expected in the transition zone or the transformation of pyroxenes into the garnet mineral majorite. A further possibility is locally high iron content in the lower upper mantle leading to small scale heterogeneities.

S31D-0789 0830h POSTER

Seismic Scattering from Heterogeneity in the Continental Crust and Upper mantle

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We document pronounced seismic scattering from three heterogeneous zones in the continental crust and upper mantle under Eurasia: (1) The lower crust, (2) The mantle low-velocity zone, and (3) An interval around the top of the mantle transition zone. We model the scattering by use of viscoelastic, full wavefield, 2D finite-difference synthetic seismograms. The calculations are for large models of seismic velocity (2500 by 550 km), which include by heterogeneous layers, defined by random fluctuations of the elastic parameters and Q-values. Our primary data source is Peaceful Nuclear Explosion (PNE) seismic data sets collected in the former Soviet Union. High-frequency signals (up to 10 Hz with centre frequencies of 2-4 Hz) from the PNEs were recorded with a nominal receiver spacing of 10-15 km along profiles of up to 4000 km length. (1) Lower crustal scattering explains the characteristics of the teleseismic (or long-range) Pn wave at all frequencies in the data. This wave propagates as a whispering-gallery phase to more than 3000 km offset from the sources with apparent mantle velocity. It requires a large, positive vertical upper mantle velocity gradient. The model is consistent with outcrop and seismic observations. We reject a previously published model for the teleseismic Pn in terms of upper mantle scattering which only explains the wavefield characteristics at high frequency, but not at low frequency. It also leads to strong damping of later arrivals, in disagreement with observations. (2) Heterogeneity in the mantle low-velocity zone below the 8^o discontinuity at 100 km depth causes scattering of the main frequencies (2-4 Hz) of the seismic wavefield. The scattering is primarily observed directly behind the first arrivals in the 800-1400 km offset range. Pronounced delay of the first arrivals beyond ca. 800 km offset demonstrates the presence of the mantle low velocity zone. The best fit to observations is obtained by including an 80 km thick heterogeneous low-velocity zone below 100 km depth. The heterogeneity is represented by fluctuations described by a von Karman distribution function with a Hurst number of 0.5 and spatial correlation lengths of 5-10 km (horizontally) and 3-5 km (vertically). (3) Pronounced reflectivity before and after the '41" reflection in the seismic sections constrains heterogeneity around the top of the mantle transition zone. The 2-4 Hz scattered signals may be explained by fluctuations in the 320-460 km depth interval with horizontal and vertical correlation lengths on the order of 20-40 km and 5-10 km, respectively. We present synthetic seismograms that include the effects from all three heterogeneous depth intervals. They explain most of the characteristics of the observed wavefield from the PNE sources.

S31D-0790 0830h POSTER

Using Array Seismology to Probe the Deep Earth With Core Seismic Phases

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Much work is undertaken to investigate the structure of the deep Earth, i.e. the core and lower mantle. Researching these regions is important, as they are thought to govern the generation of the Earth's magnetic field, as well as mantle convection. The deep mantle region includes the core-mantle interaction zone, and is potentially the origin of plumes, and the graveyard for slabs. Much controversy exists regarding the nature of the inner core, in particular its anisotropy and rotation. Up to now, seismological studies of the Earth's core have focused primarily on travel time deviations. These locate anomalous regions, but cannot determine the nature of the anomaly. The rays may have been deviated along an anomalous path (backazimuth deviation), or travelled at an anomalous phase velocity (slowness deviation). The work presented here utilises array seismology to further examine anomalies previously located by studying travel time deviations. The slowness and backazimuth of core seismic phases are calculated, and compared with global velocity models. Deviations of the different phases are analysed to resolve the location of the anomalous regions. The results are then compared with travel time deviations. This method will be employed globally, utilising arrays that lie at a suitable epicentral distance from relatively deep, strong events. Currently two arrays have been used, the German Regional Seismic Network (GRSN) and the Alaska Seismic Network (ASN). Earthquakes in Tonga-Fiji are received by the GRSN, and data from the ASN is used to further investigate the anomalous South Sandwich Islands to Alaska path. This path has been shown in recent studies to have strong anisotropy and is also used to study rotations of the inner core. Results show that deviations are present in all three phases (PKPab, PKPbc and PKPdf); deviations vary for the different paths. The Tonga-Fiji to Germany path has particularly deviated backazimuth values for all three phases, possibly indicative of lower mantle structure. The South Sandwich Island to Alaska path shows deviations particularly in the PKPdf branch (the branch that travels through the inner core).

S31D-0791 0830h POSTER

Constraints on Density and Shear Velocity Contrasts at Inner Core Boundary

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The density jump ($\Delta\rho_{ic}$) at the inner core boundary (ICB) is an important constraint on the dynamics and history of the earth's cores. Two types of seismological data sensitive to $\Delta\rho_{ic}$ have been studied since the 1970's: free oscillation eigenfrequencies and amplitudes of core reflected phases (PKiKP/PcP). The reference PREM model (Dziewonski and Anderson, 1981), based largely on normal mode data, has a relatively low value of $\Delta\rho_{ic} = 0.65 g/cm^3$, whereas most studies based on PKiKP/PcP amplitude ratios find significantly larger values, sometimes in excess of $1.0 g/cm^3$. It has been argued that, because PKiKP is rarely observed in the distance range considered $(10 - 70^o)$, the latter type of measurement provides only upper bounds on $\Delta\rho_{ic}$ (e.g. Shearer and Masters, 1990). We have analyzed 10 years of high quality global broadband data accumulated since the work of Shearer and Masters (1990). We systematically analyzed over 4500 seismograms from intermediate/deep events (depth > 70 km) and nuclear explosions, in the distance range $10 - 70^o$. The data were filtered in the band-pass 0.7-3 Hz. We performed a rigorous data selection: 1) we only considered observations of clearly identified PKiKP and PcP (within 5s of theoretical arrival time) with signal to noise ratio > 4; 2) we rejected data for which one or more of 7 other phases may be present within 15 s in front of PKiKP or PcP (P,pP,PP,PPP,S,SS,ScS). We identified 5 pairs of very clear (Quality A), and 16 possible (Quality A-) PKiKP and PcP arrivals. In addition, 62 records showed no PKiKP but a clear PcP. Together, we obtain a much less dispersed dataset than previously available, with the quality A data following the lower bound of the ensemble of amplitude ratios versus distance. We combine our high quality measurements with 2 measurements from the literature that fell within our rigorous selection criteria and obtain unbiased estimates of $\Delta\rho_{ic}$ in the range $0.65 - 0.91 gcm^{-3}$. We discuss trade-offs between $\Delta\rho_{ic}$ and the corresponding velocity jumps at the ICB.

S31D-0792 0830h POSTER

On the Existence of Seismic Discontinuities in the Inner Core

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We evaluate the possibility of seismic discontinuities within the inner core using a data set of precritical PKiKP waveforms assembled during a previous study. Recent work has suggested the presence of such structures within the inner core, relating them to either changes in anisotropy at shallow depths or at deeper locations. Another explanation is the existence of a crust below the inner core boundary and a low velocity zone, based on geophysical models of inner core growth. Because any phase reflected from a discontinuity within the inner core will have a very small amplitude, we combine source and receiver stacks in our search. For a given event we use cross-correlation to align the data from a short-period, small-aperture seismic array and then construct a receiver stack using linear summation. Next we use one of two procedures (deconvolution by an empirical source time function and envelope formation) to eliminate the signature of the source from each receiver stack. Finally, we stack the receiver stacks from each event using time shifts appropriate for a velocity model with a discontinuity at some depth below the inner core-outer core boundary. We compare the results with synthetic computations done by means of generalized ray theory and appropriate attenuation operators. We perform resolution tests to determine our capability of finding these types of structures, varying the impedance contrast, position of this discontinuity and attenuation inside the inner core. Our results show that the inner core lacks a sharp (thickness less than 4-5 km) global transition to at least 700 km below the boundary with the outer core.

S31E MCC: Level 2 Wednesday 0830h

Global and Regional Tomography I Posters *(joint with DI)*

Presiding: **M West,** New Mexico State University**; E Sandvol,** University of Missouri

S31E-0793 0830h POSTER

Geographical ISC data Characterization with Parallel Ray-tracing

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In order to improve the accuracy of existing seismic tomography methods, huge quantities of information must be computed. Our objective is to build an adaptive mesh of the Earth so it can translate to an inverse problem of tractable size. The mesh cells size will be adapted depending on the "illumination" quality, that is regions where rays have brought more information will be modeled precisely, yielding small cells, whereas cells traversed by few rays are covered by large cells . These considerations lead us to develop software programs to take into account the computational resources needed for the 3D ray tracing step and the huge quantity of data to store into the cells mesh. These per-cell data are characteristics such as the ray length, the ray density, the number of ray hits by cell face, and the quality of the spatial repartition of rays in the cell. Our parallel programs made possible to process the entire ISC data set recorded for year 1999. We ray-traced 399,406 out of the 817,101 ray records, in an Earth mesh with 11 layers of $1^o \times 1^o$ cells (712,800 cells). First we observe, that nearly half the data set cannot be traced because rays were not given a precise enough seismic signature. Secondly, we produce from the computed results, graphical 3D maps highlighting geographical zones where information brought by rays are noticeable. The graphical tool enables to visualize maps corresponding to any of the above cited characteristics. Several hardware equipments were tested (PC cluster, parallel computer, Grid computing) to run the experiment. An acceptable processing time of 400s was reached with 64 processors on SGI Origin 3800 parallel computer. Our programs showed a good scalability when the number of processors increase. Another interesting feature is our capability to process data sets by slice to overcome memory limitations, but nonetheless obtain aggregated mesh results. We think the processing of the entire ISC catalogue from 1964 to 2002 with several millions of rays is attainable.

URL: http://guenievre.u-strasbg.fr/ray2mesh

S31E-0794 0830h POSTER

Local Earthquake Tomography at the Active Tongariro Volcanic Centre, New Zealand

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Back-arc spreading caused by subduction of the Pacific plate beneath the Australian plate ranges from full oceanic spreading north of New Zealand to continental extension in the North Island. The Tongariro Volcanic Centre (TVC) in the North Island of New

Zealand marks the southern terminus of continental extension and contains three main active volcanoes – *Ruapehu*, *Tongariro* and *Ngauruhoe*. Ruapehu last erupted in 1995-96, Ngauruhoe in 1973-75 and Tongariro in 1896. From January-June 2001 twenty-three three-component broadband (0.03–50 Hz) seismometers from the SEIS-UK pool were deployed in and around the TVC. The seismometers recorded continuously at 100 samples/sec throughout the deployment. Additional seismic data were obtained from permanent network seismometers in the surrounding area. We present the results of the project, including an improved 1D velocity model ("*minimum 1D model*") for standard earthquake location in the area, accurately located local seismicity, and local earthquake tomography results. The TVC is characterised by low-velocity volcanic sediments surrounding the three large, high-velocity andesitic cones. It is flanked to the west, south and east by Tertiary sediments. The western boundary is marked by an active fault scarp along which ∼70% of the well-locatable seismicity occurred during the deployment. This seismicity occurs in several clusters concentrated in the depth range 8–15 km. Additional clusters of seismicity are located at 1–4 km depth beneath the Tongariro-Ngauruhoe system, close to sites of persistent geothermal activity. A further cluster of seismicity at shallow depth (∼5 km depth) is located at the north-western edge of Lake Rotoaira. No well-locatable crustal earthquakes are detected beneath Ruapehu. This is most likely due to the typically low magnitude of events beneath Ruapehu and the lack of sufficient nearby stations. The 3D upper-crustal velocity model produced, together with the observed distribution of local seismicity, contribute to our understanding of processes occurring within the active volcanic systems and at the tip of an incipient continental rift system.

S31E-0795 0830h POSTER

High resolution P-wave tomography for SE Romania - an earthquake prone region in SE Europe

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The Vrancea earthquake region in SE Romania is characterized by strong intermediate depth seismicity in a very limited and well defined hypocentral region. Previous studies recognized a high velocity body as locus of the intermediate depth seismicity. Present models interpret this body as a remnant of subducted lithosphere that has been detached along the Carpathian arc, now representing the final stage of slab break-off in the upper mantle. For our new results we used the teleseismic dataset of the CALIXTO tomography experiment for a nonlinear inversion of teleseismic P-wave traveltimes. The dataset consists of more than 12 000 handpicked traveltime readings from 196 events leading to a good ray coverage within the model. In previous results the influence of the poorly resolved crust caused uncontrolled smearing into the upper mantle. To overcome this limitation traveltimes were calculated through a realistic 3D crustal model for this region with a 3D-FD raytracing algorithm. Therefore the effect of the traveltime anomalies within the crust could be eliminated from the tomographic inversion. We will present high resolution images of the high velocity body and the surroundings in the upper mantle as the results of nonlinear teleseismic tomography and discuss it in terms of structure, resolution capability and solution reliability and therefore outline the boundary conditions for the geodynamic processes of this region.

S31E-0796 0830h POSTER

Exceptional High Seismic P-wave Velocity of the Uppermost Mantle around the Mirny Kimberlite in Siberia

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We present seismic velocity models along two perpendicular seismic profiles with their crosspoint 30 km to the south of the Mirny Kimberlite Pipe in Yakutia, Siberia. The data comprises recently digitized seismograms from vintage seismic sections that were acquired in 1981-1983 by use of Taiga analogue seismographs. 41 seismographs were deployed along the 370 km long, NW-striking profile I, which crosses the kimberlite pipe. 45 seismographs were deployed along the perpendicular 340 km long profile II. The sources were 20 chemical shots along each profile, loaded with between 1.5 and 6.0 ton of TNT distributed in individual charges of 100-200 kg in shallow water (<2 m deep). The data is of high quality with high signal/noise ratio to the furthest offsets. We have interpreted the data with seismic tomographic inversion of first arrivals and with 2D ray- tracing, forward modelling. The velocity models show normal cratonic structure of the ca. 45 km thick crust with only slight undulation of the Moho around Mirny. Low velocity anomalies are detected to 25 km depth in a ca. 60 km wide zone at the kimberlite pipe. Extremely high P-wave velocity (>8.7 km/s) of the sub-Moho mantle is interpreted along almost all of profile I, with an 80 km wide, low-velocity anomaly below the kimberlite. Profile II mainly shows Pn velocities of 8.0-8.2 km/s, with high velocity (>8.5 km/s) in two, ca. 100 km wide zones at its SW end. The nature of these exceptionally high, sub-Moho mantle velocities is not yet understood. The difference in velocity in the two profile directions indicate anisotropy, but the influence of unusual rock composition, e.g. from a high concentration of garnet, cannot be excluded.

S31E-0797 0830h POSTER

Travel Times in the Regional Distance Range: Results of the 3-D Ray Tracing.

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Travel times of regional body waves are primarily sensitive to seismic velocities in the upper mantle, and they are therefore useful for constraining the heterogeneous structure in tomographic inversions. Traditionally, tomographic inversions seek velocity variations with respect to a 1-D reference model, and travel time perturbations are calculated for 1-D reference rays. Strong lateral heterogeneity in the upper mantle significantly deviate rays from their reference paths, which may considerably affect the predicted travel times. The effect of misidentification of multiple arrivals observed at regional distances may be even bigger. Owing to these complications, measurements at regional distances are often neglected in tomographic studies. Travel times can be calculated more precisely by using regional 1-D velocity models, but only if the region of interest is sufficiently small and uniform to be represented by a 1-D model. To remedy this limitation, one may predict travel times using a global 3-D model at a cost of implementing a 3-D ray tracing technique. We employ a pseudo-bending algorithm (*Koketsu and Sekine*, 1998) to trace rays in global 3-D velocity models expanded over spherical and radial spline basis functions. To distinguish between multiple arrivals we trace rays bottoming in several depth ranges. We show that the first arriving phases recorded at a given distance may travel along significantly different paths in distinct tectonic settings. To improve the accuracy of the travel time calculations we incorporate a detailed global crustal model with the 3-D mantle models. We use the ray tracer to model an extensive data set of regional travel times detected at 130 stations from 192 underground nuclear explosions in the Former Soviet Union. To investigate the importance of the 3-D ray tracing we compare travel times calculated along the rays in 3-D velocity models versus those integrated along the paths predicted by a 1-D model. The comparison of the resulting residuals shows a systematic small bias of the 1-D rays towards longer travel times. Higher resolution models, constrained by surface waves and regional body waves, are needed to predict the travel times more accurately.

S31E-0798 0830h POSTER

Three-Dimensional Shear Wave Velocity Structure in the Crust and Upper Mantle of the South China Sea and its Surrounding Area

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The three-dimensional shear wave velocity structure in the crust and upper mantle of the South China Sea and its surrounding area was investigated with fundamental mode Rayleigh and Love wave group velocities in the periods 14-120 s. The path coverage is good for most of the periods. The group velocity data were inverted for the group velocity distribution maps in the studied area with 2-D tomographic technique without any a priori regionalization. The resolutions of the tomographic analysis were quite decent in most of the target region. The group velocity maps were inverted for the shear wave velocity structure in the crust and upper mantle In the shallow depth, lateral heterogeneities with short wavelength were seen in the group velocity maps. This might be related with complicated surface structures. In the middle depth, the group velocity maps were well correlated to the main tectonic features seen at the surface. The thickness of the lithosphere of the South China Sea Basin is probably 60 km. A high shear wave velocity gradient clearly exists along longitude 105E down to a depth of about 250 km. At shallower depth, the velocities are noticeably higher east of this longitude than west of it. At depth below about 85 km, both east and west of this longitude have comparable velocity distribution. This 105E structure extends southwards to the northeast side of the Red-River Fault Zone in Indochina. The Red-River Fault Zone is probably a fairly deep structure boundary, its northeastern side has higher shear wave velocity than its southwestern side. The extrusion of Indochina, due to India-Asia collision, is probably partly driven by some kind of flow in the upper mantle beneath Indochina and Sunda Shelf. Borneo, Palawan trough, Palawan and most of Sulu Basin have lower shear wave velocity.

S31E-0799 0830h POSTER

Deformation of the Aegean Slab in the Mantle Transition Zone

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Consistent with results of earlier tomographic studies, regional non-linear P-wave travel time tomography depicts a slab of previously oceanic lithosphere penetrating into the lower mantle beneath part of the Aegean region. However, our results also suggest that the slab is intensely distorted in the transition zone, with the lower mantle penetration spatially confined to a relatively small area. The deflection of the slab in the transition zone resembles that observed beneath, for instance, the Izu Bonin arc and the Tyrrhenian Sea and can be related to the slab roll-back that has accompanied back-arc extension. In addition, joint P- and S-inversion indicates that the deformed part of the slab is likely to be a bulk sound feature, which is in remarkable agreement with our previous observations pertinent to deflected slabs beneath western Pacific island arcs. The difference between the shear and bulk sound signature of slabs that either deflect in the transition zone or penetrate to larger depths thus seems robust and may contain important information about the interaction of downwellings with the upper mantle discontinuities.

S31E-0800 0830h POSTER

Inversion of Surface and S Wave Forms for Seismic-Velocity Perturbations Relative to a Three-Dimensional Reference Model

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S

Waveform inversions of surface and S waves can be formulated so as to directly constrain average seismic-velocity anomalies along the path. In the Automated Multimode Inversion scheme of Lebedev and Nolet (2003), waveform phase information is extracted from time-frequency windows uncontaminated by scattered waves and put in the form of independent linear constraints (with uncorrelated uncertainties) on seismic-velocity anomalies in the Earth. In this and similar schemes, waveforms are inverted for path-averaged perturbations, implying that lateral variations of the (Frechet) derivatives of phase velocities with respect to seismic velocities have to be assumed negligible within the waves' sensitivity volumes. This assumption is only valid within certain limits (generally different for every source-station path). For example, high heterogeneity in the Earth's crust will normally prohibit using signal at frequencies too high or modelling structure too shallow. Here we re-formulate the averaging scheme so as to expand the field of validity of the approximation, then map the limits of that field, and then use the new scheme in order to compute an upper-mantle model of Asia and surroundings. Our initial reference model is the 3-D crustal model CRUST2 (Laske, 2001) atop a laterally homogeneous mantle model. For every point of the model grid on the surface we compute phase velocities of surface-wave modes and their Frechet derivatives. For each source-station path, we then compute the reference phase velocities and the average derivatives as integrals over an estimated sensitivity area, the latter averaged over the frequency band of the inversion. Waveform inversions of tens of thousand seismograms produce linear equations which are inverted together for a 3-D model of the crust and upper mantle. Taking this 3-D model as a new reference, we repeat the whole procedure. More iterations follow and continue until convergence to a final 3-D model. We shall discuss selected features of the new model in the presentation.

S31E-0801 0830h POSTER

Teleseismic tomography of the upper mantle beneath China

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Seismic P-wave velocity variations in the upper mantle beneath China are tomographically imaged using P-wave traveltime data reported in the Bulletin of Seismological Observations of China. This data set is compiled by the China Seimological Bureau. Within the lithosphere, low velocities are observed beneath the Northeast China basin and the back-arc Yunan province. These regions are affected by late Cenozoic extension. Low velocities beneath the Northeast China basin extend down to roughly 300 km suggesting the involvement of the asthenosphere. The eastern Himalayan syntaxis is underlain by Indian shield which has fast velocity. The Sichuan basin is a stable cratonic shield and is characterized by high velocity in the upper 200 km. A high velocity zone at 150-250 km depth is imaged beneath the Qiling-Dabie suture, which was a late Triassic collision zone between the North and South China blocks. The high velocity indicates a thickened lithosphere duing the collision. The lithosphere of the South China block has a relatively high velocity.The subducted Pacific plate beneath North Korea is revealed by the tomographic image. A very low velocity anomaly, perhaps a plume, is imaged beneath southeastern China in a region just north of the Hainan Island.

S31E-0802 0830h POSTER

An Examination of Rayleigh Wave Phase Velocities, South Shetland Islands

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We examine the crustal and upper mantle structure of Bransfield Strait, the South Shetland Islands, and the Antarctic Peninsula using data from the Seismic Experiment in Patagonia and Antarctica (SEPA). We use Rayleigh wave phase velocity dispersion measurements from 20 teleseismic events to determine the interstation phase velocities at periods between 16 and 120 seconds. Maps of the velocities indicate crust with continental properties beneath the South Shetland Islands, the Antarctic Peninsula, and the area southwest of the Hero Fracture Zone. Thinner crust (less than 20 km thick) with backarc spreading mantle velocities lies within the Bransfield Basin proper. The seismic velocities indicate more established spreading in the northeastern portion of Bransfield Strait, and we see no evidence of anisotropy within the mantle.

S31E-0803 0830h POSTER

Updated Western Montana Velocity Model With Regional Model Comparison

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We determined a new crust and upper mantle velocity model for western Montana using a 1-D layered earth approach. P-wave arrival times recorded on 358 stations from 1,432 well recorded earthquakes provided input for a sparse damped least squares sensitivity matrix. We solved for 1-D velocity structure, depth boundary (refractor) positions, station corrections, and hypocentral positions from calculations of travel-time residuals. The final model showed the first layer having a velocity of 5.7 km/s and a depth of 7.0 km, the second layer having a velocity of 6.1 km/s and a depth of 19.8 km, the third layer having a velocity of 6.5 km/s and a depth of 39.7 km, and an upper mantel velocity of 8.0 km/s. We split the study area into subregions and separately determined 1-D velocity models for each subregion to observe lateral velocity variations. Velocity models determined for subregions showed a maximum difference of 0.25 km/s velocity and 3.5 km layer-thickness variations from the model obtained for the entire study area. Station corrections computed for the subregions and the entire study area were correlated to local travel-time anomalies rather than anomalies of wider extents associated with multiple stations. The new model and station corrections improve resolution and accuracy of hypocenter locations for western Montana earthquakes. A comparison of published velocity models for the Intermountain Seismic Belt of western Montana shows significant trends of the crustal thickness changes. 1-D velocity models from eastern Washington, the Yellowstone Caldera, the Snake River Plain, and eastern Montana suggest that the crust gradually thickens from NW to SE across the region. The subregions velocity model analysis showed a thicker high velocity layer for the central part of the study area. A 3-D velocity model in development for our study area should refine this interpretation.

S31E-0804 0830h POSTER

Yellowstone: A 3D Regional Delaytime Inversion Using Multiple Constraints

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The origin of the Yellowstone hotspot is a matter of debate where plume- and nonplume models are discussed. The aim of this work is to derive a high resolution 3-D regional P-wave velocity model which is compatible with constraints from a variety of different fields (e.g. geology, gravity, seismology). This provides a more comprehensive notion of the Yellowstone hotspot structure and may serve as basis and reference model for the later geodynamical modelling of the Yellowstone hotspot. The main focus is on the tomographic inversion of teleseismic delaytime data. Since the resulting model has to be consistent with many different constraints, these are incorporated as a priori information into the inversion. This is of advantage especially in the crustal regions of the model, where the resolution of the teleseismic delaytime inversion typically is rather poor. The inversion is done iteratively using 3D raytracing. The a priori information mainly consist of the geological surface structure, crustal models from local tomography and the topography of seismic discontinuities derived from receiver function analysis. In addition to that, the Bouguer gravity signal is used as additional dataset to constrain the crustal structure via the joint inversion of gravity and teleseismic data.

S31E-0805 0830h POSTER

Upper Mantle Velocity Structure Beneath Eastern Anatolian Plateau and Surrounding Regions

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The Eastern Turkey Seismic Experiment (ETSE) was designed to image the crustal and upper mantle velocity structure beneath the northernmost Arabian plate and beneath the Anatolian Plateau, constraining geodynamic models for young continent-continent collision. ETSE was composed of a 29 station broadband PASSCAL array which was deployed from October 1999 until August 2001. We have measured Rayleigh wave phase velocities across the Anatolian plateau using 45 teleseismic and regional events. We used a method that approximates the wavefield from each earthquake as the sum of two interfering plane waves to map Rayleigh wave phase velocities for periods between 30 and 140 seconds. The optimal one dimensional velocity model suggests that there is little, if any, lithospheric mantle beneath the Eastern Anatolian plateau. The Rayleigh wave phase velocity maps are consistent with the Bitlis suture?s marking an abrupt change in the lithospheric mantle velocity structure. Tomographic mapping of the Rayleigh wave phase velocities suggests that the uppermost mantle ultra-low velocity zone is underlain by relatively normal to slightly low velocity mantle. This finding is consistent with our preliminary three dimensional P-wave velocity model that was obtained using teleseismic body wave tomography. The preliminary P-wave model does not show a clear contrast in mantle properties across the Bitlis suture. Teleseismic shear wave splitting indicates that there is a relatively uniform northeast fast direction throughout the plateau. Across the eastern portion of the Anatolian plateau, there appears to be some correlation between very slow mantle lid velocity and large splitting lag times. We are investigating the depth extent of the azimuthal anisotropy beneath the eastern Anatolian plateau using Rayleigh wave phase velocities.

S31E-0806 0830h POSTER

Joint tomographic inversion of body and surface waves for upper mantle structure

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We present a tomographic method which combines teleseismic shear wave delay times and Rayleigh wave phase velocities into a single joint inversion for shear wave velocity structure. Teleseismic body wave tomography, based on PASSCAL-type broadband deployments provides, arguably, the highest lateral resolution of features in the upper mantle. However, the need to account for structures outside the resolved area limits the resulting image to a lateral comparison of relative velocity, while steeply-dipping raypaths diminish the vertical resolution at shallow depths. Conversely, surface wave inversions have their greatest vertical resolution at shallow depths, and they provide measurement of absolute seismic velocities. The long wavelengths required to probe the mantle however, lack the lateral resolution afforded by body waves. Several recent papers have used a 1D velocity model, derived from surface waves, as a baseline to which the body wave-derived variations are applied. The deployment of larger aperture seismic arrays and USArray allow the integration of spatially-varying surface wave observations. We present a straightforward method in which surface wave velocities are converted into traveltimes and sensitivity kernels that can be directly incorporated into existing body wave tomography schemes.

The strengths of this method are twofold. First, it is blind to the specific methods used to derive surface wave velocities and body wave delay times. These could be accomplished by different researchers using different events, and even different seismic arrays. Second, the approach can be applied rapidly to most body wave delay time inversion schemes with minimal modification. We demonstrate the method on data from the PASSCAL-supported LA RISTRA array in the southwest U.S. The temporary 950-km linear array provides a large set of body wave traveltimes and surface wave velocities over periods of 10-150 s. Independent crustal thickness constraints, in this case provided by receiver function analysis, can be incorporated as well. We use this data and synthetics to demonstrate the benefits of the joint inversion method as well as special considerations required to weight the two complimentary datasets.

S31E-0807 0830h POSTER

Teleseismic Tomographic Images of the Central Tien Shan

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We analyzed teleseismic P arrival times recorded by three seismic networks in central Asia (KNET, KAZNET, and GHENGIS) to produce an image of the crust and upper mantle beneath the central Tien Shan. In the uppermost mantle, the wavespeeds beneath the Tien Shan are significantly lower than those beneath the Kazakh shield, consistent with previous tomographic studies of this region. Between about 200 and 400 km depth, however, there is clear evidence of a tabular, steeply dipping region of high wavespeeds about 100 km in width situated beneath the southern part of the range. There is no evidence to suggest that this feature extends below 400 km depth. Its origin is indeterminate but the primary candidates are a delaminated lithosphere from the central Tien Shan or a detached piece of subducting Tarim Basin. In either case the body is located several tens of kilometers south of where one might expect its location to be with respect to contemporary geologic features at the surface. This suggests that the Tien Shan has migrated northwards over the mantle as the crust shortened.

S31E-0808 0830h POSTER

A New Global Model for 3-D variations in P Wave Speed in Earth's Mantle

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In an effort to improve the resolution of mantle structure we have combined complementary data sets of short- and long period (absolute and differential) travel time residuals. Our new model is based on short period P (N$\tilde{7}$.7x10**6), pP (N$\tilde{2}$.3x10**5), and PKP (N$\tilde{1}$6x10**4) data from the catalog by Engdahl et al (BSSA, 1998), short-period PKP differential times (N$\tilde{1}$600) measured by McSweeney & Creager, and long-period differential PP-P times - N$\tilde{2}$0,000 measured by Bolton & Masters and N$\tilde{1}$8,000 by Ritsema - and Pdiff-PKP (N$\tilde{5}$60) measured by Wysession. Inversion tests, spectral analysis, and comparison with geology indicate that the large-scale upper mantle structure is better constrained with the addition of PP-P, whereas the Pdiff and PKP data help constrain deep mantle structure (Karason & Van der Hilst, JGR, 2001). The long period data were measured by cross-correlation. We solved the system of equations using 400 iterations of the iterative algorithm LSQR For the short period (1 Hz) data we use a high frequency approximation and trace rays through a fine grid of constant slowness cells to invert for mantle structure. For low frequency Pdiff and PP data we account for sensitivity to structure away from the optical ray path with 3-D Frechet derivatives (sensitivity kernels) estimated from single forward scattering and projected onto basis functions (constant slowness blocks) used for model parameterization. With such kernels the low frequency data can constrain long wavelength heterogeneity without keeping the short period data from mapping details in densely sampled regions. In addition to finite frequency sensitivity kernels we optimized the localization by using a parameterization that adapts to spatial resolution, with small cells in regions of dense sampling and larger cells in regions where sampling is more sparse (the total number of cells was $\tilde{3}$50,000). Finally, we corrected all travel times and surface reflections for lateral variations in crust structure using CRUST2.0

S31E-0809 0830h POSTER

Comparing P and S Wave Speed Perturbations for Europe

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This study aims to improve our understanding of the temperature and composition of the mantle underneath Europe. We selected bodywave traveltime residuals of common source-receiver pairs from the reprocessed dataset of Engdahl and others. Due to the one to one correspondence between the P and S sampling, the resulting P and S wavespeed perturbation models have a similar ray coverage and therefore similar resolution properties. From these models we extracted the bulk sound speed, Poisson's ratio and $R = \partial lnV_s/\partial lnV_p$. The preliminary results show an almost constant R of 0.8 throughout the mantle except in the transition zone. Furthermore, we find a substantial difference in the Poisson's ratio between the cratonic and tectonic part of Europe. The bulk sound speed and shear wavespeed perturbations appear to be negatively correlated in most of the mantle. The correlation of the P and S wavespeed perturbations is positive and decreasing until ∼1500 km depth, in agreement with previous studies.

S31E-0810 0830h POSTER

Convection Beneath the Rio Grande Rift and Surrounding Regions Deduced From Tomographic Seismic Images

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We present new images of the P and S wave seismic structure of the upper mantle beneath a transect extending from the Colorado Plateau across the Rio Grande Rift to the Great Plains of western Texas. The upper mantle structure was determined using travel times from the LA RISTRA passive seismic array deployed from July 1999 to May 2001. Large seismic anomalies are seen (up to 8% variation in S wave speed and up to 5% in P wave speed) in the shallow mantle beneath the array. The seismically slow shallow mantle lies beneath the Rift as well as to the west beneath Mount Taylor, part of the Jemez lineament of volcanic activity. Relative P to S variations indicate the cause of the slow shallow mantle is primarily higher temperature with possibly a small degree of partial melt. The mantle deeper than 150 km beneath the rift is not anomalously slow. The deeper upper mantle does show several eastward dipping seismic structures. Beneath the western Colorado Plateau a fast anomaly is seen near 500 km depth that we interpret to be the trailing edge of the Farallon plate as proposed by Van der Lee and Nolet (1998). To the east of that anomaly is a slow seismic anomaly at 400 km depth that appears to connect to the slow shallow anomaly beneath Mount Taylor. Beneath the Great Plains a narrow fast structure is imaged throughout the upper mantle from 200 to 600 km depth. We interpret the deep slow anomaly to be an upwelling, possibly with higher than normal concentrations of volatiles, and the fast Great Plains anomaly to be an associated downwelling. Petrologic data indicate the lithosphere has been thinned within the past 10 Ma beneath the Rift. There has also been uplift, increased extension within the Rift, and increased volcanic activity during that time period. A possible cause of this recent tectonic activity is the removal of lithosphere from beneath the Rift and Mount Taylor. The removed lithosphere may be entrained in the imaged downwelling beneath the Great Plains.

URL: http://www.agu.org/meetings/fm02/waisfm02.html

S31E-0811 0830h POSTER

Short Period Surface-wave Tomography Beneath the Central Tibetan Plateau

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Data from the PASSCAL experiments, the Tibetan Plateau Passive Source Seismic Experiment in 1991-1992 (TIPLT), INDEPTHIII experiment in 1997-1999 and BUTHAN and stations LSA and LZH, provide an opportunity to map the subsurface geology and advance our understanding of the Plateau's dynamics and tectonic evolution. I present the results of the effort to construct least-squares tomographic maps of short-period Love and Rayleigh wave group velocities across the central and eastern Plateau. I utilize measurements made using stations and events within the Plateau to localize sensitivity to Plateau structures. The inversion is based on observations using a set of 190 shallow events recorded on the 29 broadband stations. I performed a least-square inversion using the conjugate gradient method by Paige and Saunders (1982) at the 6-to 45 s period range. The ray path coverage and checkerboard tests obtained in this study show evidence of reliable tomographic images from Rayleigh and Love wave group velocities across central and east of the Tibetan Plateau. The resolved region of the Qiangtang terrane is one of the slowest features in the model for all periods for both Love and Rayleigh waves. The Lhasa terrane is relatively fast until perhaps 40-seconds, where slow regions emerge in Rayleigh wave group velocities, particularly close to the terrane's southern boundary. An interesting feature is the low-velocity region along the southern terrane boundary. The resolution of such a small feature could be questioned, but it may indicate a region of abnormally low velocities along the suture, caused perhaps by melt or structural anisotropy. Qualitatively, these observations suggest that the upper crust of the Qiangtang terrane is slower than the Lhasa terrane to the south, and that the difference may decrease below a few tens of kilometers, in the middle crust. There is a suggestion of a low-velocity zone at a depth of 20-30 km beneath the Lhasa terrane, but the conclusion is not strongly supported by the present study. The recent characterizations of the upper-middle crust of the Lhasa terrane as containing broad regions of partial melt is neither consistent with the regional and global tomography results nor those of the local-regional tomography of this study. In constrast, the images produced here show the upper crust beneath the Lhasa terrane to be faster on average than that to the north beneath the Qiantang terrane. Deeper structures are beyond the reach of the short-period surface waves employed here, but the existence of wide-spread low-velocity regions as shallow as 12 km is not consistent with the observed group velocities. The use of short-path observations in this tomographic analysis has illuminated several problems. Foremost is the sensitivity of the observed group velocities to source location and origin time. By comparing the Eurasian model mean dispersion values for Central Tibet of Ritzwoller and Levshin (1998) and the mean values from this study the agreement is superb in the range where both data sets are most reliable and the results deviate slightly at the shortest and longest periods. The use of a large number of data has allowed us to overcome this limitation in this study as indicated by the consistent mean results after comparing with the Ritzwoller and Levshin (1998) model, and the correlation of the tomographic images with the terrane geology. Future wok involves an iterative tomographic and epicenter re-location procedure using surface-wave dispersion values to improve the event epicenters, and therefore to precisely define the geological structures in the upper crust of the Plateau.

S31E-0812 0830h POSTER

Surface Wave Studies of the Greenland Shield

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We investigate the lithospheric structure beneath Greenland using Rayleigh waves recorded by 21 broadband seismograph stations deployed across Greenland. This study forms part of the ongoing 'GLATIS' (Greenland Lithosphere Analysed Teleseismically on the Ice Sheet) project. Phase velocity curves are generated for paths between pairs of seismograph stations, using the two-station method of Gomberg et al. (1988). Dispersion curves for 45 paths have been obtained, for the period range 25-160 seconds. The results from the dispersion curves are combined to produce phase velocity maps for several Rayleigh wave periods, assuming isotropic conditions. Each map shows robust lateral structural variations across Greenland. At intermediate periods, we see a significant high-velocity anomaly in the southwest, and a low-velocity anomaly in the east is seen at intermediate and long periods. The results of the phase velocity inversion are used to construct localised dispersion curves for two parallel north-south profiles in southern Greenland. These curves are then inverted for shear-wave velocity structure. The results show a high-velocity 'lid' structure, which we interpret as the seismological lithosphere. The 'lid' overlies a zone of relatively low velocity, beneath which the shear wave velocity increases gradually with depth. A large data set of local and regional earthquakes is used to generate several hundred group velocity curves for the Greenland / western North Atlantic region. The individual dispersion curves are combined to produce a set of detailed group velocity maps for the region. The study provides us with important new information about the structure and properties of the lithosphere and upper mantle beneath Greenland and the surrounding region.

S31E-0813 0830h POSTER

Travel Time Tomography of the Uppermost Mantle Beneath Europe

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We have obtained high-resolution P-wave and S-wave velocity models of the uppermost mantle beneath Europe using travel time tomography. The main purpose of this study was to create a model that accurately predicts regional travel times and also images the main tectonic features in Europe so that it can be used as background for more detailed local studies. To obtain this model we have applied a tomographic inversion method using a subset of well located events from the ISC bulletin which contains significantly more regional data than previous global data sets. Furthermore, improvements have been done in the methodology, including the use of a 3D ray-tracer, and an irregular grid parameterization, with cell sizes that depend on the ray density. In addition, a 3D reference model containing regional features is used, instead of a standard 1D reference velocity model. Because of the data selection and the ray path distribution, our results are comparable to Pn tomography but without the usual approximations required by that method. Synthetic tests show that anomalies with wavelengths of 45 km and 90 km horizontally can be reconstructed by the P and S model respectively. To investigate the influence of the new regional data alone, the inversion is first carried out using a 1D model (ak135) as reference/starting model. The results agree well with previous studies but more details are imaged. Next the inversion is performed using a 3D reference model. In the resulting model, tectonic features are not only imaged for the uppermost mantle but also for the crust. For example, structures like the Alps or the Pyrenees are imaged as prominent low-velocity features. To test the ability of the obtained model to predict travel times, travel time residuals are computed for well located earthquakes that are not part of the used data set. Generally, the model predicts the travel times better than the 1D reference model, particularly for regions of good ray coverage like Italy, where the travel time residuals computed with the new model are smaller than the residuals computed with the 1D reference model ak135.

S31E-0814 0830h POSTER

3-D Empirical Travel Times for Global Heterogeneity

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Many applications in seismology rely on the accurate prediction of teleseismic travel times. As an alternative to travel time calculation in 1-D or 3-D seismic velocity models, we have developed a new approach based on directly smoothing and interpolating observations from large earthquake catalogues. We call the approach 3-D Empirical Travel Times (ETT). This approach is able to handle both the spatial variability in data density, as well as the many length scales of heterogeneity that influence observed travel times. An important feature of the technique is that after the empirical travel time corrections have been applied the remaining residuals are spatially uncorrelated and, in this sense, all of the signal in the data is accounted for. Travel times predicted with the new approach compare very favourably with those from 1-D and 3-D Earth models. Travel time residuals of nuclear blast data are reduced by 62%, on average, compared to 1-D reference Earth models. Tests with globally distributed earthquake data give an average residual reduction of up to 42% across a range of teleseismic phases. Tests also show that, 3-D empirical travel times reproduce the pattern of regional variation in tele-seismic phases very well. In epicentre determination of 25 nuclear blasts, the use of empirical travel times in place of 3-D global velocity models reduced the average mislocation by over 59%. The new approach can also be used for 'denoising travel times from large earthquake databases, giving a new 'data source for tomographic studies. Although developed for use teleseismic the empirical travel time approach has the flexibilityto be applied to local or regional seismicity. This model free 'database approach to travel time prediction results in a highly accurate and robust method and in a sense a return to the empirical philosophy of Jeffreys and Bullen (1940). It is likely to find applications in a range of seismological problems.

S31E-0815 0830h POSTER

Pn Tomography at the Intersection of the Rio Grande Rift and Jemez Lineament

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Between 1999 and 2001, two separate regional teleseismic studies were carried out in the southwest U.S. The PASSCAL-supported LA RISTRA and CD-ROM projects each included a linear array of several hundred kilometers across or adjacent to the Rio Grande rift. The deployments overlapped by approximately nine months. Earthquakes along the west coast provide Pn raypaths which cross one array and then the other. Inter-array Pn traveltimes are inverted for a map of Pn velocity. The synthesis of these data provides a unique opportunity to probe the state of the mantle beneath the central and northern Rio Grande rift. The Rio Grande rift extends from central Colorado into southern New Mexico. The rift has been spreading intermittently since about 36 Ma and has been accompanied by several types of volcanism. In the past 5 Myr most volcanism in the region has occurred along a northeast-trending lineation referred to as the Jemez Lineament. The inter-array Pn raypaths serendipitously cover the intersection of the Jemez lineament and the Rio Grande rift, allowing us to explore the relationship between these two features which dominate the tectonics of the southwest. In particular we seek an explanation which unifies the two features and identifies the cause of volcanism along the Jemez Lineament.

S31E-0816 0830h POSTER

Simultaneous Inversion of Mantle Mode Splitting Coefficients for V_s, V_p and ρ Using the Neighbourhood Algorithm.

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Unlike travel times or waveform data, normal mode data are directly sensitive to the density of the Earth. However, the sensitivity kernels for density are much smaller than those for velocities, so the controversy about the possibility of resolution of the mantle's density is vivid, especially since the publication of model SPRD6 (Ishii and Tromp, 1999) whose high density structures corresponding with the "plumes" under Pacific and Africa would have important consequences on deep mantle dynamics. Using least squares inversion, several authors (e.g. Resovsky and Ritzwoller, 1999, Kuo and Romanowicz, 2002) pointed out significant trade-offs between velocity and density structure. Using a stochastic method may end the controversy about the resolution of density by estimating the posterior probability density of the parameter space. Such an approach was used by Resovsky and Ritzwoller (2002) who concluded in the non resolution of the density but did not investigate further. Here we investigate the effect of other parameterizations and of an extended dataset (Widmer, 2002). In particular, we look at the possibility of resolving a spline-based shear velocity model and the scaling relations $d(lnV_p)/d(lnV_s)$ and $d(ln\rho)/d(lnV_s)$. We search for 3 scaling parameters (lowermost, middle and upper mantle) and allow spatial variations of these parameters as each degree 2 spherical harmonic coefficient is considered separately. We present the results of the sampling of the parameter space and of the appraising of the ensemble generated in the form of marginal probabilities for the different parameters.

S31E-0817 0830h POSTER

Contrasts in Cratonic Structure Within Australia From Surface Wave Tomography

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Strong constraints are placed on the cratonic structure of Australia with the aid of an augmented data set and a re-inversion of the full set of surface wave paths. The new data set incorporates re-processed data from the temporary deployments SKIPPY, KIMBA, QUOLL and WACRATON alongside new data from TIGGER (01-02). Further data from an additional 14 permanent seismic stations is used to improve the uniformity of path coverage. The waveform procedure used to calculate each 1-D model is based on the automated code of Debayle (1999) with the additional use of multiple starting models. The use of multiple starting models gives an improved estimate of both the reliability of the 1-D path specific models and their errors. Approximately 1400 paths to temporary stations and 450 paths to permanent stations are accepted through the inversion procedure; thus avoiding the previous bias towards permanent station data. These 1-D models are treated as path averages within a conventional two-stage tomographic inversion and the resulting 2-D models are defined using a spherical B-spline function. Two of the main feature of these improved models are highlighted. Firstly, a very rapid change in the overall pattern of the velocity anomaly is observed between 75 and 100km deep for much of the Australian region. Secondly, the improved path coverage through Western Australia allows us to investigate the structure below the Pilbara and Yilgarn cratons. Below 150km a strong fast anomaly is seen beneath the Yilgarn Craton. Further North, beneath the Capricorn Orogen we see a distinct slow anomaly. Although slightly less well

resolved, beneath the Pilbara region we see a grading back towards faster velocities in the very North.

S31E-0818 0830h POSTER

Seismic Structure of India from Regional Waveform Matching

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We use a neighborhood adaptive grid search procedure and reflectivity synthetics to model regional distance range (500-2000 km) seismograms recorded in India and to determine the variation in the crust and uppermost mantle structure across the subcontinent. The portions of the regional waveform which are most influenced by the crust and uppermost mantle structure are the 10-100 s period Pnl and fundamental mode surface waves. We use the adaptive grid search algorithm to match both portions of the seismogram simultaneously. This procedure results in a family of 1-D path average crust and upper mantle velocity and attenuation models whose propagation characteristics closely match those of the real Earth. Our data set currently consist of ∼20 seismograms whose propagation paths are primarily confined to the Ganges Basin in north India and the East Dharwar Craton of south India. The East Dharwar Craton has a simple and uniform structure consisting of a 36±2 km thick two layer crust, and an uppermost mantle with a sub-Moho velocity of 4.5 km/s. The structure of northern India is more complicated, with pronounced low velocities in the upper crustal layer due to the large sediment thicknesses in the Ganges basin.

S31E-0819 0830h POSTER

Thermal and compositional anomalies beneath the North American continent

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The determination of the temperature and composition of the mantle is still a remaining challenge. This issue has important implications in understanding the stability of continental roots and evaluating their extent. Nowadays, seismic tomography models have reached a resolution allowing their interpretation in terms of thermal and compositionnal variations. Seismic velocities are primarily sensitive to temperature perturbations but chemical perturbations can not be neglected. However, velocity models can not solely constrain both unknows. And an extra set of data is needed. In this study, density anomalies are used to constrain the structure of the upper mantle beneath North America and the Caribbean region. The velocity data consist of a new regional shear wave velocity model obtained by surface wave tomography, realised by inversion of 7700 fundamental mode Rayleigh wave phase velocity measurements in the period range 40-150 s. The density data are estimated using a relative density-to-shear velocity scaling factor computed for continents by combining regionally filtered seismic and gravity data. The mineralogical variations in the mantle are expressed in terms of the global volumic fraction of iron, the parameter which has the strongest influence on density and velocity. The inferred thermal and iron content anomalies are well constrained by the data and show an age dependence down to a depth of 230±50 km. Below the North American craton, the mantle is colder than average and depleted in iron. Maximum values are found at 100 km with $\overline{\delta T} = -440K$ and $\overline{\delta Fe} = -4\%$, relative to the average mantle. Such a compositional depletion is also reported in other geophysical studies using heatflow measurements or xenolith observations. These chemical and thermal characteristics induce opposite buoyancy forces which could explain the longevity of cratonic lithosphere. In stable continental areas, the signal is of lower amplitudes and beneath the western Cordillera, a tectonically active region, we see no significant thermal or chemical anomaly.

S31E-0820 0830h POSTER

Joint Analysis of Regional Broadband Waveforms and Travel Times for Crustal Structure Using the Genetic Algorithm

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A method is proposed to estimate crustal velocity structures using regional broadband waveforms and travel times. This method makes up for the weak point of waveform inversion that could produce distorted crustal stuructures in the case of low signal-to-noise ratio (SNR) of seismic data. Travel time data can complement waveform data in inverse problems for crustal structure, because P wave arrivals (e.g., Pg, PmP, and Pn) are generally clear in spite of low SNR. In addition, short-period seismograms that have nothing to do with broadband waveform modeling can be used to get travel time data. The genetic algorithm, a global optimization method, is adopted as a forward-modeling approach to avoid trapping in local minima in nonlinear problems. After updating the epicenter, focal depth, and focal mechanism based on the resulting crustal model, we update the model performing the forward computation again. We iterate this procedure until the synthetics from the estimated crustal model has no more improvement.

S31E-0821 0830h POSTER

Finite Difference Calculations of Banana-Doughnuts

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The development of banana-doughnut sensitivity kernels (Dahlen et al., 2000) promises improvement in tomographic imaging. However, the theory used to calculate them is not valid near the source or receiver, making them of limited use in regional tomography. We have developed sensitivity kernels that are valid in these areas using finite difference full wavefield calculations. Preliminary 2-D results confirm the results of Dahlen et al. to within several wavelengths, i.e., to within 30 km for a 0.5 Hz wave. For a 0.5 Hz plane wave, the kerenel has a total width of approximately 100 km at a depth of 200 km, illustrating their importance. Three-dimensional computations are underway.

S31F MCC: Level 2 Wednesday 0830h

Slabs and Wedges Posters *(joint with T)*

***Presiding:* G A Abers,** Boston University**; K C Creager,** University of Washington

S31F-0822 0830h POSTER

Estimation of the average rate for subducting Pacific plate near Kamchatka related to earthquake deformation

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The Pacific plate moves toward the Euroasia plate at an average velocity of about 8 cm/year. This movement consists of the deformation connected with subduction zone earthquakes and with slow deformation that can be the result of both creep on the plate border and of viscous relaxation in the upper mantle. In order to know the role of slow deformation, it is need necessary to estimate the deformation caused by earthquakes. The average rate of the Pacific plate toward Euroasia related to earthquake deformation can be estimated from Harvard CMT (Centroid Moment Tensor) catalog which has information for earthquakes with Mw≥4.5 for the East Coast of Kamchatka from 1976 to the present. From these earthquakes, we chose the initial time, hypocenter position, scalar moment M0 and strike, dip and slip values. For the north, central and south parts of the Kamchatka subduction zone, we estimated the average strike and dip value for all earthquakes. The values of the strike and dip for the south and central parts respectively ranged from 204°-237° and 11°-52°. For the north part, related to the junction between the Kamchatkan and Aleutian arcs, the strike and dip ranges are very large, which can be the result of a complicated fault system. For the south and central part, we found average strike and dip values of 217° and 25° respectively. For this plane we calculated the average motion per year for each area as follows: $B=\Sigma M_{0i}/\mu ST0$, where M_{0i} = scalar seismic moment for ith earthquake, S = square of averaging, μ = shear module, T0 = time of averaging. The shear module was estimated as: $\mu = \rho C^2/3$, where C= 7km/c (velocity of P-wave), $\rho = 3$ g/cm^3, $T_0 = 20$ years. The B-value (rate of subduction related to earthquakes) was calculated as 0.9 cm/year for the south part of subduction zone and 1.4 cm/year for the central part. For the north part, we are unable to make an estimation, because it was not found the common plane (dip value) for all earthquakes.

These rate estimates don't reflect the real ratio between slow or creep deformation and deformation released by earthquakes, because of the limited time of observation. In the case of the central part of the subduction zone, however, we believe that the rate in 1.4 cm/year is realistic, because an earthquakes of M_w = 7.9 occurred in this area on December 5, 1997.

S31F-0823 0830h POSTER

Configuration of the Subducting Philippine Sea Plate and the Crustal and Upper Mantle Structure Beneath the southwestern Japan arc, Revealed by Seismic Refraction/Wide-angle Reflection Profiling

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The Nankai trough region, where the Philippine Sea Plate is subducted beneath the SW Japan arc, is a well-known seismogenic zone of interplate earthquakes. A detailed crustal and upper mantle structures of the subducted Philippine Sea Plate and the overlying SW Japan arc is inevitably important to constrain the physical process of earthquake occurrence as well as the evolution process of this margin. In the summer of 2002, we conducted an onshore-offshore seismic experiment across the SW Japan arc. In this experiment, about 2,300 seismometers were deployed on a 235-km-long onshore line with NS direction, on which 10 explosives shots were fired. Data collected from on the onshore line have high signal-to-noise ratios, from which we can easily recognize prominent wide-angle reflections from the deep crust and the subducted plate boundary.

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