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This presentation illustrates results of topographic mapping and rover localization in Spirit and Opportunity landing sites. MOC/NA images, DIMES descent images, and surface Pancam and Navcam images are used to map regional and local topographic features of the landing sites. A new bundle adjustment method builds an image network with improved visual odometric data to supply enhance pointing data that are essential for high accuracy mapping and rover localization. Special 3D mapping products of the crater where Opportunity spacecraft landed are produced first time using rover images acquired from inside of a planetary crater. Traverse maps will show the comparison result of rover positions computed from the rover telemetry data with those from the image-based localization method. Analysis of the differences will be performed considering wheel slippage, IMU drift, and other factors. High quality topographic mapping products such as orthoimage base maps, 3D digital terrain models, and 3D interactive viewing tools are developed to support a series of mission operations and outreach activities, including long term science planning, rover path planning, geological mapping, wheel track property investigation, rock distribution estimation, crater modeling, and TV simulation scenes.

P33D-18 1330h POSTER

Web-based Data Information and Sharing System Using Mars Remotely Sensed Datasets

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It is well known within the planetary science community that a considerable amount of time can be dedicated to Mars data preparation before one is able to actually conduct remote sensing analyses. A prototype system developed at the Center for Nuclear Waste Regulatory Analyses (CNWRA) reduces such time by optimizing the process of locating, preparing, and retrieving MOLA PEDR, MOLA MEGDR and Themis VIS/IR datasets. A graphical user interface allows for searching data spatially, temporally, or by keywords. Spatial searches are done either by drawing a box around a map location or by entering coordinate values in planetographic/planetocentric latitude and west/east longitude coordinate systems. Temporal searches may be conducted by searching for specific Themis IR and VIS release dates. Key word searches may be conducted by searching for a particular MOLA PEDR orbit number. The retrieved data is provided in either a native format (such as ASCII for MOLA PEDR datasets) or in a format selected by the user and based on the chosen value-added product. In the case of MOLA PEDR datasets, the user can choose between two interpolation methods (Delaunay-based or natural neighbor) and may receive data in a TIFF or raster grid format. Natural neighbor interpolation produces fewer artifacts, but it is computationally intensive. The time required (minutes or tens of minutes compared with fractions of seconds used by the first method) makes it necessary to provide the user with an email notification once the interpolated dataset becomes available. The interpolated data provide effective resolution that approaches 150 m compared to the PEDR resolution of 300 m. In the case of Themis IR and VIS, data may be provided as one B/W single band image or as three-band color composite image in several raster formats. This system was successfully used to analyze Walla Walla Vallis (approximately 305.3 to 305.6E, 9.4S to 9.9S) and Aromatum Chaos/Ravi Vallis (approximately 315E to 322E, 1N to 2S) outflow channels. For Walla Walla Vallis (name provisionally approved by the International Astronomical Union), a small outflow channel, the integrated datasets helped resolve the locations of reaches that were indistinct in visible light images. For Ravi Vallis, the composite data system enhanced our understanding of how some chaotic terrain forms. As presented by Coleman, N.M. (2004 Lunar and Planetary Science Conference, Abstract #1299), thinning of the cryosphere by deep fluvial incision spawned secondary breakouts of groundwater, forming new chaos zones. The systems flexible design allows for incorporation of additional remote sensing datasets, such as those provided by MOC, TES, and MARSIS instruments. In summary, our integrated data-access system will make the wealth of new Martian data more readily available to planetary researchers enabling scientists to focus more time on analyses or algorithm development rather than on finding data and format conversions. Disclaimer: An employee of the U.S. Nuclear Regulatory Commission (NRC) made contributions to this work on his own time apart from regular duties. NRC has neither approved nor disapproved the technical context of this abstract.

P41A CC: 519 B Thursday 0830h

Physicochemical Properties of Planetary Cores I *(joint with S, T)*

Presiding: **J Badro,** Institut de Physique du Globe, Universite Paris VI; **R A Secco,** University of Western Ontario

P41A-01 0830h INVITED

Is Core Composition affected by Core-Mantle Interaction?

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The initial composition of a planetary core is the legacy of formation (the T and P paths of the constituent materials and the extent to which chemical equilibrium with the mantle phase is possible along those paths). It is conventional to consider the subsequent evolution as "closed", with the only changes arising through the redistribution across the inner core-outer core boundary as central freezing proceeds. This is reasonable if one thought that transport across the CMB were limited by solid state diffusion, since this process is inefficient even on billion year time scales. However, there are three reasons to question "core closure": (1) As the core cools, it is likely to become supersaturated in the least soluble mantle constituents, probably MgO and perhaps a high pressure phase of silica or magnesium perovskite. This material will sediment upwards to the underside of the CMB, helping to drive core convection and possibly providing an energy source for the geodynamo. If a wet adiabat develops (analogous to earth's troposphere), it may change the convective and even seismic properties of the outermost outer core. The outer core need not be compositionally uniform vertically in this picture (but still must have horizontal uniformity of density), despite vigorous convection. (2) Seismic evidence suggests that the lowermost mantle is partially molten. One possible aid to this melting is the presence of excess hydrogen fugacity in the core relative to the partially degassed mantle. Hydrogen is particularly interesting as the only chemically active element that also may have fast solid state diffusivity. In addition, the presence of liquid pathways may provide much higher chemical interaction because of the much higher diffusivity in liquid coupled with circulation or transport of the melt. (3) Independent of this, metasomatism of the topographic relief (a kilometer) at the CMB can arise to the extent that core fluid develops permeable pathways in the mantle rock (a property that depends on unknown surface tension properties).

P41A-02 0900h

Experimental Study of U,Th Solubility in Earth's Core: Toward a Solution of the Core Cooling Paradox

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Radioactive heating in the core has recently become a topic of renewed interest in core dynamics and inner core growth. We present our experimental results on the solubility of U and Th in Fe and Fe-S liquids under different temperatures and pressures using a Walker module multi-anvil press. Recovered run products were analyzed by LA-ICP-MS. Our results show that U and Th are both soluble in FeS and Fe melts. At 3 GPa , 1750°C, D_U, the partition coefficient of U (concentration of U in FeS or Fe / concentration of U in silicate), ranges from 0.03 to 0.33, which is much larger than 0.013 from Murrell et al (1984) at 1.5 GPa, 1450°C. At 9.4 GPa, 1750°C, D_U reaches 0.094. Considering only the samples with FeS, including the result from Murrell et al, there is a trend of increasing D_U with pressure. Similarly, D_{Th}, the partition coefficient of Th ranges from 0.011 to 0.152 at 3 GPa, 1750°C. When pressure is increased to 9.4 GPa and at1750°C, D_{Th} reaches 0.101. A similar trend of increasing D_{Th} with pressure is observed. These experimental results indicate that under high temperature and high pressure, U and Th can enter the Fe and FeS phases in significant amounts. The implications for U and Th radioactive heating in the core of Earth and other planetary bodies will be discussed.

P41A-03 0915h

A Seismically Constrained Composition Model of Earth's Core

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We measured longitudinal sound velocities in light-element alloys of iron (FeO, FeSi, FeS, and FeS_2) at high pressure by inelastic x-ray scattering. This data set provides a mineralogical constraint on the composition of the Earth's core, and completes the previous set formed by the compressibility and density of these compounds. The combination of these data sets and their comparison with the reference Earth models derived from seismology enables us to determine an average composition of the Earth's core. We show that the incorporation of small amounts of silicon or oxygen alone is compatible with geophysical observations and geochemical abundances.

P41A-04 0930h INVITED

Iron Melting at the Physical Conditions of the Core

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We will report new and re-analyzed sound velocity measurements of shock compressed iron at Earth-core conditions. The sound velocity data show that melting starts at 225±3 GPa (5100±500°K) and is complete at 260±3 GPa (6100±500°K), both on the Hugoniot. This is a lower melting pressure than previously reported. Also, no statistically conclusive evidence for a previously reported solid–solid phase transition on the Hugoniot near 200 GPa was observed. We will discuss the implications of these findings on the Fe phase diagram. Our recent efforts on temperature measurement at high pressure-temperature conditions, and dynamic compression along planetary isentrope will also be reported.

P42A CC: 519 B Thursday 1030h

Physicochemical Properties of Planetary Cores II *(joint with S, T)*

Presiding: **J Badro,** Institut de Physique du Globe, Universite Paris VI; **R A Secco,** University of Western Ontario

P42A-01 1030h INVITED

Liquid Core Materials: Pressure-effect on Their Density, Structure and Chemical Properties.

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Knowing the physical properties of Fe-based liquids would greatly improve our understanding of the composition of planetary cores as well as their formation. A complementary approach is the experimental determination of ternary and quaternary phase diagrams. At ambient pressure, ternary diagrams of potential liquid core materials show a large gap of miscibility (Fe-S-Si, Fe-FeO and Fe-S-C systems). This would limit for instance the solubility of Si in a primary Fe-S melt percolating through the surrounding silicates during planetary differentiation.
Two issues will be addressed: 1) what are the equations of state of simple binary liquid Fe-alloys?, and 2) how the Fe-S-Si ternary diagram evolves with pressure in terms of im/miscibility? Density of liquid Fe-Si alloys was measured *in situ* at high pressure by an X-ray absorption technique using synchrotron radiation. We compare the equations of state of Fe, Fe-Si and Fe-S liquids to identify the effect of light elements, Si *vs* S, on the compressibility, local order and P-waves velocity of these materials. These data give us a basis to apprehend more complicated though more realistic ternary systems. We report melting experiments in the Fe-S-Si system conducted in a multi-anvil apparatus up to 27 GPa. The chemical evolution of both liquids with pressure and temperature is followed by *in situ* x-ray diffraction experiments. The experiments document the change of melting relations with increasing pressure. The results have important implications for the differentiation processes of the planets and the composition of their cores.

P42A-02 1100h

Equation of State of Liquid Fe-17wt%Si: Si in the cores of planetary bodies?

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It is widely accepted that 8-18wt% light elements in the Earth's outer core can explain the 10% density deficit compared to the pure Fe at the core pressure and temperature. Si is one of the most probable light elements in the outer core and is also a candidate for other planetary bodies (Mars, Ganymede, Io). In this study, equation of state (EOS) of liquid Fe-17wt%Si is being explored to investigate the possible existence of Si in the cores of planetary bodies. Sink-float static high pressure density measurement technique with composite spheres is used to bracket the liquid density by either sinking, floating or neutrally buoyant markers. The composite spheres consist of a Pt or WC core and a ruby mantle, with adjustable density by changing the radius ratio of the core and mantle material, thus increasing the range of density measurement and accuracy of bracket value. The chemically inert mantle efficiently protects the metal core from reacting with the sample. The high density of Pt/WC core ensures a composite sphere with high enough density and relative small volume to be accommodated within the pressure cell. Density of the probe spheres at high P, T was calculated from the post-experiment geometric analyses according to the areal ratio of the mantle and core materials. Compressibility and thermal expansion coefficients of these materials were used in the third-order Birch-Murnaghan EOS to calculate composite sphere density. The density of liquid Fe-17wt%Si at room pressure was estimated to be approximately 5.86 g/cm^3, which is taken as a reference for constructing a reliable EOS. The results of experiments so far to 8GPa and at 1773K will be reported.

P42A-03 1115h

Alloying effects of Ni, Si, and S on the phase diagram and sound velocities of Fe under high pressures and high temperatures

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Iron-nickel is the most abundant constituent of the Earth's core. The amount of Ni in the core is about 5.5 wt%. Geophysical and cosmochemical studies suggest that the Earth's outer core also contains approximately 10% of light element(s) and a certain amount of light element(s) may be present in the inner core. Si and S are believed to be alloying light elements in the iron-rich planetary cores such as the Earth and Mars. Therefore, understanding the alloying effects of Ni, Si, and S on the phase diagram and physical properties of Fe under core conditions is crucial for geophysical and geochemical models of planetary interiors.
The addition of Ni and Si does not appreciably change the compressibility of hcp-Fe under high pressures. Studies of the phase relations of Fe and Fe-Ni alloys indicate that Fe with up to 10 wt% Ni is likely to be in the hcp structure under inner core conditions. On the other hand, adding Si into Fe strongly stabilizes the bcc structure to much higher pressures and temperatures (Lin et al., 2002). We have also studied the sound velocities and magnetic properties of $Fe_{0.92}Ni_{0.08}$, $Fe_{0.85}Si_{0.15}$, and Fe_3S alloys with nuclear resonant inelastic x-ray scattering and nuclear forward scattering up to 106 GPa, 70 GPa, and 57 GPa, respectively. The sound velocities of the alloys are obtained from the measured partial phonon density of states for ^{57}Fe incorporated in the alloys. Addition of Ni slightly decreases the V_P and V_S of Fe under high pressures (Lin et al., 2003). Si or S alloyed with Fe increases the V_P and V_S under high pressures, which provides a better match to seismological data of the Earth's core. We note that the increase in the V_P and V_S of $Fe_{0.85}Si_{0.15}$ and Fe_3S is mainly contributed from the density decrease of adding Si and S in iron. Time spectra of the nuclear forward scattering reveal that the most iron rich sulfide, Fe_3S, undergoes a magnetic to non-magnetic transition at approximately 18 GPa from a low-pressure magnetically ordered state to a high-pressure non-magnetic ordered state. The magnetic transition significantly affects the elastic, thermodynamic, and vibrational properties of Fe_3S. It is conceivable that the magnetic collapse of Fe_3S may also affect the binary phase diagram of the iron-sulfur system, changing the solubility of sulfur in iron under higher pressures. Study of the non-magnetic phase is more relevant to understand the properties of the Fe_3S under planetary core conditions where high pressures and high temperature ensure the non-magnetic ordering state, affecting the interpretation of the amount and properties of sulfur being in the planetary cores. If the Martian core is in the solid state containing 14.2 wt% sulfur, it is likely that the non-magnetic Fe_3S phase is a dominant component and that our measured sound velocities of Fe_3S can be used to understand the velocity profile in the Martian core.

P51A CC: 519 B Friday 0830h

Subsurface Radar Investigations of Terrestrial Martian Analogues I *(joint with GP, H, V, NS)*

Presiding: **E Heggy,** Lunar and Planetary Institute**; S Arcone,** Cold Regions Research and Engineering Laboratory (CRREL)**; S Clifford,** Lunar and Planetary Institute

P51A-01 0835h

Subsurface Radar Investigations of Terrestrial Martian Analogues: Introduction to the Session

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The Mars Exploration Program has identified the search for subsurface water on Mars as a key investigation towards understanding the hydrologic and geologic history of the planet and for identifying potential environments for the survival of primitive life forms. During the coming decade, a variety of geophysical tools will be used to address this task in an effort to reduce the ambiguities concerning the state, distribution and total abundance of water within the Martian crust. Over the next decade, this search for water will involve as many as three different radar sounding instruments, operating over a combined frequency range of 0.5 MHz - 1 GHz. The ability of these radars to detect and identify the presence of liquid water will and further subsurface features strongly depend on the physical properties, mineralogy and thermal structure of the Martian subsurface, especially by the way in which these properties influence the electrical and magnetic characteristics of the crust. Our understanding of the data returned by such investigations, will benefit from geophysical studies of terrestrial analog environments, such as the arctic, volcanic terrains and arid deserts. An important complement to these field investigations will be the electromagnetic characterization of rock and soil samples retrieved from these analog sites, mineralogical matches to the composition of the Martian regolith inferred from orbital and landed investigations, and the SNC meteorites.

P51A-02 0850h

Electromagnetic Subsurface Soundings at HF frequencies and Antenna Impedance Measurements on the Antarctic Continent

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In the frame of the NETLANDER project, a ground penetrating radar (GPR) dedicated to the exploration of the Martian subsurface has been developed. This GPR is designed for deep sounding down to a depth which is sufficient to allow possible detection of liquid water and thus operates mainly at a frequency of 2 MHz. Contrary to the normal mode of operation of subsurface radars which can be moved over the soil to be explored, the GPR of NETLANDER aims at performing 3D imaging of the underground reflecting structures even if it operates in a fixed position. This is achieved by retrieving not only the distance of the reflectors but also the direction of the backscattered waves by measuring the 2 horizontal electric components and the 3 magnetic components of the reflected waves. Two perpendicular dipoles each consisting in two 35-meters electric monopoles are used for both transmission and reception, while the receiving magnetic antenna can be successively directed along 3 mutually orthogonal directions. In addition, the perfect stability of the environment allows a very large number of coherent integrations to be performed, which provide a satisfactory sensitivity Ground tests were recently carried out on the Antarctic continent in 2004. Soundings at frequencies in the range 2-5 MHz have been performed with the NETLANDER monostatic GPR prototype and with the updated version of this instrument, which operates in a real bistatic mode. As expected the echoes due to interaction with the bedrock are detected and the magnetic component measurements provide information linked to the orientation of the reflecting structures. The first experimental results will be reported. We will present results on the electric antenna impedance measurements, which give information on the permittivity of the upper subsurface layer. We will also focus on the analysis of the backscattered signals using both electric and magnetic components of the received field. Comparisons with numerical simulations taking into account the actual environment of the GPR will also be presented.

P51A-03 0905h

The SORA experiment: a test of the penetreting radar SHARAD of the Mars Recoinnassance Orbiter mission

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