Augustine volcano has experienced 6 explosive eruptions in historic time and is located in Cook Inlet, Alaska, approximately 330 km from Anchorage. Most lavas and tephra range from primitive andesite to dacite, but minor basalt flows crop out on the island. The matrix and silicate melt inclusion glasses are more felsic, however. Volcanic gases collected from the Augustine crater during and immediately after the most recent eruptions in 1976 and 1986 were strongly enriched in HCl (Symonds et al., 1990). The presence of elevated Cl levels in magmatic gases is consistent with high concentrations of Cl in silicate melt inclusions in plagioclase and pyroxene phenocrysts in materials erupted from Augustine in 1976 and with the conclusion that the 1976 magma was saturated in a Cl-enriched fluid/vapor prior to eruption (Johnston, 1978). To determine the role of Cl and other volatiles in magmatic and volcanic processes at Augustine volcano, we have begun a systematic study of silicate melt inclusions in tephra erupted at Augustine in 1986 and also erupted $\sim$ 1000, $\sim$ 1400, $\sim$ 1700, $\sim$ 2100 years ago. We analyzed glassy silicate melt inclusions in plagioclase and pyroxene phenocrysts for major, minor, and some trace elements (including Cl, S, and F) by electron microprobe and for H_2O and CO_2 by FTIR. Preliminary results show that each of these magmas was strongly but variably enriched in H_2O, S, and Cl. Sulfur ranges from 100-700 ppm, and Cl varies from 2000 to more than 8000 ppm. Trends involving Cl, H_2O, S, and major elements in tephra from all 5 of the eruptions that we studied are consistent with the exsolution of aqueous-carbonic, S- and Cl-charged volatile phases well before eruption. Moreover, the Cl contents of most melt inclusions are quite high, and the most recently erupted (e.g., 1976 [Johnston, 1978] and 1986) magmas were particularly enriched in Cl. In fact, the Cl abundances of some inclusions approach that of the 2000 bar chloride solubility limit for felsic magmas. Thus, some fractions of the late-stage, dacitic Augustine magmas, erupted in 1976 and 1986, would have exsolved a S-bearing, hydrosaline chloride liquid with or without a S- and Cl-bearing, aqueous-carbonic vapor at 2000 bars before eruption. In summary, the geochemistry of melt inclusions of the eruptive units studied so far indicates that the exsolution of Cl-charged volatile phases is a common process that preceeds most of Augustine's explosive eruptions. (D. Johnston, 1978, Unpublished Ph.D. Diss., Univ. of Washington) (Symonds et al., 1990, Bull. Volcanol. 52:355-374)

V41E MCC: 3008 Thursday 1020h

Frontiers in High-Pressure Research: New Opportunities II *(joint with GP, MR, DI)*

Presiding: **V Prakapenka,** University of Chicago**; J Chen,** State University of New York at Stony Brook

V41E-01 1020h

Viscosity of Fluids in the Diamond-Anvil Cell

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

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

[1]University of Washington, Department of Earth and Space Sciences, Box 351310 University of Washington, Seattle, WA 98195-1310, United States

Measurement and modeling of the viscosity of fluids under high pressures is necessary to an understanding of fluid processes within the Earth and other planets. Areas of interest include terrestrial vulcanism, the flow of supercritical fluids which may induce metasomatism over large regions of Earth's upper mantle, and the dynamics of the fluid envelopes of the larger planets. We report here the application of rolling ball viscometry to supercritical fluids within the diamond-anvil cell. Recent results and the accuracies and potentials of the technique are discussed. For many fluids, viscosity as a function of pressure seems to follow Doolittle's empirical equation, roughly justified on the basis of free-volume theory. However, based on a survey of published data it has also been hypothesized that above twice the critical density the viscosities of simple, supercritical fluids are linear functions of pressure to a very high accuracy. These two functional forms are mutually exclusive and may diverge by an order of magnitude over the pressure-temperature regime of mantle fluids. Here we show that over the extended range of densities and pressures available to the diamond-anvil cell supercritical fluids are, in fact, better fit by the Doolittle equation. We show also that the law of corresponding states may still be of reasonable accuracy even at large compressions where the differences among intermolecular potentials might be supposed to preclude such scaling.

V41E-02 1035h

Pressure induced structural changes in amorphous silicates

Vitali B Prakapenka[1] (prakapenka@cars.uchicago.edu)

Guoyin Shen[1] (shen@cars.uchicago.edu)

Mark L Rivers[1] (rivers@cars.uchicago.edu)

Stephen R Sutton[1] (sutton@cars.uchicago.edu)

[1]GSECARS, University of Chicago, 5640 S. Ellis Ave., Chicago, IL 60637, United States

The study of amorphous structures provides a basis for understanding the chemical-physical properties of glass and liquid materials at extreme conditions. However, there are only a few experimental reports available characterizing amorphous silicates at high pressures. The main reason for limited experimental studies is related to the weak scattering of non-crystalline silicates in the small pressure chamber of the diamond anvil cell (DAC) and the associated small accessible 2-theta range. In this work, we have used a modified DAC with x-ray transparent cubic BN seats that results in a maximum momentum transfer above 110 nm^{-1}. The diffraction patterns were collected in full solid angle using an on-line imaging plate detector and brilliant, high energy (37.44 keV) synchrotron x-radiation at GSECARS undulator beamline (APS). For background corrections we recorded x-ray scattering patterns from an empty cell (without sample, but at the same position and conditions used for high pressure data collection). The high pressure behavior (compress/decompress) of amorphous SiO_2 and $MgSiO_3$ was studied up to 70 GPa with steps of $\sim$5 GPa at room temperature. The starting materials were synthesized by a sol-gel technique, which allows the formation of highly disordered polymer-like three-dimensional matrices where silicon/magnesium atoms are bonded to oxygen atoms in an irregular non-crystalline network. For both SiO_2 and $MgSiO_3$, we have observed clear pressure-induced structural changes rather than isotropic contraction. On decompression, reversible structural behavior was found for both silicates. The observed structural changes in the medium-range order of the amorphous network and the kinetics of this process in SiO_2 and $MgSiO_3$ provide a basis for understanding the dynamical properties of high-density non-crystalline materials at extreme conditions.

V41E-03 1050h

Direct Magnetic Measurements at High Pressures

Maxime LeGoff[1] (legoff@ipgp.jussieu.fr)

Stuart A Gilder[1] (gilder@ipgp.jussieu.fr)

Jean-Claude Chervin[2] (JClaude.Chervin@pmc.jussieu.fr)

Jean Peyronneau[1] (peyronno@ipgp.jussieu.fr)

[1]Institut de Physique du Globe, Laboratoire de Paleomagnetisme, 4 place Jussieu, Paris 75252, France

[2]Universite Pierre et Marie Curie, Physique des Milieux Condensés, 2 place Jussieu, Paris 75252, France

Direct magnetic measurements of extremely small sample volumes at high pressure are difficult, primarily because of interference from the high magnetizations of the pressure vessels. For this reason, we developed a "non-magnetic" beryllium-copper, membrane-type diamond cell that houses a system designed to measure the reversible magnetic susceptibility of micron-sized samples under pressures in excess of 30 GPa. Our system employs two unequal pick up coils wound in opposition around a diamond resulting in a virtually null magnetic surface. Around these is an inducing coil, mounted in null mutual inductance. A lock-in amplifier measures the output of the sensing coil. The cell and detection system are placed in the confines of an electromagnet. Thus the pressure of the cell is remotely controlled and the ac (reversible) susceptibility (Xrev) is measured as a function of applied field (H), with H varying from -1.2 T to +1.2 T. Because the integral of Xrev(H)dH is proportional to the magnetic moment (of the reversible part of the remanence, or Mrev), we can measure the reversible hysteresis parameters of ferromagnetic materials as a function of pressure. Example measurements and details of the method will be presented.

V41E-04 1105h

Frontiers of High-Pressure Research: Synchrotron Infrared Spectroscopy

Zhenxian Liu[1] (631-344-5502; zxliu@bnl.gov)

Ho-Kwang Mao[1]

Russell J Hemley[1]

[1]Geophysical Laboratory, 5251 Broad Branch Road, NW, Washington, DC 20015, United States

High-pressure spectroscopy provides crucial and often unique information on the properties of Earth and planetary materials from near-surface conditions to those of the deepest interiors. Vibrational infrared/Raman spectroscopy, for example, provides detailed information on bonding properties of crystals, glass, and melts, thereby yielding a microscopic description of thermochemical properties. The high brightness of synchrotron infrared radiation is ideally suited to high pressure investigations in which both small sample area and a narrow beam are required in order to generate extremely high pressure with a diamond anvil cell. The dedicated high-pressure beam line U2A on the VUV ring of the National Synchrotron Light Source, Brookhaven National Laboratory is an integrated facility for a wide range of microspectroscopic studies from ambient to ultrahigh pressures and at variable temperatures. The beam line has high IR brightness, particularly at long wavelengths, with its 40 x 40 mrad aperture. The facility includes a FT-IR vacuum spectrometer (Bruker IFS 66v/S) along with a nitrogen purged high-pressure, long working distance microscopes for high pressure (and variable temperature) applications, a vacuum microscope system for far IR high-pressure absorption measurements and a commercial, high-magnification infrared microscope for diffraction-limited micro-infrared measurements of samples at ambient and high pressures. Recently, the beamline has been upgraded to further improve the performance in far-IR range. The facility thus permits systematic high-pressure studies addressing a range of problems in Earth and planetary science. These studies include high pressure (and variable temperature) studies of planetary gases and ices; minerals of the Earth's crust, mantle, and core; geochemical reactions; organic geochemistry; surfaces and interfaces and whole-rock samples; and extraterrestrial samples. These investigations complement optical laser spectroscopy, x-ray diffraction and spectroscopy, and transport measurements carried out on the same materials. High-pressure studies of various ices continue, with new phases being uncovered by these methods. New far-IR measurements have been carried out to test proposed pressure-induced phase transformations in ice at low temperature. These techniques have also been applied to biological molecules under pressure. Far-IR spectroscopy measurements down to 20 cm-1 have been used to characterize the low-frequency dynamics of model heme Fe-CO compounds, including the long-sought doming mode in which the iron atom moves out of the porphyrin plane. New single-crystal CVD diamond has been characterized from the far- to near-IR, including both as-grown and annealed material. The method has also been used to examine a variety of natural diamonds. Examples of recent experiments also include studies of hydrous mineral, such as gypsum, OH-clinohumite, and OH-chondrodite.

V41E-05 1120h

Relaxation flow law of Fe_2SiO_4 olivine and spinel at high pressure: A stress and strain measurement using x-rays

Jiuhua Chen[1] (Jiuhua.Chen@sunysb.edu)

Li Li[1] (llili@ic.sunysb.edu)

Donald Weidner[1] (Donald.Weidner@sunysb.edu)

Michael Vaughan[1] (Michael.Vaughan@sunysb.edu)

[1]Mineral Physics Institute, State University of New York, ESS Bldg. SUNY SB, Stony Brook, NY 11794-2100, United States

Synchrotron x-rays have become an extremely compelling tool in studying material properties under high pressures. In addition to exploring means to reveal the information of material properties that is not obtainable before, developments using synchrotron x-rays have also enabled many reformations of traditional experiments. In this report, we present the results of stress and strain measurement at high pressures and temperatures using synchrotron x-ray diffraction and radiograph imaging techniques. For the first time, rheological properties of both the low pressure phase (olivine) and the high pressure phase (spinel) of Fe_2SiO_4 sample are derived from a single experiment. A clear strengthening in the material due to the phase transformation is observed. The stress and strain rate data measured at temperatures up to 1075K are used to derive the Periels plasticity flow law ($\varepsilon' = \varepsilon'_0 \exp(-\frac{Q}{RT}(1-\frac{\sigma}{\tau})^2)$) for each phase, and yield an activation energy and Periels stress of 480$\pm$20 kJ/mol and 6.7$\pm$0.5 GPa for olivine phase and 460$\pm$20 kJ/mol and 6.5$\pm$0.5GPa for spinel phase. Compared with existing data for San Carlos olivine, a significant weakening by increasing iron content in the structure is revealed. Technical details and data processing for the experiment will be discussed.

V41E-06 1135h

Structures and Properties of Silicate Glasses and Melts at High Pressure: Multi-nuclear 2 Dimensional Solid State NMR and Statistical Mechanical Modeling

Sung Keun Lee[1] (s.lee@gl.ciw.edu)

Yingwei Fei[1] (fei@gl.ciw.edu)

George D Cody[1] (cody@gl.ciw.edu)

Bjorn O Mysen[1] (mysen@gl.ciw.edu)

[1]Geophysical Laboratory, Carnegie Institution of Washington, Washington, DC 20015, United States

Essential to the transport and thermodynamic properties of silicates at high pressure is the full understanding of atomic arrangement of system under pressure. Whereas there have been significant progresses in our understanding of the atomic structures of crystalline materials or molecules at high pressure, much less is known about the structures of amorphous silicates including glasses and melts. This is largely because conventional X-rays or optical spectroscopy can only provide limited information of the various aspects of atomic disorder in densified amorphous silicates. Recent development and advances of 2 dimensional solid state NMR have offered much improved resolution, allowing us to probe structural details of amorphous silicates (Lee, Fei, Cody, & Mysen, Geophys. Res. Lett., 2003, 30, 1845; Lee and Stebbins, J. Phys. Chem. B., 2003, 107, 3141). Here we present recent 2D NMR (MQMAS) spectra of silicate glasses, quenched from melts at 6-15 GPa in a multi-anvil apparatus at Geophysical Laboratory, which reveals previously unknown details of melt structures at high pressure. The atomic structures of model glasses at high pressure are significantly different from those at ambient pressure and show evidence of extensive chemical ordering among highly coordinated network polyhedra, such as $^{[5,6]}$Al and $^{[5,6]}$Si, which affects corresponding macroscopic properties. New oxygen sites in serious of sodium silicate and aluminosilicate glasses with varying degree of polymerization at high pressure include $^{[5,6]}$Al-O-$^{[4]}$Si, $^{[5,6]}$Si-O-$^{[4]}$Si and Na-O-$^{[5,6]}$Si. The fractions of these sites increase with increasing pressure mainly at the expanse of Na-O-$^{[4]}$Si. The fraction of $^{[5,6]}$Al in aluminosilicate glasses increases with pressure, but decreases with increasing degree of polymerization of melts from $(Na_2O)_{0.75}(Al_2O_3)_{0.25}3SiO_2$ to $NaAlSi_3O_8$ at constant pressure. The effect of these structural changes and chemical ordering to the diffusivity and configurational thermodynamic properties of silicate glasses at high pressure were also explored using statistical mechanical modeling and quantum chemical calculations, in conjunction with information of the extent of disorder from NMR data. These results and methods shed light on a new opportunity of studying atomic structures of amorphous solids at high pressure and provide improved prospects on microscopic origins of melt properties at the earth's interior.

V41E-07 1150h

Elasticity, Equation of State, and Pressure Calibration Studies on MgO Using Ultrasonics in Conjunction with Synchrotron X-radiation

Kelly Woody[1] (kelsters99@yahoo.com)

Baosheng Li[1] (Baosheng.Li@sunysb.edu)

[1]Mineral Physics Institute, SUNY Stony Brook, Stony Brook, NY 11794, United States

Combined ultrasonic and synchrotron X-radiation techniques allow us to measure sound velocities, equation of state (unit cell parameters), and axial strain (sample length change) simultaneously at high pressure and temperature. It is feasible in the laboratory to conduct such measurements on millimeter-sized solids and liquids to P greater than 10 GPa and T around 1600K using a DIA-type apparatus (SAM85) installed at X-17B2, NSLS/BNL, and to P greater than 25 GPa and T greater than 1500K using the multi-anvil apparatus installed at GSECARS/Advanced Photon Source, University of Chicago. In this study, we report our progress in pressure calibration by simultaneously measuring acoustic velocities and P-V-T on pressure standard material MgO. These measurements not only allow redundant determination of elastic properties using equation of state and acoustic velocities, but also provide direct determination of sample pressure that can be compared with the NaCl pressure scale used in current high pressure experiments. Such experiments have been conducted up to 10 GPa and 1273K using hot-pressed polycrystalline sample. The MgO sample used in this study has P and S wave velocities within 0.2 percent of previously published data at ambient conditions. Travel times, X-ray images of sample, and X-ray diffraction spectra were collected in multiple heating/cooling cycles at various pressures during decompression. A third-order Birch-Murnaghan equation of state fit to the P-V data yielded results compatible with previous static compression data. The pressure derivatives of the elastic moduli (K and G) determined without using secondary pressure scale are compatible with previous acoustic data, but the sample pressures determined using current data are higher than those determined using equation of state of NaCl. This finding is consistent with that found in simultaneous velocity and X-ray diffraction measurements on other materials.

V41E-08 1205h

Shock Pressures, Temperatures and Durations in L Chondrites: Constraints from Shock-Vein Mineralogy

Zhidong Xie[1] (zhidong.xie@asu.edu)

Caroline Aramovish Weaver[1] (aramovich@prodigy.net)

Paul S. DeCarli[2] (paul.decarli@sri.com)

Thomas G. Sharp[1] (tom.sharp@asu.edu)

[1]Geological Sciences, Arizona State University, Tempe, AZ 85287-1404, United States

[2]SRI, International, Menlo Park, CA 94025, United States

Shock effects in meteorites provide a record of major impact events on meteorite parent bodies. Shock veins in chondrites, which result from local melting during shock loading, are the location of all high-pressure minerals. Shock veins contain igneous assemblages, produced by the crystallization of shock-induced melt, and metamorphic assemblages, produced by solid-state transformation in entrained host-rock clasts and wall rock. The mineralogy, distribution of high-pressure minerals and microstructures in shock veins provide a record of crystallization pressures and quench histories that can be used to constrain shock pressures and pulse duration. Here we report mineralogical and microstructural studies of shock-induced melt veins in L chondrites that provide insight into the impact history of the L-chondrite parent body. Eight L6 chondrites were investigated using FESEM and TEM and Raman spectroscopy: RC 106 (S6), Tenham (S6), Umbarger (S4-S6), Roy (S3-S5), Ramsdorf (S4), Kunashak (S4), Nakhon Pathon (S4) and La Lande (S4). Igneous melt-vein assemblages, combined with published phase equilibrium data (Agee et al. 1996), indicate crystallization pressures from less than 2.5 GPa for Kunashack and La-Lande to approximately 25 GPa for Tenham. Because shock veins quench primarily by thermal conduction, crystallization starts at vein edges and progresses inward. Variation in the igneous assemblage across shock veins, combined with thermal modelling, provides constraints on quench times and pressure variation during quench. Most samples appear to have crystallized prior to shock release, whereas Kunashack and LaLande apparently crystallized after pressure release. RC 106 and Tenham (both S6), which have thick melt veins with uniform igneous assemblages, crystallized under equilibrium shock pressures of approximately 22-25 GPa during shock events that lasted at least 500 ms and 50ms, respectively. The fact that S6 samples do not appear to have crystallized at a pressures greater than about 25 GPa, suggest that the impacts that produced shock veins in chondrites had low relative impact velocities.

V42A MCC: Level 1 Thursday 1330h

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

Presiding: **L F Dobrzhinetskaya,** Institute of Geophysics and Planetary Physics, University of California, Los Angeles**; J Hu,** Carnegie Institution of Washington

V42A-0317 1330h POSTER

OLIVINE LAMELLAE AND INTERSTITIAL BLEBS OF DIOPSIDE AND ENSTATITE EXSOLVED FROM MAJORITIC GARNET DURING DECOMPRESSION IN MULTIANVIL APPARATUS

Larissa F. Dobrzhinetskaya[1] (1-909-787-2028; larissa@ucrac1.ucr.edu)

Harry W. Green[1] (1-909-787-4505; hgreen@mail.ucr.edu)

[1]Inst. Geophys. & Planet. Phys. and Dept. of Earth Sciences, University of California, Riverside, CA 92521, United States

We present preliminary experimental data on the decompression of majoritic garnet primarily synthesized from a mineral mix of garnet peridotite bulk chemistry showing exsolution from majoritic garnet of olivine (Ol) in the form of oriented plates and pyroxenes as interstitial blebs. Experiments conducted at 14GPa/1673K demonstrate that all enstatite (En) and about 85% of diopside (Di) were dissolved into garnet yielding run products of approximately 40% Ol + 55% Grt + 5% Di. Garnet was found to be supersilicic with Si=3.17-3.31 p.f.u. Repeat of such experiments followed immediately by re-annealing at 13 and 12 GPa yielded exsolution of both Di and Ol. Olivine exsolved as micron-size plates nucleated within garnet on low-angle boundaries. In contrast, diopside exsolved abundantly as tiny blebs at garnet grain boundaries, exhibiting no typical exsolution microstructures. Similarly, in specimens annealed at 5 GPa after previous equilibration at 8GPa/1673K, En exsolved as small blebs at garnet boundaries. Under conditions similar to the latter experiments, interstitial blebs of natural enstatite also occur at garnet grain boundaries (Van Roermund et al., 2001) in Norwegian deep-seated (>200 km) subduction zone grt-peridotite. Our experiments show that Ol as well as En and Di may exsolve during decompression of majoritic garnets in the course of Grt peridotite exhumation. Examples of preservation of pyroxene exsolution lamellae in former majoritic garnets come from both xenoliths in kimberlites (Haggerty and Sautter, 1990; Sautter et al., 1991) as well as from very large garnets in subduction-zone peridotites (van Roermund and Drury, 1998). However, many other garnet peridotites from subduction zones contain Di, En, and/or Ol along grain boundaries within larger polycrystalline garnets and within embayments at the margins of smaller amoeboid garnets (e.g. Dobrzhinetskaya et al, 1996, Green and Dobrzhinetskaya, 2003). Such garnets also may contain rounded non-oriented inclusions of each of these minerals, or all three together, consistent with the results of majoritic garnet decompression presented above.

V42A-0318 1330h POSTER

Partitioning of H_2O on high pressure phase transformation of olivine

Toru Inoue[1] (+81-89-927-9658; inoue@sci.ehime-u.ac.jp)

Tomoyuki Wada[1] (+81-89-927-9658)

Rumi Sasaki[1] (+81-89-927-9658)

Tetsuo Irifune[1] (+81-89-927-9645; irifune@dpc.ehime-u.ac.jp)

Hisayoshi Yurimoto[2] (+81-3-5734-2243; yuri@geo.titech.ac.jp)

[1]Ehime University, Bunkyo-cho 2-5, Matsuyama 790-8577, Japan

[2]Tokyo Institute of Technology, Ookayama 2-12-1, Meguro-ku, Tokyo 152-8551, Japan

Water is the most abundant volatile component on the Earth's surface, and it has been supplied to the Earth's interiors by subducted slab. Water influences the physical properties and melting temperature of minerals. Olivine is the most abundant mineral in the

V