diamond by microwave plasma chemical vapor deposition (CVD) at very high growth rate of 50-150 μm/h has opened new opportunities for the creation of large perfect single crystal diamond as anvils.[1] This morphology, photoluminescence, Raman spectra, and mechanical properties of the CVD diamond have been examined in detail. Of particular interest is our finding of very high strength and improved optical properties of CVD diamond annealed at high pressures and temperatures.[2] In addition, hybrid conventional synthetic/CVD single crystals have been successfully used to generate pressures in the multimegabar range (>200 GPa).[3] A parallel initiative involves the continued development of moissanite anvils, which can already be produced as large, perfect crystals and can reach pressures above 60 GPa. Recent advances include the design and fabrication of supported moissanite anvils for enhanced sample volumes.[4] These developments will make possible new classes of high *P-T* experiments, including neutron diffraction, inelastic neutron scattering, various inelastic x-ray scattering measurements, magnetic resonance and susceptibility, ultrasonics, and rheological studies in the megabar range. [1] C.S. Yan et al., *Proc. Nat. Acad. Sci.* **99**, 12523 (2002) [2] C.S. Yan et al., to be published. [3] W. Mao et al., to be published. [4] J. Xu et al., to be published.

V32G-04 1645h

Study of Sound Velocities of Iron With Nuclear Resonant Inelastic X-ray Scattering Under High Pressure and Temperature

Jung-Fu Lin[1] (202-4788901; j.lin@gl.ciw.edu); Wolfgang Sturhahn[2] (sturhahn@aps.anl.gov); Jiyong Zhao[2] (jzhao@aps.anl.gov); Guoyin Shen[3] (shen@cars.uchicago.edu); Ho-kwang Mao[1] (mao@gl.ciw.edu); Russell J. Hemley[1] (hemley@gl.ciw.edu)

[1]Carnegie Institution of Washington, 5251 Broad Branch Road NW, Washington DC, DC 20015, United States

[2]Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439, United States

[3]The University of Chicago, 9700 South Cass Avenue, Argonne, IL 60439, United States

Iron is the most important component in the Earth's core. Understanding its physical properties under high pressures and high temperatures is crucial for interpreting and constraining geophysical and geochemical models. We have built a double-sided YLF laser heating system to study iron with nuclear resonant inelastic x-ray scattering technique under simultaneously high pressures and high temperatures. Inelastic x-ray scattering spectra of hcp-Fe have been collected up to approximately 58 GPa and 1500 K in a laser-heated diamond anvil cell. Temperature-dependent inelastic x-ray spectra provide independent temperature measurement of the laser-heated iron, in which the measured temperatures were in fairly good agreement with temperatures measured from thermal radiation spectra fitted to Planck radiation function. This independent temperature measurement of the laser-heated sample confirms the validity of temperatures determined from Planck radiation law in the laser-heated diamond anvil cell experiments. Sound velocities of hcp-Fe are obtained from the measured phonon density of states up to approximately 58 GPa and 1500 K. The compressional and shear wave velocity of hcp-Fe decrease with increasing temperature under high pressures. Our results for the compressional and shear wave velocity of hcp-Fe show that the compressional and shear wave velocity are not linearly related to the density at high temperatures and pressures. This study also provides a new technique of measuring the melting curve of iron under extreme pressures.

V32G-05 1700h

Elastic And Vibrational Properties Of Cobalt To 120 GPa

Alexander F Goncharov[1] (goncharov1@llnl.gov)

Jonathan C Crowhurst[1] (crowhurst1@llnl.gov)

Joseph M Zaug[1] (zaug1@llnl.gov)

[1]Lawrence Livermore National Laboratory, 7000 E Avenue, Livermore, CA 94550, United States

The elastic and vibrational properties of hcp Co were studied by impulsive stimulated light scattering (ISLS) and by Raman spectroscopy to 120 GPa at room temperature in a diamond anvil cell. At pressures above 60 GPa the shear elastic modulus and the Raman frequency of the E2g transverse optical mode exhibit a departure from a linear dependence on density. We interpret this behavior as evidence for the high-pressure hcp-fcc transition reported previously (C. S. Yoo et al., PRL 84, 4132 2000) that is related to the collapse of the magnetic moment under pressure.

V32G-06 1715h

Laser-driven shock compression on precompressed water: Exploring icy giant interiors

Kanani K. M. Lee[1] ((510) 643-8325; leeka@uclink.berkeley.edu); L. Robin Benedetti[2,3] (laura-robin.benedetti@cea.fr); Raymond Jeanloz[1] (jeanloz@uclink.berkeley.edu); Agnes Dewaele[3] (agnes.dewaele@cea.fr); Florent Occelli[3] (florent.occelli@cea.fr); Paul Loubeyre[3] (paul.loubeyre@cea.fr); Damien Hicks[4] (hicks13@llnl.gov); Jon H. Eggert[4] (eggert1@llnl.gov); Peter M. Celliers[4] (celliers1@llnl.gov); Andrew Mackinnon[4] (mackinnon2@llnl.gov); Stephen J. Moon[4] (moon1@llnl.gov); Gilbert W. Collins[4] (collins7@llnl.gov); Emeric Henry[5,6] (henry@castore.mib.infn.it); Alessandra Benuzzi-Mounaix[6]; Michel Koenig[6]; John Pasley[7]

[1]Dept. of Earth & Planetary Science University of California, Berkeley, 307 McCone Hall, Berkeley, CA 94720-4767, United States

[2]Physics Department University of California, Berkeley, 301 Leconte Hall, Berkeley, CA 94720-7300, United States

[3]DPTA, Commissariat a l'Energie Atomique, Bruyeres-le-Chatel 91680, France

[4]Physics and Advanced Technologies Directorate Lawrence Livermore National Laboratory, 7000 East Ave., Livermore, CA 94550-9234, United States

[5]Dipartimento di Fisica and INFM, Universitàdi Milano-Bicocca, P.za della Scienza 3, Milano 20126, Italy

[6]Laboratoire LULI, Ecole Polytechnique, Palaiseau Cedex 91128, France

[7]Blackett Laboratory Imperial College of Science, Technology and Medicine, Prince Consort Road, London SW7 2BZ, United Kingdom

Although the giant gas planets are comprised of mostly hydrogen and helium, the icy giants Neptune and Uranus are believed to be composed of ∼50% water (by mass), as well as significant amounts of methane and ammonia (Hubbard, 1984). Most of the water is in an ultra-condensed, high-temperature state forming an "icy" interior layer with pressures ranging between 10 and 500 GPa and temperatures between 2000 and 5000 K (Hubbard, 1997). It is theorized that it is in this hot, dense layer that the planet's magnetic field is produced. To explore the physical properties of water at the extreme conditions of this icy interior layer, we performed laser-driven shock experiments on precompressed samples accessing thermodynamic conditions unreachable by either static or single-shock compression techniques alone. Recent experiments using Rutherford Appleton Laboratory's Vulcan Laser achieved final pressures up to ∼200 GPa and temperatures up to 5,000 K in water samples precompressed in a diamond cell to ∼1 GPa, thereby validating this new technique.

V32G-07 1730h

Electrical Conductivity of SiO_2 above 1 Mbar

Damien G Hicks[1] (hicks13@llnl.gov); Peter M Celliers[1]; Jon H Eggert[1]; Gilbert W Collins[1]; Thomas R Boehly[2]; Elena Vianello[2]; Ryan McWilliams[3]; Kanani K. M. Lee[3]; Raymond Jeanloz[3]

[1]Lawrence Livermore National Laboratory, PO Box 808, L-399, Livermore, CA 94550

[2]University of Rochester, 250 E. River Rd, Rochester, NY 14623

[3]University of California, Department of Earth and Planetary Science, Berkeley, CA 94720

Optical reflectivities of a few percent are detected when SiO_2 is shock-compressed above the melt transition, rising steadily with increasing pressure. Measurements of the optical reflectivity of laser-driven shock waves in α-quartz and fused silica were performed over a range of pressures above 1 Mbar. By comparing the reflectivities measured on the fused silica and α-quartz Hugoniots, which probe different regions of the SiO_2 phase diagram, we can infer the temperature dependence of the electrical conductivity for fluid SiO_2. The results have implications for understanding planetary phenomena ranging from mantle-core interactions to meteorite impact processes.

V32G-08 1745h

Accurate Determination of Fluid Thermodynamics at High Pressure and Temperature

J. Michael Brown[1] (206 616 6058; brown@ess.washington.edu)

Evan H. Abramson[1] (206 616 4388; evan@ess.washington.edu)

[1]Department of Earth and Space Sciences, University of Washington, Box 351310, Seattle, WA 98195, United States

Prerequisite for geochemical modeling of deep earth systems are accurate thermodynamic properties of all constituents at elevated pressures and temperatures. Unfortunately, fundamental data above a few tenths of GPa are sparse and do not uniformly satisfy all thermodynamic cross relationships. We present an experimental strategy for the determination of an internally consistent and complete equation of state for fluids at high pressure. Sound velocities measured on a grid of pressure-temperature points can be recursively integrated to delineate density, heat capacity, thermal expansivity, energy, and all associated uncertainties. Using impulsive stimulated scattering to measure velocities of fluids in an externally heated diamond anvil cell, we have extended equations of state for several fluids into previously unexplored regimes of pressure and temperature. Properties of water have now been fully explored to 6 GPa and 673 K. The equation of state for water as recommended by the International Association for the Properties of Water and Steam (IAPWS) diverges less from experiment than other commonly used equations of state. However, even this formula predicts velocities that deviate from the highest-pressure measurements by almost 20 times the estimated experimental uncertainty. Uncertainty in densities range from 0.1% at 1 GPa (the IAPWS estimate) to 0.3% at 6 GPa (a regime formerly of prediction without associated uncertainty estimates). Heat capacities and thermal expansion have uncertainty of no more than a few percent. Hugoniot data are correctly predicted by a modest extrapolation of the new equation of state. Reinterpreted densities from inclusion studies to 3 GPa and 1873 K are also consistent with the new equation of state.

V32H MCC: 3006 Wednesday 1600h

Arc and Continental Magmatism II

Presiding: **J F Luhr,** Department of Mineral Sciences Smithsonian Institution**; A H Wulff,** Western Kentucky University

V32H-01 1600h

Recycling Lower Continental Crust: Evidence From High Mg Andesites in the North China Craton

Shan Gao[1,2] (86 27 87482737; gaoshan@cug.edu.cn); Roberta L. Rudnick[3] ((301) 405 1311; rudnick@geol.umd.edu); Hong-Ling Yuan[1]; Xiao-Ming Liu[1]; Yong-Sheng Liu[2]; Wen-Li Ling[2]; John Ayers[4]; Xuan-Che Wang[2]

[1]Key Laboratory of Continental Dynamics, Dept. Geology Northwest Univ., Xi'an 710069, China

[2]Faculty of Earth Sciences, China Univ. Geosciences, Wuhan 430074, China

[3]Geochemistry Laboratory, Dept. Geology, University of Maryland, College Park, MD 20742, United States

[4]Dept. Geology, Vanderbilt Univ., P.O. Box 105 Station B, Nashville, TN 37235, United States

Magmatic additions to the crust are dominated by basalts, while the continental crust has an andesitic bulk composition. One way to explain this compositional dichotomy is to recycle mafic-ultramafic lower crust into the deep Earth through density foundering. However, such lower crustal recycling is a difficult hypothesis to test. Geological, geochemical and geophysical lines of evidence suggest that the deep lithosphere of the Archaean North China craton was removed at some point after the Ordovician, but the mechanism and timing of this lithosphere removal event is uncertain. Early Cretaceous high-magnesium adakite, andesite and dacite from western Liaoning, North China craton, have chemical and petrographic features consistent with their origin as partial melts of eclogite that subsequently interacted with mantle peridotite: they

have fractionated REE patterns ($(La/Yb)_n$ = 12 to 36), high Ni (80-300 ppm), Cr (130-400 ppm) and Mg# (53-65) and contain chromite and orthopyroxene phenocrysts, the latter of which are chemically zoned with Mg# rising from 75 in the core, to 84 in the interior and falling again to 60-70 on the rim. Similar features observed in adakites and Archaean tonalite-trondhjemite-granodorite (TTG) have been interpreted in terms of slab melts that interacted with the mantle wedge. However, unlike their arc-related counterparts, the western Liaoning magmas carry inherited Archaean zircons and have neodymium and strontium isotopic compositions overlapping those of Archaean eclogite and garnet clinopyroxenite xenoliths derived from the deep lithosphere of the North China craton. Furthermore, the lack of correlation between isotopic composition and Mg# argues against the old isotopic compositions arising from AFC-type processes in the deep crust. We suggest that these volcanic rocks represent melts from Archaean mafic lower crust that foundered into the convecting mantle, and were hybridized by interaction with mantle peridotite during their upward migration.

V32H-02 1615h

New Geochemical Data on Postcollisional Ultrapotassic Rocks in Western Tibet

Zhidan Zhao[1,2] (+86-10-82321115; zdzhao@cugb.edu.cn); Xuanxue Mo[1]; Don DePaolo[2]; Tom Owens[2]; Zhongli Liao[3]; Dicheng Zhu[3]

[1]China University of Geosciences, 29 Xueyuan Rd, Beijing 100083, China

[2]Center of Isotope Geochemistry, University of California, 475 McCone Hall, MC#4767, Berkeley, CA 94720-4767, United States

[3]Chengdu Institute of Geology and Mineral Resources, Erhuan Rd, Chengdu 610082, China

We studied the postcollisional ultrapotassic volcanic rocks in Gongmutang (N30°48', E84°26'), Zabuye salt lake (N31°26', E84°20'), Dangreyong lake (N30°57', E86°24'), and Xuru lake (N30°4', E86°31') in western Lhasa block. These rocks erupted during the time between 27 Ma and 12 Ma ago according to published dating work. They are strongly related to the north-south trending normal faults or valley in tectonic setting. These lavas (SiO_2=45-62%, K_2O=6.0-8.8%, K_2O/Na_2O=2.0-4.3%, MgO=2.5-10.9%, TiO_2=0.8-1.6%) are very homogenous in trace element composition, with enriched LREE, Rb, Ba, Th, and U, and depleted Nb, Ta, and Ti. These samples, with ϵ_{Nd} varies from -11 to -15 and $^{87}Sr/^{86}Sr$ from 0.718 to 0.736, show much different isotopic features to the postcollisional shoshonitic-dominated rocks in North Tibet (ϵ_{Nd} varies from -5 to -9 and $^{87}Sr/^{86}Sr$ from 0.708 to 0.711). But they shift much close or even overlap the Himalayan basement and granitoid Nd-Sr field (ϵ_{Nd} range from -12 to -25 and $^{87}Sr/^{86}Sr$ from 0.733 to 0.760). The geochemical characteristics of the rocks in our study are similar to the rocks from Shiquanhe (Turner et al., 1996, J. Petrol.), Xunba (Miller et al., 1999, J Petrol), and Pabbai Zong (Williams et al., 2001, Geology). If we take the widely-accepted origin hypotheses that the ultrapotassic lavas is firstly derived from small degree partial melting of subcontinental lithospheric mantle, we could conclude that an enriched mantle source should be responsible for the lavas in western Tibet. The Nd-Sr isotopic data suggest that at least two possibilities for the structure and composition of the lithosphere in western Tibet: (1) The Himalayan basement affinity of these lavas suggest that the Himalayan crustal materials in the northern margin of Indian plate maybe a reagent that enriched the upper mantle of the western Lhasa block. If this is the fact, the northern part of India would have subducted beneath Lhasa block that suggested by some geophysical result; (2) The western part of Lhasa block are indeed have a similar features to the Himalayan crust. Then, Nd-Sr data do not show any clues for the north trend subduction of India plate.

V32H-03 1630h

Chemical Stratigraphy of Basalts From the 5000' Borehole NPR-E/WO-2, Eastern Snake River Plain, Idaho: Evidence for Mixed Asthenosphere-Lithosphere Sources.

John W. Shervais[1] ((435) 797-1274; shervais@cc.usu.edu)

Barry B. Hanan[2] (bhanan@mail.sdsu.edu)

Scott K. Vetter[3] (svetter@centenary.edu)

[1]Dept of Geology, Utah State University, Logan, UT 84322

[2]Dept Geological Sciences, San Diego State University, San Diego, CA 92182

[3]Geology Dept, Centenary College, Shreveport, LA 71104

Basaltic volcanism in the eastern Snake River Plain presents a fundamental conundrum: the major and trace element concentrations of these basalts suggest derivation from an asthenospheric source, consisting of depleted mantle and possibly a Yellowstone plume component, whereas isotopes suggest derivation from an enriched lithospheric source similar to that which underlies the Archean Wyoming province. We have analyzed 59 whole rock samples from 38 basalt flow groups from a deep bore hole pair in the eastern Snake River Plain. All of the basalts are LREE-enriched, with La ranging from 18 to 142 x chrondrite and (La/Lu)N = 2.4 to 9.9. The data generally define smooth trends on MgO-variation plots, suggesting crystal fractionation as a dominant factor in the major and trace element variations, a conclusion which is consistent with the overall low mg#s of 58-40. There is an increase in La/Lu with fractionation, suggesting crustal or lithospheric assimilation. There are three distinct depth-correlated trends in major and trace elements: first, below 2500 feet there are wide fluctuations in major and trace elements that are unrelated to fractionation; second, there are five mega-cycles of upward fractionation that occur between, and in some cases across, major sediment-bounding units, defined by a decrease in mg#s up section, and by increases in Ti, P, Zr, La, and La/Lu up section; and third, there are two super-cycles in which Cr and Ni concentrations increase-up section. The first trend is apparently the result of variable assimilation of crust and/or lithospheric mantle material. This is supported by the Pb, Sr, and Nd isotope data that shows the lowest basalts have higher $^{208}Pb/^{204}Pb$ for a given $^{206}Pb/^{204}Pb$, and higher $^{87}Sr/^{86}Sr$ and lower $^{143}Nd/^{144}Nd$ than basalts from higher in the section. The second trend may result from the fractionation of large batches of primitive magma that were stored in the crust, while the third trend represents increased melt fractions or repeated melting of a refractory source (possibly due to continued melting of a single source region). K2O/P2O5 ratios also vary widely below 2500 feet, but show a persistent upward increase above that depth, suggesting an upward increase in crustal or lithospheric assimilation. Forward modeling of crystal fractionation shows that the observed trends cannot form by low pressure crystal fractionation, even with repeated mixing and assimilation events; high pressure (6-8 kb) pyroxene fractionation is needed, but mixing and assimilation are also required. Trace element partial melting models require a plume-related, E-MORB-like source for the basalts, with 7-12% partial melting of a spinel or garnet-poor lherzolite source, consistent with estimated melting pressures of 12-18 kb. Calculations suggest mixing about 5% highly enriched lithospheric melt with 95% mantle melt will generate basalts with the chemical and isotopic characteristics observed in these core samples. We suggest that this mixing occurred in the lithosphere as the asthenospheric melts percolated upward to intrude the crust, creating a hybrid magma with plume-like major and trace element characteristics, but with lithospheric isotopic compositions. Further assimilation may have occurred during storage and fractionation in the middle crust.

V32H-04 1645h

New Field, Geochronological, and Geochemical Data on the Miocene Lovejoy Basalt and its Source, Northern California

Noah J. Garrison[1] (1-805-893-3471; garrison@umail.ucsb.edu)

Cathy B. Busby[1] (Busby@geol.ucsb.edu)

Phillip B. Gans[1] (gans@geol.ucsb.edu)

David L. Wagner[2] (dwagner@consrv.ca.gov)

[1]University of California at Santa Barbara Dept. of Geological Sciences, Webb Hall 1006, Santa Barbara, CA 93106, United States

[2]California Geological Survey, 801 K St. MS 12-31, Sacramento, CA 95814, United States

The Lovejoy Basalt is a distinctive, aphanitic olivine basalt that flowed through a paleovalley across the northern end of the Sierra Nevada from the Diamond Mountains near Honey Lake to the Sacramento Valley in northern California. Approximately 150 km3 of basalt was erupted in a tectonic setting transitional between subduction, Basin and Range extension, and hot spot volcanism, but the eruptive source and timing of the Lovejoy Basalt have remained controversial. Recent field mapping and geochemical analyses suggest that Thompson Peak, located south of Susanville, California, is the source vent for the Lovejoy Basalt. At Thompson Peak, Lovejoy Basalt forms an elongate, NNW-SSE trending ridge that is capped in its central section by the Basalt of Thompson Peak. Scoria deposits, volcanic bombs, agglutinate and other near vent deposits indicate Thompson Peak as the source for the Lovejoy Basalt. Previous and new mapping indicate that the basalt was channelized within granitic basement, and flowed south from the vent 30 km to Red Clover Creek before bending to the southwest and flowing 65 km to the Sacramento Valley. The Lovejoy Basalt consists of up to 13 flows, all aphyric except for an uppermost plagioclase-phyric flow present between Thompson Peak and Red Clover Creek that locally contains xenocrysts of olivine and garnet. At Table Mountain, the basalt appears to have ponded or inflated, forming very thick flows with prominent N-S trending pressure ridges. The Lovejoy Basalt is a quartz-normative tholeiite that is geochemically similar to the Columbia River Basalt. While a conclusive statement cannot yet be made about the source magma for the Lovejoy Basalt, initial analyses show that it does not appear to be related to the main phase of Cascade arc volcanism, which is predominantly calc-alkaline. Recently published age data for the Lovejoy Basalt suggests that it is coeval with the main phase of the Columbia River Basalt Group; however, our further attempts to date the basalt have met with difficulty, primarily due to the presence of a high percentage of altered glass in the basalt's matrix. This difficulty may account for the wide range of previously reported K-Ar dates for the Lovejoy Basalt, and call into question the recently published Ar^{40}/Ar^{39} ages. We are currently attempting Ar^{40}/Ar^{39} analyses on plagioclase crystals from the uppermost flow of the basalt, and on groundmass from more holocrystalline flows present at Table Mountain.

V32H-05 1700h

Barren Island Volcano (NE Indian Ocean): Island-Arc High-Alumina Basalts to Andesites Caused by Troctolite Disaggregation and Plagioclase Accumulation

James F Luhr[1] (202-357-4809; luhr@volcano.si.edu)

Dhanapati Haldar[2] (haldar2115@yahoo.co.uk)

[1]Department of Mineral Sciences Smithsonian Institution, P.O. Box 37012 NHB-119, Washington, DC 20013-7012, United States

[2]4/3K/2, Ho-Chi-Minh Sarani , Shakuntala Park, Kolkata 700 061, India

Barren Island (BI) is a subduction-related volcanic island lying in the northeastern Indian Ocean, about 750 km north of the northern tip of Sumatra along the same subduction zone that carries the Indo-Australian Plate northeastward beneath the southeast corner of the Eurasian Plate. The island has a diameter of only 3 km and rises to 355 m above sea level. Three eruptive episodes are known in historical time. A cinder cone formed near the center of the island in 1787, within remnants of a pre-historical caldera 2 km in diameter and open to the west. Eruptions continued intermittently until 1832. Two other episodes occurred more recently, during March to October 1991 and December 1994 to May 1995. Each eruption included strombolian and fire-fountain activity at the central and flank vents of the cinder cone and the westward flow of block lavas through the caldera breach until they cascaded into the sea. This investigation is based on 28 samples collected from Barren Island by researchers from the Geological Survey of India during expeditions to the island prompted by the eruptions of 1991 and 1994-1995. The samples include 18 lavas, 5 scoriae, and 5 bulk ashes that can be divided into 4 age groups: pre-1787 (n=6), 1787-1832 (n=4), 1991 (n=8), and 1994-1995 (n=10). Whole-rock compositions range from 50.7 to 59.8 wt.% SiO_2, and thus span the range from basalt to andesite. All samples contain phenocrysts and microphenocrysts of olivine (plus spinel), plagioclase, and clinopyroxene. A notable textural feature in many samples from all age groups is the presence of abundant (to 40 vol.%), large (to 4 mm) phenocrysts of plagioclase. These have clear tabular cores of homogeneous highly calcic composition at An_{90-95}, surrounded by normally zoned mantles, 10-150 microns thick, that range down to An_{48}. Plagioclase phenocryst abundances vary with whole-rock SiO_2 (negatively) and Al_2O_3 (positively) contents. All samples with >20 vol.% plagioclase phenocrysts have >19 wt.% Al_2O_3 and <53 wt.% SiO_2. Samples rich in plagioclase phenocrysts also have slight positive Eu anomalies. All evidence points to generation of these high-Al basalts by accumulation of calcic plagioclase during dissagregation of troctolitic xenoliths, which are found within historical lavas and scoriae. We suppose that a magmatic mush or plutonic mass of troctolite at depth beneath Barren Island is the source of this contamination. These high-Al basalts, at least, are not magmatic compositions. Six Barren Island samples were also analyzed for Sr, Nd, and Pb isotopic compositions, which show a crude trend toward more enriched values with time: overall ranges are $^{87}Sr/^{86}Sr$ = 0.7038-0.7041, ϵNd = 4.1-6.8, $^{206}Pb/^{204}Pb$ = 18.20-18.29. Trapped glass inclusions in olivine phenocrysts were analyzed for volatile contents by Fourier-transform infrared spectroscopy and electron microprobe. The highest values for total H_2O are 2.6 and 3.1 wt.% from two 1991 inclusions. Carbon species were not detected, as is typical for subduction-zone glasses. Sulfur contents ranged 0.08-0.20 wt.% SO_3, and Cl contents ranged 0.14-0.21 wt.%, reflecting the elevated Cl values that characterize subduction-

V

related glasses worldwide, in contrast with those from mid-ocean ridges or hot spots.

V32H-06 1715h

Origins of Newberry Volcano, Central Oregon: A Cascade Backarc, High Lava Plains, Basin and Range Shield Volcano?

Michael C Rowe[1] (541-737-8586; rowem@geo.orst.edu)

Adam J Kent[1] (adam.kent@science.oregonstate.edu)

Roger L Nielsen[1] (nielsenr@geo.orst.edu)

Paul J Wallace[2] (pwallace@darkwing.uoregon.edu)

Julie M Donnelly-Nolan[3] (jdnolan@usgs.gov)

[1]Department of Geosciences, Oregon State University, Corvallis, OR 97331

[2]Department of Geological Sciences, University of Oregon, Eugene, OR 97403

[3]Volcano Hazards Program, U.S. Geological Survey, MS 910, 345 Middlefield Rd., Menlo Park, CA 94025

Newberry Volcano, located 60 km east of the central Oregon High Cascades resides in a complex tectonic and volcanic region. Understanding the petrogenesis of Newberry Volcano is important to understanding the regional geological framework because of its location at the confluence of the back-arc of the Oregon Cascades, the northern end of the Basin and Range, and the western end of the High Lava Plains (HLP). The latter province includes a NW trend of propagating rhyolitic volcanism whose youngest expression appears to be Newberry. A clear understanding of Newberry's relation to the Cascades is also important due to a scarcity of backarc volcanism in this region. The first goal of this study is to evaluate the range of composition of the primary magmas that make up the parent magma array for this system to evaluate the diversity of mantle materials involved and the degree of melting. This study uses major- and trace-element data from primitive basalts (> 8 wt % MgO, > Fo# 80) and melt inclusions, coupled with volatile elements (Cl, S, CO_2, and H_2O) from high-alumina olivine tholeiite (HAOT) lavas from Newberry Volcano, the HLP, the northern Basin and Range volcanics, and the Oregon Cascades in an attempt to evaluate the primitive compositions and melting dynamics at Newberry. Using this data we hope to discern Newberry's relative importance and relation to the surrounding volcanic regions. Preliminary melt inclusion data from Newberry and surrounding regions suggests that Newberry is slightly enriched in Ba (up to 750 ppm), K_2O (1 wt %), and Rb (24 ppm) relative to samples collected from the adjacent Basin and Range volcanics and the HLP. Also significant is that Nb and Ta are relatively depleted in the Newberry melt inclusions with K/Nb ranging from 600 to 1135 whereas the samples from the Basin and Range and HLP vary from 400-570 and 180-245, respectively. This, coupled with the Ba enrichment may suggest that a subduction-related fluid component is present in the mantle source region of Newberry magmas that is absent from the Basin and Range and HLP. Additionally, Cl concentrations in melt inclusions from several Newberry samples range from 200 to 1600 ppm, similar to values for primitive basalts in the High Cascades and much higher than values for magmas from the Basin and Range and HLP. The Cascades have been interpreted as a hot, dry arc and yet an apparent subduction-related fluid signature is observed as far as 300 km inland from the trench. Therefore, this data, while not conclusive, may have important ramifications for dehydration and fluid migration models beneath young, hot volcanic arcs.

V32H-07 1730h

Composite Chemostratigraphy of Lavas From the Casitas Shield, Descabezado Grande-Cerro Azul Volcanic Complex, Chilean Andes

Andrew H. Wulff (1-270-745-5976; andrew.wulff@wku.edu)

Western Kentucky University, Dept. of Geography and Geology 1 Big Red Way, Bowling Green, KY 42103, United States

The Descabezado Grande-Cerro Azul (DGCA) volcanic complex is located at approximately 35.5 degrees S in the transitional Southern Volcanic Zone (SVZ) of the Chilean Andes. The complex is characterized by two large latest Pliocene to early Holocene volcanic edifices and many smaller vents rising above a plateau comprising lavas of an earlier shield-building stage, the Casitas Shield. This plateau has been deeply encised, revealing stacks of lava flows exposed along the valley walls. More than 100 lava flows from eight vertical stratigraphic sections have been analyzed for complete major and trace element abundances. These have been compiled in a composite chemical stratigraphy representing much of the history of this stage of volcanism. At least twelve eruptive episodes were identified based on field observations (soil development, erosional features, mingled top and bottom rubble zones, etc.). Lavas flowed south and west from the proposed vent location(s) primarily filling paleovalleys, constrained to the west by topographic highs composed of tilted metasediments and a granodioritic stock. A number of long flows served as the basis in the field for physical correlations between sections, and were used to evaluate within-flow compositional variation. The top flows on the shield have a single date of .34 My. The composite chemical stratigraphy shows changes in lava compositions reflecting both differences in parental magmas and the secular dominance of certain petrogenetic processes over others. In general, lavas become more evolved through episodes 1-5, and are relatively constant in composition during episodes 6-8. More mafic lavas erupted during episode 9, including lavas that are among the most primitive in the SVZ. These lavas are characterized by high Cr (254-267 ppm) and MgO (8-8.3%), and low LILE, P2O5, Al2O3, Na2O, and K2O, and probably represent a different parental magma. Lavas erupted during episodes 10 and 11 are progressively more evolved, becoming similar to lavas erupted more recently from Volcan Cerro Azul. Several crosscutting basaltic dikes are characterized by high MgO (11.7%), Ni (226 ppm) and Cr (776 ppm) contents, and along with high-Sr lavas (972-1061 ppm) erupted during episode 3, extend the known compositional ranges for mafic lavas in the SVZ. Most of the compositional diversity occurs during periods of apparent low eruption rate with few lava flows, perhaps including some from separate short-lived vents. Periods of higher eruptive activity are characterized by less compositional range and flows often appear in the field with flow tops mingled with the bottom of the next flow. This composite chemical stratigraphy will be compared to one constructed at the nearby Tatara-San Pedro complex.

V32H-08 1745h

Volatile, Trace Element and Isotopic Variations of Mafic Arc Volcanic Rocks from Nicaragua and Costa Rica

Kaj Hoernle[1,2] (khoernle@geomar.de); Seth Sadofsky[2]; Holly Nichols[2]; Maxim Portnyagin[1]; Paul van den Bogaard[1,2]; Guillermo Alvarado[3]

[1]GEOMAR Research Center, Wischhofstr. 1-3, Kiel 24148, Germany

[2]SFB 574, University of Kiel, Kiel 24148, Germany

[3]ICE, Apartado 10032-1000, San Jose 10000, Costa Rica

Quaternary volcanic rocks from the Central American Volcanic Arc in central Nicaragua and central Costa Rica exhibit major differences in their volatile, trace element and isotopic compositions. Olivine-hosted melt inclusions in Nicaraguan volcanic rocks with high Fo contents (>73) extend to high H_2O (up to 5.3%), S (10-6860 ppm) and Cl (490-2340 ppm) contents. The volcanic rocks have high ratios of fluid mobile to fluid immobile elements such as Ba/La (65-122), Ba/Th (484-1304) and U/La (0.08-0.17). Additionally, they have $^{143}Nd/^{144}Nd$ (0.51300-0.51307) similar to normal mid-ocean-ridge basalts (N-MORB) from the East Pacific Rise (EPR), but $^{87}Sr/^{86}Sr$ (0.7035-0.7042) ratios are much higher than those found in fresh EPR glasses. Pb isotopic compositions of the samples (e.g. $^{206}Pb/^{204}Pb$ = 18.5-19.0, $^{207}Pb/^{204}Pb$ = 15.52-15.58) form an array between EPR basalts and subducted sediments. The volatile, trace element and isotope data are consistent with mixing of fluids highly enriched in fluid-mobile elements from subducted sediments with a N-MORB-type mantle wedge to produce the Nicaraguan volcanic rocks. In contrast, olivine-hosted melt inclusions (Fo >82) in Costa Rican volcanic rocks show a similar range in H_2O (up to 5.1%) to Nicaraguan inclusions but overall have lower S (0-1340 ppm) and Cl (10-790 ppm) contents. Costa Rican lavas also have lower Ba/La (7-35), Ba/Th (55-338), U/La (0.02-0.12), $^{87}Sr/^{86}Sr$ (0.7035-0.7038) and $^{143}Nd/^{144}Nd$ (0.51292-0.51301) than Nicaraguan lavas, but $^{87}Sr/^{86}Sr$ and Pb isotope ratios (e.g. $^{206}Pb/^{204}Pb$ = 19.02-19.32) are more radiogenic than in Nicaragua and than usually found in fresh EPR MORB. Our data are consistent with the presence of Galapagos Hotspot-type components in the source of the central Costa Rican volcanic rocks, derived from the subducting Galapagos Hotspot Track and from Galapagos-type material entering the mantle wedge through a slab tear or window (Abratis and Worner, 2000; Geology). The estimated volume of volcanic rocks erupted in the last 100,000 years (Carr et al., 1990, Contrib. Min. Pet.; in press, AGU Spec. Pub.) are substantially higher in central Costa Rica than in Nicaragua, suggesting greater productivity of melting beneath Costa Rica. Since the flux of hydrous fluids appears to be similar beneath both arc segments, higher melt productivity beneath Costa Rica could reflect the presence of larger volumes of more fertile, hotter Galapagos-type mantle upwelling through a slab tear or window into the Costa Rican mantle wedge.

V41A MCC: 3006 Thursday 0800h

Birth, Growth, and Death of Magmatic Arcs: Comparisons Among Arcs in Different Settings III *(joint with T)*

Presiding: **T Rushmer,** University of Vermont**; N Petford,** Kingston University

V41A-01 0800h INVITED

Expressions and controls on intra-crustal recycling

George W Bergantz[1] (bergantz@u.washington.edu)

Olivier Bachmann[1] (bachmann@ess.washington.edu)

Josef Dufek[1] (dufek@u.washington.edu)

[1]Univ. of Washington, Box 351310, Seattle, WA 98195, United States

Heat and mass transfer associated with arc magmatism can play a significant role in crustal differentiation. However, the timescales and controls are diverse and poorly understood. To assess the expression of crustal recycling, we will review and compare three examples: the Sierra Nevada, Cascade, and Costa Rica arcs. Coupled basaltic inputs and crustal melting or reaction provides the template for crustal recycling. This process can be dominated by heat and/or fluid transport, and the relative contributions can be difficult to decipher from anhydrous, residual xenoliths and arc magmas. If the crust is young, thin, and mafic (south Cascade arc), low-K compositions dominate. The compositional diversity in the mafic rocks is nearly as great as in the silicic rocks. Wet melting by mantle input is possible, but radiogenic Os signatures limit the addition of primitive basalts and high Mg andesites as mass sources for erupted magmas. If the crust is old, thick, and silicic (Sierra Nevada), crustal recycling is expressed as a sequence of amphibolite-tonalite-granodiorite with amphibolite and granulite facies roots. High-K compositions result from a multi-stage process of "igneous distillation" but the relative roles of true melting and reaction-assimilation has not been resolved. High-K concentration can also be generated in continental arcs where thin, mafic, refractory oceanic crust constitutes most of the crustal column (Costa Rica). We suggest that the presence of high-K silicic magmas in this setting can be reconciled with repeated melting of a young, mafic lower crust, effectively by-passing the existing crustal framework.

V41A-02 0815h

Possible Melts of Delaminating Lower arc Crust Beneath Arcs

Karen Hanghoj[1] (508 289 2946; khanghoj@whoi.edu)

Peter B Kelemen[1] (508 289 2956; peterk@whoi.edu)

[1]Woods Hole Oceanographic Institution, MS#8, Woods Hole, MA 02543, United States

Theoretical models predict gravitational instability of dense igneous cumulates and orthogneisses overlying less dense upper mantle peridotites (e.g., Herzberg et al CMP 83; Kay & Kay Geol Rundsch 91; Jull & Kelemen JGR 01). This is especially likely when cumulates include pyroxenites, and when temperatures fall below $\sim 900^{\circ}C$ at pressures greater than $\sim$ 0.7 GPa, leading to transformation of high-Al arc gabbronorite to garnet granulite. This can induce viscous foundering or delamination of the base of the crust. Primitive cumulates and garnet granulites are present in small amounts near the base of the Jurassic Talkeetna arc section in south central Alaska. Recent work suggests that these are remnants of a much larger proportion of primitive cumulates, most of which is missing from the otherwise complete arc section, perhaps due to delamination (Greene et al J Pet submitted; Kelemen et al Treatise on Geochemistry, 03). If delamination of dense lower crustal rocks occurs in arcs, one might expect this component to participate in arc magmatism (Gromet & Silver J Pet 87; Kay & Kay, Tectonophys 93; Kay et al JGR 94). In the western Aleutian island arc, primitive andesites that are light REE enriched and heavy REE depleted, indicative of abundant garnet in their source, may form by partial melting of subducted eclogite, followed by reaction with the mantle during ascent into the arc crust (e.g., Kay, JVGR 78; Yogodzinski, JGR 95; Kelemen et al., AGU Monograph 03). However, Aleutian samples with this garnet signature have depleted isotopic compositions, with both $^{206}Pb/^{204}Pb$ and $^{87}Sr/^{86}Sr$ lower than in Pacific MORB sampled to date. Talkeetna pyroxenites and garnet gabbros generally have U/Pb and Th/Pb less than, and Sm/Nd