continuous wavelet transform. The detailed analysis of these parameters shows strong interaction between land-ocean-atmosphere prior to the earthquake. Such interaction shows anomalous behavior of land, ocean and atmospheric parameters that can be used in the early warning of impending coastal earthquakes.

T51F MCC: Level 1 Friday 0830h

Lithospheric Structure and Dynamics I Posters *(joint with S)*

Presiding: **B Guest,** University of California, Los Angeles**; K Mutnuri,** Rice University

T51F-0211 0830h POSTER

Crustal and Upper Mantle Structure of the Taupo Volcanic Zone, North Island, New Zealand.

Antony J Harrison[1] (+44 1223 337193; harrison@esc.cam.ac.uk)

Robert S White[1] (+44 1223 337187; rwhite@esc.cam.uk)

. Night Working Group (ajh75@cam.ac.uk)

[1]University of Cambridge, Bullard Laboratories, Madingley Road, Cambridge CB3 0EZ, United Kingdom

The Taupo Volcanic Zone (TVZ) is a major Pliocene-Quaternary NNE-SSW orientated,volcano-tectonic complex, about 250 km long and up to 60 km wide in the central North Island of New Zealand. The TVZ is one of the largest and most frequently active rhyolitic magmatic systems on Earth, characterised by intense shallow seismic activity, high natural heat flow (some 12-20 times the continental norm) and active NW-SE extension. To the north of the TVZ, subduction of the Pacific Plate beneath the oceanic lithosphere of the Australian Plate is accompanied by a region of back-arc extension (the Havre Trough). The TVZ marks the southern continuation of this back-arc extension into continental lithosphere.The TVZ therefore represents an ideal opportunity to study the onset of back-arc spreading onshore. Here we present forward and inverse models of the crustal structure beneath the TVZ. These models incorporate both active and passive source data acquired from the NIGHT (North Island GeopHysical Transect) project. Common to both models is a 2-3km deep basin of low velocity sediments which we interpret to be ignimbrite deposits. Typical basement velocities of ∼6km/s are observed beneath and to either side of the TVZ, where they correlate well with mapped outcrops of basement rocks. Velocities of around 7.3 km/s are observed at depths greater than 16 km beneath the TVZ. Such velocities may be interpreted as anomalously low velocity upper manlte or heavly intruded lower crust. Having constrained the crustal structure we then use earthquake events from the subducting Pacific Plate to yield information on the velocity structure of the upper mantle beneath the TVZ. NIGHT Working Group A. Harrison, J. Haines, R. White (University of Cambridge,United Kingdom); S. Henrys, S. Bannister, I. Pecher, F. Davey (Inst. Geological and Nuclear Sciences, Lower Hutt, New Zealand); T. Stern, W. Stratford (Victoria University of Wellington, New Zealand); H. Shimamura, Y. Nishimura, and A. Yamada (Hokkaido University, Sapporo, Japan).

T51F-0212 0830h POSTER

Strong decrease in ultrasonic Vp in lower crustal rocks at high temperature

Yoshio Kono[1] (yokouno@gold.ocn.ne.jp)

Masahiro Ishikawa[1] (ishikawa@ed.ynu.ac.jp)

Takashi Nakajima[2] (tngeoch.nakajima@aist.go.jp)

Said Rahim Khan[3] (pd@geolab.sdnpk.undp.org.pk)

Makoto Arima[1] (arima@ed.ynu.ac.jp)

[1]Yokohama National University, Ishikawa Laboratory, Graduate School of Environment and Information Sciences, 79-7, Tokiwadai, Hodogaya-ku, Yokohama 240-8501, Japan

[2]Geological Survey of Japan, Tsukuba Central 7, 1-1-1 Higashi, Tsukuba 305-8567, Japan

[3]Geological Survey of Pakistan, Shahzad Town, Islamabad 1461, Pakistan

In order to determine temperature derivatives of P-wave velocities (Vp) at pressure-temperature conditions of island arc lower crust, we measured Vp in various lower crustal rocks from exposed crustal section of Kohistan arc at temperature up to 1000 °C at pressure 1.0 GPa. The rock sample is embedded in a cylinder of pressure transmitting material (talc). Pt buffer rod is used to isolate the piezo-electric transducer from the high-temperature condition. Travel times of P-wave through the rock sample were determined with the pulse reflection technique. Sample length at experimental conditions was estimated with adiabatic bulk modulus and thermal expansion coefficient of rock samples studied. The uncertainties of Vp are ± 0.3 %. Kohistan arc lower crust is mainly composed of gabbronorite, wehrlite (Chilas complex), amphibolite, tonalite (Kamila amphibolite), pyroxene granulite, garnet granulite, garnet pyroxenite, websterite, and dunite (Jijal complex). Vp measurements were performed for 6 rock samples at 100 °C intervals up to 1000 °C. Ultrasonic determinations of Vp in the Kohistan lower crustal rocks show nonlinear temperature dependence. With increasing temperature, Vp values decrease slightly at lower temperature conditions, and decrease rapidly at higher temperature conditions. Cusp on the Vp - temperature profiles was identified for all samples. Cusp locates at various temperatures (300-800 °C) depending the rock sample measured. The temperature derivative above the cusp temperature is 1.8 - 5.8 times higher than the temperature derivative below the cusp temperature. Vp value is 7.0 km/s at 800 °C and 1 GPa for the gabbronorite, 7.6 km/s at 800 °C for the wehrlite, 7.2 km/s at 900 °C for the garnet granulite, 7.5 km/s at 900 °C for the garnet pyroxenite, 7.2 km/s at 900 °C for the websterite, and 8.0 km/s at 900 °C for the duntie.

T51F-0213 0830h POSTER

Elastic Thickness of the lithosphere below the Tehuantepec ridge

Marina Manea[1] (mary@ollin.igeofcu.unam.mx)

Vlad Manea[1] (vlady@ollin.geofcu.unam.mx)

Vladimir Kostoglodov[1] (vladimir@ollin.igeofcu.unam.mx)

[1]Dept. Seismology/Inst. Geophysics/UNAM, Ciudad Universitaria, Circuito Inv. Cient, Mexico, df 04510, Mexico

7 shipborne bathymetry and free-air gravity profiles, crossing the Tehuantepec ridge and fracture zone (TR), have been used to estimate the elastic thickness (Te) of the oceanic lithosphere, by the means of the admittance technique. The age of the oceanic lithosphere and the bathymetry in the vicinity of the TR change abruptly from the NW to SE. The assessment of the age of the lithosphere at the time of bathymetric loading of the TR can be deduced from the analysis of the experimental admittance and the elastic thickness Te. We have computed the admittance, which is interpreted in terms of isotropic elastic plate thickness. A model with a Te of 10±5 km fits well the observed admittance. The shape of the admittance (low values at low wave-numbers) suggests that TR is isostatically compensated. Using a diagram of the Te versus the age for a cut-off temperature of 450°C, the age of 15±10 Ma was obtained for the oceanic lithosphere at the time of TR onset.

T51F-0214 0830h POSTER

Structural and Stratigraphic Correlations Between the Conjugate mid-Norway and NE Greenland Continental Margins

Filippos Tsikalas[1] (+47 22856678; filippos.tsikalas@geo.uio.no)

Jan Inge Faleide[1] (+47 22856677; j.i.faleide@geo.uio.no)

Olav Eldholm[2] (+47 55583281; olav.eldholm@geo.uib.no)

Jonas Wilson[1] (+47 22856656; jonas.wilson@geo.uio.no)

[1]Department of Geosciences, University of Oslo, P.O. Box 1047 Blindern, Oslo N-0316, Norway

[2]Department of Earth Science, University of Bergen, Allegt 41, Bergen N-5007, Norway

Late Mesozoic-Cenozoic tectono-stratigraphic correlations between the conjugate mid-Norway and NE Greenland continental margins are provided based on the recently refined structural and stratigraphic framework off mid-Norway, new early opening plate reconstructions between Jan Mayen and Senja fracture zones, and a regional grid of seismic reflection profiles off NE Greenland. The Norwegian margin exhibits a distinct along-strike margin segmentation governed by across-margin transfer systems. In particular, the Bivrost Fracture Zone and its landward prolongations are well-defined features on the conjugate margins representing a first-order, across-margin tectono-magmatic boundary of prolonged structural inheritance. Regional transects across both margins reveal important vertical and lateral variations in crustal configuration and composition resulting from a complex history of rifting prior to and during the last Late Cretaceous-Early Tertiary rift episode leading to breakup and volcanic margin formation. Although the composite Late Jurassic-earliest Cretaceous rifting is the dominant tectonic episode we also observe structural and stratigraphic relations that indicate an Aptian-?Albian rift phase, probably coeval with similar events elsewhere on the NE Atlantic margins. Late Cretaceous rifting, with onset in middle Campanian time, is characterized by low-angle detachment faulting, culminating with regional uplift, intrusive igneous activity and subsequent erosion towards the end of the Paleocene. Thick seaward dipping reflector sequences manifest massive eruptions of lavas during breakup at the Paleocene-Eocene transition. The post-breakup passive margin development is characterized by the transport and deposition of large amounts of sediments in response to margin subsidence and continental uplift, particularly during two distinct phases of outbuilding in Oligocene and Plio-Pleistocene times. Of special interest are a number of mid-Cenozoic intra-basin inversion features recognized both off Norway and off Greenland, revealing a regional compressive regime.

T51F-0215 0830h POSTER

Bivrost Transfer System: A Primary Cross-margin Tectono-magmatic Feature on the Norwegian-Greenland Margin

Olav Eldholm[1] (+47 55583281; olav.eldholm@geo.uib.no)

Filippos Tsikalas[2] (+47 22856678; filippos.tsikalas@geo.uio.no)

Jan Inge Faleide[2] (+47 22856677; j.i.faleide@geo.uio.no)

[1]Department of Earth Science, University of Bergen, Allegt 41, Bergen N-5007, Norway

[2]Department of Geosciences, University of Oslo, P.O. Box 1047 Blindern, Oslo N-0316, Norway

The Norway-East Greenland conjugate margin exhibits distinct along-strike segmentation. The Jan Mayen and Senja fracture zones and their landward prolongations represent first-order features. In between, we identify several second- and third-order features. Of these, the Bivrost transfer system is the most prominent. Off Norway, it separates two different physiographic provinces, i.e. the Vøring and Lofoten-Vesterålen margins. Structural studies, analysis of potential field images on the conjugate margins, and plate reconstructions to early Tertiary opening suggest a landward prolongation of the Bivrost Fracture Zone on both margins. The prolongations appear as low-relief Late Jurassic-Early Cretaceous accommodation zones, reactivated during Late Cretaceous-Paleocene rifting. We recognize a difference in trend, and possibly in polarity, of the relative motion between the older transfer zone and the younger fracture zone. The more northerly sinistral relative motion along the fracture zone suggests two different stress regimes, however the older feature may have determined the initial location of the fracture zone. Pre-opening structural spatial relations may imply sinistral offsets also along the continental prolongations. Furthermore, we observe a northward decrease in thickness and volume of the high-velocity lower crust, interpreted as related to magmatic underplating, across the Bivrost Fracture Zone. Other changes north of the fracture zone include: breakup lavas over most of the continental slope, a reduction in the intensity of sill intrusions, and a change in style of the seaward dipping seismic reflector images to less prominent and shallower features without the typical, deep wedge-like pattern observed to the south. We interpret breakup occurring in different crustal configurations: in the south along the western flank of the deep Cretaceous Vøring Basin, and in the north along a deep-rooted detachment fault in relatively thick crust on the eastern basin flank. These settings have governed the asymmetric distribution of breakup magmatism and the construction of marginal highs.

T51F-0216 0830h POSTER

Extent of Continental Crust Thickening Derived From Gravity Profile Leading From Aden Towards the Dhala Plateau in the Yemen Trap Series

Vratislav Blecha (420-221951550; vblecha@natur.cuni.cz)

Charles University Prague Faculty of Science, Albertov 6, Prague CZ-128 43, Czech Republic

Gravity profile trends NNW from Aden and terminates at the Dhala plateau formed by Tertiary volcanics often referred to as the Yemen Trap Series. The length of profile is 120 km. Profile consists of 366 gravity stations with average distance of 300 m between stations.

The mean square error of Bouguer anomalies is 0.06 mGal. This final error includes errors of gravity and altitude measurements and error in terrain corrections. Altitudes along profile are ranging from 0 m a.s.l. in the south to 1400 m a.s.l. at the northern side of profile. In the central part of the Gulf of Aden occurs juvenile oceanic crust. Stretched continental crust is assumed on the coast. Regional gravity field decreases from +38 mGal on the coast in Aden to -126 mGal at mountains of the Dhala plateau. According to gravity modeling the decrease of 164 mGal in gravity is caused by 8 km continental crust thickening over the distance of 120 km. Regional gravity field is accompanied by local anomalies with amplitudes of tens of mGal. Sources of local anomalies are from S to N: coastal sediments (negative), Tertiary intrusions and volcanics within the Dhala graben (positive), Mesozoic sediments (negative) and Tertiary volcanics of the Dhala plateau (positive). Gravity profile is most detailed and most precise regional gravity measurement carried out in the southern tip of Arabia and brings new information about geology of the area with scarce geophysical data.

T51F-0217 0830h POSTER

An Integrated Geophysical study of the Lithospheric Structure Beneath Libya

Wesley A Brown[1] ((915) 747-5501; wesley@geo.utep.edu)

Diane I Doser[1] ((915) 747-5851; doser@geo.utep.edu)

Randy G Keller[1] ((915) 747-5501; keller@geo.utep.edu)

[1]University of Texas at El Paso, Dept of Geologicas Sciences, El Paso, TX 79968, United States

The tectonic evolution of Libya has yielded a complex crustal structure, which is composed of a series of basins and uplifts. A considerable amount of oil exploration has been undertaken in the area and numerous studies have been published on the shallow (< 10km depth) geology and geophysics of the region. In addition, over 6000 gravity measurements are available for the northern Libya region. We are using these data in conjunction with other geologic and geophysical control to construct a 3-D model of density/geology for northern Libya and surrounding regions. Knowing the surface geology and having a digital elevation model and observed gravity value at specified stations, we first calculate the gravity contribution for polygonal areas assuming infinite depth. We then calculate the gravitational contribution for the same polygonal area using the Paleozoic surface as the elevation, assuming uniform density for the volume of rocks below the Paleozoic surface. Subtracting the value calculated at the Paleozoic layer from the gravitational value at the surface yields a gravitational value matching that of the layer between the surface and the top of the Paleozoic layer. The same procedure is then repeated for the top of the Precambrian, the Moho, etc. The 3-D model will then be used to develop a regional velocity model that can be verified/modified by analysis of regional seismic waveform data we are collecting from earthquakes occurring within northern Libya. Northern Libya is the most seismologically active and highly faulted portion of the country. For this reason we have collected thirteen Landsat 5 satellite images covering the most seismically active and structurally significant regions of northeast and northwest Libya. The satellite images have been mosaicked using a seamless mosaicking technology based on ENVI's cutline feathering approached. The resulting mosaicked figures were then overlain with the previously mapped faults analyzed to identify the more recent faults.

T51F-0218 0830h POSTER

Insights into along-strike passive continental margin variability from seismic reflection, refraction and gravity data, Northwest Australia

Michael Tischer[1] (845-365-8444; mtischer@ldeo.columbia.edu); Uri Ten Brink[2]; Garry Karner[1]; Andrew Goodliffe[3]; Masako Robb[3]; Brian Taylor[3]; Neal Driscoll[4]; Damien Ryan[5]

[1]Lamont-Doherty Earth Observatory, Columbia University P.O. Box 1000 61 Route 9W, Palisades, NY 10964, United States

[2]USGS - Woods Hole Field Center, 384 Woods Hole Road Quissett Campus, Woods Hole, MA 02543-1598, United States

[3]SOEST, University of Hawaii 1680 East-West Rd., Honolulu, HI 96822, United States

[4]Scripps Institution of Oceanography, UCSD 9500 Gilman Drive, La Jolla, CA 92093, United States

[5]Geoscience Australia, GPO Box 378, Canberra, ACT 2601, Australia

We image for the first time the complete continent-ocean transition zones for the Northwest Australian passive margin, using recently collected multi-channel seismic reflection, ocean bottom seismometer wide-angle, and gravity data. Our results help to classify the margin, provide crustal models that shed light on margin formation and architecture variability, and bear insight into the evolution of adjacent margin segments. The marginal Exmouth Plateau, which forms the northern portion of the Northwest Australia margin, has been previously characterized as a wide, non-volcanic passive margin. Recently, several studies have questioned this classification: it has been suggested that its formation was due to rifting along an eastward dipping detachment that caused large lower crustal extension and was accompanied by little upper crustal brittle deformation on the plateau. Our crustal model supports this formation model, indicating a very wide continent-ocean transition zone (200 km) and a highly thinned lower crust. Besides several seaward-dipping reflector groups visible in the seismic reflection data, seismic refraction and gravity data also indicate a zone of high p-wave velocities of significant lateral extent at the bottom of the lower crustal layer beneath the plateau. This is possibly caused by underplating or magmatic intrusions, which supports the idea of the Exmouth Plateau being a volcanic margin. In contrast, the Cuvier margin, located south of Exmouth Plateau and separated from it by the Cape Range fracture zone is thought to represent a more typical volcanic margin due to its narrow width, the presence of seaward-dipping reflectors and the anomalously thick oceanic crust. Our crustal and gravity modeling confirms this by showing a relatively narrow continent-ocean transition zone (70 km) bounded oceanward by oceanic crust that thickens from 7 to 13 km towards the transition zone. Below oceanic crust, there is a zone of unusually high mantle velocity (8.5 km/s) of large lateral extend (100 km) that we believe can be attributed to mantle anisotropy with its fast velocity in the margin-normal direction. If our interpretations hold true, small-scale convection across the Cape Range fracture zone (margin-parallel), invoked in this area to explain the excess volcanism visible along the Cuvier margin is not supported by our data and other mechanisms which can explain margin variability along the Northwest Australian margin need to be sought.

T51F-0219 0830h POSTER

A Mechanism for Alborz Support and Caspian Subsidence:an Elasto-visco-plastic Model for the Last 10 Ma of Strain Accumulation in Northern Iran

Bernard Guest[1] (310-206-0650; bguest@ess.ucla.edu)

Alice Slancova Guest[2] (323-913-0724; alice.slancova@jpl.nasa.gov)

Gary James Axen[1] (310-205-6928; gaxen@ess.ucla.edu)

[1]University of California Los Angeles, 595 Young Dr. E., Los Angeles, CA 90095, United States

[2]Jet Propulsion Laboratory, 4800 Grove Oak Dr., Pasadena, CA 91109, United States

The Alborz Mountains of northern Iran are a region of 4 km topography adjacent to the south Caspian basin, one of the thickest accumulations of sediment on earth (∼20-25 km of Jurassic and younger sediment). The upper 10 km of south Caspian sediment and the 4 km of Alborz topography accumulated during the last 6 Ma, accounting for 15 km of the ∼25 km structural relief that is observed in this region. The mechanism by which this structural relief is accumulated, the nature of south Caspian basement and mechanism by which the isostatically overcompensated (rootless) Alborz can be supported are currently being debated in the earth science community. Two dimensional, elasto-visco-plastic, finite element modeling provides insight into the types of strain distributions that result when an 8 km thick oceanic slab overlain by 10 km of sediment, and an adjacent low lying continental region are subjected to 10% shortening. This configuration mimics the cross-sectional structure of the south Caspian and northern Iran just prior to ∼10 Ma. The modeling shows that geometry plays an important role in the strain accumulation: The strong upper crust of Alborz mountains and strong 10 km deep oceanic crust of the south Caspian partially maintain the stresses due to shortening and deform chiefly by crustal scale flexure. On the contrary, the weak hot lower crust of Alborz and weak 10 km thick south Caspian sediments relax much of the stress and accumulate shortening due to the presumably low Young modulus and high Poisson ratio in these layers. This "chessboard geometry" causes the Alborz upper crust to buckle upwards and the Caspian oceanic crust to buckle downwards. The model yields results that are consistent with first and second order observations from the Alborz region implying that the Alborz may have developed by upper crustal buckling over hot, buoyant lower crust and lithosphere which compensates for the lack of a crustal root. Rapid South Caspian subsidence is due to the combination of thermal subsidence and downward buckling of the oceanic slab.

T51F-0220 0830h POSTER

Back-arc Basins: Spreading and Convergence History

R. Dietmar Müller[1] (+61 2 93514254; dietmar@geosci.usyd.edu.au)

Maria Sdrolias[1] (+61 2 93513682; marias@geosci.usyd.edu.au)

[1]University of Sydney Institute of Marine Science, Building F05 University of Sydney, Sydney, NSW 2006, Australia

Back-arc basins are regions of extension between the active and remnant volcanic arc in a subduction zone setting. Although subduction is a necessary condition for the formation of back-arc basins, not all subduction zones have an associated back-arc basin at all times. A relationship between the presence/absence of back-arc spreading and the motion of the downgoing plate has previously been proposed but this relationship has not been tested in light of new plate reconstruction constraints. We present global plate reconstructions for the past 60 m.y as a series of palaeo-agegrids based upon an updated global isochron and rotation file. Our reconstructions include a revised absolute plate motion model based on moving hotspots, an improved convergence history at the circum-Pacific subduction zones due to the inclusion of East-West Antarctica motion in the global plate circuit and a globally consistent set of magnetic anomaly identifications in back-arc basins. The palaeo-agegrids also provide a reconstructed age distribution of the subducted oceanic lithosphere. The spreading history in back-arc basins is examined together with the absolute plate motion of the downgoing and over-riding plates to compute the roll-back of the subduction hinge. Our results from the seafloor spreading record in back-arc basins suggests that: (1)Spreading is episodic. There are gaps of several million years between the cessation of spreading in one back-arc basin and initiation of the next. (2)There is a high ratio of spreading centres to surface area in each back-arc basin with numerous examples of triple junctions and ridge jumps. (3)Spreading in the back-arcs record changes in regional plate configurations. Changes in the spreading directions and cessation of spreading in back-arc basins, as well as changes in convergence vectors, can be correlated with regional changes in plate motions. Further work on integrating absolute plate motion models and subduction hinge roll-back with mantle convection models will improve our knowledge on the mechanisms behind back-arc basin formation.

T51F-0221 0830h POSTER

Subduction at an Erosive Margin: Effects of Bathymetry on Fore arc Deformation in Costa Rica

Jason C Sitchler[1] (814-865-9353; sitchler@psu.edu)

Donald M Fisher[2] (814-865-3206; fisher@geosc.psu.edu)

[1]The Pennsylvania State University, Department of Geosciences, 534 Deike Building, University Park, PA 16802, United States

[2]The Pennsylvania State University, Department of Geosciences, 339 Deike Building, University Park, PA 16802, United States

The Fila Costena, an inner fore arc thrust system along the Middle America Trench, shows systematic variations in fault geometry and shortening that reflect subducting seafloor bathymetry. The thrust belt is approximately 20 km wide at the Terraba gorge and Rio Claro areas where a series of faults imbricate the late Tertiary fore arc basin sequence comprised of the Eocene Brito Fm. and Oligocene to early Miocene Terraba Fm. Strata and thrust faults strike WNW-ESE and dip approximately 15-40 degrees NE at the thrust front. Along structural strike to the ESE, the thrust belt abruptly dies at the onland projection of the Panama Fracture Zone. Displacement is greatest on the frontal thrust that separates the outer fore arc, characterized by exposed crystalline basement rocks, from the inner fore arc. Although the Fila Costena is a continuous thrust belt, there are only two regions where the Brito Fm., the basal unit of the fore arc basin sequence, has been exposed through thrusting: 1) the onland projection of the axis of the subducting Cocos Ridge and 2) the flanks of the Herradura block inboard of a major chain of subducting seamounts. There are two possibilities to explain the appearance of limestones in these localities. The basal decollement either steps down laterally into the basal limestones in these regions or the fore arc basin experienced long wavelength folding over subducting features prior to development of a decollement at constant depth. In both cases shortening based on balanced cross sections increases inboard of large subducting asperities. A comparison of cross sections at the Rio Terraba gorge and

near Rio Claro shows that total shortening increases from approximately 17km (Rio Terraba) to considerably greater values where the thrust belt nears the onland projection of the Cocos Ridge axis, as indicated by additional thrust sheets that sole into the Brito limestone.

T51F-0222 0830h POSTER

Eastward Mantle Drag on the Caribbean Plate: Insights from Neotectonic Modeling

Ana M Negredo[1] (+34 913945007; anegredo@fis.ucm.es)

Ivone Jimenez-Munt[2] (+44 20 7679 3344; i.jimenez-munt@ucl.ac.uk)

Antonio Villaseñor[3] (+31 302536722; antonio@geo.uu.nl)

[1]Department of Geophysics. Universidad Complutense de Madrid, Ciudad Universitaria s/n, Madrid 28040, Spain

[2]Department of Earth Sciences University College London, Gower Street, London WC1E 6BT, United Kingdom

[3]Faculty of Earth Sciences. University of Utrecht, Budapestlaan, 4, Utrecht 3508 TA, Netherlands

Thin-shell finite element techniques have been applied to study the neotectonics of the Caribbean plate. Model domain comprises the entire Caribbean plate and it is outlined by fault elements. Kinematic conditions applied at the lateral boundaries represent motion of Cocos, Nazca, South America and North America plates with respect to the Caribbean plate. The velocity of this plate was not fixed, so its predicted velocity was used as a test of the model quality. We also included major intraplate active or potentially active faults in order to provide some estimates of slip rates, which is relevant for their relative long-term seismic hazard evaluation. We have obtained different sets of models varying the lateral and basal boundary conditions. Velocity conditions applied at grid sides were computed assuming poles and rotation velocities deduced from global plate model NUVEL-1A and from a number of published geodetic studies. We have also considered different possibilities for shear tractions from lower mantle flow acting on the base of the Caribbean plate. We have tried the following basal boundary condition: (1) no basal traction; (2) a lower mantle static with respect to Africa; (3) an eastward lower mantle flow. Different models have been computed with systematic variation of the fault friction coefficient. The quality of the models has been evaluated by comparing their predictions of anelastic strain rates, vertically-integrated stresses and velocity fields to data on seismic strain rate, most compressive horizontal principal stress direction, horizontal velocity deduced from geodetic studies and estimates of fault slip rates. Best results are obtained assuming low fault friction coefficient and boundary conditions at model sides deduced from geodetic studies. Our validation datasets require velocities of North America and South America plates relative to the Caribbean plate higher than those of model NUVEL-1A. Moreover our results clearly indicate that the only successful models are those with a significant basal drag on the Caribbean lithosphere exerted by eastward lower mantle flow.

T51F-0223 0830h POSTER

Structure and Seismicity of West Antarctica

J. Paul Winberry[1] (winberry@essc.psu.edu)

Sridhar Anandakrishnan[1] (sak@essc.psu.edu)

[1]Department of Geosciences Pennsylvania State University, 441 Deike Building, University Park, Pa 16802, United States

A large part of the West Antarctic Ice Sheet (WAIS) is situated on the West Antarctic rift system. The base of the ice sheet is currently below sea level, which has lead some researchers to suggest that its size, volume, and flow characteristics are particularly sensitive to climate change. Much of the ice is transported from the interiors to the coast via fast-flowing glaciers and ice streams whose flow dynamics are strongly controlled by conditions at the bed. Variations in basal temperature, water content, and the distribution and lithology of sedimentary basins and crystalline basement contribute to the complexity of flow environments observed in the Antarctic. Mapping those parameters will contribute to an improved ability to model the ice sheet accurately. We report on the mapping of sedimentary layers beneath the Antarctic using broadband seismic techniques and their association with flow of the ice sheet. We also report on the first documentation of seismicity in the region. The data presented indicate that the ice sheet does not suppress seismicity as has been previously proposed. However, the observed earthquake pattern suggests the West Antarctic rift system is no longer actively extending.

T51F-0224 0830h POSTER

New 40Ar/39Ar Ages, Biostratigraphic and Geochemical Data from the Sabzevar Ophiolite, North Central Iran: Implications for Tectonic of Iranian Plate

Ali Hassanipak[1]

Mohsen Kariminia[2] (smk736@utdallas.edu)

Katayou Mobasher[1] (kmobasher1@student.gsu.edu)

Mohamad Ghazi[1] (404-463-9556; mghazi@gsu.edu)

[1]Georgia State University, Department of Geology, Atlanta, GA 30303, United States

[2]University of Texas-Dallas, Department of Geological Sciences, Dallas, TX 75083, United States

The igneous rocks of the Sabzevar ophiolite in north central Iran composed of peridotites, serpentinite, minor pyroxenite, gabbros, and a volcanic sequence that exhibits a wide range of composition from basalts to basaltic andesites to rhyodacite-dacites, rhyolites and basanites. Sedimentary rocks include a variety of Upper Triassic to Lower Cretaceous deep- and shallow-marine rocks. These include pelagic fossiliferous carbonates, which are mixed with the pillow basalts and the basaltic andesite as interlayers or exotic blocks, ranging in size from 10 to 100 meters. Also present are extensive units of radiolarian chert which are interbedded within the basalts and basaltic andesites. A combination of petrographic observations and analyses of incompatible trace elements and rare earth elements indicates the presence of at least four different types of extrusive rocks in the Sabzevar ophiolite. The geochemical data clearly identifies some of the extrusive rocks to have formed from three distinct types of basaltic melts; i) the group-1 basaltic rocks, which formed from an initial melt with N-MORB-like (LREE depleted) chemical signatures and are petrogenetically related to the gabbros, ii) group-2 basaltic rocks which have E-MORB chemical signatures, and iii) group-3 basaltic rocks with LREE-enriched signature and incompatible trace element patterns that suggest an island arc affinity. In addition, the Sabzevar ophiolite contains other volcanic rocks that have non-MORB like geochemical signatures (e.g., within-plate, island arc). The differences between these geochemical signatures could be a result of a differing composition of the upper mantle, or a different degree of partial melting of the same upper mantle. The presence of sizable Nb anomalies in the extended REE patterns for andesites and the group-2 basalts is characteristic of volcanic arc magmas, or those were the composition of the ascending magma was modified by crustal contamination. The presences of the basanites and the silica under saturated rocks could be attributed to post ophiolite emplacement extrusive activities. The most significant of the taxa recovered include Clobotruncanita calcarata (Zone 2B; uppermost Campanian)and Clobotruncanita contusa (Zone 1B, Sub-zone 1B1 to 1A: upper Maasrichtian). The two most recent Ar/Ar ages from a muscovite and hornblende from two samples of schists give consistent plateau ages of 52.8 $\pm$ 0.8 Ma and 52.97$\pm$ 0.44 Ma, respectively. They have been interpreted as the ages of emplcement of this ophiolite and the age of the closure of the Tethys in this section of the present day Middle East. Plate reconstructions suggest that the rocks of Sabzevar ophiolite are part of the Tethyan oceanic crust that was formed during rifting of a narrow but deep seaway that separated the Central Iranian Microcontinent from the Eurasian plate and it was emplaced during northeast dipping subduction (i.e., closure) of the this segment of Tethyan seaway (Sabzevar Ocean).

T51F-0225 0830h POSTER

High Resolution Surface Wave Tomography: The Structure of Lithosphere and Dynamics in East Asia and West Pacific Marginal Sea

Jieshou Zhu[1] (86-28-84078132; zhujs@cdut.edu.cn)

Jamin Cao[1] (86-28-84078047; Caojm@cdut.edu.cn)

Zhongqiong Yan[1] (86-28-84078829; yanzq@cdut.edu.cn)

[1]Chengdu University of Technology, ErXian Qiao East No1, Chengdu 610059, China

The continent of East Asia and West Pacific marginal sea was formed by convergence of a series of micro-plates and blocks in the late Paleozoic (about 250-220 Ma). Since Mesozoic (about 150 Ma) the asthenospheric material upwelling caused the lithosphere extension and thinning, and with strong activities of volcano and magma. In Cenozoic the continental margin continued to develop large scale rifts and marginal sea, a series of extending oceanic ridges and basins appeared. In Paleocene epoch the Indian sub-continent collided with the Eurasian continent causing the crust to be shortened and rapidly uplifted, forming the highest of Qinghai-Tibet plateau and the largest convergent region on the Earth. According to approximately 20,000 long-period digital seismic waveforms from 1200 events ($7.0 \geq M \geq 5.0$) recorded by 60 digital seismic stations from CDSN, GSN, GDSN, and GEOSCOPE network in Eurasia and west Pacific regions, about 6,000 accurate surface wave dispersion curves with periods ranging from 8 to 250 seconds were selected and employed for inversion. The high resolution 3-D shear wave velocity images in this area were constructed by inversion of both dispersion and waveform showing a notable lateral variation in lithosphere and asthenosphere. The images of shear wave velocity indicate that from upper crust to the depth of 70 km, high velocities are displayed in the region of eastern part of East Asia and West Pacific marginal sea, in contrast, extremely low velocities illustrated in the Qinghai-Tibet Plateau and its surrounding areas. The low velocity anomaly chain is located along the convergence belt of Tethys from Mediterranean Sea, through Turkey, Iran, Himalayan orogens, Burma to Indonesian islands. In general it is divided by a boundary at 110°E in lateral direction, and divided by depth of 70-85 km in vertical direction, the velocity images show striking differences. The western part mainly features an accumulated and thickened lithosphere caused by collision between India and Eurasia, and the eastern part displays mainly the extending and thinning lithosphere caused by asthenosphere upwelling. The lithosphere in the west part is 100 km thicker than in east part. The shear wave velocity of lithosphere in west is 0.2 km/s to 0.25 km/s higher than in east, the temperature in the bottom of lithosphere in eastern parts is 300-400°C higher than western parts. There exists a giant low velocity belt in the asthenosphere with length of about 8,000 km, width of about 2,500-4,000 km from Sea of Okhotsk, Kuril basin, Sea of Japan, North China and South China, South China Sea to Philippine Sea. The characteristics of the low velocity belt is not same with subduction zone in East Pacific, however, it is the same with the Pacific Ocean rise, Atlantic Ocean ridge and Indian Ocean ridge. The tectonic evolution may undergo the following stages. The lithosphere of east edge of Asia was broken up and the asthenosphere upwelling forming the giant rifts system in mid and late Mesozoic. The present trench-islands arc-basin system in West Pacific marginal sea is the results of interaction with Pacific plate, Australian plate and Eurasian plate in Cenozoic.

T51F-0226 0830h POSTER

Experimental Study on Acoustic Waves in Periodically Layered Media

Xiaosong Yang[1] (xsyang@eq-igl.ac.cn)

Jin Ma[1]

Liqiang Liu[1]

[1]Institute of Geology and Laboratory of Tectonophysics, China Seismological Bureau, Beijing 100029, China

The propagation of acoustic waves through periodically layered media (PLM) is experimentally investigated for the purpose of determining how the velocities and waveforms depend on periodical structures and detection frequency. In our experiments the PLM were made of stacks of plastic and steel plates with different periodical spacing. The acoustic wave frequency used in our experiments was 240MHz. Velocities and waveforms were measured by Digitization Wave-Meter with 16-bit resolution and 40MHz sampling rate. The results show that the velocity transition from the time-averaged relation to the long-wave approximation (LWA) is related to the critical ratio of λ_i/d_i(i=1, 2) (λ_i - the wavelength of wave going through medium i; d_i - the thickness of medium i in PLM) rather than to λ/d (the ratio of wavelength to the thickness of rhythmic layer). The LWA occurs when $\lambda_i/d_i > 5$(i=1, 2), and the velocities (V) approach to the Reuss bound (V^R), whereas the time-averaged velocities hold when $\lambda_i/d_i < 4$ (i=1, 2). We attribute the behavior of V $\rightarrow V^R$ to "softer shape" distribution of different rigid components in PLM. The waveforms are also frequency dependent. With larger thickness of rhythmic layer, the attenuation of the first arrival is low and the multiple waves reflected from interfaces can be observed. In the case of LWA, however, the transmitted waves tend to have relatively simple waveforms. This behavior implies that simple waveform does not always reflect simple medium structure through which the wave propagates. As $\lambda_i/d_i \sim 6$ (i=1, 2), the transmitted wave is obviously attenuated, and consequently it is equivalent to a shield layer for the wave. Therefore the influences of medium structures on velocities and waveforms should be taken into account when interpreting deep structures and compositions based on seismic data. Tectonic nature of intracrustal low velocity zones is one of the hotly debated topics. An important implication of our experimental results is that PLM are potentially low velocity zones. If extremely reflective deep crust is caused by alternating layers, the relative lower velocities observed in deep crust should probably be attributed to the rock properties that we wish to

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image, as well as to its structures, scales and detection frequencies.

T51F-0227 0830h POSTER

A Single Method for the Inversion of Anisotropic Data Sets With Application to Structural Studies

Christian David[1] (+33 1 3425 4985; christian.david@geol.u-cergy.fr)

Laurent Louis[1] (+33 1 3425 4998; laurent.louis@geol.u-cergy.fr)

Philippe Robion[1] (+33 1 3425 4910; philippe.robion@geol.u-cergy.fr)

[1]UMR CNRS 7072 Univ. Cergy-Pontoise, Av. du Parc - Le Campus - Bat. I, Cergy-Pontoise 95031, France

Due to the intrinsic characteristics as to the shape and arrangment of their components, rocks are naturally anisotropic, that is traditionally pointed out through the measurement in different directions of a given physical property. These anisotropies are in general easy to observe and quantify but not to interprete in terms of microstructure or, what remains the same, in terms of deformation if the measurements are performed for a structural study. For instance, a usual problem is to distinguish, giving an anisotropy fabric, the deformation contribution from the inherited part. Here, a unified method to analyse magnetic susceptibility and P-wave velocity data is proposed, assuming that both measurement sets can be described by a second rank tensor, which is rigorously true only for the magnetic data. For the velocity data, this hypothesis is discussed by estimating the error made during inversion with respect to theoretical estimations for transverse isotropic media. We find that the error mostly falls below 1% for simulations on published experimental data for several sandstones and limestones. Therefore our analysis promotes the use of a unique and simple method to analyse anisotropy from different data sets in structural applications. We also discuss the best strategy for data sampling in order to get a comprehensive knowledge of the anisotropic behaviour of rocks in structural studies. The method is applied to different sedimentary rocks (mainly sandstones), retrieved in both deformed and undeformed structures. We emphasize that combining data sets for different physical properties and using a single inversion scheme leads to a better understanding of the deformation processes at the microstructural scale.

T51F-0228 0830h POSTER

The Conjugate Volcanic Continental Margins Of Argentina And Southern Africa

Soenke Neben[1] (495116433128; s.neben@bgr.de)

Bernd Schreckenberger[1] (495116432797; b.schreckenberger@bgr.de)

Dieter Franke[1] (495116433235; d.franke@bgr.de)

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

In April-June 2003 the German Federal Institute for Geosciences and Natural Resources (BGR) undertook a new marine geophysical cruise along the South Atlantic continental margin off South Africa. In total more than 3,000 km of combined multi-channel reflection seismic (MCS), magnetic and gravity and an additional of 1,300 km with only magnetic and gravity were acquired. In combination with the extensive MCS (>20,000 km) data set from the Argentine margin we are able to interpret seven conjugate traverses available over almost exact conjugate parts of these volcanic passive margins. A first interpretation of the raw stacked seismic data from the South African side shows that the volcanic features seem to be mirror images to the structures found on the Argentine margin. Continental break-up and initial sea-floor spreading were accompanied by large-scale magmatism and volcanism as manifested in the seismic data by a huge wedge of seaward dipping reflectors (SDRS), and a distinct high-velocity (average value 7.3 km/s) lower crustal body beneath the SDRS. The data from the Argentine margin already suggested that the emplacement of the deeply buried, 60-120km wide SDRS was episodic as documented by at least three superimposed SDRS units. A similar distinct partitioning of the SDRS into three to four individual wedges is present on the South African margin. From the new data a detailed correlation of timing of these individual pulses is intended. Furthermore, it is possible to estimate the amount of extruded material during the phases of emplacement. The seismic data from the Argentine margin document the presence of a narrow, north-east striking half-graben system beneath the upper slope. This buried half-graben system developed during the final stage of rifting in the Early Cretaceous, whereas the east-west trending Colorado-Basin probably formed earlier. In the new data from South Africa only one half graben was identified up to now.

T51G MCC: 3007 Friday 1020h

Analysis of Plate Boundary Deformation Using Stress and Strain Rate Data in Tandem II *(joint with G, S)*

Presiding: **J Townend,** Victoria University of Wellington**; S Mazzotti,** Geological Survey of Canada

T51G-01 1020h INVITED

Using finite and infinitesimal strain indicators to decipher the evolution and vertical coherency of deformation in the northern Aegean

Corné Kreemer[1] (kreemer@geologie.ens.fr)

Nicolas Chamot-Rooke[2] (rooke@geologie.ens.fr)

Xavier Le Pichon[1] (lepichon@geologie.ens.fr)

[1]Collège de France, Europole de l'Arbois, Bat. Laennec, Hall D, Aix en Provence 13545, France

[2]Ecole Normale Supérieure / CNRS, 24 rue Lhomond, Paris 75231, France

For an increasing number of deforming regions extensive sets of geodetic data are currently available. One of the challenging prospects of this newly available information is the potential to study the relationship between the present-day surface deformation field and the magnitude and direction of 1) past crustal deformation, and 2) the inferred deformation of the lithosphere and underlying mantle. We have started an investigation into the 3-D deformation evolution of the Northern Aegean, a tectonically complex area that is known to have experienced drastic tectonic regimes changes over the last few million years. We have modelled the surface strain rate field through an interpolation of published GPS velocity vectors and with additional constraints from active faulting. The strain rate field in the northern Aegean is dominated by a shear zone along the North Aegean Trough which accommodates ∼25 mm/yr of motion, similar to the North Anatolian fault (NAF) to the east, and which terminates abruptly offshore central Greece. In variance with what is argued earlier by others, the direction of the extensional strain rate axes do not agree with published shear-wave-splitting directions that are thought to indicate anisotropy directions of the underlying lithosphere and upper mantle. Shear-wave-splitting directions also do not agree with calculated no-length-change directions from our model. Instead we find that extensional strain rate directions are oriented consistently (and significantly) 17°-40° more northward than the NE-SW oriented shear-wave-splitting directions. We argue that the shear-wave-splitting directions are relatively more consistent with published directions of middle-upper extension directions during the Miocene as inferred from stretching lineations in metamorphic core complexes. We postulate that 1) present-day extension directions are different from those in the Miocene because of the westward prolongation of the NAF which has changed the dominating regime from extension to shear, and 2) the significant extension in the Miocene has involved or affected the whole lithosphere and possibly upper mantle. We infer that the major shear zone in the northern Aegean has been established too recently to rotate anisotropy directions at depth along the direction of shear, as happened along some other major shear zones. This would agree with the fact that the timing of the westward prolongation of the NAF into the Aegean domain is estimated at 1-3 Ma. To further investigate the possible relationship between Miocene crustal and inferred lithospheric deformation, we attempt to obtain crustal finite strain estimates in order to do a relative and/or absolute comparison between Miocene crustal deformation and the seismic delay-times observed in the published shear-wave-splitting study. When we use available crustal thickness estimates we observe a strong correlation between the inferred lateral variation in beta-factors and seismic delay time. This would be the first study to observe such a correlation and this could have profound implications on our understanding of the large-scale mechanics in an extensional regime. However the validity of published crustal thickness estimates needs to be considered first, and this will be discussed as well.

T51G-02 1040h

Present Day Deformation of the Aegean Region: Short- and Long-Term Motions, Stress State and Lithospheric Rheology

Wayne Thatcher[1] (650-329-4810; thatcher@usgs.gov)

Marlene Nyst[1] (650-329-4897; mnyst@usgs.gov)

[1]U. S. Geological Survey, MS/977 345 Middlefield Road, Menlo Park, CA 94025, United States

We analyze an unusually complete set of GPS measurements to define the current pattern of lithospheric deformation in the Aegean. These results, complemented by geologic, geomorphic and seismologic data, permit us to determine the long-term kinematics, relate it to the stresses driving and resisting deformation, and constrain lateral variations in lithospheric rheology. We find that active continental deformation in the Aegean is explained well to first order using rigid plate kinematics. The intraplate stress field is dominantly extensional or trans-tensional, and deformation is focused in narrow zones that are weaker than the bounding microplates. Site velocities from 5 separate GPS networks comprising over 400 stations have been combined into a single common Eurasia-fixed reference frame to map the velocity distribution over the entire Aegean. We build upon previous work by others, especially McKenzie and Jackson (1983, 1988), Le Pichon et al. (1995), and McClusky et al. (2000) to initially specify rigid elements in central Greece, the South Aegean, and Anatolia. We use the GPS velocity field to identify deforming regions, rigid elements, and potential microplate boundaries. We apply an iterative approach, tentatively defining microplate boundaries, determining best-fit rigid rotations, examining misfit patterns, and revising the boundaries to achieve a better match between model and data. Short-term seismic cycle effects are minor contaminants of the data that we remove when necessary to isolate the long-term kinematics. We find that present day Aegean deformation is due to the relative motions of three microplates and straining in several isolated zones internal to them. The RMS misfit of model to data is about 2-sigma, very good when compared to the typical match between coseismic fault models and GPS data. The simplicity of the microplate description of the deformation is surprising and was not anticipated by previous work, which had suggested either many rigid elements or broad deforming zones that comprise much of the Aegean region. The isolated deforming zones are also unexpected and cannot be explained by the kinematics of the microplate motions. Focal mechanism data indicate that the Aegean stress field is dominantly extensional, driven by gravitational forces manifested in rollback of the Hellenic Trench, as originally suggested by Le Pichon and Angelier (1979). Horizontal least compressive stress axes locally make a high angle with the North Anatolian Fault in western Turkey, suggesting this plate- bounding fault is weaker than the adjacent Anatolian block. Localization of current deformation in narrow zones suggests that rheological weakness exerts a controlling influence on both the kinematics and dynamics.

T51G-03 1055h

Deformation Kinematics and Dynamics in the Philippine Sea - Eurasia Plate Collision Zone in the Taiwan Island Determined From Recent GPS Data

B Shentu[1] (bingming@air-boston.com)

L Flesch[3] (flesch@dtm.ciw.edu)

W Holt[2] (wholt@sunysb.edu)

M Mahdyiar[1]

[1]AIR, 101 Huntington Ave. 22nd floor, Boston, MA 02199, United States

[2]Geosciences, SUNY, Stony Brook, NY 11794, United States

[3]DTM, CIW, Washington, DC 20015, United States

The 300 km long segment of the Philippine Sea and Eurasia convergent plate boundary through the Taiwan Island involves collision, subduction, and back-arc extension tectonics. Various dynamic models have been proposed for the collision tectonics in the Taiwan Island based on geological or seismological evidence. We investigate possible dynamic processes that shape the modern tectonics in and around the Taiwan area. We first use recent GPS data to quantify the contemporary deformation kinematics in the region. A self-consistent strain rate tensor field is determined using an inversion procedure that minimizes the misfit between the model and observed GPS velocities in a common reference frame. The strain rate tensor field determined from GPS data predicts deformation styles that are in agreement with earthquake focal mechanisms and local geology, indicating that the interseismic deformation field represents the style of long-term deformation