S41C-0107 0830h POSTER

Major Existence of Very Low Frequency Earthquakes in Background Seismicity Along Subduction Zone of South-western Japan

Yasushi Ishihara (+81-45-787-2328; ishihara@yokohama-cu.ac.jp)

Yokohama City University, Seto 22-2, Kanazawa-ku, Yokohama 236-0027, Japan

The condense, high quality and equalized broadband seismic network provided us to recognize the variety of seismic sources. The active volcanoes excite seismic waves with various frequency characteristics. Some cases show the long period seismic waves greater than 10 sec associates with volcanic activities. The tectonic seismic events originated at the close to trench zone are frequently lack of high frequency, greater than 1 Hz, seismic wave component. Meanwhile, the many low frequency earthquakes and tremors whose sources are not explicated are occurred in lower crust and subcrustal region. The subduction zone of Philippine Sea plate in south-western Japan is actively genetic area of low frequency earthquake group. The broadband seismic array of Japan region observed unknown long period ground motions. The seismograms are higher amplitude between 10 and 30 sec period than ground noise level. The earthquake JMA and USGS catalogues don't list about these long period seismograms. The arrival order of wave packet means that these events locate subduction zone around Japan. The hypocenters of unknown events are estimated by arrival times of vertical peak amplitude using the assumption that the ground motion dominates Rayleigh wave. The more detailed determination of major events is performed by combined technique for moment tensor inversion and grid search. The moment magnitude of uncatalogued event is greater than 3.5 because of the detection limitation. The largest event is distributed to about 4.5 Mw level and special event is greater than 5.0. The frequency characteristics show that source time is 7 to 20 sec by comparison with synthetic seismograms. We call these uncatalogued events very low frequency earthquake. The hypocenters are located to two kinds of zones along the Philippine Sea subducting plate in south-western Japan. The one zone is very close to the trough. The seismicity listed by earthquake catalogues is low level in the zone and hypocenters are distributed in island arc side. The very low frequency earthquakes occur in outer area of seismic generation zone. The other zone is coincided with extended zone generating low frequency seismic events. Very low frequency earthquake occurs intermittently in limited area. Frequently, activity increases for some days and swarm type activity generates occasionally. To evaluate integrated seismicity for anomalous events, same class magnitude, greater than 3.0, events occurred in same and surrounding area are picked up from JMA earthquake catalogue. The analysis shows that seismicity of very low frequency earthquakes is comparative with one of normal earthquakes in background activity. We concluded that very low frequency earthquake is one of factors playing seismically important role.

S41D MCC: Level 1 Thursday 0830h

Subduction and Lithospheric Deformation in South America II Posters *(joint with T)*

Presiding: **S L Beck,** University of Arizona**; A Krabbenhoeft,** GEOMAR Research Center for Marine Geosciences

S41D-0108 0830h POSTER

Low Vp/Vs Ratio in the Archean Crust of the Southern Sao Francisco Craton, SE Brazilian Shield, by Slant Stacking of Receiver Functions.

Marcelo Assumpcao[1] (55-11-3091.4755; marcelo@iag.usp.br)

Marcelo Bianchi[1] (55-11-3091.4755; mbianchi@iag.usp.br)

Martin Schimmel[2] (schimmel@ija.csic.es)

[1]Dept. of Geophysics, University of Sao Paulo, Rua do Matao 1226 Cidade Universitaria, Sao Paulo, SP 05508-090, Brazil

[2]Institude of Earth Sciences Jaume Almera, CSIC, Lluis Sole i Sabaris s/n,, Barcelona 08028, Spain

The composition of the lower crust in Archean cratons is a matter of debate. Felsic to intermediate granulites (with relatively low Vp and low Vp/Vs ratio) have been proposed by Mooney and Durheim (1991) based on seismic refraction profiles. On the other hand, worldwide estimates of Vp/Vs from receiver functions (Zandt et al., 1995) seem to show high Vp/Vs ratios in Precambrian regions (>1.78). It is not yet clear if the Archean crust has any typical value or not (Ni and James, 2003). Determination of Vp/Vs ratios from receiver functions tend to have high uncertainties due to the weak amplitudes of the multiple reflected phases and interference effects after the first Ps conversion, and this difficulty may have prevented the determination of a "typical" value for the Archean crust. A new method is presented here for enhancing the multiple reflected phases (P2ps and Pp2s) in receiver function seismic sections. Slant stacking of receiver functions is carried out in the time x slowness-squared domain (instead of the usual time x distance domain) which allows a better alignment of the converted phases and improves the identification of their arrival times. Phase weighted stacking is also used to remove uncoherent noise. The picked arrival times can then be used to estimate the average crustal Vp/Vs ratio. Several stations located in the Archean block of the southern Sao Francisco craton and adjacent fold belts yielded Vp/Vs ratios ranging from 1.66 to 1.77 with an average value of about 1.72. This is consistent with the regional average value of 1.71 determined by a Wadati diagram from small local earthquakes. The low Vp/Vs values found for the Sao Francisco craton favour a less mafic composition for the lower crust, more in agreement with the Archean/Proterozoic crustal evolution proposed by Mooney and Durheim (1991).

S41D-0109 0830h POSTER

Surface Wave Group Velocity Tomography and Lithospheric S-velocity Structure of South American Continent

Mei Feng[1] (mei@iag.usp.br)

Marcelo Assumpcao[1] (marcelo@iag.usp.br)

Suzan Van Der Lee[2] (suzan@tomo.ig.erdw.ethz.ch)

[1]Department of Geophysics, IAG, University of Sao Paulo, Rua do Matao, 1226, Cidade Universitaria, Sao Paulo, SP 05508-090, Brazil

[2]Institut fur Geophysik, ETH Honggerberg (HPP), Zurich CH-8093, Switzerland

A new group velocity tomography is presented for the South American continent including additional stations deployed in the northern and northeastern part of the continent, which had not been covered by previous works. More than 10,000 seismograms were examined with paths principally propagating across the continent of South America. 4000 Rayleigh- and 2270 Love-wave dispersion curves with good quality were retrieved in the period range of 10-150s for Rayleigh wave and 20-70s for Love wave. Single-station group velocities were determined using multiple filtering techniques. 2D group velocity tomography was applied to fundamental-mode Rayleigh and Love waves on a regular geographical grid using a conjugate gradient method. Checkerboard tests showed that our data set permits a lateral resolution of about 300km in the central part of the continent with denser paths coverage. Regionalized dispersion curves have been then inverted for 1D S-velocity profiles inside each block, which have been used to construct the final 3D S-velocity model. Both the 2D group velocity and the 3D S-velocity maps showed good correlation with the major geological provinces like cratons, Andean range, shields and sedimentary basins etc. The lowest velocities are found in the Andean region and the highest velocities in the Amazon craton. The two flat subduction slabs in the western coast of South America were well resolved. Our 3D shear-wave velocity model not only showed general similarity to the results from Partitioned Waveform Inversion and body-wave traveltime tomography, but also improved the resolution in the northern and northeastern part of the continent not covered by previous works.

S41D-0110 0830h POSTER

An investigation into crustal structure of South America; the continent that is missing some of its Moho

Koichi Sakaguchi[1] (520-241-4456; ksa@email.arizona.edu)

Hersh Gilbert[1] (hgilbert@geo.arizona.edu)

George Zandt[1] (zandt@geo.arizona.edu)

Susan Beck[1] (beck@geo.arizona.edu)

[1]University of Arizona, Department of Geosciences 1040 E.4th Street, Tucson, AZ 85721, United States

Knowledge of the large-scale crustal structure of the South American continent is currently very sparse. In order to improve this situation we collected data from available permanent broadband seismometers in the GSN, GTSN, and Geoscope networks in South America to learn about crustal structure at each station. Data was obtained from 15 stations spanning South America from as far north as Venezuela to southern Argentina, and across the entire east-west extent of the continent. Five stations are located along the western coast of South America near the subduction zone in the forearc region west of the high cordillera of the Andes. Seven stations are located in the non-deformed shield part of the South American continent. Three stations are located in the actively deforming region of the Andes. The stations in the nearby Galapagos and Falkland Islands were also studied. We collected data from each of these stations for a time period between 1996 and 2002 and calculated nearly 1000 high quality receiver functions with the amount of data at each station ranging from less than ten to over 150. The receiver functions from these stations were investigated as a function of ray parameter and backazimuth to identify P-to-s conversions from the Moho and crustal multiples. The most striking observation we find is that we do not detect a clear Moho arrival at any of the five stations in the forearc region. This observation may be due to pervasive hydration of the forearc mantle resulting in the reduction of the shear velocity contrast at the base of the crust. We do however find a strong conversion that appears to occur at a depth corresponding to the top of the subducting slab in the range of 60-80km at these stations. The Moho under the stations in the cratonic crust can be clearly seen in the depth range of 34-47 km and Vp/Vs values are in the range of 1.63 to 1.88. We do not detect a clear geographic pattern in changes in crustal thickness and Vp/Vs across the continent, but we are currently comparing crustal properties and surface geology to find additional correlations.

S41D-0111 0830h POSTER

Constraints on South American crustal evolution and composition from crustal Poisson's ratio and thickness measurements

Chukwuemeka Chinaka[1] (785-532-2247; cch3333@ksu.edu)

Kelly H. Liu[1] (785-532-2249; liu@ksu.edu)

Stephen S. Gao[1] (785-532-2243; gao@ksu.edu)

[1]Kansas State University, 108 Thompson Hall, Dept. of Geology, Manhattan, KS 66506

Using a receiver function stacking procedure and data from 37 broad-band seismic stations installed along a 3000-km EW profile across central South America, we have determined crustal Poisson's ratio (σ) and thickness across the entire continent along 20-degree South. Similar to previous studies using various techniques/datasets, we have found a thick crust beneath the central Andes. In addition, we have found that the crustal Poisson's ratio in this area is higher-than-normal (0.27), suggesting a mafic average crustal composition. In contrast, the two sites located on the immediate east of the surface expression of the Andes are found to have low σ (about 0.23) and normal crustal thickness (36 km), suggesting a felsic composition. Under the assumption that the pre-shortening crust beneath the present-day Andes was similar to that beneath those two sites, the dramatic contrast in σ suggests underplating of mantle-derived mafic materials. Such an underplating could be achieved by thermal thinning of a weak basal lithospheric layer. Obviously, simple tectonic shortening of the felsic crust would not be able to form the inferred mafic Andean crust. This conclusion is consistent with geothermal and geochemical observations, which suggested the existence of mantle-derived rocks in the crust. Crust beneath the Parana basin and the Sao Francisco craton are found to have a normal thickness (38-44 km) with a medium-to-high σ (0.26). Possible correspondence between the observed spatial variation of crustal thickness and σ with the occurrence of the extensive flood basalt and other major tectonic events will be presented.

S41D-0112 0830h POSTER

Seismic attenuation and electrical resistivity beneath the southern Altiplano plateau

Christian Haberland[1] (+49 (0) 331 977 5411; haber@geo.uni-potsdam.de)

Andreas Rietbrock[2] (+44 (0) 151 794 5181; A.Rietbrock@liv.ac.uk)

Bernd Schurr[3] (+43 1 26030 6442; bernd.schurr@ctbto.org)

Heinrich Brasse[4] (+49 (0) 30 83870 434; h.brasse@geophysik.fu-berlin.de)

[1]University of Potsdam, Institute of Geosciences, PO Box 60 15 53, Potsdam 14415, Germany

[2]University of Liverpool, Department of Earth & Ocean Sciences, 4 Brownlow Street, Liverpool L69 3GP, United Kingdom

[3]CTBTO, IDC/Scientific Methods, Wagramerstr. 5, Vienna A-1400, Austria

[4]Free University of Berlin, FR Geophysics, Malteserstr. 64-100, Berlin 12249, Germany

The analysis of local earthquake data from the temporary seismological ANCORP network allowed the calculation of 3D attenuation (Q_p) tomographic images of crust and upper mantle beneath the southern Bolivian Altiplano around 21° S. The tomographic images show a low-Q_p middle and lower crust and a moderate-Q_p upper mantle beneath the southern Altiplano. Beneath the recent magmatic arc, Q_p is not significantly decreased at this latitude. The continental forearc and the downgoing Nazca plate generally show high Q_p. The distribution of crustal Q_p coincides with the variation of electrical resistivity, which limits the possible mechanisms causing the anomalies. Our results support the hypothesis that partial melts in middle and lower crust beneath the Altiplano are present on a large scale. We see no evidence for a shallow asthenosphere beneath the southern Altiplano.

S41D-0113 0830h POSTER

Subduction Processes Along the Peruvian Margin: Results From Wide-Angle Seismic Studies

Anne Krabbenhoeft[1] (49-431-600-2415; akrabbenhoeft@geomar.de)

Joerg Bialas[1] (49-431-600-2329; jbialas@geomar.de)

Nina Kukowski[2] (49-331-288-1318; nina@gfz-potsdam.de)

Heidrun Kopp[1] (49-431-600-2334; hkopp@geomar.de)

[1]Geomar research center for marine geosciences, Wischhofstr. 1-3, Kiel 24148, Germany

[2]GeoForschungsZentrum Potsdam, Telegrafenberg, Potsdam 14473, Germany

Within the scope of the GEOPECO (Geophysical Experiments at the Peruvian Continental Margin) project, active seismic investigations along the Pacific margin of Peru were carried out using ocean bottom hydrophones (OBH) and seismometers (OBS) recording marine airgun shots. The structure and the P-wave velocity of the oblique subducting Nazca and overriding South-American plates from 8°S to 15°S were determined by forward modeling and tomographic inversion of the wide-angle seismic data combined with the analysis of reflection seismic data. The region south of 12°S has been influenced by the southward migration of the aseismic Nazca Ridge the past 11 Myrs. Mendana Fracture Zone (MFZ) on the oceanic Nazca plate marks a transition zone of a different crustal age of approximately 28 Ma in the north to 38 Ma in the south at the Peruvian trench. The oceanic crust of the Nazca plate, with a thin pelagic sediment cover, has an average thickness of 6.4 km. An intracrustal layer can be observed across the entire Peruvian margin. The P-wave velocities of the upper crustal layer displays values from 4.7-6.1 km/s and the refractions of the lower crustal layer show velocities from 6.4-7.3 km/s. The P-wave velocity of the mantle is overall 7.9-8.1 km/s. The steep lower slope of the continental margin is associated with the frontal prism of 12-15 km width, displaying low seismic P-wave velocities of 1.9-2.0 km/s. These frontal sediments accrete against a backstop structure which is defined by higher seismic velocities of 3.5-6.0 km/s. Basal erosion is inferred by the low seismic velocities of the frontal prism, the large variations in the surface slope and the bending of the subducting slab. A subduction channel cannot be resolved by forward modeling of the refraction data but amplitude modeling indicates a low seismic velocity layer on top of the subducting slab.

URL: http://www.geomar.de

S41D-0114 0830h POSTER

Evolution of the Cordillera Blanca Normal Fault, Central Peruvian Andes: Evidence From Basin Analysis and 40Ar/39Ar Thermochronology

Melissa K Giovanni[1] ((310) 794-1807; giovanni@ess.ucla.edu)

Brian K Horton[1] ((310) 794-1815; horton@ess.ucla.edu)

Brendan McNulty[2] ((310) 243-3412; bmcnulty@csudh.edu)

Marty Grove[1] ((310) 794-5457; marty@ess.ucla.edu)

[1]University of California Los Angeles, 595 Charles Young Drive East, Los Angeles, CA 90095-1567, United States

[2]California State University, Dominguez Hills, 1000 E. Victoria Street, Carson, CA 90747, United States

The Cordillera Blanca in the Andes of central Peru is located along a segment of modern flat-slab subduction. The range is bounded to the west by a NNW-striking, moderately WSW-dipping normal fault that persists for approximately 100 kilometers along strike. The fault has been active for the past 4-8 million years and has resulted in footwall exhumation of the Cordillera Blanca batholith, producing some of the highest peaks in the Andes. Miocene to Quaternary extension has been contemporaneous with subparallel shortening to the east in the Subandean foldthrust belt. Initiation of extension may be related to the onset of flat-slab subduction or gravitational collapse. Sedimentary basin analysis and 40Ar/39Ar thermochronology have been undertaken in an attempt to reconstruct the evolution of the Cordillera Blanca normal fault. The Callejon de Huaylas extensional (supradetachment) basin forms the hanging wall of the Cordillera Blanca fault. Evidence of the unroofing history of the Cordillera Blanca is preserved within the late Miocene-Pliocene Lloclla Formation. A tuff at the base of the Lloclla Formation yields a 40Ar/39Ar age of 6.4 Ma. Measured stratigraphic sections in the Llocla Formation have thicknesses of 1300 meters and are interpreted to have been proximal alluvial and fluvial environments and distal lacustrine facies. We attribute initial basin subsidence to slip on the Cordillera Blanca normal fault. However, the only exposure of the Llocla Formation extends approximately 20 kilometers along strike of the fault while the fault itself is over 100 kilometers long. We have analyzed over 25 potassium feldspar, biotite, and muscovite samples from the central and southern Cordillera Blanca batholith that were collected along two transects perpendicular to the Cordillera Blanca normal fault. Mica results along both traverses yield consistent bulk cooling ages from 5 Ma next to the fault to 7 Ma in the core of the batholith. Preliminary analysis of potassium feldspar 40Ar/39Ar step-heating results reveal that rocks proximal to the Cordillera Blanca normal fault cooled from > 300°C at 5-6 Ma to below 150°C by 2-3 Ma. Rocks far-removed from the Cordillera Blanca normal fault exhibited a similar cooling history but began cooling about 1-2 Ma earlier. We interpret these results to reflect basement exhumation along the Cordillera Blanca normal fault and are in the process of constraining its slip history with the new thermal history results and with samples from a northern transect of the batholith.

S41D-0115 0830h POSTER

Observational Constraints on Relief on the 410- and 660-km Discontinuities in the South American Subduction Zone

Lindsey Doermann[1] (Lindsey_Doermann@Brown.edu)

Martin Polak[2] (mpolak@seismo.ifg.ethz.ch)

Suzan van der Lee[2] (suzan@tomo.ig.erdw.ethz.ch)

Jochen Braunmiller[2] (jochen@seismo.ifg.ethz.ch)

[1]Brown University, Box 3769, Providence, RI 02912, United States

[2]Institute of Geophysics, ETH Hoenggerberg, Zurich CH-8093, Switzerland

Subducting plates affect the characteristics of the deep seismic discontinuities in the mantle. The effects can be observed seismically when P-waves are converted to S-waves at the discontinuities. We studied the subduction zone beneath South America, analyzing receiver functions from the permanent station LPAZ and from 19 temporary stations in the BANJO network. Data were obtained from the IRIS Data Management Center. To achieve more robust signals, we stacked events from stations located in similar positions relative to the subducting plate. Multi-station stacks show clear conversions from the 410- and 660-km discontinuities in the transition zone oceanward of the subducting slab. Further east, stacks no longer show significant P-to-S conversion signals around 410 and 660 km. Discontinuity conversion points for station LPAZ are tightly clustered within the slab, while those for the multi-station stacks are more scattered. Sampling the slab interior at LPAZ shows a transition zone thickening to nearly 300 km. The transition zone progressively thins to the west, with the westernmost stations showing a normal transition zone thickness of about 250 km. The thickness variability agrees with predicted shallowing of the 410-km discontinuity and deepening of the 660-km discontinuity within a cool subducting slab. Further, both deep disontinuities exhibit a high likelihood that signal amplitude increases with decreasing frequency in most groups of stations, with lower probability for frequency dependence in the west. This dependence would imply either that the phase transitions take place across a greater depth interval or that the signal is scattered by relief on the discontinuities. Because we do not see the discontinuities even at long periods in the east, the phase transitions would have to be implausibly thick to explain these observations. Seeking an alternative explanation for frequency dependence, we employed a synthetic model with a Gaussian-shaped discontinuity (with a width of 60 km and amplitude of 50 km) for the slabs interior to monitor effects of discontinuity relief on the P-to-S signal. The relief can explain frequency dependence on the order we observe. The explanation based on topography is consistent with our findings of a laterally varying transition zone thickness. The topography model also would explain less frequency dependence on the oceanward side and the lack of P-to-S signal in the east where the presence of the slab causes the greatest changes in relief.

S41D-0116 0830h POSTER

Guided Wave Effects in the Subducted Nazca Plate: Their Potential and Danger for Deciphering Slab Structure and Mineral Composition

Sebastian Martin[1] (smartin@geo.uni-potsdam.de)

Andreas Rietbrock[2] (+44 151 794 5181; A.Rietbrock@liv.ac.uk)

Christian Haberland[1] (haber@geo.uni-potsdaM.de)

[1]Potsdam University, Institut fur Geowissenschaften Karl-Liebknechtstr. 24, Potsdam 14476, Germany

[2]University of Liverpool, Department of Earth and Ocean Sciences 4 Brownlow Street, Liverpool L69 3GP, United Kingdom

We use guided waves traveling up-dip along the surface of the Nazca slab to image subducted oceanic crust at the Chile-Peru subduction zone. Observed P onsets of intermediate depth events near 21°S in Northern Chile reveal wave guide behavior: with growing focal depth, low frequency energy (< 2 Hz) becomes more and more dominant, higher frequencies arrive delayed, sometimes resembling two distinct phases. 2D finite difference (FD) simulations of complete P-SV wave propagation along an up-dip profile of the subduction zone are employed to shed light on several basic issues regarding crustal wave guides: We show that the observed guided wave energy must decouple from the wave guide near 100 km depth to reach the deployed stations and that the observability of up-dip guided waves in subduction zones is related to variations in subduction angle. The guided wave effect has considerable influence on p-arrival times and thus is of major importance for source location and tomographic methods at subduction zones in general. Further, simulations yield constraints on source locations relative to the low velocity structure and wave guide thickness. The results indicate that a structure of less than 4.5 km average width and 7 % low velocity remains seismically slow compared to the surrounding mantle down to a depth of at least 160 km. Further, only seismic sources within or close to the low velocity structure (distance < 4 km) are able to produce the effect. The layer is interpreted as the unaltered lower part of the subducted oceanic crust, suggesting that complete eclogite transformation in the Chile-Peru subduction zone is unlikely to take place until beyond the volcanic front.

S41D-0117 0830h POSTER

Rapid Subsidence and Tectonic Erosion of the Continental Margin off Northern Chile

Hermann Kudrass[1] (49-511-643-2790; kudrass@bgr.de)

Harald Andruleit[1] (49-511-643-2513; h.andruleit@bgr.de)

Martin Block[1] (49-511-643-2798; m.block@bgr.de)

Christian Reichert[1] (49-511-643-3244; christian.reichert@bgr.de)

[1]Bundesanstalt fuer Geowissenschaften (BGR), Stilleweg 2, Hannover 30655, Germany

The continental margin off Northern Chile was studied by bathymetric mapping (von Huene et al. 1999), multichannel seismic profiling, and sampling by piston corers and dredges to investigate the intense tectonic erosion of this convergent margin. Coccoliths and Sr-isotopes were used to define the stratigraphic age and depositional environment of sediments and related seismic sequences. The slope sediments consists of Pleistocene to middle Miocene siliceous hemipelagic silty clay, turbiditic sequences and rare shallow-water carbonates . The combination of stratigraphic data and sedimentological analyses reveal for two ridges on the upper slope (off Iquique and Antofagasta) a sequence of vertical movements around sea level comparable to the late Miocene to present movements of the Mejillones peninsula. A rapid subsidence of more than 1 mm per year affects the middle to outer slope. The landward dipping of small piggy-back basins indicates listric faulting probably related to large-scale slumping along shallow faults affecting the upper section of sediment. The main component of the rapid subsidence is thought to be caused by tectonic erosion above the descending oceanic crust causing the ablation of the overriding continental plate.

S41D-0118 0830h POSTER

Seismoacoustic Study of Sedimentary Deformations in the Costa Rican Subduction Zone

Noemi Fekete[1] (0049-431-6002515; nfekete@geomar.de)

Volkhard Spiess[2]

Lars Zuehlsdorff[2]

Tim Reston[1,3]

[1]SFB 574, C-A. University of Kiel Wischhofstr. 1-3., Kiel 24148, Germany

[2]Marine Technology / Environmental Research, Dept. of Earth Science Klagenfurter Str. P.O.Box 33 04 40, Bremen 28359, Germany

[3]Geomar Research Centre, Wischhofstr. 1-3., Kiel 24148, Germany

R/V METEOR Research Cruise M54/1 in summer 2002 from Balboa (Panama) to Caldera (Costa Rica) aimed to image the near seafloor sedimentary structures of both the continental and oceanic plates of the Costa Rican Subduction Zone with multi-frequency seismo-acoustic methods (high resolution multichannel seismics, digital echosounder). The cruise was intended to supplement from Bremen University the marine geophysical, geological, geochemical and oceanographic data collected within Special Research Project 574: Fluids and Volatiles in Subduction Zones of the University of Kiel, and its objectives were to study 1) the volatile and material input into the sedimentary system on the oceanic plate, 2) the distribution of gas hydrates within the sediments, 3) possible pathways and resulting structures of fluid/gas escape and 4) the nature of shallow sedimentary deformations at subduction zones. Our poster contributes to the general understanding of fluid circulation and sedimentary processes in subduction zones. It addresses questions of sedimentology and tectonics at different segments of the continental and oceanic plates of the Costa Rican Subduction Zone, as seen from high resolution multichannel seismic and digital echosounder data. The following issues are addressed: - Seismic features of a proposed IODP transect; its sedimentary structures, BSR, gas and gas hydrate distribution; indications for massive subsidence and slope instability. - Normal fault deformation of the sedimentary cover of the oceanic plate and in the Costa Rican trench in high resolution seismic and acoustic data. - Deformation patterns over subducting seamounts (Jaco & Parrita Scarps): a study of the different manifestations of sediment deformation and fault patterns that result from anomalous local compression, as seen in multichannel seismic data. - Geophysical indications of fluid venting, mud diapirism, and gas hydrate occurrance on the northern, smooth-floor continental domain (Mound Culebra) from multi-frequency seismo-acoustic investigations, indications of fluid pathways and consequences on local tectonic characteristics.

S41D-0119 0830h POSTER

Modal Depth Analysis of the Oceanic Lithospheric Bending Along the Chilean Margin, from a new Detailed Bathymetric Synthesis

Valerie Clouard[1] (56- 2 678 42 96; valerie@dgf.uchile.cl)

Ricardo Zapata (rzapat2@lsu.edu)

Emilio Vera[1] (evera@dgf.uchile.cl)

[1]Dept de Geofisica - U. de Chile, Blanco Encalada 2085, Santiago 2777, Chile

The Chilean margin has been the focus of numerous study investigating the subduction style of the Nazca plate under South America. We present an analysis of the bending of the oceanic lithosphere from north to south, based on an original bathymetric compilation. Our bathymetric database includes 169 cruises with satellite navigation, digitalized bathymetric map contours from Nazca Project and bathymetric prediction grid (version 8.2) of Sandwell and Smith (1997). After crossover analysis of the single beam sonar data, only 124 cruises are kept. Prediction data are used to fill gaps where no other data are available. Our final 250m resolution grid presents a smooth transition between high and low resolution bathymetry. The resulting grid is used to characterize the bending of the lithosphere prior to subduction. From 17S to 44S, segments of 1 degree wide in latitude are extracted. Only those with high resolution data are kept to carry out a modal analysis, where depth is given as a function of distance to the trench. For each segment, the mode depth/distance contour map provides the geometrical characteristics of the bending: The amplitude of the bending along the Chilean Margin ranges from 850m at 20S, to only 25m near 26S and 36S. We built universal flexure profiles that best fit the maxima of the modes. The elastic thickness (Te) of the lithosphere is directly computed from each profile. The obtained Te for each segment is compared with the one corresponding to the age of the lithosphere. Large variations exist, which mainly correlate with the transition from flat slab to normal subduction. In this zone, an increased by more than 50% to a decreased by half elastic thickness occurs in only 2 degrees of latitude from north to south.

S41D-0120 0830h POSTER

Marine Gravity Measurements at the Subduction Zone offshore Central Chile

Ingo Heyde[1] (++49 511 6432782; heyde.i@bgr.de)

Heidrun Kopp[2] (++49 431 6002326; hkopp@geomar.de)

Christian Reichert[1] (++49 511 6433244; christian.reichert@bgr.de)

[1]BGR Federal Institute for Geosciences and Natural Resources, Stilleweg 2, Hannover 30655, Germany

[2]GEOMAR Research Center for Marine Geosciences, Wischhofstrasse 1-3, Kiel 24148, Germany

Gravity measurements were carried out during RV SONNE cruise SO-161 (SPOC) in late 2001 between 28°S and 44°S offshore Central Chile along a total length of about 17500 km. The mean accuracy of the data measured with the seagravimeter system KSS31M of BGR is better than 1 mGal. Further foreign marine gravity data were not included due to their considerable lower accuracy. Additional marine gravity data derived from satellite altimetry are needed to augment our data from the survey area. The SPOC data set was compared with 3 different satellite gravity data compilations. The data set with the best statistical results for the gravity differences was used for further gravity map compilations. The map of the freeair gravity is dominated by the anomalies of the main topographic features in the survey area. In the W the oceanic crust of the subducting Nazca Plate is characterized by weak positve gravity anomalies. Landward the anomalies decrease rapidly to less than minus 150 mGal in the Chilean trench. Further towards the coast extends a broad zone of alternating positve and negative freeair gravity anomalies. These could be interpreted either in terms of morphology of the continental slope or heterogeneous density distribution in the upper crust. Additionally Bouguer gravity anomalies were calculated. The anomalies on the Nazca Plate are strongly positive with a clear south - north trending increase of values, which reflect the increasing age of the oceanic crust. The effect of isostatic compensation was calculated assuming Vening-Meinesz models with different parameters. The gravity effect of the isostatic compensation root was eliminated from the Bouguer gravity anomalies and serves as a residual field. The interpretation of isostatic residual fields in this complicated tectonic environment leads to the detection of a series of offshore basins. In the N and the centre of the survey area the distribution of the profiles is rather uniform. For these areas 3D density models were developed. The models consider the results of the multi channel reflection seismic and especially the refraction seismic lines. The models show the density structure of the accretionary wedge which expands from N to S, the continental slope and various basins near to the coast. The possibility of a subduction channel in the southern area is discussed. The effect and trace of fracture zones before and after subduction were investigated.

URL: http://www.bgr.de

S41D-0121 0830h POSTER

Seismic Investigations of the O'Higgins Seamount Group: Aseismic Ridge Emplacement and Hydration of Hot Spot Modified Lithosphere

Heidrun Kopp[1] (hkopp@geomar.de)

Ernst R. Flueh[1] (eflueh@geomar.de)

Cord Papenberg[1] (cpapenberg@geomar.de)

Dirk Klaeschen[1] (dklaeschen@geomar.de)

SPOC Scientists[1]

[1]Geomar, Wischhofstr. 1-3, Kiel 24148, Germany

The segmentation of the South American continental margin has been linked to the subduction of bathymetric elevations on the oceanic plate. Offshore Valparaiso, Chile, the subduction of the hot spot generated aseismic Juan Fernandez Ridge correlates with the southern segment boundary of the Chilean flat slab. A causative relationship has been attributed to the enhanced buoyancy of anomalous crust and the shallowing of the Wadati-Benioff zone. In 2001, the SPOC project set out to investigate the effects of subducting aseismic ridges on the seismicity and structure of the Chilean margin. A seismic study along the easternmost extent of the Juan Fernandez Ridge reveals a magmatic origin dominated by extrusive processes for the O'Higgins Seamount Group. Hot spot magmatic processes have only moderately added to the crust of the Juan Fernandez Ridge. Thus only limited increased buoyancy may be expected from crustal thickening, insufficient to cause the shallowing of the subduction zone in the flat slab segment. The modest size of the volcanic edifices causes a flexural bending of the upper crust underneath O'Higgins Guyot, but does not affect the trend of the crust-mantle boundary. The off-axis aseismic ridge emplacement caused deficiencies of the lithosphere. These syngenetic structures are reactivated in the outer rise setting and evolve to ridge-parallel fracture zones with vertical offsets exceeding 800 m. Tomographic inversion of seismic mantle phases reveals reduced uppermost mantle velocities indicative of mineral alterations in the hot spot modified lithosphere. Uppermost mantle hydration is solely limited to the flawed lithosphere of the Juan Fernandez Ridge and is linked to the reactivation of hot spot induced fractures. Enhanced buoyancy due to crustal and upper mantle hydration may represent an important additional mechanism for shallow subduction.

URL: http://www.geomar.de/projekte/spoc/

S41D-0122 0830h POSTER

How Does a Seismic Gap Control the Propagation of the Seismicity in Central Chile (31°S-31.6°S)?

Tony Monfret[1] (33 4 92 94 26 52; monfret@geoazur.unice.fr)

Mario Pardo[2] (mpardo@dgf.uchile.cl)

[1]UMR Géosciences Azur - IRD, 250, rue Albert Einstein, VALBONNE 06560, France

[2]Departamento de Geofísica, Universidad de Chile, Blanco Encalada 2085, SANTIAGO 1, Chile

In South America, the most energetic earthquakes are mainly generated along the seismogenic interface between the Nazca and the South American plates. However, there is a place in the Central Chile seismogenic zone, between latitude 31°S and 31.6°S, where almost no earthquake occurs, even using locally recorded data or from International Centre catalogues. Hence, the estimated rupture zone of the last great magnitude event of 1943 reported in the area (Illapel, Ms=7.9) should be reconsidered. In addition, this seismic gap region acts like a barrier for the propagation of seismicity. On the northern edge of the gap, a seismic swarm composed of mainly earthquakes of magnitude 5, propagated to the South between July and August 1997 but was stopped by the gap. This seismic activity was followed by the Punitaqui mainshock (October 15, 1997), an unusual normal event downdip to the gap, but in spite of its numerous aftershocks, none was located into the gap. To the South, the gap is limited by the Juan Fernandez Ridge which subducts underneath the South America plate. Tomographic results for Vp/Vs ratio, VpVs product and Qp quality factor, stress tensor analysis and bathymetric features show an EW anomaly between the coast and the trench, on the northern edge of the gap. This anomaly is likely related to a highly fractured zone with the presence of fluids where stress is not able to facilitate the propagation of a rupture.

S41D-0123 0830h POSTER

Termination of a Central Andean arc: The Chemical Evolution of the Bonete-Incapillo Volcanic Complex, Argentina

Adam R. Goss[1] (1-607-255-9576; arg32@cornell.edu)

Suzanne Mahlburg Kay[1] (1-607-255-3461; smk16@cornell.edu)

[1]INSTOC, Snee Hall Cornell Univ., Ithaca, NY 14853, United States

The Bonete-Incapillo Volcanic Complex is situated near 28°S at the southern termination of the Central Volcanic Zone (CVZ), where the more steeply-dipping segment of the subducting Nazca Plate to the north intersects the amagmatic flatslab to the south. Dominated by the Pissis (6882m), Bonete Chico (6759m), and Bonete Grande (6436m) centers and the Incapillo Caldera, this complex includes some of the highest Plio-Pleistocene volcanoes on Earth. K-Ar ages indicate that volcanism in this region began at 6.5 to 3.5 Ma as the Miocene magmatic arc to the west broadened and eventually died out. During this period, the subducting Nazca Plate shallowed, initiating eastward broadening of the arc. The arc front migrated 50km to the east before terminating at this latitude with the formation of the Incapillo Caldera at 2.9 to 1.1 Ma. Nearly 80 major and trace element analyses from the Bonete Complex and the associated Pircas Negras andesitic lavas combined with 35 new $^{87}Sr/^{86}Sr$ analyses allow for interpretation of the regional geochemical evolution. Prior to arc migration, the Miocene Doña Ana Formation

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lavas that erupted in this region have $^{87}Sr/^{86}Sr$ ratios (0.7047-0.7056) that positively correlate with SiO_2 content (56-74 %), suggesting that MASH-style crustal contamination was a dominant process in magma evolution. In contrast, the Late Miocene to Pliocene magmas from the Bonete Complex and Pircas Negras units show a range of $^{87}Sr/^{86}Sr$ ratios (0.7057-0.7073) in samples with uniform SiO_2 contents. Unlike the older Doña Ana magmas and <3 Ma CVZ magmas further north, these migration-stage magmas exhibit steep adakitic' REE patterns (La/Yb = 40-70) indicating equilibration with garnet-bearing crust. These steep REE patterns and elevated $^{87}Sr/^{86}Sr$ ratios are consistent with source region contamination by forearc subduction erosion that resulted in transport of the missing Mesozoic igneous and forearc suites along the Chilean coast into the melt zone of the mantle wedge. A model invoking only lower crustal contamination cannot explain flatter REE patterns (La/Yb <35) in CVZ lavas to the north, as there is no obvious way to decrease crustal thicknesses beneath the CVZ arc. As magmatism waned, the Incapillo ignimbrites and domes (SiO_2 = 67-71; $^{87}Sr/^{86}Sr$ = 0.7064-0.7067; La/Yb = 40-80) represent the final stages of a residual source-enriched magma that equilibrated with garnet-bearing thickened lower crust.

S41D-0124 0830h POSTER

Deep Crustal Earthquakes in the Sierras Pampeanas Region of the South Central Andean Backarc

Patricia M Alvarado[1,2] ((520) 621-4532; alvarado@geo.arizona.edu); Susan Beck[1] ((520) 621-4827; beck@geo.arizona.edu); George Zandt[1] ((520) 621-4827; zandt@geo.arizona.edu); Robert Fromm[1] ((520) 621-4827; rfr@geo.arizona.edu); Mario Araujo[2,3] ((54-264) 423-9010; mmaraujo@inpres.gov.ar); Mario Bufaliza[2,3] ((54-264) 423-9010; bufaliza@inpres.gov.ar); Enrique Triep[2] (triep@andes.edu.gov.ar)

[1]University of Arizona, Gould-Simpson Bldg. 1040 E Fourth St., Tucson, AZ 85721, United States

[2]Universidad Nacional de San Juan, Meglioli 1160 S, San Juan 5400, Argentina

[3]Instituto Nacional de Prevencion Sismica INPRES, Roger Balet 40 N, San Juan 5400, Argentina

In the last 20 years almost 500 earthquakes with depths less than 50 km and magnitudes over 4.0 have occurred in the Andean cordillera and backarc region between 29-34S as a consequence of the compression between the Nazca and South American plates. Many of these earthquakes as well as large (M>7) damaging shallow earthquakes in 1861, 1894, 1944, 1952 and 1977 are associated with the Precordillera and Sierras Pampeanas, characterized by a thinn-skinned fold and thrust belt that contrast with the thick-skinned basement cored uplifts deformation, respectively. This high level of crustal seismicity corresponds to a segment of flat slab subduction beneath Argentina. Very few crustal earthquakes occur in the high cordillera in the volcanic arc region that shut off approximately 10 Ma ago when the subducting slab became flat. We have used regional broadband seismic waveforms recorded on the portable CHilean Argentinean Geophysical Experiment network to determine focal mechanisms and depths for 22 crustal earthquakes (M > 3.6) during 2001 and 2002. We first located the earthquakes and then used a least squares moment tensor inversion technique to match 3-component data to determine the best focal mechanism and depth. A simple crust and upper mantle velocity model was used in the inversions (crustal thickness 45 km, crustal Vp=6.2 km/sec, Vp/Vs=1.70). Our results indicate that 20 of the events have predominately thrust fault focal mechanisms with an average P-axis azimuth orientation of 97°. More than 85% of the earthquakes had locations in the Pampean Ranges and focal depths between 18 and 40 km, corresponding to mid to lower crust. The furthest east crustal earthquakes occur inland nearly 800 km from the trench. Five of the events are concentrated near the oldest part of the Pampean Ranges (Sierra Pie de Palo), which was also the site of the most recent large damaging crustal earthquake (1977 San Juan earthquake). We identified only one shallow strike-slip event (depth=7 km) near the Sierra de Cordoba (Eastern Pampean Ranges). The depths of the crustal earthquakes in the mid to lower crust implies that brittle faulting associated with the basement cored uplifts in the Sierras Pampeanas extends to deep crustal levels. This implies the Pampean crust is very cold, perhaps a result of the refrigeration effect of the flat subduction of the Nazca slab that insulates the South American lithosphere from warm asthenosphere.

S41D-0125 0830h POSTER

Crustal Thickness Beneath the South-Central Andes and Sierras Pampeanas at 30°S Inferred From Pn Apparent Phase Velocities

Robert Fromm[1] (520-6213348; rfr@geo.arizona.edu)

George Zandt[1] (520-6212273; zandt@geo.arizona.edu)

Susan L Beck[1] (520-6214827; beck@geo.arizona.edu)

. CHARGE Working Group[1] (rfr@geo.arizona.edu)

[1]University of Arizona, 1040E Fourth Street, Tucson, AZ 85719, United States

The south-central Andes and Sierras Pampeanas at 30°S represent a unique environment where the major tectonic units evolved predominantly since the Miocene as a result of the flat subduction of the Nazca plate and its associated processes. In this context, we developed a methodology to obtain a crustal thickness model in this area to constrain some aspects of the evolution of this orogenic system. We used Pn arrivals of 9 crustal earthquakes to obtain apparent inter station Pn phase velocities along an E-W trending transect consisting of 8 broadband stations deployed as part of the Chile Argentina Geophysical Experiment (CHARGE) project. The apparent velocities are defined as the ratio of the distance between two consecutive stations and the differential travel time. A two stage inversion scheme was used to match the observed and synthetic apparent phase velocities for a crustal model consisting of 8 Moho depths along the profile assuming homogeneous P-wave velocities in the crust and upper mantle. In the first stage, an initial crustal model was found by trial and error. The second stage consisted of a refinement of the optimal solution by a random search in model space. Our preferred model shows a crustal thickness of 65km beneath the High Cordillera and Precordillera and 45-60km beneath the western Sierras Pampeanas. A progressive shallowing is observed towards the east, where a 36km thick crust is observed 700km east of the trench. These crustal thicknesses are consistent with earlier results based in part on gravity modeling and deep reflection surveys. However, isostatically compensated Moho depths computed along the profile for a range of reasonable density models appear to be systematically shallower than our preferred model. This discrepancy is particularly acute (up to 15-20km) beneath the western Sierras Pampeanas, where low topographic elevations and only minor surface crustal shortening apparently contradict such deep Moho depths. This deep rooted crust might be explained by a combination of an unusually dense lower crust or upper mantle, or by lower crustal flow induced by dynamic forces caused by to the flat slab.

S41D-0126 0830h POSTER

The 2002-2003 CHARSME Experiment : Preliminary Results

Mario Pardo[1] (mpardo@dgf.uchile.cl); Tony Monfret[2] (33 4 92 94 26 52; monfret@geoazur.unice.fr); Emilio Vera[1] (evera@dgf.uchile.cl); Gonzalo Yanez[3] (gyane003@stgo.codelco.cl); Sylvain BONVALOT[1,4] (bonvalot@dgf.uchile.cl); Germinal Gabalda[1,4] (gabalda@dgf.uchile.cl); Alfredo Eisenberg[1] (aeisenbe@dgf.uchile.cl); Enrique TRIEP[5] (triep@idecom.unsj.edu.ar); Bernhard Hustedt[1] (hustedt@geoazur.unice.fr); Nicole Bethoux[1] (nbethoux@obs-vlfr.fr)

[1]Departamento de Geofísica, Universidad de Chile, Blanco Encalada 2085, SANTIAGO 1, Chile

[2]UMR Géosciences Azur - IRD/UNSA, 250, rue Albert Einstein, VALBONNE 06560, France

[3]Codelco-Chile, Teatinos 258 Piso 7, SANTIAGO 1, Chile

[4]IRD Mission-Chili, 264 Román Díaz, Providencia, SANTIAGO 1, Chile

[5]Universidad Nacional de San Juan, Meglioli 1160 Sur, SAN JUAN 1, Argentina

From Nov. 2002 to March 2003, the CHARSME project (CHile ARgentina Seismological Measurement Experiment) took place in Chile and Argentina in order to analyze the regional seismotectonic characteristics and to map the change of the subducted Nazca plate from a flat-slab to an inclined geometry. Local seismological and gravimetric data were collected. A seismic network of 30 portable broadband stations, continuous recording, was deployed between 31.5°S-34°S and 71°W-67°W, in addition to permanent stations on the Chilean side belonging to the University of Chile network. About 7200 earthquakes were detected during the experiment, however, only about the 50% have been located till now. Most of them are related with the subduction of the Juan Fernandez Ridge which takes place at the southern part of the flat-slab zone. There are also several crustal shallow events with well constrained focal mechanism, mainly located in the Andes Cordillera. These focal mechanisms confirm that most of the superficial deformation is compressive and due to shortening. Some effort has to be made to correlate this shallow activity with geological features. With the available located seismicity, we still can not have a precise image of the transition zone between the two subduction geometries, but we hope that with a local tomography we can achieve this goal. In parallel with the seismological experiment, two NS gravimetric profiles of 500 and 300 km long were performed with 2 portable gravimeters and 3 bi-frenquency GPS stations. These profiles crossed the transition zone of the slab geometry. From preliminary data, we found a variation of the gravity field between points situated above the flat-slab and inclined subduction. This variation can be generated by an asthenospheric wedge present underneath the inclined geometry and absent in the case of the flat one.

S41D-0127 0830h POSTER

Seismic Study of the Southernmost Andes. The Contact Between Scotia and South American Plates

Alejandro Tassone[1] (atassone@gl.fcen.uba.ar); Alberto H. Cominguez[2] (ahcominguezg@repsolypf.com); Daniel Yagupsky[1] (danielyag@arnet.com.ar); Patricia Alvarado[3,4] (alvarado@geo.arizona.edu); Emanuele Lodolo[5] (elodolo@ogs.trieste.it); Marco Menichetti[6] (menichetti@uniurb.it)

[1]CONICET, Dpto. Geol., FCEyN, Univ. de Buenos Aires, Ciudad Universitaria, Bs. As 1428, Argentina

[2]CONICET, Dpto. Geof. Aplicada, FCAG, Univ. Nac. de La Plata, Paseo del Bosque s/n, La Plata, BA 1900, Argentina

[3]University of Arizona, Gould-Simpson Bldg. 1040 E. 4 St., Tucson, AZ 85721, United States

[4]Universidad Nacional de San Juan, Meglioli 1160 S, San Juan, SJ 5400, Argentina

[5]Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), Borgo Grotta Gigante 42/C, Trieste 34016, Italy

[6]Istituto di Geodinamica e Sedimentologia. Universitàdi Urbino, Campus Scientifico - Loc. Crocicchia, Urbino 61029, Italy

The relationships between the sinistral Magallanes-Fagnano continental transform fault (MFS), a major segment of the boundary between Scotia-South American plates, and the northern flank of the western Scotia Sea, characterized mostly by compressional structures, have not been yet clearly identified. From data processing, depth seismic-migration modeling and interpretation of 800 km of seismic reflection profiles, this study presents one morpho-structural analysis of these two main tectonic elements. In the offshore part of the Malvinas fold-and-thrust belt, five main seismic units have been recognized. Steeply dipping (mainly to the south) reverse faults cut through the folds. Some of these faults represent old extensional faults of the Middle-Mesozoic Rocas Verdes marginal basin rifting, which have been subsequently inverted by compressional stress fields. A noticeable fault system is recognized in the seismic profile, which involves both the sedimentary cover and the acoustic basement. This fault is interpreted as the result of shear stresses produced along the transcurrent South American-Scotia plate boundary. In the SW border of Malvinas Basin, four major discontinuities were recognized. Each discontinuity represents important changes in the regional geodynamic evolution: Early-Late Jurassic rift; Thermal subsidence (Late Jurassic-Late Cretaceous); Transitional stage, to Foreland basin (Late Cretaceous-Eocene) and Foreland (since Eocene).