3D images to the deep crustal structures provides additional constraints on how to improve the understanding of the driving' geodynamic processes.

T31D-02 0855h INVITED

Volcanic Productivity During Continental Breakup from Numerical Models of Mantle Convection with Application to Atlantic Rifted Margins

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One of the most remarkable results of several decades of rifted margin research in the Atlantic has been the recognition that these margins show extreme variability in magmatic productivity at the time of breakup, ranging from essentially none along Newfoundland-Iberia to more than 30 km thick new igneous crust along Greenland and Norway. The underlying causes and processes responsible for this diversity remain the subject of intense debate. While mantle potential temperature is clearly one dominant parameter other factors have also been proposed. In this contribution we use a numerical model of mantle convection and a rifting lithosphere to investigate melt productivity during breakup and the establishment of a steady-state, passive seafloor spreading system. The model incorporates a non-Newtonian, temperature dependent viscosity that includes the feedback from melting on the physical properties of the mantle. The models show that some small-scale convection can occur during breakup, but that only modest excess productivity results from models that evolve naturally into steady-state mid-ocean ridge-like accretion. We use the model to quantify the spatial and temporal scales of volcanism associated with continental breakup under a variety of different assumptions about the viscosity, density, and thermal structure of the upper mantle. The implications of these results for understanding melt productivity observed along the Greenland margins and the Newfoundland-Iberian margins is then discussed.

T31D-03 0915h

Refraction Seismic Study in Davis Strait: The Nature of the Crust at the Transform-Rifted Margin Between Baffin Island and Greenland

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Understanding the crustal structure within Davis Strait is important for assessing the early history of mantle plume dynamics in the North Atlantic and the formation of a rifted transform margin between North America and Greenland. In August/September 2003, the NUGGET (NUnavut to Greenland GEophysical Transect) experiment was carried out in Davis Strait. The purpose of the refraction seismic study was to determine the nature of the crust in southern Davis Strait at the transition from non-volcanic style continental margins in Labrador Sea to a volcanic transform-rifted margin between Baffin Island (Canada) and West Greenland. The experiment consisted of two lines utilizing a 104-liter tuned airgun array and ocean bottom seismometers (OBS) equipped with three-component geophones and a hydrophone. Line 1 is a 620-km long East-West transect running from southern Baffin Island to Nuuk, Greenland, crossing four exploration wells. 28 OBS were deployed along the line and the data are of excellent quality. The large Ungava transform fault system crosses this line and the velocity model will provide information on the identification of possible magmatic underplating and how this fault interacted with the Greenland-Iceland plume. Line 2 is a 185-km long North-South transect running from Davis Strait into Labrador Sea, where it lies within the transitional crust of the Greenland margin. 15 OBS were deployed along Line 2 and initial analysis of the data indicates a significant lateral velocity change from north to south. The northern part of the line probably consists of thinned continental crust. The southern part, however, consists of a 12-km thick layer with P-wave velocities ranging from 6.8 to 7.0 km/s, below a 3.5-km thick layer with velocities >4.4 km/s. The depth to Moho is ~19 km. This velocity model probably indicates that there is over-thickened oceanic crust in the transition zone of the Greenland margin, which suggests that volcanic activity in Davis Strait extended farther south than previously thought.

T31D-04 0930h

The Limit of Volcanic Rifting: A Structural Model Across the Volcanic to Non-volcanic Transition off Nova Scotia

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The rifted continental margin along much of the Atlantic coast of eastern North America is classified as volcanic, with thick sequences of igneous material emplaced at the continent-ocean transition during Late Triassic to Early Jurassic rifting. A strong, linear magnetic anomaly (ECMA) is observed along the margin from the Blake Spur fracture zone to the Scotian margin, coincident with seismic images of seaward dipping reflectors (SDRs). Along the SW Scotian Margin, the anomaly changes character, becoming lower in amplitude, disjointed and weaker as it fades to the east into the regional background level. The loss of magnetic signature and disappearance of SDRs have suggested that most of the Scotian margin is primarily non-volcanic, with the transition starting northeast of the New England seamounts. Three wide-angle seismic reflection / refraction lines were collected in 2001 across the continental margin and deep sedimentary basin offshore Nova Scotia to investigate the transition in rifting style. Line 3 crossed the ECMA at the SW end of the margin, where sediment thickness is less than 10 km. The velocity model shows a 120 km-wide transition zone separating thinned continental crust from oceanic crust. P-wave velocities in the upper and lower layers of the transition zone average 6.2 and 7.2 km/s, consistent with velocities for the transition zone off the US Atlantic margin where the volcanic nature has been well-established. The upper surface of the transitional crust is coincident with SDRs, and magnetic models also support an interpretation of volcanic origin. However, total thickness of the transitional crust is only 10 km, significantly thinner than the interpreted 15 to 20+ km of igneous material interpreted off the US. Oceanic crust adjacent to the transition zone is less than 6 km thick, suggesting a change to conditions that inhibited melting during the early stages of formation of oceanic crust. These observations allude to considerable complexity associated with the gradual reduction in volcanism, and eventual transition to a non-volcanic style of rifting, along the Scotian margin.

T31D-05 0945h

The Nature of the Passive Margin in the Area of the Canary Islands, Central Atlantic Ocean

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The Canary Islands (CI) form a roughly E-W trending island chain normal to the coast of Africa. The base of the continental slope lies only 30-40 km east of the easternmost island, Fuerteventura. The oceanic lithosphere beneath CI formed about 180-150 Ma ago, during the earliest stages of opening of the central Atlantic Ocean (e.g. Roest et al., 1992). The CI hotspot has been active during the last 60-70 million years (Geldmacher et al., 2001). Detailed studies of mantle and crustal xenoliths from different islands, including point analyses of trace elements and 87Sr/86Sr isotopic ratios in minerals, show that the lithosphere beneath CI consists of highly depleted oceanic crust and upper mantle that have been metasomatized to different degrees during the CI intraplate event. The original composition of the upper mantle is best preserved in the REE concentrations in ol and opx porphyroclasts and in cpx neoblasts in the most refractory spinel harzburgite xenoliths. These are strongly depleted in MREE relative to HREE. LAM-MC-ICPMS Sr isotope analyses of cpx in these xenoliths give 87Sr/86Sr ratios of 0.7027-0.7028. This is within the range of N-MORB and significantly below the range of CI basaltic rocks (=0.7030). Modeling based on major and trace elements in the most refractory sp harzburgites suggests that the lithospheric mantle beneath CI represents the residue after about 25 percent depletion relative to the Primordial Mantle. Such a high degree of partial melting results in complete exhaustion of cpx. In these rocks cpx appears mainly as small neoblasts along the boundaries of opx porphyroclasts, and is believed to be the results of exsolution of opx, followed by recrystallization. Cpx in more highly metasomatized peridotites give 87Sr/86Sr ratios in the range 0.7029-0.7033, and have flat to LREE-enriched REE patterns. Two types of gabbroic xenoliths have been retrieved. One type, dominated by augite+plag+hornblende+mt+-ol, is interpreted as cumulates formed from alkali basaltic Canarian magmas. The other type (opx-gabbros) is mildly deformed and consists of ol+cpx+plag+-opx. Some of these show evidence of reactions with enriched magmas. Cpx and opx in the most pristine opx-gabbros have strongly depleted REE patterns. Estimates indicate formation of the opx-gabbros from N-MORB parent melts with (La/Sm)N=0.16 and (Sm/Yb)N=0.52; that is among the lowest ones recorded for MORB magmas. We conclude that in the area of CI, the oldest oceanic lithosphere was highly depleted. There is no evidence that transitional melts were involved in the formation of the oldest oceanic crust in this part of the Atlantic Ocean. Furthermore, there is no evidence that continental lithosphere is present anywhere beneath the Canary Islands. The continent-ocean transition in the area of the Canary Islands thus appears to be quite sharp, located just east of the easternmost CI, and to be quite different from the 80-130 km wide continent-ocean transition zone found further north in the Iberia Abyssal Plain (e.g. Whitmarsh and Sawyer, 1996). Geldmacher et al., 2001. J. Volc. Geotherm. Res. 111, 55-87 Roest et al., 1992. Marine Geophys. Res. 14, 1-24 Whitmarsh and Sawyer, 1996. Proc. ODP Scientific Res. 149, 713-733

T32A CC: 516 B Wednesday 1030h

Mineral Physics Perspectives on the Structure, Composition, and Dynamics of Earth's Deep Interior

(joint with S, V, MR, SEDI)

Presiding: **J Badro,** Institut de Physique du Globe, Universite Paris VI**;** **D Farber,** Lawrence Livermore National Laboratory

T32A-01 1030h INVITED

Direct measurements of sound velocities of iron with nuclear resonant inelastic x-ray scattering under high pressure and temperature

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Iron is the most abundant component in the Earth's core. Understanding the physical properties of Fe under core conditions is crucial for interpreting the seismological and geomagnetic observations deep in the Earth's interior. The physical properties of Fe have been extensively studied by dynamic and static high-pressure experiments and theoretical calculations, but direct static measurements of the sound velocities of

iron under high pressures and temperatures are still lacking. 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. Sound velocities of iron have been directly measured up to 58 GPa and 1700 K in a laser-heated diamond cell. The ''detailed balance'' principle applied to the inelastic X-ray scattering spectra provides absolute temperatures of the laser-heated sample. These temperatures are in very good agreement with values determined from the thermal radiation spectra fitted to the 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. We found that temperature has a strong effect on the sound velocities; the compressional (V_P) and shear wave velocities (V_S) of hcp-Fe decrease significantly with increasing temperature under high pressures. V_P and V_S are only linearly related to the density for a given, constant temperature, while the bulk sound velocity (V_ϕ) follows Birch's law, i.e., V_ϕ is linearly related to the density and mean atomic weight. The linear sound velocity-density line should be corrected to lower velocities in extrapolations to inner core conditions. Our results have important implications for understanding the sound velocities of the Earth's inner core as well as the fundamental physical properties of iron under extreme pressures and temperatures.

T32A-02 1045h

Bulk Properties of FeO under Zero and High Pressure Conditions

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Determining the effect of Fe on the chemical and physical properties of lower mantle minerals is fundamental to interpreting lower mantle seismic data. While ab initio computaional modelling has proven to be an invaluable tool for Fe-free systems, there are serious problems with these techniques when applied to transition metal oxides (ref to Cohen). For example, Density Functional Calculations (DFT) predict FeO to be metallic when in fact it is a wide band-gap insulator. In this study we use different hybrid functionals between Hartree-Fock and DFT as an alternative to the traditional apporaches of LDA+U and Self-configuration interactions (SIC) calculations. We determine the geometrical structures and bulk properties of different magnetic and crystallographic structures of FeO and find that the different functionals predict quite different elastic properties. By comparing with available electronic and structural experimental data, we suggest an optimum range of mixing between HF and DFT. Using this we find that the anti-ferromagnetic (AFM) NaCl-structure (B1) is the energetically most stable structure at zero temperature and pressure, and we also obtain a lattice parameter (4.36 Å) and bulk modulus (185 GPa) in good agreement with experimental values (4.34 Å and 179 GPa). Moreover, we also predict a wide band gap. We have also calculated the pressure at which stoichometric FeO undergoes a phase transition from the distorted B1 to B8 (NiAs-type) structure. This ranges from 75 to 183 GPa, depending on which method we use. Our preferred mixing predicts a phase transition of ca. 90 GPa. This phase transition is associated with a high spin (tg3, eg2, tg1) to low spin (tg3, tg3) transtion of the Fe2+ ions. Experimentally the reported observations disagree with each other. Mossbauer measurements report a high spin to low spin transtion between 90-140 GPa (Pasternak MP et al. (1997) PR Letters. 79: 5047-5049), while X-ray emission spectroscopy suggest a preserved high spin state up to 143 GPa (Badro J et al. (1999) PR. Lett. 83: 4101-4104). Our calculations, using our preferred mixing, are, thus, in favour of the observations from Mossbauer spectroscopy.

T32A-03 1100h INVITED

Post-Perovskite Phase Transition in $MgSiO_3$

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$MgSiO_3$-perovskite is believed to be a principal mineral at least in the upper part of the lower mantle, but its stability and possible phase transition at greater depths remain uncertain. Since seismic observations have shown unexplained features in the lowermost mantle, solid-solid phase transitions that could occur in this region are under debate. We performed in-situ X-ray diffraction measurements of $MgSiO_3$ at high pressure and high temperature at BL10XU of SPring-8. Experiments were made in a laser-heated diamond anvil cell (LHDAC) up to 134 GPa and 2600 K corresponding to the conditions of core-mantle boundary region. $MgSiO_3$ gel mixed with platinum powder was used as starting material. Results demonstrate that $MgSiO_3$-perovskite transforms to a new high-pressure form with stacked SiO_6 octahedral sheet structure above 125 GPa and 2500 K (2700-km depth near the base of the mantle) with an increase in density by 1.0-1.2 %. The transition pressure coincides with the depth of the D" seismic discontinuity, and its origin may be attributed to this post-$MgSiO_3$-perovskite phase transition. The new phase is likely to have strong single-crystal elastic anisotropy and develop shape preferred orientation with a platy crystal habit in the shear flow. This can cause seismically detectable anisotropy below the D" discontinuity. We observed similar phase transition in $MgGeO_3$ above 70 GPa. The post-perovskite phase of $MgGeO_3$ transformed to a different form upon decompression at room temperature.

T32A-04 1115h

Elasticity of Polycrystalline Py50Mj50 to 9 GPa and 1000K by Ultrasonic Inteferometry with Synchrotron X-radiation.

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Compressional (P) and shear (S) wave velocities have been measured on dense (99.5% of theoretical density), elastically isotropic polycrystalline Py50Mj50 to 9 GPa and 1000K using ultrasonic interferometry, in conjunction with in-situ synchrotron x-ray diffraction and imaging techniques. Fine-grained polycrystalline specimens of Py50Mj50 were fabricated in a 2000-ton uniaxial split-sphere apparatus at 16 GPa and 1500aC for 4 hrs, from a homogeneous glass starting material. The physical properties of the recovered specimens have been characterized with density measurements and x-ray diffraction. Elastic compressional and shear wave velocities determined at room temperature and pressure are in excellent agreement with the Hashin-Shrikman averages calculated from single-crystal elastic moduli. Travel times of acoustic P and S waves were measured to 9 GPa and 1000K in a DIA-type cubic anvil high-pressure apparatus (SAM-85) interfaced with synchrotron x-radiation and x-ray imaging. We will present results of the pressure and temperature derivatives of the elastic moduli and equation state of Py50Mj50 and discuss implications of the new results on velocity gradient in the transition zone of the Earth's mantle.

T32A-05 1130h

First-principles determination of element partitioning in multi-component systems

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Element partitioning of low concentration solutes in multi-phase systems is an important problem in high-pressure high-temperature mineral physics. Theoretical prediction of partitioning coefficients is especially important because precise thermodynamic equilibrium is not easily realizable in high-pressure experiments. To our knowledge, this problem has not been addressed by first principles yet. In this study we develop the general formulation for calculating partitioning coefficients and calculate it for a system of utmost importance in geophysics: partitioning of Fe^{2+} between $(Mg_{1-x},Fe_x)SiO_3$-perovskite and $(Mg_{1-y},Fe_y)O$, the dominant aggregate in the Earth's lower mantle. In this first principles pseudopotential study thermodynamic properties have been obtained from free energy computations using the quasiharmonic approximation in conjunction with vibrational densities of states obtained from linear response calculations of phonon frequencies. The method, its applicability to actual systems, and the nature of the predictions will be discussed in the context of various experiments. Research supported by NSF/EAR, COMRPES, and JSPS

T32A-06 1145h

Insights on the thermochemical state of the lower mantle

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The thermochemical state of the lower mantle is still a underdetermined problem. The increasing availability of first principles results on partitioning coefficients and thermoelastic properties is helping to reduce the number of independent unknowns and to improve the accuracy of predicted aggregate properties at pertinent conditions. In a first step, the information contained in seismic models should be interpreted in light of mineral physics results. In a second step, the outcome should be tested against constrained inferences and observables. We report here some steps taken in this direction. The procedure is based on a comparison between results from 1D seismic models and calculated thermoelastic properties of multi-component systems in thermal equilibrium. Presently the analysis is restricted primarily to systems with three components and two phases only ((Mg,Fe)O and (Mg,Fe)SiO_3-perovskite) for which detailed first principles thermoelastic properties are available. Research supported by NSF/EAR, COMRPES, and JSPS

T32B CC: 516 D Wednesday 1030h

The Structure and Formation of Atlantic Rifted Margins: Observations and Numerical Models II *(joint with GP, S, V, NS)*

Presiding: **K E Louden,** Dalhousie University**; S Dehler,** Geological Survey of Canada

T32B-01 1030h INVITED

Structural And Depositional Style Of The Syn-Rift Systems Of The West African And Brazilian Continental Margins: Regional Subsidence Independent Of Brittle Deformation

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The West African and Brazilian passive continental margins are characterized by the regional distribution of syn-rift and post-rift sediment assemblages that are inconsistent with the minor amounts of brittle deformation interpreted from seismic sections across the margin or from field mapping of exposed rift systems. Fundamentally, the rift phase of West Africa and Brazil consists of a series of stacked sag basins. Ostracod data from the West African margin indicate that the distal syn-rift sag basins, where dated, are Neocomian to Aptian in age and are contemporaneous with proximal syn-rift deposits developed inboard of a major hinge zone, the Atlantic Hinge zone. Despite being syn-rift deposits (by virtue of their age), the sag basins exhibit none of the diagnostic characteristics of brittle deformation, such as the existence of normal faults, the rotation of crustal blocks, the existence of prominent rift onset unconformities (onlap surfaces), and the generation of sediment wedges. Seismic sections across the Camamu-Almada margin of Brazil indicate that the regional generation of space is essentially independent of faulting, as indicated by an absence of stratigraphic growth across normal faults and a regional seaward dip of the entire syn-rift stratigraphic package. The