

of P and T gradients. Experiments were carried out using the double-sided Nd:YLF laser heating system at 13-ID-D of the GSCECARS sector of the Advanced Photon Source. Alignment of the x-ray and heating spots was facilitated by the placement of YAG crystals in the sample chamber. Angle-dispersive diffraction techniques were employed together with a CCD detector. Our in situ studies on SiO<sub>2</sub> show that the CaCl<sub>2</sub> phase remains stable to about 120 GPa using both stishovite and glass starting materials. No differences were found between experiments employing an Ar insulation medium and those that did not. For cristobalite starting material, the α-PbO<sub>2</sub> phase was observed at pressures above 54 GPa and room temperature. However upon heating at 80 GPa, the α-PbO<sub>2</sub> phase transformed into the CaCl<sub>2</sub> phase. A separate set of experiments on GeO<sub>2</sub> carried out at Spring-8 showed that the CaCl<sub>2</sub>-α-PbO<sub>2</sub> phase transition occurred near 65 GPa in this material.

S52C-12 1635h

Mantle Phase Transitions and Earths Thermal History

Samuel L Butler<sup>1</sup> (1-306-966-5702; sam.butler@usask.ca)

W. R. Peltier<sup>2</sup> (1-416-978-2938; peltier@atmosph.physics.utoronto.ca)

<sup>1</sup>Department of Geological Sciences, University of Saskatchewan, 114 Science Place Department of Geological Sciences University of Saskatchewan, Saskatoon, SK S7N 5E2, Canada

<sup>2</sup>Department of Physics, University of Toronto, 60 St George Street Department of Physics University of Toronto, Toronto, ON M5S 1A7, Canada

It is well known from numerical modeling that the phase transition from spinel to a mixture of perovskite and magnesiowustite, that occurs at a mean depth of 660 km in the mantle, can act as a partial barrier to convective flow. This phase transition is also known to strongly increase the time-dependence of mantle flows with mantle avalanches being the most dramatic example. The degree of layering has also been shown to increase with the strength of convective forcing or Rayleigh number which has evolved throughout the Earths history. We present a suite of calculations in which we model the Earths thermal history using numerical models of the mantle convection process that include temperature dependent viscosity, an evolving core-mantle boundary temperature, and the effects of the two major mantle phase transitions. These are compared with the results of parameterized convection modeling which showed that the inclusion of the effects of Rayleigh number dependent layering by the phase transitions allow the reconciliation of geochemical models of radioactive abundances and parameterized convection modeling and this effect is found to be important in these more detailed models as well. We also compare the time-scale of phase-transition induced mantle avalanches in models of this type and show that they are consistent with the timing of the Wilson cycle of supercontinent formation and dispersal.

S61A MCC: Hall C Saturday 0830h

Lithospheric Structure in North America and Europe: Comparisons and Recent Results I Posters (joint with T, V)

Presiding: A Guterch, Polish Academy of Sciences; G R Keller, University of Texas at El Paso

S61A-1088 0830h POSTER

3-D Tomography Study of Seismic Refraction/Wide-Angle Reflection Data Across the Variscides, SW Ireland

Brian M. O'Reilly<sup>1</sup> (+353-1-662 1333; bor@cp.dias.ie)

Michael Landes<sup>1</sup> (+353-1-662 1333; landes@cp.dias.ie)

Peter W. Readman<sup>1</sup> (+353-1-662 1333; pr@cp.dias.ie)

Pat M. Shannon<sup>2</sup> (+353-1-716 2331; p.shannon@ucd.ie)

Claus Prodehl<sup>3</sup> (+49-721-608 4492; claus.prodehl@epost.de)

<sup>1</sup>Dublin Institute for Advanced Studies, 5 Merrion Square, Dublin 2, Ireland

<sup>2</sup>Department of Geology, University College Dublin, Dublin 4, Ireland

<sup>3</sup>Geophysical Institute, University of Karlsruhe, Karlsruhe 76187, Germany

The VARNET-96 seismic experiment acquired three seismic refraction/wide-angle reflection profiles in order to examine the crustal structure in the south-west of Ireland. 170 seismic stations were used on 300 recording sites. The shotpoint geometry was designed to allow for both in-line and off-line fan shot recordings on the three profiles. A total of 34 water shots was fired. Results from 3-D raytrace and inversion modelling illustrate the pervasive lateral heterogeneity of the study area south of the Shannon Estuary. Palaeozoic strata at the south coast are about 5-6 km thick associated with the sedimentary infill of the Munster and South Munster Basins. To the north, shallow upper crust in the vicinity of the Killarney-Mallow Fault Zone is followed by a 3-4 km thick sedimentary succession in the Dingle-Shannon Basin. A zone of high-velocity upper crust (6.4-6.6 km/s) beneath the South Munster Basin correlates with a gravity high between the Kenmare-Killarney and the Leinster Granite gravity lows. Other high-velocity zones were found beneath Dingle Bay and the Kenmare River region and may be associated with the deep traces of the Killarney-Mallow Fault Zone and the Cork-Kenmare Line. The 3-D velocity model was taken as a basis for the computation of PmP reflected arrivals from the crust-mantle boundary. The Moho depth varies from about 28-29 km at the south coast to about 32-33 km beneath the Dingle-Shannon Basin, the region where the 2-D inline model shows a south-dipping reflector in the upper mantle. Pervasive Variscan deformation appears to be confined to the sedimentary and upper crustal structure and has not deformed the entire crust supporting a thin-skinned tectonic model for Variscan deformation. Deep-crustal variations only occur where they can be correlated with major tectonic features such as the Caledonian Iapetus Suture near the Shannon Estuary. The shallowing of the Moho towards the coast may result from Mesozoic crustal extension in the adjacent offshore sedimentary basins.

S61A-1089 0830h POSTER

Surface-Wave Tomography in Fennoscandia

Marianne Bruneton<sup>1</sup> (mbruneto@obs.ujf-grenoble.fr)

Helle A Pedersen<sup>1</sup> (pedersen@obs.ujf-grenoble.fr)

Véronique Farra<sup>2</sup> (farra@ipgp.jussieu.fr)

S SVEKALAPKO Seismic Tomography W.G.

<sup>1</sup>Laboratoire de Géophysique Interne et Tectonophysique, Maison des Géosciences BP53, Grenoble 38041, France

<sup>2</sup>Département de Sismologie, Institut de Physique du Globe de Paris, 4 Place Jussieu, Paris 75252, France

We developed a technique based on paraxial ray tracing to obtain 2D phase-velocity maps as a function of frequency which can subsequently be inverted for the 3D structure. The major improvement of our method compared to previous ray tracing studies is that we jointly invert for the velocity model under the array and the shape of incoming wave fronts, therefore reducing artifacts due to structure outside the study region. The stabilisation of the inversion was performed by imposing a smoothness criteria to the wavefronts and to the phase-velocity map.

The method was applied to data from the SVEKALAPKO deep seismic experiment, where the central part of the Baltic Shield, in southern Finland, was covered by a regular two-dimensional grid of 46 broad-band stations which operated for six to eight months. This exceptional stations distribution offers the possibility to undertake a high precision surface-wave tomography. P-wave and surface-wave tomography are complementary as the latter one gives an image of absolute shear-wave velocities with a relatively good vertical resolution.

We first selected 69 high quality events with the best possible azimuthal distribution. The arrival times of the fundamental-mode Rayleigh waves as a function of frequency were measured using Wiener filtering. A selection of the data was performed using a minimum signal to noise ratio of 4 and a minimum coherency of 0.95 between the signals recorded by different stations.

To obtain an average dispersion curve for the region between 10 and 200 seconds we inverted the data imposing the phase-velocity to be quasi constant. This dispersion curve was subsequently inverted for the average shear-wave velocity structure as a function of depth. This average structure shows a lithospheric mantle faster than global average models at all resolved depths.

The inversion of the same data set was also conducted using weaker constraints to obtain the lateral variations of the phase-velocity at each frequency, and after a second inversion the 3-dimensional structure of the lithosphere in shear-wave velocity.

S61A-1090 0830h POSTER

3D P-wave velocity of the Tornquist suture zone studied through inverse Monte Carlo sampling of teleseismic P-phase arrivals

Peter Voss<sup>1,2</sup> (+45 3587 5154; pv@kms.dk)

Frederik Horn<sup>3</sup>

Soren Gregersen<sup>1,2</sup>

Klaus Teddy Mosegaard<sup>1</sup>

the TOR Working Group

<sup>1</sup>Dept. of Geophysics, Niels Bohr Institute, University of Copenhagen, Juliane Maries vej 30, Copenhagen, dk 2100, Denmark

<sup>2</sup>National Survey and Cadastre - Denmark, Rentemestervej 8, Copenhagen, dk 2400, Denmark

<sup>3</sup>Ramboll, Bredevej 2, Virum, dk 4598, Denmark

Lithospheric differences are studied through a non-linear Monte Carlo tomography inversion of teleseismic P-phase arrivals. Data from the TOR-project are used. TOR was a 900km long and 100km wide antenna of 120 mobile broad band and shortperiod seismographs, that continuously collected data in Sweden, Denmark and Germany, for half a year from 1996 to 1997. The TOR-project investigated the Tornquist Zone in Germany-Denmark-Sweden as part of the EUROPROBE program. The transition between the Baltic Shield and the geologically younger lithosphere to the SW was by linear inversion found to be stepwise in narrow zones, near vertical and more than 300km deep. By a linear study using 3108 P-phase registrations from 49 earthquakes the inclination of the transition was found to be a SW-slope. Whereas two other linear studies one using 3593 P-phase registrations and one using 803 S-phase registrations both from 51 earthquakes found the inclination to be NE oriented. A high resolution inverse Monte Carlo sampling in a 200x200x300km area containing the Tornquist Zone of a limited data set of eight earthquakes, indicates, when tested through a Bayesian hypothesis, that a SW dipping transition zone is preferred by data. Marginal posteriori P-velocity distributions of vertical and horizontal profiles are presented. URL: <http://research.kms.dk/~tor/>

S61A-1091 0830h POSTER

EB95-97: Deep Lithospheric Structure of the East European Craton Beneath the EUROBRIDGE Seismic Transect

Tomaz Janik<sup>1</sup> (janik@igf.edu.pl)

EUROBRIDGE Working Group

<sup>1</sup>Institute of Geophysics, Polish Academy of Sciences, Ks. Janusza 64, Warsaw 01-452, Poland

During 1994-1997, a deep seismic sounding (DSS) experiment was conducted along a profile extending from the Baltic Sea to the Dnieper basin area. This cooperative effort is called EUROBRIDGE, and its purpose is to study the lithospheric structure of the East European Craton (EEC) between the Baltic and Ukrainian shields. Seismic data for this 1200 km long profile were acquired during two campaigns (EB95&96 and EB97) in which about 120, 3-component seismographs were deployed at a station spacing of 3-4 km. The EB95&96 effort involved recording along a 700 km long NW-SE trending transect that crossed the EEC from the West Lithuanian Granulite belt to the Ukrainian shield. Sources were 24 explosive shots of up to 1000 kg in size and were detonated at intervals of about 30 km. In addition, a large shot was fired in the Baltic Sea close to Gotland Island. Tomographic inversion and ray trace modelling established a 2-D P-wave velocity model and spatial variations in Vp/Vs. The upper, middle and lower crystalline crust exhibit velocities of 6.1-6.3, 6.4-6.8 and 6.9-7.2 km/s. P-wave velocities immediately beneath Moho are 8.2-8.35 km/s. The crust below Lithuania is about 44 km thick, and below Belarus it is about 50 km thick. A lower lithosphere reflector occurs at 65-70 km depth. S-wave velocities are relatively high in the upper crust and low in the lower crust. Correlation of our seismic structure with near surface geology tentatively suggests that the contact zones between the East Lithuanian Belt, Belarus-Baltic Granulite Domain, Central Belarussian Belt, and the Onitsk-Mikashевичi Igneous Belt all dip slightly to the southeast, consistent with the hypothesis of successive docking of these terranes during craton growth. The effort in 1997 (EB97) involved recording along a 530 km long north-trending profile. This profile traverses the northwestern part of the Ukrainian shield within the Sarmatian province of the East European craton. Chemical explosions at 18 shot points at approximately 30 km intervals provided the seismic energy. Our velocity modeling showed that there are

pronounced differences in seismic velocity structure between the three main blocks traversed by the profile: (1) The Pripjat Trough is a ca. 4 km deep graben, located in the Osnitk-Mikashевичi igneous belt in the northern block. The velocity structure is typical for a Precambrian craton, underlain by a ca. 5 km thick lower crustal layer of high velocity. The development of the Pripjat Trough appears to have only affected the upper crust without noticeable deeper thinning. (2) Very high seismic velocity and Vp/Vs ratio characterise the Volyn Block and Korosten Pluton to a depth of 15 km. These velocity values suggests a body of basic composition in the upper crust that originates from intrusion of bimodal melts derived from the mantle and the lower crust. (3) The Podolian Block is characterised by relatively low seismic velocity and Vp/Vs ratio. A pronounced SW-dipping mantle reflector extending from the Moho to at least 70 km depth is interpreted to be associated with the Proterozoic suture between Sarmatia and Volgo-Uralia. The sub-Moho seismic velocity is high everywhere along the profile, with the exception of the area above the dipping reflector. \*EUROBRIDGE95-97 Seismic Working Group: R. Garesky, A. Belinsky, G.I. Karatayev, G. Zlotski A. Astapienko (Belarus); H. Thybo, M. Knudsen, R. Sand (Denmark); J. Yliniemi, T. Tiira, U. Luosto, K. Komminaho (Finland); R. Giese (Germany); G. Motuza, V. Nasedkin, J. Jacyna, R. Sekkus (Lithuania); M. Grad, T. Janik, A. Guterch (Poland); C-E. Lund (Sweden); A.M. Kharitonov, V.D. Omelchenko, T.V. Ilchenko, D. Lysynczuk (Ukraine); J.J. Doody (UK)

### S61A-1092 0830h POSTER

#### CELEBRATION 2000: P-Wave Velocity Model of the Bohemian Massif

Pavla Hrubcov<sup>1</sup> (4202 7276 1549; pavla@ig.cas.cz)

CELEBRATION Working Group

<sup>1</sup>Geophysical Institute, Academy of Sciences of the Czech Republic, Boeni II/1401, Prague 4 142 000, Czech Republic

The Bohemian Massif is an exotic terrane that played a key role in the assembly of Western Europe in the Paleozoic. The deep structure of the Bohemian Massif, the largest outcrop of Variscan rocks in Central Europe, was studied along two refraction profiles, CEL09 that traverses the whole massif in the NW-SE direction and CEL10 that extends along its eastern edge perpendicular to CEL09. Good quality recordings were obtained: a clear first arrivals show an apparent velocity of 5.9 km/s for the crust with slightly higher gradient in NW part of the BM and an apparent velocity of 8.0 to 8.1 km/s for the mantle. Higher attenuation of energy of crustal phases visible in some sections may be connected with a specific upper crustal structures (low to zero velocity gradient zone). Moho reflections are very clear in the central part of the Bohemian Massif and indicate a well-defined Moho in that area compared with less clear Moho reflections and thus smaller velocity contrast in other parts of the Bohemian Massif. Our interpretation and analysis involved several steps. The tomographic inversion routine developed by Hole was used as an efficient tool to determine the seismic P-wave velocity distribution in the crust using first arrivals. Tomographic models were verified by forward ray tracing modelling based on a well-established algorithm developed by Cerveny and Psenick. This approach was modified and converted into an inverse modelling scheme by Zelt in which both first and latter arrivals are employed to derive 2-D velocity models. Our combined ray-trace modelling effort resulted in a model that displays a high P-wave velocity gradient zone reaching to a depth of 5-7 km followed by a small gradient and laterally homogeneous P-wave velocities in the lower crust. The depth of the Moho discontinuity ranges from 32 km to 40 km, and reflectors within the crust provide more detail about the P-wave velocity distribution. Differences in the character of velocity distribution not only in the upper crust but also in lower crust are unique to the central part of the Bohemian Massif. This velocity structure is distinct from that of related tectonic units within the massif and also defines the contacts of Bohemian Massif with neighbouring units (Carpathians, Paleozoic platform and the Alps). \*The members of the CELEBRATION Working Group are listed on our website.

URL: <http://paces.geo.utep.edu/celebration.shtml>

### S61A-1093 0830h POSTER

#### The CELEBRATION 2000 Experiment: Results from the Alpine Area

Michael Behm<sup>1</sup> (0043 1 58801 12820; mbehm@luna.tuwien.ac.at)

CELEBRATION 2000 Working Group

<sup>1</sup>Institute of Geodesy and Geophysics, Vienna University of Technology, Gusshausstrasse 27-29, Vienna 1040, Austria

The northeastern part of the Eastern Alps was covered by the third deployment of CELEBRATION 2000. Both inline and cross line shots from this experiment

supplied essential travel time information for Pg, PmP and Pn arrivals. From this information, a preliminary 3D model has been derived. The parameters of this model are given at grid points with a regular spacing in X and Y of 20 km. The grid extends from the Alpine area to the Bohemian Massif, the Carpathians and the Pannonian basin. The thickness of sediments above the crystalline basement was calculated by a 3D delay time method. The P-wave velocity structure of the crust was obtained by automatic 1D tomographic inversions using CMP-sorted data within a predefined search radius around the grid points. The calculation of Moho-depths and Pn-velocities again was based on the delay time method. PmP arrivals supply additional constraints on the P-wave velocities of the lower crust and Moho-depths. The suitability of the starting model was checked by dynamic 3D ray tracing. Furthermore, 2D-sections following the lines CEL07 and CEL10 through the 3D model were compared with the results of 2D tomographic inversions and 2D modelling by ray tracing. These results were promising, and substantial extension of the model will be possible by the integration of the new data set which was acquired during the ALP 2002 experiment.

\* The listing of the CELEBRATION 2000 Working Group can be found on our website.

URL: <http://paces.geo.utep.edu/celebration.shtml>

### S61A-1094 0830h POSTER

#### Crustal Structure Along CELEBRATION 2000 Profiles Extending from Precambrian and Paleozoic Europe Towards the Alpine Orogen

Piotr Sroda<sup>1</sup> (sroda@igf.edu.pl)

CELEBRATION Working Group

<sup>1</sup>Institute of Geophysics PAS, Ks. Janusza 64, Warsaw 01-452, Poland

CELEBRATION 2000 was a large international cooperative experiment that focused on lithospheric structure in Central Europe. It consisted of a series of interlocking profiles along which wide-angle reflection and refraction seismic data were recorded. Profiles C01, C02, C04 are located in the transition from the old Precambrian and Paleozoic Platforms to the young Alpine orogen (Carpathians). The seismic sections obtained are of high quality, with clear of seismic arrivals up to offsets of 400 km. The C02 profile is a 400-km long transect, trending from the southwest from north-east Poland through the Upper Silesian block (USB), the Malopolska block (MB), the Trans European Suture Zone (TESZ) and the East European craton (EEC). The C04 profile (830 km long) starts in the TESZ and crosses MB, the Carpathians and the Pannonian basin. Profile C01 (about 900 km long) crosses the southwest margin of the EEC, the TESZ, the Carpathians and reaches the Pannonian basin. The data were modeled using 2D tomographic and ray-tracing techniques. Along the C04 profile, we have delineated a differentiated consolidated crust. The Moho is at depths of about 35 km with the Vp below of about 8.0 km/s beneath the TESZ, uplifting to 30 km beneath the MB, dipping to 40 km beneath Carpathians with the Vp of about 8.1 km/s and shallowing to 25-30 km beneath the Pannonian basin with the Vp of about 7.9 km/s. We have also found an upper mantle boundary at a varying depth from 45 to 60 km. The most striking feature observed in the modeled structure along the C02 profile is the Krakow-Lubliniec zone. The depth of the Moho varies from 35 km in the USB to 40 km in the MB with some undulations in the Holy Cross Mountains region, reaching maximum value of 45 km in the EEC. The Pn velocities vary from 8.2 km/s in the USB to 8.0 km/s in the MB and the EEC. A distinct mantle reflector beneath the MB, TESZ and the EEC has been found at the mean depth of 55 km. Along the C01, in the TESZ area, the depth of the consolidated basement, with a Vp of about 5.8 km/s, reaches 8-10 km and low velocities <6.0 km/s continue down to 15-20 km. In the area of the Lublin unit at the southeast margin of the EEC, anomalously high velocities of about 7.0 km/s were found at depth of 20 km. The depth of Moho boundary varies along the profile from 27-33 km in the Pannonian basin area, 30-35 under the Carpathians and the TESZ to 40-45 km under the EEC. \* The CELEBRATION Working Group is listed on our website.

URL: <http://paces.geo.utep.edu/celebration.shtml>

### S61A-1095 0830h POSTER

#### Seismic Structure of the Central Europe Lithosphere in the Transition Between Precambrian and Paleozoic Platforms and Bohemian Massif from Teleseismic Receiver Functions

Monika Wilde-Pirko<sup>1</sup> (Monika-Wilde@fuw.edu.pl)

Marek Grad<sup>1</sup>

J. Saul<sup>2</sup>

TOR Working Group

<sup>1</sup>Institute of Geophysics, University of Warsaw, Pasteura 7, Warsaw 02-093, Poland

<sup>2</sup>GeoForschungsZentrum, Telegrafenberg A17, Potsdam D-14473, Germany

In the past a dozen or so years, considerable development of the receiver function (RF) technique has taken place. This development, an increase in the number of permanent and portable broadband seismic stations, and new computational algorithms and capabilities have resulted in great progress in studies of lithospheric structure. The subject of this paper is determination of the structure of a portion of Central Europe in the transition from the Precambrian platform on the east to Paleozoic platform from an international cooperative passive seismic experiment called TOR. Another target of our study was the Bohemian massif that was emplaced during the Variscan orogeny. Here we employed teleseismic records from ten broadband stations lying within and around the massif. Different techniques were employed in the interpretation of receiver function were applied including 1-D inversion of R- and Q-components, direct (forward) modelling of Vs velocity, and simultaneous determination of Moho depth and Vp/Vs ratio in the crust. These results provide new, independent information about the distribution of S-wave velocity down to ca 60 km depth. Beneath the Baltic shield, the thickness of the crust varies from about 45 to 50 km with mostly gradually increasing S-wave velocity and no sharp velocity discontinuities while for Paleozoic platform crust is thinner (29-38 km). A very distinct S-wave low velocity layer was found at depth of 8-16 km in the upper crust of the Baltic shield. In the area of Bohemian massif, the crustal thickness varies from 28 to 40 km. A relatively simple velocity structure with gradually increasing velocities in the crust and lower lithosphere is observed in the eastern part of Bohemian massif. The western part of this massif is characterized by more complicated structure with low S-wave velocities in the upper crust, as well as in the lower lithosphere. This could be related to tectono-magmatic activity in the Eger rift that started in the uppermost Cretaceous and was active in the West Bohemia-Vogland area till the late Cenozoic.

### S61A-1096 0830h POSTER

#### ALP 2002: A Seismic Experiment to Explore the Alpine Lithosphere

Ewald Brueckl<sup>1</sup> (0043 1 58801 12820; ebrueckl@luna.tuwien.ac.at)

Randy G. Keller<sup>2</sup> (001 915 747 5850; keller@geo.utep.edu)

ALP 2002 Working Group

<sup>1</sup>Institute of Geodesy and Geophysics, Vienna University of Technology, Gusshausstrasse 27-29, Vienna 1040, Austria

<sup>2</sup>Department of Geological Sciences, University of Texas at El Paso, El Paso, El Paso, TX 79968, United States

ALP 2002 is an international seismic experiment whose scientific objective is to further scientific understanding of the structure and evolution of the lithosphere in the Eastern Alps and surrounding areas of the Bohemian Massif, the Pannonian basin and the Dinarides. This effort included passive seismic monitoring during portions of June and July 2002 and an active source seismic refraction experiment conducted from 1-6 July 2002. During the active source seismic experiment, 31 appropriately designed seismic shots were fired and about 1000 portable seismic recorders were deployed along 13 lines with a total length of about 4300 km. Furthermore, local high-density deployments and additionally 8 smaller shots were carried out in Austria and Hungary. The ALP 2002 was designed to merge perfectly into the CELEBRATION 2000 experiment, and it is tied to the TRANSALP reflection line on the west. All record sections are ready being interpreted and samples of recordings demonstrating the high quality of the data will be presented. By merging the data from ALP 2002 with the data from the third deployment of CELEBRATION 2000 a unique data set will be generated. A joint interpretation of this data from them will produce a 3-D model of the crust and mantle lithosphere that will resolve the major plate tectonic features. Furthermore, it will support the planning and interpretation of future deep seismic reflection lines in this area and will aid in our understanding of earthquake activity.

\* The listing of the ALP 2002 Working Group can be found on our website.

URL: <http://www.alp2002.info>

## S61A-1097 0830h POSTER

### Towards an Integrated Image of the Mediterranean 3D Crustal and Upper Mantle Structure: Combined Results From Surface Wave Tomography and Receiver Function Analysis

Federica Marone<sup>1</sup> (+41 1 633 27 29; federica@tomo.ig.erdw.ethz.ch)

Mark van der Meijde<sup>1</sup>

Suzan van der Lee<sup>1</sup>

Domenico Giardini<sup>1</sup>

<sup>1</sup>Institute of Geophysics, ETH-Hönggerberg (HPP), Zurich CH-8093, Switzerland

The Mediterranean region is characterized by the suture zone between the Eurasian and African plates. We used new seismic data to map discontinuities and to image smooth *S*-velocity structure of the crust and upper mantle of the Africa-Eurasia suture zone with a resolution complementary to existing studies. The used data have been recorded at 23 broad band seismic stations (MIDSEA project) temporarily deployed along the plate boundary region and at permanent seismic networks. We jointly inverted linear constraints on Moho depth and upper mantle *S*-velocity structure obtained by waveform modeling of *S*- and surface wave trains and point estimates of crustal thickness (from receiver function, gravity and reflection/refraction studies). This joint inversion has yielded a Moho map and a 3D upper mantle *S*-velocity model.

The Moho map shows strong lateral variations, which confirm the complex evolution of this plate boundary region. The Moho deepens to more than 45 km beneath mountain ranges (e.g. Alps), while in locations dominated by extension it is found shallower than 15 km (e.g. Algero-Provençal Basin). Beneath the eastern Atlantic Ocean, the crust may be up to 5 km thicker than standard oceanic crust (6 km). Serpentinization of the sub-Moho mantle at the Mid-Atlantic ridge could be a process contributing to the imaging of apparently anomalous deep Moho in this region.

The 3D upper mantle *S*-velocity structure shows strong correlation between the imaged heterogeneities and the tectonics along the plate boundary. The Eurasia-Africa suture zone manifests itself in the upper mantle mainly as a belt of fast material representing subducted oceanic lithosphere. A new, striking and resolved feature of our model is a high velocity anomaly imaged beneath eastern Spain between 250 and 500 km depth. We suggest that this fast body could be a fragment of subducted lithosphere which detached in an early stage of NW subduction of oceanic lithosphere in the western Mediterranean. Not only convergence has been recorded in the upper mantle, but also extension has its own signature. This is particularly clear for the Algero-Provençal and Tyrrhenian basins, where a shallow asthenospheric layer is observed. The lithosphere-asthenosphere system of the western Mediterranean clearly differentiates itself from the structure of the older eastern Atlantic Ocean: significantly lower *S*-velocities down to 150 km as well as a thinner lithosphere (~80 km) characterize this region. Differences compared to the structure of a young ocean are also observed. Besides a narrower velocity minimum around 95 km depth and a smaller velocity gradient for the lithosphere, the western Mediterranean also shows higher velocities ( $\geq 0.1$  km/s) between 120 and 200 km depth than an oceanic structure of comparable age. Therefore we suggest that, rather than a young ocean, the western Mediterranean could be a strongly stretched continent at the back of a fast retreating slab, partly affected by spreading.

*S*-velocity anomalies in the transition zone correlate with estimates for transition zone thickness derived from receiver function analysis: positive (negative) thickness deviations correlate with high (low) *S*-velocity anomalies. A relatively thick transition zone is observed beneath e.g. eastern Spain while a thinner transition zone is found beneath e.g. the Canary Islands.

## S61A-1098 0830h POSTER

### Simultaneous Refraction and Reflection Seismic Tomography Based on SIMUL With Applications to the TRANSALP Wide-Angle Data.

Florian Bleibinhaus<sup>1</sup> (0049 89 2180 4202; bleibi@geophysik.uni-muenchen.de)

Gebrande Helmut<sup>1</sup> (0049 89 2180 4235; gebrande@geophysik.uni-muenchen.de)

TRANSALP Working Group<sup>1</sup>

<sup>1</sup>Department of Earth and Environmental Sciences University of Munich, Theresienstr. 41, Munich 80333, Germany

Seismic travel time tomography is restricted for the most part either to the direct wave or to 2D. Combined 3D refraction and reflection seismic inversion of

DSS data was introduced by Zelt et al. (1996) using a quasi-simultaneous procedure of alternating inversions of a certain seismic phase and layer stripping. We developed a 3D method to invert simultaneously for slowness and reflector depth in one step. It is based on the SIMULPS13Q version of the wide-spread SIMUL-code-family and the concepts of flexible gridding (Thurber, 1983-1999; Rietbrock, 1996).

The ray tracing/bending accuracy for large recording distances, crucial for the inversion of PMP or Pn observations, has been improved by resegmentation of the ray path and multiple path search. Modelling of reflectors has been integrated using bi-cubic splines. Reflectors can be "floating", i.e. without impact on the velocities, or discontinuous. Reflections are modelled by grid search and bending techniques. Then the linearized tomographic approach has been extended to the inversion of reflection travel times for velocity and reflector depth and tested using synthetic data.

This method has been applied to the TRANSALP wide-angle data. TRANSALP is an international project for the investigation of the deep structure of the Eastern Alps (TRANSALP Working Group, 2001,2002). The data consists of vibro- and explosion seismic signals recorded by 30 to 110 three-component stations distributed along a 220 km long segment of the profile. We obtained a model with 2.5 km x 10 km horizontal grid spacing in the upper crust decreasing to 20 km in the lower crust. Velocities at the surface correlate well with known geological boundaries and the inverted Moho depth is consistent with older models. The upper part of the Sub-Tauern ramp can be recognized by its low velocities. A LVL in the northern part of the profile is interpreted as top of the southward dipping European Basement.

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URL: <http://www.geophysik.uni-muenchen.de/TRANSALP/>

## S61A-1099 0830h POSTER

### VRANCEA2001 - 2-D Crustal Velocity Structure Across the Earthquake Prone Vrancea Region in Romania

Franz Hauser<sup>1</sup> (+49-721-608-4592;

franz.hauser@gpi.uni-karlsruhe.de); Victor

Raileanu<sup>2</sup> (raivc@infp.inf.ro); Michael Landes<sup>1</sup>

(Michael.Landes@gpi.uni-karlsruhe.de); Andrei

Bala<sup>2</sup> (bala@infp.inf.ro); Claus Prodehl<sup>1</sup>

(Claus.Prodehl@gpi.uni-karlsruhe.de); Werner

Fielitz<sup>3</sup> (Werner.Fielitz@bio-geo.uni-karlsruhe.de)

<sup>1</sup>Geophysical Institute, University of Karlsruhe, Hertzstrasse 16, Karlsruhe 76187, Germany

<sup>2</sup>National Institute for Earth Physics, Bucharest-Magurele, PO Box MG-2, Bucharest 1, Romania

<sup>3</sup>Geological Institute, University of Karlsruhe, Kaiserstrasse 12, Karlsruhe 76131, Germany

The Vrancea zone in Romania is one of the most active seismic zones in Europe. Intermediate-depth earthquakes (70-200 km) with magnitudes in excess of  $M_w=7.0$  occur in a geographically restricted area within the bending region of the south-eastern Carpathians. The seismic refraction project VRANCEA2001 was carried out in August-September 2001 in order to study the crustal and uppermost mantle structure in this region. It is a contribution to the German-Romanian research program "Strong Earthquakes - A Challenge for Geosciences and Civil Engineering" which was initiated in 1996. Ten chemical sources, between 300 kg and 1500 kg were used along this 400 km long E-W trending profile. This resulted in an average shot point spacing of 40 km, while the receiver spacing was about 1 km.

In a first step P-wave first arrival times were picked and inverted using a non-linear high-resolution tomographic technique (Hole 1992, 1995). The results show only modest variations in the crustal velocities. The most notable feature is the very deep (ca. 15-20 km) Focsani Basin. Here, velocities increase from 2 km/s at the surface to 5.8 km/s at the sediment-basement interface. Since intra-crustal and Moho reflections are prominent on most seismic sections, they can be used to constrain deeper structures. Here, results indicate a down warp of only the mid-crustal discontinuity under

the Carpathian Mountains and the Focsani Basin. Surprisingly, the Moho shows no crustal root, but shallows slightly from some 40 km in the east to about 35 km in the west.

URL: <http://www-sfb461.physik.uni-karlsruhe.de>

## S61A-1100 0830h POSTER

### Ancient to Modern History of the Jemez Lineament of North Central New Mexico

Maria Beatrice Magnani<sup>1</sup> (713 348 5325; beatrice@esci.rice.edu)

Kate C Miller<sup>2</sup> (915 747 5424; miller@geo.utep.edu)

Alan Levander<sup>1</sup> (alan@esci.rice.edu)

Karl E Karlstrom<sup>3</sup> (kek1@unm.edu)

<sup>1</sup>Department of Earth Science - MS126 Rice University, 6100 Main St., Houston, TX 77005, United States

<sup>2</sup>Department of Geological Sciences, University of Texas, El Paso, 500 W. University Ave., El Paso, TX 79968, United States

<sup>3</sup>Department of Earth and Planetary Sciences, University of New Mexico, 200 Yale Blvd NE, Albuquerque, NM 87108, United States

The continental lithosphere of the southwestern US was derived from mantle sources and accreted to the proto-North American continent, more specifically the Archean-age Wyoming province, during a succession of island arc collisions between 1.8-1.6 Ga. Many of the assembly structures, that is, the sutures between accreted island arcs and oceanic fragments, have been difficult to identify from surface geology. Likewise the tectonic significance of major lineaments in today's lithosphere remains uncertain. The Jemez Lineament (JL), originally defined as an alignment of Tertiary-Quaternary volcanic centers, is a NE trending zone characterized by active uplift, low seismic velocity in the mantle, and repeated reactivation. It also coincides with the southern edge of a 300 km wide transition zone between the Yavapai (1.8-1.7 Ga) and Mazatzal (1.7-1.6 Ga) Proterozoic provinces.

This study presents new deep crustal seismic reflection results across the Jemez Lineament of NM, and the Proterozoic Yavapai-Mazatzal terrane boundary. The crust is strongly reflective from the sedimentary column to its base at 39-42 km. The seismic data show large-scale structures that we interpret as a Proterozoic bi-vergent orogen that extends for at least 170 km laterally and roots into the mantle at the southern edge of the Jemez lineament. A significant portion of this orogen is a 20km thick, south-vergent, crustal duplex occupying at least 50% of the crust south of the JL. North of the JL the depth migrated seismic images show a set of upper crustal north verging recumbent folds and related thrusts in the Proterozoic rocks as well as a south dipping reflectivity in the lower crust that we interpret as one of the north-verging ramps associated with the orogen. Subhorizontal high amplitude reflections across the JL at about 7-15km depth are interpreted to be extensive magmatic intrusions of uncertain age. Based on the seismic and geologic data, we argue that the JL represents both a Paleoproterozoic-orogenic suture zone and a long lived, Proterozoic-to-modern, intracontinental tectonic and magmatic boundary.

URL: <http://www.geo.utep.edu/CDROM/>

## S61A-1101 0830h POSTER

### Lithospheric velocity structure across the Cheyenne Belt near Laramie, Wyoming

Seth Newton<sup>1</sup> (1-307-745-8072; snewton@uwyo.edu)

Ken Dueker<sup>1</sup> (dueker@uwyo.edu)

<sup>1</sup>University of Wyoming, Department of Geology and Geophysics/ PO Box 3006, Laramie, WY 82070, United States

The Cheyenne Belt, a south-dipping suture in southeastern Wyoming, is a major study area of the Continental Dynamics Rocky Mountains project. This 1.78 ga suture consists of Proterozoic islands arcs accreted onto the Archean Wyoming craton. A fundamental question concerning the Cheyenne Belts evolution is whether the collision, that created the suture, was thick or thin skinned. In August of 2000, 31 telemetered PASSCAL broadband seismometers were deployed for 8 months across the Cheyenne Belt near Laramie, Wyoming. Measurement of teleseismic P and S wave travel time residuals and tomographic inversion of these residuals allow us to determine the velocity structure of the crust and subcrustal lithosphere beneath this array. Xenolith suites in this area, suggestive of a south dipping suture extending to perhaps 200 km depth, reveal a strong contrast in lower crust and upper mantle composition. Strong contrasts in crustal reflectivity suggest tectonic wedging of the Archean

and Proterozoic rocks during the collision. Our preliminary results show an 8% Vp difference across the suture, indicative of a significant difference in rock composition. In addition, our transect provides excellent subsurface imaging of the 1.4 Ga anorogenic Sherman Batholith, providing constraints on the large mafic underplate predicted to underlie the batholith from petrogenetic models.

#### S61A-1102 0830h POSTER

##### Attenuation of S-Waves Beneath Southeastern Idaho and Estimation of Mantle Water Content

David C Adams<sup>1</sup> (307-739-9740; dadams@onwest.net)

Eugene D Humphreys<sup>1</sup> (gene@newberry.uoregon.edu)

<sup>1</sup>Department of Geological Sciences, 1272 University of Oregon, Eugene, OR 97403, United States

In conjunction with seismic wave velocity data, it has long been hoped that analysis of the attenuation of seismic waves could provide information on not only physical properties of the Earth but also on compositional aspects such as water content. In continental settings, however, estimation of shifts in phase and frequency content produced by attenuation has been greatly complicated by crustal effects such as reverberations in sedimentary basins and Rayleigh waves due to interaction with topography. We analyzed S-wave data from a linear, broadband, teleseismic array centered on and orthogonal to the Snake River Plain in Idaho. Two separate methods were employed. They were, first, the commonly used spectral ratio technique using multi-taper power spectrum estimation and, second, time-domain cross-correlation of synthetically attenuated signals windowed to various lengths. The former uses only amplitude information but samples a broad frequency range. The latter uses both amplitude and phase information but is most sensitive to the dominant (lower) frequencies. In addition, a form of polarization filter was applied in order to estimate the polarization direction of the teleseismic signal and enhance its energy relative to crustal signals with elliptical or otherwise different linear polarization. Results indicate that  $t^*$  (attenuation integrated over distance) varies significantly along the array, perhaps by as much as 2 seconds. In general there is a slight increase in  $t^*$  from south to north and a broad peak centered on the Snake River Plain. Superimposed on this trend are relatively sharp decreases in  $t^*$  beneath the center of the Plain and beneath a portion of the array south of the Plain. The broad trend may be attributed to the positive correlation of attenuation with temperature and is in agreement with mantle velocity data (Saltzer and Humphreys, 1997). The increase to the north may signify increased water content possibly associated with Eocene magmatism. The sharp decreases may reflect partial melt wherein water is partitioned out of crystals into the melt thereby decreasing attenuation (Karato and Jung, 1998).

#### S61A-1103 0830h POSTER

##### Teleseismic tomographic images from the Deep Probe passive seismic arrays

Huaiyu Yuan<sup>1</sup> (yuan@uwyo.edu)

Ken Dueker<sup>1</sup> (dueker@uwyo.edu)

<sup>1</sup>Huaiyu Yuan, Dept of Geology and Geophysics Univ of Wyoming, Laramie, WY 82071

Tomographic images from the Deep Probe passive source experiment reveal remarkable lithospheric velocity structures beneath the Proterozoic and Archean provinces in Colorado, Wyoming and Montana. Two 400-km long line arrays were deployed to straddle the Cheyenne belt, a suture zone separating the Archean Wyoming and Proterozoic Colorado. Using multi-channel cross-correlation technique, about 5000 teleseismic P-wave times are picked from the two arrays. Summary rays are constructed to reduce the size tomographic system of equations and equalize ray path coverage, hence resolution. Our preliminary observations are: (1) A low velocity anomaly extends to 150 km depth beneath the 10 Ma Grand Mesa volcanic field in Western Colorado. (2) Dipping high velocity anomalies appear at 200-300 km depth beneath the Cheyenne belt. Dipping high velocity anomaly beneath the Cheyenne belt is also seen 200 km to the East, in the tomographic images from the CD-ROM experiment. Given the Cheyenne belt is a suture zone, these dipping high velocity anomalies may represent Proterozoic lithospheric segments embedded in the upper mantle after the 1.8 Ga collision of the Yavapai island arc terrane and the Archean Wyoming craton.

#### S61A-1104 0830h POSTER

##### Crustal and Lithospheric Structure of the Northern Apennines as Imaged by Teleseismic Receiver Functions

Giuliana Mele<sup>1</sup> (meleg@ingv.it)

Susumu Abe<sup>2</sup> (sabe@jgi.co.jp)

Eric Sandvol<sup>3</sup> (sandvole@missouri.edu)

<sup>1</sup>Istituto Nazionale di Geofisica e Vulcanologia, Via di Vigna Murata, 605, Roma 00143, Italy

<sup>2</sup>JAPEX Geoscience Institute, Inc., 1-5-21, Otsuka, Bunkyo-ku, Tokyo 112-0012, Japan

<sup>3</sup>Department of Geological Sciences, University of Missouri-Columbia, Columbia, MO 65211, United States

Teleseismic waveforms recorded by a regional linear array crossing the northern part of Corsica and the northern Italian Apennine chain have been used to compute and stack receiver functions. This technique allows us to isolate receiver-side PS conversions generated at the crust-mantle boundary and any major velocity discontinuity. The time delay between the direct teleseismic P wave and the PS phase converted at the Moho discontinuity is used to estimate the crustal thickness beneath each station of the array. We found crustal thickness from 20 to 25 km along the western portion of the array, which is consistent with the presence of a thinned crust beneath Tuscany. The eastern portion of the array is characterized by a significant dipping of the Moho discontinuity from the Adriatic coast of Italy, where it is found at about 30 km of depth, toward the Apennine chain. Beneath the Apennine chain the crust-mantle boundary is inferred at about 50 km of depth, indicating that the northern Apennines are at least in part supported isostatically.

In order to further constrain the geometry of the major lithospheric velocity discontinuities beneath northern Italy we have also employed and adapted a prestack and poststack time migration, extensively used in reflection seismology, to receiver function analysis, to image deconvolved SV-wave component, improving further the resolution of the receiver function profile. This technique has allowed us to image an apparent westward dipping high velocity body in the mantle lid beneath the northern Apennines. This body may represent the delaminating lithosphere that has previously been proposed for this region.

#### S61A-1105 0830h POSTER

##### Gravity Field Analysis and 3D Density Modeling of the Lithosphere Along the Dead Sea Transform

Hans-Juergen Goetze<sup>1</sup>

(hajo@geophysik.fu-berlin.de); Joerg Ebbing<sup>1</sup> (jebbing@geophysik.fu-berlin.de); Fabian Hese<sup>1</sup> (fabian@geophysik.fu-berlin.de); Tanja Kollersberger<sup>1</sup> (tanja@geophysik.fu-berlin.de); Sabine Schmidt<sup>1</sup> (sabine@geophysik.fu-berlin.de); Michael Rybakov<sup>2</sup> (rybakov@gii.co.il); Mohammed Hassouneh<sup>3</sup> (mhassouneh@geologie.uni-wuerzburg.de); Mohammed Hrahsha<sup>4</sup> (dirgen@nra.gov.jo); Radwan El Kelani<sup>5</sup> (elkelani@najah.edu); . DESERT Group

<sup>1</sup>Institut fuer Geologie, Geophysik und Geoformmatik, FU Berlin, Malteserstr. 74-100, Haus N, Berlin 12249, Germany

<sup>2</sup>The Geophysical Institute of Israel, P.O. Box 182,, LOD 71100, Israel

<sup>3</sup>Institut fr Geologie, Universitaet Wuerzburg, Pleicherwall 1, Wuerzburg 97070, Germany

<sup>4</sup>Natural Resources Authority, P.O. Box 7, Amman 11118, Jordan

<sup>5</sup>AN-NAJAH NATIONAL UNIVERSITY, P.O.Box. 7, Nablus 0000, Jordan

The gravity field of Dead Sea Rift / Dead Sea Transform was investigated with regard to the isostatic state, the crustal density structure of the orogeny and the rigidity of the lithosphere in the Central Arava Valley. Our multi-national and interdisciplinary gravity group with participants from the Geophysical Institute of Israel, the Natural Resources Authority (Jordan), and the An-Najah National University (Palestine), is aiming to study the crustal density structure, the isostatic state of the lithosphere and mechanical properties of the Dead Sea Rift system under the framework of the international DESERT program which is coordinated by the GeoForschungsZentrum (GFZ, Potsdam, Germany). The study area is located about 100 km away from both the basin of the Dead Sea and the Gulf of Elat/Aqaba basin, respectively. Between March and May 2002 some 800 new gravity observations were recorded at a local (Arava valley) and regional scale (along the DESERT seismic line). Station spacing in

the Arava valley was 100 - 300 m and in the nearest neighborhood of the fault 50 m only. The survey of detailed observations covered an area of 10 by 10 km and was completed by a likewise dense survey at the western side of the valley in Israel. All gravity data were tied to the IGSN -71 gravity datum and are terrain-corrected as well. The station complete Bouguer gravity field, Free air anomaly and residual isostatic anomalies (based on both Airy and Vening-Meinesz models) were merged with the existing regional gravity data bases of the region. Constraining information for the 3D density models at regional and local came from recent geophysical field data acquisition and consist of seismic, seismological, electromagnetic, and geologic studies which represent the integrated part of the interdisciplinary research program. Novel methods e.g. curvature techniques, and Euler deconvolution of the gravity fields shed new insight into the structure of upper and lower crust and the causing density domains. In particular the "dip-curvature" reveal a clear course of underground structures which could be linked to the Arava fault system with their pull-apart structures. The results of preliminary 3D density models which are constrained by the seismic refraction and reflection profile of the DESERT program and seismic tomography show a good correlation with the near surface velocity field in the area of the Arava fault and a slightly different picture of the Moho at a depth of interface which stemmed from refraction modeling along the DESERT profile.

#### S61A-1106 0830h POSTER

##### Shallow structure of the Arava fault (Dead Sea Transform) from seismic investigations

Nils Maercklin<sup>1</sup> (nils@gfz-potsdam.de); Amotz Agnon<sup>2</sup> (amotz@cc.huji.ac.il);

Christian Haberland<sup>1</sup> (493312881280;

haber@gfz-potsdam.de); Radwan El-Kelani<sup>3</sup>

(seiscen@najah.edu); Issam Qabani<sup>4</sup>

(mona.qa@yahoo.com); Georg Rumpker<sup>1</sup>

(rumpker@gfz-potsdam.de); Trond Ryberg<sup>1</sup>

(trond@gfz-potsdam.de); Frank Scherbaum<sup>5</sup>

(fs@geo.uni-potsdam.de); Michael H. Weber<sup>1</sup>

(mhw@gfz-potsdam.de); Albrecht Schulze<sup>1</sup>

(robert@gfz-potsdam.de); . DESERT Group<sup>1</sup>

(mhw@gfz-potsdam.de)

<sup>1</sup>GeoForschungsZentrum Potsdam, Telegrafenberg, Potsdam 14473, Germany

<sup>2</sup>The Hebrew University, Institute of Earth Sciences, Jerusalem 91904, Israel

<sup>3</sup>An-Najah University, Earth Sciences & Seismic Engineering Centre P.O.Box 707, Nablus, Palestine

<sup>4</sup>Natural Resources Authority, P.O. Box 7, Amman 11118, Jordan

<sup>5</sup>University Potsdam, Institute of Geosciences PO 601553, Potsdam 14415, Germany

The Dead Sea Transform (DST), stretching from the Red Sea to the Tauros-Zagros collision zone, is one of the world's major active continental shear zones, exhibiting a total slip of about 100 km within the last 20 Myr. In the southern part, the Arava fault (AF) is considered to be the main fault strand. Within the DESERT project, the structure of crust and upper mantle in the southern part of the transform was studied by a series of geophysical experiments. Latest seismic investigation was a small-scale high-resolution experiment (receiver distance: 5 m, source distance: 20 m) which provided detailed P wave velocity models (first-break tomography) and reflection images of the shallow subsurface structure (< 1000 m) along 8 one kilometre long profiles crossing the AF at a 10 km long segment. These images directly complement previous studies at larger scale and the analysis of explosion generated guided waves in the same area. We observe a strong cross-fault velocity contrast at depths greater than 1 km, with higher velocities east and lower velocities west of the fault (which we relate to the sedimentary basin fill). In the uppermost layers (< 100 m) the velocity images appear in part patchy, on some profiles the AF seems to distinguish domains with different velocities. Even in the high-resolution tomographic pictures we see no indication for a fault-zone related low-velocity zone, but guided waves suggest that at some segments the fault shows a very narrow subvertical low-velocity layer (< 20 m wide). Our results suggest that the uppermost part of the AF is characterized by a very narrow damage zone. This can be explained by the fact that the total slip within the DST system is/was distributed in space and time over several fault strands, resulting in a reduced slip on the currently active strand of the AF. Furthermore, the shallow velocity structure probably reflects the interaction of movement along the fault and the deposition of sediments.

## S61A-1107 0830h POSTER

## Density Structure of the Upper Mantle beneath North America

Walter D. Mooney<sup>1</sup> (mooney@usgs.gov)Mikhail K. Kaban<sup>1,2</sup> (kaban@gfz.potsdam.de)<sup>1</sup>US Geological Survey, 345 Middlefield Rd. MS 977, Menlo Park, CA 94025, United States<sup>2</sup>GeoForschungsZentrum, Telegrafenberg 16, Potsdam, 14473, Germany

We present a high-resolution density model for the lithosphere and upper mantle of North America and analyse its geodynamic and tectonic implications. This model is based on an integrated analysis of gravity, seismic refraction, seismic tomography, drill-hole, and geological data. The thickness of sedimentary cover was determined from geological maps, and the average density-depth relationship was estimated for each specific basin from published data. The density model of the consolidated crust (including Moho variations) is derived from seismic determinations. By removing the effect of the crust we calculate the residual mantle gravity anomalies and the residual topography arising from density inhomogeneities in the upper mantle. A joint analysis of these results with seismic tomography data leads to a 3D density model of the upper mantle under North America that is consistent with the residual gravity and produces a dynamic topography which is close to the residual one. The obtained density variations in the upper mantle under North America change significantly with depth. We conclude that they cannot be explained solely by variations in temperature but that a substantial part of the variation might be due to compositional differences. Under the Canadian Shield this difference is negative and is equal on the average to  $-40 \text{ kg/m}^3$ , which corresponds to a 1.2% depletion. The opposite compositional anomaly is found in the southern part of North America adjoining the Gulf of Mexico, and exceeds  $30 \text{ kg/m}^3$ . The origin of this anomaly is disputable.

## S61A-1108 0830h POSTER

## CRUST '02: A new global Model

Gary S. Chulick<sup>1,2</sup> (gschulick@mail.sxu.edu)Walter D. Mooney<sup>2</sup> (mooney@usgs.gov)Shane Detweiler<sup>2</sup> (shane@usgs.gov)<sup>1</sup>St. Xavier University, 3700 W. 103rd St., Chicago, IL 60655, United States<sup>2</sup>US Geological Survey, 345 Middlefield Rd. MS 977, Menlo Park, CA 94025, United States

Thorough knowledge of Earth's crustal structure is necessary for understanding continental evolution and other geological processes. We present a recently updated contour map of the thickness of the Earth's crust using a 10-km contour interval, and a 45-km contour. This contour map was created from over 5000 individual crustal data points that have been acquired from seismic surveys during the past 60 years. The contour map honors all available seismic refraction measurements for features with a dimension greater than 2 degrees. Crustal thickness in Eurasia, North America, and Australia is well constrained by seismic refraction data, while Antarctica, South America, Africa, and Greenland are less well constrained. To a first approximation, the continents and their margins are outlined by the 30-km contour. The part of the continental interior enclosed by the 40-km contour and regions with crustal thickness of 45 to 50 km are found on all well-surveyed continents. Continental crust with thickness in excess of 50 km is exceedingly rare and accounts for less than 10% of surveyed continental crust. These observations, now available on a global basis, provide important information to be used for numerous scientific studies.

URL: <http://quake.wr.usgs.gov/study/CrustalStructure/Nam>

## S61A-1109 0830h POSTER

## An Evaluation of Regionalized Models for Eurasia

Hrvoje Tkalcic<sup>1</sup> ((858) 822-5979; hrvoje@igpp.ucsd.edu)Gabi Laske<sup>1</sup> ((858) 534-8774; gabi@igpp.ucsd.edu)<sup>1</sup>Institute of Geophysics and Planetary Physics, UCSD, 9500 Gilman Dr., La Jolla, CA 92093-0225, United States

This study evaluates recently developed regionalized models of the crust and upper mantle for Western Eurasia and Northern Africa. Such models are typically used in the CTBT effort to improve event location in regions of political interest, to model wave propagation of regional phases and to correct seismic data for

the crustal contribution. We examine the SAIC model 1.0 (Bondar, 2000), the LLNL model MENA1.1 (Walter et al., 2000) and global crustal models CRUST5.1 (Mooney et al., 1998) and CRUST2.0 (Bassin et al., 2000). These models use a relatively limited number of crustal types to describe lateral variations in structure. We investigate the feasibility of using such simple models to represent crucial parameters of the true Earth, such as crustal and sediment thickness, without a great loss of accuracy. To test this, we use the 1x1 degree digital sediment thickness map of Laske and Masters (1997) and a newly compiled 1x1 crustal thickness map as references models. In general, we find good agreement between the crustal thickness reference map and the regionalized models MENA1.1 and SAIC1.0, but significant disagreement can occur in the sediment thickness. We also identify errors in CRUST5.1. We conclude that, in contrast to crustal thickness, sediment thickness cannot be categorized using tectonic setting or basement age as criteria. We also test how accurately the regionalized models predict seismic data. We compare model predictions with observed surface wave phase and group velocity maps. For each region categorized in the models, we examine histograms of the data and compare the average dispersion values with the model predictions. This comparison confirms that some regions require a change in the structure specified and/or an additional subdivision of this region. Some regions appear quite complex, perhaps inhibiting a simple regionalization altogether. Our results show that simple crustal models may oversimplify the structure of the real Earth which can lead to erroneous predictions of seismic data.

## S61A-1110 0830h POSTER

## A Re-Assessment of the Structure of the Southern Caspian Region From Teleseismic Receiver Functions

Katy Jane Raven<sup>1</sup> (+44 (0)1223 337182; raven@esc.cam.ac.uk)

Keith Priestley (+44 (0)1223 337195; keith@madingley.org)

<sup>1</sup>Cambridge University, Bullard Laboratories, Madingley Road, Cambridge CB3 0EZ, United Kingdom

We have made teleseismic receiver function measurements at two new broadband seismograph stations in Turkmenistan in the vicinity of the south Caspian basin, and analyze an enlarged data set for three of the seismograph stations previously considered by Mangino and Priestley (1998). The new data help better constrain the crustal structure across the region and provide a better azimuthal distribution of receiver function measurements to discriminate between dipping, isotropic structure and crustal anisotropy beneath each of the sites. Along the trend of the Apscheron-Balkhan Sill-Kopet Dag Mountains the crust is  $45 \pm 5 \text{ km}$  thick. There is moderately strong tangential energy on all sites along the northern front of the Kopet Dag. Where sufficient azimuthal coverage of receiver functions is available, the tangential energy appears to arise from shallow dipping structure striking WNW, in agreement with the structure of the Kopet Dag Mountains. If anisotropy is present in the crust at these sites, its signal is weak with respect to that of the dipping interfaces. Receiver function analysis of data from one new site in the Turkmenian Lowlands confirms that the crust in this region is about 35 km thick.

## S61A-1111 0830h POSTER

## BEST: Baikal Explosion Seismic Transect

Hans Thybo<sup>1</sup> (ht@seis.geol.ku.dk); Mai-BrittJensen<sup>1</sup>; Andrew R Ross<sup>1</sup> (ross@seis.geol.ku.dk); Vladimir Suvorov<sup>2</sup>; Alexander Emanov<sup>3</sup>; Victor Seleznev<sup>3</sup>; Victor Soloviov<sup>3</sup>; Gennadi Tatkov<sup>4</sup>; Edward Perchuc<sup>5</sup><sup>1</sup>Geological Institute, University of Copenhagen, Oester Voldgade 10, Copenhagen DK-1350, Denmark<sup>2</sup>Institute of Geophysics, Russian Academy of Sciences- Siberian Branch (RAS-SB), Prospect Koptuga 3, Novosibirsk 630090, Russian Federation<sup>3</sup>Geophysical Survey (RAS-SB), Prospect Koptuga 3, Novosibirsk 630090, Russian Federation<sup>4</sup>Geological Survey of the Buryat Province, Sakhyanova Str 6A, Ulan Ude 670047, Russian Federation<sup>5</sup>Geophysical Institute, Polish Academy of Sciences, Ks. Janusza 64, Warsaw PL-01452, Poland

The Baikal Explosion Seismic Transect is composed of two deep seismic profiles: one across the Baikal Rift Zone at the southern end of Lake Baikal and a second profile along the axis of the rift into the Tunga depression. The main field project was carried out in October 2003 after a pilot project (BASE) in September 2002. Our primary goal is the study of the detailed

crustal and upper mantle seismic velocity structure beneath the rift zone. The two profiles are: (1) a 350 km long, NS-trending profile across the rift zone from Kyakta at the Mongolian border to Chermhovo north of Lake Baikal, and (2) a 300 km long EW-trending profile along-strike of the rift zone at the northern shore of the lake into the Tunga depression to Mondy at the Mongolian border. The primary seismic sources are 10 explosions in boreholes, ranging from 500 kg to 3 tonnes of dynamite supplemented by airgun shots in the lake (100 l airguns volume), and a supervibrator, located at Babushkin at the cross point between the two profiles on the shore of the lake. The data was recorded by 150 portable REFTEK Texan vertical component recorders which were rolled along to give station spacings of 650m. The primary targets of the BEST project are: (1) the crustal velocity structure, with primary attention to the graben geometry; (2) the propagation properties of seismic waves in the area; (3) the amount crustal thinning across the rift zone; (4) seismic Pn wave velocity to identify possible weak zones in the uppermost mantle and (5) relative seismic reflectivity outside and underneath the rift zone. This last aim is to identify locations of major magmatic intrusions into the lower crust and test if there is a correlation to volcanic activity at the surface. The poster will present examples of the new data with modelling results of seismic velocity, together with discussion of the implications regarding magmatism in the lower crust.

## S61A-1112 0830h POSTER

## A Waveform-based Method for Interpreting SKS Splitting Observations

William Menke<sup>1</sup> (854-365-8438; menke@ldeo.columbia.edu)Vadim Levin<sup>2</sup> (854-365-8557; vadim@ldeo.columbia.edu)<sup>1</sup>Lamont-DOherty Earth Observatory of Columbia University, 61 Rt 9W, Palisades, NY 10964, United States<sup>2</sup>Department of Geology, Rutgers University, Wright Geological Laboratory, 610 Taylor Rd., Piscataway, NJ 08854, United States

We present a new method for determining anisotropic earth models using observations of split shear waves (such as SKS). The method consists of first constructing two timeseries,  $x(t)$  and  $y(t)$ , that contain information about both the observed seismograms and a hypothetical earth model, and then varying the earth model so as to minimize the misfit,  $e(t) = x(t) - y(t)$ . The timeseries are defined by the rules,  $x(t) = h(m,t) * V(t)$  and  $y(t) = v(m,t) * H(t)$ , where  $V(t)$  and  $H(t)$  are the observed radial-horizontal and tangential-horizontal component seismograms, respectively,  $v(m,t)$  and  $h(m,t)$  are the radial-horizontal and tangential-horizontal impulse responses, respectively, predicted by some earth model,  $m$ . Here  $*$  denotes convolution. The best-fitting earth model is the one that minimizes an amplitude-normalized L2 norm of  $e(t,m)$  with respect to  $m$ . This definition of misfit is insensitive to the source wavelet, and thus eliminates that unknown quantity from the problem. We show that this method yields estimates of one-layer splitting parameters that are very similar to those achieved through traditional means, but that unlike those traditional methods it can be applied to more complicated modes (e.g. multi-layer anisotropy) without recourse to approximate "apparent splitting" parameters. We apply the method to synthetic SKS pulses generated for two-layer anisotropic earth models, and show that it can successfully recover information about both layers. We then apply the method to SKS and PKS data from PFO (Pion Flat, California) on the San Andreas fault. This station has been studied previously by Ozalaybey and Savage (1995) and Liu et al. (1995), who provide two-layer solutions based on modeling of the azimuthal variation of apparent splitting parameters. Our results are broadly consistent with theirs, but provide additional information about the statistical significance of the two-layer solution. By this measure, neither solution is significantly better than a one-layer solution, although both fit the waveform data better than the best-fitting one layer solution. This result is consistent with the interpretations of both Ozalaybey and Savage (1995) and Liu et al. (1995), who provide similar assessments of the their two-layer solutions. The fact that neither our one-layer nor two-layer solutions does very well at reducing the overall misfit strongly suggests that some process other than anisotropy is affecting SKS and PKS waveforms at PFO.

URL: <http://www.ldeo.columbia.edu/users/menke/EAP/>

## S61A-1113 0830h POSTER

## Seismic Structure of the Lithosphere in the Southwestern United States Using Receiver Functions

David C Wilson<sup>1</sup> (505-835-5691; davew@nmt.edu); Richard Aster<sup>1</sup> (aster@ees.nmt.edu); James Ni<sup>2</sup> (jni@nmsu.edu); Stephen Grand<sup>3</sup> (steveg@speer.geo.utexas.edu); Mike West<sup>2</sup> (west@nmsu.edu); Rengin Gok<sup>2</sup> (rgok@nmsu.edu); Wei Gao<sup>3</sup> (gao@speer.utexas.edu); John Schlue<sup>1</sup> (schlue@ees.nmt.edu); Scott Baldrige<sup>4</sup> (sbaldrige@lanl.gov); Steve Semken<sup>5</sup> (ssemken@shiprock.ncc.cc.nm.us)

<sup>1</sup>New Mexico Institute of Mining and Technology, Department of Earth and Environmental Science, Socorro, NM 87801, United States

<sup>2</sup>New Mexico State University, Department of Physics (MSC 3D), Las Cruces, NM 88003, United States

<sup>3</sup>University of Texas, Austin, Department of Geological Sciences, Austin, TX 78712, United States

<sup>4</sup>Los Alamos National Laboratory, EES-1, Los Alamos, NM 87545, United States

<sup>5</sup>Dine College, Division of Natural Sciences, Shiprock, NM 87420, United States

We examine the seismic structure of the lithosphere in the southwestern United States using receiver functions calculated from teleseismic arrivals recorded in the LA RISTRA (Colorado Plateau, Rio Grande Rift, Great Plains Seismic Transect) experiment. LA RISTRA was a 950 km-long PASSCAL broadband seismic line with approximately 18 km station spacing deployed during 1999-2001 along a great circle from Lake Powell, UT to Pecos, TX. The NW-SE trending network was approximately parallel to the regional Proterozoic continental accretionary gradient, and oblique to the predominantly N-S trend of faulting during Laramide compression and Cenozoic extension and rifting. We estimate Phanerozoic sedimentary layer velocities and average crustal thickness and Vp/Vs ratios using both direct and reverberated P-to-S converted modes, in concert with pre-existing refraction and other data. Crust and uppermost mantle discontinuity structure along the array is imaged by migrating receiver functions to produce a P-to-S converted mode image of the subsurface.

The average sedimentary layer Vp/Vs ratio along La Ristra is 2.0-2.1, with the exception of the San Juan basin which has a Vp/Vs ratio of approximately 2.3. This spatial distribution of sedimentary Vp/Vs ratios correlates with the median geologic age of the sediments (Paleozoic in the Great Plains and Colorado Plateau, and Mesozoic in the San Juan Basin). Basins generate very significant multiples that must be carefully considered along with independent shallow crustal constraints to avoid artifacts in the crust and upper mantle. Average crustal Vp/Vs ratios range from approximately 1.73 in the Great Plains, up to 1.77 in the Rio Grande Rift, and have an average value of 1.75 in the Colorado Plateau. We find that crustal thickness in the Great Plains ranges from 47 km to 54 km with thickness changes of up to 7 km over lateral distances of 100 km. Crustal thickness diminishes to a minimum of 34 km in the center of the Rio Grande Rift. Crustal thickness beneath the Colorado Plateau ranges from 46 km to 50 km with thickness changes of up to 4 km over lateral distances of 100 km. While the direct converted Moho phase beneath the Rio Grande Rift appears to be a single distinct phase, beneath the Colorado Plateau and Great Plains it appears to be more complex, suggesting either lower crustal layering or gradational Moho.

URL: <http://www.ees.nmt.edu/Geop/Ristra/ristra.html>

## S61A-1114 0830h POSTER

## Shear Wave Splitting and Mantle Flow Beneath the RISTRA Array

James F. Ni<sup>1</sup> (505-646-1920; jni@nmsu.edu)

Rengin Gok<sup>1</sup> (rgok@nmsu.edu)

Eric Sandvol<sup>2</sup> (sandvol@missouri.edu)

<sup>1</sup>Department of Physics, MSC 3D New Mexico State University, Las Cruces, NM 88003, United States

<sup>2</sup>Department of Geological Sciences, University of Missouri, Columbia, MO 65211, United States

Data from LA RISTRA (Colorado Plateau/Rio Grande Rift/Great Plains Seismic Transect) array, a linear array from the Great Plains (GP) through the Jemez Lineament (JL) and the Rio Grande Rift (RGR) to the Colorado Plateau (CP), are used to determine polarization anisotropy beneath these regions. The results allow us to study mantle deformation, and help to constrain mantle flow beneath the RGR and surrounding regions. The seismic anisotropy beneath the RGR, JL and adjacent regions shows a remarkably consistent

pattern with a mean fast direction of about  $40^\circ \pm 6^\circ$  and large delay time of  $1.4 \pm 0.2$  seconds. The uniform NE-SW trend of fast split SKS and SKKS waves that traverse the upper mantle beneath the Rio Grande Rift and adjacent regions is oblique to the Rio Grande Rift axis but sub-parallel to the North American absolute plate motion ( $\sim 62^\circ$ ). A low velocity zone, presumably hot upwelling mantle down to 250 km, underlies this region. Geological data suggest that the lithosphere is thin beneath the RGR and adjacent regions, thus, the anisotropy resides predominantly in the asthenosphere. The observation also argues against an E-W uniform extensional origin for the formation of the RGR. The differential horizontal motion between the North American lithosphere and westerly flow of the asthenospheric mantle best explains seismic anisotropy below the lithosphere. The approximately N-S fast direction found beneath western Texas is similar to that observed beneath the southern RGR. The difference in fast direction between northern and southern RGR can simply be explained by a larger magnitude westerly flow (in the hot spot reference frame) of the asthenosphere beneath the southern RGR. Our results show that the interior of the CP is where lithospheric anisotropy can be significant.

## S61A-1115 0830h POSTER

## Mantle Dynamics Beneath the Rio Grande Rift and Colorado Plateau.

Wei Gao<sup>1</sup> (gao@maestro.geo.utexas.edu); Stephen

Grand<sup>1</sup> (512-471-3005;

steveg@maestro.geo.utexas.edu); Mike West<sup>2</sup>

(west@nmsu.edu); Rengin Gok<sup>2</sup>

(rgok@nmsu.edu); Jim Ni<sup>2</sup> (ni@nmsu.edu); Dave

Wilson<sup>3</sup> (davew@dutchman.nmt.edu); Rick Aster<sup>3</sup>

(aster@dutchman.nmt.edu); John Schlue<sup>3</sup>

(schlue@dutchman.nmt.edu); Scott Baldrige<sup>4</sup>

(sbaldrige@lanl.gov); Steve Semken<sup>5</sup>

(ssemken@shiprock.ncc.cc.nm.us)

<sup>1</sup>Dept. of Geological Sciences, University of Texas, Austin, TX 78712, United States

<sup>2</sup>Dept of Physics , New Mexico State University, Las Cruces, NM 88003, United States

<sup>3</sup>Dept of Earth and Environmental Sci and Geophysical Research Center, New Mexico State University, Socorro, NM 87801, United States

<sup>4</sup>Los Alamos National Laboratory, EES-1, Los Alamos, NM 87545, United States

<sup>5</sup>Dine College, Division of Natural Sciences, Shiprock, NM 87420, United States

We have inverted P and S wave teleseismic delay times recorded by the LA RISTRA (Colorado Plateau, Rio Grande Rift, Great Plains Seismic Transect) array. The RISTRA array consisted of 57 broad band seismic stations most of which were deployed in a line extending 950 km from Lake Powell, Utah to Pecos, Texas. P, PKP, S, and SKS travel time delays were inverted using the LSQR algorithm to determine lateral variations in seismic velocity to about 600 km depth beneath the line. The small station spacing along the line as well as its great length result in a well resolved image of the mantle beneath the line. Within the upper 200km of the mantle slow seismic anomalies are obvious beneath the Rift with the slowest anomalies beneath Mt Taylor on the west of the Rift and Carrizozo near the east of the rift. The mantle beneath the Great Plains and Colorado Plateau is seismically faster than within the Rift but within each of the other two provinces, there are significant variations. In particular, the eastern edge of the Colorado Plateau has faster seismic wavespeeds than in the center of the Plateau (near the four corners region) and the western edge of the Great Plains shows a narrow (about 75 km wide) fast structure that is faster than the mantle further to the east in the Great Plains. These fast mantle anomalies in the upper 200 km of the mantle at the edges of the Rift may represent rifting and volcanism that has been removed from the Rift region. Alternatively, if the fast mantle anomalies are more ancient, they may provide structural control on where rifting and volcanism have occurred.

## S61A-1116 0830h POSTER

## Structure of the Uppermost Mantle Beneath the RISTRA Array From Surface Waves

Michael West<sup>1</sup> (west@nmsu.edu); James Ni<sup>1</sup>

(jni@nmsu.edu); Dave Wilson<sup>2</sup>

(davew@ees.nmt.edu); Rick Aster<sup>2</sup>

(aster@dutchman.nmt.edu); Steve Grand<sup>3</sup>; W

Gao<sup>3</sup>; Rengin Gok<sup>1</sup>; Scott Baldrige<sup>4</sup>; Steve

Semken<sup>5</sup>; John Schlue<sup>2</sup>

<sup>1</sup>New Mexico State University, Physics Department, Las Cruces, NM 88003

<sup>2</sup>New Mexico Institute of Mining and Technology, Earth and Environmental Science Department, Socorro, NM 87801

<sup>3</sup>University of Texas, Austin, Department of geologic sciences, Austin, TX 78712

<sup>4</sup>Los Alamos National Laboratory, EES-1, Los Alamos, NM 87545

<sup>5</sup>Dine College, Division of Natural Sciences, Shiprock, NM 87420

The RISTRA array extends from the Colorado Plateau across the Rio Grande Rift into the Great Plains. We explore the state of the uppermost mantle beneath these three distinct geologic provinces to understand how the lithosphere and asthenosphere are related to the tectonic evolution of these regions. 57 three-component broadband seismometers of the RISTRA array provided teleseismic and regional waveforms sampling the crust and upper mantle beneath the array. Rayleigh wave phase velocities for each region are obtained by stacking Fourier spectra for many stations and events to find the optimum slant stack velocity. Groups of stations are used to calculate lateral variations in phase velocity for periods of 7 to 150 seconds. The surface wave velocities are inverted for shear velocity structure using crustal constraints from receiver functions and mantle constraints from teleseismic tomography. The velocity structure beneath the Great Plains is similar to what is observed in cratonic shields. The interior of the Colorado Plateau has anomalously low shear wave velocities below 100 km. The velocities are up to 5% lower than at comparable depths beneath the Great Plains, suggesting that a warm mantle may be responsible for the observed uplift across the plateau. Near the Rio Grande Rift in the central part of the array we find a broad region of slow and presumably hot mantle immediately beneath the Moho extending to depths of at least 200 km. Shear velocities in the uppermost mantle are decreased by 8% under the rift. High temperatures are the most likely explanation for the low shear velocities. To explain these velocities requires temperatures that are elevated by several hundred degrees relative to adjacent regions. A strong gravity low across the rift, despite thin crust, is further evidence for hot mantle. The decrease in viscosity that accompanies high temperatures is incompatible with a thick lithosphere. We suggest that the mantle lithosphere beneath the Rio Grande Rift is thinned to a few tens of kilometers. The assertion of thin lithosphere is consistent with independent petrologic and shear wave splitting results.

URL: <http://www.geophysics.nmsu.edu/west/RI>

## S61A-1117 0830h POSTER

## Overprint of Basement-Fault Reactivation in Flexural Deformation and Deposition in the Blountian (Taconic) Peripheral Foreland Basin

German Bayona<sup>1</sup> (gbayona2@uky.edu)

William A. Thomas<sup>1</sup> (geowat@uky.edu)

<sup>1</sup>University of Kentucky, Department of Geological Sciences, Lexington, KY 40506, United States

In peripheral foreland basins, coeval drowning and exposure of different parts of the former platform and variations in stratal architecture have been attributed mainly to tectonic and depositional loading along the collisional margin. Here, we document how pre-existing structures in the continental margin and interior affect foreland-plate relief, as well as deposition, diagenesis, and composition of distal and proximal foreland strata. Stratigraphic correlations, using a bentonite-traptolite-conodont time framework and a palinspastic map, document an early episode of basement-fault inversion in the distal foreland, and heterogeneous subsidence and provenance patterns in the middle and proximal foreland. Abrupt variations in depth of erosion of passive-margin strata and in thickness of distal foreland deposits coincide with the boundaries of the intraplate Birmingham graben. Inversion of the former graben (1) increased the magnitude of erosion on new upthrust blocks; (2) increased tectonic subsidence in adjacent blocks; (3) supplied chert and quartz detritus to shallow-marine carbonate depocenters; and (4) facilitated influx of meteoric water to aquifers in shallow-marine carbonate deposits. Tectonic subsidence of middle foreland deposits reflects local irregularities in the foredeep associated probably with reactivation of transverse basement faults (TBF). Middle foreland synorogenic clastic deposits are thicker in the Tennessee embayment of the Laurentian margin than in the Alabama promontory. Differential subsidence between embayments and promontories may cause reactivation of TBF, and relief produced by reactivation of TBF may provide sources for local conglomerates interbedded with deep-water shales. Along-strike differences in orogenic-belt deformation are reflected in sandstone composition of the proximal clastic wedge. Provenance of sand-size detritus suggests deeper erosion of the orogenic belt in areas adjacent to the promontory than in areas adjacent to the embayment. Results of this study reveal the importance of considering the effects of pre-existing structures in the interpretation of along- and across-strike variations of foreland strata, and the need to include pre-existing structures in the analysis and geodynamic modelling of foreland basins and associated orogenic belts.