyon sill), a mafic dike in the Muskwa Ranges of British Columbia (Muncho Lake diabase), and three northwest-trending mafic dikes in the Tobacco Root (group B dikes) and Beartooth Mountains (Christmas Lake dike) of Montana and Wyoming. U-Pb baddeleyite analyses for eight intrusions from seven localities yield $^{207}Pb/^{206}Pb$ ages that range from 775 to 782 Ma, with most analyses less than 2% discordant. The $^{207}Pb/^{206}Pb$ dates from the eight mafic dikes and sheets are statistically indistinguishable and we have combined sixteen individual baddeleyite analyses to yield a composite U-Pb Concordia age of 780.3 $\pm$ 1.4 Ma (95% confidence level). We term this 780 Ma event the Gunbarrel magmatic event based on exposures of the Gunbarrel gabbro found along Gunbarrel Inlet, Great Bear Lake, Northwest Territories. Other mafic rocks that may be part of the gunbarrel event include some of the voluminous mafic sills that intrude the Belt/Purcell Supergroups in the U.S. and Canada and the northwest-trending dike at Mount Moran in the Teton Mountains of Wyoming. Overall, this is the geographically largest mafic event yet identified along the Neoprotoerozoic western margin of Laurentia. The origin of the mafic magmatism of the Gunbarrel event is not clear, but it may be related to mantle plume activity or the upwelling of asthenosphere leading to crustal extension accompanying initial breakup of the supercontinent Rodinia and development of the proto-Pacific Ocean. The mafic magmatism of the Gunbarrel magmatic event at 780 Ma predates the voluminous magmatism of the 723 Ma Franklin igneous event of the northwestern Canadian Shield by about 60 m.y. The precise dating of the extensive Neoproterozoic Gunbarrel and Franklin magmatic events, combined with paleomagnetic data, provide unique time-markers and piercing points that can ultimately be used for robust testing of Neoproterozoic continental reconstructions.

V31E-0978 0830h POSTER

Petrologic characteristic and Geological Model of Igneous Reservoir: An example in Zhanhua Seg, Eastern China

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The diabase is a typical igneous rock, which intrude the oil-bearing mudstone and form potential reservoir. As an example of Luo151 igneous rock in Zhanhua Seg, Eastern China, we studied the diabase reservoir in detail, including petrologic analysis, reservoir anisotropy and geological modeling. Four lithofacies zones are divided according to analyzing petrology, texture and structure, which comprise carbonaceous slate, hornfels containing cordierite and grammite, border subfacies and central subfacies, and the petrologic types include carbonaceous slate, hornfels, and diabases. The diabase construction is divided into grammite hornfels micropore and diabase porous-fracture type reservoirs. The mudstone layers in Third Member of Shahejie Formation (Es3) provide favorable hydrocarbon source rock and cap formation, diabase and hornfels belts serve as reservoirs, faults and microcracks in the wall rocks as the pathways for oil and gas migration. The invasive time was about in the later deposition period of Dongying Formation and the middle of that of Guantao Formation, the oil generated from oil source rock of Es3 in the period of the Minghuazhen formation and is earlier more than the period of diabase oil trap and porous space forming.

V31E-0979 0830h POSTER

Basaltic Volcanism of the Bruneau-Jarbidge Eruptive Center and its Surroundings, Southwest Idaho: Chemical Evidence for Multiple Mantle Sources.

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The Bruneau-Jarbidge eruptive center is a large (95x55 km) structural basin at the southwest end of the eastern Snake River Plain, formed by the coalescence of several large, nested rhyolite calderas in response to passage of the Yellowstone hot spot circa 12.5 Ma. Within the eruptive center, basaltic lavas generally postdate the youngest rhyolites, which formed 8 Ma. NW-trending faults with small displacements that parallel the western Snake River Plain are common. Twenty-four volcanic vents are found within the eruptive center, along with numerous vents that lie outside the structural basin. Most vents are small shield volcanoes (<= 5 km across) which rise a few hundred feet above the basin floor. Vents within the eruptive center are located along three distinct northwest trends; vents outside the eruptive center are more scattered but define at least one trend parallel to those inside the center. Sixty-eight samples were analyzed using XRF, microprobe, and ICP-MS. Basalts consist of plagioclase and olivine phenocrysts set in a groundmass of plagioclase, clinopyroxene, opaques, and glass. Basalts from within the Bruneau-Jarbidge eruptive center have Mg# (100* Mg/[Mg+Fe] ranging from 38.5 to 61.3, with TiO2 = 1.2 to 2.4 wt%; FeO = 10.1 to 14.0 wt%, and P2O5 = .06 to .42 wt%. Trace element abundance's are: Nb = 6-16 ppm, Sr = 153-356 ppm, Zr = 67-261 ppm, LaN (chondrite normalized) = 22-65, and (La/Lu)N = 2 to 3.5. Basalts from outside the eruptive center have Mg# = 38-42, TiO2 = 3.2-4.2 wt.%, FeO = 13.9-16.7 wt.%, P2O5 = 0.14-0.88 wt.%, Nb = 25-38 ppm, Sr = 267-373 ppm, Zr = 302-396 ppm, LaN = 125, and (La/Lu)N = 6.7x chondrite. These data show that the basalt samples from outside of the eruptive center are distinct from those erupted within the eruptive center; the differences in REE slopes indicate that these samples have distinct source regions and are not related by low pressure or high pressure fractionation. Overall, the range in compositions for basalts within the eruptive center samples are consistent with basalts of the eastern Snake River Plain. Basalts which erupted outside the BJ eruptive center are higher in Ti, Fe, and have much higher (La/Lu)N ratios, similar to basalts from the Western Snake River Plain. These sample may represent the southern extend of the WSRP as it migrates towards the southeast. The high TiO2-FeO may indicate a deeper source region than the eruptive center basalts, consistent with the high La/Lu ratios, which indicates residual garnet in the source.

V31E-0980 0830h POSTER

Chemical Stratigraphy of the Weiser Embayment Columbia River Basalt

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We present a detailed examination of the surficially exposed flows of the Imnaha and Grande Ronde subunits of the Columbia River Basalt (CRB) in the vicinity of McCall, Idaho. These samples represent the northern margin of CRB outcropping in the Weiser Embayment, and belong among the easternmost of CRB extrusions. Major and trace element data are presented along with petrographic analysis with comparison to the Imnaha and Grande Ronde Basalt type sections. Exposed Imnaha Basalt flows in the region appear to be mostly restricted to later erupted members of the American Bar chemical type with isolated flows of the Rock Creek type. The Grande Ronde Basalt of the region is relatively thin, and is predominantly composed of the N1 magnetostratigraphic unit. This study includes over 100 new whole rock major and trace element analyses by XRF and ICP-MS. Preliminary results suggest that a flow-by-flow chemical correlation is possible with the Imnaha and Grande Ronde type sections. Samples of the American Bar chemical type appear to be moderately more primitive than equivalent flows in the vicinity of the Imnaha River. This may warrant further investigation into the overall composition of the Imnaha Basalt.

V31E-0981 0830h POSTER

The Boring Volcanic Field of the Portland Basin: Diverse Primitive Mafic Magmas Erupted in a Frontal Arc Setting

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The Boring Volcanic Field is a 0.05 - 3.0 Ma field of mafic lavas associated with the tectonically complex Portland Basin. The volcanism may be associated with the along-arc propagation of mafic magmatism and intra-arc rifting in the Cascade Range of northern Oregon from the south. The Boring lavas are intriguing because they represent eruption of hot mantle-derived magmas in the frontal arc where the subducting slab may be as shallow as 80 km. These lavas thus provide important constraints on the thermal structure of the sub-Cascade mantle wedge. Several diverse types of mafic lava have been recognized: 1) low-K tholeiite (LKT), similar to mid-ocean ridge basalt, and invariably the oldest of the Boring lavas - most of them probably erupted from vents in the Cascade Range and entered the Portland Basin via ancestral Columbia and Clackamas River paleodrainages, but some were locally erupted; 2) rare within-plate-like basalt (WIP) similar to ocean island basalt, including one erupted on the western (trench-most) margin of the field; 3) a spectrum of calc-alkaline to high-K calc-alkaline to absarokitic basalts (CAB, HKCA, ABS), typical of arc-like High Cascade basalts; and 4) primitive basaltic andesites (BA) with SiO2 in the range of 53-54 wt%. The BA, WIP, and CAB-ABS spectrum lavas erupted from many scattered small centers following the major pulse of LKT volcanism. Several shield volcanoes of more evolved basaltic andesites and minor andesites were also constructed on top of the LKT bench-forming lavas. Inverse T and P calculations were performed

for suitably primitive (> 8% MgO) lavas of all types. These calculations add olivine until a composition in equilibrium with olivine of Fo90 or 91 is reached, and then use paramaterized fits to experimental data to estimate the T and P of melt generation. Results suggest, perhaps counterintuitively, that BA and the CAB-ABS spectrum were generated at the shallowest mantle depths (30-50 km) from a refractory source that likely was metasomatised by earlier subduction. LKT and WIP magmas were generated at deeper, hotter levels (60-80 km) in less refractory (but still depleted) mantle. Speculatively, the hotter MORB and WIP source mantle advected northward along the arc during intraarc rifting and reached the Portland Basin region about 3 Ma. Warming due to its encroachment resulted in remelting of arc-metasomatized lithosphere. The enigmatic location of these lavas and the results of the inversion calculations have implications for both the thermal structure of the wedge and the genesis of arc volcanism in hot subduction zones such as the Cascades.

V31E-0982 0830h POSTER

Mantle Xenoliths of Cerro Mercedes, Costa Rica, Central America

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Mantle peridotite occurs as xenoliths in lavas and bombs at Cerro Mercedes, a Plio-Quaternary potassic alkaline basalt volcano approximately 70 km behind the volcanic front of northern Costa Rica (Tournon and Alvarado, 1997). Mineral exploration led to the first discovery of abundant mantle xenoliths in Central America (Vargas and Alfaro, 1992). The compositions of 71 xenoliths recovered in January 2003 include dunite, harzburgite, lherzolite and olivine websterite. Twenty xenoliths have a diameter of at least 3 cm. The nodules are abundant in basalt outcrops and the rare bombs. In spite of substantial soil development in a rain forest environment, both xenoliths and host lava remain well preserved. Olivine, pyroxenes and spinel are common, plagioclase is present and garnet appears to be absent. There is no obvious shearing or deformation and several pyroxenes are as much as 1 cm in diameter. The mineralogy suggests a relatively shallow upper mantle source, within either the lithosphere or possibly the uppermost asthenosphere. Cerro Mercedes, at latitude 10° 58' N and longitude 82° 21' W, lies along the Rio San Juan, which is locally the border between Nicaragua and Costa Rica, Central America. This location approximately coincides with a boundary between dominantly depleted mantle to the northwest and OIB or Galapagos-like mantle to the southeast. We will use mineralogical data to better define the likely depths and oxidation states of representative nodules and isotopic data to define the type of mantle source.

V31E-0983 0830h POSTER

Petrographic and geochemical constraints on mantle xenoliths from northern Patagonia, Argentina

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Mantle xenoliths brought to the Earth's surface by alkaline basic magmatism in the back-arc setting of the northern Patagonian Andes, Argentina, provide insights on processes like mantle depletion and metasomatism near subduction zones. Petrographic and geochemical features of two sets of xenoliths collected in distinct Miocene-Pleistocene volcanic events are here presented. Cerro El Mojon xenoliths (41° 06'S;70° 13'W) are mainly depleted (Mg#84-85), anhydrous, spinel-bearing lherzolites to harzburgites with some websterites and olivine websterites. They are unveined and have protogranular textures. Some samples have clinopyroxene-rich bands and fertile characteristics. Estancia Alvarez xenoliths (40° 46'S;68deg46'W) are all veined (metasomatized?), anhydrous, spinel-bearing lherzolites with porphyroclastic to protogranular textures. We recognized depleted (Mg#85) and fertile (Mg#73-79) xenoliths. Kink bands and wave extinction in olivine and pyroxenes, and Ca exsolution and symplectic texture of spinel in orthopyroxene were observed. The REE and multi-element spidergrams are similar to both sets of xenoliths. They have relative flat REE pattern (close to the chondritic values) with slightly enrichment in LREE. On the multi-element spidergrams, both show values similar to the chondrites without negative Ti-Nb-Ta anomalies, which could be an evidence of absence of subducted-slab derived sources. Mg# = [100MgO/(MgO+FeOt)]

V31E-0984 0830h POSTER

Petrology Of Peridotitic Xenoliths From The Orapa Kimberlites, Botswana

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Xenoliths in kimberlites provide a wide window into the underlying crust and upper mantle and, with the assist of detailed petrological and geochemical study, can help us understand the characteristics of the deeper mantle. The diamondiferous Orapa kimberlites intruded into a mobile belt between Kaapvaal and Zimbabwe craton about 90Ma in the period of upper Cretaceous. The apparent tectonic setting is different from other diamondiferous kimberlites because most diamondiferous kimberlites intruded into Archean Cratons. To investigate the deep mantle beneath the mobile belt between Kaapvaal and Zimbabwe cratons, we have studied xenoliths, especially those of peridotitic, from Orapa kimberlites. The total number of the samples from Orapa kimberlites reaches 2200. In these samples, mantle-derived xenoliths include peridotites, pyroxenites, eclogites and some megacrysts of garnet or pyroxene or ilmenite. The proportion of peridotites is approximately 60%. Previous studies of the xenoliths from Orapa kimberlites were limited to the eclogitic ones because of the lack of peridotitic xenoliths. In this study, we focus on the petrology of new collection of peridotitic xenoliths. Most of the peridotites are represented by garnet lherzolites and garnet harzburgites as well as spinel lherzolites and spinel harzburgites. In the triangle of the axes of olivine, orthopyroxene and clinopyroxene, most of the modes of peridotitic xenoliths are plotted in harzbugitic area. Almost all are coarse-grained, but some show intensely deformed texture. In some cases, signatures of metasomatic reactions are existed and contain phlogopite, amphibole, rutile, ilmenite and diopside. These metasomatized peridotitic xenoliths form a metasomatic sequence from garnet peridotite (GP), garnet phlogopite peridotite (GPP) to phlogopite peridotite (PP). The Fo-value of peridotites, especially of lherzolites and harzburgites, ranges from 90% to 94%. Orthopyroxenes and clinopyroxenes are enstatitic, ranging from En90 to En95, and diopsidic, from 38wt% to 52wt% in Wo-value, respectively. On the other hand, garnets consist of both G9 and G10 and rang between 66% and 78%in pyrope component. Calculated temperature-depth relations estimated by tow pyroxene geothermometer and orthopyroxene-garnet geobarometer shows a well-developed correlation between the textures and the P-T conditions. Namely, the peridotites with deformed texture have higher temperature-depth signature than the case with coarse texture. This correlation is comparable to the data of the peridotitic xenoliths from other kimberlites in Kaapvaal craton. The highest P-T condition is around 1300 degC and 60kbars, estimated from a peridotitic xenolith with deformed texture. The compositional characters and P-T conditions indicate the presence of thick lithospheric mantle beneath Orapa. The unique tectonic setting at Orapa kimberlites is probably only at the superficial one. Depending on the new data, we constructed one of schematic cross-sections of the mantle beneath Orapa, on the basis of rock types and P-T relations at several depths.

V31E-0985 0830h POSTER

Chromite Macrocrysts from Kimberlites and Lamproites as Petrogenetic Indicators: Evidence from Mineral Inclusions

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Chromite megacrysts are the source of significant data relating to the petrogenesis of kimberlites. More than 10,000 chromite macrocrysts (0.25-1 mm) were randomly selected from heavy-mineral concentrates collected at several Yakutian and Arkhangelsk diamondiferous kimberlites, in addition to several in So. Africa, USA, Venezuela, and Australian lamproites. All chromites were systematically crushed; 350 unaltered mineral inclusions were extracted. Approximately 50 % of the inclusions are represented by Mg-olivines (Fo 86-94), following by Cr-pyropes (17 %), Cr-diopsides (16 %), enstatites (6 %), and phlogopites (2 %). Mg-calcite inclusions were discovered in 23 of the chromite grains from the XXIII Party Congress pipe (Yakutia), as well as associated with almost half of all the enstatites in chromites from the Newlands pipe (RSA). The inclusion-bearing chromites represent practically the entire range of compositions of heavy-mineral concentrates of chromites. Olivines and pyroxenes are also characterized by wide compositional ranges, albeit similar to olivines and pyroxenes from granular peridotite xenoliths and xenocrysts. Pyropic garnets possess a wide range in Cr2O3 (2.0-12.1 wt%) and CaO (1.2-15.6 wt%), and along with chromite megacrysts, they are representative of all known peridotitic parageneses: harzburgitic, lherzolitic, and wehrlitic (e.g., Sobolev et al., 1973, CMP 40). These belong to either the graphite or diamond stability fields, estimated using various geobarometers. Of special significance in this study is the discovery of abundant Mg-calcite inclusions, some of which are associated with pyrope in Yakutian kimberlites. This is interpreted to be a signature of involvement of a carbonatitic component in the genesis of the chromite-silicate association. There is increasing evidence worldwide for the involvement of carbonatitic fluid/melt with the formation of diamonds. The present study has discovered additional evidence for carbonatitic components having interacted with the mineralogy of the diamond host rocks in the mantle.

V31E-0986 0830h POSTER

Origin and evolution of the potassic magmatism in the Campanian region (South Italy) as inferred from new geochemical and isotopic data for Mt. Vesuvius and Phlegrean Volcanic District.

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In the Campanian region (South Italy) potassic magmas are erupted through a thinned continental lithosphere. Magma generation is related to NW subduction of the Ionian plate, and rising is a consequence of extension of the Tyrrhenian Basin. Magmas are variably enriched in K and related trace elements. New geochemical and isotopic investigations have been carried out on potassic volcanic rocks representative of the magmatic activity of the Phlegraean Volcanic District, which includes the Campi Flegrei caldera and the islands of Procida and Ischia, and Mt. Vesuvius. The results of these investigations allowed us to define at least three distinct components in the petrogenesis of the magmas erupted in the Campanian region. Two components, located in the mantle, include a T-MORB type mantle source and a slab-derived component, likely representing fluids and partial melts of sed-

iments of the subducting Ionian plate. The third component is represented by continental material (crust-derived fluids or partial melts) which are incorporated into mantle-derived magmas. This last component is acquired in the crust, probably at 8-10 km of depth where seismic tomography and other geophysical studies, as well as pressure estimates resulting from melt inclusion analyses, identify an horizontally extended low-velocity layer. This layer is interpreted as the top of the present magma reservoirs in the areas beneath Mt. Vesuvius and the Phlegraean Volcanic District. We have detected an eastward spatial variation in the isotopic characteristics of the volcanic rocks, from Procida and Ischia islands to the Campi Flegrei caldera and Mt. Vesuvius. This variation can be interpreted as the result of variable contribution of the slab-derived component to the mantle source, due to the variable position of the volcanoes with respect to the Ionian plate, presently sinking beneath the Southern Tyrrhenian sea. We speculate that within the crust there are multiple sill-like bodies where magmas stop, permeate and interact with the crust. This structure would consist of rocks permeated by various portions of melt, in such a way to individuate different reservoirs at different depths. The existence of different depths of cristallization (10-22 km) and the occurrence of discrete isotope values in the volcanic rocks strongly suggest that different magma batches, starting from the mantle source, stop at various depths during their ascent towards the surface. Such a condition would determine a large surface of contact between magma and whole rock which could favour contamination.

V31E-0987 0830h POSTER

Volcanic rocks from Somma-Vesuvius (Italy): Evidence from an extensive geochemical and Sr-isotopic database, diverse magma sources, and crustal contamination.

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An extensive database of rock compositions from Somma-Vesuvius now exists that spans the volcanic products from 25 ka to 1944 AD. The database was produced by the University of Napoli (Italy) Federico II and the US Geological Survey (in press as an Open File report) and includes newly acquired major-, trace-element and Sr isotopic analyses as well as a compilation of data produced over the last decade. New data were obtained mostly on pyroclasts and lava flows from the Older (25 to 17 ka), Protohistoric (3.5 to 2.8 kaP), Ancient (79 to 472 AD) and Medieval (472 to 1631 AD) interplinian events, and from Somma caldera lava (> 25 ka) and selected plinian products (e.g. Ottaviano, 8 ka; Seggiari, 14 ka). The rocks are potassic to ultrapotassic, increasingly enriched in K (and Na-La-Nb) with decreasing age of the eruptions. Three main compositional trends are distinguished: 1) potassic rocks older than 8 ka; 2) Avellino, Pompei, Protohistoric and Ancient ultrapotassic products; 3) ultrapotassic rocks with age equal or younger than the 472 AD eruption. All rocks have low Mg numbers (< 40), low Ni and Cr contents (< 80 and 300 ppm), and a span for $^{87}Sr/^{86}Sr$ from ~ 0.70628 to 0.70807. Major- and trace-element and Sr-isotopic variations of the ultrapotassic rocks reflect a complex interplay of contributions from mantle sources, and particularly from the enhanced effects of crustal contamination. Crystal fractionation and phenocryst entrapment as the magmas ascended and were stored in the crust are key processes accounting for the geochemical variations. In particular, phenocryst entrapment was a widespread mechanism that amplified the effects of crustal contamination, as crystal mush generated (and contaminated) during previous magma storage in the crust can be ingested by new rising magmas thus decreasing the mass of wall rock necessary to vary the Sr-isotope composition of magmas. Compositional, volcanological and geochronological data show that a critical transition links an older volcanic phase (characterized by the eruption of low porphyritic and moderate K-rich magmas) to a younger phase (characterized by the eruption of highly crystalline and high K-rich magma) and culminated during the Pollena eruption. The Pollena eruption reflects the progressive exhaustion of the shallow-level magma chamber and magma replenishment from deeper storage, perhaps exceeding 11 km.

V31F MCC: 3006 Wednesday 1020h

The Origins of Hot Spots, LIPs, Seamount Chains, and Volcanic Ridges V *(joint with OS, T)*

Presiding: **G R Foulger,** University of Durham**; D C Presnall,** Carnegie Institution of Washington

V31F-01 1025h INVITED

Low Temperature Origin of Oceanic Ridges and Associated Hot Spots

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In the absence of melting, the small amounts of H_2O (100-300 ppm) in the MORB mantle would be totally dissolved in nominally anhydrous minerals and no hydrous phases would occur. These amounts of H_2O would lower the solidus only an insignificant amount. In contrast, the solidus temperature is a very weak function of the mount of CO_2, and even the smallest amount would reduce the solidus at P>1.9 GPa by >300°C. The consistent occurrence of vesicles in MORBs and the strong dominance of CO_2 in these vesicles indicates that at least some CO_2 exists in all or almost all of the mantle beneath ridges. The seismic low-velocity zone (LVZ) closely follows the ocean ridge system, and with rare exceptions (Iceland, Afar, and possibly a few other localities), it does not extend to depths greater than ~250 km. The minimum potential temperature (Tp) required for the generation of basalts is ~1240°C, a Tp that could not avoid producing carbonatitic melts at very low melt fractions in the depth range of ~65-300 km. This confirms earlier conclusions that partial melting occurs in the LVZ. For a Tp of 1240-1260°C, both the depth range of melting and depth of maximum melting (~70 km) predicted by the phase relations closely match the observed S velocity variations that define the LVZ beneath oceanic ridges. This supports the presence of CO_2 as the cause of melting and a low Tp range for almost all ridges. Here the carbonated lherzolite solidus is extrapolated to higher pressures in a way that minimizes the solidus-adiabat intersection and thereby maximizes the viability of high Tp values. Even with this conservative extrapolation, melting models that involve strongly variable potential temperatures ranging up to ~1450-1500°C (McKenzie and Bickle, 1988; Langmuir *et al.*, 1992) imply melting at depths extending into the mantle transition zone for a carbonated lherzolite. For almost all ridge segments, shear wave tomography does not support melting at these extreme depths and is consistent only with low potential temperatures. If the Azores, Galapagos, and Tristan "hot spots" are hot, their broad topographic swells extending over >2000 km suggest the existence of deep and broad low shear velocity anomalies that should be easily visible by global seismic tomography. The absence of such anomalies supports low potential temperatures also for these near-ridge "hot spots".

V31F-02 1045h

No Core Contribution in Mantle Plumes: New Evidence From Tungsten Isotopes

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Os isotope ratios provide major constraints on the sources of ocean island basalts, but are currently interpreted in two dramatically different models. One implies interaction with the outer core, and as a corollary of coupled ^{186}Os-^{187}Os anomalies requires early inner core formation, whilst the other involves a source of recycled oceanic crust. Tungsten isotope data on the same set of picrites used to establish ^{186}Os-^{187}Os anomalies for Hawaiian picrites have ϵW= -0.06 to 0.04 with errors of ±0.11 to ±0.31. Similarly a suite of selected South African kimberlites, which have also been proposed to contain a core contribution, have ϵW= -0.07 to 0.03 with errors of ±0.10. The isotope budget of tungsten in the Earth is well characterised. Given that bulk Earth is chondritic (ϵW = -2) and the silicate Earth has ϵW = 0 (by definition), then the core ϵW = -2.1. Tungsten is siderophile during core formation and incompatible during mantle melting, which leaves it depleted in the mantle (1.9-15 ppb) but strongly enriched in the core (~500 ppb) and the crust (850-1100 ppb). Thus, tungsten is a sensitive tracer of core contributions in the source of mantle melts. We explore two different models of simple core-mantle mixing where mantle W-depletion and inner core crystallisation history are the two most important parameters. None of the samples analysed have the negative W-isotope values of -0.2 to -0.6 ϵW predicted from our preferred core contribution model. Extreme combinations of all critical input values have to be assumed to achieve any overlap between modelled and measured ϵW. Hence a simple core-mantle mixing scenario appears to be ruled out, and other explanations need to be sought. Mn-nodules have high $^{190}Pt/^{188}Os$ ~0.2-0.5, low Re/Os ~0.1-0.5 but high [Os] ~1-3 ppb and $^{187}Os/^{188}Os$ ~0.5-1. ~2% of recycled Mn-nodule in the peridotite source reproduces the observed Os isotope trends and it would be associated with an increase of just ~0.5 wt% Mn.

V31F-03 1100h

Noble Gas Partitioning Behaviour During Mantle Melting: A Possible Explanation for 'The He Paradox'?

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New UVLAMP measurements of experimental noble gas crystal/melt partitioning values (including He) suggest reasonably incompatible behaviour for both olivine and cpx and no significant fractionation of noble gases relative to one another. This is consistent with models of noble gas incorporation at crystal lattice sites in both crystals (1). However the determined D values of approximately 8 x10-4 for cpx and 5 x10-3 for olivine suggest a small but significant amount of noble gas might be retained in the mantle after melting. It is also apparent that He is three orders of magnitude less incompatible than U and Th in olivine. As opx is predicted to show similar characteristic to olivine, melting to produce a highly depleted harzbugitic (low-cpx) mantle would involve the preferential removal of U+Th relative to He. This in turn would allow a relatively undisturbed primordial/radiogenic 3He/4He ratio to be retained in association with low He abundance. Thus, recycling of previously depleted mantle into the source region of 'hot spots' provides one possible explanation for the paradox of high 3/4 He ratios previously thought to indicate an undegassed, primordial lower mantle reservoir, with low He abundance indicating a degassed source (2). Preliminary UVLAMP depth profiles for noble gas diffusion in mantle minerals confirm that although sub-solidus diffusive removal of He relative to other noble gases from a gas-rich mantle plum is theoretically possible, the short distances involved are unlikely to produce an effect that can be sustained though a hot spot melting event. The slow diffusion rates and lack of fractionation of noble gases in our partitioning experiments suggests that low He/Ar (and Ne/Ar) ratios observed at hot spots are most likely to be features inherited from the source, or subsequently imposed by some shallow level process. In our partitioning experiments, it proved surprisingly difficult to grow olivine crystals that are free of bubbles, even from volatile undersaturated melts. These bubbles nucleate on the crystal surface and can become included as the crystals grow. Although inclusions can be avoided using our micro-analytical technique, their bulk effect is to produce high crystal+bubble/melt D values and fractionation of light from heavy noble gases due to decreasing solubility in the melt for the latter. If such bubble capture occurs in nature as suggested by (3), the cumulative crystal rock would show enrichment in light noble gases and the residual melt will be depleted. This effect is similar to degassing but may be independent of saturation and depth of emplacement and decoupled from other volatile behaviour. The removed volatiles will also be retained in the cumulate rock rather than degassed. Differences in crystal growth processes and bubble trapping during MORB and IOB emplacement could contribute towards different He/Ar and Ne/Ar ratios. 1. R.A. Brooker et al., Nature 423, 738-741.