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Abstracts

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The 13th International Symposium on

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Abstracts

Organizing Committee for SEISMIX2008

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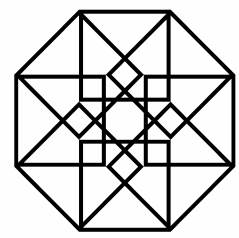

ABSTRACTS

(in alphabetical order by first author: presenter is marked by an asterisk)

Oral & Poster

INTEGRATED SEISMIC IMAGING OF ACTIVE AND PASSIVE DATA FOR THE DELINEATION OF ACTIVE FAULTS AND CRUSTAL STRUCTURE IN THE KITAKAMI LOWLAND, NORTHEAST JAPAN

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The deep geometry of active faults and the mid-crustal detachment at the base of seismogenic layer is important for understanding active tectonic process and accessing the risk of destructive earthquakes. To investigate the deeper extension of active faults within the seismogenic layer, we conducted a seismic reflection profiling experiment across the western marginal faults of Kitakami lowland, northeast Japan. The combination of telemetry and independent recording system has provided the deployment of wide-angle survey line with dense seismic array. The simultaneous data acquisition of regional refraction, low-fold wide-angle reflection and dense reflection survey has been optimized by the integration of vibrator source focused on effective low-frequency bandwidth of sweep signal and the three-component digital accelerometers with broader frequency responses. The seismic reflection profile shows that the deeper extension of the western marginal faults of Kitakami lowland converges on the mid-crustal detachment. Along the reflection survey line, a dense seismic array with the combination of short-period seismometers and digital accelerometers was deployed for teleseismic and local-earthquake observation. We utilized multimode prestack migration for receiver function and interferometric seismic imaging for back scattered phases to investigate the lower crustal structure and Moho boundary. We further discuss the practical difficulties and potential capabilities for joint imaging of active and passive seismic data.

Oral

COLLISION AND SUBDUCTION STRUCTURE OF THE IZU-BONIN ARC IN CENTRAL JAPAN

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The Izu-Bonin arc (IBA) has been colliding with the Honshu crust in central Japan since middle Miocene. To reveal the crustal structure of the Izu Collision Zone (ICZ) in terms of seismic velocity, we reanalyzed the seismic profiling data (Odawara-Kiryu 2003 seismic survey) by refraction method. The seismic line in N-S direction was located along the eastern flank of the ICZ. The obtained structure provided direct evidence on the collision and subduction structure. The low velocity body of the Tanzawa Mountains corresponds to the upper crust and the upper part of the middle crust of the IBA. This body is characterized by the aseismic region. From its wedge-thrust structure, the Tanzawa block is expected to be delaminated from the subducting slab. Relocated hypocenter distribution using refraction velocity model showed seismic activity around the collision boundary, which implies that the Tanzawa block thrusted into the weak zone in the Honshu crust. By comparing with velocity structure along the Izu-Bonin intra-oceanic arc, we found the slab corresponds to the lower crust of the IBA.

Poster

CRUSTAL STRUCTURE BENEATH THE EASTERN PART OF THE IZU COLLISION ZONE, CENTRAL JAPAN, REVEALED BY REFRACTION/WIDE-ANGLE REFLECTION ANALYSIS

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The Izu-Bonin arc (IBA) has been colliding with the Honshu crust in central Japan since middle Miocene. Tonoki-Aikawa Tectonic Line (TATL) is a major boundary between the Honshu and the Tanzawa block of the IBA. To reveal the collision and subduction structure of the IBA in terms of seismic velocity, we reanalyzed the seismic profiling data (Odawara-Kiryu 2003 seismic survey) by refraction tomography and forward ray tracing. The seismic line is located along the eastern flank of the ICZ and crossing the TATL in its middle part. The velocity structure by our analysis showed the clear velocity variation across the TATL. It is interesting that low velocity Tanzawa block is characterized by aseismic region in contrast to high velocity Honshu crust characterized by active seismicity. From its wedge-thrust structure, the Tanzawa block is expected to be delaminated from the subducting slab. Relocated hypocenter distribution using refraction velocity model showed seismic activity around the collision boundary, which implies that the Tanzawa block thrusted into the weak zone in the Honshu crust. By comparing with velocity structure along the Izu-Bonin intra-oceanic arc, we found the slab corresponds to the lower crust of the IBA.

Oral

HETEROGENEOUS MANTLE: CONSTRAINTS FROM JOINT INTERPRETATION OF SEISMIC AND THERMAL DATA

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Geochemical studies of abundant mantle-derived xenoliths indicate signicant compositional heterogeneity of the continental lithospheric mantle as reflected in densities and seismic velocities measured in laboratory studies of mantle xenoliths. However, xenoliths provide "Nature's sampling" of the Earth's deep interior, which is random, uneven, and in many areas sparse. The goal of this study is to examine if geochemical constraints on global-scale compositional variations in the mantle are consistent with modern geophysical data. Global geophysical models (seismic tomography and mantle gravity anomalies) reflect large-scale variations in mantle seismic velocities and densities. Since both of the parameters are temperature-dependent, large scale gravity and seismic anomalies are commonly attributed to regional variations in mantle temperatures. However, the analysis of global seismic tomography models shows that in the upper 150 km T-variations alone are sufficient to explain the amplitude of seismic Vs and Qs only in ca. 50 per cent of continental regions. A set of profiles through the lithospheric mantle of Precambrian cratons constrained by seismic velocity variations of a non-thermal origin (calculated from global Vs seismic tomography data and lithospheric temperatures) clearly indicates strong vertical and lateral heterogeneity (non-thermal in origin) in the continental lithosphere. In agreement with global xenolith data, strong positive velocity anomalies on non-thermal origin (attributed to mantle depletion) are clearly seen beneath the cratons; their amplitude, however, varies laterally and reduces with depth. Cratonic regions, where kimberlite magmas erupted, show only weakly positive compositional velocity anomalies, suggesting that xenoliths provided by the "Nature's sampling" may be non-representative of the "intact" cratonic mantle.

Poster

IDENTIFICATION OF THE HALES REFLECTOR IN SW IBERIA. SOME CONSTRAINTS ON ITS NATURE

***Ayarza, P.[1], Palomeras, I.[2], Simancas, F.[3], Carbonell, R.[2], Martínez-Poyatos, D.[3], Azor, A.[3], Pérez-Estaún, A.[2] and González-Lodeiro, F.[3]**

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The Hales discontinuity has been generally described as a positive impedance contrast representing the phase transition between spinel and garnet occurring at depths of 60-90 km depending on the tectonic setting. However, there is not total agreement concerning the origin of this discontinuity and an increase in olivine lattice preferred orientation, development of shear zones in the mantle after continent-continent collision, anisotropy linked to plume flow or relic slabs in the upper mantle have been also proposed to describe the nature of this interface. Two ~300 km long, controlled source, wide angle seismic reflection profiles have been shot in SW Iberia as part of the IBERSEIS seismic experiment. These profiles sample three different tectonic zones that were probably assembled and deformed during Variscan times. The resulting seismic sections provide information on the upper mantle reflectivity down to depths of more than 70 km. Slightly above this depth, a mantle reflector has been observed at offsets over 180 km and has been modelled as a fairly continuous feature in all the shot records where the distance between shot and receivers is long enough as to allow its identification. This interface implies a Vp jump from 8.2 to 8.4 km/s on average and the fact that the recording stations are very closely spaced (150-400 m) indicates that it is very continuous. Laboratory measurements of physical properties of typical mantle rocks (lherzolites, harzburgites, pyroxenites, peridotites, dunites, eclogites) suggest that an increase in the amount of eclogites within the mantle mixture can physically account for the observed reflectivity, and therefore this velocity change could be attributed to the spinel-garnet phase transition. Thus, we suggest that the reflector observed at upper mantle levels in SW Iberia has the characteristics ascribed for the Hales reflector. Our data strengthen the interpretation that this interface represents a mineral phase transition since no recent tectonic or magmatic events seem to have affected the area. After integration of different seismic datasets we may suggest that in the SW Iberian Massif, this reflector always appears around 68 km and therefore is quite flat, staying at a fairly constant distance from the base of the crust.

Poster

P-WAVE VELOCITY STRUCTURE OF THE CRUST AND THE UPPERMOST MANTLE OF THE SUBDUCTED PACIFIC PLATE NEAR THE JAPAN TRENCH BY AIRGUN-OBS SEISMIC SURVEY

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The Japan Trench subduction zone shows regional variations in seismic activity along the plate boundary in several aspects. For example, in the shallowest part of the interplate seismogenic zone, the location of the trenchward limit of the interplate earthquakes varies along the trench. In order to clarify variations in the structure of the subducting Pacific slab corresponding to the differences in the interplate seismic activity, we carried out a seismic survey along a profile of about 350 km in length, located 20 km landward from the axis of the Japan Trench. In the surveyed area, the depth to the plate boundary is expected to be about 8~10 km referring to previous studies. In the record sections obtained from the OBSs, the refractions from the subducted oceanic crust layer 3 and the slab mantle are clearly

observed as the first arrivals. Although severe distortion of the apparent velocities due to rough seafloor topography along the profile forbids examining lateral variations in intra-slab structure, we will be able to clarify characteristics of the seismic velocity structure of the subducted slab by analyzing these seismic data in detail.

Poster

3D MODEL OF EAST FENNOSCANDIA DEEP STRUCTURE: RESULTS OF GEOLOGICAL INTERPRETATION

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The geological interpretation of seismic profiling result, 3D density model jointly with spatiotemporal associations map enables to contour three large terrains — Kola & Karelian cratonisated at Archean, Svecofenian cratonisated at Paloproterozoic. First two terrains are divided by Paleoproterozoic Kandalahksha-Arkhangelsk zone. Five types of structures with various history of development and deep structure are allocated: 1 – Meso-Neoarchean crust is represented by alternation large gentle sin-and antiforms in the upper crust with flat-bedded middle-low crust (main part of Kola terrain and a southwest part Karelian); 2 - Mesoarchean mobile crust consolidated at Neoarchean is characterized by thin smallfolding upper crust with not dismembered middle-low crust (Karelian northeast part -Karelian Belomorie); 3 - Paleoproterozoic crust is characterized by high thickness increased by low crust, lateral and vertical differentiation, presence of inclined asymmetric forms (Svecofenian terrain); 4 - linear structures of Paleoproterozoic destruction of Archean crust – two subtypes: synclinorium in upper-middle crust with intrusion of abnormal high density mass in axial part (Kandalahksha-Arkhangelsk zone) and asymmetric anticlinorium with shortened high density crust (Imandra-Varzuga & Shombosero-Vetrenniy belt intracraton zones sybparallel to boards of first subtype zone); 5 - Archean crust with Paleoproterozoic tectonic activization is characterized by crust synclinorium, including flexure of M, growth of low crust, a series intrusion of high density mass in middle-upper crust. All this testifies to specificity Archean-Neoproterozoic geodynamic conditions.

Poster

THE IBERARRAY SEISMIC PLATFORM: ASSESSING THE DEEP STRUCTURE OF THE LITHOSPHERE BENEATH THE IBERIAN PENISULA

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Assessment is the process of documenting, usually in measurable terms. The seismic part of the IBERARRAY instrumentation platform aims to acquire new seismic data with an unprecedented resolution to assess and unravel the lithospheric structure of the Iberian Peninsula and its margins. The dataset collected should provide new constraints on the processes, nature and dynamics of the Earth's interior. They are an asset to understand the evolution of a wide range of surface processes, including the very existence of plate tectonics, intraplate volcanism, magnetic events from the short to the longterm, the state of stress in the lithosphere, and vertical motion from basin to continental scales manifested in

uplift and subsidence with impact on drainage systems and geomorphology. The seismic Iberarray platform is composed by a dense network of broad band recorders. The plan is to deploy the stations in an approximately 60x60 km grid to cover the entire study area in three stages. The first stage, which has already been completed, involved deployment of 55 BB stations (35 in the Peninsula and 20 in northern Morocco). This network is dedicated to acquire data in the area of complex interaction between the European and African continental plates. The digital seismic network consists of Taurus recording units and Trilium 120s sensors (both from Nanometrics). Earthquake data at local, regional and teleseismic scales will be analyzed using different methodologies aiming at different objectives. A first phase would be an increase in the precision on the location of the regional seismicity by considering waveform analysis and other advanced techniques. A special emphasis will be attributed to the use of tomographic inversion schemes to obtain 3 dimensional maps of physical properties (P and S seismic wave velocities) to study large scale structural elements within the Iberian Peninsula. This includes research using travel times and waveforms of P and S arrivals at different scales (local, regional and global) and surface waves, using dispersion measurements and studies dealing with the background/environmental noise. In addition, receiver function analysis for seismic imaging of deep lithospheric features and splitting analysis of shear-wave arrivals will also be applied.

Poster

LITHOSPHERIC STRUCTURE OF THE SOUTHERN IBERIAN VARISCAIDES: A 600 KM LONG TRANSECT

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An almost 600 km long deep seismic image that constrains the structure of the SW-Iberia has been compiled. It extends from the Tajo basin southward till Gulf of Cadiz. The 20 s (twtt), deep seismic reflection image provides key constraints in the crustal structure of the southwestern Iberian. This images is a composit of 2 Vibroseis deep seismic reflection profiles acquired within the IBERSEIS and ALCUDIA projects. It offers a unique opportunity to study transpression tectonics. The seismic profile crosses key elements of the Variscan Orogen, runs across major tectonic units including the South Portuguese Zone (SPZ), Ossa Morena Zone (OMZ) and a large percentage of the Central Iberian Zone. Cutting across two major suture zones and some major geological structures and domains, with the Iberian Pyrite Belt being of the greatest interest, the Pulo do Lobo Unit, the Aracena metamophic belt, the Central Unit, the Santa Elena fault, the Almadén syncline, the Alcudia anticline, and the Toledo fault, and some major magnetic anomalies. The composite image reveals that the crust is 30 km thick in average,in both profiles, with a horizontal Moho, a highly reflective mid-to-lower crust with a few mantle reflectors and well defined features in the upper crust with the indication of detachments zones that might link to the mid-crustal reflective zone. The main contributions of this long transect address: a) the characterization of the seismic facies of the SW Iberian lithosphere, with a view to differentiate crustal and lithospheric domains; b) the architecture of the major tectonic contacts; c) the deep geometry of the transpression tectonics located in specific areas. The seismic data reveals the existence of a mid-crustal reflective body (IRB) located within the OMZ. This 140 km long and up to 5 km thick high amplitude reflective band cuts across the sutures that limit the OMZ. The amplitude characteristics of the seismics, mineralization studies related to magmatic ore deposits, and the surface geology suggest that the IRB is a mantle-derived mafic intrusion. The geophysical, geological and petrological data suggest that the IRB is most probably an

Early Carboniferous (approximately at 350-340 Ma) mantle-derived intrusion possibly linked to plume activity that took place in Europe in the Carboniferous and Permian. South of the CIZ the image reveals a sudden change in the seismic fabric indicating the acreation of two different continental crusts.

Oral

SEISMIC IMAGING OF THE STRUCTURE OF THE CENTRAL IBERIAN ZONE: THE ALCUDIA DEEP SEISMIC REFLECTION TRANSECT

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ALCUDIA is a new 250 km long, vertical incidence Vibroseis seismic reflection profile acquired in spring 2007. It Central Iberian Zone, extending from Toledo to Fuenteovejuna. Its main goal was to continue the structure obtained for the crust and mantle from the IBERSEIS transect towards the N and NE. The ALCUDIA transect crosses some important structures, such as the Toledo fault, Santa Elena Fault, Alcudia anticline, Almadén syncline, and some major magnetic anomalies. The acquisition parameters, 35 m station spacing, 70 m VP spacing resulted in a 60-90 fold high resolution seismic reflection image. A 20 s long Vibroseis sweep was recorded by a 400 station recording cable. After preliminary processing, the upper crust shows a moderate reflectivity that can be easily correlated with identifiable surface geologic features, mainly folds. The section can be divided in 4 domains of reflectivity that can be key to stablish different domains of crustal evolution. A highly reflective mid-to-lower crust with a few mantle reflectors and well defined features in the upper crust with the indication of detachments zones that might link to the mid-crustal reflective zone. Upright folds mapped on surface are well imaged in the upper crust and appear to be detached from the middle crust, being evidenced by the flat upper limit of the reflectivity and some individual subhorizontal reflections. The middle and lower part of the crust is strongly reflective for 4,5 s to 10 s (twtt). This highly reflective band thickens towards both ends, most probably due to later deformation. The high reflectivity is indicative of strong lamination, crosscating, that has been afected by deformation, although to a different extents. The southern part of the profile images a sudden change in the seismic fabric, which is marked on surface by the existence of the Pedroches batholith. South of this batholith, a doming structure within the mid-crust marks a sharp change in the seismic signature. The same is observed in upper crust which differs notably from that of the rest of the transect. This changes jointly with other geological constraints provide evidence to interpret this zone as a boundary, most probably an acreationary contact between two crustal domains of different nature.

Poster

DELINEATING TECTONIC UNITS IN THE ABITIBI-GRENVILLE PROVINCE, CANADA, AND DONBAS FOLDBELT, UKRAINE, BY MAPPING CORRELATION LENGTHS IN LITHOPROBE AND DOBRE DEEP REFLECTION DATA

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Statistical analysis of deep reflection data can provide valuable additional information regarding the fabric of deeper crust and upper mantle of mature continental cratons, and help their delineation in terms of litho-tectonic units. Stochastic structure of the LITHOPROBE and DOBRE deep seismic reflection data was estimated using windowed average lateral autocorrelations. From this, von Karman models for the causative reflectivity were obtained, in terms of a lateral correlation length and a power law exponent, and their associated Bayesian uncertainties. The maps - obtained after a final upscaling - exhibit systematic spatial variations in the stochastic parameters in the regions below the Abitibi-Grenville Province, Canada, and Donbas Foldbelt (DF), Ukraine. The lateral correlation length turns out to be a robust delineator given the low associated uncertainties. Although the general outline of the correlation length maps conforms to the classical line-drawing tectonic interpretations, interesting new features can be seen. In the LITHOPROBE case for example, not only are the Abitibi and Opatica tectonic blocks separated from each other by correlation length, but internally, they also show separated units. The DOBRE maps point towards significant variation of fabric in the seemingly homogeneous middle crust, allowing for new speculation on crust-mantle interactions.

Oral

MAPPING CORRELATION LENGTHS OF LOWER CRUSTAL HETEROGENEITIES FROM DEEP REFLECTION DATA FOR DELINEATING TECTONIC UNITS

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We have enhanced and benchmarked an existing seismo-statistical technique which estimates horizontal stochastic parameters from migrated deep reflection data, thereby mapping von Karman seismic heterogeneity distributions in the crust. The von Karman stochastic parameters estimated are lateral correlation length and power law exponent, they are measures for scale lengths in the causative heterogeneity. Lateral correlation length estimates using sliding seismic data windows yield objective maps of crustal fabric. As an enhancement, Bayesian uncertainties are also computed, associated with the parameter estimates. During benchmarking with synthetics, we investigated the systematic underestimation of lateral correlation length as obtained from seismic reflection data, the discriminating ability of the method, and the effects of seismic scattering regime and migration on estimations. The resulting parameter maps indicate significant spatial variation in crustal macro-scale petrofabric of the lower continental crust (LITHOPROBE, DOBRE). Correlation length, which carries useful information about scale lengths of heterogeneous bodies, is an especially revealing parameter with moderate associated uncertainties. Although the general outline of the maps conforms to the classical line-drawing tectonic interpretations, interesting new features can be seen. The macro-scale petrofabric is seen to vary significantly within the classic tectonic terrains, in depth as well as laterally.

Poster

RADIAL ANISOTROPY IN THE CRUST AND UPPER MANTLE BENEATH THE TIBETAN PLATEAU

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To provide seismic information of crust/mantle deformation in Tibet, we collected surface wave data from events of magnitude Ms ≥ 5.0 and shallow or moderate focal depth occurred between 1980 and 2002: 713 events generated Rayleigh waves and 660 of Love waves recorded by 13 broadband digital stations in Eurasia and India. Up to 1,525 source-station Rayleigh waveforms and 1,464 Love wave trains were earlier analysed to obtain Love- and Rayleigh-wave group velocity curves in the period range 10-105 s. We performed tomographic inversion to obtain period-dependent group velocities at the grid nodes with grid-size of one by one degrees after averaging out the azimuthal effects, but the models of isotropic seismic wave velocities in the crust and upper mantle could never well fit simultaneously the Rayleigh and Love wave group velocities dispersion curves that we inverted. This discrepancy of Love and Rayleigh wave propagation well established the existence of radial anisotropy in the crust and upper mantle likely. Radial anisotropy computed from the Love-Rayleigh discrepancy and its spatial extent beneath Qinghai-Tibet Plateau are shown as maps of percentage anisotropy at various depths down to 170 km and cross-sections along five profiles of reference. Areas in which radial anisotropy is in excess of ~4% and 6% on the average anisotropy are found in the crust and upper mantle underlying most of the plateau, and up to 8% in some places. The strength, spatial configuration and sign of radial anisotropy seem to indicate the existence of a regime of horizontal compressive forces in the frame of the convergent orogen, laterally varying lithospheric rheology and a differential movement as regards the compressive driving forces.

Oral

MANTLE HETEROGENEITIES AND THEIR SIGNIFICANCE: RESULTS FROM LITHOPROBE SEISMIC REFLECTION AND REFRACTION/WIDE-ANGLE STUDIES

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Within LITHOPROBE's ten transects that span the North American continent, data from more than 20,000 km of land and marine multichannel reflection profiling and 13 multiple-line refraction/wide-angle reflection surveys were acquired. While the main interpretations relate to the crust, the data generated significant results for the sub-crustal lithospheric mantle. They show that the mantle has substantial heterogeneity, mainly relating to tectonic processes involved in its development. Images of fossilized subduction zones from Eocene through Paleoproterozoic to Neoarchean times demonstrate that current plate tectonic processes have been active for more than 2.6 Ga. The Archean Superior craton formed from north to south through recurring accretionary tectonic processes. Vestiges of the last stage of these processes are identified through an unusual anisotropic high velocity layer that may represent relic oceanic lithosphere. Long-offset data (to 1300 km) in both the Paleoproterozoic Trans Hudson Orogen and the Archean Hearne-Wyoming craton reveal a distinct coda of coherent arrivals later than the Pn phase and with slightly higher apparent velocities. Finite-difference modeling shows that the coda can be generated by fine-scale heterogeneities introduced into a layer between 90 and 150 km depth in the continental lithosphere. The heterogeneous layer may have formed through lateral flow or deformation within the upper mantle.

Oral & Poster

HIGH RESOLUTION SEISMIC IMAGING AT THE MILLENNIUM URANIUM DEPOSIT, CANADA

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In 2007, a 3D-seismic survey was undertaken over the 6.5 sqkm area on top of the Millennium uranium deposit, hosted within steeply dipping Archean to Paleoproterozoic crystalline basement rocks. Data were acquired using an 1800-station 3-component I/O system and a VIBSIST source. The 3D survey was integrated with MSP and VSP measurements performed in a well drilled close to the centre of the 3D survey area. MSP data were acquired at the same time with the 3D survey by means of 8 three-component receivers placed at 5m intervals, between 482.5 and 517.5m depth. VSP data were subsequently recorded at 5m intervals between 202.5 and 637.5m from a total of 31 shot points. The same VIBSIST source was used as for the 3D and MSP survey. The main objective was to map the unconformity and major Post-Athabasca structure in the vicinity of the deposit. The ability to meet this objective depends, among others, on limitations imposed by the frequency content of the data and on the relative geometry of the sources and receivers. By the higher frequencies recorded and by extending the range of view angles of the targets, the integration of the MSP and VSP data to the 3D framework lead to a more robust understanding of the geology and structural geometry in the central region of the deposit area and provided a greater level of detail of the unconformity as well as direct images of structural features.

Oral & Poster

3D-SEISMIC SURVEY AT THE MILLENNIUM URANIUM DEPOSIT IN THE ATHABASCA BASIN, CANADA

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The Millennium uranium deposit, located in the Athabasca Basin, Canada, is hosted within steeply dipping Archean to Paleoproterozoic crystalline basement rocks, locally overlain with 500-700 m of flat-lying Athabasca Group metasediments. To assist in mine development a 3D-seismic survey (6.5 sq. km) was undertaken over the deposit area in 2007. The main objectives were to map the unconformity and major Post-Athabasca structure in the vicinity of the deposit. Data were acquired using an 1800-channel I/O system and a VIBSIST source. Clear reflections are observed from the unconformity, primarily at offsets >800 m, and not over the entire area. The variability in the reflections is likely due to complex geology, in particular hydrothermal alteration. Reflections are often obscured by guided P- and S-waves and suffer large time delays due to variable overburden conditions. Combined source and receiver delays can be ~100 ms, making refraction statics essential. The unconformity depth map shows a N-S striking non-symmetric central depression, indicating a half-graben structure with vertical displacements of ~100-150 m, although reflections from the unconformity are vague within the depression. Drilling and other geophysical data support the imaged N-S trending structural pattern.

Poster

SEISMIC REFLECTION MEASUREMENTS ACROSS THE HIKURANGI BACK-ARC REGION, NEW ZEALAND

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Seismic reflection data recorded across the Hikurangi subduction margin of North Island, New Zealand, image a distinct reflector inferred to correspond to Moho at 5.5 s two way travel time (twt) under the eastern part of the back-arc extensional basin - the Taupo Volcanic Zone (TVZ). This reflector dips steeply eastwards under the East Cape peninsula to depths of about 30 km (9 seconds twt). Further east, a deep (5 seconds twt) sedimentary basin overlies the subducting Pacific plate. Wide angle seismic measurements, to the south of this region, show that the inferred shallow Moho is underlain by low seismic wave speed mantle. This shallow low wave speed mantle underlies a region of strong active faulting and is characterised by discontinuous reflecting elements that extend down to a band of sub-horizontal reflectors within the mantle wedge at a depth of about 11 - 12 seconds twt from the subducted plate to under the TVZ. The discontinuous reflecting elements are interpreted as underplated or highly intruded lower crust. Further west, away from the plate boundary, a similar narrow region of discontinuous reflecting elements is imaged, coincident with the extrapolation of the oceanic Havre Trough rifting trend.

Poster

A REGIONAL TRANSECT ACROSS THE SOUTH NEWFOUNDLAND BASIN NONVOLCANIC MARGIN

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New seismic reflection data from the Grand Banks of Newfoundland and the Newfoundland Basin add to the knowledge of composition, structure and history of this nonvolcanic margin. Two parallel profiles over the shelf platform image deep crustal fabric representing Precambrian or possibly Appalachian deformation as well as Mesozoic extension. Progressively more intense extension of continental crust is imaged oceanward below the continental slope without the highly reflective detachments frequently seen on profiles off Galicia. A landward-dipping event ‘L’ is imaged sporadically and appears to be analogous to a similar event on the approximately conjugate Iberian IAM9 profile. The transition zone is probably unroofed serpentinized mantle as interpreted off the Iberian margin although there appears to be a difference in the character of ridge development and reflectivity. The distinctive ‘U’ reflection in the Newfoundland Basin is highly regular and continuous except where interrupted by basement highs. ‘U’ is also seen to have a major impact on the ability to image underlying basement. A full transect from completely unextended continental crust to oceanic crust has provided two estimates of extension and the pre-rifting location of the present continental edge; 85 km based on faulting and 120 km based on crustal thickness.

Poster

MAPPING POST RIFT SILLS ALONG THE NEWFOUNDLAND PASSIVE MARGIN

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A high amplitude reflector package at the base of the sedimentary sequence in the Newfoundland Basin sampled during ODP Leg 210 results from thin diabase sills. Chemical analyses and dating suggest that the sills were emplaced in two separate postrift thermal

events, probably related to hot spot activity. Seismic data tied to the borehole reveal that the sills are widespread and continuous over hundreds of square kilometers. Spectral decomposition is used here on high quality seismic profiles (migrated near trace gathers) in order to map the peak energy frequency variation of the U reflections throughout the basin which is then related to thickness of sills. The analysis is complicated due to limited signal bandwidth and the complexity of the sill geometries but trends are apparent throughout the basin. The lowest frequencies (thickest sills) are associated with the central basin, particularly towards the south. Higher frequencies (thinner sill) are associated with the upper sill in the north but the upper sill in the south central basin is low frequency. Based on sill thickness variations, the source of magma is proposed to be in the south central basin close to the present day Newfoundland Seamounts.

Poster

ELECTRONIC AND MAGNETIC PROPERTIES AND LATTICE DYNAMICS OF γ-Fe_2SiO_4: GROUND STATE AND THE EFFECT OF PRESSURE

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Typical mantle olivine, $(Mg0.9,Fe0.1)_2SiO_4$, transforms to a modified spinel β-phase) at about 400 km and then to a γ-phase with a spinel structure at 500 km depth in the earth. The Fe compound, fayalite, transforms directly to the γ-phase at about 4-6 GPa and 700-1300 K. The spinel phase of olivine contributes significantly to the thermoelastic behaviour of the mantle transition zone and to the observed seismic discontinuities. We use the density functional theory (DFT) with GGA and GGA+U approach to study the electronic and magnetic properties and lattice dynamics of γ-Fe_2SiO_4. Ferromagnetic (F) structure and the structure with antiferromagnetic (AF) alignments of Fe spins were found to be the stable ground states. Although the energy of the AF structure was found to be lower, the energy difference between the two stable states is negligible. This result is consistent with the fact, that the λ-transition of γ-Fe_2SiO_4 occurs at extremely low temperature of 11.8 K. While the GGA predicts a metallic ground states, the insulating solution was obtained with GGA+U, implying that the strong electron-electron repulsion plays an important role in the gap opening mechanism in this system.

Oral & Poster

CRUSTAL STRUCTURE OF NORTHERN LAKE BAIKAL, RUSSIA

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As one of only a small number of Cenozoic continental rifts, the Baikal Rift Zone (BRZ) is a natural laboratory for understanding processes of rifting. Located in south-central Russia, the rift zone is known for Lake Baikal, a rift valley lake that contains 20% of the world's fresh water. Rifting in the region began about 25 Ma along the boundary between the Archean-Paleoproterozoic Siberian craton and the Early Paleozoic age Sayan-Baikal orogenic belt. Here we present a new velocity model for the structure of the crust along a 160-km transect in the north basin of Lake Baikal. The data, recorded in 1992, come from five 4-component ocean bottom seismometers (OBS) deployed at ca 40 km intervals. The source consisted of 2 air guns with a combined volume of 120 liters, that were fired at 240 m intervals along the transect. The data are of moderately good quality and are characterized by strong first arrivals to offsets of 40 km and a series of wide-angle reflections from interfaces in the crust, including the Moho. Travel times for both P- and S-wave arrivals from the crust were picked from the data. The velocity model, obtained through a combination of forward modeling and inversion, contains two shallow layers associated with basin sediments, a low velocity zone

(LVZ) at 6 to 9 km depth, mid-crustal interfaces at ca. 12 and 22 km depth, a high velocity layer at ca. 33 km and Moho at ca. 40 km. The evidence for two distinct layers within the sedimentary section is consistent with geologic models that have proposed that there have been two distinct stages of rifting. Beneath the sedimentary layers, the crust is unusually fast with average velocities of 6.5 km/s at 5 km depth, increasing to 7.4 km/s at Moho. Possible origins for the low velocity zone are still being investigated. Joint analysis of the P- and S-wave models suggests that it has a Poisson's ratio greater than 0.3. The interface at 20 km may correspond to a detachment zone between 18 km and 22 km that has been proposed by previous workers. A ca. 7-km thick layer with velocities of 7.4 to 7.5 km/s forms the base of the crust. The Moho is essentially flat along the entire transect. The Low Velocity Zone in our model is consistent with an LVZ found in teleseismic and Deep Seismic Sounding (DSS) studies in the area. The mid-crustal reflector in our model coincides with a distinct band of reflectivity, suggestive of rifting, detected from DSS results. Seismic transects across and along the central basin of Lake Baikal detect a high velocity layer at the base of the crust similar to our model for the north basin.

Poster

PRELIMINARY RESULTS OF OBS AND COINCIDENT MCS PROFILE STRIKING PARALLEL TO THE WEST IBERIAN MARGIN

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The west Iberia margin is located at the southern end of the European North Atlantic Margins. This margin was formed due to the Mesozoic rifting of the Paleozoic continental crust and subsequent sea-floor spreading. During Miocene the margin was compressed, what produced uplift and inversion of the Mesozoic basins. The tectonic processes in the margin are still active in the Present. The Iberia continental crust broad seismic structure is well known since the nineties, when deep seismic sounding experiments were performed. The stretching of this continental crust towards the ocean is known to be depth dependant. The lower continental crust pinches-out ~50 km seaward of the coast line, and the remaining continental crust extends further ~50 km to the west. Our goal is to focus other important questions regarding the offshore extension of the inland structure, namely (i) the variability of structure along the margin and (ii) the offshore prolongation of main tectonic accidents. We present a preliminary P-wave velocity model from wide-angle and coincident multi-channel seismic reflection profile IAM6, striking parallel to the margin at ~5-10 km off the coast line.

Poster

APPLICATION OF SKELETONIZATION-MIGRATION IN DEEP CRUSTAL REFLECTION SEISMIC PROFILING

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The nature of tectonic features and related scattering phenomena is three-dimensional, yet most crustal-scale surveys are acquired along quasi-linear profiles due to the high cost of 3-D data acquisition. In the unavoidable presence of out-of-plane events, standard 2-D wave equation migration algorithms produce significant mislocation errors that increase with recording time, complicating the interpretation of dipping lower crustal and mantle reflections. Out-of-plane features may be mislocated by 10's of km and show spurious apparent dip after migration. Here, we introduce a skeletonization-migration method that accounts for the out-of-plane of scattering for both specular reflections and diffractions. This method generally

requires a priori knowledge of the strike direction of crustal reflectors, but where correlatable intersecting profiles are available it is sometimes possible to solve for reflector strike. We achieve the visualization of results in 3-dimensions by representing reflection segments as planar Fresnel patches. We demonstrate the usefulness of the method with results drawn from synthetic modelling experiments and deep crustal reflection seismic profiles, for which the reflector strike is well constrained. Our algorithm is coded in matlab and available for research purposes upon request.

Oral & Poster

WIDE ANGLE CONVERTED SHEAR WAVES: FURTHER CONSTRAINT ON THE STRUCTURE OF VOLCANIC RIFTED CONTINENTAL MARGINS IN THE NORTH ATLANTIC

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High-quality, wide-angle, ocean bottom seismometer (OBS) data have been acquired with a low frequency (9 Hz) seismic source across two North Atlantic volcanic rifted continental margins where Tertiary flood basalt sequences provide a challenge to deep seismic imaging. Converted S-wave arrivals were recorded at 170 4-component OBS locations. Tomographic inversion of over 70,000 converted S-wave crustal diving waves and Moho reflections produced S-wave velocity models and, when combined with P-wave velocity models, a measure of Vp/Vs. The lower crust at the continent-ocean transition has high P-wave velocities of up to 7.5 km/s and low Vp/Vs ratios of ~1.75 associated with intense high-temperature intrusion during break-up. A P- and S-wave low velocity zone (LVZ) is present beneath the basalt on the Faroes margin; modelled properties indicate the presence of some Paleocene (or older) sedimentary rock rather than solely igneous hyaloclastites similar to those found beneath the basalt in a nearby well. Beneath the LVZ, a unit with Vp/Vs ratios of 1.80-1.85 and P-wave velocities of 5.5-6.0 km/s is interpreted as sill-intruded sedimentary rock of a pre-breakup Mesozoic basin.

Poster

ULTRASONIC SEISMIC VELOCITIES IN FIRE AND ODDP SAMPLES, FINLAND, FENNOSCANDIAN SHIELD

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Longitudinal (Vp) and shear (Vs) velocities of several Outokumpu Deep Drill Core (ODDP) and seismic reflection (FIRE) samples were determined. A custom built ultrasonic instrument allowed estimating the velocities encountered under crustal temperatures and pressures. The velocities provide estimates of the reflection coefficients and Poisson ratios in various rock types of Finland and thus improve interpretations of crustal structures. The measurements are necessary to understand recent reflection profiles in Finland. The ultrasonic instrument measures simultaneously longitudinal and shear wave phase velocities in rock samples (featuring two parallel smooth surfaces) under varying temperature and uni-axial pressure (0-300 MPa for 25 mm sample diameter). The device is the result of collaboration between the Solid Earth Geophysics Laboratory and the Electronics Research Laboratory. First results (dry samples, ambient temperature and pressure) of FIRE samples from Keuruu area indicate values of 4000-5200 m/s for Vp and 1800-2900 m/s for Vs (Vp/Vs ratio 1.67-2.4) depending mostly on sample condition (micro/macro cracks). Under crustal conditions (300ºC, ~100MPa) Vp and Vs values raised to <5700 m/s and <3100 m/s, respectively (Vp/Vs ratio 1.68-2.2). Currently the extended measurements of other FIRE and ODDP samples (e.g. water saturated) are ongoing and will be presented.

Oral & Poster

BOREHOLE SEISMIC SIDE-SCANS FOR MINERAL RESOURCE DELINEATION

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Mineral resource delineation by seismic techniques is seen as a promising technique with benefits for reduced economic risk, shorter project timelines and more accurate resource evaluations. Various aspects of lithological delineation, with diverse geometries, from semi-horizontal thin folded and faulted dikes to nearly vertical irregular pipes are discussed for kimberlite delineation. The country rock can range from very competent (Finch mine, South Africa) to fractured and weathered (Diavik mine, Canada) and diverse physical properties, with contrast inversions relative to the country rock within the same body, pose real challenges for the seismic imaging task. With seismic velocities of 5000–6000 m/s, a frequency band of 500–3000 Hz is needed to provide spatial resolution on the order of a meter. A borehole tool consisting of a time-distributed swept-impact piezoelectric source and an inline array of 20–30 hydrophones placed at 1-2 m intervals has been used. The range of the side-scan seismic investigations is estimated at more than 150 m in working mine conditions. To obtain sub-meter accuracy the velocity must be correctly estimated to +/- 1% across the imaged volume. Pierce points at the bottom of the hole and/or in its vicinity did help significantly the velocity calibration. Side-scans from adjacent boreholes were used to produce 3D delineations of the targets. Information from borehole logs and generic geological data has been used to calibrate the interpretation. Borehole high-resolution seismic methods were successful in delineating the kimberlite–country rock contact in all case histories presented. If applied routinely, they can provide a cost effective way to increase knowledge of geology and raise confidence in the geological model, reducing risk in resource estimation.

Oral

INTERNATIONAL WORKSHOP “MODELS OF THE EARTH’S CRUST AND UPPER MANTLE”

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The international workshop “Models of the Earth’s Crust and Upper mantle” was held at VSEGEI, St. Petersburg, in September 2007. The workshop was arranged by the Federal Agency on Mineral Resources of Russia, VSEGEI, SEVMORGEO, and IGCP 474 “Images of the Earth’s crust & upper mantle”. Over 80 specialists from 24 Russian institutions and geoscientists from Australia, China, Netherland, Ukraine, Japan took part in the forum. The am of the workshop was to promote studying the deep structure, perfection of the procedure of geological and geophysical surveying, search for efficient possibilities of data processing and interpretation.Thirty five presentations and over 30 posters concerning following main subjects were given: 1) results of generalizations on the Russia’s deep structure; 2) research on the deep profiles network of Russia; 3) deep studies in various regions of the world; 4) procedure and technology of data processing and interpretation. The participants were informed on main trends and results of work on the State network of deep geological-geophysical profiles of Russia, trends of work under IGCP 474 “Images of the Earth’s crust & upper mantle”, and the Australian programme on deep seismic profiling. Much attention was paid to the deep investigations of shelf. Ascertaining, that the forum promoted strengthening of scientific communications in the deep structure researches from the different countries, participants recommend continuing practice of similar workshop.

Oral

LATERAL VARIATION OF SUBDUCTION-COMPRESSION STRUCTURES ALONG THE NORTH IBERIAN MARGIN FROM DEEP SEISMIC REFLECTION DATA

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The North Iberian Margin, located at the southern flank of the Bay of Biscay underwent successive tectonic regimes of rifting, passive margin, and limited subduction and compression from Mesozoic to Tertiary times. The main effects of the alpine orogeny included the NW-SE oblique convergence between the European and Iberian plates, the partial closure of the recently formed Bay of Biscay, the deformation of the margin and the uplift and deformation of the Cantabrian Mountains. The end of the convergence at the Miocene aborted the collision between the plates that had already started further west in the Pyrenean region. Deep seismic reflection lines belonging to the Marconi, IAM and oil related commercial projects which have been pre-stack depth migrated, show variations in the shape and style of the compresional structures related to the convergence episode from West to East. Those differences arise from the distinct continental or oceanic substratum of the subducted plate and are greatly influenced by the previous rifting structures. The North Iberian Margin provides a unique setting were incipient subduction and compression structures are fossilized beneath a thick blanket of pos-tectonic sediments.

Oral & Poster

IGCP PROJECT 474: AN INFORMATION RESOURCE FOR DEEP SEISMIC PROFILING AND IMAGING

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IGCP PROJECT 474 is an International Geoscience Programme (IGP) project under UNESCO/IUGS. IGP is the successor to the International Geological Correlation Project (IGCP). This programme focuses on bridging the gap between scientific effort and public interest, and also seeks to foster international cooperation and knowledge transfer. One focal point for the UNESCO/IUGS programme is on the deep Earth and how it controls and affects various communities and our environment. The deep seismic profiling project IGCP Project 474 - Images of the Earth's crust & upper mantle operates within the IGP deep Earth programme. IGCP Project 474 brings to public attention the very large amount of information on the structure of the Earth's crust that is obtain using seismic profiling methods that was slowly being lost as a result of technology advancement and the movement of key players into other fields of endeavour. Through web-based information and links available to the general public, these projects seek a better community understanding of crustal architecture and tectonic history/processes, fundamental to any appreciation and understanding of landscapes, surface geology, natural hazards, and mineral/energy resource development at a local, regional and global scale. The projects also seek to provide a platform for research earth scientists to communicate and archive transect information from around the world. Examples of comparative studies will be presented.

Poster

ON-LINE DEEP SEISMIC REFLECTION PROFILES WITHIN THE IBERIAN PENINSULA

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A compilation of a relatively large amount of seismic transects within the Iberian Peninsula has been carried following the principal ideas of the IGCP-474. One of the main objectives of this project is to provide ready access to geophysical data, such as images of the Earth's basement geology and deep crust and upper mantle and thus, create a standard set of definitions describing images of the Earth's interior. In order to get this, on-shore and off-shore seismic data acquired from 1961 to 2007 have been collected in a standard SEGY format in a geophysical data base. All seismic data in the collection are accessible through the web page http://xeon.ija.csic.es/ to the scientific community. This base comprises data from several Spanish funded projects (e.g. ESCI, IAM, IBERSEIS, URSEIS) in different processing stages such as shot gather data or migrated stacks. One of the expected results of this project is to contribute to more informed debate on issues related to geological paradigms, tectonic processes, the natural environment, natural hazards, and sustainable use of natural resources. Therefore, to get a better understanding of geological processes that have shaped the surface features of the Earth's continents and its margins.

Oral

A CRUSTAL SEISMIC PROFILE ACROSS SICILY (ITALY): PRELIMINARY RESULTS

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The preliminary interpretation of a deep crustal seismic reflection profile, acquired in Sicily, from the Tyrrhenian coast to the Hyblean foreland (SI.RI.PRO multidisciplinary research program), will allow to improve the crustal geological knowledge of Sicily. The data were acquired using dynamite sources with charges up to 30 kg, shot in holes at depths down to 30 m. The recording instrument was a Sercel SN 408 XL with 240 channels, an asymmetric or symmetric split-spread recording, 12 km long, according to the variable structural settings of the crust along the line, 110 km long. The coverage was 2400%. The acquisition started in December 2007 and was completed in January 2008. Conventional processing of the data is in progress and here we present the first seismic images along the transect. Starting from South the most important reflector dips northwards reaching 7.5 s TWT in the central part of the line. A huge complex tectonic edifice composed of a stack of carbonate and terrigenous embricates characterizes the northern part of the line and its main interface dips from North down to 6.5 s in the central Sicily. These geometries are in agreement with the high negative Bouger anomaly (100 mGal) there evidenced.

Oral & Poster

INSIGHTS INTO THE STYLE AND GEODYNAMIC IMPLICATIONS OF CIRCUM-ANTARCTIC PASSIVE CONTINENTAL MARGINS AND THEIR CONTINENT-OCEAN TRANSITIONS

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Antarctica was a center-piece of the Gondwana supercontinent. About 85 percent of Antarctica's 10000 km long continental margins are of a rifted divergent type, and about 1200 km have been converted from a subduction-type to a passive margin after ridge-trench collision along the Pacific side of the Antarctic Peninsula. The separation of South America, Africa, India, Australia and New Zealand from Antarctica and the creation of a continuous Southern Ocean began in the Jurassic and continued until the mid Tertiary. In recent years, the amount of geophysical data along the continental margin of Antarctica has increased substantially, which allows to differentiate the crustal characteristics of its continent-ocean boundaries and transitional zones (COB/COT). The data and geodynamic modelling indicate that the cause, style and process of breakup and separation are highly variable along the Antarctic margin. A circum-Antarctic map summarizes the crustal styles of the margin and the location and geophysical characteristics of the COT. Definitions and identifications of the COT and an understanding of its process of formation have consequences for plate-kinematic reconstructions, geodynamic syntheses and isostatic considerations.

Oral

IMAGING AUSTRALIAN ENERGY PROVINCES USING SEISMIC REFLECTION PROFILING

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Geoscience Australia continues to acquire high quality deep seismic reflection data as part of its mandate to provide datasets and information for understanding the structure and evolution of the Australian Continent. Deep seismic transects are a major component of the new Onshore Energy Security Program (OESP), which is designed to encourage exploration for hydrocarbon, geothermal and uranium resources by acquiring new datasets from frontier areas. Deep seismic reflection surveys completed under the OESP include the 2006 Mt Isa Survey, the 2007 Isa-Georgetown-Charters Towers Survey and the 2008 Rankin Springs survey (Darling Basin). Surveys in the Gawler Craton, Curnamona Province, and Officer Basin are scheduled for 2008, while more lines are planned for the Canning Basin and Paterson Province in 2009. The deep seismic data are a key element of regional projects aimed at realising the energy potential of Australian geological provinces. Deep seismic is particularly useful for mapping regional-scale basin architecture and imaging deep mantle-tapping structures that may conduct mineralising fluids to the near-surface. The understanding of seismic characteristics within the upper crust is an important component in interpretation of data from mineral provinces and petroleum basins because reflection seismic is the best method for directly and uniquely imaging structures to depth on a regional scale. These seismic surveys have provided exciting images of the crustal architecture along 2D transects which, when combined, provide depth constraints for 3D geological framework models. Data from these surveys are a fundamental component of understanding tectonic evolution, as well as providing vectors to possible mineral and hydrocarbon systems associated with the tectonics. The seismic data provide context for explorers who are assessing the petroleum and mineral potential of an area, and allows them to better focus their targeting efforts. Results from several seismic surveys will be presented to demonstrate how deep imaging of the Australian crust reduces risk in onshore energy exploration in frontier regions.

INVITED Oral

EUROPEAN CRUST AND MOHO DISCONTINUITY: ONE HUNDRED YEARS FROM THE DISCOVERY OF THE CRUST – MANTLE BOUNDARY

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In 1910 the Croatian seismologist Andrija Mohorovičić (1857-1936) published his important paper "Potres of 8.X.1909" (Earthquake of 8 October 1909). In this paper he studied seismograms of an earthquake in the Kupa Valley (Croatia) together with other events from this region and he discriminated two distinct pairs of compressional P and shear S waves. The interpretation of the two sets of arrivals led him to discover the existence of the velocity discontinuity in the uppermost Earth, at depth of 50 km, with P-wave velocities 5.60 km s-1 above and 7.747 km s-1 below (Mohorovičić 1910). Studies during the next one hundred years showed that the sharp seismic discontinuity discovered by Mohorovičić was found worldwide, and that it separates crust from underlying upper mantle. It was named the Mohorovičić discontinuity, or Moho in abbreviated form, or even M-discontinuity (for lazy people and people having problem with the pronunciation of this Croatian name).

In terms of elastic parameters and density, the Moho is a distinct discontinuity. It can be studied relatively easily using geophysical methods – seismic waves propagated through the crust and mantle with different velocities, as well as by modelling of gravity anomalies with use of large density contrast at the Moho. Seismic methods are most effective for studying the Earth's interior, and they use different types of seismic waves - body P and S waves, surface waves, as well as different techniques – near-vertical reflection profiling, deep seismic sounding using refracted and wide-angle reflected waves, receiver function, and modelling of dispersion curves of phase and group velocities and waveform modelling.

We show examples of crustal structure studies and recent compilation of a new digital European plate Moho depth map. In general three large domains within European plate crust are visible. The oldest Archean and Proterozoic crust has a thickness of 40-60 km, the continental Variscan and Alpine crust has a thickness of 25-35 km, and the youngest oceanic Atlantic crust has a of thickness 10-20 km. Knowledge of the crust is essential to explain and predict propagation anomalies for seismic waves and to correct for crustal effects when probing deeper into the Earth (e.g. in seismic tomography of body and surface waves, studing lithosphere-asthenosphere boundary).

We will try to anticipate what is a future for crustal studies in Europe.

Reference: Mohorovičić, A., 1910. Potres of 8.X.1909, Godišnje izvješće zagrebačkog meteorološkog opservatorija 9(4/1), 1-56 (and English translation in 1992: Earthquake of 8 October 1909, Geofizika, 9, 3-55).

Poster

EUROPEAN PLATE CRUST AND NEW DIGITAL MOHO DEPTH MAP

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The integration of models derived from recent active and passive seismic experiments allows the construction of the Moho depth map for the European plate comprising an area from Ural Mountains in the east to mid-Atlantic ridge in the west, and from Mediterranean Sea in the south to Spitsbergen and Barents Sea in Arctic in the north. The map is compiled from more than 250 data sets of individual seismic profiles, 3D models obtained by body and surface waves, receiver function, and seismic and/or gravity data compilations. In general three large domains are observed: the oldest Archean and Proterozoic crust is 40-60 km thick, continental Variscan and Alpine crust is 25-35 km thick, and the youngest oceanic Atlantic crust is 10-20 km thick.

Oral & Poster

SEISMIC IMAGING OF THE CHILEAN SUBDUCTION ZONE AROUND THE HYPOCENTER OF THE 1960 VALDIVIA EARTHQUAKE

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In the frame of the interdisciplinary project TIPTEQ (from The Incoming Plate to mega-Thrust EarthQuake processes) a reflection seismic image of the hypocentral area of the 1960 Valdivia earthquake was acquired. The application of Kirchhoff prestack depth migration for both P- and S-waves as well as two advanced imaging techniques (Fresnel Volume Migration, Reflection Image Spectroscopy) clearly show the subducted oceanic Nazca plate below the segmented forearc and a highly reflective overriding South American plate. The reflectivity varies across the section and appears to be weak around the area of the 1960 earthquake hypocentre. We associate the high reflectivity at the plate interface with the existence of a subduction channel with a varying thickness of 2-5 km down to a depth of at least 38 km. The continental Moho in the overriding plate is not clearly visible. The reflectivity east of the hypocenter shows horizontal structures at various depths, which give rise to different eastward continuations of the continental Moho. The combination of the obtained high resolution seismic image together with the results from other geophysical investigations provides the first detailed picture of the nucleation point of the 1960 megathrust earthquake.

Poster

EFFECTS OF DECIMATION INPUT DATA ON FULL WAVEFORM TOMOGRAPHY. APPLICATION TO COMPLEX SYNTHETIC MODELS

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Seismic tomography can be roughly categorized into travel-time tomography (TTT) and full-waveform tomography (FWT). TTT uses the high-frequency contents of the seismic data to fit traveltimes, whereas FWT uses the whole seismogram as information to adjust both amplitudes and phases. TTT and FWT are inverse problems, in which the seismic data are given and the goal is to determine different attributes of the medium such as wave speed, anisotropy, attenuation or density. The new advances in hardware are making FWT a feasible approach to seismic wide-angle and normal incidence characterization of the deep crust and lithosphere, and it has been proved to be an efficient tool to obtain high resolution images of the crust. Realistic synthetic testing is required in order to fine tune the existing algorithms and for a full validation of the approach before it can be routinely used in real field data sets. We have used two models to simulate onshore and offshore acquisitions. The aim has been to find the optimal acquisition geometry required to achieve reliable results. The starting model is built using the results from the first arrival travel times tomography with the sources and the receivers covering a larger area than the target.

Poster

BRIGHT REFLECTOR IN THE UPPER CRUST BENEATH THE EASTERN ATHABASCA BASIN IN SASKATCHEWAN, CANADA

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The Wollaston Lake Reflectors were discovered during the last phase of the Trans-Hudson Orogen transect study of the LITHOPROBE project. These bright reflections extended over 160 km along a major seismic profile. The depth of these reflective bodies ranged from ~ 5.5 to 14.0 km (1.8 - 4.6 sec, TWT). In recent industrial surveys similar anomalous seismic signatures are now recognized; some more than hundred km apart, beneath the eastern portion of the Athabasca Basin. All are located at the shallower end of the above depth limits, ascending closer to the surface at the southern region of the basin. The architecture of these seismic signatures is highly variable. A single wave form may extend over a 1.00 sec. wide parallel set of events, or they may branch out enclosing a significant zone of crustal transparency. In several locations, the reflectors are offset by shear zones. In some localities these faults zones ascend near to the surface. The highly comparable seismic signatures of the isolated surveys, suggest that the tabular bodies extend over at least 30,000 km2. The anomalous large amplitude of the seismic signals indicates significant acoustic contrast in a vertical zone of 50 to 150 m. The origin of these enigmatic sheet-like complex zones is not resolved. One suggestion is that they are sill-like bodies, representing subsurface expressions of the ca. 1,265 Ga (post-Hudsonian) Mackenzie diabase suite. However, instantaneous phase, amplitude strength and other seismic signal attribute analyses reveal that a variety of geologically acceptable acoustic contrasts, including one due to remnant fluid inclusions, cannot be ruled out. The region of this anomalous subsurface reflectivity property is under extensive mining exploration; therefore, a resolution of the true nature of the complex geologic interval of the upper crust is of high interest. In one locality a major fault zone of a prominent ore-body appears to be connected to the underlying bright reflective zone.

Poster

LITHOPROBE'S TRANS-CONTINENTAL LITHOSPHERIC CROSS-SECTION: IMAGING THE INTERNAL STRUCTURE OF NORTH AMERIC

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The LITHOPROBE trans-continental lithospheric cross-section provides a synthesis of more than two decades of coordinated multidisciplinary research. The section is based on seismic reflection and refraction data combined with a broad range of geological, geochemical and geochronological data. The 5000 km-long corridor, displayed with earth's curvature, traverses the North American continent at ~50ºN. The cross-section emphasizes relationships between orogens, which are stacked upon one another such that one forms basement to the next. For example, the modern Atlantic passive margin overlies the ~0.4 Ga Appalachian orogen, which overlies the ~1.0 Ga Grenville orogen, which in turn overlies the volcanic arcs and microcontinents that were assembled by ~2.6 Ga to form the Superior Province. Strong evidence for assembly of this Archean province by plate tectonic processes is provided. With a few notable exceptions, the Moho is generally flat across the continent, irrespective of topography, the age of the crustal rocks or the time when the last major deformation occurred. Most significant changes in Moho depth occur at rifted margins (active and preserved) and at relict subduction zones. Preserved thickened crust beneath orogens is rare; the ~1.8 Ga western Trans-Hudson orogen, an unextended continent-continent collision zone, contains the only crustal root in the entire section.

Oral & Poster

SEISMIC IMAGE OF THE FENNOSCANDIAN SHIELD ALONG THE BALTIC SEA - WHITE SEA TRANSECT

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We present a 1120 km long transect extending across the Precambrian Fennoscandian Shield, from the Belomorian greenstone belt in the east, across the Archaean Karelian craton and the Proterozoic Western Finland Arc Complex (WAC) to the Proterozoic Southern Finland Arc Complex (SAC). The transect gives a comprehensive view of the crust and uppermost mantle across the Fennoscandian Shield , imaging the break-up of the Archaean craton and tectonic processes which compiled the Shield during the Svecofennian orogeny (1.9-1.8 Ga). Most of the seismic reflection data along the transect was acquired by the FIRE (Finnish Reflection Experiment) consortium - the Geological Survey of Finland, and Universities of Helsinki and Oulu, with Russian Spetsgeofizika S.G.E. as a contractor. The consortium carried out seismic reflection surveys in Finland in 2001-2003 on four lines with a total length of 2135 km. The first two lines, FIRE 1 and 2, form the 860 km long southern part of our transect, running roughly NE-SW across the Fennoscandian Shield from the Finnish-Russian border to the southern coast of Finland. The northeastern part extending from the White Sea to the Finnish border along the Kem-Uchta line was shot by Spetsgeofyzika in 1999.

Poster

SEISMIC REFLECTIVITY AND ANISOTROPY IN OUTOKUMPU, FINLAND BASED ON HIGH RESOLUTION SEISMIC SURVEY AND BOREHOLE DATA

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In May 2006 a high resolution seismic survey was conducted in Outokumpu, Finland near the International Continental Drilling Program (ICDP) deep research borehole that was drilled in 2004-2005. The main lithologies observed in Outukumpu deep drill hole were mica schist (upper 2 km) underlain by unexpected pegmatic granite. The ophiolite-related Outokumpu assemblage rocks were observed at depth range of 1,3-1,5 km. Seismic soundings were done in two crooked lines perpendicular to each other using a vibrator source with linear upsweeps between 15 and 250 Hz. The survey included both simultaneous walk-a-way VSP and surface reflection/refraction seismic data aquisition. The surface source and receiver spacings were 20 m and 4 m, respectively while the 3-C downhole receiver was positioned at depths of 1000, 1750 and 2500 m. Tomographic modelling of layer thicknesses and P-wave velocities was required to calculate the static corrections necessary to account for variations in topography and the near-surface low-velocity layer. Processing of the reflection seismic data revealed a good correlation between the seismic section and the lithologies observed in the deep drill hole. Acoustic impedance variations derived from the density and sonic logs also strongly correlate with the reflections visible in seismic section. Forward modeling of a transversely isotropic medium with fluid-filled penny-shaped cracks was carried out in an attempt to fully describe the anisotropic seismic velocity of the schist between 50-1000 m in depth, and good agreement was found between the theoretical model and the walk-away VSP measured velocities.

Oral

3D SEISMIC STRUCTURE OF THE FOREARC AREA IN EASTERN HOKKAIDO, JAPAN, BY USING OCEAN BOTTOM SEISMOGRAPHIC OBSERVATION

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We estimated 3D seismic velocity structure of the forearc region in eastern Hokkaido by using the P and S wave arrival time data recorded by land and offshore seismic stations. Travel time data obtained by 30 OBSs deployed for about 10 month and three offshore cabled stations helped to constrain hypocenter locations and seismic velocities in offshore area. In the obtained velocity model, the crust and mantle of the subducting Pacific slab are well imaged as the landward dipping low/high velocity layers. In the studied area, a large interplate earthquake, the Nemuro-oki earthquake (M 7.4) occurred in 1973. The depth to the plate boundary is estimated to be less than 30 km from the obtained velocity model, which indicates that the subducting Pacific slab contacts to the crust of the overriding plate in most of the rupture area of the 1973 earthquake. The mantle of the overriding plate has normal Vp and Vs values (~ 8km/s and 4.5 km/s) beneath the forearc area, suggesting cold and dry state of the forearc mantle. The rupture area of the 2004 Kushiro-oki earthquake (M7.1) is located beneath this high velocity forearc mantle, which can accommodate unstable sliding along the slab surface.

Oral

HETEROGENEITY MAPPING AS AN APPROACH TO CHARACTERIZING COMPLEX REFLECTION WAVE FIELDS

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Reflection wave fields associated with geometrically complex geology contain highly localized information about the spatial properties of the geology. Therefore, mapping the variation in the spatial properties of the wave field (heterogeneity mapping) provides a pseudo-image that characterizes geologic heterogeneity and can be used to map macro-scale geology in the subsurface. We will discuss a range of issues pertinent to both the qualitative and quantitative use of heterogeneity mapping. In particular we will address the resolution of the mapping process and the limitations imposed by both the temporal and spatial bandlimits of the data. To demonstrate the effectiveness of technique will show a set of examples that assess the nature of heterogeneity at scales ranging from shallow aquifers to petroleum reservoirs to the continental crust.

Poster

HOW MANY SOURCES ARE ENOUGH IN A VIRTUAL WORLD?

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Creation of virtual seismic sources through interferometry is a rapidly developing technique that shows promise for applications ranging from crustal-scale to mining-scale seismic imaging. Much of the development work has focused on situations in which the area of interest for imaging can be completely surrounded by relatively closely spaced real sources. Since this restriction is not practical in real world active source imaging, more work is

needed to understand how far a field experiment can depart from the ideal condition and still provide useful information. We present a synthetic study that is designed to investigate the limits of using the virtual source concept to decrease the source effort required or to fill gaps in source patterns. This application is relevant to seismic data acquisition situations where complete 2D or 3D imaging is impractical for logistical or cost reasons. In particular, we focus on the detection and imaging of sub-Fresnel zone targets such as ore bodies for which the seismic response is dominated by scattering and the quality of imaging is sensitive to the completeness of illumination.

Oral & Poster

SEISMIC ANISOTROPY STUDY AT THE HIGH STRAIN RATE ZONE (NIIGATA-KOBE TECTONIC ZONE), IN CENTRAL JAPAN

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In central Japan, high strain rate zone which was called the Niigata-Kobe Tectonic zone (NKTZ) was detected by the GPS studies. It is well known that elastic anisotropy of the earth is closely related to mantle dynamics. The studies of shear-wave splitting will be important to know the mantle dynamics beneath NKTZ. We conducted seismic observation at the area with a spatially high dense seismic array. The seismic network with 73 seismic stations was used for the analysis of shear-wave splitting at NKTZ. The deep earthquakes with depth of deeper than 250 km were used. The large lateral variation was found on the polarization directions. The large lateral variation with large time-lag values, which is larger than 0.6 sec, could be explained by the mantle anisotropy. The cause of anisotropy with the heterogeneous mantle structure could not be ruled out. However, the observed polarization directions are highly consistent with the subduction direction of Philippine Sea slab. The observed shear-wave splitting can be explained by the preferred orientation of the olivine crystal which is caused by the mantle flow. The trend of preferred orientations of olivine crystals does not support the plate convergence model as the cause of NKTZ.

Oral & Poster

FINE SEISMIC STRUCTURE AROUND THE ATOTSUGAWA FAULT REVEALED BY SEISMIC REFRACTION AND REFLECTION EXPERIMENTS

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A large right-lateral fault, Atotsugawa fault, is located inside Niigata-Kobe Tectonic Zone (NKTZ), which is a high strain rate zone in central Japan. Low velocity area was detected in the lower crust beneath the Atotsugawa fault from tomographic studies. A seismic experiment with seven explosive sources with charge size of 300 kg - 500 kg and with 1108 seismic stations was conducted around the Atotsugawa fault in October, 2007. The refraction and reflection experiments have done with the profile line length of 170 km. A clear later phase was found on the record section. The later phase was observed at the seismic stations which is located near the Atotsugawa fault. The phase appeared around 7 sec on the time section of the reflection profile. The later phase is considered as the reflected wave at the boundary with a depth of around 20 km. The phase is observed at the seismic stations on the profile line with a lateral scale of 40 km. The location of the boundary is consistent with that of the low velocity zone beneath the Atotsugawa fault. This feature is consistent with the week zone model, which is a formation model of the inland earthquake fault.

Poster

SUHANKO REFLECTION SEISMIC PROFILE AND INTEGRATED GEOLOGICAL-GEOPHYSICAL MODEL OF THE PORTIMO AREA

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The Suhanko higher resolution seismic line and the FIRE 4 studied here are located to one of the best mineral prospecting area in Finland. FIRE 4 runs over the Narkaus Intrusion of the palaeoproterozoic Portimo Layered Complex, while the Suhanko line cross-cuts (east to west) the Archaean basement complex, the Suhanko Intrusion and the overlying Peräpohja Schist Belt, including mafic sills intrusions in the Belt. The eastern margin of the Suhanko Intrusion is known to host disseminated contact type PGE-Ni-Cu mineralization some 30-50 m in thickness. The Suhanko Intrusion showed up well seismically and matches the known surface geology and gravity interpretations. The interpreted down-dip extension of the Suhanko also matches the geologically anticipated structure well. The principal positive exploration implication is the considerably long extension of the Suhanko Intrusion westwards at a shallow, economically drillable depth. The seismic results suggest that the basal contact of the Suhanko Intrusion (and associated mineralization) may extend almost 3 km along the down-dip strike underneath the Peräpohja Schist Belt. Examining the Suhanko and the less-detailed FIRE 4 profile together revealed a set of structures which are obviously related to the same rifting episode as the Suhanko and Narkaus Intrusions.

Oral

INITIAL STRUCTURE OF THE ITOIGAWA-SHIZUOKA TECTONIC LINE EMERGING FROM THE RECENT DEEP SEISMIC PROFILINGS , CENTRAL JAPAN

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The Itoigawa-Shizuoka Tectonic Line (ISTL) is one of the significant faults in Japan, which divides the Japanese island arc into the two; Northeast and Southwest. The ISTL was originally made associated with the opening of Japan Sea and the formation of the Japanese island arc in middle Miocene. Although the present ISTL is composed of three segments, the northern, the central, and the southern, its initial structure was considerably different from the present one. The initial structure must have been severely modified by the successive collision of Izu-Bonin arc against the Japanese island arc which started simultaneously with the opening of the Japan Sea. Only the southern segment probably preserves the initial structure. The recent accumulation of deep seismic profiles across the ISTL suggests that initial ISTL ran east of the present northern and central segments. We will introduce the essential information to reconstruct the initial structure and discuss the deformational process of the ISTL from its birth.

Oral & poster

SEISMICITY AND TOMOGRAPHY ALONG JAPAN TRENCH REVEALED BY HYBRID METHOD FOR HYPOCENTER DETERMINATION USING WAVEFORM AND TRAVEL TIME

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The Pacific plate is subducting beneath Tohoku, northeastern Japan, is subducting along the Japan Trench. The seismicity along the plate boundary is the highest in the world. The regional seismicity varies from north to south along the Japan Trench. Recent seismic tomography images also propose that the lateral heterogeneities in seismic velocity structure correspond to lateral variations of interplate seismic coupling at the subducting plate interface. Because these results were obtained from the active source profiling by ocean-bottom seismometers, or the seismic tomography that were calculated from the natural earthquakes observed with both OBS and landward seismic stations, the target regions were restricted within the OBS network. In general, sub-ocean earthquakes whose hypocenters are calculated by only onshore seismic network are not used in regional seismic tomography because of low accuracy of their estimated location, especially depth. However, it is important to use many sub-oceanic earthquakes in the seismic tomography in order to image the velocity structure in a forearc region. Here we report the velocity structure that is calculated from sub-oceanic earthquakes, whose depths are located by waveform and travel-time analyses using landward seismic network, along the Japan Trench. We also discuss the relationship between seismicity and velocity structures around the plate boundary.

Poster

SUBDUCTION STRUCTURE BENEATH THE EASTERN PART OF THE KII PENINSULA, SW JAPAN, FROM REFRACTION/WIDE-ANGLE REFLECTION EXPERIMENT

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In 2006, onshore-offshore seismic refraction/wide-angle reflection survey was conducted in the eastern part of the Kii Peninsula and its offshore area. This experiment, supported by JAMSTEC, was aimed to elucidate the geometry of the Philippine Sea (PHS) plate and inhomogeneous structure of in and around the seismogenic zone of the 1944 Tonankai earthquake (M7.9). The onshore seismic line, 87.8 km in length, is a northwest extension of an offshore profile line by JAMSTEC, crossing the Median Tectonic Line (MTL). On this profile, 5 shot points and 519 receivers were set. The obtained records were of good quality, and clear wide-angle reflections from the PHS plate are recognized in almost the entire part of the profile. The uppermost crust is characterized by a surface layer with Vp=5.0-5.4 km/s overlying a crystalline basement with a velocity of 5.6-5.8 km/s. The MTL is recognized as a steeply northward dipping reflector. The midcrustal reflectors are identified at depths of 12 and 18 km north of the MTL, while at depths of 12-20 km south of the MTL, indicating structural change at the MTL. The PHS plate is traced as a northward dipping strong reflector, whose depth is 22 km at the southern edge of the profile.

Oral & Poster

GEOMETRY OF ACTIVE FAULT SYSTEMS DEVELOPED ALONG ITOI-GAWA-SHIZIOKA TECTONIC LINE, CENTRAL JAPAN, FROM RECENT SEISMIC REFLECTION SURVEYS

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The 250-km long Itoigawa-Shizuoka Tectonic Line (ISTL), running with NS direction in Central Japan, is a major tectonic boundary between NE and SW Japan. The northern segment of the ISTL has been under a compressive stress regime since the late Neogene to form an active fault system with the largest slip rates (4-9 mm/yr). This part is recognized as an earthquake fault with the highest risk. Several seismic reflection surveys were conducted across the ISTL under the national projects including “Integrated Research Project for Active Fault System along Itoigawa-Shizioka Tectonic Line”. The aim of these surveys is to elucidate the variation in fault geometry along this tectonic line. In the northern part of the ISTL (north of the Suwa lake), the fault show a gentle eastward dipping geometry (10-30 degrees) dominated by the thin-skinned tectonics. On the other hand, the southern part of the ISTL has a westward dips of 15-30 degrees. In the recent seismic experiments in 2006 and 2007 near the Suwa Lake, the ISTL shows transient change in its geometry from an eastward dip to a westward dip. The re-sults so far obtained strongly suggest an existence of remarkable segment boundary near the Suwa Lake.

Oral

AN INTEGRATED GEOPHYSICAL RESEARCH FOR ATOTSUGAWA FAULT (AGF), CENTRAL JAPAN

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An integrated geophysical observations in and around the Atotsugawa fault system (AGF), central Japan, delineated the clear relationship of fault characteristics and the surrounding inhomogeneous crustal structure. The AGF is located within a zone of high strain rate running in the northern part of central Japan with ENE-WSW direction, and responsible for the 1858 Hietsu earthquake (M 7.0). This observation project, which started from 2004, involves dense seismic observation, magnetotelluric survey, GPS measurement and refraction/wide-angle reflection experiments. Major finding so far obtained is a very low velocity anomaly (~5%) in the lower crust beneath the AGF. The upper crustal structure around the AGF is characterized by high velocity (6~6.3 km/s) patches of 10~20 km in size, probably representing asperities of the Hietsu earthquake. The low velocity body in the lower crust extends upward to the boundary part of the high velocity patches. This upwelling part shows low resistivity, indicating the existence of fluid. The GPS measurement indicates almost the entire part of the AGF is locked. Present results suggest that the prominent lower crustal velocity anomaly controls the loading process to the AGF and the stress concentration at the boundaries of asperity with aid of fluids.

Poster

2,5-D SEISMIC MODELING OF THE LITHOSPHERE BETWEEN EEC AND CARPATHIANS MOUNTAINS ON THE BASE OF THE NET OF CELEBRATION2000 PROFILES

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CELEBRATION2000 project was a large international experiment that focused on the lithospheric structure in Central Europe. It consisted of several wide-angle and refraction profiles. Among others, the dense net of profiles cover collision zone between EEC and Carpathians Mountains crossing main tectonic units of the southeastern Poland. Results of 2-D modeling and interpretation along five main lines of the area were published (CEL01 and CEL04 – Sroda et al., 2006; CEL02 – Malinowski et al., 2005; CEL03 – Janik et al., 2005; CEL05 – Grad et al., 2006). We present results of 2-D raytracing forward modeling for nine profiles, interpreted together with five main, lines. New lines are the second and third rang profiles comparing dense and volume of the record sections of the previous ones, but have substantial influence for general image of the seismic model of the area. The values obtained for the models of the main lines were taken into account in constrain of new models. A large number of crossing profiles enabled quasi 3-D modelling, and reinterpretation of some details in the models of the main lines.

Poster

COMPARISION OF P- AND S- WAVE VELOCITY MODELS OF POLAR AND HUKKA WIDE-ANGLE REFLECTION AND REFRACTION PROFILES WITH FIRE4 REFLECTION TRANSECT, THE NORTHERN FENNOSCANDIAN SHIELD

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Our poster presents analysis of the crust and upper mantle in the northern Fennoscandian shield, based on new P- and S-wave 2-D velocity models of the POLAR and HUKKA wide-angle reflection and refraction profiles and on results of a new seismic reflection experiment in Finland (FIRE). The wide-angle and reflection profiles are almost collocated and crossed the area around the Proterozoic Lapland-Kola orogen that separates Archean Karelian craton and Kola Province. The seismic Moho boundary is very clear in both types of these data, but substantial difference between the wide-angle Moho and the reflection Moho (5-8 km) was found. In order to explain this disagreement, we developed new P and S wave velocity models using reprocessing of the old data and compared them to record sections of collocated reflection profile and to published values of Vp and Vp/Vs for the main types of lower crustal and mantle rocks. The study showed that the main reason for disagreement is that the wide-angle Moho and the reflection Moho correspond to different lithological boundaries.

Poster

NUMERICAL EVALUATION OF THE CRYSTAL STRUCTURE AND PROPERTIES OF BRUCITE

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Brucite - $Mg(OH)_2$ is one of the simplest minerals containing OH groups and having important H-H interaction which possibly leads to emergence of disordered phases or superstructure. Crystallographic water and hydrogen plays significant role in the thermodynamics of the earth. The hydration-dehydration processes such as fluid release in the subduction zones are crucial to our understanding of subduction zone processes. The brucite serves as a very good model system for hydrous phases of the Earth's interior yet it's structure is not trivial and pose many interesting fundamental questions. We have studied behaviour and structure of brucite in the wide range of geophysically interesting conditions of elevated temperature and pressure. Especially, the mechanical properties of the compound appear to depend very strongly on the hydrogen bonds present in the crystal as well as on the exact structure formed by this atoms. The comparison of results obtained from the calculation with available experimental data will be presented as well as comparison with results of previous theoretical studies of the structure of this compound. The calculations have been performed using density functional theory (DFT) within framework of the Generalized Gradient Approximation (GGA), employing VASP quantum mechanical code.

Oral

SUB-HORIZONTAL REFLECTIONS AT 2-5 KM DEPTH AT THREE DIFFERENT SITES ALONG THE BALTIC SEA AND THE GULF OF BOTHNIA: FRACTURE ZONES OR MAFIC SHEETS?

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High resolution reflection seismic surveying has proven useful for locating fracture zones in crystalline rock. Siting of potential high-level nuclear waste repositories is a particularly important application of this method and surveys have been carried out at the Oskarshamn site in southeastern Sweden, the Forsmark site in central Sweden, and the Olkiluoto site in southwestern Finland. All three sites are close to the coast and the site investigations at the three locations have focused on relatively undeformed granitic rock. Borehole control shows that many of the sub-horizontal reflections in the upper 1 km of rock can be correlated to fractures zones at all three sites, particularly at the Forsmark and Olkiluoto sites. Also common for all three sites is the presence of deeper sub-horizontal to gently dipping reflections originating from depths of 2-5 km and extending over nearly the entire investigation areas. These reflectors have not been drilled. If the deeper reflections originate from fractures zones then these are likely to contain fluids that could influence the large scale water circulation patterns near a radioactive waste repository. Further reflection seismic and/or drilling is necessary to clarify the nature of the reflections and their geological significance.

Oral

REFLECTION SEISMIC IMAGING OF THE END-GLACIAL PÄRVIE FAULT SYSTEM, NORTHERN SWEDEN

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The Pärvie fault system extends over more than 150 km and has a throw exceeding 10 meters. Based on studies of Quarternary deposits in its fault scarps it is inferred to be end-glacial in age and to have been generated by an 8 magnitude earthquake. A key question in understanding the nature of the Pärvie fault, and other similar faults in the northern Baltic Shield, is what the stress field was at the time of faulting. By assuming the tectonic stress to have been the same as today and knowing the geometry of the faults then the stress field at time of faulting can be estimated. In order to investigate the geometry of the Pärvie fault a c. 20 km long reflection seismic profile was acquired in 2007. Rocks exposed at the surface consist mainly of supracrustals with granitic rocks expected at deeper levels. First results indicate that the supracrustals extend to about 1 km depth with the base generating a strong wide-angle reflection. Three surface mapped faults are crossed and imaged; with the westernmost one, the main fault, dipping at 50-60 degrees to the east, the central one dipping at 70-80 degrees to the east and the easternmost one dipping 50-60 degrees to the west.

Poster

THE SWEDISH DEEP DRILLING PROGRAM

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The Swedish Deep Drilling Program (SDDP) has been initiated to study fundamental problems of the dynamic Earth system, its natural history and evolution, with an emphasis on problems which are important for the Nordic countries. Current proposals include the deep structure of the Scandinavian Caledonides, a deep rock laboratory at the Dellen impact structure, active post-glacial faulting in northern Sweden, the dimensions, geometry and processes during accretion in the hot Svecofennian (Palaeoproterozoic) orogen, and the ore districts in northern Sweden. These targets address several world class problems such as the evolution of plate tectonic processes from the Palaeoproterozoic to present, the deep biosphere, the Earth's core tides, glacial rebound, end- and post-glacial faulting, and the evolution and structure of complex impact craters. Basic science components of the program include the role of fluids in the crust, the deformation history of the crust, and heat flow studies. Tasks in applied science are mineral prospecting, geothermal energy, nuclear waste storage, deep underground construction, CO_2 storage and dam safety. Studies in drilling and sensor technology are also part of the scientific programme. Furthermore, education and training of young scientists and engineers will be important within the program.

Poster

SEISMIC IMAGING OF CRUSTAL DEFORMATION IN THE CENTRAL SCANDINAVIAN CALEDONIDES

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The Caledonides in Scandinavia represent a deeply eroded section of the collisional orogeny ~430–390 Ma ago. The Central Caledonian Transect is a series of deep seismic reflection profiles from the Norwegian coast across the Caledonian thrust sheets and onto the exposed Precambrian basement in Sweden. We focus on the ~160 km long Swedish section of the CCT. The data show very continuous reflectors down to ~15 km depth, interpreted as dolerites in Precambrian basement. This interpretation is supported by regional magnetic data which indicate large intrusions of strongly magnetized granites, belonging to the Transscandinavian Igneous Belt. The belt is known to contain horizontal and vertical dolerite intrusions in its southern part, from where it stretches underneath the Caledonian thrust cover to northern Norway. Based on the CCT seismics there appears to be crustal thinning and a less distinct reflection Moho underneath the granite. We explain the less distinct Moho by the granite emplacement at 1.85-1.65 Ga and the thinning by extension at ~1.0 Ga, the latter supported by deep dipping reflections. The extension allowed the dolerites to intrude the granite, and Caledonian compression later deformed the granite-dolerite system, resulting in the observed pattern of reflections.

Oral

SHALLOW-DEPTH SHEAR WAVE VELOCITY STRUCTURE OF THE SOUTHERN KOREAN PENINSULA OBTAINED FROM TWO CRUSTAL-SCALE SEISMIC PROFILES

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Short-period Rayleigh waves from the two crustal-scale seismic refraction profiles, KCRT2002 and KCRT2004, were analyzed to determine the shear wave velocity and attenuation structure of the uppermost crust in different tectonic regions of the Korean peninsula and to examine if this can be related to the surface geology and tectonics of the study area. The refraction profiles were obtained using large explosive sources along a 294-km WNW-ESE line in 2002 and a 335-km NNW-SSE line in 2004. The two refraction profiles, recorded on 2-Hz portable seismometers, contained Rayleigh waves in the period range of 0.2 to 1.2 s, and the distance range up to 30–60 km from the sources. The profiles, which traverse four tectonic regions (Gyeonggi Massif, Okcheon Fold Belt, Yeongnam Massif and Gyeongsang Basin), were divided into twelve subsections based on the tectonic boundary and lithology. We obtained shear wave velocity models in the upper 1.5 km of the crust. The average shear wave velocity of the twelve subsections increases from ~2.4 km/s at the surface to ~3.2 km/s at 1.5 km depth. Overall, the shear wave velocities for the Okcheon Fold Belt and Gyeongsang Basin are lower than those for the Gyeonggi Massif and the Yeongnam Massif by ~0.3 km/s. Shear wave velocity differences also exist among the subsections within the same tectonic region when there are distinct differences in lithology. We obtained the values of $Q\beta^{-1}$ in the upper 0.6 km. $Q\beta^{-1}$ for the Okcheon Fold Belt (~0.025) is approximately twice larger than $Q\beta^{-1}$ for the massif areas (~0.012). The low shear wave velocity and high attenuation for the Okcheon Fold Belt seem to be related to the rock types of the area, which are mostly conglomerates and phyllites.

Oral & Poster

UPPER MANTLE STRUCTURE OF THE PAN-AFRICAN MOVIL BELT, EAST ANTARCTICA, FROM ACTIVE AND PASSIVE STUDIES

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Multidisciplinary crust – upper mantle studies by active and passive sources were conducted at the Pan-African terrain of the Lutzow-Holm Complex (LHC), East Antarctica. DSS carried out on continental ice-sheet of LHC in 2000 and 2002 revealed the clearer images of reflections of the crust-mantle boundary, together with several inner crustal reflections. Detailed processing, by NMO corrections and CDP stacking, DSS data extracted lithospheric imaging which implies tectonic influence of compression stress during Pan-African age. Depth variations of the upper mantle discontinuities (410 and 660 km), derived from long period receiver function analysis using 62 teleseismic events recorded at local broadband arrays. Shallow depths in topography of the discontinuity particular for 660 km are found beneath the continental ice sheet SE apart form the arrays, which might reflect paleo upwelling of mantle plume associated with Gondwana break-up. Lithospheric mantle anisotropy derived by SKS splitting analysis anticipates relationship between 'fossil' anisotropy and past tectonics. Since fast polarization directions are mainly NE-SW direction; consistent with paleo compression during Pan-African. Origin of mantle anisotropy might originated chiefly by lattice preferred orientation involving Gondwana assembly, rather than present asthenospheric flow parallel with Absolute Plate Motion.

Poster

BROADBAND SEISMIC DEPLOYMENTS IN EAST ANTARCTICA: IPY 2007-2008 CONTRIBUTION TO UNDERSTANDING THE EARTH'S DEEP INTERIOR

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"Deployment of Broadband Seismic Stations on the Antarctica Continent" is an ambitious project to improve the special resolution of seismic data across the Antarctic Plate. The project has several components, including 1) process-oriented experiments such as 3D-arrays; 2) evolving regional arrays; and 3) a permanent backbone network. Temporary broadband stations deployed on outcrops and continental ice sheet around Eastern Dronning Maud Land – Enderby Land areas will contribute strongly to IPY related major programs such as the 'POLEr observation NETwork (POLENET) (IPY project #185)' in West Antarctica. The Antarctica's Gamburtsev Province (AGAP) /GAMSEIS (IPY Project #147), in contrast, is the core project in East Antarctica. The observed data during IPY will be available from Japanese library servers (ex., POLARIS of NIPR), and sent to world data centres (IRIS/DMS, PACIFIC21), and to AMD/JCADM of the SCAR/ANTEC. In addition to lithospheric studies, data from the large span arrays of broadband stations will allow more detailed investigations of the Earth's deep interior under high southern latitudes.

Poster

RESEARCH IN COUPLED MEGA-THRUST EARTHQUAKES AROUND THE NANKAI TROUGH SOUTHWESTERN JAPAN

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In the Nankai trough, mega thrust earthquakes are occurring with an interval of 100-200 years. As previous studies, the structural research using active source seismic has succeeded to image key structures around the Nankai trough. Moreover, results of mega thrust earthquake recurrence cycle simulation show that the first ruptures are occurring around the Tonankai earthquake rupture zone in each recurrence cycle. In the fact, initial ruptures of mega thrust earthquakes 1854 and 1944/1946 were starting from the Tonankai seismogenic zone ahead of the Nankai seismogenic zone with intervals of 32 hours and 2years in each event. The results of simulation are consistent with past two events. We are establishing a new research project to focus on the recurrence pattern of the next mega thrust earthquake. Especially, the estimation of recurrence cycle between the Tonankai and Nankai earthquake is very important for disaster preventions. To improve simulation model, we are proposing research plans as follows; 1) construct the detailed crustal medium around the Nankai trough using controlled sources and seismic tomography, 2) apply scientific results of Nankai seismogenic zone drilling to the detailed crustal medium for simulations, 3) develop and construct the real time monitoring system around the Nankai trough.

Poster

THE CONFIGURATION OF AN ASEISMIC SLAB BENEATH THE COLLISION ZONE BETWEEN IZU AND JAPAN-HONSHU ARCS, INFERRED FROM WIDE-ANGLE REFLECTION AND RECEIVER FUNCTION ANALYSES

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In the northern part of Izu Peninsula, where the Izu-Bonin arc collides with the Japan-Honshu arc, a low seismicity associated with the Philippine Sea (PHS) plate subduction has been reported while the PHS plate subductions were confirmed from seismicity and seismic velocity analyses, in the western and eastern sides of this aseismic zone. From the reflection surveys' results, Sato et al. (2006) pointed out the existence of the PHS plate in this aseismic zone. In this study, we developed a new analysis method to reveal the 3-dimensional configuration of the reflector using fan-shooting data and estimated the surface location of the PHS plate. We also carried out a densely-arrayed seismic observation in the northern Izu Peninsula in 2006. Receiver function analysis was applied to the obtained teleseismic waveforms and clear positive peaks were found beneath the study area. These peaks were interpreted to be the top of the PHS plate from their locations. From compiling these results, the upper boundary of the PHS plate is located in the depth of 15-40 km and it inclines northwest in the aseismic zone. The estimated surface of the PHS plate is not smoothly connected to those estimated in the eastern and western sides. Such complicated configuration is important to understand what phenomena happen in the arc-arc collision zone.

Oral

FORMATION PROCESS OF CONTINENTAL CRUST IN THE IZU-BONIN INTRA-OCEANIC ARC REVEALED BY ACTIVE - PASSIVE SEISMIC STUDIES

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In order to investigate formation processes of continental (or intermediate component) crust, JAMSTEC has conduced intensive seismic studies in the Izu-Bonin intra-oceanic arc where the Pacific plate is subducting beneath the Philippine Sea plate. We found several new seismological constraints on formation processes of continental crust from results of active seismic study along the present-day volcanic front: e.g.., crust of continental composition having Vp of 6 – 6.8 km/s has been predominantly generated beneath basaltic volcanic centers along the volcanic front. A passive seismic study coved a part of the arc provided seismic velocity and random inhomogeneities images of the mantle wedge beneath the volcanic front. Both images show strong lateral variations which are likely correlated with the volcanoes, but they do not perfectly matched with the volcano locations. In the rear-arc region where is proposed to be formed by rifting of arc crust, we discovered a seismological evidence indicating a paleo-arc crust. A variation patter of the volume of continental component of crust along the rear arc is similar to that we found in the present-day volcanic front. This suggests that roots of crustal growth have not changed since the paleo-arc has been separated.

Poster

NORTH EUROPEAN TRANSECT – A PRELIMINARY COMPILATION

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A nearly continuous, 3600 km long, NE-running North European Transect (NET) is combined from the existing deep seismic reflection data sets in the Baltic Sea (BABEL, 1600 km), Northern Finland (FIRE 4-4A, 580 km) and Russian Arctic (1-AR, 1440 km). The transect starts as with a BABELA marine profile from the Bay of Lybeck, runs through the Baltic and Bothnian Seas (BABEL B,C,1,3&4), continues with FIRE4&4A profile crossing northern Finland. In Kola Peninsula, the transect is continued with profile Line 1-AR (1440 km total length with 1330 km at sea and 110 km on land) connecting the super-deep hole-3 on the Kola Peninsula (town of Zapolarny, Russia) with the hole 1-Hayes on Franz Joseph Land and transecting the Barents Sea.Geologically the North European Transect covers the transition from Phanerozoic Europe to Precambrian Europe and back to the Phanerozoic Barents Sea shelf. In the Phanerozoic Europe, the crustal thickness is 36-28 km, in the Precambrian Fennoscandian Shield it is 48-65 km and in the rifted Barents Region it is 37-39 km. On the islands and uplifts, the thickness reaches platform thicknesses of 38-42 km. Rift-related grabens are characterized by 33-36 km – thick crust. The transect shows differences in regional reflectivity patterns. e.g. in thinner areas the Moho is well reflective and in thicker areas it is interpreted from the gradational disappearance of crustal reflectivity.

Oral

COLLAPSE STRUCTURES OF THE SVECOFENNIAN OROGEN

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The Palaeoproterozoic Svecofennian orogen has been formed by accretion of island-arcs and microcontinents to the Karelian continental margin ca. 1.9 Ga ago, followed by extensional collapse (1.88-1.87 Ga). At surface it is a typical Precambrian orogen with a 10-15 km deep erosion level characterized by granitoids and highly deformed supracrustal units metamorphosed under upper amphibolite or lower granulite facies conditions at 1.89-1.87 Ga. The recently acquired seismic tomographic (SVEKALAPKO) and reflection data (FIRE) sets show, how a collisional structure, characterized by thick-skin and thin-skin thrusting, has later been modified by extensional collapse structures. The central part of the Svecofennian orogen is occupied by the enigmatic Central Finland granitoid complex. It is characterized by two suites of granitoids and associated gabbroic and volcanic rocks: older calc-alkaline (1.9-1.88 Ga) and younger subalkaline (1.88- 1.87 Ga). The older suite is pervasively deformed and contains remnants of folded supracrustal fragments whereas in the younger suite deformation is restricted to localized shear zones. These shear zones are imaged as listric, subvertical and low-angle reflections in the upper crust. Listric shear zones are soling out on a basal detachment surface delineating the upper-midcrustal boundary. The middle middle crust is thinned and lower crust and upper mantle have bulged upward, suggesting crustal-scale extension. The complex is surrounded by schist belts with lower metamorphic degree suggesting that the granitoid complex is the exposed metamorphic core of the Svecofennian orogen.

Oral

GEOLOGICAL SIGNIFICANCE OF THE REGIONAL CHANGE IN REFLECTIVITY BETWEEN THE UPPER AND MIDDLE CRUST IN THE SVECOFENNIAN PROVINCE

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In several areas of the Svecofennian Province, a major discontinuity has been recognized between Svionian complexes, strongly deformed and metamorphosed at ~1.92 Ga, and overlying post-1.92 Ga Bothnian volcano-sedimentary sequences. We test the hypothesis that this discontinuity is responsible for the vertical change in reflectivity identified by Kukkonen et al (2006, FIRE volume) in some FIRE sections at about 10-15km depth. In the FIRE 3A profile (Sorjonen-Ward, 2006, FIRE volume) across the Western Pohjanmaa Belt (WPB), and the Central Finland Granitoid Complex (CFGC), the discontinuity, within the WPB, between the Svionian Lappfors Group and the overlying lower Bothnian Evijarvi group (Williams et al., in press, Precambrian Research) can be correlated with the vertical change in reflectivity between upper and middle crust beneath the CFGC. The whole middle crustal package containing the system of reflectors with listric type geometry, identified by Kukkonen et al, may correspond to imbricated components of the extensive accreted Svionian marginal basin. The relationship between reflectors across the middle/upper crustal boundary, also noted by Kukkonen et al, may then be attributed to reactivation of early ~1.92 Ga structures in the Svionian complex during post-1.92 Ga Bothnian extensional and compressional deformations, associated with volcanism and granitoid emplacement.

Oral

PETROLOGICAL CRUST-MANTLE BOUNDARY VS. SEISMIC MOHO IN THE CENTRAL FENNOSCANDIAN SHIELD: CONSTRAINTS FROM COLLOCATED WIDE-ANGLE AND NEAR-VERTICAL SEISMIC PROFILES

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We presents analysis of the crust-mantle boundary in the Precambrian Fennoscandian shield based on comparison of P- and S-wave 2-D velocity models of wide-angle reflection and refraction profiles to correspondent collocated new reflection profiles in Finland (FIRE). Lateral variations of Vp, Vp/Vs and reflectivity show that the crust-mantle transition is very complex there. The lower crust above the seismic Moho is composed of very different rocks, including mafic granulites and garnet granulites, eclogites and pyroxenites. Below the seismic Moho, both mantle peridotites and high-density eclogites can be distinguished. As a consequence, the seismic Moho boundary does not always coinsides with the petrological crust-mantle boundary and the 'reflection Moho', if seen, differs from the 'wide-angle Moho' in several places. Different types of crust-mantle transition can be explained by differences in crust-forming processes in the region and can be classified into several major groups. However, no simple correlation between tectonothermal age of crustal terrains and seismic signatures of the correspondent crust-mantle boundary has been found. Significant differences in composition, density and mechanical properties of rocks of the lower crust and upper mantle should be taken into consideration, when estimating rheology of the lithosphere of the shield and response of the lithosphere to glacial isostatic adjustement.

Oral

POLENET/LAPNET – A MULTIDISCIPLINARY SEISMIC ARRAY RESEARCH IN NORTHERN FENNOSCANDIA: FIRST RESULTS

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Deep structure of the crust and upper mantle of the northern, mainly Archaean part of the Fennoscandian shield, is poorly known, as the number of permanent seismic stations and controlled-source seismic profiles there has been always significantly lower compared to its southwestern part. However, even these rare studies showed that the upper mantle there is heterogeneous and seismically anisotropic. In order improve this knowledge, a temporary seismic array was deployed there during May and September, 2007. The array is a part of POLENET multidisciplinary project during the International Polar Year 2007-2009. The array consists of 33 temporary stations and permanent broadband stations in northern Finland, Sweden and Norway. The array will record teleseismic, regional and local events during 2007-2009. As most of the stations of the array are located beyond the polar circle, operation of broadband instruments in extreme polar climate conditions is a challenging task. The research aims to obtain a 3D seismic model of the crust and upper mantle down to 670 km (P- and S-wave velocity models, position of major boundaries in the crust and upper mantle and estimates of seismic anisotropy strength and orientation) in northern Fennoscandian Shield. An important part of the LAPNET project is study of regional and local seismic events. In northern Fennoscandia, local seismic events are quarry blasts and weak earthquakes originating from re-activated ancient fault zones. These events can be used to create a 3-D velocity model of the crust, which is a necessary constraint in all studies using waves from teleseismic events. We present the first results of LAPNET local event studies.

Poster

COMPOSITION OF THE UPPER MANTLE BENEATH THE LAPLAND-KOLA OROGEN (NORTHERN FENNOSCANDIAN SHIELD) OBTAINED BY 3-D MODELING OF BOUGUER ANOMALY

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To estimate response of the lithosphere of the Fennoscandian shield to glacial isostatic adjustement, it is important to know differences in density and mechanical properties of rocks in the upper mantle. These properties are usually estimated using seismic velocity models that are interpreted in terms of rock composition and temperature. However, the same velocity anomalies can be explained also by seismic anisotropy, as the upper mantle beneath the shield is generally seismically anisotropic. The anisotropy is caused by large-scale fabric in the upper mantle due to preferred orientation of olivine. As the gravity data is not sensitive to seismic anisotropy, modeling of the gravity data can be applied in order to distinguish between velocity anomalies caused by seismic anisotropy and anomalies caused by variation in rock composition and temperature. An example is a high velocity anomaly in the upper mantle beneath the Lapland-Kola orogen, where a regional maximum of the Bouguer anomaly is observed. The structure of the crust there is well constrained by controlled-source wide-angle and near vertical reflection seismic studies. Using this data as a constraint, we made forward modeling and inversion of the Bouguer anomaly in the area of the orgen. We show that the major source of the regional Bouguer maximum is a well-preserved dense eclogitic root beneath the orogen that continues to a depth of more than 70 km.

Oral & Poster

UPPERMOST MANTLE REFLECTORS AND MOHO-CUTTING REFLECTORS IN CENTRAL FENNOSCANDIA: DELAMINATION STRUCTURES?

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A number of upper mantle reflectors and Moho-cutting reflectors have been reported in the area of thick high velocity lower crust in Fennoscandia in near-incident and wide-angle reflection, and seismic array studies. The reflectors have been commonly interpreted as traces of collision and subduction, with an inherent assumption that the materials behaved as solids during the orogeny. In this study, we present an alternative model for the reflectors. Thermal and rheological models of the Proterozoic evolution of the area together with geological evidence from kimberlite-hosted lower crustal xenoliths and xenocrysts suggest that the lowermost part of the collisionally thickened (>70 km) Svecofennian crust became eclogitized and was very probably delaminated after the ~1.87 Ga peak of the Svecofennian orogeny. With high Moho temperatures of about 1000 deg-C the dynamic viscosity of the lower crust and upper mantle decreased to levels ($\leq$ 1e21 Pas) which allowed Rayleigh-Taylor type delamination of the eclogitic layer in a time frame of 7-50 Ma. Delamination is essentially a process of gravitatively rearranging immiscible fluids with a density contrast. The delamination model provides a new way to interpret the upper mantle and Moho cutting reflectors either as material which was delaminated but became deposited at depths of change in mantle density and/or viscosity, or as structures which were “frozen-in” during post-orogenic cooling.

Oral

PROJECT HIRE: HIGH RESOLUTION REFLECTION SEISMIC SURVEYS IN ORE EXPLORATION OF CRYSTALLINE ROCK AREAS

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The project HIRE (High Resolution Reflection Seismics in Ore Exploration 2007-2010) is a current project of the Geological Survey of Finland (GTK). Our aims are 1 is to bring reflection surveys to exploration of the Precambrian crystalline bedrock of Finland, 2 to apply 3D visualization and modeling techniques in interpretation, and 3 to improve the structural data base on the most important mineral resource provinces in Finland. In compiling models of targets we use reflection seismic data, airborne and ground geophysics, geological maps and drilling data. Our list of targets comprises exploration and mining camps in a very diverse selection of geological environments and types of Cu, Ni, PGE, Zn, and Au deposits, most of them economic, as well as the Finnish site for nuclear waste disposal. Field work is carried out in 2007-2008. Most of the surveys are 2D lines measured using either Vibroseis sources or dynamite shots in shallow drill holes. Usually one target area is covered with a network of connected lines with a total length of 30-100 line-km, which produces a good data base for 3D modeling. A true 3D survey of about 10 sq-km area is also on the agenda. Our seismic contractor is AE Spetsgeofizika, Moscow, Russia, who is responsible of the field acquisition and basic processing of the data. Institute of Seismology, University of Helsinki, is our research partner in the project and responsible of the more detailed processing of the results. In the presentation we will review the ongoing project and present selected first results of the HIRE surveys.

Poster

DETAILED STRUCTURE OF THE LOCKED-SLIDING TRANSITION ON THE SUBDUCTING PLATE BOUNDARY BENEATH THE SOUTHERN PART OF KII PENINSULA, SOUTHWESTERN JAPAN

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The Nankai trough region, where the Philippine Sea Plate is subducted beneath the SW Japan arc, is a well-known zone of interplate earthquakes. Detailed structure of the subducting Philippine Sea Plate and the overlying SW Japan arc are important to constrain the process of earthquake occurrence. Recent seismic experiments reveal the relation between the crustal structure and the seismogenic zone. However, little is known about the deeper part of the plate boundary, especially the transition zone on the subducting plate. To reveal the detailed structure of the transition zone on the subducting plate, we conducted a deep seismic reflection profiling in the southern part of Kii Peninsula, southwestern Japan. 280 seismometers were deployed on a 60-km-long line in the east-west direction with about 200 m spacing. Three explosive shots were fired on EW-line. We obtained high signal-to-noise ratio data along the entire length of the profile. The seismic reflection method was applied to these data to obtain a detailed and clear image of deeper structure. Seismic reflection image shows the lateral variation of the reflectivity along the top of the subducting Philippine Sea plate. A broad reflection band is present where the clustered tremors occurred.

Oral

SEISMIC STRUCTURE OF THE SOUTH CHINA SEA OCEAN BASIN

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We made a systematic investigation on the major structures and tectonic units in the South China Sea Basin based on a large magnetic and seismic data set. We present seismic interpretation from 2D reflection seismic lines of about 2000 km long, which cover all major units of the continental margin rifting basin. The combination of magnetic and seismic data enable us to gain a better 3D mapping on structures of the basin. It is shown that the transition from the southwest subbasin to the east subbasin is characterized by a major ridge formed probably along a pre-existing fracture zone, and a group of west-dipping faults forming the exact magnetic boundary between zone D and E. The northwest subbasin has the deepest basement (top of oceanic crust) among the three main subbasins (i.e., northwest subbasin, the northwest subbasin, and the east subbasin). Our seismic data also reveal a strongly faulted continent-ocean transition of a little over 100 km wide, and this zone may become wider and dominated with magmatism further to the northeast.

Poster

REFLECTION SEISMIC STUDIES OF THE ULLARED DEFORMATION ZONE, SOUTHERN SWEDEN

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Approximately 15 km of high resolution reflection seismic data were acquired across the Ullared Deformation Zone (UDZ) in 2007. The UDZ is the only structure in Scandinavia, and one of few worldwide, containing decompressed eclogite facies rocks of Precambrian age. Between 3 and 10 source records were acquired at 641 source points using a VIBSIST source and a SERCEL 408UL recording system. Initial processing steps included, decoding of source-records, geometry set-up, first break-picking and preliminary refraction static corrections. Additional pre-stack processing included spectral equalization, bandpass filtering, preliminary reflection static corrections, and preliminary velocity analysis of CMP gathers. Post-stack processing consisted of FX-deconvolution and migration. Reflections are most clearly seen in the northern and southern parts of the profile in the upper 3 km of crust. The northern ones dip gently northwards and can be correlated to eclogite bearing gneissic rocks, while the southerly ones have a more sub-horizontal orientation and appear to be associated with meta-basites. The reflection seismic studies provide geometrical information on the deformation zone at depth and will aid in interpretations of the tectonic setting and in the understanding of how the eclogites were brought to the surface.

Oral

SUBDUCTION ALONG THE SUNDA-BANDA ARC TRANSITION

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The joint German-Indonesian project SINDBAD, carried out within two cruises from October until December 2006 on the German R/V SONNE, focuses on seismic traverses along the Sunda-Banda Arc transition. We investigate the varying influence of the incoming plate (oceanic Roo Rise and Argo Abyssal Plain, continental Scott Plateau) on the evolution of the

overriding plate using geophysical methods: multichannel reflection seismic imaging and wide-angle refraction data acquisition with ocean bottom seismometers accompanied by swath bathymetry, sediment echo sounding, gravimetric and magnetic measurements. We image the smoothly dipping and complex structured top of the subducting plate beneath the accretionary wedge and the outer arc high about 70 km landward of the trench. The incoming oceanic sediments are not accreted, but nearly completely dragged down to the base of the prism. The prism and the up to 12 km thick outer arc high are characterized by sedimentary-type velocities and composed of landward dipping imbricate thrust sheets with major thrust faults connecting seafloor and detachment. Pronounced unconformities and varying seismic facies within the Lombok forearc basin, together with abrupt vertical displacements on the outer arc high, indicate strong recent deformation activity und thus a tsunami hazard.

Poster

SUNDA-BANDA ARC TRANSITION: MARINE MULTICHANNEL SEISMIC PROFILING

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Within the joint German-Indonesian project SINDBAD (Seismic and Geoacustic Investigations Along the Sunda-Banda Arc Transition)in 2006 we investigate the varying influence of the incoming plate (oceanic Roo Rise and Argo Abyssal Plain, continental Scott Plateau) on the evolution of the overriding plate using geophysical imaging and mapping methods. Based on nearly 5000 km seismic reflection data along six N-S running, 300-400 km long lines plus additional transverse lines, we image a great variety of structures: the oceanic outer trench, accretionary prisms and their toes, the main detachment between upper and lower plate, outer arc ridges with imbricate thrust sheets, piggy-back basins and deeply reaching splay faults, as well as forearc basins. Data were acquired using a 51-liter tuned airgun array, 50 m shot spacing and a 3-kilometer streamer with 240 channels. Seismic processing included pre-stack depth migration (PSDM). Seismic velocities were obtained from PSDM-focussing analysis for the upper parts of the sections and extended towards greater depths using the results of tomographic inversion of the wide-angle refraction data. We used a 4-120 Hz frequency range with a lower range towards greater depth. Echo sounding and hydrosweep bathymetry provided correlation with seafloor morphology.

Poster

BAYESIAN DETERMINATION OF THE UNCERTAINTY IN THE TRAVEL TIME INVERSION

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Seismic travel times tomography is commonly used to invert travel time data into a velocity/depth model. Both the error due to the bandlimited noisey data and model parameterisation creates uncertanty in the resultant model, so as with any scientific result, it should be presented with an uncertainty estimation. We propose a Bayesian based analysis as an appropriate method to determine a quantitative estimation of the uncertainty. We use the Metropolis-Hastings algorithm to generate a Markov chain which can then be analysed to determine the level to which the data supports the given result. We demonstrate the algorithm using real data in a 2D joint inversion of travel times from refracted and reflected

waves. Even for relatively simple models with a small number of parameters this analysis is time consuming to assure sufficient steps to give robust posterior statistics. As the number of parameter increases the likelihood function quickly looses its ability to guide the Markov chain but this can be partly addressed by providing additional prior information to the Metropolis-Hastings algorithm. We compared our final uncertainty estimation against that obtained by averaging results from mulitple inversion runs where the input travel time data had been statistically perturbed to represent the estimated precision of each pick. We conclude that the latter method gives a minimum uncertainty estimate compared with our Bayesian based analysis.

Poster

3D MODEL OF THE UPPER CRUST OF THE ADMIRALITY BAY AREA

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The Antarctica is the last not well examined tectonic area. The structure of its crust is necessary to understand the global tectonic. The experiment in the Admirality Bay in 2007 was performed to investigate the local shallow structure of the upper crust in that area. The total number of 498 air gun generated waves were observed using 45 stations in two deployments. The good quality data well distributed in the area allowed a 3D interpretation. This is the first presentation of the results. The sonar measurements data were used to generate the bathymetry. Using this result the first arrivals of the P-waves were inverted for the structure of the crust using two different inversion codes IBP and JIVE3D. The results shows clear fault crossing through the studied area. Additional uncertainty estimation has been performed to check the reliability of the model and obtained fault is well documented.

Poster

3D/4D GEOLOGICAL MODELING OF THE PALAEOPROTEROZOIC SKELLEFTE ORE DISTRICT, NORTHERN SWEDEN: IMPLICATION FOR CRUSTAL ARCHITECTURE AND MINERAL POTENTIAL

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The Skellefte Ore District in northern Sweden is well known for its VHMS deposits and new gold discoveries. In the western part, the Kristineberg mining area has been the focus for extensive geophysical and geological work for constructing a crustal scale 3D geologic model. Significant effort has been made in a pilot study to demonstrate the potential of integrating results of seismic reflection data with potential field modeling, magnetotelluric data and geological observations. The pilot study led to the establishment of the consortium Centre for Applied Ore Studies (CTMG), a collaboration between universities and industry. CTMG aims to develop geologic models that visualise the key spatial, geological, geophysical, geochemical and economic parameters of major mineral districts of Sweden, in 3D and 4D. The primary focus is to improve and extend the pilot 3D geologic model to the central part of the Skellefte district. Seismic reflection profiling (>100 km) will constitute the backbone of the project. The derived 3D and/or 4D geologic models will help in better understanding the structural relationships between major ore-bearing volcanic rocks and the overlying metasediments and various intrusions. In addition, they may help in targeting new potential VHMS and gold mineralization.

Oral & Poster

HIGH POISSON'S-RATIO ZONE ACCOMPANIED ACCOMPANYING SLOW EVENTS BENEATH THE SOUTHWESTERN JAPAN

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With regard to the Philippine Sea plate beneath southwestern Japan, slow earthquakes such as deep low-frequency non-volcanic tremors (LFTs), short-term slow-slip events (S-SSEs), long-term slow slip events (L-SSEs), and very low-frequency earthquakes are observed along the strike of the PHS plate from Tokai to the western Shikoku regions. The National Research Institute for Earth Science and Disaster Prevention has deployed the high-sensitivity seismograph network of Japan (Hi-net). Plenty arrival time data enable us to clarify the fine-scale 3D Vp and Vs structure beneath the southwestern Japan. LFT and S-SSE are distributed along the zone with high Poisson's ratio. We found that they may occur at the plate boundary where the PHS plate first encounters the serpentinized wedge mantle of the Eurasian plate. The mantle wedge has high Poisson's ratio with 10-30 % serpentinized peridotite if there is serpentinized. The zone with high Poisson's ratio extends to the seaward where L-SSE occurs. L-SSE may be caused by high pore pressure at the plate boundary between the PHS plate and the lower crust of the Eurasian plate.

Poster

CONFIGURATION OF PHILIPPINE SEA PLATE BENEATH KANTO AND TOKAI REGION, CENTRAL JAPAN, ESTIMATED WITH DISTRIBUTION OF REPEATING EARTHQUAKES AND SEISMIC TOMOGRAPHY

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Repeating earthquakes (REs) on small asperities has been used to determine the rate of slip on plate boundaries. The Pacific (PAC) and Philippine Sea (PHS) plate subducts beneath the Kanto region and Tokai region. We estimate the plate boundary using both seismic tomography and distribution of repeating earthquakes. National Research Institute for Earth Science and Disaster Prevention (NIED) operated the Kanto-Tokai seismic network (KT-net) there from 1979 and it was replaced to high-sensitivity seismograph network (NIED Hi-net) in 2002. REs with low-angle thrust focal mechanism are distributed along the low-velocity oceanic crust at the uppermost part of the subducting plates beneath Kanto region, however, they are located in the slightly high-velocity part in the oceanic crust. For example, beneath the northern Boso peninsula, REs occur in the high-V zone where the the low-V oceanic crust of the PHS plate becomes obscure. The focal mechanisms are considered to occur where the PHS plate encounter the high-velocity stiff material of the overriding Eurasian plate. Beneath the Tokai region, the low-angle thrust REs also occur along the low-V oceanic crust of the PHS plate. These events are located in the expected source region of the mega-thrust Tokai earthquake.

Oral

3D MODEL OF EAST FENNOSCANDIA DEEP STRUCTURE: INTEGRATION OF SEISMIC PROFILING AND GRAVIMETRIC DATA

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One of the primary tasks in the course of geological interpretation of deep geophysical researches is extension of the geology-geophysical information obtained along seismic

profiles to 3D space. This problem is resolved by using of gravimetric and geological data. The main idea is to compile 3D density model for the region based on gravity field interpretation. Generalized seismic (structural-velocity) models of region are used for limitation of ambiguity interval of density heterogeneities distribution, realized in the course of inverse gravimetric task. Spatiotemporal associations map and petrophysical legend are used for compilation of rock association model of seismic and calculated (cross to the first one) profiles. As a result, 3D geological-petrophysical model is obtained; physical-geological parameters are estimated in it for the Earth's crust of region. The method is illustrated exemplified by the interpretation of seismic profiling materials and gravimetric data on Eastern Fennoscandia. The aggregate of mono-method models represented by structural section on CDP materials, continuous velocity distribution section on DSS materials, 3D density model, structural-petrodensity legend of rock associations and map of spatiotemporal associations allow compilation of coordinated multi-attribute geological-geophysical models along transects line, as well as interpolation and extrapolation of obtained results within the regional scope.

Poster

INITIAL RIFTING STURUCTURE IN THE NORTHERNMOST MARIANA REGION REVEALED FROM DEEP SEISMIC PROFILES

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Mariana Arc (MA) is one of typical oceanic island arc on the earth actively evolved associated with subduction of the Pacific Plate, locating the eastern edge of the Philippine Sea Plate. The MA is one piece of former arc split by the backarc opening of Mariana Trough (MT) since ~10Ma from the West Mariana Ridge (WMR), which is another piece of the former arc recently being an inactive remnant arc. The MT is actively opening with the following different ways as spreading stage south of 22°N and rifting stage north of 22°N, and pinching out around 24°N connecting the MA and WMR. Oceanic island arc as the Izu-Bonin and Mariana Arcs is one of candidate to form felsic continental crust from mafic materials. However, the influence of rifting to the arc evolution is not well understood. Therefore, we have conducted wide-angle reflection and refraction seismic surveys using ocean bottom seismographs to reveal deep seismic profiles around the northernmost Mariana region. From the deep seismic profiles around 24°N, the thickest crust is not at the MA but at the portion between the MT Axis and the WMR, suggesting that the crustal accretion of the rifting is larger than that of arc.

Poster

DEEP STRUCTURE MODEL OF THE SOUTH SIBERIAN PLATFORM BASED ON RESULTS OF DEEP SEISMIC PROFILING AND GRAVIMETRIC DATA

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Joint usage of deep seismic profiling data, including those recently obtained, and the digital statistic and spectral-correlation analysis of data accompanied by the construction of very detailed 3-D potential field models allowed more precise determination of the block structure of the south Siberian Platform and compilation of the chart of crustal types in this region and its folded framing. Crustal thickness maps and the position of boundaries of vertical crustal macrodivisibility have been revised. Models of major type platform structures of the Irkineevo-Vanavara aulacogene, Baikal-Taimyr zone, etc., the joint zone with the Altai-Sayan and Baikal fold regions were compiled. The models are based on the joint interpretation of

results of the 3-D interpretation of the gravimetric field and seismic profiling data, which parameters are also used for restricting density heterogeneity distribution for solving the inverse problem of gravimetry. Main parameters of the Earth's crust such as thickness, amount of megalayers, K-coefficient of maficity (relation of the intermediate and lower megalayers thickness and the consolidated crust thickness) were used for compiling the crustal types chart; the thickness of the sedimentary megalayer was used as an additional parameter.

Poster

SEISMIC TRANSECT ACROSS THE TONANKAI-TOKAI EARTHQUAKE SEGMENTATION BOUNDARY, CENTRAL JAPAN

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Although great interplate earthquakes occur in every 100 years off the Kii Peninsula, central Japan, different characteristics of slip distribution of those earthquakes estimated by tsunami and seismic data, respectively. Recent onshore seismic study shows a drastic change of the Moho geometry of the subducting Philippine Sea plate (PSP) beneath the northeast of the Kii Peninsula. It is possible that the subducting plate geometry off the Kii Peninsula changes along the Nankai Trough. The plate geometry is considered to have a strong influence on the slip pattern of great earthquakes and make the Tonankai-Tokai earthquake segmentation boundary. To investigate the subducting PSP geometry and variation of structure across the Tonankai-Tokai earthquake segmentation boundary, an onshore-offshore wide-angle seismic survey was conducted in 2006. The result of this survey is shown here. The onshore structure shows the subducting PSP with an angle of ~7 degree. It seems that deep slow earthquakes occur within the subducting oceanic crust. The offshore structure shows the irregular geometry of the subducting PSP considered to be corresponding to the subducted ridge found off the Tokai district. This research is funded by 'A research program for subduction earthquakes in Nankai and Tonankai' sponsored by MEXT.

Oral

CURVELET DENOISING: A NEW APPROACH FOR IMPROVED CRUSTAL REFLECTION IMAGES

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Incoherent noise present in seismic reflection data can often lead to misinterpretation. Thus, separation of signal and noise is an important issue in seismic data processing, particularly in crustal data where the S/N ratio is low. In seismic data, wave fronts (i.e., reflectors), arise from the interaction of the incident wave field with inhomogeneities in the Earth's subsurface and correspond to so-called two-dimensional singularities. Curvelet expansion belongs to a family of multiscale and multidirectional transforms. Two-dimensional singularities are sparse whereas noise is not in the curvelet domain. This makes curvelet transform the ideal choice for detecting wave fronts and suppressing noise. We apply curvelet denoising on post-stack seismic reflection data recorded along LITHOPROBE's SNORCLE Line 1 across Paleoproterozoic-Archean domains in Canada's Northwest Territories. The processed seismic profile shows that this denoising technique is able to identify and isolate coherent events while suppressing incoherent noise. The resultant image is better than that achieved using traditional processing schemes (e.g. F-X deconvolution, Q-inverse filtering, coherency filtering). In addition, curvelet denoising is much less computationally intensive. Based on this success, we are investigating the effectiveness of this method as a two-stage process: application to pre-stack data followed by application on the post-stack processed data.

Poster

PALEOPROTEROZOIC SLAB SUBDUCTION IN NW CANADA FROM NEAR-VERTICAL AND WIDE-ANGLE DATA

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Near-vertical incidence (NVI) and wide-angle reflection (WAR) seismic data were recorded along the crooked SNORCLE Line 1 across a Paleoproterozoic-Archean orogen in Canada's Northwest Territories. A parallel pair of reflectors imaged by the NVI data can be traced from Moho levels (~33 km) down to ~70 km and were interpreted as the top and bottom of ~1.8 Ga subducted oceanic crust. Further inboard, where the seismic line changes its direction from east-west to nearly north-south, another pair of reflectors extends subhorizontally for about 100 km at ~70 km depth before dipping downward. These reflectors were not associated with the dipping slab; instead they were interpreted as a separate feature. However, they roughly coincide with a horizontal interface modeled from WAR data. Considering the crooked line acquisition geometry, we re-examined both the NVI and WAR data using 2-D and 3-D forward and inverse modeling algorithms. Our results demonstrate that the subhorizontal reflectors are the continuation of the relict subducted slab, which now extends laterally for 350 km. Its base is the source of the WAR data, whereas the apparent flattening for the NVI data is most likely an artifact of projecting a 3-D geometry onto a 2-D cross section.

Oral

GEOPHYSIC MODEL OF THE LITHOSPHERE ACROSS THE VARISCAN BELT OF SW-IBERIA: MULTIDISCIPLINARY ASSESSMENT

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A multidisciplinary geophysical study in the Variscan Belt of SW-Iberian Peninsula has been carried out. The main objective has been to validate the Lithospheric model derived from the seismic data. The lithosphere of SW-Iberia has been mapped with a 300 km long normal incidence profile (IBERSEIS) and two wide-angle seismic transects. The IBERSEIS profile provided the structural information of the lithosphere and wide-angle data provided the seismic velocity (Vp) distribution within the crust and upper mantle. The velocity models feature a relatively high velocities at mid-crustal levels (6.8-7.0 km/s). These velocities are higher than the velocities for these depth of the average velocity models for typical continental crusts. The interpretation of these seismic data resulted in a complex model that includes a middle crust with a series of mafic dikes emplaced within. The purpose of our work is to validate if this model which includes a relative mafic crust constrained by the seismic interpretation and see if it is consistent with other geophysical observables such as geopotentials, geoid and topography. Therefore, from both wide-angle seismic surveys two density models were calculated using Sobolev and Babeyko's (1994) relationship. Geoid height, Bouguer anomaly and elevation were calculated from the density models using a finite elements code that solves, simultaneously, the geo-potential, lithostatic, and heat flow equations (CAGES). The resulting elevation, Bouguer anomaly and geoid height variation are then compared with the measured values (observables) and the crustal and lithospheric mantle geometry and density is modified until the best fit is obtained. The resulting density models are consistent with the existence of relatively high density bodies in the mid-crust providing further support to the seismic interpretation.

Poster

THE NATURE OF THE CRUST AND UPPER MANTLE ACROSS THE VARISCAN OROGEN OF SW-IBERIA

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Two 300 km long dense wide-angle seismic transects have been acquired across the SW Iberian Peninsula. They run across major tectonic contacts and geological provinces (Southportuguesse Zone, Ossa Morena Zone and Central Iberian Zone), with the Iberian Pyrite Belt being of the greatest interest. A total of 690 digital seismic recording instruments (650 TEXANS and 40 Reftek 3 component units) from the IRIS-PASSCAL Instrument Pool have been used. The transects, (A and B) consist of 3 and 6 shot points, respectively, with an, approximately, 60 km shot point interval. The charge sizes range from 1000 kg at the edges to 500 kg at the center. These recently acquired experiment was designed to provide velocity constraints on the lithosphere and complement the previously acquired normal incidence seismic profile (IBERSEIS). Both data sets are part of the SW-Iberia project which was developed within the EUROPROBE program and designed to address the fundamental questions about the nature and dynamics of the Variscan lithosphere. The acquisition parameters provide closely spaced wide-angle seismic images of the lithosphere beneath SW-Iberia, thus, in transect A, the station spacing was of 400 m, in average and along transect B the receiver spacing was of 150 m, approximately. Frequency analysis revealed that the events feature relatively low frequencies (6-14 Hz). The shot records after a preliminary processing and interpretation reveal high amplitude and well defined arrivals. For example, the interpreted PmP arrival is characterized by a high amplitude and relatively low frequency (6-10 Hz) located at, approximately 11 s (normal incidence travel time). Also well defined Pn arrivals appears at offsets beyond 120 km. At far offsets, more than 180 km, an upper mantle reflection is observed. Furthermore, within the upper crust the shots records feature, a relatively high velocity arrival (located a 4-5 s normal incidence travel time). A preliminary analysis of this arrival indicates that it probably corresponds the top of the Iberian Reflective Body identified in the IBERSEIS deep seismic profile.

Oral

3D PRESTACK DEPTH IMAGING OF A LOW VELOCITY ZONE ALONG THE NANKAI SUBDUCTION ZONE, SOUTHWEST JAPAN

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In order to figure out detailed crustal structure and physical property of the Nankai subduction zone off southwest Japan, we have acquired three dimensional (3D) multi-channel seismic (MCS) data. For the 3D bin gathers after pre-conditioning, we have constructed and updated interval velocity volume model for 3D prestack depth migration (PSDM). The 3D PSDM results provide us with both very fine seismic image and P-wave velocity (Vp) of the Nankai accretionary wedge. Based on reflection characteristics and the Vp, we identify three major seismic units in the outer wedge between outer ridge and prism toe; upper, middle, and lower units. The upper unit with Vp 1.6-3.5 km/s is characterized by many folds and imbricate thrust faults. We interpret this high-reflectivity upper unit to be offscraping layer. The middle unit just above decollement reflection with strong amplitude

shows Vp 2.7-3.2 km/s and a few subparallel reflectors. We interpret this low-reflectivity middle unit to be underplating layer. The lower unit immediately beneath the decollement reflection shows Vp 3.5-4.0 km/s and almost reflection-free character. We interpret this reflection-free lower unit to be underthrusting layer. In this talk, we will focus on formation and implications of the low-velocity middle unit along the Nankai subduction zone.

Oral & Poster

THE AGULHAS-KAROO GEOSCIENCE TRANSECT: STRUCTURES AND PROCESSES ALONG THE SOUTHERN AFRICAN CONTINENTAL MARGIN

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The southern African continental transform margin is of great interest for the understanding of processes related to continental breakup, transform fault formation and vertical plate motion. Open questions include the cause and consequences for the high topography of southern Africa, neotectonic activity along the Agulhas-Falkland Fracture Zone and the formation of the Outeniqua Basin. As a component of the project “Inkaba yeAfrica”, the 900 km long Agulhas-Karoo Geoscience Transect was carried out in order to shed light on the tectonic structure, evolution and processes along this margin. Two onshore-offshore seismic refraction/wide-angle reflection profiles are part of this transect, which extends from the Karoo Province, across the Cape Fold Belt, the Outeniqua Basin and the Agulhas-Falkland Fracture Zone to the Agulhas Plateau. Thinning of the continental crust begins landward of the coast line and continues beneath the shelf which has a thickness of 28-30 km.The transition from stretched continental to normal oceanic crust in the Agulhas Passage occurs at the Agulhas-Falkland Fracture Zone. The oceanic crust south of the Agulhas Passage is significantly thickened to 24 km, forming the Agulhas Plateau where high seismic velocities of greater than 7 km/s are modelled for the lower 50 % of the crust.

Oral

TECTONIC SETTING OF FINNISH MINERAL DEPOSITS: EVIDENCE FROM THE FINNISH REFLECTION EXPERIMENT (FIRE)

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Results of the FIRE (Finnish Reflection Experiment) reflection seismic program in Finland provide insights into deep crustal architecture, which facilitate our understanding of structural controls on Archean and Paleoproterozoic mineral deposits. Over 2100 km of seismic imaging throughout Finland record the structure of the crust to depths of up to 80 km. Several metallogenic zones are transected by the profiles. Interpretations show the Paleoproterozoic VMS deposits of the Vihanti-Pyhäsalmi Zn-Cu-Pb metallogenic zone, together with Ni-Cu intrusions within a tectonically com-plicated zone accreted to the Archean craton margin, and the possibility of crustal scale imbrication controlling distribution of granitoids associated with orogenic Au. The structural geometry of the Outokumpu Cu-Zn-Ni-Co deposits is also well defined and imaged seismically. Paleoproterozoic PGE mineralization of southern Lapland occupies a major zone of Paleoproterozoic rifting at an Archean/Proterozoic boundary. The typical orogenic tectonic setting of Paleoproterozoic Au mineralization in Central Lapland is confirmed by FIRE data, but significant new structures are identified and the influence of these on Au-Cu deposit distribution requires review.

Poster

LITHOSPHERE STRUCTURE OF THE SOUTHERN PART OF THE FENNOSCANDIA

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Several seismic profiles cross the southern part of the Fennoscandia Shield: Fennolora, Coast, BABEL, Baltic Sea, Pribalt and 1-EB. The reinterpretation of the old DSS data, the migration of refraction and wide-angle reflection data of the Baltic Sea profile and the comparison with the other profile data, made it possible to trace a large belt along the southern margin of the shield between the Aseda shear zone and the Jothian-Vendian Basin. The belt crust is thick (up to 55-60 km) with high velocities at its bottom. The upper mantle velocity is also high - 8.5 km/s. The deep graben-like structures are determined in the crust at both sides if the belt. Several reflectors dipping to the north, were revealed beneath the Moho. The latter is a complicate transition zone. From the DSS data migration it is the basic boundary that generates strong wide-angle reflections from the top of the heterogeneous upper mantle. The CDP data present the Moho as a boundary between the high reflectivity lower crust and the transparent mantle. A change of the inhomogeneity size at the Moho and thin layering with combination of the lower and higher (anisotropic) velocities in the uppermost mantle explain the observed data.

Oral

RHEOLOGICAL MODEL OF THE UPPER MANTLE FROM THE LONG-RANGE SEISMIC DATA

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The long-range seismic profiling made in Russia with Peace Nuclear Explosions reveals structural regularities in the continental upper mantle which characterize its rheological stratification. The latter is difficult to describe in form of the asthenosphere-lithosphere system because the ‘thermal’ asthenosphere is not traced. The regular change of horizontal inhomogeneity determines three layers of different plasticity which are divided by thin weak zones (seismic boundaries N and L) at depth of 100 and 200 km. The boundaries are not simple discontinuities, they are heterogeneous (thin layering) zones. Beneath the N boundary the block structure typical for the upper brittle part of the lithosphere disappears and low velocity layers are often observed. At L boundary the Q factor decreases and upper mantle structure is changed showing the isostatic equilibrium at this bottom of the ‘thermal’ lithosphere. It looks not occasional that the deep earthquakes are also concentrated around the depths of 100 and 200 km. They may be a result of deep fluids detonation at some critical PT levels. The fluids change mechanical properties of the matter, they initiate partly melting and earthquakes as well. The matter flow along the weak zones results in origin of the corresponding seismic boundaries.

Poster

STRUCTURE OF THE BAIKAL RIFT BASED ON THE INTERPRETATION OF P AND S-WAVES DATA –PHYSICAL DIFFERENTATION OF THE CRUSTAL-MANTLE TECTONIC BLOCKS

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The aim of the BEST (Baikal Explosion Seismic Transects) project was to study the structure of the crust and upper mantle below the Baikal Rift and surrounding areas. We focus on the profile 1 crossing BRZ from northwest to southeast. This profile consists of 10 land shot points and air-gun shots in the Baikal lake, recorded by three arrays located on both sides of the Baikal lake. Tectonically, the investigated area belongs to three different tectonic units mentioned above. We modelled the structure using tomographic inversion of first-arrivals and forward ray-tracing techniques. In addition, prestack depth migration was applied to the air-gun recordings. We obtained very good fit between both the kinematic and dynamic model response of our final P and S-wave velocity models and the recorded data. Additionally, we show frequency dependence of the waves penetrating the lower crust and the upper mantle below the rift. Significant differences between the BRZ and adjacent areas can be observed, in particular for the arrivals from the transition between crust and upper mantle. These differences, manifested in velocity, layer structure and physical properties (Vp/Vs), are basic for better understanding of metamorphic processes in the investigated rift zone. Seismic structure modeled along profile 1 from the BEST experiment resembles a typical rift structure.

Oral

REFRACTION MIGRATION AT SEISMIC STUDIES: POSSIBILITIES AND POBLEMS

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The refraction migration technique uses both kinematic and dynamic characteristics of wave fields recorded at large offsets when distance source-receive are much larger than depth to researched boundary. In such cases the reflection migration cannot be applied. Unlike the reflection migration the refraction migration uses separately of velocity model of media for covering and refractive layers, and an image is formed for a part of the media under a refractive boundary. Each shot or receiver gather is migrated individually using a pre-determine velocity model of the media. Possibilities and problems of refraction migration are illustrated on the models and on the marine wide-angle reflection and refraction experimental data. They show that in case of a sparse observation system the refraction migration can be applied to the seismic data and it results in the image of the small details of the crustal structure. The best results are obtained at studying the refracting boundary with considerably higher velocities than in the covering layer. Position of the shot point in relation to structural elements on the refracting boundary is an important factor influencing on wave field and the migration results.

Oral

WAVE IMAGES OF THE CRUSTAL STRUCTURE FROM REFRACTIONS AND WIDE-ANGLE REFLECTIONS MIGRATION ALONG THE DOBRE PROFILE (DNIEPER-DONETS PALEORIFT)

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The DOBRE profile crosses the Donbus Foldbelt that is an uplifted part of the Dnieper-Donets paleorift. The depth to the basement reaches 20 km. The refraction and wide-angle reflection survey was carried out along 360 km line with 245 recording stations and 11 shot-points. The traditional velocity modeling traced the basement surface and the Moho as continuous boundaries. The refraction and wide-angle reflection migration applied to the data, unable to reveal many new structural features of the basin crust. It determines a system of faults which divide the basement in several flat segments with stepwise increasing of their depths. In the center part of the profile beneath the basin a strong refraction boundary is imaged at a depth of 15-25 km. In the southern and northern parts of the profile the Moho was traced as a sharp boundary at a depth of 35-40 km, in the middle part the crust-mantle transition zone is characterized by thick reflective zone. The Moho reflection migrations show several short reflectors in this transition zone which may be interpreted as the ancient and young Moho or as a combination of the Moho with the uppermost mantle faults.

Oral

EXPLORING DEEP AUSTRALIA USING ACTIVE AND PASSIVE SEISMIC ARRAYS

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In the last decade, a dense rolling array of short period seismometers has been used to achieve a cumulative coverage of over 400 sites throughout southeast Australia. This experiment, known as WOMBAT-SE, has recorded large volumes of passive seismic data for use in teleseismic tomography, ambient noise tomography, receiver function analysis and array studies of deep mantle and core structure. Deep crustal reflection profiling of the Australian continent has been facilitated by ANSIR, the national research facility for Earth Sounding, since the mid 1990s. Recently, a major program of geotransect segments across Australia has been made possible by the AuScope initiative. These transects will comprise deep reflection profiling, augmented by passive seismic recording and MT stations. The focus of this presentation will be recent results from southeast Australia, where both passive and active source seismic imaging have been used to illuminate the deep structure beneath the Palaeozoic fold belts that span much of this region, and host world class deposits of copper and gold. As well as providing important constraints on the structure and tectonic evolution of the continent, the new results will contribute towards a more effective predictive framework for current and future exploration.

Poster

STATISTICAL-DYNAMICAL PROCESSING OF DEEP SEISMIC PROFILING DATA

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At present, statistical methods of seismic data processing, such as differential seismic exploration method (DSE method, “Spetsgeofizika”), KOSKAD-3D (“MGRI”), Stream SDS and REAPAK-RD (“SNIIGGiMS”), and statistical-dynamical analysis method (SDA method, “VSEGEI”) are widely used in Russia. SDA feature consists of the fact that seismic data for further statistical analysis are processed with preservation of dynamical record characteristics. At the same time, this method is not associated with the particular packages of processing programs. Dynamical data processing can be made in ProMax, Focus, SCS etc. systems, statistical can be made in every statistical analysis package up to the self-design programs. Statistical methods and dynamical processing technology necessary for them became actual after substantiation by N.A. Karaev of a theory of heterogeneous seismo-geological environments adequate to geological formations of the crystalline crust. Theoretical prerequisites raised by this fact allowed elaboration of a method of practical resolving of problems, which faced deep CDP seismic exploration at the end of the 20th century. Vast data of deep seismic profiling carried out in Russia in the last years showed that SDA utilization is the most effective for geological environments of complex structure and fields of reflected-scattered waves associated with them. However, geological effectiveness of a new method is proved in various geological environments.

Oral

IMAGING & INTERPRETING CONTINENTAL LOWER CRUST: FROM POTENTIAL PROBLEMS TO PROBABLE PROCESSES

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Located below sedimentary basins and upper mantle, continental lower crust (CLC) presents quite a few challenges for seismic imaging & geological interpretation. The melange of reflection (near-vertical and wide-angle) and refraction techniques used frequently yields inherently incompatible results leading to conflicting conclusions. (pre)Processing and image-enhancing techniques need thus to be carefully evaluated regarding their suitability for, and possible effect on, imaging of vast quantities of deep seismic data. Careful processing can, on the other hand, yield images that provide valuable constraints on the tectono-thermal evolutionary history of the CLC. Direct verification of the interpretation being mostly impossible, the processing philosophy needs to be robust - without many assumptions. Deterministic processing of deep seismic reflections - using single-scattering theory developed for basin studies - and of wide-angle reflections can profit from validation by statistical analysis of the data. Use of the entire recorded wave-field (including multiple scattering) in this approach provides a robust delineation of the causative complex medium (CLC).

Oral

PALEOZOIC MANTLE-CRUSTAL OROGENIC STRUCTURES AND PRESENT SURFACE GEOLOGICAL FEATURES OF THE MIDDLE URALS (BASED ON THE ESRU TRANSECT DATA)

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Deep seismic reflection studies on the 741 km long ESRU transect across the Middle Urals, Russia were carried out in 1993-2006. These reflection CMP studies have been combined with earlier DSS, gravity, magnetic data and with newly acquired results of geochemical, geochronological and geological studies; resulting in a more exact crustal and upper mantle model of the Middle Urals. In particular, most of the first-order crustal structures are allochthonous, rootless. The boundary between the West-Uralian folded zone and the Central Uralian uplift is located 15-20 km west that marked on present-day tectonic maps. A weakly dislocated sedimentary cover of the East-European platform is present under thrusts of the Western slope of the Urals. The main Uralian suture zone – Main Uralian Fault – dips eastwards at an angle of ~45° down to depths of 30-35 km. Furthermore, it is cut by a west-dipping reflecting zone, which penetrates into the upper mantle. Reactivation of this probable collisional zone and penetration of mantle surface-active fluids into the crust through it may have induced Pliocene growth of the present Ural Mountains. These fluids could also play an essential role in generation of hydrocarbon deposits in the West Siberia and Pre-Uralian basin.

Poster

OFFSHORE MULTI COMPONENT DEEP SEISMIC INVESTIGATIONS

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The advantage of OBS measurement is the possibility of multi component recording. It allows picking of not only P waves but also PS waves. During last 12 years Sevmorgeo has acquired more than 500 four-component OBS deployments in Barents-Kara region on regional lines 1-AR, 2-AR, 3-AR and 4-AR. The revision of the data was aimed at PS-wave processing resulted in S-velocity model building. Several segments of the regional lines were chosen after four component record analyses. The key factors were: 1 geological background 2 the possibility to trace PS waves. Preprocessing and picking have been performed in order to create PS wave travel time data base. New data base has been merged with existed P wave travel time date base. S velocity models down to Moho boundary along segments selected have been constructed due to kinematic modeling in framework of SeisWide software although different approached were also investigated. Geological interpretation of the S velocity models obtained is presented.

Poster

DEEP STRUCTURE OF THE NORTHERN PART OF THE BARENTS-KARA REGION ALONG THE TRANSECT 4-AR (TAIMYR PENINSULA – FRANZ JOSEF LAND ARCH)

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During 2005-2007 "Sevmorgeo" State Company has been carried out integrated geophysical survey including wide-angle reflection/refraction profiling (WARRP), multichannel seismic (MCS), gravity/magnetic survey and geochemistry measurements on the regional geophysical line 4-AP (Taimyr Peninsula – Franz-Josef Land Archipelago). The line 4-AP of 1370 km long became a part of the reference network aimed at studying deep structure of the Barents-Kara region. Parameters of MCS (used streamer 6000 m active length, fold equal 80) provided the detection of reflecting horizons on times up to 8 c and gave a detail description of the sedimentary cover section. The powerful elastic waves source (120 literes) and dense system of observations (250 m between sources, 10 km between bottom seismic stations) were used in WARRP. The velocity section of earth crust on its all thickness was constructed and the seismic MCS section was supplement with dynamic image of Moho boundary. A sedimentary unit of 3-5 km thick which was thought to be of Upper Riphean-Vendian age was mapped at the Eastern side of the Svalbard Platform. The thickness of sedimentary cover in the Barents-North Kara Megatrough was estimated to be 15-16 km. The section of earlier identified Ushakovsko-Urvantsevsky graben-rift with the base lying at depth of 8-9 km was differentiated. New sedimentary trough composed of Cretaceous-Cenozoic strata was found in the Eastern part of the Kara Sea.

Poster

DEEP SEISMIC INVESTIGATIONS ALONG THE TRANSECT 2-DW "MAGADAN - SOUTHERN KURILS" IN THE OKHOTSK SEA

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Since 2006 the "Sevmorgeo" State Company along with other prospecting companies has been carrying out integrated geophysical survey in the Sea of Okhotsk on the reference geophysical line 2-DV-M targeted at constructing a modern model of the deep geological setting of the area. Offshore leg of 1700 km long runs from the town of Magadan to the Kuril Islands. The investigations include seismic surveys (wide-angle reflection/refraction profiling - WARRP, multichannel seismic - MCS, shallow seismic profiling) and gravity/magnetic survey. The extended processing flow for MCS was applied. This was caused by great number of multiply reflected waves, variable thickness of sedimentary cover, difficult basement geometry. A dense system of WARRP measurements with intervals between bottom stations of 10-12 km and between sources of 250 m, refraction/reflection tracking at the 150 200 km source-receiver offsets enable to compare the possibilities of MCS and WARRP surveys and of different methods of the data processing: 1D solutions, tomographic inversion of first waves traveltime curves, ray-tracing method, the Moho wave imaging. The extended processing flow for MCS was applied. The efficiency of integration of seismic methods for studying of the earth's crust deep structure is proved.

Poster

PRE-SURVEY FEASIBILITY ASSESSMENT OF DETAILED 3D SEISMICS IN CRYSTALLINE BEDROCK

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Posiva Oy takes care of research and development on spent nuclear fuel disposal in bedrock in Finland. The disposal is planned at c. 400 m depth level in Olkiluoto. Geological-geophysical investigations started 1989, including wide variety of airborne, ground and drillhole surveys, and in 2004 commenced excavation of underground characterization premises “ONKALO”. Different seismic techniques have been applied during the course, and in 2005 a 3D reflection survey was advised. Pre-feasibility study before implementation was consulted by Pöyry Environment Oy. Task was to define would the 3D seismic survey be feasible in characterization of reflecting structures in hard rock to > 500 m, and to find out cost efficient way to implement. Work consisted on literature review, discussions with Uppsala University and SKB on their experiences of 2D surveys in similar conditions, and review of preceding geophysical information. Numerical modeling used Olkiluoto specific data. The reflectivity, contrasts, frequency content, attenuation, and recommendable survey laoyout (line and station densities, extent, sources) and processing techniques were assessed. The field works in 2006 and 2007 were run and processed by Vibrometric and Uppsala University. Survey applied mechanical Vibsist1500 source, and digital seismographs, with 240-270 active channels, and completed with good results.

Poster

A TWO-SHIP SEISMIC REFLECTION PROFILING OF THE SOURCE FAULT OF THE 2007 NOTO HANTO EARTHQUAKE (M6.9), CENTRAL JAPAN

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In 2007, the northwestern part of the Noto peninsula, central Japan, was attacked by damaging earthquakes of M 6.9. To correlate seismogenic source faults with geologic structure we conducted seismic reflection profiling of focal areas. We used two vessels; a gun-ship with 1500 cu. inch air-gun and a cable-ship with a 1.2-km-long, streamer cable and 480 cu. inch air-gun. On land, high-resolution reflection data were obtained using single vibroseis truck. The obtained seismic sections portray the faults, which displaced shallowest part of the reflectors. Deeper extension of such active fault was traced down to 4 km in depth on the seismic section. Deeper extension of the imaged fault accords well to the linear distribution of hypocenters of aftershocks, providing a direct evidence of fault reactivation at depth. Seismic sections suggest the three tectonic phases; the early Miocene rifting, late Miocene and Quaternary shortening deformation. The 2007 Noto Hanto earthquake was generated by the reverse and strike-slip faulting of Miocene normal fault under a compressional stress regime with a WNW-ESE rending P-axis. The ruptured fault segment is strongly controlled by transfer faults, which was formed during the rifting.

Poster

ON-GOING DEEP SEISMIC PROFILING PROJECTS IN JAPANESE ISLANDS FOR EARTHQUAKE HAZARD MITIGATION

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Japanese islands have a high seismic risk. For example, the economic loss of the 2007 Chuetsu-oki earthquake (M6.8) reaches to 12.5 billion USD. Information of the crustal structure and geometry of source faults is important key for better estimation of seismic hazards. On such context, the Japanese Government maintains many projects for earthquake research and seismic hazard mitigation. We introduce several on-going mainly on-land research projects, which include studies of crustal structure by active and passive sources, such as the Special project for earthquake disaster mitigation in metropolitan Tokyo area, the Intensive surveys and study on the concentrated strain zone (inverted rift zone along the Japan Sea coast of northern Honshu and eastern part of the Japan Sea), and the Integrated study on the Itoigawa-Shizuoka Tectonic line active fault system (central Honshu) and the studies on crustal structure under the Research project on prediction of earthquakes and volcanic eruption (current target area is around the active faults in central Japan). These projects aim to reveal the mechanisms of strain build up and earthquake occurrence through the research on the structure of seismogenic zone.

Oral

DEEP SEISMIC PROFILING IN THE KINKI REGION, CENTRAL JAPAN: SUBDUCTION, BASIN DEVELOPMENT AND SLIP-PARTISIONING OF ACTIVE FAULTS

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The Kinki district, central Japan, is marked by dense distribution of active faults. To reveal the deformation mechanisms of the crust and deep geometry of major active faults, seismic reflection profiling was performed across Lake Biwa and major active faults in 2006. The deep fault geometry of major active reverse faults, such as the Yoro, Katata faults and Median Tectonic Line, was imaged down to 6 to 8 km in depth. Deep geometry of Katata fault, W-dipping thrust, revealed the slip partitioning between the Hanaore fault, vertical strike-slip fault, located on the hanging wall of the Katata fault. A 100 km-long seismic section across Lake Biwa portrays the lithospheric image. The clear reflectors in the lower crust show down warp beneath Lake Biwa. The hypocentral distribution also accords well with this flexure. Lake Biwa is marked by large negative gravity anomaly and subsidence since the late Pliocene. The upper surface of the Philippine Sea plate (PHS) is identified by strong reflections. The subsided area near Lake Biwa is marked by down warp of the crust and steep angle subduction of the PHS slab. It is highly probable that the subsidence of Lake Biwa has been produced by subduction induced mantle flow.

Poster

VARIATION OF THE CRUST-MANTLE TRANSITION LAYER BENEATH THE VOLCANIC FRONT ALONG THE IZU-BONIN ISLAND ARC DEDUCED FROM THE AMPLITUDE MODELING

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In the Izu-Bonin island arc, the continental middle crust has been produced (e.g., Suyehiro et al., 1996). The detailed information of the region between the deeper crust and uppermost mantle, especially the crust-mantle transition layer, has been inadequate to elucidate the crustal growth model of this arc, yet. We obtained the velocity contrast values of the top and bottom of this transition layer beneath the volcanic front along this arc using the comparison of the observed and synthetic waveforms wide-angle seismic data to clarify the nature of this layer. The top of this transition layer has a velocity contrast value of about 0.4 km/s along this arc, except for the northern tip of this arc (0.25 km/s). Meanwhile, the velocity contrast value at the bottom of this layer has a large variation (0-0.6 km/s) along this arc. These results and the average P-wave velocity in this transition layer indicate that this transition layer beneath the volcanic front along this arc is a mixture of the mafic residues and olivine cumulates formed during the crustal growth, and the Moho beneath the volcanic front probably has a complex signature.

Oral

EVALUATION OF SEISMIC STRUCTURE OF NORTHEASTERN YILGARN CRATON FROM AMBIENT NOISE TOMOGRAPHY

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The Yilgarn Craton is the largest known remnant of Archaean continental crust in Australia; it is important economically because of its many large deposits of gold, nickel, and other minerals. We create high resolution group wave-speed maps of the northeastern Yilgarn Craton by inverting the Rayleigh wave type Green's functions from cross-correlation of ambient seismic noise field between 1 second and 5 seconds. By analysing the available seismic data from 120 short-period portable recorders deployed in the Yilgarn Craton and 10 permanent stations around the region, we are able to extract over 4000 Green's functions between stations. The shear wave velocity structure of the region is mapped by creating group wavespeed dispersion curves and inverting in a nonlinear 2-D tomographic technique. Our results clearly reveal the seismic velocity structure of the Yilgarn Craton which agrees with t previous studies.

Oral

SEISMIC-REFLECTION IMAGING OVER THE SOUTH-PORTUGUESE ZONE FOLD-AND-THRUST BELT, SW IBERIA

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We re-processed an ~35 km-long part of the IBESREIS seismic reflection profile which runs over the Iberian Pyrite Belt section of the South Portuguese Zone, SW Iberia, with the goal to image the upper crust (<15 km depth). The applied processing sequence enhanced numerous prominent reflections and diffraction patterns within the uppermost 5 s traveltime relative to high-amplitude source-generated noise. A complex subsurface characterized by conflicting dips and a survey following winding roads requires a crooked-line pre-stack migration scheme for coherent imaging. To interpret sources of diffracted energy, we additionally employed a diffraction imaging scheme which enhances diffractions at the expense of reflections. The final seismic images show south-vergent imbricate fold-and-thrust tectonics, documenting the contractive deformation that the South Portuguese Zone experienced during the Variscan Orogeny. Based on surface geological information, we correlate a low reflective unit with the shallow Upper Carboniferous Flysch group, a highly reflective unit ranging in depth from 2 km to 4 km with the Middle Carboniferous Volcano-Sedimentary Complex group, which hosts massive sulfide deposits, and a moderately reflective unit with the Upper Devonian Phyllite-Quartzite group. Below these units, another low-reflective facies is present that may represent older Paleozoic metasediments. In addition, the seismic and diffraction images reveal bands of high reflectivity and distinct diffraction patterns interpreted as extensive layers of mafic intrusions. These proposed mafic bodies may be related to the huge hydrothermal activity assumed in Early Carbonifereous times.

Oral & Poster

STRUCTURAL FEATURES OF THE SUBDUCTING SLAB BENEATH THE KII PENINSULA, CENTRAL JAPAN: 1. SEISMIC EVIDENCE OF SLAB SEGMENTATION

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Offshore the Kii Peninsula, central Japan, the “Tonankai” and “Nankai” fault segments recurrently suffer megathrust earthquakes every 100 to 150 years, and the next earthquakes may occur within 50 years. To detect the seismological feature of the subducting Philippine Sea slab (PHS) beneath the Kii Peninsula, we applied a receiver function (RF) analysis and found PHS segmentations. In this study, we stacked both radial and transverse RFs with allowance for the time-shift caused by the dipping slab Moho, and searched for optimal parameters based on the grid-search technique at each station. Comparing the RF-estimated interface dips with the direction of slab motion determined by GPS, we classified the slab beneath the Kii Peninsula into three segments. The segments correspond to both the source fault zones of past megathrust earthquakes and to the spatial distribution of intraslab seismicity. The double-layered intraslab seismicity is observed at the boundary between the eastern and central regions. The boundary between the central and southern regions is coincident with the segment boundary of megathrust earthquakes in the Nankai region. The structural features revealed by RF-stacking may be a key in distinguishing the source regions of megathrust earthquakes in this region.

Poster

STRUCTURAL FEATURES OF THE SUBDUCTING SLAB BENEATH THE KII PENINSULA, CENTRAL JAPAN: 2. EVIDENCE FOR ANISOTROPIC ROCK EXISTENCE

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Seismic receiver functions (RFs) observed at Hi-net / F-net seismic stations in the Kii Peninsula, central Japan, may be influenced by anisotropic rocks just above the seismic Moho within the subducting Philippine Sea plate. Comparing the RF-estimated slab Moho with depth contours of slab seismicity, the plunge azimuth of the RF-estimated slab Moho is rotated clockwise relative to the top of intraslab seismicity beneath the southwestern part of peninsula. The rotations abruptly change counterclockwise beneath the southeastern part. Since we assume isotropic media to estimate the slab-Moho plunge azimuth, this divergence may be influenced by anisotropy. To confirm this hypothesis, we calculate synthetic RFs for the model with an anisotropic oceanic crust or mantle wedge. Based on numerical experiments, we confirm that the observed plunge-azimuth discrepancy can be explained when the anisotropic layer exists above the slab Moho with fast axis aligned N-S direction. The slab bends in a north-dipping valley-shape in this region, suggesting that the oceanic crust receives E-W directed compressional stress parallel to slab convergence. We hypothesize that the major axes of low-velocity inclusions may align in the N-S direction under stress to cause the inferred anisotropic features beneath the southern Kii Peninsula.

Poster

SUNDA-BANDA ARC TRANSITION: WIDE-ANGLE SEISMIC MODELLING

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The Sunda-Banda arc transition is a region with varying style of subduction: from an oceanic-island arc type to a continental-island arc collision. We investigate the changes of the crustal structures along this transition. Modelling is based on a refraction seismic survey of 245 ocean bottom seismometers, deployed along 1020 n.miles of seismic profiles. A joint tomographic method (refracted and reflected phases) is used to recover velocity structure. The sedimentary layers were incorporated form the analysis of high-resolution MCS data . The models exhibit strong changes of the incoming oceanic crust for the different profiles: off eastern Java - crustal thickness of ~17 km, likely related to the presence of an oceanic plateau (Roo Rise). Profiles off Lombok - oceanic crust of 8-9 km thickness in the Argo Abyssal Plain. Crustal and upper mantle velocities are decreased seaward of the trench, indicating fracturing and related serpentinization due to bending and associated normal faulting. Lombok Basin profiles show a sedimentary infill of 3.5 km thickness and sediment velocities of 1.75-3.0 km/s. A reflector at 17 km depth and velocities of 7.4-7.8 km/s beneath it suggest the presence of a shallow forearc mantle and a hydrated mantle wedge in this part of the margin.

Poster

INTERPRETATION OF WIDE-ANGLE REFLECTION AND REFRACTION RECORDINGS OF VIBROSEIS SIGNALS AND 3-D GRAVITY MODELLING ALONG FIRE4 PROFILE, NORTHERN FINLAND

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The Finnish Reflection Experiment (FIRE) was a deep CMP reflection seismic survey made by Vibroseis technique along four profiles in Finland during 2001 – 2003. During the experiment thirteen recording stations were deployed along the FIRE4 profile to record wide-angle signal from vibrator sources. The profile is 235 km long. The first arrivals and reflected P-waves penetrate to a depth of 5 km and can be traced to offsets of 20 – 60 km. Using these arrivals, we obtained a P-wave velocity model of the uppermost crust with both forward raytrace modelling and inversion. The major geological units can be seen in the model as horizontal variations in the P-wave velocity. The most interesting feature in the velocity model is a zone of high P-wave velocity at a depth of about 2 – 3 km inside Central Lapland Granitoid Complex that is marked also by high reflectivity on FIRE4 reflection section. A large-scale maximum of the Bouguer anomaly is also observed above this area. To constrain the depth of this feature and explain it in terms of rock composition, we applied inversion of Bouguer anomaly and calculated a 3-D density model of the uppermost crust for the area around the profile.

Poster

RIFTING IN THE NORTHERN NEWFOUNDLAND BASIN AT A NONVOLCANIC MARGIN

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ERABLE profiles presented here provide a more comprehensive data coverage along the southern margin of Flemish Cap extending into the Newfoundland Basin. Combining these data with SCREECH seismic profiles, two ODP drill sites, and other geophysical data have allowed the mapping of distinct zones of continental, transitional, and oceanic crust in this region. We compare these results to crustal boundaries on the Iberia margin that are well constrained from detailed seismic surveys and drilling. Results indicate asymmetry in the conjugate pair, with the zone of extended continental crust and transitional crust being much wider on the Iberian margin compared to the Newfoundland margin. Also, there is evidence of possible detachment faulting on both margins, although less wide spread on the Newfoundland margin. We propose either a simple shear or simple shear/pure shear combination model involving a westward dipping detachment fault, with the Newfoundland margin acting as the upper plate. However, the Newfoundland margin has a long and complex rifting history which cannot be explained completely with 2-D rifting models. Thus Late Jurassic to Early Cretaceous rifting and break-up is presented as a possible scenario to account for the present day structure of the southern margin of Flemish Cap.

INVITED Oral

SEISMIC METHODS APPLIED TODAY IN MINERAL EXPLORATION AND FOR RESOURCE ASSESSMENT OF CRYSTALLINE ROCK

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Over the past several decades seismic reflection profiling and grids have become the primary tool of petroleum exploration and therefore the subject of intense technique development. Transfer of this technology to application in crystalline rock environments has been steadfastly attempted, but never as enthusiastically embraced for mineral exploration. That situation may be starting to change. Crystalline basement terrains typically have more rugged topography and variable near-surface materials than do large sedimentary basins. The ever-increasing number of channels available to modern seismic acquisition systems and cable-less technology mitigate these handicaps by allowing denser and more regularly spaced 2-D and 3-D acquisition arrays to be used and thus more robust surface statics analysis is possible. Three-component sensors now allow both P- and S-waves to be analysed with confidence. Here a few examples of these new developments will be highlighted. New uses made of older, regional profiles by the adaptation of the 10-20 km offsets used in deep reflection profiling for near-surface tomography and new 3-D modelling that more fully integrates regional seismic sections with geologic data sets. The crustal-scale seismic reflection sections define fault surfaces at depth and can be built into fault surfaces using 3-D visualization tools. These in turn can be combined with regionally consistent strain models to predict where dilation would have occurred along these fault surfaces and thus where mineralizing fluids probably accumulated. This approach has successfully vectored potential deposits in Western Australia.

At more local scales, high-resolution surveys (5–25 m source and receiver spacings) help define individual ore deposits. Where mined bodies have sharp contacts with country rock, as do diamondiferous kimberlites in northern Canada, surface and bore-hole seismic sections provide economical ways to reduce mining effort by decreasing dilution of ore. Mapping of deformed “stratigraphy” reveals the context or settings of ore deposits to help predict mine extension; a particular stratigraphic horizon may host ore and provides vectors comparable to those of electro-magnetic exploration methods. Where more diffuse boundaries occur, the combination of P- and S-wave velocity models into Poisson’s ratio maps, while very familiar from crustal scale interpretations, also shows great promise in mineralized settings based on compilations of physical rock properties of common rocks and ores.

Poster

APPLICATION OF POWERFUL VIBRO-SOURCES FOR ACTIVE SEISMOLOGY AND DEEP EARTH SOUNDING

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Success of active seismology in deep probing of seismically-active zones depends on parameters of used sources. It is unacceptable to use strong explosions or powerful stationary vibration sources for this purpose because of ecologic reasons as well as poor spatial coverage. Low-power vibration sources (which are commonly used for seismic prospecting purposes) are also ineffective, because of low translucence aperture and small penetration depths. Field investigations using powerful (40-60 tons) transportable vibrators

have been carried out by Siberian Branch of the Russian Academy of Sciences since 1989. For the period of 20 years, a considerable data volume is accumulated in various regions of Siberia (Sayan region, Altay-Sayan and Okhotsk-Chukotski regions). Use of powerful transportable vibro-sources was developed into effective working technology. Optimal transportation unit was developed for work in hard-to-reach areas on the base of high performance cross-country vehicles. Data processing revealed quality wave fields for both longitudinal and shear waves reflected from a reference boundary in the Erath crust and Moho which were recorded for 0 – 300-400 km source-receiver offsets. Data show high stability and repeatability. Many data sets were recorded using both explosions and vibro-sources at different offsets and in presence of tectonically active zones. A database of records registered in near-field zone was accumulated for various geology (from low-velocity sediments to crystal rocks). We present some examples of using powerful transportable vibrators, including deep sounding and monitoring data, recording equipment, and observation systems.

Oral & Poster

SEISMIC IMAGING OF MINERAL SYSTEMS AT VARIOUS SCALES: SOME COMPARATIVE VIEWS FROM ON TOP AND DOWN UNDER IN FINLAND

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Seismic reflection images have already proven to be of great value in defining large scale crustal architecture and have been used in assessing structural controls in relation to prospectivity of various mineral systems. This applies particularly to late orogenic gold deposits, where seismic fabric is a proxy for structural geometry at the time of mineralization. Alternatively, extensional rifting and accommodation of sedimentary and volcanic sequences and subsequent inversion may also be discernible in seismic sections. As well as structural architecture, mineral endowment naturally depends also on access to source terrains for fluid and metal extraction, and appropriate permeabilities and thermal regimes for effective transport and precipitation. Nevertheless, the number of surveys published provides enough comparative material for assessing whether there are distinct orogenic and extensional architectures, or basement-cover relationships that would seem inherently favourable. This overview thus compares the attributes of several Archean and Proterozoic terrains in Australia, with recently published interpretations from the FIRE seismic program in Finland.

Oral & Poster

SEISMIC IMAGING OF INTERACTION BETWEEN DEFORMATION AND PLUTON EMPLACEMENT IN EASTERN FINLAND

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The Archean – Proterozoic boundary zone in central Finland is an ideal area for investigating interactions between granitoid emplacement and tranpressive deformation partitioning. Bedrock mapping and isotopic dating, combined with airborne geophysical data provide a framework for structural analysis at the present erosion level, while information on deep crustal architecture and composition is available from seismic reflection and refraction surveys, and also from kimberlite xenolith suites. The FIRE 1 and 3A reflection data image major listric structures, which may represent high strain zones transferring magma from source regions to sites of pluton construction in the middle and upper crust, with clear

correlation between reflectivity and concordant sheet-like bodies of granite. These features also integrate well with regional structural evolution, which records a transition from thrusting to a system of NW-trending ductile shear zones and bivergent thrusting and folding, subparallel to the former craton margin; this kinematic framework applied from 1.89 to at least 1.84 Ga. Pluton geometry is consistent with a vertical transition in deformation style and architecture, and a combination of magma flow through steep shear zones and lateral accumulation as more gently dipping bodies in adjacent domains.

Poster

PROPERTIES OF REFLECTIONS FROM THE UPPERMOST MANTLE OF THE WEST CARPATHIANS – KINEMATIC AND AMPLITUDE MODELLING FROM CELEBRATION'2000 DATA

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Modeling of CELEBRATION'2000 seismic dataset from the West Carpathians revealed a prominent inclined reflecting discontinuity in the upper mantle, located at 40-70 km depth and north-dipping. It is well constrained thanks to strong reflections observed on several profiles, both for in-line and off-line recordings, and can therefore be modelled with high confidence. The dip of the reflector is opposite to the direction of presumed Carpathian subduction. Therefore it may be interpreted as a shear zone or set of shear zones, originated in a compressional regime during collision of the lithospheric plates. In this study, traveltime data from in-line and off-line shots from trans-carpathian profiles were used in order to constrain the geometry of the reflector, using raytracing-based 3-D inversion of the reflected traveltimes. Furthermore, the analysis of the reflection amplitudes was performed using full-waveform modelling in 2-D in order to estimate the magnitude of the Vp contrasts and scale of the inhomogeneity at the reflector. The amplitude modelling indicated that arrivals from a dipping discontinuity can be satisfactorily modelled only for far-offset shots, but for short offsets the wavefield characteristics do not fit the observed data. Therefore, alternative models of the structure at the discontinuity were analysed.

Poster

CRUSTAL STRUCTURE OF AFRICA'S SOUTHERN MARGIN FROM GEOPHYSICAL EXPERIMENTS

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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 yeAfrica 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-Falkland 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.

Poster

EFFECTIVE SUPPRESSION OF (SUB)HARMONIC NOISE FROM VIBROSEIS RECORDS

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In the framework of the project DESIRE 2006, a part of the reflection traverse was recorded with high-fold vibroseismics. Here (to our knowledge for the first time), strong subharmonic wave-portions were observed, i.e. in addition to the fundamental frequencies prescribed by the utilized vibroseis-sweep (and some less surprising harmonic multiples of them) the actual source signal contains a significant amount with half of the fundamental frequencies after propagating from the baseplate to the geophone. After crosscorrelation with the pilot-sweep these subharmonic partials become especially disastrous (with respect to the seismogram quality) for the simple reason that the corresponding correlation ghosts are imaged towards later traveltimes where the signal amplitudes have already considerably decayed (whereas the ghosts of the less crucial harmonic partials are imaged towards earlier traveltimes where the signal amplitudes are still relatively high). A mathematical procedure has been developed to recognize, separate, and selectively suppress these extremely disturbing (sub)harmonic side-bands. For this, the recorded vibrograms are transformed into a domain, that could be best named as '(sub)harmonic domain', where all (sub)harmonic frequency portions focus separately from each other and can be properly eliminated before backward-transformation. Results of application to DESIRE vibroseis records will be shown.

Poster

CRUSTAL STRUCTURE OF THE CENTRAL OSLO GRABEN: RESULTS FROM THE MAGNUS-REX SEISMIC EXPERIMENT

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A new crustal scale seismic profile was recorded across the Oslo Graben as part of the Magnus-Rex seismic project (2007). The goal of the survey was to image the velocity structure of the lithosphere and to add constraint on the extent the crust of the Oslo Graben has been altered by magmatism. The Oslo line passes through the middle of the graben, through the region of lowest gravity anomaly and across the lowest gravity gradients at its margins. Single component seismographs were deployed along the line at 2 km spacing, except for a 120 km wide section across the graben where the instrument spacing was reduced to 750 metres. Seven shots of 100-400 kg charge size were fired along the Oslo line. Key phases observed on the shot gathers are: Pg arrivals with velocities of 6-6.4 km/s (all shot gathers); strong PmP or lower crustal reflections at offsets greater than 50 km (all shot gathers). Pn arrivals from beneath the rift are observed ~0.5 seconds earlier than those to the west. Preliminary results for the Oslo line show a thinner crust for the graben, compared to the west. High velocities are found at shallower depths within the graben crust.

Oral

LITHOSPHERIC STRUCTURE OF THE SOUTHERN SCANDES: RESULTS FROM THE MAGNUS-REX SEISMIC EXPERIMENT

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Magnus-Rex, a new lithospheric scale seismic exploration project across the southern Scandes Mountains was carried out in 2007. Key goals of the Magnus-Rex project are to image the velocity structure of the lithosphere of southern Norway and to establish whether a crustal root is present. The negative Bouguer anomaly of the southern Scandes points to the high mountains here being isostatically compensated by a crustal root. However, from coarse refraction profiling of the region, predominantly in the late 1970's, no crustal root was found and a sub-Moho density anomaly for compensation of high topography has been inferred. Three seismic lines of around 400 km in length were deployed across southern Norway including the high southern Scandes. Two km instrument spacings were used and a total of 26 shots of 100-400 kg charge size were fired along the three lines. Three key phases are observed on the shot gathers: Pg arrivals with velocities of 6-6.4 km/s (all shot gathers); Strong PmP or lower crustal reflections at offsets greater than 50 km (all shot gathers); Pn arrivals from 6 of the 26 shots. New velocity models for the lithosphere from the three new seismic profiles in the southern Scandes will be presented.

Poster

STUDY OF THE UPPER MANTLE 3D STRUCTURE BENEATH SIBERIA FROM PEACEFUL NUCLEAR EXPLOSION DATA

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We have digitized data for 12 stations of Altay-Sayan seismological network from 57 shots located in Siberia at offsets of 200-3500 km. Analog seismograms have been presented by Altai-Sayan division of the Siberian Branch Geophysical Survey of the Russian Academy of Science. The record sections show complicate and contrast changing of travel times of the first arrival waves which propagated along different directions in the upper mantle beneath the West Siberian, North Kazakhstan plates and Siberian platform. We are going to present 3D model of the upper mantle in addition to 2D models along super-longer profiles published in many articles. At processing all data we pursue two main purposes. The first is to locate horizontal velocity heterogeneity, the second - to estimate influence of the Earth surface curvature and deep discontinuities (especially at 440 and 660 km) in 2D and 3D models of the upper mantle by forward ray tracing modeling. The main difficult is to separate layering from horizontal heterogeneities because observed data is not enough to do that clearly. In numerous previous researches the basic attention was given to layering of the upper mantle.
Researches supported by the Russian Foundation for Basic Research, the Grant No 06-05-64584.

Poster

VARIATIONS OF SEISMIC STRUCTURES IN THE IZU-OGASAWARA-MARIANA ARC BROUGHT BY CRUSTAL EVOLUTION

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JAMSTEC has carried out the active seismics in the IBM arc since 2002. In this presentation, we discuss variations of the arc crusts and the origins. The IBM arc crust is generally characterized by the middle crust (MC) with P-wave velocity (Vp) of 6 km/s, the lower crust (LC) with Vp of 6.5-7.5 km/s and crust-mantle boundary layer with Vp of 7.4-7.7 km/s. However, we can identify structural characteristics of three arcs, which are current volcanic arc (CVA), the rear arc (Oligocene or Miocene arc, RA) and the outer arc high (Eocene arc, OAH). Although MC has Vp of 6.0-6.5 km/s beneath CVA and RA, it beneath OAH has higher velocity, 6.4-6.6 km/s, suggesting that process of the crustal evolution beneath OAH is different with others. LC beneath the Sumisu rift has low Vp comparing with surrounding arc crusts, suggesting that the initial rifting bring advanced crustal differentiation. The crust-mantle boundary layer underlies the reflector with velocity contrast only beneath CVA, suggesting that the crustal evolution develops beneath CVA rather than other arc regions. Thus, structural variations in the arc crusts are brought by the differences of the formation process to produce the crust and the stages of the rifting.

Oral

FINE SCALE HETEROGENEITY IN THE EARTH'S CRUST AND MANTLE

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New high-resolution seismic techniques provide evidence for pronounced fine scale heterogeneity in the Earth’s crust and mantle. Whereas other depth intervals appear transparent in the frequency band of 0.5-15 Hz, fine scale heterogeneity has mainly been demonstrated in four distinct depth intervals: 1 The Mantle Low-Velocity Zone (LVZ) below a depth of 100±20 km is globally observed from a pronounced seismic coda, which shows that the zone is highly heterogeneous at characteristic scale lengths of 5-15 by 2-6 km. We interpret that the rocks in the LVZ have a temperature close to the solidus or even may contain small fractions of partial melt. 2 Significant scattering from around the top of the Mantle Transition Zone indicates the presence of pronounced heterogeneity at scale lengths of 8-20 by 3-8 km in the depth range of 320-450 km. This observation probably requires significant chemical heterogeneity. 3 The deepest ever controlled-source seismic reflections from above the Core-Mantle Boundary image a heterogeneous zone, which we ascribe to a very high percentage of partial melts. 4 Multiple underside reflections from lower crustal heterogeneity fully explain the enigmatic Teleseismic Pn Wave, which cannot be ascribed to the uppermost mantle as previously interpreted by other authors. The scale lengths and velocity contrasts of the mantle heterogeneity are statistically represented in our 2D Finite Difference simulations of seismic wave propagation. This technique does not allow direct detection of structure, but the heterogeneous structure of zones in the mantle is now well demonstrated, probably caused by different petrologic and thermal processes.

Oral

CONTINENTAL RIFTING WITH FLAT MOHO

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Rifting is a fundamental plate tectonic process that creates elongated depressions in the Earth's surface, which become filled with sedimentary and volcanic material, as it is presently observed at the Baikal, East African, Rhine Graben and Rio Grande Rift Zones. All rifting models predict Moho uplift due to crustal thinning, and reduced seismic velocity in the uppermost mantle due to decompression or heating from the Earth's interior. However, recently acquired data from the presently active Baikal Rift zone in Siberia and the failed Dniepr-Donets rift zone in Ukraine are examples where there is no Moho topography that can related to the rifting process. Further, data from the Kenya Rift Zone shows sign of less Moho uplift than expected from the actual extension. At all these rift zones, we observe a localized zone in the lower crust which has exceptionally high seismic velocity and is highly reflective. We suggest that rift related crustal thinning took place, but the expected Moho up-warp was compensated by magmatic intrusion in the lower crust at the high-velocity zone. This finding has significant implications for modelling of the evolution of sedimentary basins around rift structures.

Poster

SPECIFICS OF DATA ACQUISITION AND PROCESSING FOR CARRYING OUT DEEP CMP SEISMIC INVESTIGATIONS IN OIL-BEARING REGIONS

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One of the main objections of deep CMP seismic studies in oil-bearing regions is detection of the relationship of deep Earth crust structure and distribution of hydrocarbons. That determines the necessity of obtainment of high quality information on deep earth crusts zones as well as rather detailed study of sedimentary cover. That forms specific requirements to: 1) field acquisition methods, survey and source; 2) location of lines; 3) processing of acquired data. Only task-oriented selection of these items may guarantee the obtainment of high quality time sections and solving of the given tasks.

Poster

CRUSTAL VELOCITY MODELS AND MOHO MAP FOR THE KAINUU-PERÄPOHJOLA REGION IN FINLAND

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Two-dimensional seismic velocity models and Moho depth map have been compiled for the Kainuu-Peräpohjola region in eastern and northern Finland. The region belongs to the Archean Karelian craton and it includes the areas of most active seismicity in Finland. Our data comprise local earthquakes and quarry blasts recorded by the Finnish permanent seismic network and by mobile stations. The events have been arranged into ten seismic profiles covering the study area. The refracted, reflected and postcritical phases have been modeled using 2-D ray-tracing technique. The results image a typical three-layer Archean crust with thickness ranging between 40 and 54 km. The upper and the middle crust are 15-20 km thick, with average P-wave velocities of 6.1-6.3 km/s and 6.6-6.7 km/s, respectively. A 5-20 km thick lower crust has velocities varying between 6.9 and 7.3 km/s. In the uppermost layer, Vp/Vs= 1.71 is determined from good quality Pg and Sg wave travel times. For other S-wave phases travel times are correlated as an envelope of arrivals, and the Vp/Vs ratios

are 1.74 in the middle crust and 1.76 in the lower crust. For the uppermost mantle a standard value of 1.73 is assumed, which fits quite well observed Sn wave travel times. The crust is thinnest (40-42 km) under the Pudasjärvi block in north-western part of the area. This block is bordered by Proterozoic schist belts, and its northern margin coincides with the Peräpohja aulacogen. The thickest crust (50-54 km) is found at the south-eastern corner of the area, where the Archean crust is overthrust on younger Svecofennian crust. Another local maxima in crustal thickness is located below the Salla greenstone belt, north-eastern Finland. This feature is tentatively linked to continent-continent type collision of Archean crustal blocks as suggested by FIRE4 data.

Poster

3D SEISMIC IMAGING IN THE FLIN FLON MINING CAMP, CANADA

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The Flin Flon mining camp comprises more than 25 producing or past-producing Cu-Zn mines with total production and reserves exceeding 110 million metric tonnes. Mining in the Flin Flon area dates back to the early 1900's with a mine and smelter having been established by the late 1920's. The 62.4 Mt Flin Flon mine deposit, which exceeded the size of other deposits in the area by an order of magnitude, ceased production in 1990. Production of a number of smaller deposits in the area (e.g., Trout Lake, 777, Callinan) continues to supply the smelter in Flin Flon. In a concerted effort to support exploration for new ore deposits in the vicinity of Flin Flon and surrounding region, a combined 2D and 3D seismic program was conducted in the summer of 2007 with the ultimate goal of constructing a 3D geological model for the mining camp. The 3D survey covers an a 3.2x3.6 km area and utilized 3200 3-component sensors that were live for each shot. The 3D survey is supplemented by 40 km of 2D profiling. Initial results from this seismic program will be presented.

Oral

MAGMATISM ON THE NORTH ATLANTIC CONTINENTAL MARGINS: SEISMIC CONSTRAINTS AND GEOLOGICAL INFERENCES

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We show new constraints on the extrusive and intrusive magmatism on the North Atlantic volcanic rifted margins from normal incidence profiles and tomographic inversion of wide-angle data. The cause of the magmatism is still disputed, specifically as to what extent it is due to increased mantle temperatures. Deep-penetration seismic profiles show that melt is intruded into the lower crust as sills which cross-cut the continental fabric, rather than as 'underplate' of 100% melt as has previously often been assumed. This means that measured lower-crustal velocities on the continent-ocean transition represent a mixture of continental crust and new igneous rock. By comparison with theoretical curves of igneous thickness versus seismic velocity (H–Vp), our well constrained velocity measurements suggest that the dominant control on the melt production is elevated mantle temperatures, with no requirement for either significant active small-scale mantle convection under the rift or of the presence of fertile mantle at the time of continental breakup as suggested for the North Atlantic by other authors. The mantle temperature anomaly was about 130–150°C above normal at the time of continental breakup, decreasing steadily by about 75°C over the first 10 Ma of seafloor spreading.

Poster

THREE-DIMENSIONAL SEISMIC VELOCITY STRUCTURE IN THE OFF-MIYAGI AND OFF-FUKUSHIMA FOREARC REGION

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The Japan Trench is a plate convergent zone where the Pacific Plate is subducting below the NE Japan arc. The off-Miyagi and the off-Fukushima regions show different characteristics of the interplate seismic activity. We performed a 3D seismic tomography to clarify differences in seismic velocity structures between these two regions. Most of the relocated hypocenters are along the plate boundary. Beneath the plate boundary, the subducting oceanic crust was imaged as the landward dipping low velocity layer, overlain by a zone of high velocity corresponding to the mantle wedge of the overriding plate. In the mantle wedge, we found that the location of high Vp, high Vs and low Vp/Vs anomaly corresponds to the rupture areas of the large interplate earthquakes. We interpret that the high seismic velocity is indicative of less serpentinized state of the forearc mantle allowing large thrust type earthquakes to occur along the plate boundary. In the off-Fukushima forearc region, we found that the high Vp/Vs anomaly at the toe of the mantle wedge. We think that the existence of the serpentinized mantle delimits the spatial extent of the interplate seismogenic zone in the off-Fukushima region, where large earthquakes rarely occur.

Poster

BOLIVAR: CRUSTAL STRUCTURE OF THE CARIBBEAN–SOUTH AMERICAN PLATE BOUNDARY BETWEEN 60°W AND 70°W FROM WIDE-ANGLE SEISMIC DATA

***Zelt, C.A.[1], Christeson, G.L.[2], Magnani, M.B.[3], Clark, S.A.[4], Guedez, M.C.[5], Bezada, M.[1], Levander, A.[1] and Schmitz, M.[6]**

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We present the results from five wide-angle seismic profiles collected onshore and offshore Venezuela in 2004 as part of the Broadband Ocean Land Investigation of Venezuela and the Antilles arc Region project (BOLIVAR). The study area is the diffuse plate boundary between South America (SA) and the SE Caribbean plate (CAR) covering roughly 1000 km by 500 km. Over the past 55 My the Leeward Antilles island arc that borders the CAR plate has been colliding obliquely with the SA continent resulting in a collision front that has migrated from west to east. The five wide-angle profiles, sampling different stages of the time-transgressive margin, show tremendous lateral heterogeneity, crossing features such as normal oceanic crust, oceanic plateau crust, an accretionary wedge, active and remnant island arcs, forearc and foreland basins, a major strike-slip system, a fold and thrust belt, and the edge of cratonic continental crust. The first-order results are 1 strong support for the continuity of the Aves and Leeward Antilles Arc, 2 high crustal velocities at all depths within the arcs compared to the South American continent, 3 an offset in the Moho roughly beneath the strike-slip fault system, suggesting that the deformation is not confined to the crust, and 4 a general smoothing and flattening of Moho topography from the youngest to oldest parts of the margin.

INVITED Oral

FORWARD AND INVERSE MODELING OF CONTROLLED-SOURCE SEISMIC DATA

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Controlled-source seismic data are used to investigate the Earth from the shallow subsurface (upper tens of meters) to structures in and below the lithosphere. Today seismic data are recorded on fairly dense linear (2D data) and areal (3D data) arrays of portable seismic instruments, numbering in the hundreds to thousands. In this talk I will present an overview of the current methodologies used to forward and inverse model controlled-source data, and discuss the likely important future directions in this field. Controlled-source experiments and data can often be divided into near-vertical reflection and refraction/wide-angle reflection. The former usually leads to a data processing approach, the latter to a model-based data analysis approach. A combined reflection/refraction experiment yields wide-aperture data suitable for both approaches. In this talk I will focus on forward and inverse model-based techniques, including ray tracing, wavefront tracking methods, finite-difference solutions of the wave equation, traveltime inversion, amplitude modeling, wide-angle migration, full waveform inversion, and joint inversions. I will also discuss the consideration of S-waves, density, attenuation, anisotropy, fine-scale heterogeneities, and model assessment. Important future directions will likely include frequency-dependent traveltime inversion, very efficient simulations of 3D wave propagation at realistic frequencies, including those using rock-properties-based model parameterizations, and combined controlled-source/teleseismic inversions.

Poster

CRUSTAL STRUCTURE ACROSS THE LITHOSPHERE THINNING BELT FROM WIDE-ANGLE SEISMIC DATA IN NORTH CHINA

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North China block is intriguing with the remarkable Mesozoic lithosphere thinning. Crustal structure can be used to reveal the crustal response and the depth-dependence of deformation from lithosphere thinning. Here, We present our interpretation of crustal structure under one wide-angle seismic profile featured as the lithosphere thinning from the Northern China Plain (NCP) with the thinned lithosphere (about 60 km) to the Yanshan Mountain folded belt (YFMB) with about 100 km thick lithosphere in the North China, 2D P-wave velocity structure of the crust was constructed under the 320-km-long Anxing-Kuancheng wide-angle seismic profile acquired in 2002. Along the profile, crustal thickness variation from 37 km under the YMFB to about 31km under the NCP is well accompanying with the corresponding lithosphere thickness variation trend from 100-180 km to 60-80 km. About 1/7 crustal thinning calculated from crustal model between the North China Plain (NCP) and the Yanshan Mountain folded belt (YMFB), is approximately ten to twenty seven percent less than the medium-magnitude basin-scale extension (24-41 percent), and about ten percent lower than lithosphere-scale (about 25 percent) recorded in the NCP, which suggests the extensional strain has been not homogeneous with depth across this portion of the column. Precluding the estimation uncertainties in extension factors, the differences of extension factors in the scale of crust and lithosphere may be attributed to magma intrusion in the crust (from lithosphere) and lithospheric mantle (from asthnosphere), which leads to the underestimation of crustal scale extension factor and may be the seismic signature of crustal response to lithosphere thinning. The high velocity thin layer underlying Moho and the

P-wave velocity lateral variation in the lower crust may be seismic signature of melting material reservoir above Moho and lateral flow of melting materials from the NCP to YMFB.

Poster

CRUSTAL STRUCTURE UNDER MOBA-GUIDE DEEP SEISMIC PROFILE IN EAST TIBET

***Zhang, Z.[1], Bai, Z.[1], Mooney, W.[2], Chen, Y.[1] and Teng, J.[1]**

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We present our interpretation of new seismic refraction/wide-angle reflection data across the southern and the middle East-Kunlun faults. The 380km-long profile extends from Moba to Guide in the East Tibet. We find the crust can be roughly divided in to three tectonic belts: Songpan-Ganzi, southern Kunlun block as continental arc (featured with P-wave velocities of 5.95-6.1 km/s in the upper crust) and the middle Kunlun block. Along the profile, crustal thickness is about 60 km under Songpang-ganzi block, 60-62 km under South Kunlun block, and 60-58 km under the middle Kunlun block. Lateral variation both in the upper crust and lower crust are very strong along the profile, which indicates strong deformation in the corresponding layers. 3-10 km thick Late-Triassic flysch sediments under Songpang-Ganzi and 2-8 km Middle-Triassic flysch sediments were revealed. Our crustal velocity model also presents strong deformation in the upper and lower crust, which may suggest there is new deformation superposed on the northward subduction or arc-continent collisions in the southern Kunlun fault. Integrating the interpretations of related seismic sections across Kunlun fault reveals the west-east section with decreasing Moho step and crustal velocity from the west Kunlun to the east Kunlun.

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