magnetic susceptibility using a large number of discrete samples taken from both reference sites were carried out. Magnetic anisotropy across the proto decollement zone increase its degree along the depth. Shape parameter of magnetic tensor ellipsoid indicates those increase of the anisotropy degree reflects gradual increase of compaction effect on sediments. As an important notice, some characteristic spikes showing low magnetic anisotropy were observed around the proto decollement zone at both sites. These low anisotropy spikes indicate magnetic particles keep random fabrics against sedimentary compaction, and their depth are also corresponding with similar spikes on results of P-wave velocity measured on shipboard. Based on these magnetic and physical properties, hemiperagic mudstone unit at Site 1177 initially has characteristic random grain fabric, and possibly spans to the Muroto Transect. Then, compressive strain during accretion causes destruction of sediments like decollement zone easily within the sedimentary sections consisting of random grain fabric.

T41A-0858 0830h POSTER

Origin and Evolution of the Decollement Zone in the Nankai Trough Accretionary Prism

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Origin and evolution of a plate boundary decollement zone remain a big puzzle. Ocean Drilling Program (ODP) Legs 190 and 196 performed coring and logging while drilling near the toe of the Nankai Trough accretionary prism. Here, the decollement zone is well expressed on seismic profiles. We examined the nature of the decollement zone using samples and data collected during Legs 190 and 196.

At reference site (Site 1173), structural features on cores and resistivity-at-the bit (RAB) images of the borehole show no clear evidence for the proto-decollement zone. However, magnetic fabrics indicate the age equivalent decollement is located at the bottom of the domain marked by weakly developed compaction fabric. Below the decollement horizon, the degree of compaction increases with depth. Vertical anisotropy data of P-wave velocity and resistivity reflects change in compaction state across the decollement horizon

The decollement zone at the toe of the prism (Site 1174) is marked by the breccia zone in which the mudstone is broken into mm- to cm-scale coherent fragments bounded by discrete slip surfaces. Based on microstructure, magnetic fabric, and vertical anisotropy data of P-wave velocity and resistivity, random fabric with small pore space characterizes coherent fragments, while preferred orientations of clay minerals develop along discrete slip surfaces. These features suggest the unique deformation history and stress path of the decollement zone: undrained deformation followed by isotropic consolidation and shearing under drained condition. Consequently, core samples from the decollement zone have lower porosities than those from above and below.

RAB images at Site 808 located 1 km landward of Site 1174 suggest dilated horizons in the decollement zone. Dilated horizons correspond to the horizons where cores were not recovered during previous leg. Dilated horizons may result from shear failure under the critical state that is expected after shearing under drained condition. Presumably, dilated horizons are filled with high-pressured fluid, resulting in strain decoupling across the decollement zone.

T41A-0859 0830h POSTER

Structure and cold seep of the Nankai accretionary prism off Kumano

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Seafloor survey by submersible was conducted on the slope of the Nankai accretionary prism off Kumano. The Nankai Trough extends about 700 km from the Izu-collision zone to the northern end of the Kyushu-Palau Ridge. The eastern and western parts of the Nankai Trough have been well investigated by the KAIKO projects since 1984, dense seismic survey and the deepsea drillings. In contrast, only few studies have so far been made at the Kumano area located at the central part of the Nankai Trough. The epicenter of the 1944 Tonankai earthquake is estimated north of this area. Our survey using submersible "Shinkai 6500 (JAMSTEC)" was conducted to understand relationship between fluid circulation, prism growth and seismogenic zone development. Recent seismic reflection studies off Kumano indicates development of a large out-of-sequence thrust at the upper slope and two large thrust faults at the toe and the middle slope of the prism (Park, unpublished data). Chemosynthetic biological communities were observed along these major fault scarps suggesting fluid expulsion along the fault planes. The exposures of the scarp are mainly composed of highly tilted siltstone, alternations of sandstone and siltstone, and light-colored tuff. These sequences are regarded as accreted trench-fill sediments by offscraping based on the seismic reflection profile. However, the rock collected from the toe has porosity of 45 percent, which correspond to the deepsea drilling sample off Shikoku at the depth of 500 meters below the seafloor. It is inferred that the prism toe off Kumano is suffered from active erosion after frontal accretion.

T41B MC: Hall D Thursday 0830h

Viscoelastic Deformation of the Earth: Observations and Models I

(joint with G, S, DI, MR)

Presiding: **J X Mitrovica,** University of Toronto; **S Zhong,** University of Colorado

T41B-0860 0830h POSTER

Earth's Potentiosphere

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Viscoelastic fluid theory suggests that Earth's upper mantle and transition zone comprise a coherent thermomechanical boundary layer. Based on the remarkable correspondence between theoretical predictions and observable seismic features in the upper mantle, this finding has important ramifications for global tectonics. The theory, parameterized in terms of Weissenberg number (Wi) and scaled using the average thickness of the mechanical lithosphere (about 100km), is a logical extension of mantle convection theory based on the Rayleigh-Benard problem. Wi is a dimensionless measure of residual normal stress, assumed to be inversely proportional to temperature. The theory predicts a significant potential component for mantle flow above a depth of 693 km, with essentially dissipative conditions below. Thus the terms potentiosphere and rheosphere are coined for the mantle shallower and deeper than 693 km, respectively. Also predicted is a characteristic spatial dimension for inertial rupture, on the order of 10 km. Together, these concepts provide a simple physical explanation for the globally observed seismicity cutoff at the base of the upper mantle, implicitly tied to thermal state. Seismically observed reflectors in the mantle correspond to intrinsic boundary conditions, either coupled or uncoupled. An energy minimum, associated with uncoupling, is predicted at a depth of 666 km. This implies that the equilibrium phase change commonly associated with the 660-km seismic discontinuity actually might be mediated by localized shear near that depth. Similar situations, although associated with coupled conditions, are predicted at 400 and 324 km depths. The latter might represent the X reflector observed in subduction environments. The theory also predicts a change in the character of deformation from distributed and isotropic below a depth of about 200 km to localized and anisotropic above, generally consistent with the Lehmann discontinuity. A fundamentally weak zone, associated with uncoupling, is predicted at a depth of 173 km. Finally, another coupled flow boundary is predicted immediately beneath the assumed mechanical lithosphere at a depth of 124 km, consistent with the controversial 125-km constant temperature boundary condition of Parsons and Sclater (1977). Thus, the new theory satisfies both seismic and thermal observations critical for global tectonics.

T41B-0861 0830h POSTER

Transition Wavelength Theory

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Viscoelastic single-layer folding theory predicts a transition from distributed to localized deformation at a specific normalized wavelength - transition wavelength - as a function of the competence contrast at the layer boundaries. This transition is independent of stabilizing forces such as gravity and surface energy. The effect of viscoelasticity, compared to the viscous case, is to destabilize folds at wavelengths shorter than the transition wavelength, and stabilize those at longer wavelength. Transition wavelength theory, therefore, not only provides an explanation for the common observation of thrust faults cross-cutting fold hinges in fold-thrust belts, but also the generally short normalized wavelengths of observed natural folds. Fold-wavelength frequency distributions of natural folds, normalized to layer thickness, display marked skewness, with an overall range from about 3 to 35 and modes in the range 4 to 7. Comparison of these data with the theory suggests that competence contrasts attending deformation in fold-thrust belts range from about 10 to 36. This conclusion stands in contrast to those drawn from dominant wavelength theory for both Newtonian and power law viscous rheologies, which suggest competence contrasts in the range of 500 to 1000 or more. Note that the predicted 10 to 36 range is consistent with the classic analysis of Sherwin and Chapple (1968), and well below those values at which Lan and Huddleston (1995)demonstrated the formation of a finite neutral surface in single-layer buckle folds using power law viscous rheology. Observed natural folds generally lack a finite neutral surface. These findings demonstrate the importance of viscoelasticity for fold formation, and raise the often ignored question of extrapolating empirical relationships based on rock mechanics data to deformation at tectonic strain rates. While the power law viscous and Maxwell viscoelastic rheologies are useful for modeling observable time dependencies, mathematically they cannot capture deformation in deep time. However, other more general constitutive models such as used in the present theory can.

T41B-0862 0830h POSTER

Postseismic Reloading: A Mechanism for Temporal Clustering of Major Earthquakes on Individual Faults

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On a single fault segment, geologic and paleoseismic evidence from locations such as the Basin and Range [Friedrich et al. JGR, submitted] and Dead Sea Transform [Marco et al., JGR, 1996] indicate that occurrence of major earthquakes in time is often extremely heterogeneous and may, in fact, exhibit temporal clustering. We consider major earthquake clustering as the occurrence of multiple event sequences with intra-cluster inter-event times much shorter than the average time between clusters. Many factors may contribute to temporal clustering of major earthquakes. Over multiple event time scales, time-dependent postseismic stress transfer may play an important role.

After major earthquakes, time-varying deformation transients occur. These transients result from diffusion of stress away from zones of stress concentration generated during the coseismic rupture. As a consequence, the coseismic fault is reloaded at a rate that is initially much higher than the background rate derived from far-field plate motions. On a given fault, earthquake recurrence intervals are moderated by various sources of system noise, including stress perturbations due to neighboring earthquakes, crustal heterogeneity, and fault evolution. Depending on the relative timing and magnitude of earthquakes in a sequence, therefore, the postseismic stress available for transfer to the coseismic fault may be greater or less than average. This may lead to a situation in which postseismic stress transfer becomes a significant factor in controlling the time to the next event.

To investigate these longer-term postseismic processes, we develop a spring-dashpost-slider model of time-dependent stress transfer in the earth. With this tool, we gain an understanding of how variations in rheology, fault slip-rate, and system noise affect a fault's behavior. In tectonic environments with a weak lower crust/upper mantle, we find that small random variations in the fault failure criteria generate temporally clustered earthquake sequences. This effect is enhanced as the geologic slip-rate on the fault decreases. By analogy, areas such as the Basin and Range are particularly susceptible to clustering induced by long-term postseismic stress effects.

T41B-0863 0830h POSTER

An Independent Test of a Subresonant Mechanical Damping Spectrometer

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To estimate the precision and accuracy of an apparatus built to measure mechanical damping in crustal rocks, we have constructed a structure from aluminum and high-Newtonian-viscosity silicone oil. This structure is similar in design to many shock absorbers, but with no moving piston. Oil is forced from a reservoir, through a capillary, by elastic deformation of the reservoir wall. Oil returns through the capillary as the deformation relaxes under diminished load. The structure can be modeled as a linear set of elastic and viscous elements. The dynamic structural behavior of this structure was analysed mathematically, and its damping as a function of frequency was calculated. Measurements were made of the structure in the damping spectrometer using frequencies in the range 1 mHz - 100 Hz, and both sets of results are compared. The Debye peak predicted by calculation is well resolved in the measurement, and, within uncertainty, experiment and theory agree in the region of the peak. This confirms that the spectrometer is useful in this range. Further use of a calculated structure similar to this could aid in mechanical damping measurements under less favorable conditions such as under confining pressure, and possibly lead to the development of a low-frequency mechanical damping standard.

T41B-0864 0830h POSTER

Mantle viscosity from postglacial rebound

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Relative Sea-level Data (RSL) in the Hudson Bay during the postglacial rebound are used to infer the Earth's mantle viscosity profile. These data are inverted by the Metropolis algorithm together with an annealing schedule. The forward model is based on a self gravitating multi-layered viscoelastic incompressible planet. Preliminary results, computed by a five layer model, suggest that the best fitting viscosity profile is characterized by a shallow upper mantle with viscosity of 3×10^{20} Pa.s and a lower mantle with viscosity close to 10^{21} Pa.s. The main finding is the presence of a stiff transition zone, with viscosity close to 10^{22}. This solution agrees with previous findings concerning postglacial rebound observables and global geodynamic signatures. The inversion can be improved increasing the number of the viscoelastic layers to test the sensitivity of the RSL data to more complex viscosity profiles. The results of these inversions can be interpreted as mean viscosities of the layers considered: the linear viscoelastic rheology seems to provide a good description of the relaxation process due to postglacial rebound. However, experimental studies of the mantle minerals suggest nonlinear relaxation mechanisms. A step forward in the interpretation of the observed sea level changes can be achieved by a more realistic rheology for the lithosphere and mantle, and also considering the variations of crust and lithosphere thicknesses beneath the Hudson Bay area. We present a finite element model to study the postglacial deformations of the northern America, with a composite rheology for the mantle, in which the transition between diffusion and dislocation creep is self-consistently determined by the deviatoric stress. Our aim is to provide an alternative fit to observed RSL data by a more realistic model.

T41B-0865 0830h POSTER

Folding in a Cooling Crust with Elasto-visco-plastic Rheology: An Example from Venus

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We investigate the effects of simultaneous shortening and cooling on fold wavelengths in a crust with elasto-visco-plastic (EVP) rheology, in order to better understand the interplay between rates of shortening and cooling on the anelastic response of the crust. We apply our techniques to Venusian crustal plateaus, which show ubiquitous, low-amplitude folds with a continuous range of wavelengths from < 100 m to > 30 km. Previous studies have proposed that these folds (and other characteristic crustal plateau structures) originated during crustal plateau formation by interaction of large mantle plumes with the surface during a time of globally thin lithosphere [1]. In this scenario, a plume arriving at the lithosphere erases existing structures and produces a mechanically homogeneous surface by heating and/or melting the crust. Subsequent cooling results in a surface layer that is capable of recording strains and that thickens with time. We investigate the conditions under which folds matching those observed in Venusian crustal plateaus are created in a finite element model simulating concurrent shortening and cooling, as motivated by the tectonic scenario in [1]. Our models are novel because a) the EVP rheology more accurately represents the actual crust than viscous or viscoelastic models; and b) other models generally specify *a priori* a folding layer thickness and geometry, with material properties different from those of the surrounding rock, and this pre-determines the resulting fold wavelength(s). By contrast, our models incorporate spatially uniform material properties but temperature-dependent rheology [2], so that the strength profile through the crust evolves with cooling. This allows the thermal and stress conditions to determine the instantaneous effective folding layer thickness at each time step, which in turn determines surface fold wavelengths. We investigate conditions under which short wavelength folds are initiated when the effective folding layer is very thin, and the fold wavelength increases with cooling and the resultant increase in layer thickness. This progression requires a rather specific set of conditions, and most notably may place constraints on the shortening rate, surface temperature, and thermal gradient during folding.

[1] Phillips, R.J. and V.L. Hansen 1998. Geological evolution of Venus: A geodynamical and magmatic framework. Science, 279,1492-1497.

[2] Mackwell, S.J., M.E. Zimmerman and D.L. Kohlstedt 1998. High-temperature deformation of dry diabase with application to tectonics on Venus. JGR 103, 975-984.

T41B-0866 0830h POSTER

Antarctic Ice Mass Change and Predictions of Crustal Seismicity and Lithospheric Stress

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Numerous examples in Laurentia and Fennoscandia of bedrock offsets that postdate late-Quaternary glacial polish suggest faulting caused by postglacial rebound. Over the past 5 years the theory of postglacial faulting has witnessed some major advances. The effect of glacial isostatic adjustment (GIA) on the faulting potential of the Antarctic lithosphere is examined here. Our application assumes an incompressible rheology, permitting a semi-analytical theoretical development. Our metric is the quantity, ΔF, defined by *Wu and Hasegawa [GJI Vol. 125, 1996]* as the differential Coulomb stress. In earthquake stress transfer theory this is called the Coulomb failure stress change. One feature of GIA in Antarctica is that substantial ice load change has probably continued up to mid-Holocene times and possibly at a reduced rate up to the present. This is in contrast to most of North America and Fennoscandia, where ice mass change ceased in early Holocene times. A revision of the D91 Antarctic ice history of *James and Ivins [JGR Vol. 103, 1998]* is used as input to calculations of stress change in the Antarctic lithosphere. The revised load includes recently developed constraints on grounding line retreat in the Ross Sea, coastal Antarctic Peninsula, and Weddell Sea regions, and new constraints on interior ice heights at Last Glacial Maximum (LGM). During the culmination of LGM, seismicity is suppressed relative to the 'no-load' reference state although the suppression is limited in its spatial extent. The relatively youthful deglaciation in some parts of Antarctica produces large present-day values of ΔF of 1 to 8 MPa at depths of 12 - 19 km within the Antarctic crust. These ΔF values are a factor of 20 or more larger than those computed recently for the post-seismic stress shadowing effects in the Californian and Anatolian interplate shear zones. This suggests that ice loading effects in Antarctica are important in modulating and possibly generating seismicity. It will, however, be important to evaluate the effect of possible values of the poorly known background tectonic stress in future studies, as the background stress also affects predictions of the Coulomb failure stress change.

T41B-0867 0830h POSTER

Dramatic Short-Term Changes in Host Rock Strain Rates and Viscosities During arc Plutonism

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Estimates on rock viscosities from fieldwork are difficult to obtain since potential field tools are not well established. However, our fieldwork in pluton aureoles of the Tuolumne Intrusive Suite (California) shows that dramatic gradients in finite strain exist along pluton margins. Further, different host rock types show a different viscous response to the plutonic heat source such that some rock types are much stronger deformed than others. Although our field data do not provide quantitative constraints on rock viscosities, from a qualitative point of view, our data suggest that host rock viscosities may be subject to dramatic variation during pluton emplacement. We design a simple model to test this hypothesis.

Geodynamic modelers typically use generic viscosity contrasts and assign a single viscosity to large regions of the crust. Since studies of magma-host rock systems occur on a much smaller scale than geodynamic processes, we are primarily interested in viscosity heterogeneity on the outcrop scale, or at least magma-host rock boundaries. Hence, we take a different approach and estimate variations in effective rock viscosities numerically to investigate deformation along pluton boundaries. We construct a hypothetical magma chamber, surrounded by homogeneous quartz-rich rocks, whose growth results in pronounced spatial and temporal variations of stress and temperature in the host rock. Growth of the spherical chamber is facilitated by two different means: (1) A feeder dike with constant filling rate, and (2) pervasive flow supplying magma with chamber size dependent flux rate. We use a power flow law calibrated experimentally for dislocation creep of quartzite and calculate stress and temperature as a function of time and distance to obtain strain rates for any given point in the pluton aureole. We use the strain rates obtained to calculate effective viscosities using a stress/ strain relationship. Future modeling will account for variable strength of the host rocks.

Our results indicate that viscosities may vary from 10^5 to 10^8 MPas, which is in the range of the viscosity of bitumen. Our study is intriguing and suggests that aureole rocks may undergo dramatic changes in strain rates and effective viscosities over extremely short time periods during periods of active magmatism.

T41B-0868 0830h POSTER

Effects of the Cowling Approximation on Predictions of Glacial Isostatic Adjustment

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The vast majority of previous studies of glacial isostatic adjustment (GIA) consider the response of spherically symmetric, viscoelastic Earth models. In the normal mode theory traditionally applied in these studies perturbations in gravitational potential are coupled to perturbations in the density field through Poisson's Equation. Recently, an effort has been initiated by several independent groups to develop numerical methods to solve for the response of laterally varying Earth models. In these efforts it is advantageous to use the Cowling approximation. In this approximation the effects of the zeroth order potential field on displacements are included without simultaneously solving for the associated potential perturbation. In this poster, we investigate the effects of the Cowling approximation on a

large suite of GIA predictions using spherically symmetric, rotating Earth models with Maxwell rheology. We compare the solutions obtained with and without the Cowling approximation both on global scale observations, such as $\dot{J}_2$, and on local observations, such as relative sea level predictions. These results bound the error introduced by the Cowling approximation and thus serve as a guide to the development of numerical methods for 3-D GIA.

T41B-0869 0830h POSTER

The Method of Lines in Computing Viscoelastic Relaxation of the Earth

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The initial-value (IV) approach to the modeling of viscoelastic relaxation of spherical compressible self-gravitating Earth models to loading processes was designed as an alternative to the approach based on the Laplace transform applied to the time variable. The feature of overcoming the burden of inversion of Laplacian spectra of complex models encouraged extensive developments, including generalization for 2-D and 3-D viscosity distribution. Whereas our original IV formulation utilized the Euler scheme for integrating governing partial differential equations in time as an intrinsic part of the theory and a series of boundary-value problems had to be solved, now we present a formulation, in which the governing equations are discretized in all spatial variables first (a technique known as the method of lines). The obtained set of ordinary differential equations forms a linear IV problem in time, which can be numerically integrated by optimized library routines. Despite a high degree of numerical stiffness emerging due to both underlying physics and applied discretization, appropriate integrating routines reveal the time evolution of relaxation curves of complex Earth models with outstanding speed and stability. It is an important feature of the new formulation that the processed IV problem can be recast into the form of a matrix eigenvalue (EV) problem. The resulting eigenspectrum covers the complete physical relaxation spectrum and also allows us to appraise and alleviate the impact of non-physical modes, which originate in spatial discretization. We show outputs of joint employment of the IV and EV strategies to the forward problem of viscoelastic relaxation of Earth models with complex spatial stratification, discuss applicability of various discretization grids and display attained computational times. Two examples: our code based on the EV strategy running on a Pentium III computes the entire viscoelastic spectrum of a model discretized by 30 radial layers within 0.05 sec per angular order, the same time of 0.05 sec is enough for the IV code to integrate one time step for a model with 100 layers; the isostatic equilibrium can be reached within few tens of adaptive time steps.

T41C MC: Hall D Thursday 0830h

Processes Within the Subduction Factory: Slab and Mantle Wedge

(joint with OS, S, V, DI, MR)

Presiding: **T Plank,** Boston University**; R J Stern,** U Texas at Dallas

T41C-0870 0830h POSTER

Dynamics of Retreating Slabs: Insights from 2-D Numerical and 3-D Laboratory Experiments

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We use a combined set of 2-D numerical and 3-D laboratory models to analyze the long-term dynamics of an oceanic slab falling into a passive stratified, viscous mantle. The aim of this study is to investigate self-consistently the dynamic evolution of trenches and to identify the factors that influence the subduction process. We obtain self-consistency of slab dynamics using no imposed kinematic input, i.e. the slab is driven by gravity, only.

With the numerical experiment we analyze and review the effect of a wide range of rheology presented in earlier solid mechanical studies such as purely elastic, linear visco-elastic, and visco-elasto-plastic slabs. With 3-D laboratory analogue we focus on the interaction of the slab with the induced passive mantle flow by widely varying mantle volume flux boundary conditions. The choice of rheological parameters is guided by the validity field assessed in the numerical investigation.

Assuming a one to one relation between trench retreat and back arc spreading, enigmatic observations of episodic opening of back arc basins can be explained by our experimental observations. An application of these results is presented for the natural case of the Central Mediterranean.

T41C-0871 0830h POSTER

How Large a Feedback Effect Does Slab Dewatering Have on Itself ?

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Arc magmas are generally believed to be produced when the mantle wedge melts as a result of fluxing of a hydrous fluid from the subducting plate. Fluids liberate from the slab at different P-T conditions; key to understanding the fate of these fluids is the knowledge of the thermal structure of the downgoing plate. Earlier works have shown that this thermal structure is a function of several variables like the age of the incoming oceanic lithosphere, the convergence rate, and the dip angle. However, the impacts of chemical reactions and heat transport by fluid flow have yet to be thoroughly explored.

Fluid fluxing from the slab results from metamorphic phase transitions which consume latent heat. Latent heats for the different reactions have been quantified in experimental studies. However, little is known how this cooling effect changes the timing, location, and intensity of fluid release. One way to explore this problem is to use numerical models, as previously done by Peacock et al. Here, we present results of a new self-consistent, chemo-thermo-dynamical model for mantle flow, melting, and fluid release. To solve the governing equations of the model we use a combined finite elements, finite differences, and tracer particle advection scheme. For proper internal consistency we include the cooling effects of fluid release within the temperature solution.

In this study we analyze the impact of the cooling effect of metamorphic dehydration reactions on fluid release at subduction zones and water recycling into the deeper mantle. For this analysis, we divide the incoming plate into a crustal and mantle layer consisting primarily of hydrated basalts and hydrated peridotites, respectively. We then prescribe for each layer different values for the latent heats released during dewatering. In accordance to experimentally determined values, in a series of model runs, we gradually augment the chosen values for the latent heats from a minimal to a maximal cooling effect and analyze the impact of this on the timing, location, and intensity of water release. These numerical experiments provide new insight into the interactions between fluid release and latent heat consumption.

T41C-0872 0830h POSTER

Modeling Subducting Slabs: Structural Variations due to Thermal Models, Latent Heat Feedback, and Thermal Parameter

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The thermal, mineralogical, and buoyancy structures of thermal-kinetic models of subducting slabs are highly dependent upon a number of parameters, especially if the metastable persistence of olivine in the transition zone is investigated. The choice of starting thermal model for the lithosphere, whether a cooling halfspace (HS) or plate model, can have a significant effect, resulting in metastable wedges of olivine that differ in size by up to two to three times for high values of the thermal parameter (φ). Moreover, as φ is the product of the age of the lithosphere at the trench, convergence rate, and dip angle, slabs with similar φs can show great variations in structures as these constituents change. This is especially true for old lithosphere, as the lithosphere continually cools and thickens with age for HS models, but plate models, with parameters from *Parson and Sclater* [1977] (PS) or *Stein and Stein* [1992] (GDH1), achieve a thermal steady-state and constant thickness in about 70 My. In addition, the latent heats (q) of the phase transformations of the Mg_2SiO_4 polymorphs can also have significant effects in the slabs. Including q feedback in models raises the temperature and reduces the extent of metastable olivine, causing the sizes of the metastable wedges to vary by factors of up to two times. The effects of the choice of thermal model, inclusion and non-inclusion of q feedback, and variations in the constituents of φ are investigated for several model slabs.

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Tomographic Imaging of the Three-Dimensional P-wave Velocity Structure Beneath Costa Rica: Constraints on Subduction Processes

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Subduction of the Cocos plate beneath Central America and its associated processes cause a high seismic activity in Costa Rica. Two separate seismic networks (OVSICORI-UNA and RSN) exist in Costa Rica to routinely locate earthquakes associated with the tectonic activity. We merged these two independent datasets to achieve a high-quality and consistent earthquake data set for Costa Rica. From the merged dataset we selected 3790 well locatable events with a GAP less than 180 degrees and more than 6 P-wave observations to invert for three-dimensional P-wave velocity structure and hypocenter locations.

Resolution of our tomographic model is good throughout most of Costa Rica down to a depth of 60-70 km. At greater depth, good resolution is limited to a region parallel to the subducting slab and the overlying mantle wedge. Except for southern Costa Rica, we identify the subducting Cocos plate as a dipping high-velocity feature consistent with relatively cold and mafic oceanic crust being subducted. In southern Costa Rica subducting of the extremely thickened and young oceanic crust of the Cocos Ridge, causes lower velocities. Based on seismicity and seismic velocities we are able to trace the subducting Cocos plate down to a depth of 150 km beneath northern Costa Rica. Seismicity ceases beneath central Costa Rica and we loose the trace of the subducting Cocos plate at a depth of 80 km. A zone of very low seismic P-wave velocities and high seismic activity is found at 60 to 80 km beneath Central Costa Rica. We interpret these low velocities and the abundance of seismicity at this depth as an indication of ongoing dehydration and subsequent release of fluids in the subducting slab. A zone of high seismic P-wave velocities, possibly representing subducted cold material, separates the mantle wedge underlying northern and central Costa Rica. The position of this zone coincides with a change in the dip of the subducting Cocos plate with a steep subduction angle to the north and a shallowed subduction angle to the south. It also coincides with the transition in the geochemical signature of arc lavas showing a more depleted mantle source in northern Costa Rica and southern Nicaragua and a more enriched mantle source in central Costa Rica. We interpret our results as more evidence that two different kinds of mantle material underlie Costa Rica separated by a zone of colder subducted material.

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Thermal and Seismic Signature of the Trailing Fragments of the Farallon Slab

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