S51B CC: 220 C-E Friday 0830h

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

Presiding: **J F Lawrence,** Washington University**; V Levin,** Rutgers University

S51B-01 0830h POSTER

Tomographic Images Of The Witwatersrand Basin Structure Using First P-Wave Arrival Times From Local, Regional And Mining - Induced Events

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Three-dimensional structure of first P wavespeeds of the crust beneath the Witwatersrand basin (22.75° 29.25°S, 23.50° 29.50° E) down to the depth of 28 km has been derived using the tomographic inversion method of Zhao et al. (1992a). The tomographic images presented in this study are based on 1225 first P-wave arrival time observations from 91 events recorded by 25 out of the 84 stations of the 1997-1999 Southern African Broadband Seismic Experiment. The tomograms at 0, 18 and 28 depths all indicate that the area around the Witwatersrand basin is underlain by high and low wavespeed anomalies that appear to the associated with the Vredefort impact structure. With a grid spacing about 0.66° x 0.80°, horizontal profiles at depths 0 and 18 km show a large north-east facing crescent-shaped high wavespeed anomaly between about 24.0°S 29.0°S and 25.0°E 28.0°E, in juxtaposition with a large north-concave low wavespeed anomaly located between about 25.0°S 28.0°S and 26.0°E 29.5°E. The crescent-shaped positive anomaly coincides with the western edge of the Witwatersrand basin. Furthermore, the tomograms at 0 and 18 km depths indicate a homogeneous crust relative to the tomograms at 28 km depth. These results show that complexity of the crust increases with depth. Receiver functions indicate an increase in crustal thickness from about 40 to 50 km in the northern part of the study region. This information is being used to construct tomograms in which both variation in crustal thickness and wavespeeds in the lower crust are allowed.

S51B-02 0830h POSTER

New observations of Q quality factors of a few gravest normal modes from superconducting gravimeters of the Global Geodynamics Project (GGP)

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The high quality of the GGP superconducting gravimeters contributes to the clear observation of seismic normal modes at frequencies lower than 1mHz and offers a good opportunity for studying the behaviour of these modes. The interest of scientists for the gravest normal modes is due to the fact that these modes do contribute to a better knowledge of the density profile in the Earth, helping to constrain Earth's models. These modes have been clearly identified after some large recent events recorded on superconducting gravimeters. The Peruvian earthquake of June 2001 provided us with individual spectra (in a unique station) with a clear splitting of the fundamental mode 0S2 and identification of each of the five individual singlets, with a resolution never obtained from broadband seismometers records. The Q quality factors have been determined from the apparent decrease of the amplitude of each singlet with time, according to a well suited technique (Roult and Clevede, 2000). The results are compared to the theoretical frequencies and Q quality factors computed in the PREM model, taking into account the rotation and the ellipticity of the Earth. The two datasets (frequencies and Q quality factors) exhibits a larger splitting on the observed values than on the predicted ones. That seems to point out that rotation and ellipticity don't explain the observations and that we have to take into account additional effects. A new dataset of Q quality factors of the gravest modes is under construction, including the 0S0 radial mode and the 2S1 mode recently identified by Rosat et al. (2003).

S51B-03 0830h POSTER

Surface-Wave Focal Mechanism, Velocity and Q Models of the 22 March 2003 Yellow-Sea Earthquake

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The Yellow-Sea earthquake event of 22 March 2003 was reported by the USGS as follows: mb = 4.8, Origin Time = 20:38:40.46, Latitude = 35.06N, Longitude = 124.41E. In this study, I will present the focal mechanism of this event, as well as the velocity and Q models from inversions. Corrected Love-wave and Rayleigh-wave amplitude data from 15 GSN stations (BJT, ENH, HIA, INCN, KMI, LSA, MAJO, MDJ, QIZ, SSE, TATO, ULN, WMQ, XAN, and YSS) were used in the search for focal mechanism employing the technique of Nguyen and Herrmann (1992, SRL). Eigenfunctions were computed from the average crustal model that was obtained by inversion from surface-wave group velocities of these stations. Surface-wave attenuation coefficients were obtained using the technique of Tsai and Aki (1969). The focal mechanism of this event has a nodal plane with dip= 75 deg, slip = 165 deg, and strike = 25 deg. P-wave first motions were used to constrain the nodal planes. The seismic moment obtained is 1.75E+23 dyne-cm. The source depth is 13 km. The average velocity and Q models obtained by inversions are respectively tabulated as follows: Layer Thickness (km), P(km/sec), S (km/sec), Density (g/cm3), Model Std Dev, Qa/Qb, Qb-1 Std Dev. 1st Layer: 3.00, 3.9825, 2.2993, 2.3169, 0.574, 421/187, 0.5426E-03. 2nd Layer: 9.00, 5.8373, 3.3702, 2.6675, 0.204, 443/197, 0.4348E-03. 3rd Layer: 24.00, 6.6402, 3.8337, 2.8865, 0.084, 550/244, 0.3397E-03. Half Space: 0.00, 7.6596, 4.2994, 3.1943, 0.335, 921/409, 0.5959E-03.

URL: http://home.cfl.rr.com/bao/AGU

S51B-04 0830h POSTER

QLM9: A new radial quality factor (Q) model for the mantle

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We inverted 30,000 ScS-S differential attenuation measurements for a spherically-averaged radial quality factor Q model. One major challenge facing studies of quality factor (Q) is that the low-Q upper mantle overpowers the high-Qm lower mantle signature. The ScS-S differential attenuation measurement reduces the effects of upper mantle quality factor on the attenuation measurement. Therefore the inversion has greater sensitivity to lower mantle quality factor than previous models. QLM9 differs from PREM and QL6 in several significant ways. First, the quality factor increases, on average, with depth through the lower mantle. Second, there are two quality factor highs in the lower mantle at 1000 and 2500 km depth. These high-Q layers may correspond to viscosity highs observed by Forte and Mitrovica [1996]. Third, quality factor decreases near the core-mantle boundary. By relating quality factor to homologous temperature we are able to demonstrate that homologous temperature decreases with increasing depth through the lower mantle. This indicates a divergence between the solidus and melting temperature. The seismic attenuation, and therefore also the homologous temperature, increases sharply within the lowermost 100 km of the mantle, which is consistent with the presence of a thermal boundary layer. Aside from the lowermost 100 km, there is no indication of a significant quality factory boundary within the lower mantle, which indicates the lack of a globally consistent, sharp chemical or phase transition.

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

S51B-05 0830h POSTER

The Regional Difference Of Mantle Heterogeneity Revealed From Envelope Characteristics Before And After The *ScS* Arrival

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Scattered waves of *ScS* waves sometimes dominate over the original coda waves composed of scattered *S* waves and scattered surface waves around the world and there are offset behavior and coda decay rate change before and after the *ScS* arrival. Examining seismogram envelopes of regional earthquakes registered by the IRIS network in Central Asia and Sakhalinsk, Russia with focal depths deeper than 150km in 1s-20s periods for a wide lapse time range up to 2000s, we estimated total scattering coefficients using the Direct Simulation Monte Carlo method based on the radiative transfer theory for isotropic scattering process for the lithosphere and upper mantle and for the lower mantle with assuming a two-layered velocity and attenuation structure according to the PREM, scattering process of *S* waves. The resultant total scattering coefficients are 1.129×10^{-3}km^{-1} and 6.230×10^{-4}km^{-1} at 4s, 4.510×10^{-4}km^{-1} and 2.710×10^{-4}km^{-1} at 10s in Central Asia, and 1.129×10^{-3}km^{-1} and 6.230×10^{-4}km^{-1} at 4s, and 6.771×10^{-4}km^{-1} and 2.770×10^{-5}km^{-1} at 10s in Sakhalinsk, Russia for the lithosphere and upper mantle and for the lower mantle, respectively. In the lower mantle, much stronger scattering than intrinsic attenuation causes the offset behavior and coda decay gradient change after the *ScS* arrival for 4s and 10s.

S51B-06 0830h POSTER

Measuring Body Wave Amplitudes of Shallow Earthquakes

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We present and evaluate a method to measure body wave amplitudes of shallow earthquakes. Compared to deep events the measurement is complicated by crustal echoes and more complex source time functions, but the effort of processing this data is very worthwhile since shallow events are far more abundant than deep ones. We use a linear model that inverts for source time function, moment tensor and amplitudes in an iterative least squares procedure. The waveform fitting is tested on digital broadband seismograms from the temporary PASSCAL line array LA RISTRA and on global GSN data. We find that robust and reproducible amplitude measurements can be obtained. Signal-to-noise ratios are adequate for fitting waveforms of shallow earthquakes with magnitude of 5.9 and higher. Waveform fits to seismograms from the same event routinely achieve a coherence of 90%-98%. Observed amplitude anomalies are on the order of ±20%, with outliers being as large as ±60%. The accuracy is estimated from a limited set of doublet eartquakes and was ±3% in the best case, for time series lowpassed at 16 second period. Along the 1000-km-long RISTRA array we find several smooth amplitude trends on the scale of hundreds of kilometers. At least one of these trends changes sign depending on the event azimuth, which may indicate that the effect is caused by refraction in the mantle.

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S51B-07 0830h POSTER

Seismic Anisotropy in the Upper Mantle Beneath Adak Island Records Relative Plate Motion.

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Along the Aleutian Arc, convergence between the Pacific and the North American plates becomes progressively more oblique from east to west. At the Adak Island, in the center of this arc, the Pacific plate subducts at an angle of nearly 45° to the trench. Using data from a long-running seismic observatory on the Adak Island, we carried out a study of birefringence in 41 core-refracted shear waves (SKS, SKKS, PKS) observed betweed 1994 and 2003. Single-phase estimates of birefringence performed using a cross-correlation algorithm show considerable scatter, although a large fraction of them yields fast directions in the 120° - 150° SE range. Values of the delay never exceed 1 s. Direction-dependent scatter in shear-wave birefringence measurements may indicate that more than one anisotropic system is contributing to the signal, or that the axes of anisotropic symmetry are tilted. To investigate these possibilities, we selected a subset of records well distributed in backazimuth, and performed group inversions for four model classes: (1) one layer with horizontal fast axis; (2) two layers with horizontal fast axes; (3) one layer with arbitrarily oriented fast axis; and (4) one layer with arbitrarily oriented slow axis. Best single-layer solutions cluster around the fast direction of 130°SE, with delay < 1 s, consistent with an apparent trend in individual measurements. The addition of an extra layer does not yield a significant improvement in data fit. All best fitting two-layer models contain a layer with a fast direction in the 120° - 150° SE range, while the fast axis of the second layer is either very close, or else nearly orthogonal to the first. As splitting effects of two orthogonal fast axes cancel out, such two-layer models cannot be considered distinct from those of the single-layered class. Finally, models where the anisotropic symmetry axis (fast or slow) can plunge provide somewhat better fits. The preference for the fast axis at ∼130°SE is retained, however, and is further confirmed by slow-axis inversion that yields NE (i.e., orthogonal to the SE fast) directions. Therefore, the finding of fast shear wave speed direction of ∼130° SE appears to be very robust. It is very close to the relative direction of motion between the Pacific and the North American plates. Thus birefringence of shear waves observed at Adak likely reflects mantle corner flow induced in the supraslab mantle wedge.

S51B-08 0830h POSTER

Serpentine Elastic Wave Anisotropy and Magnetic Susceptibility Anisotropy

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The seismic properties and their directional dependence have been measured in eleven serpertinized dunite samples from Vourinos Ophiolite (France). Laboratory measurements include compressional and shear-wave velocities at confining pressures to 300 MPa, density, velocity anisotropy and shear-wave splitting. Compressional wave velocities were measured to confining pressures along mutually orthogonal directions oriented with respect to the visible textural properties of rocks when apparent. Shear-wave velocities were measured at two orthogonal polarizations for each direction to determine shear-wave splitting and correlate it with P-wave anisotropy. Observed Vp anisotropy varies from quasi-isotropic to 1̃1%. Shear wave anisotropies up to 1̃1% are also observed with shear splitting ranging as high as 0.33 Km/sec. Above confining pressures of 100 MPa, both P and S-wave velocities remain nearly constant indicating that microcracks are only influential at lower pressures in these rock and suggesting that mineralogic texture is the predominant factor controlling anisotropy. In addition, magnetic fabrics, sensitive indicators of low-intensity strain, were obtained from the anisotropy of magnetic susceptibility (AMS) measurements on the same samples. Magnetic anisotropies are up to 2̃0%. Optical microscopy shows microcracks guided by the serpentine (lizardite) penetrative network. The relationship between wave velocity anisotropy and their directional dependence at pressure and relationship between petrofabric and magnetic fabric, compare favorably.

S51B-09 0830h POSTER

Seismotectonics of Western Canada From Regional Moment Tensor Analysis

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Moment tensor analysis of regional earthquakes (distances < 1000 km) in western Canada is now possible due to the installation of more than 40 three-component broadband stations in western Canada, the U.S. Pacific Northwest, and southeast Alaska. Regional moment tensor (RMT) analysis using robust waveform fitting techniques are employed to routinely calculate source mechanisms, moments, and depths of earthquakes with $M > 3.5$-4.0 in and near western Canada. This has resulted in about 10 times as many solutions per year for this region than have been calculated with teleseismic methods which are limited to earthquakes about $M > 5.0$. To date, more than 370 RMT solutions have been calculated for western Canada and adjacent regions for the years 1995-2003. These solutions provide new insights into a number of tectonic problems in western Canada. Local magnitudes (ML) are calibrated with moment magnitudes (Mw) providing a more consistent estimate of the magnitude of an earthquake. This is particularly important in the offshore region of British Columbia where RMT analysis shows that ML is underestimated by 0.3-0.7 magnitude units compared with Mw, depending on the amount of oceanic crust present in the source-receiver travel path. Focal mechanisms from RMT solutions are also used to constrain the motions of the Explorer plate, a small oceanic plate off the coast of British Columbia. Rotation poles calculated from earthquake slip directions show that the Explorer plate is undergoing intense internal deformation, and strain tensors calculated from RMT solutions give a deformation rate of 5.5 mm/yr over 100 km. Stress tensors calculated for western Canada from RMT solutions show stress pattern changes throughout western Canada. Most of western Canada is being compressed in a NE-SW direction except in the region opposite the Cascadia subduction zone where the stress regime changes to N-S compression. Principal strain and stress directions for the northern Canadian Cordillera have similar orientations to one another suggesting that the earthquakes occur on faults which are favourably oriented for failure and are not particularly weak.

S51B-10 0830h POSTER

Waveform Validation of the Crustal Structure in China

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One way of validating earth structure obtained by travel-time tomography is to calculate synthetic seismograms for comparison with the observed seismograms. We use this approach to validate velocity models for China. We have constructed a 3-D P and S velocity structure of the crust and uppermost mantle of China and surrounding areas using high quality first arrivals extracted from the Annual Bulletin of Chinese Earthquakes (ABCE). We used 345,000 P wave, and 230,000 shear wave arrivals. We represent the area of interest by 2338 points with a 1° × 1° (latitude, longitude) interval. At each point a five-layer 1-D model was determined by performing a Monte-Carlo random search (Sun et al., 2004). By combining and smoothing the 1-D models, an equivalent 3-D model has been generated. The model has good correlation with tectonic features and was generally consistent with the existing models constructed by other researchers. The predicted travel times through the 3-D model matched well with the observed ones at local and regional distances. To validate both P and S velocity models we generated synthetic seismograms and test their agreement with observed ones. We use eight events with M5.0 to M6.0, occurring between 2001 and 2003, in different areas of China. Each event is recorded by up to 47 broadband stations in the China Digital Seismic Network (CDSN). For each event, we select waveforms recorded in the stations at different azimuths and at distances ranging from 50 km to 1000 km. Where structure is laterally uniform we use the discrete wavenumber method (Bouchon, 2003) to generate seismograms based on the 1-D averaged velocity profile between the source and the station. P and S waves and Rayleigh and Love waves fit well in eastern China. For regions where structure is laterally heterogenous we use finite difference modeling on smoothed 2-D slices of 3-D model to generate the synthetic seismograms. These show that models of northern and southeastern China also fit well although we find that travel-time based velocity models require some modifications in the complex transition zones.

S51B-11 0830h POSTER

BROADBAND SEISMOMETERS WITH ELECTROCHEMICAL MOTION SENSORS: Past, Present, Future.

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First conceived in the fifties, electrochemical seismic sensors (ESS), despite their many attractive features, until relatively recently could not compete successfully with traditional electromechanical instruments. ESS are characterized by ruggedness, low to extremely low power consumption, no need in any maintenance (mass locking and centering), ability to operate normally at large installation tilts. The main shortcoming was ESS insuffi-cient parameter stability and limited dynamic range. The only way to overcome these deficiencies was to introduce a force-balancing feedback. A seemingly more suitable (both physics- and design-wise) magnetohydrodynamic feedback was thorough investigated and while provided for adequate stability, proved highly ineffective in expanding the dynamic range on higher frequencies. Finally, after many unsuccessful attempts, we man-aged to incorporate an electrodynamic feedback which solved both problems. In order to enable using such a feedback it was necessary to completely re-evaluate the hydrodynamic and electrochemical properties of the motion sensor and work around numerous parasitic effects which required re-evaluation of the sensor's mathematical model and exhaustive experimentation. This work resulted in the development of a family of high-performance seismometers. Further R&D effort is two-fold: improvement of the present sensors and development of a broadband seismometer with noise below the NLNM across the whole passband.

URL: http://www.eentec.com