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-still-stand' 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.

T31D-0864 0830h POSTER

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.

T31D-0865 0830h POSTER

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

mantle lithosphere. We compare the time series of topography and rates of drip descent between the laboratory and numerical experiments and test the sensitivity of these measurable quantities to variations in crustal rheology and the geometry of the mantle instability (linear vs. axisymmetric point instabilities). Evolving surface topography is tracked on the free-surface of the numerical models and a high precision laser scanning system measures the surface of the analogue models. The models demonstrate simple subsidence for a strong crust end-member, but significant internal deformation and topographic variation for certain weaker crustal configurations. Topographic evolution and drip descent rates are consistent between numerical and analogue experiments for the case of the linear 2D instability. In general, the variation of topography in the laboratory experiments displays more complexity due to 3D effects (i.e., out-of-plane relaxation) and the development of second-order instabilities, which are absent in the numerical runs. Internal crustal deformation tends to be more pronounced in the analogue experiments with point instabilities, due to the focused convergence of mantle flow and the generation of greater in-plane stresses in the overlying crust.

T31D-0866 0830h POSTER

Thermal and Chemical Variations in Subcrustal Cratonic Lithosphere: Evidence from Crustal Isostasy

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The Earth's topography at short wavelengths results from active tectonic processes, whereas at long wavelengths it is largely determined by isostatic adjustment for the density and thickness of the lithosphere. Using a global crustal model, we estimate the long-wavelength topography that is not due to crustal isostasy. Our most important finding is that cratons are generally depressed by 300 to 1500 m in comparison with predictions from pure crustal isostasy. We conclude that either: (1) cratonic roots may be 50 to 300 $^{\circ}$C colder than previously suggested by thermal models, or; (2) cratonic roots may be, on average, less depleted than suggested by studies of shallow mantle xenoliths. Alternatively, (3) some combination of these conditions may exist. The thermal explanation is consistent with recent geothermal studies that indicate low cratonic temperatures, as well as seismic studies that show very low seismic attenuation at long periods (150 s) beneath cratons. The petrologic explanation is consistent with recent studies of deep (>140 km) mantle xenoliths from the Kaapvaal and Slave cratons that show 1-2% higher densities compared with shallow (<140 km), highly depleted xenoliths.

T31D-0867 0830h POSTER

Lithospheric Thermal Structure, Rifting-related Metasomatism, and Subsidence of the East European Platform

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A new mechanism for Paleozoic (Pz) subsidence of the early Proterozoic (ePt) East European Platform (EEP) is suggested, since a model of lithosphere tilting during the Uralian subduction (Mitrovica et al., 1996) does not explain the post-Uralian sedimentation record. The high topography of cratons is commonly attributed to depleted, low-density composition of the cratonic lithospheric mantle. Rifting, however, leads to a density increase of the cratonic lithosphere due to an intrusion of Fe-rich basaltic melts and can be responsible not only for subsidence due to thermal relaxation, but also for compositional subsidence. I propose that the Pt and Pz rifting events modified the cratonic lithosphere and are responsible for the post-Uralian subsidence of the EEP. To support this hypothesis, (a) the thermal regime of the EEP lithosphere is analyzed, and (b) lithospheric density variations of non-thermal origin are calculated from free-board constraints. The results suggest that the EEP subsidence can indeed result from chemical variations in the lithospheric mantle, possibly caused by metasomatism during Pt and Pz rifting. Pt rifting led to a decrease of lithospheric depletion from ca. 1.4% (Kola-Karelia) to 0.6-0.8% (central EEP) and possibly to a formation of a two-layer lithosphere, that can produce a seismic pattern similar to the top of a seismic LVZ at ca. 90-150 km depth. Pz rifting resulted in a compositional modification and/or detachment of the entire lithospheric column and the consequent, on-going, subsidence of the southern EEP.

T31D-0868 0830h POSTER

Cool Cratons and Thermal Blankets: How Continents Affect Mantle Convection

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Mantle convection models with moving continents show that continents profoundly affect the form of mantle convection. If the continents are wider than the wavelength of convection cells (about 3000 km), they cause neighboring thermal upwelling zones to coalesce into a single focused upwelling. This focused upwelling zone will have a potential temperature anomaly of about 200 degrees C, much higher than the 100 degree C temperature anomaly of upwelling zones generated beneath typical oceanic lithosphere. This excess temperature anomaly persists for about 100 Ma after supercontinent breakup. In contrast, small continental blocks (<3000 km diameter) do not induce focused upwelling zones. Instead small continental blocks are dragged to mantle downwelling zones. As a result of emplacement over relatively cold mantle (downwellings), small continental blocks develop thick, cold thermal boundary layers (cratonic roots), and are geologically favored to keep these roots and to have low geothermal gradients.

T31D-0869 0830h POSTER

Grenvillian History Of The SW Amazon Craton: The Accretionary History Of The Paragua Craton In A Rodinia Framework.

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The tectonic history of the Amazon craton plays an essential role in the amalgamation of the Rodinia supercontinent, with many postulating a position of the Amazon along the eastern margin of Laurentia. Recognition of a two-stage Grenvillian history of the SW margin of the Amazon craton is based on recently obtained U-Pb, 40Ar/39Ar, and Rb-Sr data that demonstrate at least two discrete metamorphic and deformational events during end Mesoproterozoic times. The record of the younger ca. 1.09 Ga event is preserved almost exclusively in the metasediments of the E-W trending Nova Brasilandia belt, whereas the older ca. 1.18 Ga event is recorded entirely in the polydeformed basement rocks of the Amazon craton to the N. We interpret the Nova Brasilandia belt to record the accretion of the Paragua craton to the Amazon craton in the final stages of the construction of Rodinia. We report new 40Ar/39Ar data from the Paragua craton that record the original igneous age distributions of 1.35 - 1.55 Ga. These data are interpreted to reflect the rigid behavior of the Paragua craton in the Rodinia framework, suggesting that accretion of this cratonic block took place largely through strike-slip motion. We propose a Cordilleran-type margin for the Grenville collision between the nuclei of North and South America, a scenario that allowS for the polychronous tectonic evolution observed in the North American Grenville province and the emplacement of exotic terranes.

T31D-0870 0830h POSTER

The Trench Retreat Effect: Dynamics and Slab Folding

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Subduction influences plate tectonics by modifying the surface area and velocities of plates, and plates connected to slabs move faster than plates without slabs. Most of the subduction zones on Earth show the trench retreat effect, which influences the subduction process and geologic deformation at the surface. To investigate the trench retreat effect we used the 2D finite differences code FDCON (Schmeling and Marquart, 1993). In order to start subduction, we assumed that initially one edge of the subducting plate dips into the mantle. An overriding plate was not included in the models. The models are isotherm and viscous (Stokes flow) with a visco-plastic subducting lithosphere. The plastic rheology of the plate is described by the Byerlee law, mimicking brittle deformation in the shallow lithosphere. The density and viscosity of the mantle and the lithosphere are advected with the tracer approach. We used periodic and reflective free slip boundary conditions. Numerical experiments were done to analyze the relationship between the trench retreat and various subduction parameters using different viscosity structures: (1) homogeneous mantle viscosity and, (2), stratified viscosity to model the upper and the lower mantle. The viscosity of the plate and the mantle, the thickness and the length of the lithosphere were varied. We found that the flow in the lower part of the model box for the models with periodic and reflective boundary conditions influences the way in which the slabs are folded. For the trench retreat, we observed that it depends predominantly on the viscosity of the mantle, rather than on the viscosity of the slab. The velocity of trench retreat decreases when the slab touches the boundary between the upper and lower mantle.

T31D-0871 0830h POSTER

Late Neoproterozoic Paleogeography of the Western Part of Baltica- Constraints From Paleomagnetic and Tectonic Analysis.

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Neoproterozoic break-up of supercontinent Rodinia resulted with development of several individual lithospheric plates, including Baltica. Global configuration of continents after break-up, in particular paleogeographic position of Baltica and its relation to Godwana, are the matter of recent disputes. According to Scandinavian paleomagnetic poles (c.f. Torsvik and Rehnström, 2001) in the late Neoproterozoic and Cambrian time the Baltic plate occupied moderate paleolatitudes of southern hemisphere. Vendian paleomagnetic pole from the White Sea region (Popov et al., 2002) is, however, completely different. It implies moderate northern paleolatitudes of Baltica in the Vendian time and probably equatorial position of this plate in the Early Cambrian (c.f. Nawrocki, 2003). In the present contribution we discuss impact of recent paleomagnetic and tectonic analysis conducted for the western part of Baltica on the above mentioned issue. As a consequence of the break-up process the western and central part of Baltica became a site of intensive basic volcanism (Orsha-Volhyn Zone) and development of sedimentary basins related to rifting. Geochronology of volcanic processes at the western slope of Baltica is poorly controlled, except of its expiring, dated by U/Pb method as 551 Ma (Compston et al., 1995). However its geotectonic setting is geochemically documented as rift-related (Bialowolska et al., 2002). Subsequently during the late-most Neoproterozoic-Middle Ordovician a system of sedimentary basins developed, controlled by post-rift thermal sag mechanism. Regional pattern of their subsidence allows to reconstruct passive continental margin along western margin of Baltica (Peri-Tornquist Zone, corresponding to later Trans-European Suture Zone) (Poprawa et al., 1999). Preliminary paleomagnetic analysis of the Vendian basalts and underlying basaltic tuffs from the Volhynia (NW Ukraine) revealed paleomagnetic directions concordant with the data from the White Sea region (Popov et al., 2002) . Paleomagnetic pole from tuffs (pole long. 145oE, pole lat. 37oS) is close to the late Vendian pole of Popov et al. (op. cit). Paleomagnetic data from basalts indicate subsequent drift of Volhynian part of Baltica from moderate paleolatitudes (c.a. 40o) to its equatorial position in the latest Vendian - early Cambrian. References:

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earliest faunal zone within the Late Precambrian of the east Poland. Journ. Geol. Soc. London, 152: 599-611 Nawrocki J., 2003. Where was the Baltic plate in the Early Cambrian ? Prz. Geol., 51(9): 750-753 Popov., Iosifidi A., Khramov A., Tait J., Bachtadse V., 2002. Paleomagnetism of Upper Vendian sediments from the Winter Coast, White Sea region, Russia: Implications for the paleogeography of Baltica during Neoproterozoic times. Journal of Geophysical Research, 107: B11, EPM 10, 1-8. Poprawa P., Sliaupa S., Stephenson R.A. & Lazauskiene J., 1999. Late Wendian-Early Palaeozoic tectonic evolution of the Baltic basin and its regional implications. Tectonophysics, 314: 219-239 Torsvik T.H., Rehnström E.F. 2001. Cambrian palaeomagnetic data from Baltica: implications for true polar wander and Cambrian palaeogeography. Journal of the Geological Society, London, 158: 321-329.

T31D-0872 0830h POSTER

Formation of the Jan Mayen Microcontinent, the Norwegian Sea

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We have conducted a global study of microcontinents, which we define as crustal fragments with continental-like structure and composition, isolated in oceanic crust, with an extent of less than 10^6 km ^{2}. Microcontinents are formed in both extensional and transtensional tectonic regimes, and exhibit a range of distinct features such as (1) bathymetric highs, (2) positive free-air anomalies, (3) magnetic quiet zones, (4) prograding sedimentary sequences on the flanks, (5) older than surrounding crust, and (6) different heat flow signatures than the surrounding crust. They commonly also contain some amount of magmatic complexes. Only eight structures worldwide are true microcontinents by our definition, including the Jan Mayen microcontinent in the Norwegian Sea. The Jan Mayen microcontinent is a 500 km long and 160 km wide NNE-trending structure, comprising the bathymetric prominent Jan Mayen Ridge in the NE and a western and southern part with a more subdued bathymetric expression. Its crustal thickness reaches a maximum of 15 km with a lower crustal root displaced 10 km east of the axis of the ridge. The root has seismic velocities in the range from 6.7 to 7.0 km/s and is associated with a magnetic quiet zone, both suggesting a continental origin. A new continent-ocean boundary delimiting the microcontinent has been interpreted based on the extent of the magnetic quiet zone, the free-air gravity anomaly signature, seismic reflection data, and the velocity distribution. The Jan Mayen microcontinent separated from the volcanic rifted Voring and More margins off mid-Norway during Early Tertiary continental breakup and sea floor spreading. Close to the Eocene-Oligocene transition, the Kolbeinsey Ridge spreading axis started to propagate northwards from the Reykjanes Ridge into the East Greenland margin, thus constituting a prograding-retreating pair of axes with the Aegir Ridge. Sea floor spreading along the entire Kolbeinsey Ridge was obtained near the Oligocene-Miocene transition, leading to complete separation of the Jan Mayen microcontinent from the East Greenland continental margin. This event was concurrent with the extinction of the Aegir Ridge.

T31D-0873 0830h POSTER

Tectonic Flows Modeled by the Method of Smoothed Particle Hydrodynamics

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In order to study the flow of highly deformable yet heterogeneous material, we investigate the application of the Smoothed Particle Hydrodynamics modeling method to geophysical fluid dynamics. SPH is a grid-free, Lagrangian method that solves the continuum equations (continuity, momentum, energy) on a set of interpolation points (particles). These interpolation points correspond to representative volume elements which track the material points of the fluid and it's state variables (density, stress, temperature). The evolution of the state variables for a given volume element is calculated by considering the influence of each neighboring element and summing over all neighbors. Volume elements interact with boundaries through mirror particles which enforce a no-slip boundary condition by mirroring the element's material properties, stress and velocity. The method includes several advantages over irregular grid-based approaches including easy parallelization of the calculations and efficient tracking of material properties in regions of high deformation rate. We test two-dimensional, mechanical models of unconfined, viscous fluid flow for both quasi-static flows, applicable to tectonics, and dynamic flows such as landslides. Our SPH implementation is tested by comparing model results to analytic solutions for several confined and unconfined fluid flow problems. In particular, we compare our model with three test cases for homogeneous viscous flow; Poiseuille channel flow, Stoke's flow past a cylinder, and unconfined flow down an inclined plane.

T31E MCC: Level 2 Wednesday 0830h

Structure and Tectonics of the Western U.S. and the Gulf of California I Posters *(joint with G, S, V)*

Presiding: **D R Lageson,** Montana State University

T31E-0874 0830h POSTER

Lithospheric Structure from the Jemez Lineament to the Cheyenne Belt, Southern Rocky Mountains

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We present the modeling and interpretation of a 955km long refraction profile and a 170km long deep reflection profile acquired as part of the Continental Dynamics of the Rocky Mountains (CD-ROM) project. The refraction profile extends across the major features of the Rocky Mountain region, from the Jemez Lineament (JL), in northern New Mexico through the Proterozoic Mazatzal and Yavapai Provinces, to the Cheyenne belt in southern Wyoming. The reflection profile parallels the refraction profile in northern New Mexico and targets the lithospheric structure of the Jemez Lineament. We inverted travel-time data from the 10 refraction records using both layer based travel-time inversion and first-arrival travel-time tomography methods. In the shot records we identified two refracted arrivals, one from the crystalline crust and one from the upper mantle (Pg, and Pn) as well as prominent reflections from the middle crust (PcP) and from the Moho (PmP). We modeled the Bouguer gravity along the profile using the interfaces of the layer based refraction model and densities derived from a standard density-velocity relationship. Calculated gravity fits the observations to +/- 14 mgal. The upper and middle crust shows low velocities (6.0-6.2 km/s) beneath the JL and at the center of the profile, beneath the Colorado Mineral Belt. Upper and mid crustal velocities increase (6.2-6.5 km/s) north of the Cheyenne belt and south of the JL, where the deep reflection profile images a Proterozoic crustal duplex. The lower crust across the profile exhibits a relatively low velocity, with an average velocity of 6.7 km/s, and a variable thickness, with the thinnest section (10 km) beneath the JL and the thickest section beneath the northern Colorado Mineral Belt (22 km). Moho depths vary from near 40 km beneath the JL to more than 50 km in the northern half of the profile. Upper mantle velocities are low (7.85 km/s) with the lowest velocities (7.70-7.76 km/s) found beneath the thinnest crust (40-41 km) across the JL. The average CD-ROM one dimensional velocity function has lower values for the crust and the upper mantle than the Christensen-Mooney global average velocities for continents and for orogens. Low velocities in the upper and middle crust can be explained by widespread Proterozoic and Phanerozoic felsic batholiths. Low velocities throughout the crust are also a result of high heat flow (63 to >105 mWm-2) in the Rocky Mountains south of the Cheyenne Belt. Attenuated velocities of the lower crust and the upper mantle, together with the Quaternary basalt flows, recent uplift and high heat flow, suggest temperatures in the mantle that are above the peridotite solidus, particularly beneath the JL. The reflection profile in the JL images bright linear reflections at mid-crustal depths which we interpret as modern mafic sills, consistent with the hypothesis that the mantle beneath the JL is partially molten and provides basaltic melt to the crust.

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High Resolution Aeromagnetic Survey of the Big Bend National Park Region, Texas

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The Big Bend National Park region of west Texas has experienced a complex geologic history, including such events as the Paleozoic Ouachita orogeny, Laramide compression, Tertiary magmatism, and Basin and Range/Rio Grande rift extension. During late fall of 2002, a high resolution aeromagnetic survey was flown over this region for the purposes of improving present geologic maps and developing a better understanding of igneous stratigraphy in the region. Total-field anomaly data was acquired with a 400 meter flight-line spacing and continued to a draped surface at a constant level of 400 meters above the ground surface. Reduction to pole, pseudogravity, and analytic signal filters were applied to the total-field anomaly grid, revealing many features that correlate well with mapped geology and many additional, unmapped features. A set of northeast trending, long wavelength anomalies correlate well with mapped trends of rocks of the Ouachita orogenic belt, especially a magnetic low that correlates with the Ouachita interior zone. A prominent magnetic and pseudogravity high indicates the presence of a large (30 by 25 km) igneous body underlying the Chisos Mountains. Superimposed on this anomaly is a set of smaller anomalies that correlate with mapped locations of the Pine Canyon and Sierra Quemada calderas. Numerous short wavelength anomalies correlate with mapped locations of Tertiary volcanoes and intrusions, plus many similar anomalies indicate the presence of unmapped and buried intrusions. In the Christmas Mountains, a large negative anomaly indicates that a magnetic reversal is recorded in the rocks of this area. Northwest-trending normal faults produced by Tertiary extension produce magnetic anomalies where they cut and offset magnetic rocks of the South Rim and Chisos Formations, most notably within the Terlingua Abaja and Punta de la Sierra fault belts. These faulting trends are enhanced in the analytic signal map, which will allow delineation of unexposed faults by extrapolation from their surface exposures. Future fieldwork to collect magnetic rock property data will allow detailed modeling to take place.

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Extensional Domains of the Northwestern Basin and Range Province

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Compilation of new and existing geologic, geochronologic, and thermochronologic data reveal that broad regions of northern Nevada have significantly different Tertiary histories in terms of timing and amount of extension. Definition of these different extensional domains allows better insight into the regional relationship of magmatism to extension and points to zones that acted as boundaries between areas that extended at different times. Much of central Nevada (roughly lat. 38-40) is blanketed by thick sections of Oligocene-Early Miocene volcanic rocks. Prominent unconformities in these sections indicate that parts of central Nevada underwent episodic and variable amounts of extensional faulting and tilting from Oligocene to Early Miocene time. Subsequently, rapid slip occurred along range-bounding faults at 17-15 Ma. Despite apparently synchronous and rapid extension across an area stretching from the Wasatch front to the Wassuk Range east of the Sierra Nevada, volcanic rocks were erupted only locally in central Nevada at this time. In contrast, the Oligocene to Early Miocene volcanic rocks in northwestern Nevada are capped by the voluminous 17-15 Ma basalt-rhyolite sequence associated with the Northern Nevada Rift and the Yellowstone hot spot. The absence of angular unconformities in the volcanic section demonstrates that no faulting and tilting took place over the interval 30-15 Ma. The only extension to occur in this large