

SHEAR-WAVE SPLITTING TOMOGRAPHY IN CENTRAL AMERICA AND THE IMPLICATIONS FOR MANTLE WEDGE FLOW

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Shear-wave splitting is a powerful diagnostic of anisotropy that has been widely used to interpret mantle fabric and flow, and resolving the pattern of mantle wedge flow is fundamental for understanding wedge thermal structure, slab dehydration, melt generation and transport, and slab dynamics. We have obtained a dataset of nearly 800 high-quality local-S and over 50 SKS splitting observations in Costa Rica and Nicaragua from the TUCAN seismic array and use it to help constrain flow in the Central American subduction zone. Local-S splits show a large amount of scatter in fast polarization direction ($f\ddot{O}$), but arc-parallel fast directions are more prominent than arc-normal. Despite these variations, some regions display consistency, suggesting some amount of coherent structure at depth. Stacked SKS splits have more uniformly arc-parallel $f\ddot{O}$ and much larger average splitting times than local-S splits (2 s vs. 0.3 s), indicating significant sub-slab and deeper (>200 km) wedge anisotropy.

Rather than directly interpreting these splitting observations in terms of fabric orientation, we tomographically invert the local-S splits for crystallographic orientation in the mantle wedge. The inversion utilizes the Christoffel equation in the forward calculation of splitting, and an iterative, linearized, least-squares solution for LPO is found. Our best-fitting model of anisotropy exhibits arc-parallel olivine fast-axes throughout much of the mantle wedge, with smaller regions of arc-normal fast-axes. Given that arc-parallel fast-axes subsist beneath the arc and into the back-arc wedge, where the cold, high-stress conditions needed for B-type fabric development are unlikely, we interpret our model to indicate the presence of dominantly along-arc flow in the mantle wedge. Isotopic evidence from arc lavas corroborates this interpretation. A distinct $^{208}\text{Pb}/^{204}\text{Pb}$ and $^{143}\text{Nd}/^{144}\text{Nd}$ signature, attributable to a chain of seamounts on the subducting Cocos Plate, is found in diminishing quantity for ~400 km along the arc from Central Costa Rica northwest into Nicaragua. Estimated arc-parallel mantle wedge flow rates from this isotope data (63-190 mm/yr) are comparable with subducting plate velocity (85 mm/yr). Arc-parallel may be the result of plate edge effects coupled, slab roll-back, and non-planar slab geometry, as suggested by both numerical and laboratory modeling, but a mechanism for decoupling the wedge from the slab over a broad lateral and depth extent is still required.

POSTER 54

EXTRACTION OF ABSOLUTE P-VELOCITY FROM RECEIVER FUNCTIONS

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Receiver functions constitute an important tool in regional and global studies of crust and upper mantle structure and are frequently employed to constrain crustal thickness and bulk V_p/V_s ratio. The methods commonly used to compute these parameters assume a known crustal P-velocity; however, this quantity trades off with crustal thickness. We demonstrate that P-velocity and V_p/V_s ratio can be readily computed through solution of a linear system of equations incorporating traveltimes of direct conversions and free-surface reverberations representing a range of horizontal slowness. Determination of crustal thickness follows trivially. We apply this approach to data from station HYB on the Indian craton to determine bulk V_p/V_s ratio, P-velocity, and thickness of 1.79 ± 0.007 , 6.1 ± 0.13 km/s and 30.5 ± 0.8 km, respectively. The addition of average crustal P-velocity to the suite of parameters accessible from receiver function data may prove useful in constraining bulk crustal composition and its secular evolution.

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JOINT INVERSION FOR 3-DIMENSIONAL S-VELOCITY STRUCTURE AND RADIAL ANISOTROPY IN THE MANTLE ALONG THE TETHYAN MARGIN

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We construct a new 3-D S-velocity model by jointly inverting regional S and Rayleigh waveform fits, teleseismic S and SKS arrival times, Rayleigh group velocity measurements, and the Moho estimates from receiver functions, refraction lines, and gravity surveys for the region which extends from the western Mediterranean region to the Hindu Kush. The benefit of the joint inversion lies in the fact that the different types of data sets we use cover the same general volume of the mantle and crust along the Tethys margin but cover the volume in very different, but complementary ways; Rayleigh-wave group velocities and regional S and Rayleigh waveforms have good resolution for the uppermost and upper mantle, while teleseismic S and SKS arrival time data do for the deep upper and lower mantle, thereby significantly improving overall resolution. We have fitted the waveforms of regional S and Rayleigh waves from over 5600 seismograms using Partitioned Waveform Inversion. We have accumulated over 4700 crustal thicknesses from receiver functions, gravity measurements, and refraction profiles. We have measured Rayleigh wave group velocities for hundreds of new paths recorded at the MIDSEA stations and combined them with thousands of existing paths transecting the region. We have over 5000 teleseismic S arrival times measured through cross correlation and 220,000 more from picks originally reported to the ISC. We also estimate radial anisotropy in the uppermost mantle by using constraints from Love waveform fits and Love-wave group velocities. We discuss features of our new model, which includes oceanic structure, cratons, subducting slabs, low-velocity mantle plumes, rifts, and basins and characteristics of radial anisotropy in the uppermost mantle.

POSTER 53

RAYLEIGH WAVE DISPERSION ANALYSIS IN THE LOWER GREAT LAKES REGION

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The Grenville orogen located at the eastern edge of the Canadian Shield has been relatively quiescent since it was generated by a continental-continental collision about 1Ga. This Proterozoic orogen probably resembles the Himalayas at the present time, which were built by the collision between the strong India plate and a relatively weak Eurasia plate. If so, we would expect a weaker lithosphere under the Grenville Province than the Canadian Shield and seismic anisotropy should follow the trend of the Grenville orogen. Regional surface wave tomography models indeed show a low velocity indent at the eastern edge of the North American craton at the Grenville Province. However, high resolution travel time tomography in southeast Ontario reveals significant velocity variations in the area and seismic anisotropy from shear-wave splitting indicate a strong influence of the asthenospheric flow.

To better understand the mechanisms of the Grenville orogen and its interaction with the Canadian Shield, we will construct a higher resolution velocity model in southeast Ontario, the lower Great Lakes region. The data are from 33 broadband seismic stations of POLARIS/FedNor seismic network and the permanent stations of the Canadian National Seismograph Network (CNSN). A total number of 51 events with the magnitude larger than 5.5 will be evaluated. Only those events with clean dispersive phenomena will be included in the inversion. Rayleigh wave phase velocities and azimuthal anisotropy at the periods of 30-150 s will be obtained by applying the two-plane-wave inversion method. This model along with anisotropy measurements will illustrate more details of the lithosphere beneath the Grenville orogen. We will present preliminary results from the dispersion analysis and discuss their implications.

POSTER 62

ADJOINT TOMOGRAPHY OF THE DESCENDING SLAB IN THE JAPAN SUBDUCTION ZONE

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The descending slabs in the subduction zones play a very important role in plate tectonics and the evolution of the Earth's interior. In this study, we use a new adjoint tomography technique to obtain more detailed 3-D image of the descending slab in the Japan Subduction Zone and the seismic velocity models in the neighboring region beneath Eastern China. This adjoint tomography technique is an effective tool for using 3-D models as initial models and refining them by iteratively minimizing the misfit between the synthetics and data. We have very dense station coverage of our study area with total 845 stations from Hi-net (more than 600 stations), F-net and Global Seismographic Network (GSN) stations. We use Zhao et al.'s (1994) 3-D model embedded in Lebedev and Nolet's (2003) model as the initial model in the tomographic inversion. According to finite-frequency theory, the sensitive region along the ray path is given by a 3-D 'banana-doughnut' kernel, and the overall spatial distribution of the sum of all available event-station kernels determines the resolvable volume in the inversion. We select a total of 269 events with Mw from

4.5 - 8 to obtain maximum coverage of this region while avoiding redundancy. We processed the data and synthetics using two types of bandpass filters: 6--30~s for all the records and 24--120~s for F-net and GSN records. The adjoint sources are constructed based upon the frequency-dependent traveltimes misfit between synthetics and data. Given the adjoint sources, we use the adjoint spectral-element method to calculate banana-doughnut kernels for P, S and surface waves for the selected records. The weighted sums of the banana-doughnut kernels for all event-station pairs, with weights determined by the traveltimes measurements, can be used to construct misfit kernels. These gradients will be used in a non-linear conjugate gradient algorithm to further improve the existing 3-D models.

POSTER 79

DETACHED EURASIAN MANTLE LITHOSPHERES BENEATH THE TIBETAN PLATEAU INFERRED FROM TRIPLICATED P WAVEFORMS

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P-wave waveforms in the upper-mantle distance range between 12 and 30 degrees were analyzed to investigate upper-mantle P velocity structures beneath the Tibetan Plateau and surrounding areas. The waveform data were from 1,715 earthquakes of magnitudes larger than 5.0 between 1990 and 2005 that occurred within 30 degrees from the center of the plateau. We divided the studying area into 6 regions and modeled upper-mantle-distance P waveforms with turning points beneath each region separately. The results show that the upper-mantle P-wave velocity structures beneath India, the Himalayas and the Lhasa Terrane are similar and contain a high-velocity lid about 250~km thick. The Tarim Basin also lies above a high-velocity upper-mantle lid. The upper-mantle velocities over 200~km beneath the Qiangtang and Songpan-Ganzi Terranes are lower than those in the north and south, especially beneath the Songpan-Ganzi Terrane. The 410 discontinuity beneath these two terranes are elevated by 20~km. High-velocity anomalies were found in the transition zone below 500~km under the Lhasa and Qiangtang Terranes. The results suggest that the Tibetan Plateau was generated by the thrusting of the Indian mantle lithosphere under the southern part of Tibet. Portions of the thickened Eurasian mantle lithosphere were delaminated, which are now sitting atop of the 410 discontinuity below northern Tibet and in the transition zone beneath southern Tibet.

POSTER 74

RADIALLY ANISOTROPIC CRUSTAL VELOCITY STRUCTURE OF NW CANADA FROM AMBIENT-NOISE TOMOGRAPHY

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We use ambient-noise cross-correlation to image crustal seismic-velocity structure in NW Canada. Our focus area surrounds the CANOE (CANadian NORTHwest Experiment) array, a 16-month deployment of 59 broadband seismic stations. The geometry of the CANOE array was designed for studying the processes of continental accretion and the characteristics of continental lithosphere, and as such it extends from the Northern Cordillera on the west into the Archean Slave province to the east, crossing crustal terrains that span ~ 4 Ga of Earth history. We expand our study area westward and eastward by including 42 broadband stations from the Canadian National Seismograph Network and the POLARIS network. We estimate the Green's function for each pair of stations by cross-correlating day-long time series of ambient noise in the time period July 2004 - June 2005, following the steps outlined by Bensen et al. (2007). In addition to the familiar observation of fundamental-mode Rayleigh waves on cross-correlated vertical-component records, we also observe fundamental-mode Love waves when the transverse components of noise are cross-correlated. All azimuths are well represented by the station coverage in this region, and the signal-to-noise ratios of the impulse responses are strongest for paths perpendicular to the Pacific coastline.

We determine group velocities for the fundamental-mode surface waves in the period range 5-30 s. The amplitude spectra of the surface waves are strongly peaked at 7-10 s and 17-23 s, consistent with signal generation by the primary and secondary microseisms, and we focus on these period bands for the structural interpretation. Initial results show group-velocity variations of $\pm 15\%$, with the fastest velocities found within the Slave province and very slow velocities associated with thick sedimentary layers at short periods. We invert the group-velocity values (>2500 interstation paths) for 3-D radially anisotropic shear-wave velocity within the crust, using a layered parameterization and constraints on crustal thickness from CANOE receiver functions, LITHOPROBE reflection profiles, and CRUST2.0 (Bassin et al., 2000). In particular, we test the common assumption that crustal shear velocity is isotropic at length scales sampled by teleseismic data.

POSTER 58

HYDROGEN IN THE UPPER MANTLE: ARE WATER-RICH REGIONS RED OR BLUE?

Thomas Duffy (Princeton University)

Interpretation of seismic data requires an understanding of how the sound velocities and hence elastic and anelastic properties of minerals vary with pressure, temperature, crystal structure, and composition. $(\text{Mg,Fe})_2\text{SiO}_4$ polymorphs such as olivine and wadsleyite are expected to be the major minerals in the Earth's upper mantle. In recent years, there has been growing recognition that the olivine polymorphs have the capacity to accommodate appreciable amounts of H under mantle conditions up to ~1 wt % H_2O . Hydrogen even in small quantities might strongly influence a number of important properties of the mantle including rheology and melting temperature. The presence of water in the upper mantle and transition zone has the potential to explain a number of seismic phenomena such as shear velocity anomalies or uplift and broadening of the 410-km discontinuity. The presence of H_2O in the transition zone has also been frequently invoked to reconcile laboratory elasticity data on olivine polymorphs with seismic data for the amplitude of the 410-km discontinuity.

Recent measurements of the single-crystal elastic properties of a suite of olivines and wadsleyites containing 0.4–1.7 wt.% H_2O at both ambient and high pressure enable determination of the effects of H_2O incorporation on P- and S-wave velocities at high pressures for the first time. The effect of water depends strongly on crystal structure: 1 wt% H_2O markedly reduces the sound velocities of wadsleyite but has a much smaller effect on olivine. For wadsleyite, pressure derivatives of elastic moduli of hydrous and anhydrous forms are indistinguishable. However, for olivine, the pressure derivatives of the hydrous phase are greater than the corresponding anhydrous phase. This yields the surprising result that olivine containing ~1 wt% H_2O has faster elastic wave velocities than anhydrous olivine at deep upper mantle pressures. Implications of these results for seismic structure of the upper mantle will be explored. Other potential effects of water will also be examined including the role in H_2O in partial melting, anelasticity, and the transition zone seismic gradient.

RAYLEIGH WAVE PHASE VELOCITY STRUCTURE OF THE NANGA PARBAT HARAMOSH MASSIF USING PASSIVE SOURCES

Alexander Hanna (California State University Northridge), Dayanthie Weeraratne (California State University Northridge)

Nanga Parbat is located in the western syntaxis of Himalaya, a continental-continental subduction zone that has undergone rapid orogenesis at a rate of 5-10 mm/yr over the last 3 Ma. The area is characterized by extreme topography and very high erosion rates, as glacial and monsoon fluvial forces act on the world's highest topographic gradient with 7 km of vertical relief over 21 km of horizontal distance. Unlike the eastern Himalayan syntaxis, the western syntaxis shows a more diffuse accommodation of shear, indicated by a broad deflection of orogenic structures, and a gentle apparent deceleration of plate velocities near the plate edge. The Nanga Parbat Haramosh massif (NPHM) is a N-S oriented antiform flanked by faults and shear zones that dip toward each other and form a crustal-scale pop-up structure. Field observations of S-C fabrics, mica fish, asymmetric feldspar augen and stretching lineations indicate a fairly uniform upward sense of slip on the Diamar and Rupal shear zones, which implies that the core of the Nanga Parbat Haramosh Massif is moving northwest, overthrusting the Kohistan-Ladakh terrane.

The goal of this project is to define seismic and anisotropic patterns in order to answer structural questions about the NPHM. To do this, we will apply a surface wave inversion to a dataset of 116 teleseismic events collected from an array of 13 broadband seismic stations deployed from 1995-1996. This project will primarily utilize GMT (Generic Mapping Tools), SAC (Seismic Analysis Code) and a two-plane wave inversion technique to analyze data and solve for phase velocities. GMT is used to visually define a set of seismic events and their geographic distribution around the NPHM. SAC is used to window, filter, and perform cuts to separate out the Rayleigh waves from other arrivals. The events analyzed have good surface wave data in the period range 20s-100s with high signal to noise ratio, and should yield clear isotropic and anisotropic phase velocity data within the study area. This dispersion curve should allow us to identify crust and mantle structures within the syntaxis, including brittle-ductile transitions within and surrounding the massif.

POSTER 72

CRUSTAL ROOTS AND VP/Vs VARIATIONS IN THE SOUTHERN APPALACHIANS: A COMPARISON OF RECEIVER FUNCTIONS WITH MIGRATED SECTIONS DERIVED FROM THREE-COMPONENT, WIDE-ANGLE P & S REFLECTION DATA

Robert Hawman (University of Georgia), M. Scott Baker (University of Miami)

Wide-angle reflection profiling with quarry blasts yields migrated depths for Moho that are consistent with receiver function analysis of two permanent broadband stations and allows more detailed mapping of crustal thickness and V_p/V_s variations across the southwestern end of the Blue Ridge, Inner Piedmont, and Carolina Terrane.

The blasts were recorded with a 20-station array of three-component, 4.5-Hz instruments. Migration of deconvolved shot gathers shows a pronounced thickening of the crust from about 38 km beneath the Carolina Terrane (Appalachian gravity high) to 52 km along the foothills of the Blue Ridge Mountains (Appalachian gravity low). Receiver functions computed for USNSN broadband stations GOGA (along the boundary between the Carolina Terrane and Inner Piedmont) and MYNC (in the Blue Ridge) show a similar variation in crustal thickness. Migration of wide-angle P (vertical component) and S (transverse component) reflections recorded within the Blue Ridge Mountains shows significant variations in crustal thickness from a minimum of 47 km beneath the Asheville Basin to as much as 55-59 km beneath some of the higher elevations. These values are consistent with crustal thicknesses predicted for local compensation of the existing topography, assuming a density contrast of 200 kg/m³ between the upper mantle and crustal root, and match the long-wavelength component of Bouguer gravity anomalies. This value for the density contrast is also consistent with values derived by Fischer (2002) for orogens older than 100 my.

Estimates of V_p/V_s derived from traveltimes ratios of Sg/Pg arrivals (which sample down to 10 km) and SmS/PmP arrivals show trends that correlate with shorter-wavelength gravity anomalies, with variations in lithology within the Blue Ridge thrust sheet, and with variations in thickness of the underlying duplexes of platform sediments (largely carbonates) interpreted from ADCOH reflection profiles. The highest values of V_p/V_s for the direct arrivals (1.78) correlate with the thickest sections of overthrust carbonates; the wide-angle raypath coverage allows those sections to be mapped beyond the ADCOH line.

POSTER 63

MULTI-PATH DETECTORS, I. METHOD

Don Helmberger (Caltech), Daoyuan Sun (Caltech)

Current tomographic models of the Earth display perturbations to a radial stratified reference model. Structures in the mantle that are chemically dense with low Rayleigh numbers can develop enormous relief, perhaps with boundaries closer to vertical than radial. Several new methods have been developed to simulate 3D synthetics for such structures that involve both analytical and numerical techniques. The method we use approximates 3D effects by adding out-of-plane contributions from virtual receivers at neighboring azimuths with two related to the inner Fresnel zone and two longer-period contributors sampling the outer Fresnel zone. The four responses are scaled by diffraction operators that are defined by the source duration and travel time from the sharp edge structures. Here, we develop a new tool for processing array data based on such a decomposition referred to as a multi-path detector which can be used to distinguish between horizontal structure (in-plane multi-pathing) vs. vertical (out-of-plane multi-pathing) directly from processing array waveforms. We demonstrate the usefulness of this approach by processing samples of both P and S data from the Kaapvaal array in Southern Africa.

POSTER 80

IMAGING CRUSTAL FAULTS IN KANTO, JAPAN, WITH MeSO-net AND ACTIVE SOURCE DATA

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In central Japan the Philippine Sea plate (PSP) subducts beneath the Tokyo Metropolitan area, the Kanto region, where it causes mega-thrust earthquakes, such as the 1703 Genroku earthquake (M8.0) and the 1923 Kanto earthquake (M7.9). The vertical proximity of this down going lithospheric plate is of concern because the greater Tokyo urban region has a population of 42 million and is the center of approximately 40% of the nation's economic activities. An M7+ earthquake is evaluated to occur with a probability of 70 % in 30 years by the Earthquake Research Committee of Japan. We started the Special Project for Earthquake Disaster Mitigation in Tokyo metropolitan areas, a project to improve information needed for seismic hazards analyses of the largest urban centers. Under the project we will deploy a 400-station dense seismic array in metropolitan Tokyo and Kanto, referred to as the Metropolitan Seismic Observation network (MeSO-net) in next 4 years. We use the MeSo-net to acquire passive and active seismic sources for high-resolution imaging of the crust and upper mantle.

The target area of the present project is unique in tectonic setting because two oceanic plates, Philippine Sea plate (PSP) and Pacific plate (PAC), are subducting beneath the Kanto and also a volcanic arc, Izu-Bonin arc, is colliding with Honshu arc. The situation makes the tectonics complicated: there are both zones of smooth subduction and collision of the oceanic plate with the landward plate, either the Eurasian plate or the North American plate. Furthermore, the PSP encounters the PAC at shallow depth in the eastern Kanto region.

The newly developing MeSO-net will contribute to understand the generation mechanism associated with the plate subduction and collision. Assessment in Kanto of the seismic hazard requires identification of all significant faults and possible earthquake scenarios and rupture behavior, regional characterizations of the PSP geometry and the overlying Honshu arc physical properties.

POSTER 52

COMPARISON BETWEEN TWO 3D VELOCITY STRUCTURES IN THE SAN FRANCISCO BAY AREA

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In this study we performed 3D waveform modeling of 10 small to moderate events (Mw 4.1-5.4) in the San Francisco Bay Area using the USGS SF06 3D velocity model, 05.1.0 and 08.2.0 (Brocher et al., 2005; Jachens et al., 2005, Brocher and Jachens). In the simulations we assumed the source parameters reported in the Berkeley Seismological Laboratory (BSL) Moment Tensor Catalog. Broadband seismic data from the Berkeley Digital Seismic Network (BDSN), and strong motion data from the USGS and the California Geologic Survey California strong motion arrays were used in the analysis. We analyzed and modeled the data in three frequency bands, namely 0.03-0.15 Hz, 0.1-0.25 Hz, and 0.1-0.5Hz. The velocity model 05.1.0 predicts many important features of observed seismograms, and peak ground velocity. On the other hand, the simulated both body and surface waves are systematically early. Recently the USGS published an updated version of the velocity model, 08.2.0 (<http://www.sf06simulation.org/geology/velocitymodel/ver-08.2.0.php>) which increased both P and S wave velocity by 10% from the model 05.1.0. This model predicts the arrival time better, but there remain discrepancies in estimated amplitudes which is remedied by including attenuation in the calculation. In our presentation we will compare observed and simulated peak ground velocity maps and waveforms for both point-source and the finite-source models for the moderate earthquakes.

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POSTER 61

SOUTHEASTERN CARPATHIAN FORELAND DEFORMATION IN RELATION TO THE VRANCEA SEISMOGENIC ZONE OF ROMANIA: RESULTS FROM ACTIVE AND PASSIVE SOURCE SEISMIC DATA

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Integration of active and passive source seismic data was employed in order to study the genetic relationships between the crustal seismicity and geologic structures in the southeastern (SE) Carpathian foreland of Romania, and the possible connection with the Vrancea Seismogenic Zone (VSZ) of intermediate-depth seismicity. Relocated crustal earthquakes and focal mechanisms were correlated with four deep industry seismic profiles, the reprocessed DACIA PLAN and the DRACULA (Deep Reflection Acquisition Constraining Unusual Lithospheric Activity) II and III profiles in order to place constraints on the duration, timing, and scale of tectonic deformation genetically related to the VSZ. Projection of crustal foreland hypocenters onto the deep seismic lines helped identify active crustal faults such as the Trotus, Sinaia and the newly observed Ialomita Faults. Specifically, results of this study (1) image the full crustal and uppermost mantle structures of the Focsani Basin in the close proximity of the VSZ, (2) show evidence for a sub-horizontal, slightly east dipping Moho in the vicinity of the VSZ and thinning of the crust towards the Carpathian orogen, (3) illustrate the conspicuous absence of westward structures in the crust and across the Moho, (4) present evidence that the Trotus Fault is a crustal scale active fault with a dextral sense of motion, (5) suggest that the Paleozoic age Peceneaga-Camena and Capidava-Ovidiu Faults have not been reactivated in recent times, and (6) show evidence for a new active crustal scale fault in the south, named Ialomita fault, with a sinistral motion, possibly a continuation of the seismogenic Sinaia fault further to the north. The seismogenic Vrancea body and the Focsani Basin deformation appear to be bound by the Trotus Fault in the north and the Sinaia-Ialomita Fault in the south suggesting a coupled deformation between VSZ and the foreland deformation, possibly accommodated on these two faults. These results contradict both the 'subduction in place' and 'slab break-off' hypotheses as feasible explanations for the Vrancea intermediate-depth seismicity and revise the current models of active crustal architecture of the Southeast Carpathian foreland.

POSTER 82

THE MIDDLE ASIAN ACTIVE SOURCE (MANAS) PROFILE: PRELIMINARY RESULTS FROM AN INTEGRATED SEISMIC TRANSECT IN THE TIEN SHAN OF KYRGYZSTAN AND CHINA

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Recognized as one of the highest, youngest, and most active orogenic systems on Earth, the Tien Shan are situated internal to the Eurasian continent, up to 3000 km from the former plate boundary with the Indian subcontinent. Existing geologic constraints imply that up to 200 km of shortening may have occurred within the Eurasian plate in Late Tertiary to Recent time. Additionally, geologic, topographic, and gravimetric data suggest that continental lithosphere of the Tarim basin may presently be subducting beneath the southern margin of the Tien Shan, in the absence of an oceanic slab. While geodetic measurements document that the Tien Shan currently record about half of the shortening between India and Eurasia, geologic data dictate that active faults are restricted to only several of the individual ranges that make up the mountain belt. Passive-source seismological studies have suggested the perhaps surprising result that the orogenic crust is thickest (65-70 km) at both the southern and northern margins of the Tien Shan, and thins dramatically (to ~35 km) within the internal part of the orogen.

New near-vertical deep seismic reflection data, acquired during the summer of 2007, constitute an ~350 km lithospheric transect from the northwestern Tarim Basin in China to the central Tien Shan of Kyrgyzstan. Key targets of the MANAS (Middle AsiaN Active Source) Profile included (1) the top of the Tarim crust as it descends beneath the southern Tien Shan, (2) an inferred crustal-scale frontal ramp, representing where the continental plate may have broken and is now descending into the upper mantle, (3) the geometry of demonstrably active faults below the shallow depths to which they can be inferred from surface geologic constraints, (4) the topography and seismic reflection signature of the Moho, especially given the unexpected variations in crustal thickness across the orogen, and (5) the significance of both crustal and upper mantle conductivity anomalies previously identified through magnetotelluric studies. The experimental design involved roll-along of stand-alone seismometers (Reftek-125A), allowing essentially continuous CMP coverage along the entire ~350-km transect, despite the challenging terrain. These seismic reflection data are coincident with broadband array (40 stations at ~10 km spacing for two years) and magnetotelluric measurements along the profile route to provide an integrated geophysical fingerprint of the lithospheric structure of intracontinental mountain building. Of particular note in our preliminary analysis is the dramatic inconsistency of estimates on crustal thickness as determined from passive and active seismology. MANAS Profile data suggest crustal thickening to as much as 50+ km within the central Tien Shan, in contrast with results from passive source analysis.

S-SPLITTING MEASUREMENTS AND THE TAIWAN OROGENY

Hao Kuo-Chen (Binghamton University), Francis Wu (Binghamton University), David Okaya (University of Southern California), Ruey-Juin Rau (National Cheng Kung University), Bor-Shouh Huang (Institute of Earth Sciences, Academia Sinica), Wen-Tzong Liang (Institute of Earth Sciences, Academia Sinica)

Shear wave splitting measurements have provided a basis for understanding anisotropy in the upper mantle and crust. We use broadband teleseismic shear waves, both SKS and SKKS, recorded at the temporary TAIGER (Taiwan Integrated Geodynamic Research) network stations as well as the existing, permanent, BATS and CWB stations in Taiwan to obtain the splitting parameters; the fast shear wave polarization direction (ϕ) and the delay time (δt). Altogether, 58 new measurements were added to the database. Our measurements agree in general with previous results (Huang et al, 2006; Rau et al., 2000), that the fast directions follow the local structural trend. The new measurements in western Taiwan around the Peikang basement high show a clear wrap-around pattern. The conformance of the fast direction with the structural trend in northernmost Taiwan as well as the transition from the island-parallel to nearly EW, is better defined with the new data. When we include the new data, a dependence of the delay time on back azimuth begins to emerge. This could indicate that mantle anisotropy properties are distinct east and west of Taiwan. The maximum delay time (2.6 sec) is at ENLB near the northern end of the Coastal Range and the minimum delay time (0.3 sec) is at TAIB in southwestern Taiwan.

Shear wave splitting measurements from local crustal earthquakes (depth above 40 km), demonstrate that the fast direction corresponds to each geological province and the delay time measurements vary less distinctly than teleseismic results. In Chiayi and Tainan region, the Coastal Plain, the fast direction measurements are mainly EW, possibly representing the strike of Yichu Fault. In contrast, at the boundaries between the Western Foothills and the Backbone Range as well as between Hsuehshan Range and Backbone Range, the fast direction measurements are mostly NS, sub-parallel to the geological fabrics, and mostly agree with the teleseismic results.

From the delay time measurements of teleseismic and local events, we conclude that the anisotropic source most likely resides in the upper mantle. The Coastal Plain area indicates distinctive fast directions possibly showing the effects of deformation at depth above 20 km. However, the fast directions in general follow the foliations of the rocks or other structural trends indicating possible vertically coherent deformation through the crust into the upper mantle.

POSTER 67

UPPER MANTLE STRUCTURE OF THE CARIBBEAN-SOUTH AMERICAN PLATE BOUNDARY

Michael Landes (Indiana University, Department of Geological Sciences), Tammy K. Bravo (Indiana University, Department of Geological Sciences), Gary L. Pavlis (Indiana University, Department of Geological Sciences), Fenglin Niu (Rice University, Department of Earth Science)

We summarize results of recent studies of upper mantle structure in the vicinity of the Caribbean and South American plate boundary under Venezuela and the southern Antilles. This includes S wave splitting, P wave tomography, and P and S wave receiver functions derived from passive array data collected for the Bolivar project. Data were recorded by 33 stations of the Venezuelan national network, 36 temporary broadband stations, 15 broadband ocean bottom seismometers from the OBSIP facility, and 44 stations from the University of the West Indies Seismic Research Unit. The results from this set of analyses are consistent with the model of the Caribbean being dominated by trench rollback. P wave tomography illuminates the southern edge of the Atlantic slab, which is seen dipping gently westward from Trinidad to cross the base of the transition zone under the Maracaibo region. This edge truncates parallel to, but slightly south of the plate boundary as defined at the surface. S wave splitting measurements reinforce this model as they show a strong maximum of SKS split times over the point where the southern edge of the Atlantic slab intersects the base of the anisotropic region of the upper mantle. S receiver functions resolve clear variations in lithospheric thickness across the Caribbean-South American plate boundary. Furthermore, we find no evidence for extensive southward subduction of the Caribbean plate as proposed by a number of previous tectonic models for this region. The current results are consistent with a model of low angle underthrusting of the Caribbean beneath the Maracaibo block in northwestern Venezuela only.

POSTER 71

IMAGING THE UPPER MANTLE STRUCTURE UNDER TAIWAN— A TAIGER PROJECT

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The young, currently active, orogen of Taiwan is an ideal natural laboratory for answering questions regarding mountain-building processes. Key issues include determining the fate of the Eurasian plate: is it currently subducting eastward under Taiwan, or is it in collision with the Philippine Sea Plate. To distinguish between these two geodynamically possible models, imaging of the deep structure below Taiwan is necessary. The lack of an east-dipping Benioff zone in the vicinity of Taiwan demands that we look for other signs of a subduction zone, namely an inclined high velocity anomaly. Previous imaging studies were mostly aimed at crustal structures, due to sparse teleseismic data.

One of the main targets of the ongoing TAIGER (TAiwan Integrated GEodynamics Research) is the subduction zone. By making use of both the TAIGER passive broadband data (on land and on the ocean bottom) and active source recordings of teleseisms we can image the mantle to a depth of 400km. The ocean bottom deployment is in progress but the land-based network has been partially processed. We further expand this dataset in both space and time with the BATS (Broadband Array in Taiwan for Seismology) and CWB (Central Weather Bureau) data from 2004-present. Combining all the broadband (CMG, STS etc.) recordings with those of the active source (TEXAN 4.5 Hz) recordings allows for dense station spacing in critical areas. Observationally, we see gradual changes in the relative arrival times along the active source lines as well as the broadband network stations, patterns that clearly indicate systematic dependence of arrival times with subsurface structures.

We have used the combined dataset in a tomographic inversion. While the resolution is poor as of yet in northern Taiwan, our preliminary results show a clear east-dipping high velocity zone under southern Taiwan.

POSTER 68

MAPPING THE LITHOSPHERE AND ASTHENOSPHERE BOUNDARY IN SOUTHERN AFRICA BY S RECEIVER FUNCTIONS

Shuqin Ma (Geosciences Department, University of Houston), Aibing Li (Geosciences Department, University of Houston)

How deep a craton does extend is a debatable question. Southern Africa, which contains two of the most aged continental blocks on the earth, the Kaapvaal and Zimbabwe cratons, is an ideal place to address this question. Previous body and surface wave studies in southern Africa concluded that lithosphere below the Kaapvaal and Zimbabwe cratons extends to the depths of at least 250 km and roughly 180 km, respectively. Since the discrepancy arises from the different methods and criteria that are applied to define the lithosphere, it motivates us to further study this problem.

The goal of this study is to image the LAB in southern Africa from S receiver functions. S receiver functions on which S to P converted phases are detected have been used to map the lithosphere and asthenosphere boundary (LAB). Unlike P receiver functions on which the P to S conversion from the LAB is masked by crustal multiples, the S to P conversion from the LAB can be identified on S receiver functions without the contamination of reverberations from the Moho. Our data come from the southern Africa seismic experiment array. We choose teleseismic events with $M_w \geq 5.6$ and epicentral distances between 58° and 105° from the array center. The waveforms of 39 events are good for S receiver function analysis. Individual S receiver functions will be stacked by station. It is anticipated that the depth of the LAB correlates with geological provinces, from shallow at the youngest, the southern end of Africa, to deep at the Kaapvaal and Zimbabwe cratons. We will compare our results with those constrained from tomography models.

POSTER 59

CRUSTAL STRUCTURE OF THE CAUCASUS AND CASPIAN REGION FROM RECEIVER FUNCTIONS

Robert Mellors (San Diego State University), Rengin Gok (Lawrence Livermore National Laboratory), Ugur Teoman (Kandilli Observatory and Earthquake Research Institute, Bogazici University), Niyazi Turkelli (Kandilli Observatory and Earthquake Research Institute, Bogazici University), Tea Godaladze (Nodia Institute of Geophysics, Tbilisi), Zurab Javakblishvili (Nodia Institute of Geophysics, Tbilisi), Gurban Yetirmishli (Azerbaijan Seismic Center, Baku), Rumi Takedatsu (San Diego State University), Jason Ricketts (San Diego State University), Eric Sandvol (University of Missouri)

The Caucasus/Caspian region is an area of enigmatic crustal structure that lies between the Black Sea and South Caspian basins. Previous studies based largely on refraction data indicate that the crust in this region thins greatly at the western edge of the South Caspian basin, which may be underlain by oceanic crust. Data from broadband stations in Azerbaijan, Georgia, and Eastern Turkey is analyzed to resolve variations in crustal structure across the Caucasus region using receiver functions. The receiver functions have been analyzed in two ways: slant stacking with varying Moho depth and V_p/V_s ratio and by forward modeling of stacked receiver functions sorted by azimuth and distance. Stations located within the Kura depression show indications of thick sediments while stations located at the northern edge in Greater Caucasus display strong variations with azimuth suggesting structural complexity. Preliminary results indicate a Moho depth of 30-35 km near the South Caspian basin and increasing to the west with depths of 40-45 km in the Lesser Caucasus.

POSTER 78

P AND S BODY-WAVE TOMOGRAPHY OF WESTERN CANADA

Jean-Philippe Mercier (University of British Columbia), Michael Bostock (University of British Columbia)

Western Canada offers an ideal setting to study subsurface variations in structure, geometry, and physical properties from Archean to the present day. It also offers an opportunity to explore the complex tectonic environment of an active margin that is a transition from convergent to transform boundary. We have produced P and S body-wave velocity models of western Canada using 23,420 hand picked delay-times measured on the vertical component at 234 broadband and short-period seismic stations, and using 15,805 delay-times measured on the transverse component at 194 Broadband stations, respectively. Our data-set was assembled from seismograms acquired at the following permanent and temporary networks: ANSS, ATWS, Alaska regional network, Batholiths, CANOE, CNSN, and POLARIS-BC. The azimuthal coverage is good at most of stations with only one unsampled corridor between 200 degrees and 250 degrees. Checkerboard tests indicate good resolution for both P and S inversions at depths roughly between 100 and 600 km, along the CANOE and Batholiths arrays, and in southwestern British Columbia including Vancouver Island where the station density is highest. A fair reconstruction is observed outside these regions. In this poster, we focus our attention on 3 dominant features: 1) a high-velocity zone in southwestern British Columbia which represents the thermal signature of the Juan de Fuca plate and provides information on the northern extent of the subducted oceanic lithosphere beneath the continent, 2) a large low-velocity anomaly that surfaces near Nazko cone in the Anahim volcanic belt and that appears to originate from beneath the subducting plate, and 3) the transition between low to high velocity across the cordilleran front. We also provide a comparison between our results and those from global body-wave and surface wave studies.

POSTER 75

3D STRUCTURE OF THE SE CARIBBEAN PLATE BOUNDARY: INTEGRATION OF ACTIVE SOURCE SEISMIC DATA, RECEIVER FUNCTIONS, AND SURFACE WAVE TOMOGRAPHY

Meghan S. Miller (Rice University/University of British Columbia), Alan Levander (Rice University), Fenglin Niu (Rice University), Gary Pavlis (Indiana University), BOLIVAR working group (Rice, UTAustin, FUNVISIS, Indiana, Memphis)

The southeastern corner of the Caribbean is a complex tectonic regime, forming an odd junction of three lithospheres of different origins: the Caribbean oceanic lithosphere, the South American continental lithosphere, and the oceanic lithosphere of the South American plate (Atlantic Ocean). There are two plate boundary structures: 1) The El Pilar – San Sebastian right lateral strike slip fault system which is the surface expression of the boundary between the Caribbean plate and continental South American plate and 2) The active Antilles island arc and subduction zone where the South American oceanic plate is subducting beneath the Caribbean plate. The juncture of the continental lithosphere of South America and the oceanic lithosphere beneath the Atlantic Ocean, a continuous plate east of the strike-slip system, must tear as the oceanic portion subducts. Complementary seismic studies from the BOLIVAR/GEODINOS experiment image different aspects of this system; these studies include a series of onshore-offshore active-source profiles perpendicular to the Caribbean-South American plate boundary, relocated local seismicity, surface wave tomography, P-to-S receiver functions, and SKS shear wave splits. The various seismic datasets, in combination, illustrate the complex, three dimensional geometry of the southeastern Caribbean region and provide evidence for an active lithospheric tear that is progressively detaching the oceanic lithosphere from continental South American lithosphere as the Antilles subduction zone rolls back along the northern edge of the continent. As the tear propagates eastward forming the right lateral strike slip boundary, the South American continental lithosphere becomes deformed and rebounds, controlling the development of mountains and basins along the northern margin of South America.

POSTER 51

CRUSTAL IMAGING OF THE EURASIAN-PHILIPPINE SEA PLATE BOUNDARY IN TAIWAN: THE TAIGER 2008 LAND REFRACTION EXPERIMENT

David Okaya (Univ. Southern California), Chien-Ying Wang (National Central University), Francis Wu (SUNY/Binghamton), Larry Brown (Cornell University), Horng-Yuan Yen (National Central University), Bor-shouh Huang (IES/Academia Sinica), US Taiwan (working groups for TAIGER)

The ongoing orogeny of Taiwan involves a complex interaction often considered the type example of arc-continent collision. Tectonic models to explain how this collision occurs and produces associated mountain building, of which Taiwan's is one of the fastest rising in the world, range from thin-skinned to lithospheric-scale end-members. In the thin skinned model, subduction of continental Eurasian mantle and lower crust is separated from a deforming crustal wedge by a plate boundary decollement. In the latter, deformation of crust and mantle occurs within a vertically contiguous system, with progressive thickening of continental mantle beneath the core of the mountain belt. The 3D geophysical signatures are fundamentally different between these models.

The Taiwan Integrated Geodynamics Research (TAIGER) project is a joint USA-Taiwan effort to understand this arc-continental collisional system. Scientific questions of this project include: Does continental subduction play an important role in arc-continent collision? Is the mass of incoming continental crust balanced by crustal thickening and erosion? How does such an orogen evolve over time? The TAIGER project uses passive seismology, controlled-source seismology, magnetotellurics, petrophysics, and geodynamical modeling to obtain new 3D subsurface constraints. Results of these methods are presented in companion posters.

During Feb-Mar 2008, the TAIGER team conducted a controlled source land refraction seismic experiment across Taiwan. Two transects across northern and southern Taiwan used sources ranging between 500-3000 kg which were recorded by PASSCAL Texan and R-130 instruments. Three ancillary arrays were deployed to collect cross-line and fan shoot data for 3D imaging. Independent piggyback arrays were deployed in the Taiwan Strait and near-shore People's Republic of China. Due to the high rate of tectonic seismicity, the instruments were configured to record long time windows - numerous local and regional earthquakes were recorded even by the Texan instruments. Preliminary examination of the data reveal crustal Pg, PmP, Pn and intermediate crustal reflection phases. In this poster we present these data; they provide the first direct seismic detection and image of the continental Moho under Taiwan and the sharp Moho root configuration associated with mountain building during the arc-continent collision.

POSTER 73

SURFACE WAVE IMAGING OF THE SOUTHERN APENNINES USING TRANSPORTABLE ARRAY DATA

Ahmet Okeler (University of Alberta), Jeff Gu (University of Alberta), Arthur Lerner-Lam (Lamont-Doherty Earth Observatory, Columbia University), Michael S. Steckler (Lamont-Doherty Earth Observatory, Columbia University)

We analyze the surface wave records of one of the largest regional earthquakes recorded by Calabria-Apennines-Tyrrhenian/Subduction-Collision-Accretion Network (CAT/SCAN), a temporary deployment of 40 broadband stations in the southern Apennines from late 2003 to October 2005. By combining forward, inverse and Monte Carlo approaches, we were able to match the waveforms and phase delays of Love and Rayleigh waves on three-component station records. The interpolated 3-D shear velocity model of the region shows a highly-anisotropic, low-velocity anomaly striking parallel (within 10°) to the southern Apennines at the depths of 30-50 km, possibly deeper. This lower crustal anomaly converges with a slightly weaker, shallow (near 6-12 km) low-velocity layer, roughly 20 km south of Mount Vulture where volcanic rocks with upper mantle signatures have been identified. Partial melting could be mainly responsible for the observed shear velocity variation and the presence of three-dimensional seismic anisotropy at lower crust and/or upper mantle depths. The existence of low-velocity channels in the lower crust and/or upper mantle could have significant implications for the dynamics and evolution of the southern Apennine region.

POSTER 76

MOHO VARIATIONS ACROSS THE NORTHERN APENNINES CONVERGENCE ZONE: HUNTING FOR A SUBDUCTION-INDUCED DIVIDE IN CRUSTAL STRUCTURE

Jeffrey Park (Dept of Geology & Geophysics, Yale University), Irene Bianchi (Dept of Geology & Geophysics, Yale University), Tara Mayeau (Dept of Geology & Geophysics, Yale University), Nicola Piana Agostinetti (Istituto Nazionale di Geofisica e Vulcanologia, Arezzo), Vadim Levin (Dept of Earth and Planetary Sciences, Rutgers University)

The link between lithospheric dynamics and the uplift of the Northern Apennines (Italy) in the late Cenozoic is poorly known. Helium and fission-track dating suggests accelerated uplift (roughly 1mm/yr) since 5Ma across a slowly-converging (or halted) subduction zone. Mantle anisotropy indicators from shear-wave splitting and surface-wave scattering suggest that trench-parallel asthenospheric flow behind the retreating Apennines slab is evident only south of 44°N. This suggests that accelerated uplift is correlated with the end of subduction, even though the stalled slab is evident in tomographic images.

Past research (active source, receiver functions (RF) and crustal P-wave tomography) has suggested a thin crust (20-25km) for the extensional region bordering the Tyrrhenian Sea, and thick crust (40+ km) for the compressional region bordering the Adriatic Sea and Po Valley. Using teleseismic RFs and crustal surface-wave dispersion from the 50-station RETREAT portable seismic deployment, we have confirmed the division of crustal properties across the Apennines crest. Using the Zhu and Kanamori RF stacking algorithm, we find that the Tyrrhenian region (mainly Tuscany) is characterized by a shallow Moho (20-25 km) and a sharp impedance contrast. Northeast of the Apennines crest, the definition of the crust-mantle boundary is problematic, suggesting a gradual and/or complicated crust-mantle transition in the Adriatic domain. However, where resolved by RF-stacking, the crustal thickness is 35 km or more. Surface wave dispersion confirms distinct Tyrrhenian and Adriatic crustal domains, with slower 20-30s phase velocities in the latter.

We extended the RF processing to stack data from different stations at common Ps conversion points in the deep crust and mantle, extending earlier algorithms to estimate the harmonic terms of Ps conversion amplitude with back azimuth. A south-dipping pair of interfaces descend roughly from the base of the crust (40 km) at the Apennines crest into the shallow mantle (80 km) beneath Tuscany, with a dip angle 20° or less. However, the dipping Ps conversions do not ascend through the crust on the Adriatic side, and are weak or absent at greater distance and depth on the Tyrrhenian side. The Ps conversions have a strong 2-lobed amplitude variation indicative of anisotropy, and so may represent an interval of intense shear where the Apennines slab detaches from the overriding crust.

INTEGRATED CONTROLLED-SOURCE AND PASSIVE SEISMIC ANALYSIS BY THE CD-ROM PROJECT IN THE ROCKIES

Eva-Maria Rumpfhuber (University of Texas at El Paso), Randy Keller (University of Oklahoma), Aaron Velasco (University of Texas at El Paso)

We conducted an integrated analysis of the controlled-source and passive seismic datasets from the Continental Dynamics of the Rocky Mountains (CD-ROM) 1999 seismic experiment in the Rocky Mountains. We determined the crustal structure using four different receiver function methods. The resulting migrated image and crustal thickness determinations confirm and define prior crustal thickness measurements based on the CD-ROM and Deep Probe datasets. We employed receiver function migration and common conversion point (CCP) stacking, and the combined interpretation of all the results shows: 1) northward crustal thickening in central Wyoming, and 2) the presence of a strong lower-crustal reflector in the area beneath the Wyoming province and 3) its termination north of the Cheyenne belt at 42° latitude. This result provides a seismic tie between the CD-ROM and Deep Probe seismic experiments and produces a continuous N-S transect extending from New Mexico into Alberta, Canada. This new tie is particularly important because it occurs close to a major tectonic boundary, the Cheyenne belt, between an Archean craton and a Proterozoic terrane.

The controlled-source seismic dataset was subject to forward modeling and inversion to establish a two-dimensional velocity and interface model of the area. We developed a picking strategy, which helps identify the seismic phases, and improves quality and quantity of the picks. In addition, we were able to pick and identify S-wave phases, which furthermore allowed us to establish an independent S-wave model, and hence the Poisson's and V_p/V_s ratios. The final P-wave velocity and interface model is compared to prior results, and the results are jointly interpreted combined with the receiver function study. Thanks to the integration of the controlled-source and receiver function results, we were able to construct a well-constrained structural model and tectonic interpretation that shows the structural framework of the transition from the Wyoming craton to the north across the suture Cheyenne belt suture zone to the Proterozoic terranes to the Proterozoic terranes on the south. The interpretation that crustal-scale crocodile structures are present provides an explanation for the south dip of the Cheyenne belt in the upper crust and the north-dipping slab in the mantle. The very distinct crustal structures north and south of the suture zone are clearly shown in our model.

POSTER 83

SHEAR WAVE SPLITTING AND SEISMIC VELOCITY STRUCTURE OF THE CHILE RIDGE SUBDUCTION REGION

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We present new shear wave splitting measurements of SK(K)S and PKS phases recorded at 39 broadband seismic stations in the Chile triple junction region. The network, deployed December 2004-February 2005 and operated jointly by the University of Florida and the Universidad de Chile (Santiago), spans the region where the Chile Ridge subducts beneath South America, from the Pacific coast of the Taitao Peninsula to the Argentine border, and extends 250 km north and south of the actual triple junction. Given increasing temperature with depth, it has long been hypothesized that ridge subduction should result in creation of slab windows – asthenosphere-filled gaps between continually separating edges of oceanic lithosphere formed at the Earth's surface. The Chile Ridge Subduction Project was formulated in part to test this notion. The network was demobilized during January-February 2007.

In conjunction with teleseismic travel time inversions and studies of seismic attenuation in the Chile Ridge subduction region, shear wave splitting as recorded at the Project network provides an excellent snapshot of upper mantle flow in the region: Shear wave splitting in the study area, which may be caused by mineral alignment during upper mantle flow or possibly by aligned pockets of partial melt, is strong (delay times up to 3 s) and highly variable, with a marked change from trench-parallel in the northern network to trench normal in the western Taitao Peninsula, near the most recently subducted Chile ridge segment.

POSTER 66

SEISMIC LOW VELOCITY ZONE BENEATH THE SLAVE CRATON CHARACTERIZED USING P AND S RECEIVER FUNCTIONS

Andrew Schaeffer (Department of Earth and Ocean Sciences, UBC), Michael Bostock (Department of Earth and Ocean Sciences, UBC)

Seismic studies over the last decade have identified a low velocity layer above the transition zone at various locations around the globe. It is conjectured to be a lens of dense silicate melt that is ponding atop the 410 km discontinuity, beneath the silicate melt density-crossover theorized to exist within the upper mantle. We have assembled a P- and S-wave dataset from the Canadian National Seismograph Network (CNSN), the Canadian Northwest Experiment (CANOE), and the POLARIS Slave array in an attempt to quantify the extent, depth and Poisson's ratio of this layer beneath northern Canada. The study area in northern Canada, including the Yukon, Northwest Territories, Nunavut, and northern British Columbia and Alberta, is situated favourably with respect to the distribution of global seismicity. Our initial focus is restricted to the Yellowknife Array operated by the CNSN, where this layer has been observed previously. There are ~2500 P receiver functions for the Yellowknife array corresponding to epicentral distances between 30 deg and 95 deg within the back-azimuthal corridor of 274 deg to 313 deg, and an additional 1500 receiver functions between 131 deg and 181 deg. An epicentral distance of 95 deg was used as an upper limit as the Pdiff arrival tends to be weaker and lower frequency than the direct P arrival. P receiver functions for each station are generated by transformation of particle velocity to upgoing wavefield components, followed by least squares deconvolution. We have generated a suite of 1-D velocity models based on IASP91, but with varying thicknesses and velocity ratios for a hypothetical layer above the 410 km discontinuity. From these models, we compute moveout curves from travel-times for each unique source-receiver geometry. A grid search is carried out over all possible models, where we shift and stack autocorrelations to get an estimate of both the best fitting model, and the delay time between the direct converted phases (Ps) and the reverberation phases (Pps, Pss, and Ppp). Preliminary results from our data set indicate clear direct arrivals as were observed in prior Slave studies. Upper mantle and transition zone arrivals with moveouts compatible with both direct and reverberatory phases can be observed in the raw sections, while work is ongoing to better pull up their amplitudes in stacked autocorrelation sections. The nature of these signals and their implications for the low velocity layer will be discussed.

POSTER 65

EVIDENCE FOR A COMPOSITIONAL BOUNDARY WITHIN THE LITHOSPHERIC MANTLE BENEATH THE KALAHARI CRATON FROM S RECEIVER FUNCTIONS

Paul Silver (Carnegie Institution of Washington, DTM), Brian Savage (University of Rhode Island)

S and P receiver functions from the Southern African Seismic experiment are analyzed for lithospheric discontinuities beneath the Kalahari craton. Besides the Moho, the most prominent feature is a discontinuous reduction in seismic velocity of about 4.5% at approximately 145 km depth. The discontinuity appears to have a width of about 15 km. Termed the K-discontinuity, this feature is restricted to the northern half of the array, extending from the Zimbabwe craton south to the TML (Thabazimbi-Murchison lineament), and in the west from Botswana to the edge of the Kalahari craton in the east. It spans several Archean sutures and is thus unlikely related to Archean tectonics. It does, however, appear to be related to subsequent magmatic episodes. The strongest anomaly is coincident with the most intense Karoo volcanism, and it extends to the northern edge of the Bushveld intrusion. From mantle xenoliths and xenocrysts, the entire lithosphere in this region appears to have experienced a long-term infiltration of basaltic melt and metasomatic fluids. We propose that the K-discontinuity reflects the influence of this melt/metasomatic infiltration, which has, over time, intruded and refertilized the lithosphere. Based on kimberlites pipes that show obvious signs of melt metasomatism and likely Karoo influence, the observed reduction in seismic velocity is plausibly consistent with the observed major-element and volatile enrichment at 145 km depth in such kimberlites. If this interpretation is correct, then the high-temperature kimberlite nodules that most clearly reflect this perturbation likely represent the general state of the lower lithosphere, rather than only reflecting local mantle properties in the immediate vicinity of the kimberlite eruption.

POSTER 64

SLAB MELTING AND SERPENTINIZATION BENEATH CENTRAL MEXICO

Teh-Ru Alex Song (Department of Terrestrial Magnetism, Carnegie Institution of Washington), Don Helmberger (Seismological Laboratory, Caltech)

Slab melting (partial melting of subducting oceanic crust) and serpentinization of subducting oceanic mantle are the two important processes related to the arc magmatism, water transport and the occurrences of intra-slab earthquakes in subduction zones. However, most debates focus on petrological and geochemical evidences, whereas no seismic analysis is invoked to provide independent constraints. We show, beneath Central Mexico, a thin, ultra-slow layer (3-5 km, S wave velocity ~ 2.0 - 2.7 km/s) within the subducting Cocos plate, suggesting the presence of slab melting. Intra-slab events are located inside a relatively thick low velocity layer (10-20 km; P wave velocity ~ 7.4 km/s) directly below the ultra-slow layer, suggesting a 35% partially hydrated layer inside the subducting oceanic mantle. Along-strike variations in these findings are evident and supported by the age difference of the subducting plate, earthquake activities and along-strike variations in magma geochemistry. These discoveries provide direct seismic constraint on the thermal state, water budget, strength and buoyancy of the slab, and link to subduction process operated in the early Earth.

POSTER 85

SEISMIC ANISOTROPY AND MANTLE DYNAMICS IN THE RIVERA SUBDUCTION ZONE

Gerardo Leon Soto (New Mexico State University), James Ni (New Mexico State University), Stephen Grand (University of Texas at Austin), David Wilson (University of Texas at Austin), Marco Guzman Speziale (Universidad Nacional Autonoma de Mexico), J Gomez Gonzalez (Universidad Nacional Autonoma de Mexico), Tonatiuh Dominguez Reyes (Universidad de Colima)

Shear-wave splitting measurements are determined using data collected from the MARS (MApping the Rivera Subduction zone) project to study the origin of seismic anisotropy in the mantle wedge of the Rivera subduction zone. Results show that, except for those stations near Colima volcano, the fast directions are approximately perpendicular to the trench and sub-parallel to the convergent direction between the Rivera plate and Jalisco block. The trench orthogonal fast direction suggests that the anisotropy is caused by finite strain induced from the corner flow within the wedge of the subduction zone. This interpretation is consistent with the roll-back Rivera plate that was imaged from travel time tomography.

POSTER 60

MULTI-PATH DETECTORS, II. APPLICATIONS

Daoyuan Sun (Caltech), Don Helmberger (Caltech), Shengjie Wei (Caltech), Laura Alisic (Caltech)

Many array observations suggest multi-pathing, some involving the deep mantle and some in the upper mantle. Generally, shallow sharp structures affect all phases while deep features are only sampled by core related phases. Then applying Multi-path detectors (MPD) on different phases is an efficient way to distinguish the location of the sharp features. Here, we discuss a number of applications of such array processing involving plumes, ULVZ's and sharp edges along slab boundaries. In particular, we present evidence for a narrow plume-like feature emitting from the top of the African Superdome structure. A detailed SKS wavefield is assembled for a strip along the southern edge by combining multiple events from East Pacific Rise recorded by the Kaapvaal Array. Applying MPD to this composite data set, we locate a prominent ultralow velocity zone at the edge of a 1000 km high jagged wall. We have also applied this method to USArray data. Two examples will be presented. One involves ULVZ's along the edge of an anomaly beneath Central America. The other one investigates the S complexity observed beneath the northwestern US, where many of the shallow features can be seen in anomalous Pn waveform data.

POSTER 81

LOW ANGLE THRUST EARTHQUAKES IN THE "LOCKED ZONE" BENEATH THE CENTRAL CASCADIA CONTINENTAL MARGIN

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In the summer of 2004, two clusters of "repeating" earthquakes occurred beneath the continental shelf of the central Cascadia subduction zone near 44.5N, 124.5W where the subduction megathrust is thought to be locked or transitional. The largest event in each cluster had moment magnitude $M=4.8-4.9$. Seismicity has continued since with small ($M<3$) earthquakes occurring in each cluster on August 23-25, 2007 and an $M=2.9$ event in the southern cluster on May 1, 2008. Moment tensor analysis for the main shock in each cluster indicates thrusting on a 6-15° eastward dipping fault plane. These earthquakes are occurring on a transect along which crustal structure is well known from active source seismic experiments, and raytracing through this crustal model to match observed relative arrival times of secondary phases places the mainshocks within 1 km of the plate boundary. This segment of the forearc also displays several anomalous characteristics including: a subducted ridge on the downgoing plate; a "bright spot" on the plate boundary at a depth of ~15-20 km; a transition in plate coupling indicated by inversion of GPS data; geologic indications of active folding in the upper plate; and anomalous deformation in the adjacent oceanic plate.

We have recently deployed the Central Oregon Locked Zone Array (COLZA), which comprises 15 ocean bottom seismometers (3 broadband, 12 short period instruments deployed in September 2007) and 5 EarthScope USArray Flexible Array stations (installed in January 2008, including at 2 former USArray sites). A primary objective of COLZA is to better define the spatial and temporal patterns of seismic activity in the nominal "locked zone," the neighboring Juan de Fuca plate, and the adjacent down-dip region, where episodic tremor and slip is occurring.

see: Trehu et al., Probable low-angle thrust earthquakes on the Juan de Fuca-North America plate boundary, *Geology*, v. 36, p. 127-130, 2008.

POSTER 77

SKELETON-MIGRATION IN DEEP CRUSTAL SEISMIC PROFILING

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The reflection geometry of the sub-surface earth is three-dimensional in character. A three-dimensional seismic data acquisition and processing would be the ideal modus operandi for true seismic interpretation. However, almost all deep crustal reflection profiles recorded on land world-wide follow quasi-linear geometry for economic reasons. Although conventional processing of the lines accommodates crooked-line geometry, the migration algorithms used to produce seismic images for interpretation are generally 2-D. Consequently, the effects of 3-D geometry are not usually well-accounted for. For example, the out-of-plane reflections lead to mislocation errors. These errors increase with recording time. The events may be mislocated by 10's of km and show spurious apparent dip after migration. In order to circumvent these problems and to gain insight into 3-D structures, we present an easy-to-implement "Skeleton-migration" algorithm.

The skeleton-migration method follows a two-step procedure. In the first step, seismic skeletonization of the data being investigated is carried out. This yields a digital catalogue of two-way travel times from the 2-D stack reflection profiles. In the second step, ray-based migration is applied. Essential to the ray-based migration is the availability of two-way travel times of the 2-D stack and an a priori knowledge of the dip direction and velocity of the reflecting layer. We illustrate the usefulness of the method with examples from both the synthetic and deep crustal seismic reflection data in understanding the influence of 3-D geometry of reflecting surfaces in conventionally-processed 2-D reflection profiles.

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MODES OF LITHOSPHERIC DISMEMBERMENT, MAGMATIC INPUT, AND IMPLICATIONS FOR RHEOLOGICAL MODELS OF THE GREAT BASIN AND COLORADO PLATEAU REGIONS, NEVADA AND UTAH; IMPLICATIONS FROM DEEP MT RESISTIVITY SURVEYING

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The U.S. Great Basin offers unique opportunities to understand controls on and manifestations of extensional deformation of the lithosphere in that it spans a former Precambrian continental margin with Paleozoic accreted terranes, all of which have experienced thin-skinned overthrusting and extensive plutonism prior to Late Cenozoic rifting. One approach is to attempt to image geophysically the major zones along which deformation or magmatism currently are concentrated and to correlate them with prior fabric and composition, and with subdomains of deformation. Recent magnetotelluric (MT) profiling which spans nearly the entire Great Basin and Colorado Plateau (GB-CP) interior reveals families of such structures commonly dominated by high-angle conductors interpreted to reflect crustal scale fault zones or mantle upwelling. In western and central Nevada, major conductive crustal-scale structures appear to connect conductive lower crust below Dixie Valley, the Black Rock Desert in NW Nevada, and in east-central Nevada in the Monitor-Diamond Valley area, to the near surface. Trends of crustal earthquakes and concentrations of mantle-derived tritium support that at least some of these zones are actively fluidized with a mantle melt-derived component. The Dixie Valley structure in particular lies along the original Precambrian continent-ocean boundary. In the GB-CP transition of Utah, the main structures revealed are a series of nested low-angle detachment structures underlying the incipient development of several rift grabens. All these major fault zones appear to overlie regions of particularly conductive lower crust interpreted to be caused by recent basaltic underplating. With higher resistivities in the upper mantle below, this geophysical section supports the “jelly-sandwich” model of lithospheric rheology. Across the GB-CP transition also, long period MT data show an anisotropic low-resistivity upper mantle upwelling below concentrated conductive lower crust and nested detachment faults, and this is advanced as a source region for melt underplating. MT, with its wide frequency bandwidth, allows views of nearly a complete melting and emplacement process, from mantle source region, through lower crustal intrusion, to the brittle regime deformational response.

POSTER 70

JOINT INTERPRETATION OF TAIGER PASSIVE AND ACTIVE SOURCE DATA FOR IMAGING THE OROGEN

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Imaging of subsurface structures in detail is at the core of the TAIGER project. The project aims at the testing of existing orogenic models and exploring general geodynamical processes for Taiwan. Coordinated active and passive are included in the project. For active source imaging on land two wide-angle seismic profiles, one in northern and one in southern Taiwan, have been completed. Along each profile five shots, ranging from 500 Kg to 300 Kg, at four sites were fired. These were recorded on “Texans” with 4.5 Hz sensors with 100m spacing. Two NS lines of “Texans”, 3 component 2 Hz sensors with RT-130 recorders and broadband (BB) instruments, at 2 km spacing, were also deployed, one down the middle of Taiwan, following the Lishan fault part of the way and the other along the Longitudinal Valley. There was also a short “fan-shot” profile along the mid-Taiwan transect when the northern shots were fired. For passive studies we have deployed altogether 47 BB stations from 6/2006-4/2008, in stages. These were deployed along the northern and southern transects referred to above and also along a middle transect. Very important is the permanent BB and short period (SP) networks established by CWB and IES, Academia Sinica, for extended time and space coverage. In total there were about 100 BB stations in operation during the peak of the TAIGER deployment.

In this paper we discuss one particular and key aspect of the imaging effort, namely the joint passive-active source arrival time 3D-tomography for the crust and uppermost mantle. The data available to us are the P arrival times of natural events recorded by the BB and SP networks, natural events recorded by Texans during the active experiments. These data are used in various combinations based on a number of factors. One obvious consequence is to increase the ray density in parts of the model. For example, the shallow part of the model in many parts of Taiwan are much better resolved with the addition of the wide-angle data. But the models based on different types of data can provide cross check for each other. An additional layer of integration is in the interpretation of our 3-D tomography and two-D wide-angle sections. The fan-shot profile, for example, can cross check the geometry of the root of the Central Range. In summary, the TAIGER passive and active source data when used jointly is expected to produce a significantly better resolved model useful for tectonic interpretation.

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REGIONAL THREE-DIMENSIONAL SEISMIC VELOCITY MODEL OF THE CRUST AND UPPERMOST MANTLE OF NORTHERN CALIFORNIA

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We present a 3D tomographic model of the P-wave velocity (V_p) structure of northern California. We employed a regional-scale double-difference tomography algorithm that incorporates a finite-difference travel time calculator and spatial smoothing constraints. Arrival times from earthquakes and travel times from controlled-source explosions, recorded at network and/or temporary stations, were inverted for V_p on a 3D grid with horizontal node spacing of 10 to 20 km and vertical node spacing of 3 to 8 km. Our model provides an unprecedented, comprehensive view of the regional-scale structure of northern California, putting many previously identified features into a broader regional context and improving the resolution of a number of them, and revealing a number of new features, especially in the middle and lower crust, that have never before been reported. Examples of the former include the complex subducting Gorda slab, a steep, deeply penetrating fault beneath the Sacramento River Delta, crustal low-velocity zones beneath Geysers-Clear Lake and Long Valley, and the high-velocity ophiolite body underlying the Great Valley. Examples of the latter include mid-crustal low velocity zones beneath Mount Shasta and north of Lake Tahoe.

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