for independent corroboration of a young, major, deep-water gateway through the Fram Strait.

### T12D-0499 1330h POSTER

## Axial Seamount crustal structure inferred from gravity modeling and seismic constraints

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Axial seamount is a young and active volcano, located at the intersection of the intermediate spreading rate Juan de Fuca Ridge and the Cobb hot spot (46N, 130W). Similar to the adjacent mid-ocean ridge, intermittent lava flows at Axial have built a volcanic edifice. Likewise, rifting has occurred at Axial's summit caldera. The caldera walls of Axial Seamount and the axial valley walls on the Juan de Fuca Ridge are of similar vertical extent. However, Axial stands 700 m higher than the rest of the nearby Juan de Fuca Ridge. This paper presents results from a recent gravity survey and modeling of Axial Seamount's crustal structure. In general, the narrower a feature, the more a traditional slab approximation underestimates bulk density. Initial density determinations of Axial and other seamounts have been low and then refined (e.g. Hildebrand, et al., 1990). A usual practice is to assume some higher density, such as a standard density of 2670 kg/$m^3$ and then model features of interest, such as density excesses or deficiencies. Taking topographic effects into consideration, this paper presents a new method of modeling bulk density and application of the method to Axial. Using constraints on crustal density from seismic velocity (West et al., 2001) and new gravity data, this paper presents a model of low bulk density crust. Combining geophysical information from gravity and seismic surveys, results of gravity modeling are presented here, which place new constraints on upper crust porosity and seamount evolution.

### T12D-0500 1330h POSTER

## Hydrothermal circulation and subsidence of ocean basins : a case study from the South-East Indian Ocean

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The South-East Indian Ridge (SEIR) flanks between 105°E and 130°E are characterized by anomalously low subsidence rates, less than about 280 m/sqrt(Ma) [Hayes and Kane, JGR, 1994]. While individual estimates of the upper mantle temperature variations below the SEIR axis may vary significantly from one study to the other, all geophysical (axial morphology, seismology and geoid) and geochemical (major and trace elements systematics) evidence is compatible with variations of less than about 100°C. Such a temperature anomaly is not sufficient to fully explain the observed anomalously low subsidence rates, using the present available models for the thermal evolution of the lithosphere. Ad hoc explanations, such as, for instance, variations in mantle thermal parameters cannot be readily rejected, but are not completely satisfactory because they cannot be supported by direct estimates. In contrast, of direct evidence is the lack of sedimentation that characterizes the flanks of the SEIR and the fact, recognized from heat flow data, that in absence of sediment cover, seawater penetrates into the ocean crust and plays a key role in the mechanisms of heat transfer through the seafloor. Although it is now widely accepted that seawater may penetrate massively into poorly sedimented off-axis crust, the contribution of water circulation to the seafloor subsidence rate has only been considered so far near crestal areas, but not at the scale of tens of millions years. We thus propose a simple model which assumes, at first approximation, that seawater penetrates into highly permeable off-axis crust to a depth H below the seafloor and maintains the temperature equal to Tc at that depth (Note : H may depend on age crust). Assuming that hydrothermal circulation is active over large periods (of tens of Ma, for instance), the subsidence rate is controlled by Tm-Tc. The model thus predicts that variations in the hydrothermal regime, by affecting Tc, may affect the subsidence rate. Estimates for the best fitting values of Tc and H are proposed and discussed. Agreement with re-assessed subsidence estimates a posteriori supports the model hypothesis, suggesting that in absence of sedimentation sealing the upper crust, anomalously low temperatures could be forced for tens of millions of years, down to the base of the layer penetrated by the diffusive seawater circulation.

### T12D-0501 1330h POSTER

## Micro-earthquake seismicity of the Mid-Atlantic ridge at 5°S: a different style of tectonic extension

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Based on an ocean-bottom micro-earthquake survey of the Mid-Atlantic ridge just south of the 5°S transform fault/fracture zone, we find seismic activity to be concentrated within the western half of the median valley. The median valley seismic zone is bounded in along-axis direction by the transform faults to the north, and the tip of the axial volcanic ridge to the south. A few scattered events occurred within the inside corner high, on the transform fault, and in the western side wall close to the segment center. Earthquakes reach a maximum depth of 8 km below the median valley floor and appear to be predominantly in the mantle although a few crustal earthquakes also occurred. The presence of earthquakes in the mantle indicates it is not extensively serpentinized. We infer the median valley seismic activity to arise from slip on two parallel low-angle normal faults which dip from the inside corner toward the spreading axis.

### T12D-0502 1330h POSTER

## Upper Crustal Variations due to Mantle Temperature Variations Along the Southeast Indian Ridge

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A systematic variation in axial morphology and axial depth is observed along the Southeast Indian Ridge (SEIR) with distance away from the Australian Antarctic Discordance, an area of cold mantle downwelling. Since spreading rate and mantle geochemistry appear constant nearly along this portion of the SEIR, variations are attributed to a gradient in mantle temperature. We carried out a multichannel seismic (MCS) survey on the SEIR to determine the effect of changes in mantle temperature on melt supply and crustal structure. The MCS reflection data was collected along six segments, showing a range of axial morphology. The MCS data demonstrate a systematic variation in upper crustal structure. Segment P1 (101°E) is characterized by a well developed axial high. It shows an axial magma chamber under ~60% of the axis at an average depth of 680 ms twtt (~1800 m) and average layer 2a thickness of 270 ms twtt (~325 m). Segment P2 (102°E) is characterized by a poorly developed axial high. Axial magma chambers are found underneath ~40% of the axis, at an average depth of 1000 ms twtt (~2200 m) and an average layer 2a thickness of 400 ms twtt (~ 475 m). Segment P3 (105°E) shows a transition along the segment from an axial high in the west to an axial valley in the east. The axial high portion of the segment has an axial magma chamber (AMC) under almost the entire section located at an average depth of 975 ms twtt (~2000 m), and an average layer 2a thickness of 350 ms twtt (~420 m). The transitional part of the segment again has an axial magma chamber found almost along the entire section, located at a deeper average depth of 1000 ms twtt (~2200 m), and an average layer 2a thickness of 400 ms twtt (~ 475 m). The axial valley part of the segment has no magma chambers, and an average layer 2a thickness of 750 ms twtt (~890 m). Segment S1 (110°E), characterized by an axial valley, shows only a few scattered deep AMC reflections located at an average depth of 1200 ms twtt (~2250 m), and highly variable average layer 2a thickness of 600 ms twtt (~900 m). This section of the SEIR is characterized by a clear relationship between axial morphology, depth to the AMC and thickness of layer 2a along this section of the SEIR. Although axial morphology changes progressively along the axis, AMC extent and layer 2a thickness show abrupt changes along the axis. Magma chambers are commonly observed under axial high segments. As the axial high becomes less developed, AMC reflections become deeper but are still imaged over significant parts of the segment. An axial magma chamber is rarely observed at segments with an axial valley. Layer 2a thickness roughly doubles with the transition from an axial high to an axial valley.

### T12D-0503 1330h POSTER

## The Terceira Rift as Hyper-Slow, Hotspot-Dominated Oblique Spreading Axis: A Comparison With Other Slow-Spreading Plate Boundaries

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We suggest the 550km long Terceira Rift (Azores Plateau) is the world's slowest-spreading (hyper-slow, 4mm/a plate separation; 2.3-3.8mm/a perpendicular to oblique axial segments) organized accreting plate boundary. In its slightly sinuous (ca. 300km radius of curvature) axial trace, its oblique spreading angles (ca. 40°-65°), and in frequency and first motions of earthquakes, the TR resembles better-known ultra- or super- slow spreading ridges (e.g., Gakkel and Southwest Indian ridges). Interpreted simply as volcanically unfilled rift valley segments, the inter-island basins (e.g., the 3200m deep Hirondelle Basin) are slightly wider (30-60 km), but not significantly deeper (1000-2200 m) than the Mid-Atlantic Ridge median valley (20-28mm/a; 10°N-53°N). However, along-axis segmentation wavelengths (ca. 100km) are double those along the central MAR, but make TR comparable to the ultra-slow (15-16 mm/a) Southwest Indian and Gakkel (7-13 mm/a) ridges. If this segmentation wavelength reflects Rayleigh-Taylor instabilities, the viscosity contrast between the overlying axial lithosphere and the partial melt zones is about an order of magnitude greater at ca. 4-16 mm/a than at 20-30 mm/a. The Terceira Rift differs dramatically from ultra-slow ridges only in the large amplitude of along-strike topography (2000-4000m; 4200m totalvariation) owing perhaps to a copious melt flux from the Azores hotspot, combined with a spreading-rate-determined greater axial flexural strength and plate thickness, and slower export of volcanics from the rift axis. The probable TR youth (ca. 1 Ma, requiring less than 4km new oceanic crust) indicates lack of steady-state spreading conditions, which may explain the published gravity evidence against TR spreading. Absolute plate motions support the creation of the Azores Plateau by successive NE jumps of the rift axis to maintain its position over a fixed hotspot.

# T12E MCC: 3007 Monday 1340h

## Seismotectonics of the Eastern San Francisco Bay Area II *(joint with G, S)*

***Presiding:*** **D E Moore,** U.S. Geological Survey**;** **D A Ponce,** U.S. Geological Survey

### T12E-01 1345h

## Pliocene Reorganization of Hayward-Calaveras Fault Junction, San Francisco Bay Region, California, USA

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Paleogeographic reconstruction of the East Bay Fault System has revealed that about 100 km of post 12 Ma offset was passed onto the Hayward Fault from faults to the south (Graymer and others, 2002). This relation is reflected in the present day by transfer of 9 mm/yr of fault slip from the central Calaveras Fault to the Hayward Fault (Working Group on California Earthquake Probabilities, 2003). The surface manifestation of the connection between the two faults is a zone

of (oblique?) reverse faults at least 4 km wide and 25 km long. Potential field geophysical studies suggest, however, that the original configuration of the junction involved transfer of Calaveras Fault offset onto a third fault (the Silver Creek Fault of Jachens and others, 2002), and from there onto the Hayward Fault through a right-step resulting in a pull-apart basin (Evergreen Basin). The reorganization of the junction, and the switch from largely extensional to largely compressional deformation, has resulted in the central part of the Evergreen Basin being overthrust by a wedge of Mesozoic rocks along west-vergent faults that root into the central Calaveras Fault. This cap of older rocks is reflected in the local decrease in amplitude of the gravity low associated with the Evergreen Basin. Pliocene non-marine deposits in the footwall of the thrust represent the youngest strata deposited in the pull-apart basin, and suggest that the fault junction reorganization began in Pliocene time. Latest Pliocene to early Pleistocene gravels locally cap thrust faults, suggesting that reorganization was accomplished by that time, although the same gravels are elsewhere themselves faulted, reflecting the ongoing compressional manifestation of the fault junction. However, INSAR studies have detected a ground water barrier in the upper 100 meters of Quaternary alluvium roughly aligned with the Silver Creek Fault that may reflect some amount of continued tectonic activity, though the lack of any geomorphic expression precludes large recent offsets. The westward extent of the overthrusting, the surface manifestation of the Silver Creek Fault in the overthrust region, and the amount of Quaternary offset on the Silver Creek Fault are currently unresolved. Joint detailed geologic and geophysical studies are being applied to produce a 3-D model of the region and address those issues.

### T12E-02 1400h INVITED

## Estimates of slip rates on Bay Area faults from space geodetic data

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In an effort to put together the most comprehensive picture of crustal deformation in the San Francisco Bay Area, The UC Berkeley Active Tectonics Group has created the Bay Area Velocity Unification (BĀVŪ, "Bay-View"). This dataset unites campaign and continuous GPS data for nearly 180 GPS stations throughout the greater San Francisco Bay Area from Sacramento to San Luis Obispo. We have reprocessed and combined data collected by six agencies between 1991 and 2003 using a uniform methodology with the GAMIT/GLOBK software package. BĀVŪ has 88 GPS stations in the eastern San Francisco Bay Area with 64 of those within 15 km of the Hayward fault. GPS data are complemented by InSAR range-change rates estimated from a stack of $> 20$ interferograms spanning 1992-2002. Where we can compare the data sets directly, they agree within the reliability of each method. We use the consistent velocity field from BĀVŪ to quantify fault slip rates and strain accumulation using a 3-D elastic dislocation model of the San Francisco Bay Area, as well as more a detailed inversion for the creep rate on the Hayward fault. We find that the estimated rates of slip deficit accumulation are mostly consistent with geologic estimates of fault slip rates. On the Hayward fault, creep rates vary along strike and are temporally complex.

URL: http://seismo.berkeley.edu/~burgmann/research/BAVU

### T12E-03 1420h

## Relationship Between Mapped Fault Stepovers and Earthquake Fault Planes at Depth

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The San Andreas fault system in the San Francisco Bay area is complex, consisting of several subparallel strands with numerous stepovers and bends. Source characterization of future likely earthquakes in the Bay Area requires understanding of the role these fault stepovers and bends play in fault segmentation. Absent aftershocks or microseismicity, it is difficult to determine the subsurface fault geometry. To better understand the role of geometric complexity in controlling earthquake ruptures, I have examined data from several recent major strike-slip earthquakes. The 1995 Mw6.9 Kobe earthquake originated within a 5-km right (dilatational) step in a right-lateral fault and produced a bilateral rupture. Wald (J. Phys. Earth, 1996) showed that the hypocenter occurred at the intersection of the two well-constrained, offset fault planes that were steeply dipping toward each other. A 3-km right step in the San Andreas offshore from the Golden Gate inferred from seismic and potential field data consistently produces normal faulting microearthquakes. The 1906 earthquake with its bilateral rupture is thought to have originated along the offshore segment of the San Andreas fault near the Golden Gate; by analogy with the Kobe earthquake, we have suggested that the 1906 also nucleated within a stepover region. Modeling dynamic rupture propagation constrained by near-fault ground motion records for the 1999 Izmit M7.4 earthquake, led Aochi and Madariaga (BSSA, 2003) to conclude that this rupture was rapid and continuous on a smooth fault structure with a bend of only a few degrees beneath a 5-km right (dilatational) stepover mapped at the surface in the vicinity of Sapanca lake. Similarly, aftershocks and surface faulting of the1995 Mw7.2 Landers earthquake suggest continuous rupture across a 5-km dilatational jog, utilizing an oblique fault connecting the 2 offset fault segments; whereas, the rupture across a second, 2-km dilatational jog appears more diffuse, with no continuous through-going structure (Felzer and Beroza, GRL, 1999). Relocated East Bay microseismicity using the double-difference technique indicates a continuous zone consisting of straight, near-vertical fault planes connecting the Calaveras and Hayward faults across a 5-6 km left (restraining) step (Waldhauser and Ellsworth, JGR, 2002; Ponce et al., EOS, 2003; Simpson et al., EOS, 2003). These near-vertical planes are well-defined below 5 km depth, in contrast to a complex pattern of surface fault traces with no through-going, connecting structure. The data suggest that, for at least some fault stopovers, the earthquake rupture surface at depth may be far simpler and more continuous than surface fault traces suggest and that fault stepovers and bends mapped at the surface do not necessarily represent segment boundaries or major energy barriers to rupture at depth. These observations raise intriguing questions about how, absent microseismisty, to determine if a fault stepover may have a simple connection at depth and what parameters, e.g. step size, total displacement, rock type, relative fault strength, etc. might control the depth variation in structural style

### T12E-04 1435h INVITED

## A 2000-Year Preliminary Record of Large Earthquakes on the Southern Hayward Fault

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The Hayward fault, a major branch of the right-lateral San Andreas fault system, traverses the densely populated eastern San Francisco Bay region, California. We are conducting a multiyear paleoseismic investigation to better understand the Hayward fault's past earthquake behavior. Our site is near the south end of Tyson's Lagoon, a sag pond formed in a right step of the fault in Fremont. Because the Hayward fault creeps at the surface, we identified paleoearthquakes primarily using features which we judge to be unique to ground ruptures or the result of strong-ground motion, such as the presence of fault-scarp colluvial deposits and liquefaction. We correlate the most recent event evidence to the historical 1868 M 6.9 earthquake, which caused liquefaction in the pond. We recognize nine additional paleoruptures since about AD 115 (+/- 135 yr) and two earlier events as yet undated. Event ages were estimated by chronological modeling, which incorporates historical and stratigraphic information as well as radiocarbon and pollen data. The preliminary mean recurrence interval (RI) for these ten events is 195 +/- 15 yr. This long-term (AD 115-1868) RI is somewhat greater than a previously determined RI of 130 +/- 40 yr for the period AD 1470-1868. Our event sequence includes event evidence from fault traces on both sides of the pond by tracing key stratigraphic units across. Our continuing work at this site focuses on carefully examining the possibility of missing events due to a hiatus in sedimentation to verify that the current record of paleoearthquakes is complete over the 2000-yr period. More age data is still needed to refine and complete the chronologic model to characterize the aperiodicity of the recurrence interval for the southern Hayward fault.

### T12E-05 1455h

## Long-term Creep Behavior (1928-2002) of the Hayward Fault at Depth in the Claremont Water Tunnel, Berkeley, CA

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The Claremont Tunnel, a nine foot horseshoe shaped water tunnel conveying up to 175 million gallons per day (mgd) of treated drinking water to 800,000 residents on the east side of San Francisco Bay, crosses the Hayward Fault approximately 850 feet from the west portal of the tunnel. Creep along the fault has offset the tunnel at a depth of about 130 feet below the ground surface. Completed in 1928, the tunnel has undergone two inspections (1966 and 2002) in which detailed survey measurements have been made of the creep movements of the fault. There have been few opportunities to secure creep measurements below the ground surface. This paper will present the results of the two surveys showing the creep that has occurred at a depth of 130 feet and give time-based creep rates based on survey measurements. It will compare these measured creep rates with the tectonic creep model developed by NOAA. Due to the large time interval between the two surveys, surveying technology has dramatically changed. A discussion of the techniques used in each survey will be presented with discussions of how current technology compares with historical methods and what impact this has on the results.

### T12E-06 1510h

## Faulting Plumbing: Spring Response to Creep on the Hayward Fault

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Two prominent sets of thermal springs lie along the western edge of the left step over region between the Calaveras and Hayward faults: the Alum Rock springs, San Jose, CA, and the Warm Springs, Fremont, CA. Co- and postseismic flow increases at both spring locations have been well documented (King et al., 1994 and Waring, 1915). Until recently, however, spring response to creep events was unknown. In January 2003, we documented a 20% decrease in discharge at the Warm Springs due to a 0.31mm right lateral creep event on the southern Hayward fault. The Warm Springs emanate from the Warm Springs fault that lies at the base of Mission Peak and merges with the Mission fault. The observed decrease in discharge is directly proportional to fluid pressure drop within the fault and therefore we suggest that creep on the Hayward fault resulted in a rapid stress change within a neighboring secondary fault. We present an analytical model that explains the observed discharge change and provides an estimate for the depth of fault zone permeability changes. Our results indicate that ongoing monitoring, geochemical sampling, and modeling of thermal springs within active faults zones offers the potential to directly observe fluid-fault interactions and better constrain the interactions of major fault zones with neighboring secondary faults.

### T12E-07 1525h

## Absence of Late Neogene Offset on the Northern Calaveras Fault

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The northern segment of the Calaveras Fault (NCF) runs from Calaveras Reservoir north along the western edge of the Livermore and San Ramon Valleys. Previous mapping extends the Calaveras Fault as far north as the town of Danville (Graymer et. al., 1996), and earlier works extended it even farther north. A high-resolution aeromagnetic survey collected by the U.S. Geological Survey shows a linear aeromagnetic

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high crossing the mapped trace of the Calaveras Fault on the western edge of the San Ramon Valley, near Crow Canyon. This anomaly is associated with Miocene Neroly Sandstone that outcrops west of the fault in the Las Trampas Ridge Anticline, suggesting that the sandstone is continuos without appreciable offset across the mapped fault trace into the subsurface of San Ramon Valley. Therefore, Neogene offset on the NCF must terminate at or south of the latitude of Crow Canyon, and slip previously inferred for the NCF must be assigned to other structures in the region. The amount of slip previously assigned to the NCF varies between 28 km and 80 km. Recent palinspastic reconstructions (Graymer and others, 2002) indicate that most of the right-slip offset is taken up by the Palomares-Miller Creek-Moraga-Pinole fault system to the west. Others (Unruh and Lettis, 1998) suggest that slip is transferred from the NCF by means of multiple folds and small displacement faults west of the Calaveras Fault. The 2003 Working Group on California Earthquake Probabilities suggests that slip on the NCF is transferred across the Mt. Diablo antiform onto the Concord Fault. This transfer of slip would be a right step in a right lateral system, which should produce extensional features at this step. However, only compressional structures exist between the NCF and Concord Fault. The lack of extension at this right step, combined with little or no late Neogene offset on the NCF indicate that the proposed Concord-NCF right step is either a very young tectonic element or does not exist at all.

## T21A MCC: 3007 Tuesday 0800h

### New Views of the Structure and Composition of the Deep Earth II

*(joint with GP, S, V, MR, DI)*

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

### T21A-01 0800h

### Tangent Cylinder within the Outer Core and the Constraints from Normal-Mode Data

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Recently, the tangent cylinder within the outer core has received a renewed interest as a structure that may explain observations of seismic waves travelling through the core. This is an important issue, not only because seismically detectible heterogeneity within the outer core has implications to its dynamics, but also because inferences of inner core anisotropy depends upon outer core structure. Instead of using travel time measurements, we rely mainly upon normal-mode splitting data to investigate the velocity and density difference between regions within and without the tangent cylinder. The lateral heterogeneity within the Earth, such as the tangent cylinder, is observed in seismic spectra as the splitting of normal-mode resonance peaks. Because isolated modes are standing waves, splitting measurements of these modes are only sensitive to even-degree structure. This limitation does not affect the investigation of the tangent cylinder, since this structure consists only of spherical harmonics at even degrees. In addition, biasing of data due to uneven coverage is less prominent in splitting data than in travel-time measurements, hence the normal-mode data are better suited to study large-scale structure. The normal-mode data are divided into subsets based upon their sensitivity to different parts of the Earth. Inversions of these data sets with various model parametrisations are performed to obtain and test the robustness of the strength of the tangent cylinder. The resulting ranges of velocity and density heterogeneity within the cylinder are then used to analyse the effects on travel-time measurements and on inner-core anisotropy.

### T21A-02 0815h

### Upper Mantle and Transition Zone Geochemical Heterogeneity: Seismic Constraints on the 80% Peridotite Solution

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The size of mantle geochemical heterogeneities spans from the length-scale of grains to the thousands of km lateral length-scales associated with subducted slabs. Grain-scale heterogeneities are difficult to probe remotely, while the large-scale heterogeneities associated with recent subduction have been extensively investigated. At intermediate length-scales, observational evidence is accumulating that abundant mantle heterogeneities exist in the 10 to 100 km size range: such sizes of heterogeneity may be associated with either moderately stirred ancient subduction, or with regional magmatic events. The ability to seismically detect such intermediate-sized features hinges on their type of mineralogic heterogeneity, and thus the velocity- or impedance-contrasts of such regions with the normal background of upper mantle peridotite. Two distinct types of mineralogic heterogeneity can be seismically detected in the upper mantle: (1) assemblages bearing free silica, such as occurs in many eclogites at pressures above about 2 GPa; and (2) at depths less than 300 km, highly garnet-enriched assemblages. Abundant amounts of eclogite can be detected through the observation of seismic discontinuities generated by phase transitions within their silica component: such eclogite could be generated through remixing of subducted oceanic crust or delamination of basaltic lower crust. At depths less than 300 km, garnet-rich zones have substantially higher seismic velocities than those of coexisting peridotite: such garnetite zones may be generated by magmatic processes, and have been documented to occur beneath the Pitcairn hot-spot chain. In the case of both silica and garnet-enrichment, seismic observations indicate that, within different geodynamic environments, geochemical heterogeneities can be detected at the 10 to 100 km length scale. Such detections provide critical constraints on regional deviations from a peridotite-only mantle, and thus on the nature and length-scale of mantle heterogeneity.

### T21A-03 0830h

### Large Scale Anisotropy in D" from Global Waveform Inversion

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The Earth's core-mantle boundary is both a thermal and chemical boundary layer between the silicate mantle and the fluid iron outer core. The mantle-side region (D") is also a mechanical boundary layer for the convection of the mantle, leading to intense deformation. This strain field can lead to detectable seismic anisotropy, either through the alignment of anisotropic crystals or of layers (or inclusions) of materials with strongly contrasting elastic properties (Karato, 1998; Kendall and Silver, 1996). Anisotropy in D" is observed in several regions using Sdiff or ScS (Vinnik et al., 1989; Kendall and Silver, 1996; Lay et al., 1998). However, these studies only sample limited areas of D". A global picture of long-wavelength anisotropic D" structure would clearly aid both dynamic flow modeling and mineral physics interpretations. Therefore, we have adapted a global tomography approach (Li and Romanowicz, 1996) to develop a 3D global model of mantle radial anisotropy using three component time-domain waveforms of surface and body waves. The model is parameterized by isotropic $V_S$ and $\xi$ ($\xi = V_{SH}^2/V_{SV}^2$), a measurement of radial anisotropy in shear velocity. In our model, D" is characterized by a strong degree 0 signature of positive $\delta \ln \xi$ ($V_{SH} > V_{SV}$), similar to the uppermost mantle in previous anisotropic models such as PREM. The 3D isotropic velocity imaged in D" is consistent with earlier tomographic models of $V_S$ in this depth range (Masters et al., 1996; Mégnin and Romanowicz, 2000), and is characterized by a strong degree 2 component representing a fast ring surrounding two low velocity features ("superplumes") beneath the central Pacific and Africa. For $\xi$ in D", the degree 0 component dominates, but the regions that deviate most from this structure correlate well with the locations of the superplumes. We see reduced $\delta \ln \xi$ under the central Pacific, Africa, and the south Atlantic, including patches with negative values ($V_{SV} > V_{SH}$). The observed anisotropy in D" is consistent with a boundary layer dominated by horizontal flow, while emphasizing the unique character of the two superplume regions. Our results also suggest similar relationships between anisotropic signature and flow prevail in the uppermost and lowermost mantle.

### T21A-04 0845h INVITED

### Extreme Short Scale Variations in D" Topography Beneath the Pacific Ocean Just West of Central America

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In this study we use a wavefield migration technique to infer D" reflectance and topography in a densely sampled region just west of Central America beneath the Cocos plate. High quality broadband waveforms from seismic networks in California of 13 deep focus South American earthquakes are instrument and source wavelet deconvolved to displacement, aligned on ScS as a reference phase, then studied for coherency of energy between ScS and S. A search for potential lowermost mantle reflector locations is achieved by migrating the wavefield for each earthquake to each node of a 3D grid of potential reflector locations, with spacing every 1 deg laterally and 10 km vertically (with ranges: -2 to 18 deg N; -100 to -80 deg E, 2200 to 2888 km depth). Grouping our data into densely sampled latitudinal bins resulted in 41 clusters of bounce points between 0 and 15 deg N. The migrated images for all bounce point clusters show an abrupt increase in velocity that is thickest to the north in our study area (up to 300 km and greater) and dramatically reduces to as thin as 100 km thick in the south. We also see evidence for the main positive velocity increase being underlain by a negative velocity discontinuity in the northern half of our study region, though this feature is not visible in all migrations. These results are compatible with the general picture from simpler 1D studies (which indicate a thicker high velocity D" layer to the north beneath the neighboring Central American and Caribbean than that to the south) but demonstrate increased complexity at shorter scale lengths. The thickening of the D" layer to the north coincides with inference for higher velocities there implied by ScS-S and S-SKS differential travel time residuals. Evidence for out of plane reflections is also visible in some migrated images. Such strong topographical variations ( 200 km change over several hundred km laterally) are likely intimately coupled to overlying mantle currents related to subduction, such as localized flow complexities or being near the edge of a larger scale downwelling. These results, including the less well-constrained mid-D" velocity decrease, will be compared to larger scale velocity heterogeneity and gradients as inferred from tomography, as well as recent ultra-low velocity zone results.

URL: http://garnero.asu.edu/research/earthslowermantle.html

### T21A-05 0900h

### Phase relations and phase transformation kinetics of the subducted oceanic crust and the seismic reflectors in the lower mantle

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We determined phase relations in dry and hydrous mid-ocean ridge basalt (MORB) at high pressure and temperature by in situ X-ray diffraction study together with conventional quenching experiments. In the lower temperature range around 1000-1100C at 20-30 GPa, we observed CaMg-cubic perovskite phase both under the dry and wet conditions. However, quenching experiments with a long duration revealed that the cubic perovskite is metastable, and it eventually decomposes into two perovskites. The metastable cubic perovskite might exist in the cold slabs. The phase boundary of the perovskite appearance in the wet MORB has a positive slope, and is about 1 GPa lower than that in the dry MORB (Hirose and Fei, 1998). The results presented above suggest that water can play an important role in slab dynamics near the 660 km discontinuity. The density relations between the basalt and peridotite implies that there is no density crossover between the basalt and the underlying peridotite layers in the wet slabs along the cold slab geotherm, resulting in higher density of the basalt layer throughout the transition zone and the lower mantle compared to the peridotite portion of the slabs. Thus, the hydrated slabs