

THE FATE OF THE JUAN DE FUCA PLATE

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The Earthscope Transportable Array now provides seismic data spanning the western United States from the coast to eastern Arizona, Utah, Idaho and central Montana. Combining data from this network with that of regional seismic stations we invert traveltimes from a combined network of more than 800 stations to constrain velocity structure beneath the North American continent. Our Dynamic North America model (DNA08) uses finite frequency theory to combine datasets from different frequency bands improving the overall resolution of the continent. DNA08 shows some common features which have been imaged before such as the high velocity anomaly beneath the Cascades and the low velocity anomaly beneath the Yellowstone National Park. However, the unprecedented dense station distribution and improved resolution kernels allows us to see deeper and reveals new features. The imaged Juan de Fuca subduction system does not extend very deep into the mantle despite ongoing subduction for ~150 Ma. The lower edge, around 500 km depth, can be explained by interaction with the proposed Yellowstone plume head arriving around 17 Ma. Beneath Yellowstone today there is no vertical conduit extending directly into the lower mantle. Instead, low velocities in the lower mantle appear to connect to the Yellowstone caldera through a more complex path. Immediately south of the Mendocino triple junction low velocity anomalies are imaged to 400 km depth, consistent with upwelling around the southern edge of the Gorda slab, and the high velocity Pacific plate is imaged abutting against the low velocity North American plate along the trace of the San Andreas Fault System.

FEEDING THE (DATA) NEED: RETAINING USARRAY TA STATIONS IN THE PACIFIC NORTHWEST

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The mission of a Regional Seismic Network (RSN) is to enhance public safety by seismic monitoring. The products RSNs deliver include information about earthquakes and ground motion needed by public safety officials, planning officials, engineers, the public, scientists and educators. Stations of the Transportable Array (TA) component of the EarthScope facility may contribute significantly to an RSN's capability to provide these products permanently by allowing RSNs to purchase stations so they can be retained in a region once TA has moved on. The Pacific Northwest Seismic Network and its partners, Washington state, Oregon state, and the Pacific Northwest National Laboratory (PNNL) have retained 21 complete TA stations and four empty seismic vaults. This has approximately doubled the number of broadband stations available for near-real-time seismic hazard monitoring in the region.

In the Pacific northwest, the retention of these stations has taken significant advanced planning, the good will and hard work of many individuals, and some old-fashioned good luck. Major planning steps on the part of the PNSN represent a sort of bootstrap process that includes: (1) determining how many stations are needed to meet and RSN's performance criteria, and how many may receive support for operation and maintenance, (2) raising the necessary funds to acquire the stations, (3) identifying the most desirable and important stations to retain, (4) coordinating with USArray personnel to determine the mechanisms and timing of transfer, (5) obtaining permission and land use approvals from the landowners involved, (6) deciding how best to continue the flow of data during a period during which responsibility for reporting data to the archive transitions, and (7) upgrading individual sites so that they optimally provide hazard monitoring data, and (8) training RSN personnel to operate and maintain TA seismic and telemetry equipment. Funding to purchase the equipment was provided by a grant from the M.J. Murdock Charitable Trust, by PNNL, and by the state of Oregon. Funding for continued operation and maintenance is planned to be borne by the US Geological Survey, Washington state, the DOE.

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THE MAUPIN, OREGON EARTHQUAKE SWARM OF 2007-2008

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The region near the town of Maupin, Oregon has seen more than 200 earthquakes since December 2006. These recent events ($M > 1$) occurred ~ 10 km southeast of the town in central Oregon, about 20 km east of the Cascade Mountains. Locations by the Pacific Northwest Seismic Network show a NW-SE trending cluster of earthquakes with apparent depths of 12-24 km. The largest swarm event ($M_c = 3.8$) occurred on June 14, 2007, and 10 other events with a magnitude of 3 or greater have occurred in this time span; these larger events were felt locally. The swarm occurred while surrounded by the EarthScope USArray seismic stations, providing a unique high-quality dataset. Waveform similarity at the closest USArray site (G06A) indicates that the large events occurred within a source region much smaller than suggested by the epicenter distribution from routine PNSN location. Regional moment tensor inversion using dense USArray station coverage reveals nearly identical strike-slip mechanisms on a plane striking $\sim 15^\circ$ NW for the three largest 2007 events. The April 2008 $M_c = 3.6$ event is rotated about 10° clockwise, which is consistent with slight changes of G06A three-component waveforms relative to the 2007 events. Preferred centroid depths are in the 15-20 km range.

Historically, the northeast Oregon and southeast Washington region is characterized by sporadic bursts of clustered seismicity. The largest instrumentally recorded earthquake near Maupin ($M_w = 4.6$) occurred in 1976. Earlier swarm activity was observed in 1987, but only ~ 2 events/yr occurred between the 1987 and the current swarm. In spite of this recurrent seismic activity, surface rocks exposed in the area around Maupin are relatively undeformed lava flows of the Columbia River Basalt Group and older John Day volcanics. The geologic map of Oregon shows a single NW-trending dip slip fault near the epicenter area inconsistent with moment tensor solutions. Through continued analysis of these events, including determination of precise relative locations, additional mechanism solutions and better magnitude calibration, we will constrain models for the cluster's origin.

POSTER 138

SNOWPLOW TECTONICS: POST 2.1 GA LITHOSPHERIC EVOLUTION OF THE HUDSON BAY REGION

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The 1.9 Ga Trans-Hudson orogen is similar in scale and tectonic style to the Himalayan-Karakorum orogen and formed due to a collision between two Archean domains, the Superior and Churchill Provinces of the Canadian Shield. During collision the leading edge of the lower plate, the volcanic rifted margin of the Superior Province, had the form of a 'double indenter' with a deep embayment that is presently situated in the SE corner of Hudson Bay. This study synthesizes regional studies and combines reprocessed and interpreted potential-field data with new constraints from the ongoing Hudson Bay Lithospheric Experiment (HuBLE), a part of the POLARIS initiative, to investigate the less-studied central segment of the Trans-Hudson orogen. An enhanced Bouguer gravity map, corrected for water depth in Hudson Bay, facilitates regional correlation of the Superior margin owing to a thick, dense package of tholeiitic basalts along its outboard edge. Taken together with magnetic data, the gravity results also provide evidence for tectonic escape ("snowplow tectonics") via upper-crustal extrusion into the embayment, ultimately overstepping the margin by > 200 km at some locations. The narrow apex of the escape wedge coincides with anomalously thick crust (> 48 km) inferred from receiver functions, supporting a previous interpretation that flexure caused by a point-like crustal load may explain the nearly circular Nastapoka arc delineated by the present SE shoreline of the Bay. The Paleozoic Hudson Bay intracratonic basin sits astride the pre-existing embayment structure and is cored by large positive gravity anomaly. This feature can be modeled as a block of dense material near the Moho, possibly of eclogitic composition. All of these elements strongly suggest that the double-indenter configuration of the NE paleomargin of the Superior Province formed an orogenic template that exerted a profound and long-lasting influence on the lithospheric evolution of this vast part of Laurentia.

POSTER 123

NEW CONSTRAINTS ON MANTLE SEISMIC STRUCTURE BENEATH THE NORTHWESTERN UNITED STATES

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The goal of this study is to understand the dynamics of the Juan de Fuca subduction system as it relates to the evolution of tectonomagmatism across the backarc, including the Columbia River basalts, the High Lava Plains, and the time-progressive Newberry and Yellowstone hotspot tracks. We utilize broadband seismic data from several arrays, including the USArray Transportable Array and the ~100 stations of the High Lava Plains (HLP) seismic array currently in operation. In total, we have evaluated well over 1,000,000 waveforms recorded at ~700 broadband stations across the northwestern U.S. to provide new constraints from a host of seismic analyses.

Images from the body wave tomography and upper mantle discontinuity receiver function results are broadly consistent, and demonstrate that the Juan de Fuca slab is well imaged and extends to depths of ~500 km and perhaps deeper. Significant zones of focused reduced seismic velocities are evident beneath both the Newberry region and the surface expression of the Columbia River basalts. At lower mantle depths (700 km and deeper), we image planar deep structures that may be consistent with a slab break at ~15 Ma. We find no evidence for mantle plume-type structures across the HLP/Newberry/CRB region. Similarly, we find no evidence for a zone of low velocities beneath the Juan de Fuca slab. Further, we demonstrate through a thorough series of resolution tests that the absence of a slab signature in central Oregon, interpreted by some groups as a “hole” in the slab, is rather an inversion artifact due to imperfect ray coverage and the presence of the reduced velocity zone coincident with Newberry.

Results from shear splitting analyses show a pattern of remarkably strong, relatively simple azimuthal anisotropy across most of the region. Fast polarization directions across the region are dominantly rotated just slightly N of E-W for most areas; regions of more complex fast directions are evident near the accreted terranes W of the Cascades and across the arc itself. Splitting times average ~2.0 s, with a region of larger (~2.75 s) splitting times present beneath southern Oregon, broadly coincident with regions of Recent volcanism across the area and near the edge of the Juan de Fuca slab, which may indicate the presence of shape-preferred orientation of partial melt that significantly enhances the splitting signal.

POSTER 134

DETECTING DELAMINATION? RECEIVER FUNCTIONS AND REGIONAL WAVEFORMS FROM THE CENTRAL AND NORTHERN SIERRA NEVADA

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The Sierra Nevada EarthScope Project (SNEP) investigates the processes of lithospheric foundering beneath the Sierra Nevada batholith. This study presents teleseismic receiver functions, records of P-S converted waves generated by seismic discontinuities in the crust and upper mantle, to provide estimates of crustal thickness, composition and anisotropic deformation fabric. In order to provide a complete image of the lithosphere beneath Sierra Nevada, this study combines the analysis SNEP broadband seismic dataset, as well as reprocessed findings from the 1997 Sierra Paradox Experiment and new results from EarthScope Transportable Array and regional networks operated by University of California-Berkeley, University of Nevada-Reno, and the California Institute of Technology.

Several major tectonic features appear ubiquitous in receiver functions collected throughout the Sierra Nevada. We see reduced coherency of the crust-mantle boundary from east to west across the range, entering a region bordering the Great Valley previously referred to as the “Moho hole”. The center of this region coincides with clusters of deep earthquakes, coupled with a gradual westward thickening of the crust, approaching 60 km thickness in the foothills of Yosemite National Park in the central Sierra. Conversely, we see 30-35 km thick crust and a sharp crust-mantle boundary throughout the highest elevations of the Sierra Nevada along the entire length of the range. We also detect a significant region of seismic anisotropy localized along the Moho throughout the eastern Sierra Nevada. In addition, we present preliminary record sections of P_n arrivals from several regional earthquakes to further investigate the changing velocity contrast at the crust-mantle boundary and its implications for the distribution of lithospheric foundering. These findings represent an image of continental lithosphere being actively modified by the foundering of an ultramafic root; sharpening the crust-mantle boundary where this process is complete, imparting a seismically anisotropic shear zone as evidence of this deformation, and obscuring the crust-mantle boundary where lithospheric foundering and deformation is on-going.

POSTER 131

SURFACE WAVES ACROSS THE TA: AN INTEGRATED SEISMIC AND GEODYNAMIC ANALYSIS OF MANTLE DEFORMATION BENEATH CALIFORNIA

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Surface deformation across the western US plate boundary depends on not only the mantle forces driving the deformation, but also on the strength of the crust and mantle lithosphere that transmit those forces. Previous analyses of seismic anisotropy in the region imply that Pacific-NA plate boundary deformation penetrates into the mantle in northern California, while the surficial (plate) motions and mantle deformation are largely decoupled across the plate boundary in southern California. In this project, an integrated seismic-geodynamic analysis is being developed to better quantify deformation across the plate boundary. The heart of this analysis is the characterization of anisotropy beneath California using surface waves traversing the TA. This TA-enabled study is transforming our research in at least three ways. First, we have developed a new cross-correlation procedure to measure frequency-dependent phase delays of surface waves. Conceptually similar to multi-channel cross-correlation algorithms for body-wave tomography and earthquake location, this analysis exploits the similarity between nearby recordings of the surface wavefield to more precisely estimate relative phase and amplitude. These phase-delay and amplitude measurements in turn provide more precise estimates of wave velocities within the array, including subtle azimuthal variations that are diagnostic of anisotropy. Second, in order to more directly interpret the anisotropy in the context of plate-boundary deformation, we are constructing numerical models of mantle fabric that can be directly incorporated as constraints in the seismic modeling. The numerical models simulate upper-mantle flow beneath the plate boundary using a viscous fluid subject to surface and basal boundary conditions derived from geologic and kinematic data, testing a variety of rheologies. Combined with the seismic observations, these models allow us to quantitatively test conceptual models of deformation and rheology across the plate boundary. Finally, we are integrating these analyses using 3D “banana-doughnut” Frechet kernels that are computed by fully coupled normal-mode summation. These kernels are highly accurate but expensive to calculate, and in order to utilize them, we have reformulated the algorithm using a pre-calculated database of strain Green’s functions. This modification allows the benefits of 3D Frechet kernels to be realized for large datasets such as that provided by the TA.

SPATIAL VARIATIONS OF ATTENUATION IN THE MANTLE BENEATH NORTH AMERICA FROM P WAVE SPECTRAL RATIOS

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We estimate the spatial variation of the seismic parameter t^* using teleseismic (30-90°) P wave spectra of about 200 deep (> 200 km) earthquakes recorded by broadband seismometers in North America. We estimate P wave spectral ratios ($\ln R_{ij}$) up to 1 Hz for about 500,000 station pairs i - j with high signal-to-noise ratio and impulsive P waveforms. The slope of the best-fitting line through $\ln R_{ij}$ yields estimates of Δt^* between stations i and j ($\Delta t_{ij}^* = t_i^* - t_j^*$), assuming that $\ln R_{ij}$ is proportional to $\pi f \Delta t_{ij}^*$ (i.e., Aki and Richards, 1980). The Δt_{ij}^* measurements are inverted for t^* at each station by least-squares inversion. While scatter is large, variations of t^* are correlated with the tectonic terrains of North America. Predominantly low values of t^* are obtained in central North America and high t^* values are obtained for stations in the North American Cordillera and within the Appalachian Mountains. This variation is similar to short period amplitude anomalies (e.g. Butler, 1984) and spectra (e.g. Der et al., 1982) and Q variations inferred from surface wave amplitude data (e.g. Dalton and Ekström, 2006), suggesting that intrinsic attenuation is the predominant cause.

POSTER 132

CONSTRUCTING THE RAYLEIGH WAVE PHASE SPEED TRAVEL TIME SURFACE IN WESTERN US USING THE EARTHSCOPE/TA: APPLICATION TO EIKONAL TOMOGRAPHY AND EMPIRICAL FINITE FREQUENCY SENSITIVITY KERNELS

Fan-Chi Lin (University of Colorado at Boulder), Morgan Moschetti (University of Colorado at Boulder), Michael Ritzwoller (University of Colorado at Boulder)

We demonstrate how to construct Rayleigh wave phase speed travel time surfaces in western US using ambient seismic noise observed at over 450 broad-band stations from the EarthScope/TA and regional networks. All vertical component time series between Oct 2004 and Nov 2007 are cross-correlated to estimate the Rayleigh wave Green's function between each station pair. The estimated Green's functions are then used to measure the phase velocity dispersion curves and the phase travel times between 8 and 40 sec period. For each station and period, we construct a Rayleigh wave phase speed travel time surface for a vertical source located at that station by fitting a smooth surface to all inter-station travel time measurements having that source station in common.

Two applications are presented here. First, we show the result of both isotropic and anisotropic Eikonal tomography in the western US based on these surfaces. By assuming the wave's phase varies more rapidly than its amplitude in space, the Eikonal approximation states that the amplitude and direction of the gradient of the travel time surface is equal to the local slowness and the direction of wave propagation. This allows a statistical estimate of the azimuthal-dependent phase velocity and its uncertainty at each point. This novel tomography method naturally accounts for off-great-circle effects and includes no regularization parameter. Clear 2-psi velocity variations are observed for Rayleigh waves between 12 and 32 sec period where the fast directions at 32 sec generally agree with the fast directions indicated by SKS splitting studies.

In the second application, we construct empirical Rayleigh wave finite frequency sensitivity kernels based on the travel time surfaces. Here, we utilize the source-receiver duality of the stations used in ambient noise cross-correlation and use the travel time surfaces centered at two different stations to mimic the regular and adjoint wave fields in the numerical adjoint method described of Tromp et al. (2005). The empirical sensitivity kernel constructed here reflects the sensitivity kernel of the wave to the real Earth instead of a 1D or 3D reference model. Comparison of the empirical kernel and the analytical kernel based on a 1D model shows significant differences in regions with great velocity contrasts. This demonstrates potential shortcomings of inversion methods that solely rely on a 1D reference model to construct either rays or sensitivity kernels.

POSTER 121

CRUSTAL SHEAR-WAVE VELOCITY STRUCTURE AND RADIAL ANISOTROPY BENEATH THE WESTERN UNITED STATES FROM AMBIENT NOISE MEASUREMENTS

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We present crustal and uppermost mantle shear-wave velocity and crustal radial anisotropy estimates beneath the western United States (US) from an inversion of ambient noise surface wave measurements. By cross-correlating three-component time series from USArray Transportable Array (TA) and regional network stations between October 2004 and December 2007, we generate empirical Green's functions for all possible inter-station paths from more than 500 stations. Rayleigh and Love wave group and phase velocities are measured on the empirical Green's functions and inverted to provide short- to intermediate-period (6 - 40 sec) dispersion maps. These results comprise the data set for our inversion. We use Monte Carlo methods to invert the dispersion maps for crustal and uppermost mantle shear-wave velocities. Receiver function crustal thickness estimates, made at USArray TA stations, constrain the inversion. The southern edge of the Juan de Fuca plate requires the introduction of a very low velocity layer in the uppermost mantle to fit the data. A Rayleigh-Love data mismatch occurs below 40 sec period across broad regions of the western US. The Rayleigh and Love data are separately inverted for perturbations to the isotropic model within the crustal layers in the model. Positive radial anisotropy ($V_{sh} > V_{sv}$) is observed in the middle to lower crust for minimally-anisotropic models; neither upper crustal nor upper mantle anisotropy resolves the data mismatch. Regions of high crustal radial anisotropy correspond to extensional provinces in the western US. The model allows for examination of important crustal and mantle structures in the western US, including the Basin-and-Range province, the mantle wedge and slab edge effects related to Juan de Fuca plate subduction. We infer the presence of a serpentized layer in the uppermost mantle at the southern edge of the Juan de Fuca plate from the low upper mantle velocities observed. Mid- to lower-crustal radial anisotropy presumably results from mineral alignment by crustal flow within extensional tectonic regions. Emerging USArray TA data promises to extend the high resolution maps across the US and allow for examination of the velocity structures and tectonic processes across the coterminous US.

POSTER 125

INTEGRATION OF EARTHSCOPE TRANSPORTABLE ARRAY STATIONS INTO THE UTAH REGIONAL SEISMIC NETWORK

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In this presentation we report on the integration of Earthscope Transportable Array (TA) stations into the Utah Regional Seismic Network (URSN) using examples from: (1) routine data analysis, (2) the 2007 Crandall Canyon mine collapse, (3) the 2008 M 6 Wells, Nevada earthquake, and (4) a 2007 seismo-acoustic experiment. The TA stations began moving into the Utah region in May, 2006 (although the majority were installed during 2007) and will begin moving out August, 2008. Beginning in May, 2007 the TA data were integrated into the near-real-time processing and used to generate data products (including ShakeMap). This integration involved adding the stations into an Earthworm system and merging the data into the event files reviewed by analysts. The addition of the TA stations increased the number of broadband stations in the region from 17 to 78. For routine data analysis, the greatest benefit noted to date is the improved azimuthal coverage. However, we will also show a comparison with the EarthScope Array Network Facility catalog for the Utah region and discuss the possibility of previously unknown source areas in this region. Overall, the timing of the TA deployment in the Utah region has been remarkably fortuitous. The records from these stations greatly enhanced the data sets collected from both the Wells earthquake and Crandall Canyon mine collapse. We recognize the importance of these additional stations and are actively trying to secure funds to adopt some of the stations. To date, we are in discussions for funding for two to three stations in and near the central Utah coal mining region and are exploring ways to possibly fund the adoption of one to two more stations.

POSTER 122

REGIONAL CONDUCTIVITY STRUCTURE OF CASCADIA: PRELIMINARY RESULTS FROM 3D INVERSION OF USARRAY TRANSPORTABLE ARRAY MAGNETOTELLURIC DATA

Prasanta Patro (Oregon State University), Gary Egbert (Oregon State University)

In conjunction with the USArray component of EarthScope, IRIS is acquiring long period magnetotelluric (MT) data in a series of arrays across the US. Initial deployments in 2006 and 2007 acquired 110 sites covering Washington and Oregon, and extending into eastern Idaho. The MT sites, distributed with the same nominal spacing as the seismic transportable array (~75 km), produced data in the period range 10-10,000s of very good (2007) to excellent (2006) quality. We present initial results from processing and 3D inversion of this dataset. The most striking and robust features revealed by the inversion are extensive areas of high conductivity in the lower crust beneath the Northwest Basin and Range, and beneath the Cascade mountains, contrasting with very resistive crust in Siletzia (basement rocks in the Coast ranges, Willamette Valley and Puget Lowlands) and the Columbia Embayment. Significant variations in upper mantle conductivity are also revealed by the inversions, with the most conductive mantle beneath the Northeastern part of the array, and the most resistive corresponding to subducting oceanic mantle. Comparison with interpretations from previous 2D MT transects shows reasonable agreement at the large scales resolved by the USArray MT data. Resolution of fine details, especially in the upper crust, is clearly limited, both by the wide station spacing, and the lack of high frequency data. Nonetheless, our preliminary results are extremely encouraging. In spite of the wide site spacing and limited control over near-surface distorting structures, a very sensible and coherent large scale picture of regional scale conductivity variations appears to result from the 3D inversion. These results demonstrate that the EarthScope MT project, in conjunction with recent and ongoing development of 3D inversion capability, has a strong potential to provide useful new regional scale constraints on physical state and composition (in particular fluid content) in the North American crust and upper mantle.

POSTER 126

MAPPING LG Q AND ANISOTROPY USING THE USARRAY

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We find that USArray data can be used to resolve Lg attenuation to half a degree over wide areas of the western United States. This is a dramatic improvement over tomographic studies carried out in Asia using a sparse station network (1.5 degrees at best). Western US Lg Q ranges from 60 to 550, and shows striking correlation with regional geology and topography. These correlations build confidence in the attenuation model, which can then be used to isolate source effects, and predict ground motions. Tomographic techniques applied to Pg/Lg ratio data yield residuals that reflect focal mechanism for a Walker Lane event, which we confirm with short distance (< 250 km) first motion observations. The inclusion of Q anisotropy terms reduces variance 10% and high-Q directions (maximum variation 50%, median 12%) run parallel to topographic fabric in many areas. USArray data will be of great value in testing sparse network monitoring techniques by comparing results with those from decimated data sets, and could provide high quality calibration for future use with the permanent Backbone Array.

POSTER 133

SEISMIC INSTRUMENT SITING USING GEOSPATIAL TECHNOLOGY

Dana Piwinski (LAGT), Jean Miller (LAGT), Karen Kwasnowski (LAGT)

A significant challenge to the acquisition of high quality seismic and geodetic observation data is the identification, evaluation and selection of sites that are suitable for instrumentation. The Transportable Array component of the NSF EarthScope program being implemented by IRIS utilizes 400 portable seismometers that are being moved systematically across the United States. The footprint of these thousands of sites would ideally form a uniform grid, however a number of sources of seismic noise conspire against this. Supporting IRIS, IAGT has put geospatial information technologies (GIT) to work to make the site selection and monitoring process more efficient and effective, saving program time and cost. GIT tools have been developed to enable consideration of the myriad factors that influence selection of a particular site, including: adjacency to transportation infrastructure, site geology, active construction, land ownership and accessibility. Both web-based and highly portable desktop tools have been developed and are in use. The result of these efforts directly impacts project engineers who can now more effectively concentrate their in-the-field analysis work on sites whose suitability strengths and weaknesses are known in advance.

POSTER 135

IMAGING MANTLE DISCONTINUITIES BENEATH THE JUAN DE FUCA AND PACIFIC PLATES

Nicholas Schmerr (Arizona State University), Edward Garnero (Arizona State University)

We use underside reflections off the 410- and 660-km discontinuities that occur as precursors to the seismic phase SS to map discontinuity depths underneath the Pacific plate. The 410- and 660-km discontinuities are globally observed features that bound the mantle transition zone of the Earth, a region where the minerals olivine, pyroxene, and garnet transform into denser, more compact structures. The depth of each phase change is highly dependent upon the thermal and chemical state of the mantle, thus lateral heterogeneity in temperature and composition will produce topography on the seismic discontinuities. We gathered a broadband dataset consisting of over 65,000 high-quality, transverse-component, shear-wave seismograms that densely sample beneath the Pacific plate, and stacked the data into geographic bins that share similar SS bouncepoints. Our method differs from past SS precursor studies of this region in that we extend our dominant period down to 10 seconds to image smaller-scale structures and exclude epicentral distances that contain arrivals interfering with the precursors. We also take advantage of the dense coverage provided by the EarthScope USArray and utilize a histogram stacking approach to detect the presence multiple discontinuities. We find that mantle transition zone thickness beneath the Pacific plate is close to the global average of 242 km \pm 5 km, with several notable exceptions. Beneath the Hawaiian hotspot, the mantle transition zone is thinned by 15-25 km, consistent with a hot, upwelling anomaly in the mantle. This feature is predominantly formed by a shallow 660 km discontinuity and extends 1000-1500 km from the surface location of the Big Island of Hawaii. We also observe 5-15 km of thinning beneath several other volcanic chains, including the Cook, Louisville, Bowie, and Samoa hotspots. Beneath the subduction zones in our study region, the transition zone is 10-20 km thicker than average and we find a shallow 410 km and deep 660 km boundary, consistent with lower-temperature materials entering into the transition zone. The depths of the 410- and 660-km discontinuities are anti-correlated, consistent with the expected Clapyeron slopes for phase transformation of olivine, implying a thermal origin for perturbations in discontinuity depths observed beneath the Pacific and Juan de Fuca plates.

POSTER 127

WAVEFIELD IMAGING OF THE TRANSITION ZONE ACROSS USARRAY

Josh Stachnik (University of Wyoming), Aaron Ferris (Weston Geophysical)

Using the USArray seismic network, we analyze the wavefield from a series of Queen Charlotte and western Mexico earthquakes that are recorded at a distance of 5-30 degrees. At far-regional distances, the wavefield interacts with upper mantle heterogeneity to generate a variety of phenomena that provide

insight into the structure of the upper mantle transition zone. For these particular earthquakes, mantle multipathing produces amplified triplicate arrivals from the 410 and 660 km discontinuity. These signals exhibit large amplitudes and are recorded by a large portion of the network. By applying advanced array processing techniques, we construct record sections of the wavefield for a series of back-azimuth swaths from the earthquake epicenter. The record sections sharply define the P410 signals, as well as the corresponding pP410 depth phase. The distance range across the network is such that almost a

complete P410 travel-time branch can be observed, capturing both caustic points near 14 deg and 22 deg distance range. For the Queen Charlotte earthquakes, the back-azimuth swaths illuminate the variation in the wavefield across different portions of the network. To further interrogate the wavefield

and gain a better understanding of the upper mantle structure beneath the Juan de Fuca plate, we are applying wavefield continuation methods and direct tau-p inversions to generate velocity-depth profiles for each back azimuth swath. While our results are preliminary, we observe well-defined tau-p curves with initial inversions indicating a moderately thickened transition zone beneath the Juan de Fuca plate. Ongoing research is focused on refining the inversion algorithm and including S410 arrivals, specifically targeting negative velocity gradients as seen by others atop the 410 km discontinuity.

POSTER 136

GEOPHYSICAL DETECTION OF LITHOSPHERIC DELAMINATION BENEATH THE CENTRAL GREAT BASIN, UNITED STATES

John West (Arizona State University), Matthew Fouch (Arizona State University), Jeffrey Roth (Arizona State University)

The goal of this study is to better understand lithospheric-scale processes across the Great Basin of western North America. In this study, we evaluate new results from shear wave splitting analyses and body wave tomography in tandem with regional geophysical and geological data to provide new constraints on lithospheric dynamics in this region of western North America.

Data for the shear wave splitting component of this study come from over 80 stations combined from the USArray Transportable Array (TA) and long-lived regional stations. We processed seismic waveforms for SKS splitting analysis using a combination of the rotation-correlation, minimum energy, and eigenvalue methods. Data for the seismic tomography component utilizes regional broadband stations, TA stations, and stations from the ongoing High Lava Plains experiment (HLP), which currently has nearly 100 broadband stations located in Oregon, Nevada, and Idaho. We determined relative delay times for P waves from over 400 broadband stations in the northwestern United States and invert these to obtain a 3D relative velocity model of the region.

Shear-wave splitting results reveal a circular pattern of anisotropy fast-axis orientation, centered at approximately 39N, 116.5W. In general, shear-wave splitting delay times become small (sub 0.5 seconds) near the center of the pattern and increase to approximately 2 seconds at the edges of the pattern. P-wave tomography results for this region exhibit a region of high relative velocities approximately centered in the circular pattern in shear wave splitting, with a cylindrical structure extending vertically from roughly 75 to 250 km depths. This cylindrical feature is corroborated by preliminary inversions of S waves and is well-resolved.

The central Great Basin is a region of relatively thin (~30-35 km) crust, thin (<100 km) lithosphere, and high (>75 mW/m²) heat flow. Significant local variations are evident; for instance, anomalous reduced heat flow values are approximately co-located with the seismic anomalies. We propose that the combination of the shear wave splitting pattern, locally high seismic wavespeeds forming a cylindrical column, and other geophysical data is most likely due to a downwelling of delaminated mantle lithosphere. Geodynamical models of lithospheric delamination using appropriate regional constraints support this interpretation, and suggest that such delamination events might be very short-lived in geological terms.

POSTER 130

BOOTSTRAP ANALYSIS ON SURFACE WAVE DISPERSION AND TOMOGRAPHY DERIVED FROM AMBIENT NOISE CROSS-CORRELATION

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Ambient noise cross correlation method has been widely used to retrieve surface wave empirical Green function (EGF) between stations. Procedures involve stacking of cross correlation of continuous data for long enough time series. The total length of data required for Green function to converge is empirical and highly frequency dependent: generally the longer the period the longer the time is needed. Furthermore, the ambient noise source and station site conditions (including instrumentation stability) are uncertain. However, a major feature of the method is that the whole process is completely repeatable with different time segments, which make it possible to evaluate the uncertainties. Here we adopt a bootstrap method to quantify the errors in Rayleigh group velocity dispersion measurements and group velocity tomographic maps from ambient noise cross correlation. We apply the method to 48 China National Seismic Network (CNSN) stations and a dozen other stations in the neighboring regions with 18 months of continuous data.

We obtain the EGF using one month of data for each of the 18 months. 18 months among the months that we have data were selected randomly with replacement to obtain stack EGF. Dispersion curves for all station pairs were measured and tomographic maps were constructed as usual. This process was repeated for 50 times. The mean and the standard deviation of the dispersion curve for each station pair from the 50 dispersion curves obtained whereafter. Similarly, we obtain the standard errors of our tomographic models using the models obtained from the 50 iterations described above.

Most of the pairs show similar dispersion curves between different runs and small standard deviation (generally less than 0.1 km/sec), indicating good data quality and convergence of the Green function. Group velocity at long period end generally has a larger error, which is consistent with the notion that the long period needs longer time to converge. There is only subtle difference in tomography maps between different runs, suggesting that our solution is very stable. Standard deviation in the region with good ray coverage is small (generally less than 0.1 km/sec), indicating a stable and reliable solution in that region. A pitfall of the method is that the standard deviation in the region with poor ray coverage is also small, due to regularization in the tomographic inversion process.

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AMBIENT SEISMIC NOISE AND TELESEISMIC TOMOGRAPHY IN THE WESTERN USA: HIGH-RESOLUTION 3-D IMAGES OF THE CRUST AND UPPER MANTLE FROM EARTHSCOPE/USARRAY

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This study applies two new complementary methods of surface wave tomography, ambient noise tomography (ANT) and multiple-plane wave teleseismic tomography (MPWT), to the rapidly accruing data resources in the western US, predominantly from the Transportable Array (TA) component of EarthScope/USArray. Ambient noise tomography (ANT) is based on the extraction of empirical surface-wave Green functions by cross-correlating long sequences of ambient seismic noise. Multiple-plane-wave tomography (MPWT) interprets the variation in amplitude and phase of teleseismic surface waves observed across a regional seismic array in terms of phase velocity variations within the foot-print of the array. Both methods measure surface wave dispersion, but in complementary period bands: ANT (6 - 40 sec) and MPWT (25 - 100 sec). Used in combination, the methods produce surface wave dispersion maps (Rayleigh and Love wave, group and phase velocity) across the western US from about 6 sec to 100 sec period on a 25-50 km geographic grid.

Using the combined phase velocity dispersions at periods from 6 sec to 100 sec, we perform 3-D shear velocity inversion to obtain a high-resolution shear velocity model from surface to ~160 km in the W. US. The model possesses a wealth of features. High velocities are seen associated with various tectonic processes, such as the subducting slab of Juan de Fuca and Gorda plates, the downwelling lithosphere beneath the southern Central Valley and the Transverse Ranges, and the thick lithosphere of Rocky Mountains. Low velocities are imaged beneath the High Lave Plains, the Great Basin and the Snake River Plain in the upper mantle associated with high temperature and/or probably the presence of partial melt.

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3-D ISOTROPIC AND ANISOTROPIC S-VELOCITY STRUCTURE IN NORTH AMERICA

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The tectonic diversity of the North American continent makes it ideal to investigate the structure and dynamics of the continental upper mantle. Investigations of timely geophysical questions, such as the relation to geological age of the variations in the lithospheric thickness, the relation of upper-mantle anisotropy to present day asthenospheric flow and past tectonic events, the nature and strength of the lithosphere/asthenosphere coupling and the driving mechanisms of plate motions, are contingent upon obtaining high-resolution 3-D tomographic models of the mantle structure of the continent.

In the framework of non-linear asymptotic coupling theory (NACT; Li and Romanowicz, 1995), we have developed a regional 3-D tomographic model of the upper mantle beneath North America that includes both isotropic S velocity structure as well as radial and azimuthal anisotropy (Marone et al., 2007; Marone and Romanowicz, 2007). This model was constructed from a joint inversion of fundamental and higher mode surface waveforms together with constraints on azimuthal anisotropy derived from SKS splitting measurements. The model showed evidence for the presence of two layers of anisotropy beneath the stable part of the North American continent: a deeper layer with $V_{SH} > V_{SV}$ and with the fast axis direction aligned with the absolute plate motion direction suggesting lattice preferred orientation of anisotropic minerals in a present day asthenospheric flow and a shallower lithospheric layer likely showing records of past tectonic events. Under the tectonically active western US, where the lithosphere is thin, the direction of tomographically inferred anisotropy is stable with depth and compatible with the absolute plate motion direction.

Here we present the updated 3-D model of the upper mantle beneath North America. Our isotropic shear-wave images show greater details beneath the cratonic upper mantle, benefitting from the augmented waveform datasets from the US array and newly deployed PASSCAL and Canadian Polaris arrays. The radial anisotropy and azimuthal anisotropy images are generally consistent with our published model. Secondary features appear in the shallow upper mantle, correlating well with the surface expression of some past and ongoing NA tectonic events. Our larger SKS dataset sample larger cratonic area, therefore puts tighter horizontal constraints in our azimuthal anisotropy inversion. The final 3D model will be presented at the workshop.

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