Upper mantle seismic structure beneath Southern Africa determined from SH body waveform inversion

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ABSTRACT

We present new one-dimensional (1-D) shear (SH) wave velocity models of the upper mantle beneath Southern Africa obtained from waveform inversion of triplicated seismic phases sampling from 38 to 871 km depth. The seismic waveform data produced by Mw=5.9 and Mw=5.8 earthquakes located near Lake Tanganyika in East Africa were recorded by the IRIS Kaapvaal passive array at distances of 12.1° to 28.7° sampling eastern- and central Southern Africa and by Africa Array stations at distances of 9.1° to 26.1° sampling western Southern Africa, respectively. For eastern Southern Africa we find a zone of high velocity which extends down to ~130 km depth. Below this zone velocity decreases to a minimum near 220 km depth. For central and western Southern Africa the high velocity within the lid is slightly lower than to the east and velocity also decreases below this zone to a minimum near 220 km depth. Velocity is significantly lower beneath western Southern Africa relative to the east to about 340 km depth. Lithosphere thickness and shear velocity below the western seismic lid are lower than found beneath other cratons. Our velocity models support the hypothesis put forward by Nyblade and Sleep (2003) of upper mantle buoyant support for the "African Superswell". We determine a thickness of 250 km for the mantle transition zone below the whole of Southern Africa which is similar to the global average but the velocity gradient is steeper than in standard global models (PREM and IASPEI) for the transition zone. We also find larger velocity jumps across both the 410 and 660 km discontinuities than in global models. Our results indicate upwelling from the "African Superplume" may affect the mantle transition zone although an alternative explanation is that the transition zone seismic structure in global reference models needs to be refined.

Key words: African Superswell, Upper mantle, Shear wave, Velocity model, Inversion.

PRESENTER'S BIOGRAPHY

Martin B. C. Brandt has been working at the Council for Geoscience since 1993 as a Seismologist in seismological mapping and data interpretation from the South African National Seismograph Network and Local Networks at large dams and sites of future nuclear power plants. This includes analysis of the spatial/temporal distribution and size of earthquakes, active fault/seismotectonic province delineation, and deterministic large reservoir induced seismic hazard analysis. Martin is also involved in regional velocity model calibration for the CTBTO and compiled the catalogue of historical earthquakes for Southern Africa for the period 1620 to 1970. He is currently busy with a part time Ph.D. at the University of the Witwaterstand / University of Texas at Austin in mantle tomography and upper mantle imaging under Southern- and Eastern Africa.

Improving models of the upper mantle beneath Australia: making use of an evolving large scale deployment

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ABSTRACT

Over a number of years there have been many temporary deployments of broadband seismometers, with station spacing varying from 400 to 25 km, within the Australian continent. In the mid 1990s, the SKIPPY experiment provided reasonable coverage across the whole continent. Subsequently, deployments have tended to be focused on particular regions, e.g., in the Kimberley (97-98), Western Australia (2000-) and around the expected location of the Tasman Line (2004-05). Data from these, and other, sites have been used in a number of different studies investigating the 3D seismic structure beneath the continent. This study will look at the development of surface wave models of the uppermost mantle and how they have changed as additional information has become available from newer deployments.

The location of the mantle component of the "Tasman Line", often muted as the boundary between the Precambrian west of the continent and the Phanerozoic terranes in the east, is a useful example of the evolution of the tomographic model. Early models, with good path coverage through the region, showed a broadly north-south running transition from fast shear wavespeeds in the west to slower wavespeeds in the east. However, the addition of data, from stations specifically located to investigate the structure in this region, suggests that the transition is more complicated. A series of steps in the wavespeed structure is seen, illustrating a structure comparable to that observed beneath the Trans-European Suture Zone. The new models highlight the importance of station coverage, as opposed to simple path coverage, in order to recover the detailed structure.

Within the Australian lithospheric mantle the seismic velocity profile is not compatible with a simple model of constant composition and a cratonic geotherm. Intriguingly this complexity has been observed in a number of recent studies of old continental lithosphere. From the present surface wave tomography there is a limitation in the potential resolution, both laterally and vertically due to the choice of period most suitable to the inversion technique. It is, therefore, particularly important to combine data from different types of seismic studies; data at shorter period will provide more information on crustal structure and improve resolution in the anomalous region just below the Moho. Furthermore, recent deployments with close station spacing, and the use of array techniques, lead to the potential of higher resolution studies. Developing methodologies to integrate this range of information, and to test physically plausible models, is one of the challenges that lie ahead.

Key words: Upper mantle, Temporary broadband deployment, Tomography, Australia, Lithosphere

PRESENTER'S BIOGRAPHY

Stewart Fishwick completed a PhD at the Research School of Earth Sciences, Australian National University in 2005, then following a post-doctoral position (2006-2007) at the University of Cambridge (UK), took up a New Blood Lectureship in Geophysics at the University of Leicester (UK) in October 2007.

Crustal Seismic Anisotropy and Stress Field in North China

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ABSTRACT

Seismic anisotropy is widely observed in the Earth's crust, mantle and core. Compared with mantle anisotropy and core anisotropy, crustal anisotropy shows in general greater complexity due possibly to short wavelength structural and stress variations within a thin crustal layer. Information about crustal anisotropy, however, is important in interpretations of various observations of crustal activities. Shear-wave splitting is an efficient tool in studies of seismic anisotropy. This study adopted the data from the Capital Area Seismograph Network (CASN), the largest regional seismograph network in China. The CASN was set up in Capital Area of China in 1999 and started to run from 1 October 2001. CASN consists of 107 seismograph stations and is the largest, most closely-spaced regional seismograph network in Chinese mainland, with 500 *km* east-to-west, 400 *km* north-to-south and an average of 40 *km* station-to-station separation. We used the waveform data of CASN to study seismic anisotropy in the crust in *North China*. We determined the *PFS* (polarization of fast shear-wave), a parameter of shear-wave anisotropy, with small crustal earthquakes (from January 2002 to August 2005) by limiting their focal depths below 5 km to reduce influence of the uppermost a few km of the crust. The *PFS* orientations are remarkably uniform, almost parallel to the E-W direction (NE86º ±41º in average and standard deviation), over the whole study area of about 500×400 km^2. We interpret this result as a consequence of general E-W alignment of opening planes of cracks within the crust in response to the regional compressive stress in the E-W direction. The inferred stress field is consistent with the results of focal mechanism studies, drilling-based analyses and GPS measurements. This study obtains the regional distribution of principal compressive stress in the capital area by the analysis of shear-wave splitting. It is a new idea to obtain stress field in crust by seismic anisotropy with a dense regional seismograph network. (Grateful to support by NSFC grant 40674021)

Key words: seismic anisotropy, shear-wave splitting, crust, North China, Seismograph Network

PRESENTER'S BIOGRAPHY

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Research interests: Seismic anisotropy in the crust and in the mantle; Deep Earth structure from seismic wave; Seismic source and seismicity.

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Investigation of active plate boundaries using large temporary seismic arrays equipped with GIPP instruments

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ABSTRACT

In the last years large effort has been made to set up instrument pools consisting of a large number of portable seismic instruments for active and passive seismic experiments aiming to study the Earth's structure and the ongoing geological processes. As one of these pools, the Geophysical Instrument Pool (GIPP) was installed at the German Research Centre for Geosciences (GFZ) and currently provides more than 350 portable seismic stations equipped with broad-band seismographs, short-period geophones or magnetotelluric sensors. In the past these stations were installed in more than 200 geophysical experiments covering a wide variety of scales and geographical regions.
The GIPP is not primarily dedicated to a particular geographical region. However, successively installed temporary deployments of GIPP stations have formed regional-scale networks at the South-American active continental margin and in the Middle East. The instruments can be used in active as well as in passive seismic investigations allowing to study the geological structure with different, concerted experiments. The studies cover a wide range of scales and include regional upper mantle studies as well as high-resolution investigations of the continental crust.
In 2005, two large, dense, amphibious, temporary seismic networks consisting of 180 seismic stations were set up in Southern Chile to study the structure of the subduction zone at a regional scale. In this collaborative and international project local earthquake tomography, moment tensor inversion and receiver function analysis together with reflection/refraction experiments, magnetotelluric investigations and geological studies were used to reveal the structure of the seismogenic zone in the nucleation area of the giant 1960 earthquake. In northern Chile, southern Bolivia and northern Argentina a set of several temporary seismic arrays deployed in the last decade (number of simultaneously recording instruments ranged between 25 and 50) formed a regional network which allowed to study the deeper structure of the recent magmatic arc, the high Altiplano-Puna plateau and the seismogenic zone. in each case, more than 20,000 P- and S-wave observations of several hundred local earthquakes formed the base for the local tomographic studies. The derived velocity images, particularly the distribution of vp/vs, show distinct anomalies which are related to the variations of the tectonic setting along the subduction zone. The tomographic inversion reveal a rather thick forearc crust in southern Chile suggesting a wide contact zone between the upper and lower plate. Moreover, significant trench-parallel variations in the structure of the forearc and the mantle wedge exist between north and south.

Key words: Temporary seismic network, instrumentation, active continental margin

PRESENTER'S BIOGRAPHY

Christian Haberland is a senior scientist at the German Research Centre for Geosciences (GFZ) in Potsdam, Germany. He graduated in 1993, and received his PhD from the Free University of Berlin in 1999 with a study of the seismic attenuation derived from local earthquake data from South America. During a research stay at the GFZ he was involved in a series of controlled source experiments in Jordan and Israel studying the structure of the Dead Sea Transform. At Potsdam University he was in charge for a large seismic deployment in Southern Chile. His recent research interest include the structure of and processes at active continental margins using local earthquake tomography and active seismic investigations. Currently, he is responsible for the German Geophysical Instrument Pool.

Strategy of receiver function tomography: retrieve of velocity contrasts and configurations of velocity discontinuities

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ABSTRACT

Over the Japan Islands, the nation-wide seismic networks have been developed and a large number of high-density short-period and broadband seismic instruments have been installed. We have investigated fine structures of velocity discontinuities in the crust and the upper mantle beneath the Japan Islands using receiver function (RF) analyses of teleseismic waveforms obtained at these dense stations. Stacked images of depth-transformed RFs have clearly revealed the top of the slab, the oceanic Moho and partly the bottom of the slab for the subducting Pacific slab in northeast (NE) Japan (e.g. Tonegawa et al, 2006) and for the Philippine Sea slab in southwest (SW) Japan (e.g. Yamauchi et al., 2003). These results of RF image, however, may be distorted depending on the assumed reference model, which is usually 1-D model different from the actual 3-D velocity structure. Therefore, we proposed RF tomography which combines the local travel time tomography method with RF analyses to aim at obtaining both fine structures of 3-D velocities and the configuration of velocity discontinuities (Hirahara, 2006). In fact, in Japan, there have existed a number of tomographic 3-D velocity models with or without velocity discontinuities. Even if velocity discontinuities are included in the models, their configurations are a priori assigned but are not estimated through inversion, which may lead to false velocity structures. This is why we should develop RF tomography, adding information on waves converted (or reflected) at velocity discontinuities.

In this study, we present the detailed strategy of RF tomography. Especially, we show how to reconstruct the velocity discontinuity structures sandwiched by 3-D smoothly varying velocity layers using synthetic examples. Our model consists of several layers with 3-D smoothly varying velocities divided by velocity discontinuities with 2-D configurations. RF tomography estimates both the velocity values at 3-D grids in each layer and the depths of velocity discontinuities at 2-D grids. In the model, velocities and discontinuity depths are interpolated with 3-D and 2-D spline functions. Referring to the published 3-D structures in the crust and the upper mantle including the subducting Pacific slab in NE Japan, we synthesize RFs based on Gaussian Beam method that is faster than numerical methods such as FD. In the experiments, starting from the smooth 3-D velocity model without velocity discontinuities, we try to retrieve the velocity discontinuity structures through non-linear fitting of the synthesized waveforms of observed RF. In these experiments, assuming the 3-D velocity structure in each layer is already obtained through a local travel time tomography and fixing 3-D velocity structures except for structures around the discontinuity boundary region in each layer, we show how to retrieve the velocity contrasts and the configuration of the velocity discontinuities such as the slab top, the oceanic Moho and the slab bottom. Based on comparison of these experiments with the observed RFs, we discuss the physical meanings of the complex velocity structures around the velocity discontinuities.

Key words: Receiver function, Travel time tomography, 3-D velocities, Velocity discontinuities, Slab

PRESENTER'S BIOGRAPHY

1981: Ph.D. Graduate School of Science, Kyoto University: Title 'Three-dimensional seismic structure beneath the Japan islands –the subducting Pacific and Philippine Sea plates-'

1983-1989: Researcher at Disaster Prevention Research Institute, Kyoto University: involved in seismic tomography and crustal deformation studies using GPS

1989-1996: Associate Professor at Disaster Prevention Research Institute, Kyoto University: involved in GPS studies including GPS meteorology and J-Array project

1996-2005: Professor at Graduate School of Science, Environmental Studies, Nagoya University: involved in receiver function analyses and numerical simulation of earthquake cycles

2005- : Professor at Graduate School of Science, Kyoto University: involved in numerical simulation of earthquake cycles, especially the Nankai trough great earthquake cycles, and receiver function tomography study

Seismic Structure and Geodynamic Evolution of the Lithosphere and Upper Mantle in the Pannonian - Carpathian Region

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ABSTRACT

The Pannonian Basin is the largest of a group of Miocene-age extensional basins within the arc of the Alpine-Carpathian Mountain Ranges. These basins are extensional in origin, but the surrounding Carpathians result from sustained convergence during and since the period of active extension. A significant part of the mantle lithosphere here has been replaced, as gravitational instability caused an overturn of the upper mantle. The Carpathian Basins Project (CBP) is a major international broadband seismology experiment, supported by geodynamical modelling and designed to improve our understanding of the structure and evolution of the lithosphere and upper mantle beneath the Pannonian and Vienna Basins. Between 2005 and 2007 we deployed 56 portable broadband seismic stations in Austria, Hungary and Serbia, spanning the Vienna Basin and the western part of the Pannonian Basin. Arrival time residuals from teleseismic earthquakes are delayed by about 0.8 sec in the Vienna Basin and early by a similar amount in southwest Hungary. Tomographic inversion of the travel time residuals shows relatively fast P-wave velocities in the upper mantle beneath the western Pannonian Basin and slow P-wave velocities beneath the West Carpathians. Seismic anisotropy (SKS) measurements reveal an intriguing pattern of lithospheric anisotropy: in the north-west the fast direction is generally elongated EW, perpendicular to the shortening direction across the Alps. Across the Vienna Basin the fast direction is NW-SE, perpendicular to the major bounding fault systems. Across the Pannonian Basin the dominant fast direction is EW, but in several locations the vectors are rotated toward NW-SE. The Mid-Hungarian Line, a major strike-slip structure already clearly identified in the gravity field, also is associated with abrupt changes in the azimuth of lithospheric anisotropy, and crustal receiver function signature. The object of these investigations is to use the seismic data to discriminate between different models for how this orogenic system evolved. In support of this aim we are developing 2D and 3D mechanical models of lithospheric deformation driven by boundary stresses and gravitational instability of the mantle lithosphere.

Keywords: Seismic Tomography, Seismic Anisotropy, Extensional Basin

PRESENTER'S BIOGRAPHY

Greg Houseman is a graduate of the University of Sydney, and gained his PhD at the University of Cambridge in 1982. He has worked at Harvard University, the Australian National University, and Monash University in Melbourne and, since 2001, is Professor of Geophysics in the School of Earth and Environment at the University of Leeds. His research interests revolve around the quantification of lithospheric-mantle interaction and the application of seismic tomography in revealing structure of lithosphere and upper mantle. He is currently a Vice-President of IASPEI.

Integrative model of the European lithosphere

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A new integrative model of the European lithosphere has been constructed based on the analysis of several data sets, which are principally improved compared to previous studies.One of the data sources is EuCRUST-07, a new 3D crustal model, which is based on several hundred seismic profiles and receiver functions results. This model is used to determine crustal parameters and lithology and offers a starting point in any kind of numerical modeling, which has to resolve a trade-off between crustal and mantle effects. Next is a new tomography model for P and S velocity anomalies beneath Europe, which contrary to previous models is corrected for the crustal effect before-hand. These data provide a possibility for robust determination of temperature variations within the lithosphere. Based on a joint analysis of the new thermal model and receiver function determinations we determine position of the lithosphere-asthenosphere boundary (LAB) under Central and Western Europe. The data on the lithosphere structure are used to estimate gravity effect of mantle density anomalies and to characterize principal factors controlling mantle heterogeneity. The improved residual mantle gravity anomalies and residual topography are estimated after removing of the crustal effect from the observed field. These anomalies reflect the effect of mantle density variations, which are induced by temperature and compositional anomalies. Using temperature distribution in the mantle and the position of LAB we have determined the gravity effect of the temperature variations in the upper mantle on the gravity field and dynamic topography topography and compare it with the total fields. A big difference is found between the residual mantle gravity and the gravity effect of the tomography model converted to temperatures. This discrepancy likely evidence for a strong compositional differentiation of the upper mantle, which is not imaged by seismic tomography.

Keywords: Tomography, mantle, gravity model, Europe

Presenter's Biography

Mikhail K. Kaban

Mikhail Kaban is currently employed as a senior scientist at GeoForschungsZentrum, Potsdam. The research topis are generally related to construction and evaluation of density models of the Earth's crust and upper mantle based on an integrative interpretation of gravity, seismic and geological data; and modelling of the global mantle density structure with construction of a snap-shot global dynamic model of the Earth mantle. M. Kaban has defended his PhD thesis entitled "Isostatic compensation of the Earth's crust structures"in 1987. In 2003 he has got a habilitation degree (Dr. of Scince) with the paper "Density inhomogeneities of the upper mantle, lithosphere isostasy and geodynamics". Before GFZ, M. Kaban has been working at the Institute of Physics of the Earth, Moscow and up to now he keeps a part time position at this Institution as a leading scientist.

Crustal structure of southern Africa

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ABSTRACT

In this study, receiver functions and Rayleigh wave group velocities have been jointly inverted to model subsurface structure across southern Africa. The broadband data used for this study come from the Southern African Seismic Experiment (SASE), which consisted of 82 stations deployed between 1997 and 1999, the Kimberly Broadband Array, which was also part of the SASE, GSN/IMS stations, and permanent AfricaArray stations. In all, data from 103 stations were modeled, and from these, good quality results were obtained for 91 stations. The group velocities used for the inversion were taken from the group velocity maps published by Pasyanos (2007), and the inversion method used was taken from Julià et al. (2000, 2003).

The shear wave velocity (Vs) results across the geological terrains of southern Africa show several types of anomalous crustal structure (1) Lower than average Vs (< 4.0 km/s) characterizes the lower crust in the central part of the Kimberley terrain and western part of the Tokwe segment in the Kaapvaal and Zimbabwe cratons respectively. (2) Higher than average Vs (≥ 4.0 km/s) characterizes the lower crust in the Namaqua-Natal Belt (NNB), Cape Fold Belt (CFB), Bushveld Complex (BC), Kheis and Swaziland terrains. (3) Higher than average Vs (Vs > 3.7 km/s) characterizes the upper crust (~ 10 km thick) in the Namaqua-Natal, Kheis and Okwa terrains. The low Vs in the central part of the Kimberley terrain could be due to thinning of the crust from extension during basin forming events e.g. Ventersdorp tectonomagmatic event, that affected the western part of the Kaapvaal Craton between c. 3.0 Ga and 1.8 Ga. The high Vs in the upper and lower crust of the mobile belts (e.g. NNB) could be attributable to mafic material preserved during suturing events.

PRESENTER’S BIOGRAPHY

My name is Eldridge Kgaswane. I am a South African by birth. I completed my MSc degree in seismology at the University of the Witwatersrand in South Africa by the year 2001. I am currently employed as a seismologist at the Council for Geoscience, Pretoria, South Africa. My current responsibilities at the Council for Geoscience are to help with station installations and research into analytical methods that will help in the location and understanding of the seismic characteristics of seismicity in southern Africa

I have recently started my PhD research project as part of the Africa-Array program. This research project is conducted under the partnership of the Council for Geoscience, University of the Witwatersrand and Penn State University, who are all the founding partners of the Africa-Array program.

The SIMBAAD experiment in W-Turkey and Greece: A dense seismic network to study the crustal and mantle structures

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ABSTRACT

SIMBAAD (Seismic Imaging of the Mantle in the Aegean-Anatolian Domain) is a temporary seismic experiment which aims at investigating the crustal and mantle structure beneath Western Turkey, the Aegean Sea, and continental Greece. This tectonically very active region has experienced a variety of geodynamic processes and its geology and kinematics have been extensively studied. It is thus a good place to test competing hypotheses on how the surface kinematics is related to mantle structure and dynamics. In the spring of 2007, we have installed a temporary network of 33 broadband stations in Turkey, Greece, and S-Bulgaria for 2- year duration. It complements the permanent broadband networks (~90 stations) to give a regular grid with an inter-station spacing of ~100 km in the area [20-34°E; 35-41°N]. The common database of broadband continuous records that we are building from permanent and temporary networks will be the first one with such a dense spacing in this area. The temporary SIMBAAD experiment also includes 2 north-south profiles of more densely-spaced stations (~15 km) crossing Western Anatolia at 18°E and 31.5°E. A preliminary receiver-function analysis of the western transect documents a rather flat Moho at ~30 km depth with negligible variations of the crustal thickness under the major grabens and core complexes (e.g. Menderes). We interpret this result as an indication for a hot and ductile lower crust which vertically decouples upper crust deformation from mantle deformation.

Key words: Aegean, Turkey, Lithosphere, Geodynamics, Tomography

PRESENTER'S BIOGRAPHY

Denis Hatzfeld is a French seismologist involved for the last decade in the study of the seismotectonics and of the seismological structure of the Eastern Mediterranea and Iran

Seismic Investigations of Lithospheric Transitions between the Northern and Southern Australian Cratons (BILBY)

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We aim to determine the nature of the transition at lithospheric depths between the northern and southern Australian cratons. What are the controlling factors of the regions with anomalously slow velocities beneath the central Australian intercratonic suture zones? Do these intercratonic transitions propagate with depth and, if so, in what manner? To answer these questions, 25 broadband seismic stations were deployed in August-September 2008 and remain operational for approximately one year.

Much of the Australian continent is an amalgamation of several smaller cratons and multiple orogenic events. The transitions between any two cratonic regions, however, do not necessarily reflect the same processes. The transition between the Yilgarn and Pilbara cratons through the Capricorn Orogen is consistent with cool lithosphere and high seismic wavespeeds extending to substantial depth. In Central Australia, there are lowered seismic wavespeeds in the upper mantle down to at least 75 km depth, yet with low attenuation. Yet by 125 km depth the whole zone is covered by fast wavespeeds. Such behavior is difficult to reconcile with a purely thermal influence.

The experiment configuration is designed specifically to connect the Gawler Craton in the south to components of the North Australian Craton and to examine the lithosphere in the region influenced by the Alice Springs Orogeny (400-300 Ma). A combination of rigorous analysis tools, such as joint velocity and attenuation tomography coupled with receiver functions, will help to provide a comprehensive understanding of the amalgamation of continental cratons and the associated intercratonic transitions. In addition, a significant amount of information will be added to the present understanding of intercratonic suture belts and further constraints on the Australian lithospheric structure and overall continental amalgamation will be realized.

WOMBAT: A high density rolling array experiment for passive seismic imaging in Australia

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ABSTRACT

The WOMBAT experiment is an ambitious program of rolling passive seismic array deployments designed to cover a significant portion of the Australian continent. Over the last decade, approximately 450 sites have been occupied in southeast Australia during the course of 11 separate deployments lasting up to one year. Although both short period and broadband instrumentation have been used, the primary means of detection has been short period seismometers with a natural frequency of 1 Hz. These have been deployed with station spacings varying between 15 km (in Tasmania) and 50 km (mainland Australia).

The large volume of recorded data is ideal for various classes of study, including teleseismic tomography, crustal receiver functions, ambient noise tomography and array seismology (e.g. probing fine scale core structure). In this presentation, a variety of new results from WOMBAT will be presented. These include (1) joint passive and active source tomography of the Tasmanian lithosphere; (2) combined array teleseismic tomography from the mainland; and (3) ambient noise tomography from multiple arrays.

A limitation of conventional teleseismic tomography is that crustal structure is usually poorly resolved, which requires mitigation via station correction terms or the inclusion of *a priori* structure. In Tasmania, both teleseismic data from WOMBAT and 3-D wide-angle data from a previous experiment are available, a combination which promises good resolution throughout the full lithospheric thickness. We simultaneously invert both passive and active source data for the 3-D structure beneath Tasmania, and find that the recovered velocity and Moho variations provide strong support for a number of recent ideas about the architecture of the Tasmanian lithosphere. In particular, we show that there is little evidence for Tasmania comprising two juxtaposed continental fragments, which is still a commonly held view.

To date, teleseismic data from five mainland arrays have been combined in a single inversion for 3-D P-wavespeed. The resulting model contains many well resolved features, but the most pronounced is a strong velocity contrast between the Proterozoic lithosphere that underpins the Delamarian Orogen in the west and the Proterozoic lithosphere beneath the Lachlan Orogen in the east. Rayleigh wave group velocity maps of the mid-upper crust derived from ambient noise tomography reveal significant variations in wavespeed near the edges of the Murray Basin, but show little evidence for a transition between the two orogens at shallow depths. A long term goal of WOMBAT is to try and combine all available data types (teleseismic, ambient noise, surface wave, receiver functions) in a single inversion for the 3-D crust and upper mantle structure beneath southeast Australia.

Key words: Australia, seismic tomography, teleseismic, ambient noise, joint inversion

PRESENTER'S BIOGRAPHY

Nick Rawlinson completed his PhD at Monash University in 2001, and moved to the Australian National University, where he is now a Fellow at the Research School of Earth Sciences. Together with Prof. Brian Kennett, he has been largely responsible for the funding, design and deployment of the WOMBAT experiment, and has interpreted much of the data that has been recorded. His current research interests include seismic tomography, wave propagation, and the structure and evolution of the Australian continent.

Crustal structure and Upper mantle Anisotropy along the Indo-Gangetic Profile, India

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The Indo-Gangetic plains, a down warp of the Himalaya foreland is converted into flat plains by continuous sedimentation of Quaternary sediments. The thick sedimentary cover often obliterates the underlying geology and acts an impediment in understanding the tectonic evolution of the continents. To unravel the crust mantle structure a 10 broad band seismological stations profile is being operated in the Indo-Gangetic plains and the neighbouring Bundelkhand craton. Using receiver function technique the crustal structure has been determined. The upper mantle anisotropy along the profile has also been obtained using SKS shear wave splitting technique. The salient results of these studies along this profile shall be discussed.

Crustal Structure of Africa's Southern Margin from Geophysical Experiments

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ABSTRACT

A number of geophysical on-shore and off-shore experiments were carried out in a profile across the southern margin of the African continent in the framework of the Inkaba ye Africa project. Refraction seismic experiments have shown that the crustal thickness decreases rapidly from over 40 to around 30 km well inland of the present coast, before gently thinning out towards the Agulhas Falkland Fracture Zone, which marks the transition zone between continental and oceanic crust. This is consistent with a non-volcanic mode of breakup due to shear along the Agulhas-Flakland Transform Fault. In region of the abruptly decreasing Moho depth inland from the coast, lower crustal P-wave velocities up to 7.4 km/s are observed. We interpret these to represent metabasic lithologies of the Mesoproterozoic Namaqua-Natal Metamorphic Complex, or intrusions of gabbroic material added to the base of the crust by younger magmatism. This magmatism could be the result of the mid-Jurassic Karoo-Ferrar-Chon Aike event.

The velocity model for the upper crust has excellent resolution, and is consistent with the known geological record. A high velocity anomaly north of the centre of the BMA is much better resolved than previously. A comparison of the velocity model with electrical conductivity models shows that a zone of high seismic velocities north of the centre of the Beattie Magnetic Anomaly, one of the largest magnetic anomalies, correlates well with a resistive zone. Furthermore, a synclinal low velocity feature has been identified in the Mesoproterozoic basement beneath the front of the Cape Fold Belt, south of the above mentioned zone. The northern edge of this feature correlates with that of a magnetic body, which magnetic modeling shows is necessary to reproduce the surface trace of the Beattie Magnetic Anomaly. Contrary to existing interpretation, the Beattie Magnetic Anomaly does not origin from an area which is electrically conductive but seems to correlate with a source region which is resistive and has high seismic velocities.

Key words: Seismic Tomography, Magnetotellurics, Beattie Magnetic Anomaly, Inkaba ye Africa.

PRESENTER'S BIOGRAPHY

Jacek Stankiewicz graduated with a PhD in Earth Sciences from the University of Cape Town in 2004. He is currently a PostDoc at the Deutsches GeoForschungsZentrum in Potsdam, Germany, involved with deep geophysical sounding techniques. His other interests include river network geometry, climate change and water supply forecasting, as well as Gondwana reconstruction.

SEISMICITY AND TECTONICS OF CHINA CONTINENT AND SURROUNDING REGIONS

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The study area (15°-58°N,60°-135°E) contains the Chinese continent, the collision zone of the India plate and the Eurasia plate and the Philippine subduction zone to the Eurisia. With the development of geophysical surveys our understanding of the tectonics in this area has progressed rapidly. However, synthesis of the data from these surveys with earthquake data is complicated because of large location errors for many events, particularly in depth. We begin to address this problem by assembling a data set of more than 18000 well-constrained earthquakes in this region during the period of 1967-2004 with more accurate focal depths estimated using the EHB* method with careful review. Hypocenter determination, especially focal depth, is improved by combining the arrival times of local, regional and teleseismic P and S phases, PKiKP, PKPdf, and teleseismic depth phases in the relocation procedure. These systematically determined and improved hypocenters provide better definition of seismicity features. Intermediate-depth events are mainly distributed in the two syntaxises of Himalaya and the Okinawa trough. 1) The foci distribution in the Burma Range shows an inclined Benioff zone up to 150-170 km. 2) The Pamir-Hindukush region is characterized by high concentrations of intermediate-depth earthquakes. Under the western and central parts of the Hindukush the seismicity zone dips 60°-90° to the northwest at depths of 100-300km. In contrast, under the Pamir the seismicity zone dips 45°-70° southwards and mostly is at shallower depths of 80-200km. 3). The penetration depth of the northwestwards inclined seismicity zone dipping 50° is 298km in the south Ryukyu, decreases to 157km dipping 40° in the north Ryukyu. 4) In China continent seismic activity in the western part is much higher than in the eastern part. Only in Tibet around 92°E, 27°N, 87° E, 28°N, 90°E,30°N, and 75.5°E,36°N are there events with depths > 70 km. Most shallow earthquakes in China are distributed belt-like patterns.

Key words: EHB relocation, Seismicity, China

SUN Ruomei

Ms. SUN Ruomei works in the Institute of Geology and Geophysics, Chinese Academy of Sciences. I have been dealing with relocation and tomography for many years. The study is supported by the Chinese National Science Foundation (40434009 and 40234042)

*E.R. Engdahl, Van der Hilst, R.D., and Buland, R.P., 1998, Global teleseismic earthquake relocation with improved travel times and procedures for depth determination: Bulletin of the Seismological Society of America, v. 88, p. 3295-3314.

Three-Dimensional Seismic Tomography of California at Multiple Scales

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ABSTRACT

We have taken advantage of earthquake and quarry blast arrival-time data recorded by permanent networks and temporary arrays and explosion travel times from refraction experiments to construct three-dimensional (3D) seismic velocity models of California at multiple scales. These model range from ~10 km square areas imaged at sub-kilometer resolution to regions hundreds of kilometers in size imaged at ~10 km horizontal resolution. The fine-scale model results were enhanced by the application of the new method of double-difference tomography using the algorithm tomoDD (Zhang and Thurber, 2003). The large-scale modeling was enabled by the extension of tomoDD to the spherical Earth case (Zhang and Thurber, 2006). Several examples of out tomography work will be presented. At the fine scale, our 3D images of the upper crust around the San Andreas Fault Observatory at Depth (SAFOD) site and the associated high-precision target earthquake locations provided critical guidance for the SAFOD drilling trajectory. At a slightly larger scale, our image of the 2004 Parkfield earthquake rupture zone reveals a strong relationship between structure and fault behavior. At a regional scale, we find an anomalous structure associated with the subducted Gorda slab that may be responsible for the false S phase of Byerly (1937) and crustal low velocity zones beneath several volcanic areas that have not previously been detected.

Key words: seismic tomography, California, SAFOD.

PRESENTER'S BIOGRAPHY

Prof. Thurber is an international leader in research on three-dimensional seismic imaging (seismic tomography). His primary research interests are in the application of seismic tomography to fault zones, volcanoes, and subduction zones. Other areas of Thurber's expertise include earthquake location, geophysical inverse theory (the topic of a book he recently coauthored), and nuclear explosion monitoring.

Observations from EarthScope's USArray

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ABSTRACT

The geographical extent of USArray allows unprecedented observations of geophysical targets over a range of scales. The three seismic observatory components of USArray presently span the contiguous United States. The Transportable Array (TA) component of USArray has already occupied over 650 sites in the western United States, from the Pacific coast through the Rocky Mountains, and continues its multi-year migration towards the Atlantic coast. The three component broadband TA stations are deployed in a grid-like arrangement, with 70 km separation between stations. At any given time there are approximately 400 station sites operating, occupying a ~1900 km by 800 km "footprint." Each TA station is operated for two years. The Flexible Array (FA) component of USArray provides a pool of instruments, ranging from high frequency geophones to three-component broadband sensors, and are typically deployed for focused geological targets at spatial scales two to four orders of magnitude less than the TA, and for time periods ranging from days to years. Finally, the Reference Network provides a fixed, permanent reference frame for the TA and FA, with approximately 100 broadband stations deployed across the contiguous US, at roughly 300 km spacing between stations. USArray also includes a magnetotelluric (MT) component. The MT observatory includes seven permanent backbone stations distributed across the US, as well as a pool of instruments deployed campaign-style each summer, and which have now occupied 170 distinct sites.

The data collected by USArray have supported a wide range of studies and have been processed in numerous ways. For example, the spatial extent and density of the TA deployment allows visualization of the seismic wavefield. These visualizations allow direct observation of seismic amplitude variations and off-great-circle wave propagation. A number of standardized data products are produced from the USArray data, including analyst reviewed phase picks, wave-field animations, and comprehensive compilations of ambient noise field measurements. We present an overview of these products, as well as a review of the current status of USArray. We also discuss ways in which the seismological education and research communities have been able to participate in and leverage the FA and TA efforts.

Key words: seismology, network, wave propagation, noise

Robert Woodward

Robert (Bob) Woodward is the Director of the EarthScope USArray project for the Incorporated Research Institutions for Seismology (IRIS). The USArray project, funded by the National Science Foundation, is a multi-year project deploying networks of seismographic instrumentation to study the structure of the Earth. Prior to joining IRIS he worked for Science Applications International Corporation (SAIC), where he managed a variety of geophysical research and development projects and large-scale systems integration efforts. Prior to his work with SAIC, Bob managed the Data Collection Center at the US Geological Survey's Albuquerque Seismological Laboratory, collecting and managing data from the Global Seismographic Network. Bob earned his PhD at Scripps Institution of Oceanography, University of California, San Diego, and his BA from the University of California, Berkeley.