

solely on 2-D optimally oriented planes best describe the aftershock activity whereas in thrust, or mixed-mode regions, the 3-D calculation is more consistent with the data. We develop a graphical technique to compare the mapped regional structure in each area with both the aftershocks and with the pre-mainshock events and, in all cases, find that both the preshocks and the aftershocks occur on faults consistent with the mapped structural trend. This result implies that the best way forward is to use any available information about mapped structure and preshocks to constrain the orientations of faults capable of producing aftershocks in any particular area. Maps of the likely spatial aftershock distribution can then be produced by resolving stress perturbations onto planes within that limited range of orientations.

## S52C MCC: 134 Friday 1330h

### Seismic Discontinuities, Phase Transitions, and Mantle Dynamics II (joint with T, V, DI, MR)

**Presiding:** Y Shen, University of Rhode Island; Y Gu, Harvard University; Y Fei, Carnegie Institution of Washington

#### S52C-01 1330h

##### A systematic search for seismic discontinuities in the upper and lower mantle

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We perform a systematic search for reflectors in the upper and lower mantle using a global data set of SS-precursors. A bootstrap resampling algorithm is employed to determine robust reflectors (within the 95% confidence level). The results demonstrate that reflectors can be found from a range of depths and our observations can be used as a probe for local mantle composition and temperature.

A stack for the entire data set clearly shows the transition zone discontinuities at 410, 520 and 660 km depth. Stacks for particular tectonic regions, for example North America or Indonesia, show additional reflectors in both upper and lower mantle at depths of 220 km and 1000-1200 km. To address the question of regional existence and lateral variations of upper mantle discontinuities, we systematically searched spherical caps with 10° radius for robust reflectors and compared with synthetic seismograms. The locations of the discontinuities are also compared with shear wave velocities from tomographic models.

Leaving the transition zone discontinuities aside, the largest number of robust reflections comes from a depth of 220 km, suggesting that the Lehmann discontinuity is a major reflector in the upper mantle. This discontinuity is observed below both continental and oceanic areas, though the largest amplitudes appear beneath the continents. There is also evidence for weak discontinuities at approximately 260 and 310 km depth, for example in the region of the South Pacific Superwell which could be related to processes in the upwelling plume.

There are also suggestions of lower mantle reflectors with a weak peak for 800 km depth; deeper in the lower mantle there are reflections from a continuous range of depths. Clear reflections from 1000-1200 km depth are found below North America and in the Indonesian subduction zone area, where other studies have found similar reflections. The locations correlate with fast features in tomographic models.

As we find discontinuities from a range of depths in different types of tectonic regions, we do not expect that only one mechanism is responsible for all reflections. We will discuss different possible explanations for the seismic discontinuities in terms of phase transitions, compositional and/or rheological changes.

#### S52C-02 1345h

##### Elasticity Measurements of Phase Transition in Pyroxenes and the Upper Mantle Reflectors

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The upper mantle reflectors, Lehmann and X-discontinuities, have been observed locally and interpreted as a result of compositional gradients, anisotropy, phase changes, volatiles and temperature, which all play significant roles in determining the seismic reflectivity structure. The phase transition in Ca-poor pyroxene (enstatite) from orthorhombic to high pressure monoclinic has been proposed to be responsible for the Lehmann or X-discontinuities if the regional petrological environment is a Ca-poor pyroxene-rich mineral assemblage.

High-P clinoenstatite is unquenchable. Because of this, the elasticity of high-P clinoenstatite has to be studied in its stability field. A rapid development of the ultrasonic technique in the large volume apparatus in conjunction with in-situ X-radiation techniques has made possible to the elasticity measurement at mantle conditions. Using these techniques, the key parameters determining the elasticity of mantle materials, travel times (P and S waves), length of the specimen, pressure and temperature, can be collected simultaneously at mantle conditions.

The starting polycrystalline orthoenstatite specimens used in this study were synthesized using the multi anvil pressure at High Pressure Laboratory at University Stony Brook. The high pressure ultrasonic experiments were performed using the 1000 ton press at beamline 13ID, GSECARS, Argonne National Laboratory, Advanced Photon Source. During the acoustic experiments, the orthoenstatite specimens were transformed into high-clinoenstatite in-situ at peak P-T conditions (11.15 GPa, 900 degree C) for two hours. P and S wave velocities were measured across the orthoenstatite phase and the stability field of high-pressure clinoenstatite. Our results have shown clear P and S wave velocity jumps across the phase transformation from orthoenstatite to high-pressure clinoenstatite. As indicated from our measurements, the magnitude of S wave velocity jump at this transition is almost twice that of P wave. In this meeting, we will present the elasticity measurements of the pyroxenes and discuss the relationship of the phase transition in pyroxenes and the upper mantle discontinuities.

#### S52C-03 1400h

##### Seismological Evidence for the Presence of Water Near the 410 km Discontinuity

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Water can remain in the subducting plate down to the transition zone as shown by high-pressure experiments. It is, however, unknown whether and how much water indeed is transported to 400 km and below. Also, the effect of water on the behaviour of the 410 km discontinuity is not yet completely understood.

Here we show new seismological evidence for water being present at depths near 400 km. We have searched for P-to-S converted waves in over 500 seismograms recorded at 17 temporary broadband stations from the MIDSEA project and 6 permanent broadband stations in the Mediterranean region. Events are mainly located between 60° and 95° epicentral distance due to the geographical location of the Mediterranean region with respect to seismogenic zones.

We have found that P-to-S conversions from the 410 km discontinuity are not as clear as and spatially more variable than those from the 660 km discontinuity. For several stations we observe an unambiguous frequency dependence of the P-to-S conversion at the 410 km discontinuity. This finding indicates that the phase transition is not sharp and occurs over depth intervals of up to 30 km. We interpret this thickened transition of olivine to wadsleyite as being due to 500 to 700 ppm water, present in olivine, at depths near 400 km.

The presence of H<sub>2</sub>O as a free fluid could significantly decrease the velocities in the upper mantle, especially the S-velocities. We suggest that most of the water present around 400 km depth could be incorporated in the minerals themselves and is not present as a free fluid since no sudden drop nor significant lower S-velocities are observed beneath the studied stations.

#### S52C-04 1415h INVITED

##### Phase Transition Complexity and Multiple Seismic Reflectors in Subduction Zones

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Patterns of seismic wavespeeds within subduction zones are significantly affected by the laterally varying phase relations associated with slab thermal structures, especially in the upper mantle where equilibrium phase changes contribute fine structure to the overall fast anomalies expected from thermal effects alone. Such lateral variations in the properties of associated seismic reflectors contribute to non-uniformity in the visibility of and detectable topography on seismic "discontinuities" in the transition zone.

The 410-km seismic discontinuity is usually attributed largely to the  $\alpha \rightarrow \beta$  phase transition in (Mg, Fe)<sub>2</sub>SiO<sub>4</sub> olivine, more accurately written as the  $\alpha \rightarrow \alpha + \beta \rightarrow \beta$  reaction series. The apparent sharpness of and apparent topography on the associated seismic wavespeed feature have been subjects of debate, especially in regions near subduction zones.

I argue that some of the apparent discrepancies arise from the common oversimplification of representing the relevant phase relations in the vicinity of subducting slabs simply as an  $\alpha \rightarrow \beta$  transition. The low temperatures of subduction zones cause the equilibrium olivine phase relations within slabs to shift from the  $\alpha \rightarrow \alpha + \beta \rightarrow \beta$  reaction series to the more complex  $\alpha \rightarrow \alpha + \gamma \rightarrow \alpha + \beta \rightarrow \beta$  reaction series. Even lower temperatures in slab interiors cause the entire  $\alpha \rightarrow \alpha + \beta \rightarrow \beta \rightarrow \beta + \gamma \rightarrow \gamma$  reaction series to give way to an  $\alpha \rightarrow \alpha + \gamma \rightarrow \beta + \gamma \rightarrow \gamma$  reaction series.

The more complex reaction series within cold subduction zones yields bifurcations in seismic wavespeed contrasts. The  $\alpha \rightarrow \alpha + \gamma$  onset of the reaction series is strongly uplifted to shallower depths, but this transition is relatively broad. The  $\alpha + \gamma \rightarrow \alpha + \beta$  and colder  $\alpha + \gamma \rightarrow \beta + \gamma$  reactions, on the other hand, are univariant and therefore very sharp, but these transitions are not as strongly uplifted. The resulting seismic wavespeed signature to be expected above 410 km in a subduction zone consists of a strongly uplifted diffuse contrast overlying a weakly uplifted sharp contrast. Indeed, the univariant portions of the olivine reaction series in a slab may potentially give rise to the brightest seismic reflectors in the upper mantle.

#### S52C-05 1430h

##### South African Archaean Cratonic Keels Extend to the Upper Mantle Transition Zone

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Teleseismic body waves recorded by temporary broadband seismic networks are used to image the mantle seismic discontinuity structure beneath southern Africa. Stacking of over 3000 radial receiver functions reveals P-to-S conversions from seismic discontinuities near 410- and 660-km depth, which mark the upper mantle transition zone. Relative traveltimes delays across the seismic networks are used as a first approximation to correct for velocity heterogeneity beneath the stations. Variations in the transition zone thickness coincide with distinct geologic provinces. The transition zone beneath the Archaean Zimbabwe and Kaapvaal cratons is thicker than in the iasp91 model and the global average by up to 20 km. Thinner-than-normal transition zones are found beneath the Cape Fold and Namaqua-Natal belts, and a normal transition zone exists beneath the Bushveld province. The thickening of the transition zone beneath the Archaean cratons results primarily from shoaling of the 410-km discontinuity.

Observations of converted phases with a dominant wavelength of 30 km indicate that the olivine-to-wadsleyite phase transformation associated with the 410-km discontinuity occurs over a depth interval less than 15 km, half the wavelength of the converted phase. Water, which reduces the pressure of, but substantially broadens the olivine-wadsleyite transformation, is therefore unlikely the primary cause of the shallower-than-normal 410-km discontinuity beneath the cratons. The depth to the discontinuity varies in magnitude much greater than the induced effect of moderate compositional variations. For a Clapeyron slope of 2.9 MPa/K for the 410-km discontinuity, the decrease in the depth to the discontinuity beneath the cratons is equivalent to a temperature reduction of 230 K. The findings implicate that the deeply rooted Archaean cratonic keels or associated cold downwelling extend greater than 400 km depth, and are therefore likely to play an important role in mantle flow and plate tectonics.

## S52C-06 1445h INVITED

## Modeling of the Effective Temperatures in the Upper Mantle Transition Zone

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One of the difficulties in assessing the temperature variations in the mantle is the diversity of structures predicted by existing shear and compressional velocity models. These differences arise due to differences in the types of data used, modeling strategy, and assumptions. By applying simple statistics we obtain an effective velocity model from a number of existing shear and compressional velocity models. The resulting model provides an effective temperature measure of the mantle with realistic error estimates. Using a similar approach we calculate the average topography of the 410- and 660-km discontinuities from several existing global measurements obtained from secondary reflected and converted waves; this apparent topography model adds an additional constraint for the temperature variations near the upper mantle transition zone. With relatively small uncertainties both models suggest the presence of large amount of subducted oceanic lithosphere in the western Pacific subduction zones; this is evidenced by a large-scale depression of the 660-km discontinuity and fast shear and compressional velocities in the same region. The error estimates indicate much larger uncertainties for the subduction zones in South America and the southern Atlantic ocean, despite a modest anticorrelation between the topography of the 660-km discontinuity and fast seismic velocities predicted by some models. Our analysis also allows us to examine the temperature conditions of olivine to perovskite and magnesio-wüstite transformation, particularly in the presence of majorite garnet (see Hirose, 2002). Although our analysis are designed for global features, it is also useful for understanding phase transitions under extreme, local temperature conditions, e.g., the fate of mantle plumes near the 660-km discontinuity.

## S52C-07 1520h INVITED

## Global comparison of SS precursor and Ps conversion data from the upper mantle seismic discontinuities

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SS precursor observations from the 410 and 660 km discontinuities sample the upper mantle and the mantle transition zone beneath the surface bounce points of SS. They are therefore very useful to study regions with few seismic stations, like oceans. Ps conversions sample the mantle below a seismic stations. Therefore only very few and noisy data exist in oceanic regions. We have added to the published continental Ps conversions new data from oceanic stations. In order to compare the SS and Ps data sets directly, we have transformed the differential travel time data of both techniques into depth using the global reference model IASP91. Both data sets are not overlapping completely. Apparent depths of the 410 (which are influenced by velocity and depth anomalies) in oceanic regions are clearly larger in the Ps data than in the SS data. We think the reason is that oceanic stations are located on the tops of thin mantle plumes and the steep Ps rays travel longer inside the slow plumes than the less steep SS rays. The thickness of the mantle transition zone and the depth of the 410 correlate negatively in good agreement with the predictions by the Clapeyron slopes of the phase transformations causing the seismic discontinuities. The global distribution of the transition zone thickness determined by the Ps and SS data agrees well. The transition zone under major oceans seems to be about 20 km thinner than under some major continents, leading to about 200°C hotter temperature under oceans. A larger thinning is observed under only very few plumes in the Ps data, indicating that most plumes may not be present in the transition zone.

## S52C-08 1535h INVITED

## Seismic Constraints on Mantle Discontinuities: What We Know and What We Don't Know

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Seismic constraints on the depth, topography, amplitude and sharpness of the upper mantle discontinuities are of great importance in resolving the chemical, rheological, and dynamical properties of the mantle. Much progress has been made in the last decade through the identification and processing of reflected and converted seismic phases that are directly sensitive to discontinuity properties. We review these results, highlighting the consistencies and inconsistencies among the different studies. The latest generation of long-wavelength topography models for the 410- and 660-km discontinuities based on joint topography/velocity inversions of SS precursors and direct body- and surface-wave arrivals are in generally good agreement. These models show 20 to 30 km depressions in the 660-km discontinuity associated with areas of current and past subduction. Topography on the 410-km discontinuity is much more subdued and appears uncorrelated with 660 topography.

Comparisons of these models to receiver function results exhibit weak to poor correlations, in part owing to differences in the data coverage and resolution between the approaches. The most robust and puzzling difference between SS precursor and receiver function studies is an apparent ~10 km difference in average transition zone thickness (~241 km for the SS precursors vs. ~252 km for the receiver functions).

Observations of transition zone discontinuity phases are sufficiently precise that determining the globally averaged depths of the upper mantle discontinuities should be possible within a few kilometers. However, converting observed travel times to absolute depths is surprisingly tricky, owing to the effects of Q, baseline differences between standard Earth models, travel time offsets introduced by application of topography and crustal corrections, and variations in data coverage. Thus, comparisons of absolute discontinuity depths among different studies should be made with caution.

Regional receiver function studies have often shown significant topography on the upper mantle discontinuities over short distances. The amplitude of these depth variations is hard to explain with simple phase-change models for the discontinuities because of the large lateral temperature variations that would be required. However, the reliability of these features has not yet been fully established because: (1) corrections for crust and upper mantle structure are of critical importance, and (2) they are generally based on 2-D experiments that could be biased by off-axis structures. The planned USArray experiment will permit true 3-D migration of the data and provide greatly improved images of discontinuity structure beneath the United States.

## S52C-09 1550h INVITED

## In Situ X-ray Diffraction Measurements of the Postspinel Transition in a Peridotitic Composition

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Seismic discontinuities in the Earth's interior are the major features observed by geophysicists. The interpretation of these discontinuities relies on laboratory experimental data at high pressures and temperatures. For a peridotitic mantle composition, the postspinel transformation (spinel = perovskite + periclase) of olivine is believed to be responsible for the observed 660-km seismic velocity discontinuity in the mantle. Previous high P-T experiments on this transformation have mostly been conducted in the system Mg<sub>2</sub>SiO<sub>4</sub> - Fe<sub>2</sub>SiO<sub>4</sub>. In this study, we report in-situ measurements of the postspinel transformation in a peridotitic composition. A natural spinel hercynite KLB-1 and a synthetic pyrolytic glass were used as the starting materials. Experiments were conducted in a multi-anvil apparatus at the SPring-8 synchrotron facility (Japan) over a temperature range of 1400-1900°C, in which pressures were determined by in-situ X-ray diffraction measurements. In each experiment, we loaded multiple internal pressure standards (Au, Pt, and MgO) to address the recent controversy regarding the transition pressure of the postspinel phase boundary. Additional experiments with run duration up to 2 days at 1900°C and 23 GPa were performed by the quench method to examine the equilibrium of the reaction. We have further examined

the effect of Al on the postspinel transformation by using pre-synthesized silicate spinel-bearing assemblage as the starting material. The geophysical implications of these experiments will be discussed.

## S52C-10 1605h INVITED

## Phase Transitions and Dynamics at 660-km Depth and Mid-Lower Mantle

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The 660-km depth boundary has long been believed to be a barrier for the mantle convection, impeding both subduction of slabs and upwelling of hot plumes, because the post-spinal phase transition boundary has a negative Clapeyron slope. The seismic tomographic images revealed the stagnant slabs around 660-km depth beneath subduction zones. In contrast, plumes, many of which may originate from the lower mantle, are not stagnant around this depth. High-pressure experiments using multi-anvil apparatus showed that stability of majorite significantly expands relative to Mg-perovskite above 1800°C both in the simplified system MgSiO<sub>3</sub>-Mg<sub>3</sub>Al<sub>2</sub>Si<sub>3</sub>O<sub>12</sub> and in the natural pyrolytic mantle composition (KLB-1) [Hirose 2002, JGR]. A large density decrease occurs by phase transition from Mg-perovskite to majorite at temperatures higher than 1800°C, which has a positive Clapeyron slope. Phase transition in hot plumes facilitates their ascent through the 660-km depth boundary.

The seismic low-velocity layer in the mid-lower mantle (1400-1600-km depth corresponding to 60-70 GPa) suggests the presence of ancient basaltic crusts with a neutral buoyancy [Kaneshima & Helffrich 1999, Science]. We conducted in-situ high-pressure and high-temperature X-ray diffraction measurements in a laser-heated diamond anvil cell to determine the phase transition boundaries and the thermoelastic properties of minerals comprising peridotitic mantle and subducted MORB crust in the mid-lower mantle conditions. The results demonstrated that MORB crust becomes denser upon transition to the perovskite-dominant lithology at 26 GPa (720-km depth) but it is less compressive than peridotitic mantle in deeper levels. It is primarily due to the large bulk modulus of stishovite compared to other lower mantle minerals, which occupies large volume (> 20%) in the MORB crust. Small amount of Al<sub>2</sub>O<sub>3</sub> (2.1 wt%) in stishovite has little effect on its compressibility. Phase transitions also have a little effect on the density relationship. The NaCl-type FeO wüstite transforms to the NiAs-type structure above 70 GPa and 1300°C. It could lead to a dissociation of magnesio-wüstite into two oxides below 1600-km depth in the mantle. The rutile-type stishovite undergoes a second-order transition to the CaCl<sub>2</sub>-type structure above 70 GPa and 1300°C, and possibly a further transition to the α-PbO<sub>2</sub> type structure at a higher pressure in the MORB crust. Our data supports the density crossover between basaltic composition and peridotitic mantle at 1500-2000-km depth.

## S52C-11 1620h INVITED

The Enigma of High-Pressure Silica Polymorphs: Is There a Post-CaCl<sub>2</sub> Phase in the Lower Mantle?Sean R Shieh<sup>1</sup> (609-258-3594; shieh@princeton.edu)Thomas S Duffy<sup>1</sup> (duffy@princeton.edu)Guoyin Shen<sup>2</sup> (shen@cars.uchicago.edu)<sup>1</sup>Department of Geosciences, Princeton University, Princeton, NJ 08544, United States<sup>2</sup>GSECARS, University of Chicago, Chicago, IL 60637, United States

The high-pressure polymorphs of silica have attracted much attention due to their geological, materials science, and crystal chemical importance. It has been suggested that phase transitions in SiO<sub>2</sub> may be related to seismic structure at 1000 km depth, the mid-mantle discontinuity, and anomalous structure near the core-mantle boundary. Stishovite is known to transform to the CaCl<sub>2</sub> form near 50 GPa on the basis of Raman spectroscopy, x-ray diffraction, and theoretical calculations. Many studies have investigated possible post-CaCl<sub>2</sub> phases at lower mantle conditions but current results are contradictory. Because the post-CaCl<sub>2</sub> phases are believed to be energetically competitive, different results among experimental studies could depend on differential stress, pressure and temperature gradients, starting material, and heating history. In this study we used a variety of different starting materials (stishovite, cristobalite, silica glass) and also varied the heating environment. Sample materials were mixed with Pt and loaded into a Re gasket hole. In most experiments, Ar was used as an insulator and pressure transmitting medium, but a few experiments were performed with no insulation to investigate the effects

of P and T gradients. Experiments were carried out using the double-sided Nd:YLF laser heating system at 13-ID-D of the GSCECARS sector of the Advanced Photon Source. Alignment of the x-ray and heating spots was facilitated by the placement of YAG crystals in the sample chamber. Angle-dispersive diffraction techniques were employed together with a CCD detector. Our in situ studies on SiO<sub>2</sub> show that the CaCl<sub>2</sub> phase remains stable to about 120 GPa using both stishovite and glass starting materials. No differences were found between experiments employing an Ar insulation medium and those that did not. For cristobalite starting material, the α-PbO<sub>2</sub> phase was observed at pressures above 54 GPa and room temperature. However upon heating at 80 GPa, the α-PbO<sub>2</sub> phase transformed into the CaCl<sub>2</sub> phase. A separate set of experiments on GeO<sub>2</sub> carried out at Spring-8 showed that the CaCl<sub>2</sub>-α-PbO<sub>2</sub> phase transition occurred near 65 GPa in this material.

S52C-12 1635h

Mantle Phase Transitions and Earths Thermal History

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It is well known from numerical modeling that the phase transition from spinel to a mixture of perovskite and magnesiowustite, that occurs at a mean depth of 660 km in the mantle, can act as a partial barrier to convective flow. This phase transition is also known to strongly increase the time-dependence of mantle flows with mantle avalanches being the most dramatic example. The degree of layering has also been shown to increase with the strength of convective forcing or Rayleigh number which has evolved throughout the Earths history. We present a suite of calculations in which we model the Earths thermal history using numerical models of the mantle convection process that include temperature dependent viscosity, an evolving core-mantle boundary temperature, and the effects of the two major mantle phase transitions. These are compared with the results of parameterized convection modeling which showed that the inclusion of the effects of Rayleigh number dependent layering by the phase transitions allow the reconciliation of geochemical models of radioactive abundances and parameterized convection modeling and this effect is found to be important in these more detailed models as well. We also compare the time-scale of phase-transition induced mantle avalanches in models of this type and show that they are consistent with the timing of the Wilson cycle of supercontinent formation and dispersal.

S61A MCC: Hall C Saturday 0830h

Lithospheric Structure in North America and Europe: Comparisons and Recent Results I Posters (joint with T, V)

Presiding: A Guterch, Polish Academy of Sciences; G R Keller, University of Texas at El Paso

S61A-1088 0830h POSTER

3-D Tomography Study of Seismic Refraction/Wide-Angle Reflection Data Across the Variscides, SW Ireland

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The VARNET-96 seismic experiment acquired three seismic refraction/wide-angle reflection profiles in order to examine the crustal structure in the south-west of Ireland. 170 seismic stations were used on 300 recording sites. The shotpoint geometry was designed to allow for both in-line and off-line fan shot recordings on the three profiles. A total of 34 water shots was fired. Results from 3-D raytrace and inversion modelling illustrate the pervasive lateral heterogeneity of the study area south of the Shannon Estuary. Palaeozoic strata at the south coast are about 5-6 km thick associated with the sedimentary infill of the Munster and South Munster Basins. To the north, shallow upper crust in the vicinity of the Killarney-Mallow Fault Zone is followed by a 3-4 km thick sedimentary succession in the Dingle-Shannon Basin. A zone of high-velocity upper crust (6.4-6.6 km/s) beneath the South Munster Basin correlates with a gravity high between the Kenmare-Killarney and the Leinster Granite gravity lows. Other high-velocity zones were found beneath Dingle Bay and the Kenmare River region and may be associated with the deep traces of the Killarney-Mallow Fault Zone and the Cork-Kenmare Line. The 3-D velocity model was taken as a basis for the computation of PmP reflected arrivals from the crust-mantle boundary. The Moho depth varies from about 28-29 km at the south coast to about 32-33 km beneath the Dingle-Shannon Basin, the region where the 2-D inline model shows a south-dipping reflector in the upper mantle. Pervasive Variscan deformation appears to be confined to the sedimentary and upper crustal structure and has not deformed the entire crust supporting a thin-skinned tectonic model for Variscan deformation. Deep-crustal variations only occur where they can be correlated with major tectonic features such as the Caledonian Iapetus Suture near the Shannon Estuary. The shallowing of the Moho towards the coast may result from Mesozoic crustal extension in the adjacent offshore sedimentary basins.

S61A-1089 0830h POSTER

Surface-Wave Tomography in Fennoscandia

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S SVEKALAPKO Seismic Tomography W.G.

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We developed a technique based on paraxial ray tracing to obtain 2D phase-velocity maps as a function of frequency which can subsequently be inverted for the 3D structure. The major improvement of our method compared to previous ray tracing studies is that we jointly invert for the velocity model under the array and the shape of incoming wave fronts, therefore reducing artifacts due to structure outside the study region. The stabilisation of the inversion was performed by imposing a smoothness criteria to the wavefronts and to the phase-velocity map.

The method was applied to data from the SVEKALAPKO deep seismic experiment, where the central part of the Baltic Shield, in southern Finland, was covered by a regular two-dimensional grid of 46 broad-band stations which operated for six to eight months. This exceptional stations distribution offers the possibility to undertake a high precision surface-wave tomography. P-wave and surface-wave tomography are complementary as the latter one gives an image of absolute shear-wave velocities with a relatively good vertical resolution.

We first selected 69 high quality events with the best possible azimuthal distribution. The arrival times of the fundamental-mode Rayleigh waves as a function of frequency were measured using Wiener filtering. A selection of the data was performed using a minimum signal to noise ratio of 4 and a minimum coherency of 0.95 between the signals recorded by different stations.

To obtain an average dispersion curve for the region between 10 and 200 seconds we inverted the data imposing the phase-velocity to be quasi constant. This dispersion curve was subsequently inverted for the average shear-wave velocity structure as a function of depth. This average structure shows a lithospheric mantle faster than global average models at all resolved depths.

The inversion of the same data set was also conducted using weaker constraints to obtain the lateral variations of the phase-velocity at each frequency, and after a second inversion the 3-dimensional structure of the lithosphere in shear-wave velocity.

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3D P-wave velocity of the Tornquist suture zone studied through inverse Monte Carlo sampling of teleseismic P-phase arrivals

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Lithospheric differences are studied through a non-linear Monte Carlo tomography inversion of teleseismic P-phase arrivals. Data from the TOR-project are used. TOR was a 900km long and 100km wide antenna of 120 mobile broad band and shortperiod seismographs, that continuously collected data in Sweden, Denmark and Germany, for half a year from 1996 to 1997. The TOR-project investigated the Tornquist Zone in Germany-Denmark-Sweden as part of the EUROPROBE program. The transition between the Baltic Shield and the geologically younger lithosphere to the SW was by linear inversion found to be stepwise in narrow zones, near vertical and more than 300km deep. By a linear study using 3108 P-phase registrations from 49 earthquakes the inclination of the transition was found to be a SW-slope. Whereas two other linear studies one using 3593 P-phase registrations and one using 803 S-phase registrations both from 51 earthquakes found the inclination to be NE oriented. A high resolution inverse Monte Carlo sampling in a 200x200x300km area containing the Tornquist Zone of a limited data set of eight earthquakes, indicates, when tested through a Bayesian hypothesis, that a SW dipping transition zone is preferred by data. Marginal posteriori P-velocity distributions of vertical and horizontal profiles are presented. URL: <http://research.kms.dk/~tor/>

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EB95-97: Deep Lithospheric Structure of the East European Craton Beneath the EUROBRIDGE Seismic Transect

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During 1994-1997, a deep seismic sounding (DSS) experiment was conducted along a profile extending from the Baltic Sea to the Dnieper basin area. This cooperative effort is called EUROBRIDGE, and its purpose is to study the lithospheric structure of the East European Craton (EEC) between the Baltic and Ukrainian shields. Seismic data for this 1200 km long profile were acquired during two campaigns (EB95&96 and EB97) in which about 120, 3-component seismographs were deployed at a station spacing of 3-4 km. The EB95&96 effort involved recording along a 700 km long NW-SE trending transect that crossed the EEC from the West Lithuanian Granulite belt to the Ukrainian shield. Sources were 24 explosive shots of up to 1000 kg in size and were detonated at intervals of about 30 km. In addition, a large shot was fired in the Baltic Sea close to Gotland Island. Tomographic inversion and ray trace modelling established a 2-D P-wave velocity model and spatial variations in Vp/Vs. The upper, middle and lower crystalline crust exhibit velocities of 6.1-6.3, 6.4-6.8 and 6.9-7.2 km/s. P-wave velocities immediately beneath Moho are 8.2-8.35 km/s. The crust below Lithuania is about 44 km thick, and below Belarus it is about 50 km thick. A lower lithosphere reflector occurs at 65-70 km depth. S-wave velocities are relatively high in the upper crust and low in the lower crust. Correlation of our seismic structure with near surface geology tentatively suggests that the contact zones between the East Lithuanian Belt, Belarus-Baltic Granulite Domain, Central Belarussian Belt, and the Onitsk-Mikashевичi Igneous Belt all dip slightly to the southeast, consistent with the hypothesis of successive docking of these terranes during craton growth. The effort in 1997 (EB97) involved recording along a 530 km long north-trending profile. This profile traverses the northwestern part of the Ukrainian shield within the Sarmatian province of the East European craton. Chemical explosions at 18 shot points at approximately 30 km intervals provided the seismic energy. Our velocity modeling showed that there are