waveform analyses suggest a decrease of S-wave velocity by 2-6% and an increase of density by 2-9% within the reflector. There is almost no difference in P-wave velocity (<1%) between the reflector and the surrounding mantle. The estimated thickness of the reflector is about 12 km. These observations indicate that the observed seismic structure is more likely to be a chemical reservoir rather than a purely thermal anomaly. The seismic reflector might be a piece of subducted oceanic crust, as suggested by a previous study. It also could be related to the break down of the D-phase of dense hydrous magnesium silicates (DHMS) at mid-mantle pressure condition reported by recent mineral physics studies. Both scenarios imply that either mechanical or chemical segregation might occur within the subducted slab at mid-mantle condition.

T31C MCC: Level 2 Wednesday 0830h

Late Cenozoic Tectonics, Climate, and Topography in the Central and Southern Andes I Posters *(joint with G, H)*

Presiding: **R Allmendinger,** Cornell University**; M Strecker,** University of Potsdam

T31C-0851 0830h POSTER

Tectonic and Climatic Control of Landscape Evolution in the Northern Sierras Pampeanas, Argentina

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Rock uplift, surface uplift and exhumation can be constrained if thermochronologic data can be converted to exhumation and if geological relations provide a datum. In the northern Sierras Pampeanas of Argentina, the Cenozoic Santa María basin, which overlay resistant crystalline basement prior to rapid exhumation, provides an ideal setting to examine the effect of contrasting thermal and erosional regimes. There, tectonically active reverse-fault bounded blocks partly preserve a basement peneplain at elevations >4500 m. Prior to exhumation, the study area was covered by 1 to 1.6 km of ca. 12-6 Ma sediments; this sequence begins with shallow marine deposits immediately overlying the regional erosion surface which are superseded by sandstones and conglomerates. These rapidly deposited sediments have low thermal conductivity and are readily eroded, in contrast to underlying resistant basement. Apatite fission-track data were obtained from two vertical transects in the Calchaquíes and Aconquija ranges bounding the basin. At Cumbres Calchaquíes, erosion leading to the development of the peneplain commenced in the Cretaceous; limited late Neogene cooling is documented by track-length modeling. In contrast, Sierra Aconquija cooled rapidly between 5.5 and 4.5 My. At the onset of this rapid exhumation, sediment was quickly removed, causing fast cooling, but relatively slow rates of surface uplift. Syntectonic conglomerates could only be produced when faulting exposed resistant bedrock; this change in rock erodability lead to enhanced surface uplift rates but decreased exhumation rates. The creation of an orographic barrier after the range had attained sufficient elevation further decreased exhumation rates on the leeward side and increased surface uplift rates. This imbalance cannot be sustained for extended periods of time; either crustal strength or bedrock fluvial incision will ultimately limit the magnitude of relief which can be created before tectonism, and hence rock uplift, migrates to other locations. Differences in the magnitude of exhumation at the two transects are related to both differences in the thickness of the sedimentary basin prior to exhumation and differences in effective precipitation due to an orographic barrier in the foreland.

T31C-0852 0830h POSTER

Testing the Origins of Nonmarine Stratigraphic Sequences, Iglesia Basin, Northwest Argentina

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The Iglesia Basin is an entirely nonmarine Andean foreland basin consisting of approximately 3.5 km of Tertiary strata unconformably overlying Paleozoic basement. Best described as a wedge-top basin, Iglesia Basin is located in San Juan Province, Argentina at S 30-31°between the Frontal Cordillera and Precordillera fold-thrust belt. Interpretations of seismic reflection profiles and field reconnaissance have suggested basin-wide stratigraphic sequences. Additionally, radiometric and magnetostratigraphic data constrain sequence deposition between approximately 17 and 4 Ma. However, a fundamental question remains unanswered: temporal variability of which control caused development of unconformity-bound nonmarine sequences? Prior to this work, hypotheses about the factors at play, notably tectonism and climate change, remained untested, and fieldwork provided only localized information about the nature of the sequences. The present study examines basin lithofacies more broadly and will independently constrain discharge history (a proxy for climate) and intrabasinal tectonics. Thus far, fuller knowledge of the sedimentation patterns, structural expression, and volcanic history of Iglesia Basin is supplied by information from new outcrop localities near the northern paleomargin and basin center, and from reinterpretation of previously studied localities. A substantial volcanic component to the history of the oldest sequences is inferred from age relationships and continuity of deposits in proximity to the Cerro Negro intrabasinal andesitic center. Reassessment of field-assigned sequence boundaries in terms of continuity and expression, both along-strike and across intrabasinal faults, suggests that lithofacies shifts are more prevalent than erosive surfaces. Radiometric dating of additional tuffaceous units in the Tertiary sequences will allow more conclusive correlation among discontinuous outcrops. Floodplain assemblages of Aridosols and Inceptisols indicate notable sedimentary hiatuses, allow pedofacies definition, and provide material for temporally constrained ^{13}C and ^{18}O analysis as a proxy for climate fluctuation. Preliminary interpretation of paleosol micromorphology and isotopic time series suggests minimal diagenesis, as well as an evolution towards moisture-stressed conditions and depletion of heavy isotopes, possibly caused by the orographic effect of the rising Andes. Isotopic signal variability can be compared to sequence chronostratigraphy to test the hypothesis that sequence formation results from stream discharge variations.

T31C-0853 0830h POSTER

Late Quaternary Sedimentation and Erosion Rates Derived From Luminescence and Cosmogenic Nuclide Dating of Intermontane Basin Sediments, NW Argentine Cordillera

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The easternmost basins of the central Andean cordillera (22°-25°S) are characterised by multiple Late Quaternary and Holocene alluvial fill-cut terraces. Humid phases in the central Andes, interpreted from cores of Late Pleistocene and Holocene lacustrine deposits, have been previously linked to periods of increased frequency of landsliding events. Large landslides lead to rapid increases in local base level and aggradation. Subsequent headward erosion propagates through the basin and produces a characteristic alluvial terrace, common to many active mountain belts. Although climate may be the predominant control on these events, small and young intra-basin faults could also be diverting fluvial systems and reorganising drainage basins and sediment pathways. We have integrated optically stimulated luminescence (OSL) with ^{10}Be cosmogenic nuclide dating techniques to produce a chronology of three of these depositional and erosional sequences in the Quebrada de Humahuaca. From each sequence, multiple OSL samples were collected from the fluvial and (debris flow and stream dominated) alluvial fan deposits to quantify sedimentation rate; four cosmogenic samples were collected from a 1.5 m pit on each terrace surface to quantify surface exposure age, as well as basin-scale erosion rate. Integrating these two dating techniques allows us to test how episodic deposition-erosion events are linked to periods of pronounced climatic variability in the central Andes and to quantify landscape response time to incision events.

T31C-0854 0830h POSTER

The New ILP Database of Quaternary Faults and Folds in South America

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As part of the International Lithosphere Program's Task Group II-2, we have completed the compilation of Quaternary faults and folds in South America and have established an Internet website for this data. The underpinning maps and reports have been released as electronic U.S. Geological Survey Open-File Reports (pdfs, see poster). The maps show the location, time, sense of slip, and activity rate of major earthquake-related features such as faults and fault-related folds. The maps are accompanied by descriptions of their Quaternary activity. The primary elements of the 10-year project are supervision and interpretation of geologic/tectonic information (Costa and Machette), data compilation (project participants), database design and management (Cisneros), and GIS input and management (Dart). A dozen experts in Quaternary faulting, neotectonics, paleoseismology, and seismology compiled the data: questions about individual faults or additions to the database should be directed to them. Prior to this project, digital maps of Quaternary faults did not exist for any of the South America countries, even though understanding the extent and character of active and older Quaternary faults are critical elements of seismic-hazards analysis. These new data will help extend the relatively short record of instrumental and felt seismicity that is the primary parameter for current seismic-hazard assessments in South American countries. Although some fault data were available for most of the countries (i.e., Venezuela), the degree of completeness varies as a function of the remoteness and vegetation cover (i.e., Brazil). A few faults such as the Bocono have had detailed investigations involving modern paleoseismic techniques. Other faults have been studied in some detail, usually in association with concerns about hazards to urban areas or the safety of critical facilities such as mining operations, oil-and-gas pipelines, or power-generating facilities. However, the general state of knowledge for active faults in South America is probably best described as incomplete and of a reconnaissance nature. With the exception of some historic surface faulting events, little is known about fault chronology and overall rates of fault activityinformation that is difficult to acquire but critical to seismic-hazard assessments.

T31C-0855 0830h POSTER

Along-Strike Variations in Focal Mechanisms of Central Andean Crustal Earthquakes: Northern Peru through the Argentina Sierras Pampeanas

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120 shallow focal mechanisms in the crust above the subducted Nazca plate were assembled from the Harvard CMT catalog and published studies covering over 40 years of seismicity. The study area included the Andes crust above three major segments of the subducted plate, the Peruvian and Argentinean flat-slab segments and the intervening segment where the subducted Nazca plate dips more steeply. The most seismically active regions continue to be the thick-skinned foreland thrust belts in the eastern Andes of Peru and the Sierras Pampeanas. The earthquakes there are clearly associated with youthful tectonic structures with strong topographic signatures as revealed by the new 90 m SRTM digital elevation models. The mechanisms are dominantly of the thrust type but include a minority of strike-slip orientations. However the P axes remain consistent. The thin-skinned thrust belts east of the central Andean Plateau show significant activity only near Santa Cruz, Bolivia and northern Argentina; most of the Sub-Andean thrust belt of Bolivia and southern Peru remains aseismic. The central Andean plateau itself also remains aseismic except for the region of southern Peru and two earthquakes in the Puna. The crustal seismicity in southern Peru is largely

concentrated on the western side of the plateau. The focal mechanisms show a strong grouping of T axes in a horizontal, north-south orientation. Both normal and strike-slip mechanisms occur in this region, with no obvious correlation with elevation or surface structures. Remarkably, with the exception of one normal fault type mechanism near the Cusco basin, the earthquakes occur in regions of the western parts of the Altiplano that do not exhibit topographic evidence of substantial crustal deformation. These results are consistent with a model in which the Altiplano of southern Peru, with a trend most oblique to the overall direction of convergence, manifests a left-lateral shearing component across the orogen.

T31C-0856 0830h POSTER

Assessing Mechanisms of Exhumation in the Cordillera Real, Bolivia, Based on Regional Structural Mapping and Thermochronology

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In the Eastern Cordillera of the central Andes, the change from lower elevation, more subdued relief south of 18° S to higher elevation and relief to the north corresponds with increased precipitation northward along the eastern margin of the central Andean plateau. Although distinguishing between climate- and shortening-related uplift or their interplay is difficult, constraining the kinematic history of shortening in a fold-thrust orogen is a critical first step in understanding climate-tectonic interactions. An ideal area to investigate the possible link between climate and high topography is the Cordillera Real in the Eastern Cordillera of Bolivia, where elevations over 6000 m decrease dramatically eastward towards the Andean foreland (several thousand meters over a few tens of kilometers) and some of the highest precipitation in the Andes is concentrated along its eastern margin. Here, new 1:50,000 scale geologic mapping, 40Ar/39Ar and apatite fission track analyses are being integrated to better constrain the kinematic history of fold-thrust structures in the Cordillera Real. Although granitic plutons in the Cordillera Real and Quimsa Cruz have been previously considered to be relatively undeformed, geologic mapping has revealed that they are deformed by regional faulting which continues into the surrounding Paleozoic wallrocks. 40Ar/39Ar biotite cooling ages ranging from 107.2 Ma to 38.3 Ma are interpreted to have been thermally reset at approximately 40 Ma. Muscovite cooling ages between 200 Ma and 42.9 Ma exhibit a disturbed age spectra, possibly due to retention of excess argon, and increasing age discordance with the biotite results westward along the transect. Apatite fission track analyses in the Cordillera Real yield ages nearly indistinguishable within error from 16.2±1.3 Ma to18.2±1.1 Ma despite 1555 m of total vertical relief between the samples. This is inconsistent with simple vertical cooling through denudation. Two of the most northwestern samples, which are separated by 760 m of vertical relief, yield a hangingwall age of 16.2±1.3 Ma for the higher sample and a footwall age of 8.57±0.7 Ma across an east-directed thrust fault. A similar age relationship is observed in the Ar/Ar data, with the hanging wall yielding an age of 40.7 Ma and a footwall age of 38.3 Ma. By first constraining the kinematic history of the Cordillera Real through regional structural mapping and thermochronogy, the role of climate in exhumation of the Eastern Cordillera can be better assessed.

T31C-0857 0830h POSTER

Investigations into the Numerical Ages of post-Miocene Fluvial Landforms in the Atacama Desert, Chile

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The hyper-arid Atacama Desert of northern Chile is virtually devoid of precipitation and vegetation, yet it is characterized by a succession of fluvial landforms (stream terraces and alluvial fans) that reflect periodic changes in climatic and/or tectonic regimes. The eastern regions of the desert, which rise toward the Andean foothills, possess a series of gravelly to bouldery geomorphic surfaces capped by the prominent Atacama Gravels. The Atacama Gravels have been dated via 40Ar-39Ar on ash and are well known to be Miocene age (15.3 to 10.5 Ma). Recently, Nishiizumi et al. have dated surficial boulders of Atacama Gravels via cosmogenic radionuclide (CRN) chemistry (10Be, 26Al, 21Ne), finding that the samples were at secular equilibrium with respect to 10Be and 26Al. However, with 21Ne, those authors were able to calculate CRN ages of 8.2-9.0 Ma, in accord with independent age estimates of ash 40Ar-39Ar ages. In addition, the CRN data indicate the lowest boulder erosion rates in the world outside of Antarctica, suggesting that younger surfaces should be amenable to CRN dating using 10Be and 26Al (if younger than secular equilibrium). We report on our initial exploration of the numerical ages of post-Atacama fluvial surfaces in three watersheds along a precipitation gradient of the Atacama Desert. All three watersheds contain what appear to be a similar sequence of well-defined post-Atacama Gravel geomorphic surfaces (K-Ar of biotite in ash in one location constrains the age of the surfaces to Pliocene or younger: 4.8 Ma). CRN analyses of surface boulders, combined with 40Ar-39Ar analyses of volcanic ash in related terraces, should provide an initial perspective into the sequence of ages of some of the oldest post-Atacama gravel surfaces in the region, and are the beginning of an effort to determine if there is a regional synchrony to the terrace and fans deposits of the central Atacama Desert.

T31C-0858 0830h POSTER

Landscape Evolution Changes Along the Western Andean Mountain Front of Peru and Northern Chile

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We describe the along-strike changes in geomorphology on the western Andean mountain front of Peru and northern Chile, using the newly released SRTM 90 m digital topography. Strong contrasts in drainage systems and slope distributions occur along the mountain front between Lima, Peru and Santiago, Chile in concert with major latitudinal changes in climate. The climatic gradients appear to have been approximately stable since the middle Miocene. We link morphologies observed in satellite images, topography, topographically derived slope, and river networks to along-strike variations in erosional processes occurring along the climate gradient. The areas characterized below include: 1) between $12 - 15^{\circ}$S, a zone where landforms suggest the important role of local precipitation, 2) from $15 - 18^{\circ}$S the landforms are indicative of no significant local precipitation but significant stream power from upland regions, 3) from $18 - 25^{\circ}$S there is neither local precipitation nor appreciable stream power and 4) between $25 - 32^{\circ}$S where the influence of the westerly air masses gradually increases the amount of local precipitation falling on the western mountain front. Near Lima, on the western coast of Peru, the landscape is actively eroding with high median values of slope and well-developed drainage systems. We interpret this to signify that precipitation is delivered directly on the mountain front. The western mountain front of southwestern Peru contains possibly the greatest relief on earth. There, we see a bimodal slope distribution highlighting the steep slopes of the canyon networks and the low slopes of the smooth, low relief interfluve areas. The interfluves are little eroded geomorphic surfaces suggesting that precipitation rarely falls on the mountain front and that most of the water required to cut the deep canyons are derived from snow melt on the high elevations in the northernmost Altiplano. Channel profiles of the deeper canyons in this sector show that, relative to the interfluve, the river has cut back substantially into the Altiplano. A similarly smooth mountain front landscape with deeply incised canyons exists around the Arica bend in Northern Chile. However, these canyons are much smaller in drainage area and the depth of incision is much less. The channel profiles of the largest canyons in northern Chile have the same form as the interfluve, suggesting that the rivers are downcutting into the western slope but are not cutting back into the Altiplano. Slope distributions for the northern Chile region peak at approximately 3.5 degrees, the slope of the western monocline, and then fall off quickly towards higher slopes. The smooth slopes show a lack of fluvial dissection in northern Chile, which is most likely related to prolonged long-term aridity in this sector. In the north-central part of Chile, well-developed drainage systems and high median slope distributions return as the strength of the Westerlies increase towards the south.

T31C-0859 0830h POSTER

Continental Margin Tectonics Along the Convergent Plate Boundary of Central Chile

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Multibeam bathymetry along central Chile provides a detailed map of recent tectonic deformation of the margin and incoming oceanic plate from about 28? S to 36? S. The data were collected during R/V SONNE cruises 101, 102, 104 and 161 and a cruise with R/V Vidal Gormaz. Individual pings were edited and cleaned and the different surveys have been merged after depth calculations using a different measured velocity function for each of them. The oceanic Nazca plate is covered by about 100 m of pelagic sediment and the morphology of the igneous basement is displayed well in the bathymetric maps. The oceanic plate topography changes markedly along the subduction zone and exerts a first order control in the distribution of trench sediment infill and in the tectonic style of deformation of the margin. A major boundary occurs at latitude 32?-33? S where the hotspot volcanic chain of Juan Fernadez is currently subducting. The chain subducts oblique to the margin strike and thus the tectonic boundary has been migrating along the subduction zone through time. South of the area of ridge subduction the trench is filled with turbidites and a 20-40 km wide accretionary prism occurs at the front of the continental slope. The upper slope has a smooth morphology indicative of a quiet tectonic domain. At the current area of ridge subduction and north of it (28?-33?S) the trench has a reduced turbiditic infill. The trench infill seems to be at minimum at 31-32S and slightly larger to the north as the trench axis becomes deeper. Here, a small ridge at the slope toe may indicate that reduced accretion is active. The continental slope is deeper and more rugged that to the south displaying a series of small midslope basins. Here, the continental slope morphotectonic structure is the product of tectonic erosion due to the passage of the volcanic ridge.

T31C-0860 0830h POSTER

Topography of the Central Andes: Effects from Above and Below

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The topography of the central Andes is the product of an interaction between solid earth and atmospheric processes – tectonic processes tend to build topography and climatic ones erode and redistribute it. Here we can assess the relative significance of these effects because tectonic and climate patterns have very different spatial characteristics relative to the high plateau. The stable Nazca-South America plate motions of the mid-Tertiary to present, and the consequent dynamics of the modern Andes, have a high degree of spatial order – principally a bilateral symmetry on a vertical-ENE trending plane across the plateau, parallel to particle motions of both plates. This pattern is strongly violated by climate – wet in the north on the east side of the plateau, and dry in the south – and consequent erosion. To resolve these effects on the topography, we consider vertical profiles across the mountain belt and subduction zone. Parallel sections equidistant from but on opposite sides of the symmetry plane experience similar kinematics but different climate effects. Although precipitation amounts vary considerably north to south along the eastern edge of the plateau, the topography there is very similar on both sides of the symmetry plane. On the other hand, the geometry of the subducted Nazca plate varies north to south, though the plate kinematics do not vary. These and other observations suggest that the overriding and subducting plates are partially coupled by viscous stresses across a narrow asthenospheric wedge, such that the mountain

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belt and subduction zone dynamically respond to variations in loading at the earth's surface (caused by erosion in the north versus the lack thereof in the south). Both the South America and Nazca plates deform as they slide past one another nearly face-to-face across the asthenospheric wedge. The incremental deformation of the overriding plate is probably less than that of the subducting plate; however, the former is stationary and accumulates deformation (to build the plateau) while the latter is constantly refreshed. Indeed the upper plate must be relatively strong (i.e., resists deformation) and the mantle beneath deforms owing to drag on its stable upper surface to accomodate the flow induced by subduction. Thus, minor climate effects, causing uneven erosion of the plateau, may affect the geometry and motion of the subducted slab.

T31D MCC: Level 2 Wednesday 0830h

Mantle Dynamics and Continent-Mantle Interaction I Posters *(joint with S, V, MR, DI)*

Presiding: **L Moresi,** Monash Cluster Computing, Monash University

T31D-0861 0830h POSTER

Arrangement of Convection in the Earth by Lunar Gravity,II: Geotectonics Under a Minute Wsstward Tilt, With TPW

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G. Darwin's lunar retarding torque is magnitude orders too small to cause lateral motion in a viscous passive Earth [1]. Nevertheless plate-motion data suggesting an apparent net lithosphere rotation seem to accumulate, confirming that given convection under gravity, this can scarcely be immune to an asymmetrical field component. Investigative obstacles have lain in establishing an ITRF tying surface benchmarks to Earth's interior, and a dynamics quantitatively capable of shaping the convection. By delimiting the lunar orbital expansion (irrespective of whether due to marine or body-tide dissipation, or yield under convection itself), LLR [2] delimits the secular, whole-Earth, day-averaged field under which mantle convection takes place. Thus a derived value 600 seconds of the lunitidal interval indicates that masses not reaching equilibrium add to the secular field a component tilted by arcsin[(600secs)/(25hrs24 min)] = 0.38 degrees (relative to symmetrical standard-**g**,- the latter pertinent only to an isolated Earth). The derived value delimits also the dissipation, and accords with the increase in l.o.d. and Earth/Moon astronomic history. Conversely, were $\mathbf{g}_{tot}$ not minutely west-tilted, a couple would not exist, hence Earth-Moon distance not increase. Assumption that the convection develops under a symmetrical tensor field **g** in strict accordance with NNR, neglecting the tilt inherent in observed tidal components, is thermodynamically untenable. Convection at all scales must be to some extent asymmetrical. How to assess the effect in a heterogeneous Earth of a system so minute, but operative throughout geological time? Plate motion and ocean development combined with paleomagnetically established TPW [3,4,5,6] display the following:- During Mesozoic times until -110Ma the pole was located at 'quasi-stillstand' in extreme NE Siberia,present coordinates; the regime of convection then operative resulted in N Atlantic birth, under NW-SE extension. Associated with a regime change at about -85Ma, causing or in consequencec of mass displacement in IndOcean development [7], the pole then drifted towards its present location. Coincident with the change in tilt azimuth there took place the Cenozoic global plate reorganization early discovered by NOAA [8], entailing "reorientation of relative plate motions with large N-S components into large E-W components"; constituting birth of the S Atlantic, development of the Atlantic Ocean as a whole, still ongoing, and E-W motion of the large Pacific plate. In sum, the record back through Mesozoic times suggests that the minute tilt inherent in the tidal component of $\mathbf{g}_{tot}$ is not without consequence: that given autonymous mantle convection and equally inevitable TPW [9], a flow bias is likely since early times, in polarity surface-westward *referred to the contemporary pole of rotation.* Theory and data suggest that as base for modeling convection and geotectonics it would be rewarding to relax confinement to NNR, admitting an element of net-lithosphere-rotation whilst still conserving *system* angular momentum. [1] Bostrom, R.C., 1973, *Phil. Trans. Roy. Soc. A274: 397-407.* [2] Dickey, J.O. et al., 1994, *Science 265:482-490.* [3] Van der Voo, R., 1993. *Paleomagnetism. Cambridge U.P., 411 pp.* [4] Prevot, M.P., et al., 2000, *EPSL 179:517-528.* [5] Sager, W.W., & A. Koppers, 2000, *Science 287: 455-459.*[6] Besse,J. & V. Courtillot, 2002, *JGR 107(B11) EPM 6-1.* [7] Bostrom, R.C., 1990, *Tectonophysics 182: 393-402.* [8] Rona, P.A. & E.S. Richardson, 1978, *EPSL 40: 1-11.* [9] Goldreich, P.,& A. Toomre, 1969, *JGR 74:2555-2567.*

T31D-0862 0830h POSTER

Crustal Constraints on the Origin of Mantle Seismicity in the Vrancea Zone, Romania: The Case for Active Continental Lithospheric Delamination

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The Vrancea zone of Romania constitutes one of the most active seismic zones in Europe, where intermediate-depth (70-200 km) earthquakes of magnitude in excess of M=7.0 occur with relative frequency in a geographically restricted area within the 110 degree bend region of the southeastern Carpathian orogen. Geologically, the Vrancea zone is characterized by (a) a laterally-restricted, steeply NW-dipping seismogenic volume (30x70x200 km), situated beneath (b) thickened continental crust within the highly arcuate bend region of the Carpathian orocline, and (c) miscorrelation of hypocenters with the position of an inferred Miocene suture zone in the Carpathian hinterland. Geologic data from petroleum exploration in the Eastern Carpathians, and reprocessing of industry seismic data from the Carpathian foreland indicate that (1) crust of continental affinity extends significantly westward beneath the thrust nappes (Sub-Carpathian, Marginal Folds, and Tarcau) of the Eastern Carpathians, (2) Cretaceous to Miocene strata of continental affinity can be reconstructed westward to a position now occupied by the Transylvanian basin, and (3) geologic structure in the Carpathian foreland (including the Moho) is subhorizontal directly to the east and above the Vrancea seismogenic zone. Taken together, these geologic relationships imply that the Vrancea zone occupies a region overlain by continental crust and upper mantle, and does not appear to originate from a subducted oceanic slab along the length of the Carpathian orogen. Accordingly, the Vrancea zone appears to be a unique place to establish evidence for active lithospheric delamination as opposed to relic subduction.

T31D-0863 0830h POSTER

Evidence for Rifting Above Hotter Than Normal Mantle : Deep Seismic Sounding at the Continental Margin of Korea in the East Sea (Japan Sea)

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The continental margin of the Korean Peninsula is little known in its crustal structure, although various opening models of the southwestern part of the East Sea (Japan Sea) have been presented. Accordingly, continental rifting and subsequent seafloor spreading processes in the East Sea have not been adequately addressed. The crustal and sedimentary velocity structures were investigated across the Korean margin into the adjacent Ulleung Basin from multi-channel seismic reflection and ocean bottom seismometer data. The Ulleung Basin shows crustal velocity structure typical of oceanic although its crustal thickness of about 10 km is greater than normal. The continental margin featuring rapid transition from continental to oceanic crust exhibits a remarkable decrease in crustal thickness accompanied by shallowing of Moho over a distance of about 50 km. The crustal model of the margin is characterized by a high-velocity lower crustal (HVLC) layer that is thicker than 10 km under the slope base and pinches out seawards. The HVLC layer is interpreted as magmatic underplating emplaced during continental rifting in response to high upper mantle temperature. The acoustic basement of the slope base shows an igneous stratigraphy developed by massive volcanic eruption. These features suggest that the evolution of the Korean margin can be explained by the processes occurring at volcanic rifted margins above the hot upper mantle, which is supported by global earthquake tomography and magnetic observations across the Korean margin.

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An Anisotropic Viscous Representation of Mohr-Coulomb Failure for use in Modeling Coupled Mantle-Continent Dynamics

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In mantle convection models it has become common to make use of a modified (pressure sensitive, Boussinesq) von Mises yield criterion to limit the maximum stress the lithosphere can support. This approach allows the viscous, cool thermal boundary layer to deform in a relatively plate-like mode even in a fully Eulerian representation. In large-scale models with embedded continental crust where the mobile boundary layer represents the oceanic lithosphere, the von Mises yield criterion for the oceans ensures that the continents experience a realistic broad-scale stress regime. In detailed models of crustal deformation it is, however, more appropriate to choose a Mohr-Coulomb yield criterion based upon the idea that frictional slip occurs on whichever one of many randomly oriented planes happens to be favorably oriented with respect to the stress field. As coupled crust/mantle models become more sophisticated it is important to be able to use whichever failure model is appropriate to a given part of the system. We have therefore developed a way to represent Mohr-Coulomb failure within a code which is suited to mantle convection problems coupled to large-scale crustal deformation. Our approach uses an orthotropic viscous rheology (a different viscosity for pure shear to that for simple shear) to define a prefered plane for slip to occur given the local stress field. The simple-shear viscosity and the deformation can then be iterated to ensure that the yield criterion is always satisfied. We again assume the Boussinesq approximation - neglecting any effect of dilatancy on the stress field. An additional criterion is required to ensure that deformation occurs along the plane aligned with maximum shear strain-rate rather than the perpendicular plane which is formally equivalent in any symmetric formulation. It is also important to allow strain-weakening of the material. The material should remember both the accumulated failure history and the direction of failure. We have included this capacity in a Lagrangian-Integration-point finite element code and will show a number of examples of extension and compression of a crustal block with a Mohr-Coulomb failure criterion, and comparisons between mantle convection models using the von Mises versus the Mohr-Coulomb yield criteria. The formulation itself is general and applies to 2D and 3D problems, although it is somewhat more complicated to identify the slip plane in 3D.

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Time-Dependent Crustal Response to Linear and Point Mantle Lithosphere Instabilities: Analogue and Numerical Modeling

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Tectonic deformation of some intraplate regions may be caused by the Rayleigh-Taylor (RT) instability of dense sub-crustal lithosphere (mantle lithosphere) as it descends into the mantle. Here we report on a series of 3D analogue and 2D numerical experiments of coupled crust-mantle dynamics. In particular, the topographic evolution of a stratified model crust is investigated in response to RT instability of the underlying