preliminary results indicate that 31% of 8 by 8km cells experienced a significant (one sigma) increase in seismicity rate during the first year after the 1992 M_W 7.3 Landers earthquake (in comparison with the preceding six years), while the number of cells experiencing significant rate increases in other one year increments, from 1984 to 1991, ranged from 16% to 20%. For rate decreases, 8% of cells experienced a significant downturn in the year after Landers, while a similar percentage of cells (ranging from 7% to 10% and averaging 8.5%) experienced significant rate decreases from 1984 to 1991.

S31A-05 0900h INVITED

Assessment of Spatial Aftershock Probabilities: a Feasibility Study in Earthquake Hazard

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Non-linearity in the generating dynamics of earthquakes which may forbid deterministic earthquake prediction does not preclude the estimation of earthquake probability and, in particular, how this might change in space and time. Recent developments in the understanding of stress triggering of earthquakes allow us satisfactorily to explain the special variation of aftershock distributions following any large earthquake. To date, however, this assessment of aftershock probability has only been by the back analysis of completed aftershock sequences. The power of modern microcomputers, the great number of local and telemetered seismic networks, the rapid acquisition of data from satellites coupled with the speed of modern telecommunications and data transfer, all mean that it may be possible that these techniques may be applied in a forward sense. Here we describe the PRESAP Project which has been funded by the European Community and which reported this autumn. The aims of the project were: 1) to assess the extent to which our scientific understanding of the physical phenomena controlling the variation and seismicity following a large event permits the forward modelling of aftershock sequences; 2) to assess the extent to which data which is presently collected is sufficient to allow inversions for slip and stress perturbation fields to be calculated in useful time-frames of between say 0.1 days and 10 days following the main shock; 3) to assess the extent to which current date transfer speeds are sufficient to allow access to the appropriate data within these time-frames. In this presentation, we describe the main work packages of the PRESAP Project and outline its findings. In particular, we describe the pseudo real time scenario which was used to assess the success of the protocols which have emerged from the project.

S31A-06 0915h

Coulomb Stress Modelling as a Practical Tool in Real-time Aftershock Hazard Assessment: the Example of the PRESAP Blind Test

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We present results of a pseudo real-time scenario that was performed in the framework of the PRESAP (Practical, Real-Time Estimation of Spatial Aftershock Probabilities) project. The aim of the PRESAP project is to assess the feasibility of using Coulomb stress modelling to make real time estimations of the likely spatial distribution of off-fault aftershocks following a large event. As part of this project, the scenario was designed to test the practicality of making such assessments in real time. Data from a recorded earthquake, not studied in the PRESAP project and not known in advance by the participants, were made available in the time ordered sequence and in the raw form as it would have arrived. The test was managed through a website where data and results were continually posted by the participants located all over Europe. Results show that CST may indeed provide useful guidance in the identification of potential fault sources. The location of aftershocks in association with a-priori knowledge of the kinematics of potentially active faults played a key role in decision-making. In the case where the number of available aftershocks would have been sufficient, statistical tests could have also been used. The success of the blind-test was in part due to the "simple" vertical strike-slip faulting tectonics of the region concerned but in particular due to the good knowledge of the active faults. In regions where the tectonics is more complex (e.g. Athens 1999 earthquake, Umbria-Marche 1997 sequence), the exercise may not be so straightforward. Nevertheless, real-time estimates may be improved by pre-computing a range of potential fault scenarios for both Coulomb stress perturbations and expected ground motions that are likely to affect the critical sites of interest.

URL: http://www.errigal.ulst.ac.uk/

S31A-07 0930h

Are foreshocks explained by cascades of triggered seismicity: empirical tests and comparison with the Olami-Feder-Christensen SOC model

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The observation of foreshocks preceding large earthquakes and the suggestion that foreshocks have specific properties that may be used to distinguish them from other earthquakes have raised the hope that large earthquakes may be predictable. Among proposed anomalous properties are the larger proportion than normal of large versus small foreshocks, the power law acceleration of seismicity rate as a function of time to the mainshock and the spatial migration of foreshocks toward the mainshock, when averaging over many sequences. Using Southern California seismicity, we show that these properties and others arise naturally from the simple model that any earthquake may trigger other earthquakes, without arbitrary distinction between foreshocks, aftershocks and mainshocks. With the quality of available catalogues, we do not find a convincing dependence of the foreshocks precursory properties on the mainshock size. Taken at face value, this would imply that earthquakes (large or small) are predictable to the same degree as seismicity rate is predictable from past seismicity by taking into account cascades of triggering. We also find that cascades of triggering give rise naturally to long-range and long-time interactions, which can explain the observations of correlations in seismicity over surprisingly large length scales. Most of these properties are found at a qualitative level in synthetic earthquake catalogs generated by the OFC spring-block model. Following S. Hergarten and H.J. Neugebauer, Phys. Rev. Lett. 88.238501, 10.1103, 2002, we apply the same analysis to synthetic catalogues generated by the OFC model. In addition, and in contrast with the ETAS model and with observations, we find in the OFC model a dependence of foreshock rate on the size of the mainshock, which can be explained by the concept of the"critical earthquake. In the OFC model, large events are therefore slighly more predictable than smaller events.

S31A-08 0945h

After the lightning and before the thunder; non-Omori behavior of early aftershocks?

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Mainshock rupture is immediately followed by the receding drumbeat of aftershocks, which have been known to obey Omori's law for nearly a century. Unfortunately, the initial few minutes of aftershocks are difficult to observe due to the mainshock coda, network clipping, and the confusion of nearly simultaneous events. Yet this interval holds valuable clues about how stress-induced ruptures may be delayed, often in fits and starts, and the friction laws that govern temblors. With the advent of continuous recording on dense networks, we can pry open a window to reveal aftershock activity 1 to 5 minutes after moderate and large earthquakes. We high-pass-filter 100-sample-per-second three-component recordings to minimize reverberating coda, and select stations for low noise and impulsive arrivals to reveal patterns of P and S arrivals. We have examined close-in recordings of six earthquakes recorded on TriNET in southern California (M4.0 2001-10-28 Compton, M4.7 2002-09-21 Yorba Linda, and M7.2 1999-10-16 Hector Mine) and on Hi-Net in Japan (M7.3 2000-10-06 Tottori, M5.1 2003-05-11, and M5.4 2003-5-17). Visual examination of high-passed seismograms typically detects several times more events in the first few minutes than are recorded in the best catalogs. Calibration of observed amplitudes with the magnitudes of those events that are in the catalogs allows all detected events to be assigned a magnitude. Preliminary results suggest a deficit of aftershocks by roughly a factor of two from 100 to 300 sec after the mainshock relative to 1/t rate decline with time. This deficit is comparable to the one tentatively found for much smaller M1 to M2 (Rubin, JGR, 2002, p 3-10). This pattern is consistent with the existence of such an interval in rate-and-state friction models prior to the 1/t aftershock decay rate that (Dieterich, JGR, 1994, interval b). We expect that capturing early aftershock rates will aid in the understanding of the transition from propagating rupture to sporadic aftershock activity.

S31B MCC: 3011 Wednesday 0800h

Pumping Iron: The Core *(joint with V, DI)*

Presiding: **D A Wiens,** Washington University**; Y Shen,** University of Rhode Island

S31B-01 0800h

Can we achieve consistent inner-core models from ISC travel-time data and waveform data?

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While it is now generally believed that the Earth's inner core is anisotropic to compressional wave propagation, the magnitude and existence of depth variations of seismic anisotropy are still controversial among the seismological community. Same is also true on whether there is a hemispherical variation in both the velocity (including the isotropic wavespeed and the magnitude of seismic anisotropy) and the attenuation structure at the top of the inner core. The discrepancy between the inner-core models is, however, deeply related to the type of data used in deriving them: hand-picked differential travel-time data (*PKiKP-PKIKP* and *PKP-PKIKP*), ISC absolute travel-time data of PKIKP, or normal-mode data. Models from the first type of data appear to have strong lateral and radial variations of seismic anisotropy, as well as the hemisphericity of the inner core, while the other two types of data tend to favor models with seismic anisotropy homogeneously distributed within the entire inner core. Such a discrepancy could result from the sparse and biased sampling of the differential travel-time data, or the large uncertainties in the ISC absolute travel-time data, or both. To solve this discrepancy, we analyzed a total of ~2.1 million *PKIKP* travel time data reported to the International Seismological Center (ISC) in the period of 1964-1999. We first computed the ISC travel-time residuals of PKIKP with respect to the PREM model. We used high-quality relocation catalogs with relatively accurate earthquake locations and origin times in the calculation. We then calculated corrections on the *PKIKP* travel time due to the heterogeneous mantle structure. Our preliminary results suggested that the corrected travel-time residual data are, surprisingly, very consistent with differential travel-time data. For example, we found that travel times are systematically smaller, by about 0.5-2 s, for waves that travel the "eastern" hemisphere compared to those travel the "western" hemisphere. The consistence suggested that the ISC travel-time data, with its great coverage, has the potential to shed light on those unresolved regions, such as the innermost part of the inner core.

S31B-02 0815h

Transition From Isotropy to Anisotropy in the Upper Inner Core

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We investigate models of the radial structure of the western hemisphere of Earth's inner core. Differential travel times of PKiKP − PKIKP indicate that the outermost inner core is isotropic and slightly slower than global models such as PREM. On the other hand, observed travel-time residuals of PKP_{BC} − PKIKP and PKP_{AB} − PKIKP increase systematically from 1 to 6 s as a function of increasing ray turning depths for ray paths that are parallel to Earth's spin axis. Rays perpendicular to the spin axis typically have slightly negative residuals. These observations suggest the outermost inner core is nearly isotropic and that strong anisotropy exists deeper in the inner core. We invert these times for models characterized by an outer isotropic layer and a deeper anisotropic layer separated by a transition zone with thickness varying from 0 to 150 km. Models determined by linear inversions using ray paths calculated from isotropic models can only adequately fit the observations if the isotropic layer is between 50 and 150 km thick. However, the strong gradients imposed by the anisotropic model force large deviations in ray paths, so a non-linear scheme with appropriate ray tracing is needed. Using anisotropic ray tracing we find that models with an isotropic layer ranging from 150 to 300 km thick all adequately fit the travel-time data. However, thick isotropic layers require correspondingly stronger anisotropy below. Finally, models with discontinuities and linear gradients up to 150 km thick cannot be distinguished by travel times alone. On the other hand, synthetic seismograms demonstrate that amplitudes of direct and reflected arrivals are very sensitive to the width of the transition zone. While there is some evidence for secondary arrivals in the seismograms, robust stacks of waveforms across regional arrays do not exhibit coherent arrivals, suggesting either that the transition is broad, or that sharp transitions are not coherent over large spatial scales.

S31B-03 0830h

Entire Array Observation of Near-vertical PKiKP: Observation of Sharp ICB, Sharp Inner Core Reflector/Discontinuity, and no ICS Signal

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Clear observation of near-vertical PKiKP is known for its rareness, preventing detailed seismological investigation of the top part of the inner core. We present an entire array observation of such near-vertical PKiKP from a recently deployed Japanese seismic network (Hi-net). The record section of an intermediate depth earthquake in Mariana (2001/01/07, Mw6.5) shows remarkably clear arrivals of PKiKP in an epicentral distance range of 14-24 degrees. From more than 170 individual picks of PKiKP, we could further perform array analysis of PKiKP related seismic phases with unprecedented high quality. Both PKiKP and PcP show strong similarity in waveform up to a frequency of 2 Hz, which suggests that ICB may be as sharp as CMB and no thicker than 2 km. Slant stacks for a 1-2 Hz frequency band where PKiKP and PcP show the peaked energy, SKiKP can be identified with the appropriate slowness. In this band where the background noise level is 2-3 % of PKiKP, however, no other conspicuous phase is identified except a slight indication of pPKiKP; thus the inner core appears highly transparent in this frequency range. In the lower frequency band of 0.5-1.0 Hz, on the other hand, the slant stack for the PKiKP slowness contains two clear signals (above four standard deviations) at about 75 and 85 seconds after PKiKP. The former phase is likely to be pPKiKP. The later phase, which is about 20 % larger in amplitude, could be identified as a pPKiKP crustal reverberation phase, but the amplitude appears too large; further, no corresponding phase is seen in PcP stack while pPcP is seen at 75 sec after PcP. It is then possible to interpret this phase as a reflection from a slightly dipping discontinuity inside of the inner core at a depth of 470 km below ICB. The reflection coefficient (half of the impedance contrast) should be about $3 \pm 1\%$, and the transition thickness is about 5 km. The reflection points are located in the so-called "eastern hemisphere" of the inner core where a relatively thick (∼400 km) outer isotropic layer have been observed. Geophysical consequence of such sharp ICB and a sharp inner core discontinuity, as well as the apparent lack of ICS (inner core scattering), will be further discussed.

S31B-04 0845h

Near-antipodal PKPdf observations from the Trans-Antarctic Mountains Seismic Experiment (TAMSEIS): Constraints on inner-core anisotropy from a seismic deployment in Antarctica

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The Trans-Antarctic Mountains Seismic Experiment (TAMSEIS), a temporary deployment of broadband seismographs in Antarctica, offers a unique opportunity to observe nearly antipodal PKPdf phases propagating sub-parallel to the axis of inner core anisotropy. Such phases are highly important for understanding inner core anisotropy but are rare in the global dataset. The 43 seismographs extend from the Ross Island region (-75, 163) to the East Antarctic Plateau (-82, 102) and, together with the South Pole station, provide a wide region of high latitude coverage. The seismographs were deployed in November, 2001 and will be recovered in December, 2003. Noise characteristics of the stations are good, as indicated by high quality recording of small events from the Arctic ridge, and reliability is generally excellent from November through March. An Arctic Ridge earthquake (Dec 8, 2001, Mw 5.2) was well observed at distances of 169 to 176 degrees. PKPdf anomalies relative to IASPEI91, determined by waveform correlation, range from about -4.3 s to -6.0 s, and PKPdf-ab anomalies range from -4.0 to -6.4 s. PKPdf-ab anomalies show a stronger correlation with df anomalies rather than ab anomalies, suggesting that the signal in the differential anomalies is largely accumulated along the df path. Both the PKPdf and the PKPdf-ab anomalies show a trend towards larger anomalies for smaller ray angles (relative to the earth's spin axis) in the inner core. This trend suggests strong anisotropy near the center of the inner core and is inconsistent with recent models for inner core anisotropy that contain an innermost inner core of reduced anisotropy or different fast axis orientation. Alternatively, the observed travel time variations could be caused by strong inner core heterogeneity. Several other events are well observed at distances of 148-156 degrees. These waveforms show no evidence of a secondary df phase arrival previously observed on different polar paths and used to infer a discontinuity in the uppermost inner core. Instead, PKPdf arrivals at all distances seem to show high intrinsic attenuation.

S31B-05 0900h

On PKiKP Recorded at Short Distance on the Warramunga Array and the High Frequency PKiKP Coda

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PKiKP is the P-wave reflected on the inner core boundary (ICB). PKiKP is frequently observed on the Warramunga seismic array in Australia for events of magnitude larger than 6 in the distance range 15-45 degrees. In the frame of the Comprehensive Test Ban Treaty, the Warramunga array has been upgraded with a high dynamic range (24 bits) recording system and broadband sensors. This improvement permits to detect PKiKP on single traces, without stacking. PKiKP is a sharp arrival in the frequency band 2 Hz to 5 Hz. Its waveform is sometimes showing some complexity: it can be preceded by a small onset or can exhibit double or triple pulses, not observed on PcP. In this frequency band, the amplitude of PKiKP is larger than the event's coda. The coda of PKiKP is quickly decreasing within the first 20 seconds. We do not observe the slow (60 s.) building up of amplitude in the PKiKP coda observed by Vidale et Earle (2000) on LASA data which lead them to infer strong kilometer-scale heterogeneites beneath the ICB. We filter the signal in 5 different bandpasses. In each bandpass, we compute the average of the maxima of the 24 traces in successive 2 seconds moving windows. This simple processing exhibits the decay of the coda as a function of time and frequency along the entire seismogram. For reflected phases like PcP or ScP, usually the coda decreases rapidly after the phase arrival time and returns to its level before the arrival of the phase. For the S phase, the amplitude of the coda remains higher after the S arrival time than before: a coda offset is generated at the time of S. The same occurs for PKiKP. PKiKP is followed by a coda with an amplitude about half that of PKiKP, predominantly in the frequency range 3 Hz -6 Hz. This high frequency PKiKP coda seems to ring for a very long duration. Unfortunately, for the events of magnitude 6-7 available, the sensitivity level of the recording system is reached near 1200-1300 s and the coda amplitude becomes smaller than the recorder intrinsic noise level. The amplitude of the coda increases later, around 1800 s, due to PKKP scattering. The ICB seems to be a complex interface which (1) reflects high frequency PKiKP, (2) transmits low frequency PKIKP and (3) generates a high frequency PKiKP coda lasting more than 200 seconds. We present an hypothetical velocity model that may behave like the ICB and attempt to relate it to the mechanism of growth of the inner core.

S31B-06 0915h

New Evidence for Inner Core Scattering from Observations of PKiKP Coda

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The existence of small-wavelength scatterers in Earth's inner core has been suggested based on the frequency dependence of inner core Q, and as a partial explanation for PKP and PKKP precursors. However, recent observations of anomalously large PKiKP coda waves have provided the first direct seismic evidence of inner core scatterering (ICS). There is no consensus on the physical nature of the proposed scatterers, though possibilities include the presence of partial melt and variations in the strength and orientation of anisotropy. We have recently begun a search for evidence of ICS using PKiKP data from the small aperture array stations of the International Monitoring System. These stations generally have poorer slowness resolution than LASA (the now defunct array at which the original ICS observations were made), but are small enough that high frequency energy remains coherent across the array and can be substantially enhanced through beamforming. We selected events having favorable focal mechanisms and occurring in the distance range of 50-90 degrees, where the theoretical PKiKP amplitude is very small. We processed the data in four overlapping frequency bands using a sliding window, time domain, beamforming algorithm that uses a coherency measure as a weighting factor. Out of 260 viable event/receiver combinations, 52 were positive for an anomalously large PKiKP coda, an additional 26 were inconclusive, and the remainder were negative. The majority of the positive observations had a maximum coda amplitude quite close to the theoretical PKiKP arrival time. In these cases it is unclear if the coda is being created by scatterers within the inner core, or by scatterers within the crust and mantle acting on an unusually large PKiKP phase. However, in approximately 15 cases the maximum of the PKiKP coda occurred 20-60 s after the predicted PKiKP arrival, strongly suggesting an origin in the inner core.

URL: http://mnw.eas.slu.edu/People/KKoper/CORE/

S

S31B-07 0930h

Examination of systematic mislocation of south sandwich islands earthquakes from station pairs: Implications for inner core rotation

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One of the most robust observations for the inner core rotation is that the differential PKP BC-DF travel times from South Sandwich Islands (SSI) earthquakes to College, Alaska (and some other stations in Alaska) have increased systematically over the past 50 years. The time shift in the differential time residuals is about 0.12 s per decade. However, the time-dependence was questioned because of possible systematic earthquake mislocation. Here we examine about 40 years of P arrival times between pairs of stations. We examine how the difference in P residuals of one station at similar azimuth as the path from SSI earthquakes to Alaska and the other station at the opposite azimuth changes with time. Because the differential horizontal slowness between the P arrival times of the pairs is 10 to 20 times that of the differential BC-DF times, mislocation would cause a time shift of the differential P times an order of magnitude larger than that of BC-DF times.

Our preliminary results from time picks of earthquake bulletins suggest that most of the station pairs have a a very small increase of differential P residuals with time and some station pairs have a decrease of residuals with time. After removing all the means of the residuals of different station pairs, the combined data suggest an increase of 0.1 to 0.2 s per decade. Assuming the time shift is caused by mislocation, the corresponding time shift for the differential BC-DF times at Alaska stations would be less than 0.02 s per decade, which is much less than the observed time shift of the BC-DF times. We have also collected P waveforms of a selected few stations. Results from the precise time picks of these stations will be presented.

S31B-08 0945h

Three-dimensional structure of inner core anisotropy from PKP differential travel times and waveforms

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Discussion with Prof. Don Anderson was one of the most inspiring and stimulating experiences in my science career when we were searching for evidence for inner core anisotropy a little over ten years ago. At the time, the hypothesis of inner core anisotropy was not fully accepted. Now models of 3D inner core anisotropy have been proposed. Recent studies suggest that the uppermost inner core is nearly isotropic and western and eastern hemispheres of the inner core are different in both velocity and anisotropy. Yet differential PKP travel times at near antipodal distances show convincingly that significant anisotropy exists in the bulk of the inner core at both hemispheres. Recently Xinlei Sun and I assemble differential PKP travel-time measurements at distances of 145 to 180^{o}, obtained by us and others over the years, to investigate the 3-D structure of the inner core anisotropy. These differential times reduces the biases from earthquake mislocations and heterogeneous upper mantle. We invert for 3D inner core anisotropy by dividing the inner core into four layers in radius and six sectors in longitudes. The top 100 km of the inner core is assumed to be isotropic. Our inversion suggests that at depth of 100-500 km below the inner core boundary, the quasi-eastern hemisphere (40 to 160^{o}E) is nearly isotropic (less than 1% of anisotropy) while the western hemisphere is strongly anisotropic (3 to 5% anisotropy). However, at depth of 500-900 km, both hemispheres are anisotropic (about 3% anisotropy). At the innermost 300 km of the inner core, the form of anisotropy seems distinctly different. One of the most dramatic manifestations of changes in anisotropy is the observation of seismic triplication of inner core waves; a type of multipathing effect due to heterogeneity that Don challenged to think about even in the early days. The best example is the seismic triplication observed from South Sandwich Islands earthquakes recorded at stations in Canada and Alaska.

S31C MCC: Level 2 Wednesday 0830h

Splitting and Anisotropy I Posters

(joint with T, MR)

Presiding: **M D Long,** Massachusetts Institute of Technology**; D L Schutt,** University of Wyoming

S31C-0779 0830h POSTER

Shear-wave polarization anisotropy in the mantle wedge beneath the southern part of Tohoku, Japan

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We investigated shear-wave polarization anisotropy in the mantle wedge beneath the southern part of Tohoku, Japan, by using waveform data of intermediate depth earthquakes with M>2.5 recorded by the seismic networks of Tohoku University and Japan Meteorological Agency (JMA). We selected waveform data with ray paths whose incident angles to the surface are 35 degrees or less to avoid contamination of particle motions by converted phases. All the seismograms thus selected were filtered with bandpassed ranges of 2-8 Hz. Cross-correlation method [Ando et al., 1983] was used for determining delay time between the leading and following shear-waves (delay time) and the leading shear-wave polarization direction (fast direction). Two horizontal components of observed seismograms were rotated with the direction from 0 to 180 degrees with an interval of 5 degrees, and shifted one horizontal component by a time lag. The time lag varied from 0 to 1 s with an interval of 0.01 s. The length of time window used to calculate correlation coefficient was set to be nearly equal to one cycle of the shear-wave. We do not use the data whose maximum correlation coefficient is less than 0.8. Obtained results show that most of the fast directions at stations in the back-arc side are nearly E-W, whereas those at stations in the fore-arc side are N-S. We infer that the anisotropy caused by lattice-preferred orientation of olivine, which is probably produced by flow in the mantle wedge, is a likely candidate for the observed shear-wave splitting with E-W trend fast directions in the back-arc side. Although it is not certain what causes the N-S trend fast directions in the for-arc side, the same trend is seen in the previous studies of other areas in Tohoku [Okada et al.,1995; Nakajima, 2002]. Observed delay times are mostly 0.1-0.3 s, which is consistent with the results of Okada et al. [1995] and Nakajima [2002]. Acknowledgments: We are grateful to the staff of the JMA for allowing us to use their data.

S31C-0780 0830h POSTER

Array Averaged Particle Motion and Polarization for Southern California

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We measure array-averaged particle motion and polarization for teleseismic P-waves within the large aperture (∼ 70 km) Anza Broadband Array (http://eqinfo.ucsd.edu). Using three component Anza seismic data and a multi-wavelet method developed by *Bear, et al.*, we compare our results to *Schulte-Pelkum, et al.* more traditional cross correlation techniques. The applied multi-wavelet technique, a hybrid of Fourier and time-domain principal component methods yields insights into the relationships between phase velocity (i.e. the slowness vector) and particle motion which are not as attainable from traditional techniques. As seen in previous studies, we expect to find longitudinal departures in P wave particle motion due to regional anisotropy. Examination of thirteen events (5.1< Mb <6.1) yields comparable particle deviations for both methods, yet significant differences exist in frequency dependence of these events.

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Rayleigh wave phase velocities, shear wave structure and azimuthal anisotropy beneath southern California

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We use normal mode Rayleigh wave phase and amplitude data recorded at the TriNet network in southern California to invert for phase velocities at periods from 25 to 143 s. These phase velocities were used to obtain 3-D S-wave velocity structure in the upper mantle. Phase velocities on the Pacific plate side of the plate boundary are systematically higher than on the North American side, suggesting that seismic velocity contrast between these two plates extends to the upper mantle. In the upper mantle, there is a pronounced low velocity anomaly beneath the Long Valley/Mono Lake region, which has not been observed by previous tomographic studies. This low velocity anomaly is consistent with melting extending to the base of the crust beneath this part of the western Basin and Range province, as suggested based on the composition of late Cenozoic basalts (Wang et al., JGT, 2002). There is a high velocity anomaly under the Transverse Range and a slightly slow velocity anomaly under the Salton Trough, both of which have been observed in previous body and/or surface wave tomographic studies. Assuming uniform anisotropic structure in the whole study area, the strength of anisotropy is about 2.5% at all periods. However, the fast direction varies with period. The fast direction of apparent anisotropy is nearly W-E at periods less than 50 s, consistent with the fast polarization axis of SKS splitting measurements in Southern California. At periods larger than 67s, the fast direction changes to NW-SE, subparallel to the plate boundary. This two-layer azimuthal anisotropy structure is in contrast to the one-layer SKS splitting model for southern California, implying that lateral heterogeneity may affect the apparent anisotropy of long-period surface waves. If anisotropy is allowed to vary laterally in our models, we find a minimum in azimuthal anisotropy in the vicinity of the Transverse Range, suggesting possible more vertical alignment of the olivine a-axis in a region of downwelling.

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Mantle Anisotropy Beneath the Alaska Range Inferred From S-wave Splitting Observations: Results From BEAAR

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The tectonics of southern and central Alaska are dominated by the subduction of the Pacific plate beneath the North American plate. The Broadband seismic Experiment Across the Alaska Range (BEAAR) was a 2.5-year PASSCAL deployment utilizing 36 closely spaced (10-15 km) broadband sensors. These instruments were deployed across the Alaska Range and above the subducting Pacific plate in roughly north-south and east-west lines. Much of the study region is underlain by a mantle wedge, which gradually pinches out at the southernmost stations. The depth of the subducting slab increases to the northwest with the deepest earthquakes occurring at 150 km, just north of the Alaska Range. Teleseismic SKS and S phases, in addition to S waves from local earthquakes in the subducting plate, were used to study the anisotropic behavior of the upper mantle in central Alaska. Two distinct regions of anisotropy are observed, reflecting both flow in the direction of plate convergence and flow parallel to the strike of the subducting plate. The transition between these two zones appears to be very sharp occurring near the 70-75 km contour of the subducting plate. Waves arriving through material southeast of this line (through the shallow corner of the mantle wedge) show fast directions that are parallel to the plate convergence direction. North of the 70-75 km slab contour the fast directions abruptly change orientation to roughly parallel the strike to the subducting plate. This direction is also parallel to the trend of several major tectonic features in the area, including the Alaska Range, and the right-lateral strike slip Denali and Tintina faults. Stations that are located above the 70-75 km contour of the subducting Pacific plate show characteristics of both regions, depending on the back azimuth of the arrivals. These observations set strong constraints on the location of the transition zone between the two regions. While teleseismic observations may represent anisotropy (or flow) in the mantle wedge, in the subducting Pacific plate, or beneath the subducting plate, observations from local slab events indicate that a significant portion of the signal comes from the mantle wedge and that the sharp change in direction is a feature of the mantle wedge.

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Variations in S-Wave Splitting Across an Array in the Fore-arc Region of the Hikurangi Subduction Zone, New Zealand

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