

regional, and teleseismic events over a 9 month period. We have obtained first group data already. The regional broadband array will be used to provide important constraints on the stress field in the crust (earthquake locations and source characteristics), the depth to Moho beneath eastern Tibet (receiver functions and high-frequency surface wave dispersion), the presence of absence of a weak lower crustal layer (propagation speed and attenuation of seismic waves), the level of the mechanical coupling between crust and mantle (tomographic imaging and seismic anisotropy), and the presence of lithosphere scale faults and the off set across them.

### S33B-07 1330h POSTER

#### A Crustal Fluid Based Interpretation of the Frequency Dependent Shear Wave Attenuation Observed in the Lithosphere Beneath the Kanto Area, Japan.

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Seismic attenuation measurements in the band 0.01 - 10 Hz have now been reported for a large number of tectonic areas. For tectonically active regions, the measured attenuation appears higher and more frequency-dependent than for passive regions. It has been hypothesized that such an observation reflects the presence of a high density of fluid-saturated fractures along the paths of the seismic waves used to estimate the attenuation. In order to quantitatively test this hypothesis, both a seismic attenuation data set that spans a large band of frequencies and a quantitative seismic absorption model that involves fluids are needed. This hypothesis is tested here using the set of shear-wave attenuation data reported for the Kanto Area, which shows a clear maximum in attenuation near one Hz, and the squeeze-flow mechanism model (i.e. squirt-flow adapted to the field-based fracture-porosity scale and crustal hydraulic attributes), which predicts well-defined attenuation maxima. The modelling results show that the squeezing of fracture-bound saline fluid produces shear-wave Q values that match the magnitude and frequency dependence of the data-inferred shear-wave Qs. In particular, the depth-distribution of squeeze-flow Qs for the sampled area shows a zone of very high absorption and pronounced frequency dependence that correlates well with a zone of impedance contrast imaged via body wave tomographs reported for the same area. Thus, the squeeze-flow mechanism supports the hypothesis that viscous flow of crustal fluids effectively attenuates high-frequency seismic waves in the crust and so suggests a cause for the shear-wave Q versus frequency trend observed in the Kanto area.

### S33B-08 1330h POSTER

#### Constraints on the Shallow Velocity Structure from Wide-Angle P/S mode Conversions in the First Arrivals: Application to ACCRETE Data

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P/S mode conversions identified in the first arrivals could provide valuable information about S-wave velocity contrasts within the shallow subsurface. Near-receiver P/S conversions are routinely employed to constrain the crustal thickness in teleseismic seismology, in a technique known as receiver functions. Recently, Morozov et al. (2002) applied this method to recordings from an ultra-long-range refraction profile in Northern Eurasia and showed that travel-time lags between the direct P- and converted P/S waves could be utilized to map the thickness of the sediments along the profile. However, in wide-angle crustal, as well as in exploration seismology, mode conversions in the first-arrival coda has still not been utilized. In this study, we use the P/S phases to constrain the shallow subsurface in the records from a crustal ACCRETE profile acquired in 1994 across the Coast Plutonic Complex in SE Alaska and Coastal British Columbia. The dataset included 1700 km of marine multichannel profiling in BC fjords that were also recorded by 60 three-component Reftek seismographs deployed at 3-5 km spacing on land. To date, this dataset provides some of the best-quality S-wave recordings, including consistent reflections and conversions from the Moho. Three-component particle motion analysis and receiver-function-type deconvolution reveal P/S mode conversions in the first arrivals in almost all the receiver gathers. Particle motion changes from linear (primary P-wave) to circularly-polarized transverse (P/S converted mode) within 100-200 ms milliseconds of the first arrivals. The delay between the P/S and P waves is independent of shot

locations and is indicative of a P/S conversion on S-wave velocity contrasts near the receiver. The locations of these contrasts were estimated from the time delay and polarization of the P/S waves. These results suggest that in the ACCRETE area, mode conversions take place on the sediment-basement contact. Therefore, identification of mode conversions in the coda of the first arrivals helps constraining the shallow near-receiver structure. In future experiments with dense three-component recording, this technique could provide a valuable tool for mapping the three-dimensional shallow subsurface using remote seismic sources.

### S33B-09 1330h POSTER

#### Study of recent seismic activity in the basin and transform faults of the Gulf of California

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Deployment of broad-band seismic stations around the Gulf of California since 2002 have greatly improved the location of small to medium size earthquakes. This is the result of a joint project between CICESE, Utrecht University and Caltech. This network consists of the RESBAN-CICESE network (eight broad band stations and five short period stations) and the NARS-Baja network from the Utrecht University (thirteen broad-band stations). For example, an earthquake of magnitude 5.6 occurred on November 12, 2003 and it was located east of the Bahía de los Angeles town at 29.034° Latitude North and 113.251° Longitude West, over the North Salsipuedes Basin. Fault geometry was obtained with the body waveform modeling using Herrmann (1987) reflectivity code. A preliminary fault geometry with a strike of 320°, a dip of 70°, a slip of -100° and a focal depth of 5 km was calculated. Seismic station BAHB located at about 22 km west of the epicenter showed a clear triangular source time function of 4.5 seconds. Over the southern end of the Gulf of California occurred bursts of earthquake activity on January 13 and 14, 2004 with events in the magnitude range from 3.5 to 4.4 over the Pescadero Basin at the average geographic coordinates of 24.634° ± 0.011° Latitude North and 109.296° ± 0.10° Longitude West. Again on February 9, 2004 another earthquake swarms occurred with events in the magnitude range from 4.0 to 5.3. Preliminary locations of the events indicated that the events are located in the Pescadero Basin. Focal depths of the earthquakes are uncertain. We will show the best-located events that we have been able to locate with the RESBAN-NARS-Baja network of the Gulf of California.

### S33B-10 1330h POSTER

#### A Synthesis of Anisotropy Measurements in New Zealand

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New Zealand (NZ) straddles the boundary between the Australian and Pacific plates; a large number of recent anisotropy studies there allows us to gain insights into processes of plate boundary deformation. The tectonics of the north island of NZ is dominated by oblique subduction at the Hikurangi margin, which gives way to transpression along the Alpine fault in the south island. In the southernmost south island there is a transition to oblique subduction again (Puysegur subduction zone). The fast directions obtained from shear wave splitting of teleseismic phases (such as SKS) are remarkably consistent throughout the variety of tectonic regimes in NZ. In the north island, trench parallel fast directions are found both above and below the slab, suggesting trench parallel asthenospheric flow in both these regions. Anisotropy in the lithosphere is likely to be due to shear deformation. Throughout the south island, the fast directions from Pn and teleseismic phases are sub-parallel to the Alpine Fault, suggesting widespread (at least as wide as the south island) shear deformation of the underlying mantle. Results from local phases suggest that in the crust and uppermost mantle, the shear zone is narrower than in the deeper mantle. Throughout much of NZ fast directions measured from both local and teleseismic phases are sub-parallel to the geological features. This suggests that the crust and mantle deform coherently and that there is vertical coupling. However, there are variations in some locations in the

fast directions obtained using local phases, probably reflecting shallow structure. The teleseismic delay times in NZ are amongst some of the highest in the world. Results from local phases suggest that anisotropy exists to at least 200 km depth throughout much of NZ. Petrophysical analysis of mantle xenoliths suggests that for the north island a significant portion of the anisotropy must reside in the asthenosphere. Many regions have been studied in detail and show a departure from the general observations above. Preliminary results from the tip of the north island show little splitting. The Central Volcanic Region (CVR) in the north island is a zone of active back arc extension. In the western CVR fast directions from local phases are perpendicular to the trench, suggesting asthenospheric flow in the extension direction. In the eastern CVR there is a mixture of fast directions, suggesting a transition between the western CVR and trench parallel fast directions further east. There is also a back azimuthal dependence from teleseismic phases. At Mt Ruapehu (southernmost CVR) temporal changes in anisotropy appear to be related to a volcanic eruption, which could eventually lead to an eruption monitoring tool. In the lower north island lateral variations in anisotropy are measured with teleseismic S and ScS phases. A large number of splitting measurements at the permanent station SNZO in Wellington show significant variations with propagation and incoming polarization directions, as well as waveform frequency. This suggests that the anisotropic structure here is complicated. The northern south island (Marlborough region) is a transition between subduction and oblique transform faulting; here the shallow anisotropy is attributed to a thick layer of subducted crust (metamorphosed schist). In southernmost NZ the fast directions are not fault parallel, but are consistent with crustal strain extension directions. However, the smaller strain in this region is not consistent with the delay times. The Puysegur subduction zone could also be affecting the splitting measurements in this region.

### S43A CC: 516 D Thursday 1330h

#### Seismology From Crust to Core: The Science of the Global Seismographic Network I (joint with G, T)

**Presiding: L Wen**, State University of New York at Stony Brook; **J Park**, Yale University

### S43A-01 1335h

#### Earth Noise: A survey of the Global Sesimographic Network stations

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The IRIS Global Seismographic Network (GSN) consists of widely distributed, similarly equipped, and well-calibrated stations. Using data from the 118 GSN stations operating during the year July 2001 through June 2002, we have made over 738,000 hourly spectral estimates of the observed ground motion in seventh-decade (approximately half-octave) bands for periods between 1000 and 0.07 seconds. From these estimates we have developed a robust earth noise model and characterized the performance of the network. We note the differences in vertical and horizontal component of the noise and in the performance of the 4 models of seismometers used in the network. In addition to the well known microseismic noise peaks, at many stations there is an additional peak at about 125 seconds. At longer periods, the vertical component of earth noise is considerably quieter than previously reported. Indeed, these lowest noise levels can only be observed on one of the GSN sensors - the STS-1.

## S43A-02 1350h INVITED

## Discovering earthquakes and other phenomena with the GSN

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With more than 100 well-distributed stations, the Global Seismographic Network (GSN) provides a continuous record of broadband ground motion of the Earth's surface. Data from many GSN stations are routinely used for traditional high-frequency detection and location of earthquakes, but research using GSN data has until recently been focused almost exclusively on the analysis of seismograms from known events for the determination of detailed earthquake characteristics or Earth structure. The potential for signal monitoring and event discovery using the broadband signals of the GSN is only now starting to be realized. Over the last two years, we have developed a technique to use the GSN as a global, steerable array to search for localized sources of intermediate-period (40–150 s) Rayleigh waves. We use a method of surface-wave cross correlation and stacking to search for seismic events using archived and near-real-time data from the GSN. Given a test location, seismograms are corrected for propagation effects to each station in the network. The envelopes of the resulting waveforms are stacked and cross correlated with a model wavelet to determine a detection. Maximizing the cross correlation as a function of latitude and longitude leads to the determination of an origin time and location. The method detects nearly all standard earthquakes with magnitudes greater than 5. In addition, we regularly find 10–15 M=5 events each month that are not listed in standard earthquake catalogs (PDE, ISC, REB). Among these unassociated events, we have identified a new class of seismic events that involve the sudden sliding motion of glaciers. These events appear to have a characteristic duration of tens of seconds, and we infer that they involve the displacement of several cubic kilometers of ice by several meters. During a period of 10 years, we have found more than 100 M=5 glacial earthquakes on Greenland. We have also found approximately 10 events of this type in Antarctica and Alaska. Many other unassociated events await analysis and interpretation. Results from our real-time search for seismic events can be found on our web site, [www.seismology.harvard.edu](http://www.seismology.harvard.edu).

## S43A-03 1410h INVITED

## Identification of the fault planes of deep earthquakes from analysis of source finiteness

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One of the basic issues regarding the physical mechanism for deep earthquakes is the extent to which they occur on pre-existing faults: Do deep earthquakes reactivate faults that formed in the oceanic plate prior to subduction? A previous study of the Tonga subduction zone (Jiao et al, 2000) compared nodal plane distributions between outer-rise events to events as deep as 450 km depth, and found them to be very similar. While this comparison provides some support for the pre-existing fault hypothesis, a more stringent test of the hypothesis is available by identifying the actual rupture planes of these events. We are developing the methodology to perform such a test based on the detection of source finiteness. First, we examine rupture directivity with long-period *P* waves. For earthquakes with primarily unilateral rupture, the pulse width will vary depending on the angle between the rupture direction and the takeoff vector to the station. For 66 large, globally-distributed earthquakes recorded by the GSN between 1993 and 2000, we estimate variations in pulse width over the focal sphere from differences in frequency content at different stations. We use these pulse-width estimates to determine the best-fitting rupture direction and to identify which nodal plane of the Harvard CMT solution is most consistent with this rupture direction. In about 40% of the cases, one of the two nodal planes produces a much better fit to the data and can be identified as the true fault plane. Our second approach to studying source finiteness is to identify and locate subevents using broadband *P* waveforms. This allows us to detect source finiteness even

for events that are not characterized by unilateral rupture, and to analyze a larger catalog of smaller, shallower events. We seek to apply these two approaches, augmented by the observation of aftershocks, to determine the distribution of rupture-plane orientations of deep- and outer-rise seismicity for the Tonga subduction zone.

## S43A-04 1430h

## The Global Seismographic Network and the Earth's Inner Core

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The Global Seismographic Network (GSN) has been providing high-quality open-access broad-band seismic data to the scientific community since its establishment in 1986 by the Incorporated Research Institutions for Seismology (IRIS). The accumulation of the GSN data has led to many discoveries of unique features of the Earth's inner core. Among them are the hemisphericity of seismic velocity and attenuation, and the correlation of high velocity with high attenuation in the top of the inner core. In this presentation, we present recent results of the seismic velocity and attenuation structures for the top 400 km of the inner core along the equatorial path using the GSN data. Our datasets consist of differential travel times and waveforms of the PKIKP-PKIKP phases observed at the epicentral distance range of 120°-141° and the PKPbc-PKIKP phases observed at 146°-159°. The observations show these characteristics: (1) both the observed PKIKP-PKIKP and PKPbc-PKIKP differential travel times exhibit a clear "east-west" hemispheric pattern. PKIKP phases arrive about 0.7 second earlier for those sampling the "eastern" hemisphere (40°E-180°E) than those sampling the "western" hemisphere (180°W-40°E); (2) amplitude ratios of the PKIKP/PKIKP phases observed at the distance range of 131°-141° and the PKIKP/PKIPbc phases observed at 146°-151° are in general smaller for the PKIKP phases sampling the eastern hemisphere than those sampling the western hemisphere. At distances larger than 151°, the observed PKIKP/PKIPbc amplitude ratios are indistinguishable between the two hemispheres; (3) PKIKP phases sampling the eastern hemisphere bifurcate at smaller epicentral distances for those sampling the eastern hemisphere. These observations can be explained by two different types of seismic velocity and attenuation models for the two hemispheres of the inner core. For the eastern hemisphere, the velocity model has a *P* velocity increase of 0.748 (km/sec) across the inner core boundary and a flat velocity gradient of 0.0042 (km/sec)/100 km in the top 235 km, followed by a gradual velocity transition of 0.1 (km/sec)/100 km extending from 235 km to 375 km and the PREM velocity gradient in the deeper portion; the attenuation model has an average *Q* value of 250 in the top 300 km followed by an average *Q* value of 600 in the deeper portion. For the western hemisphere, the velocity model has a *P* velocity increase of 0.645 (km/sec) across the inner core boundary and a velocity gradient of 0.049 (km/sec)/100 km in the top 375 km, followed by the PREM value in the deeper portion; the attenuation model has an average *Q* value of 600 in the top 400 km of the inner core. The top portion of the inner core in the eastern hemisphere is anomalous, in having a flat velocity gradient, high velocity and high attenuation. Our models also suggest that the hemispheric variation in seismic velocity possibly extends deeper than 375 km below the inner core boundary. We will discuss possible interpretations and implications of these seismic results.

URL: <http://geophysics.geo.sunysb.edu/wen/>

## S43A-05 1445h

## 3D Whole-Mantle Velocity and Quality Factor

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We present seismic inversions for 3-D whole-mantle velocity and quality factor (*Q*) with the same spatial resolutions in order to better characterize anomalous seismic structures. By analyzing both the elastic and

anelastic properties of a medium, we may better characterize anomalies as chemical, thermal, phase change, or mechanical. Using over 70,000 differential measurements of travel time and attenuation between SS-S, ScS-S, SKS-S, sScS-sS, and sSS-sS, and ScS-SS, as well as over 30,000 absolute *S* arrival time and attenuation measurements, we invert for velocity and quality factor with similar spatial resolutions. These inversions produce a model, VQ3DA, that provides a first look at 3D whole-mantle quality factor as it affects shear body waves on a global scale. Using both radial and tangential measurements, we are able to measure anisotropy for both velocity and quality factor. We characterize regions within the Earth as having anomalous high-*Q* and high-*V*, high-*Q* and low-*V*, low-*Q* and low-*V*, and low-*Q* and high-*V*. We then correlate anisotropy with each of these four categories to explain some possible dynamic processes responsible for or resultant from the anomalies. To first order there is excellent agreement between quality factor and velocity throughout the mantle. Interestingly, there is also a strong agreement between velocity anisotropy and attenuation anisotropy. Subduction zones and spreading ridges are the predominant features observed in the model. Nevertheless, smaller second-order anomalies are also resolvable. The quality factor models agree with upper mantle models inverted from *P*-wave and *PP*-wave attenuation, normal mode, and surface wave attenuation. Similarly, the velocity model agrees well with recent models such as S16U6L8. This study shows that resolvable 3-D quality factor anomalies extend into the lowermost mantle.

URL: <http://epsc.wustl.edu/seismology/jfisher/>

## S44A CC: 516 D Thursday 1530h

## Seismology From Crust to Core: The Science of the Global Seismographic Network II (joint with G, T)

Presiding: L Wen, State University of New York at Stony Brook; J Park, Yale University

## S44A-01 1530h

## The IRIS Data Management Center: Providing Efficient Access to GSN data

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The IRIS Data Management Center (DMC) in Seattle, Washington is the host of the largest seismological database of its kind in the world. The Global Seismic Network (GSN) lies at the center of the DMC holdings. The DMC relies heavily upon a petabyte mass storage system for waveform storage and Oracle for its relational data base infrastructure. During the past several years, emphasis has been placed upon the development and implementation of robust and effective technologies that allow access to the information at the IRIS DMC in a variety of ways. This talk will highlight the general structure of the IRIS DMC and the method we use to manage the gigabytes of information in Oracle as well more than 100 terabytes of time series data we have in our mass storage systems. An overview will be given of the methods through which users can access the information in our relational database systems as well as the mass storage systems in order to conduct their research using GSN and other data. A discussion of three distinctly different approaches will be presented. These include an email-based method, a web-based method as well as a multi-tier distributed computing environment we call the Data Handling Interface (DHI). The DHI is based upon Common Object Request Broker Architecture (CORBA) and provides direct connections between client applications, normally provided by IRIS, and data center servers established at several data centers within the United States. The DHI presently supports the distribution of information about seismic events, information about the seismic stations that record the time series and finally the time series (seismograms) themselves. The system is capable of transmitting seismic waveform data in real time. Waveform data and all associated metadata are available through this interface allowing direct access to information at the DMC within client applications running on a users workstation.

URL: <http://www.iris.edu/>