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Subduction is conventionally thought of as the underthrusting of dense, negatively buoyant oceanic crust beneath continental crust. However, in a small number of areas around the world, evidence suggests that continental crust has or is being subducted. The Pamir-Hindu Kush region is one area in which there is geophysical evidence for continental subduction occurring today. It is one of the most active areas of intracontinental intermediate-depth earthquakes in the world.

We use topography and gravity anomaly data gridded at 5' x 5' to create flexural and gravity models of the Tien Shan and surrounding regions. The continental lithosphere is treated as an elastic plate and its flexure is modeled using a finite difference method. Bouguer gravity anomalies are calculated in the wavenumber domain.

East of the Talas-Ferghana fault isostatic anomalies beneath the Tien Shan are zero to slightly positive. Observed Bouguer anomalies can be well fit by a continuous plate with Te<=35 km such that the mountains are regionally supported by the elastic flexure of the lithosphere and the broad crustal root thus created. In contrast, negative isostatic gravity anomalies beneath the Pamir indicate these mountains are overcompensated with respect to Airy isostasy. Previous work shows that flexure of a continuous elastic plate cannot explain the pattern and amplitude of the gravity anomalies, whereas invoking a broken plate with an applied bending moment does provide a reasonable fit to the observed Bouguer anomalies. Our interpretation of the data is that over-thickening and sinking of the crust and mantle lithosphere may be occurring in the western Tien Shan and Pamirs. The variation in style in isostatic compensation between the eastern and western Tien Shan suggests that an east-to-west transect along the chain can provide a time history of the initiation of intracontinental subduction.

T41F-06 1135h

Active tectonics of the South Caspian Basin

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We use observations of surface faulting, well-constrained earthquake focal mechanisms and centroid depths, and velocity structure determined by surface wave propagation and teleseismic receiver functions to investigate the present-day deformation and kinematics in and around the South Caspian Basin. The lack of earthquakes within the basin itself indicates that it behaves as a rigid block, though its sedimentary cover is deformed by numerous folds that are decoupled from its rigid basement by overpressured mud. The basin contains a sedimentary sequence almost 20 km thick above a relatively high-velocity basement that is thinner within the basin than on its margins. The basement beneath the basin could be either unusually thick oceanic crust or thinned, but relatively high-velocity, continental crust. The South Caspian Basin is surrounded by active earthquake belts on all sides. No earthquakes deeper than 30 km can be confirmed in the Kopeh Dag, Alborz and Talesh, which bound the NE, S and W sides of the basin. By contrast, earthquakes occur to depths of at least 80 km on the Apsheron-Balkhan sill, which bounds the N side of the basin and where no earthquakes can be confirmed that are shallower than 30 km. We interpret these deeper earthquakes to indicate the onset of subduction of the South Caspian Basin beneath the central Caspian, a process which appears to occur aseismically at shallow levels. Although oblique shortening is partitioned into pure strike-slip and pure thrust in many areas, conjugate right-lateral and left-lateral components in the Kopeh Dag and eastern Alborz suggest that the South Caspian Basin has a westward component of motion relative to both Eurasia and Iran. This motion enhances westward underthrusting of the basin beneath the Talesh mountains of Iran and Azerbaijan. We estimate the present motions of the South Caspian Basin to be about 13–17 mm/yr to the SW relative to Iran (a maximum value) and about 8–10 mm/yr to the NW or NNW relative to Eurasia. We suspect that these motions are all relatively recent, and may have begun only in the Pliocene (3–5 Ma ago). The South Caspian Basin will ultimately be destroyed by subduction or underthrusting and its present situation may represent an intermediate stage between that of the eastern Mediterranean and that of the seismically active slab beneath the Hindu Kush.

T42A MC: Hall D Thursday 1330h

Multidisciplinary Insights From Seismic Tomography, Mantle Dynamics, Geological Origins, and Evolution I *(joint with S, V, DI, MR)*

Presiding: **F Dubuffet,** Minnesota Supercomputer Institute

T42A-0908 1330h POSTER

Sensitivity Simulation of Magnetic Field Induction Associated with Mantle Electrical Conductivity Anomalies

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Recent laboratory experiments measured *in situ* electrical conductivities of mantle materials, and suggest that the contrast of conductivities due to the temperature anomaly in a hot plume (σ_p) and in the surrounding mantle (σ) can be as large as an order of magnitude, i.e., if the temperature difference is $\sim$500 K, σ_p/σ is $\sim$5.7 for pyrolite and $\sim$10.2 for eclogite cmposition in the transition zone depths (410 to 660 km), $\sim$15 for upper mantle (200 to 410 km), and $\sim$2.5 for lower mantle (800 to 900 km), respectively. Using the conductivity anomalies thus estimated, we carried out computer simulations to test if the anomalous plume-like distribution is observable in the induced magnetic fields. We used a fully parallelized, time-domain 3-D finite difference code (Chou et al., 2000) that is particularly suitable for simulating transient responses such as those due to magnetic substorms whose prominent frequency band is typically from 0.00001 to 0.00005. Skin depths of this frequency band fall around the mantle transition zone. We tested EM responses for a variety of conductivity anomalies that are in a plume tail with a diameter of 100 to 400 km and an overlying broader layer ($\sim 1000 \times 1000\ km^2$) in the mantle, given a plane electric field (or a vector potential **A** differentiated by time) that oscillates with a period of $\sim$13 hours to 1 day in the x-direction. After sufficient computation time ($\sim$3 to 5 times the oscillation period of the external field), the induced field at the surface was evaluated. Results show notable differences of EM responses (B_y) to the 3-D mantle conductivity anomalies. B_z (induction in the z-direction) is also induced by the anomalies.

T42A-0909 1330h POSTER

The Influence of the Temperature-Dependence of Phonon Lifetimes in Lattice Thermal Conductivity on Mantle Convection

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The conventional temperature dependence of lattice thermal conductivity goes like 1/T and was derived by solid-state physicists for simple ionic crystal structures, like sodium chlorides, and has been used extensively in the geophysical literature for over the last 30 years for both thermal modelling in both the crust and mantle Recently Hofmeister (1999) has developed a semi-empirical model for mantle thermal conductivity, based on infra-red spectroscopic constraints , such as phonon lifetimes. This formulation has been shown to be applicable to a wide suite of crystal structures with more complicated bonding and coordination number. The applicability of this formulation is broad and includes minerals such as oxides, silicates, spinels , and garnets. This formulation for lattice conductivity differs from the former 1/T dependence in that it is now split into two multiplcative terms A(T)*B(T), where A(T) = $(298/T)^a$ and B(T) is an exponential function of T , which describes the change of frequency and volume with temperature ,where a is a parameter which measures the sensitivity of the temperature dependence of the principal phonon lifetimes The argument inside B(T) have the average Grueneisen parameter and also an integral of the variable thermal expansivity over the temperature interval. Previous studies on the influence of lattice conductivity on mantle dynamics have fixed the values of a, like 0.3 and 0.9. We have conducted both 2-D and 3-D numerical simulations to show that there is a great sensitivity in the dynamics to variations of this parameter a , as the temperature-dependence of the phonon lifetimes is reduced for smaller values like 0.1. We have found that there is as much, if not, greater dynamical difference in the solutions between a =0.3 and 0.1 than between a =0.9 and 0.3, very similar to the development of a threshold effect. From the standpoint of mineral physics, there is no reason not to expect values of a smaller than 0.3 , especially for garnet- bearing minerals. Smaller values of the power-law index a , such as 0.1 , promote the development of large plumes and more vigorous convection. There is a nonlinear coupling between internal heating and the decrease in the parameter a . We see an analogy in the dynamical sensitivity of the value of a in thermal conductivity and the power-law index n in nonlinear aspects of mantle rheology.

T42A-0910 1330h POSTER

A Stabilizing Dynamical Influence in the Deep Mantle due to the Radiative Thermal Conductivity and a high temperature at the Core-Mantle Boundary

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The thermal conductivity of mantle materials has two components, the lattice component k_{lat} from phonons and the radiative component k_{rad} due to photons. The temperature (T) derivatives of these mechanisms have different signs, with d k_{lat}/d T negative and d k_{rad}/d T positive. This attribute of a positive temperature derivative on the part of k-rad offers the possibilities for the actual temperature at the core-mantle boundary (CMB) to be a stabilizing factor on boundary layer instabilities at the D ". We have parameterized the weight factor between k_{rad} and k_{lat} with a dimensionless number f , where f =1 corresponds to the reference conductivity model given by Hofmeister (1999). For this thermal conductivity model (f =1) we have found that by increasing the temperature at the CMB, T_{cmb} , from 3000 to 4200 K, the boundary layer instabilities are quenched more and become more stabilized for surface Rayleigh numbers between 10^6 and $5x10^6$ in an aspect-ratio 6 box. For purely basal heating situations the time-dependent chaotic flows at T_{cmb} =3000K become stabilized for values of f between 1.5 and 2. As we increase the T_{cmb} to 4000 K the critical value of f, f_c , needed for flow stabilization is correspondingly reduced . For T_{cmb} greater than 4200 K, f_c becomes less than 1. Our results , obtained from a detailed parametric study, would argue for the important role played by the T_{cmb} in controlling the stability of the D" layer in the presence of any sort of radiative thermal conductivity. Greater contribution of k_{rad} together with a high T_{cmb}, greater than 3500 K , would act to stabilize D" thermal instabilities. On the other hand, a lower T_{cmb} would greatly promote secondary instabilities in the D" layer. These results argue for the possible constraints on T_{cmb} from the presence of radiative thermal conductivity in the deep mantle and the development of secondary instabilities on the CMB. Too high a T_{cmb} would quench instabilities.

T42A-0911 1330h POSTER

Interactive Statistical Analysis of Complex Mantle Flows with the WEB

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Up to now ,all of the figures in mantle convection literature have been presented in a static manner, where the fields at one scale are shown on a printed page . With the spatial resolution increasing at an ever rising clip and the appearance of the issue of multi-scale structures, we can no longer afford to display and look at the results in the same old statical way as in a book, because of the onslaught of data-flooding and the growing complexity of strongly time-varying physical fields from compressible mantle convection, such as the adiabaticity, and other thermodynamical heating functions. We have developed a new approach for interrogating data coming out from numerical simulations. This is based on a interactive two-dimensional map which is used over the WEB by a client-server paradigm. We have applied this to investigate mantle convection flows in both two-and three-dimensional situations. Some questions asked by us are the degree of adiabaticity in different parts of the mantle plume with radioactive and mechanical heating (adiabatic and viscous dissipation). The distributions of thermal anomalies found are no longer Gaussian but sometimes have long tails, especially near the edges of plumeheads. The same is found also for the distribution of mechanical heating, which can be quite skewed. Our experiences with this new interactive mode of data-query have shown both the educational and scientific importance of using the WEB media to quiz handily the data taken from large-scale numerical simulations.

URL: http://www.msi.umn.edu/~heather/zack.html

T42A-0912 1330h POSTER

Secondary Instabilities Developed in Upwellings of High Rayleigh Number Convection.

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The purpose of this work is to show how these secondary instabilities can develop as a consequence of the interaction of the shear flow developed by the large-scale circulation and the rising plume. This will be conducted first within the framework of a constant viscosity fluid. First, we will employ a two-dimensional axisymmetric spherical-shell model within the framework of a Boussinesq fluid with an aspect-ratio of around six. Second, we have used a three-dimensional Boussinesq model with an aspect-ratio of $3 \times 3 \times 1$. Two-dimensional simulations are carried out from 3×10^7 to $Ra = 10^{10}$. Secondary plume bifurcation takes place at a Ra a little bit higher than 10^7 in 2-D. As Ra moves above 10^8, the tendency to plume branching increases and is accompanied by multiple foldings. In 3-D we have gone up to 5×10^7 in a $5 \times 5 \times 1$ box and did not find any signs of plume bending. Then at $Ra = 10^8$ plumes are found to be bent severely by the large scale circulation produced at this high Ra and have gone to $Ra = 10^9$. We may expect some sort of layered convection to take place in 3-D configuration for Ra between 3×10^{10} and 10^{11}.

We have demonstrated here within the framework of a constant viscosity model that the secondary instabilities can develop in a self-consistent manner in both 2-D and 3-D large aspect-ratio convection with bifurcation Rayleigh numbers of $O(10^7)$ and $O(10^8)$ respectively.

T42A-0913 1330h POSTER

Numerical simulation of mantle convection with mobile lids using three-dimensional spherical shell model

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Dynamic interaction between mantle convection and movable high viscosity lids (HVL) is investigated using numerical model of the mantle convection in a three-dimensional spherical shell. Mantle is assumed to be an incompressible fluid with an infinite Prandtl number. The size of the mantle is set to correspond to the Earth. Except the HVLs, the viscosity of the mantle is constant and the Rayleigh number is 10^6. The viscosity and thickness of the HVLs is ten time larger than surrounded mantle and 200 km, respectively. The HVL is defined as undeformable region in the mantle and is drifted with the horizontal averaged velocity within it. Numerical simulations are carried out for varying the ratio of the area of the HVLs to the whole mantle top surface, $c \sim 0.1 - 0.4$. The effects of the phase transitions are also considered for $c \sim 0.2$. Two equal sized HVLs, which are adjoining each other, are abruptly placed on the top surface of the convective mantle. In all the cases, the mantle temperature beneath the HVLs (continental part) increases rapidly compared with that excluded the continental part (oceanic part), since the plume is generated by the thermal insulation effect under th HVLs. The HVLs first move toward opposite directions each other by the whole mantle scale ($l = 1$) flow associated with the plume. When the HVLs travel away from the plume, for $c < 0.2$, the $l = 1$ flow weakens and no systematic movement of HVLs is found. However, in the case of $c > 0.2$, the $l = 1$ flow is maintained until the HVLs gather at the antipodal place, beneath which new plume emerges. These results suggest that the time scale of the survival of the plume is larger than that of the traveling of the HVLs to the antipodes for $c > 0.2$ and that the cyclic movement of the continents, i.e., breakup-dispersal-aggregation, may occur for $c > 0.2$. In the case of $c \sim 0.2$ with the phase transitions, there is almost no temperature difference between continental and oceanic parts. The HVLs meander on the mantle surface, being controlled mainly by the short scale horizontal flow in the upper mantle. Phase transitions of the mantle weaken the interaction between the HVLs and mantle convection.

T42A-0914 1330h POSTER

Convective Cooling of a Initially Stably Stratified Fluid with Temperature Dependent Viscosity

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Convective cooling of a stably stratified fluid with a strongly temperature dependent viscosity is important in understanding the thermal evolution of the oceanic upper mantle, cratonic lithosphere, and planets. Potential causes of compositional stratification are partial melting due to adiabatic decompression and magmatic differentiation.

In the absence of compositional stratification, we explore the relationship between temperature dependent viscosity and the onset time of convection and subsequent thermal evolution using 2D numerical experiments with secular cooling. For secular cooling after the initiation of convection, the viscosity ratio across the convecting thermal boundary layer (ctbl) evolves to nearly constant value independent of the temperature dependence of the viscosity comparable to that for volumetric heating. However in the initial stages of convection, this ratio is significantly larger and varies inversely with the temperature dependence of the viscosity.

In the presence of an initial stable compositional stratification, the convective motions in isoviscous fluids are initially restricted to a vertical scale proportional to $(\alpha\ \Delta T\delta/\gamma)^{1/2}$ where $\gamma=1/\rho(d\rho/dz)$ is the conductive lid thickness at the onset of convection and ΔT is the temperature across the convecting region. The onset of convection can be determined by a critical Rayleigh number, where relevant length scales are δ and the depth of the initial convective motions. The convective motions either decay in time leaving a relatively unmixed fluid or amplify to form a convecting mixed layer that grows in time. Thickening of the convecting region occurs by the penetration of subsequent downwellings (plumes) further into the underlying stratified fluid. Following buoyancy arguments, the amount of cooling is proportional to the convecting region thickness.

Initial numerical experiments with both temperature dependent viscosity and compositional stratification show behavior similar to the isoviscous experiments. There again exists a finite amplitude oscillatory mode of convection which transfers more heat than purely conductive cooling but introduces little to no chemical mixing. Mixed layer growth is expected to be controlled by the thickness and temperature difference across the ctbl.

T42A-0915 1330h POSTER

Time-dependent surface topography in a free surface crust-mantle convection model

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Most numerical models used to study mantle-flow induced dynamic topography include only a rudimentary lithosphere which usually does not participate in the dynamics of the system. We consider in more detail crust-mantle interactions during convection and in particular study the associated evolution of surface topography. The thermomechanical numerical model uses the arbitrary Lagrangian-Eulerian (ALE) finite element method and includes a free surface at the top of the solution space. A series of experiments are conducted wherein we test various temperature-dependent Newtonian and non-Newtonian rheologies in the convecting crust-mantle system. The results suggest that with the presence of a buoyant crust that is able to self-consistently deform in response to the underlying mantle flow, there can be a strong time-dependence to the surface topography. The behavior is sensitive to the relative strength of the crust compared to the underlying mantle, as well as the density of the crust.

T42A-0916 1330h POSTER

Three-Dimensional Numerical Simulation on Passively Excited Flows by Distributed Local Hot Sources Settled at the D" Layer Below Hotspots and/or Large-Scale Cool Masses at Subduction Zones Within the Static Layered Mantle

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To unveil dynamic process associated with three-dimensional unsteady mantle convection, we carried out numerical simulation on passively exerted flows by simplified local hot sources just above the CMB and large-scale cool masses beneath smoothed subduction zones. During the study, we used our individual code developed with the finite difference method. The basic three equations are for the continuity, the motion with the Boussinesq (incompressible) approximation, and the (thermal) energy conservation. The viscosity of our model is sensitive to temperature. To get time integration with high precision, we used the Newton method. In detail, the size and thermal energy of the hot or cool sources are not uniform along the latitude, because we could not select uniform local volumes assigned for the sources within the finite difference grids throughout the mantle. Our results, thus, accompany some latitude dependence.

First, we treated the case of the hotspots, neglecting the contribution of the subduction zones. The local hot sources below the currently active hotspots were settled as dynamic driving forces included in the initial condition. Before starting the calculation, we assumed that the mantle was statically layered with zero velocity component. The thermal anomalies inserted instantaneously in the initial condition do excite dynamically passive flows. The type of the initial hot sources was not 'plume' but 'thermal.' The simulation results represent that local upwelling flows which were directly excited over the initial heat sources reached

the upper mantle by approximately 30 My during the calculation. Each of the direct upwellings above the hotspots has its own dynamic potential to exert concentric down- and up-welling flows, alternately, at large distances. Simultaneously, the direct upwellings interact mutually within the spherical mantle. As an interesting feature, we numerically observed secondary upwellings somewhere in a wide region covering east Eurasia to the Bering Sea where no hot sources were initially input. It seems that the detailed location of the secondary upwellings depends partly on the numerical parameters such as the radial profile of mantle viscosity especially at the D" layer, etc., because the secondary flows are provoked by dynamic interaction among the distributed direct upwellings just above the CMB. Our results suggest that if we assume not only non-zero time delays during the input of the local hot sources but also parameters related with the difference of their historical surface flux rates, the pattern of the passively excited flows will be different from that obtained with the simultaneously settled hot sources stated above.

Second, we simultaneously incorporated simplified thermal anomaly models associated with both the distributed local hotspots and the global subduction zones, as dynamic origins in the initial condition for the static layered mantle. In this case, the simulation result represents that the pattern of secondary radial flows, being different from those in the earlier case, is sensitive to the relative strength between the positive dynamic buoyancy integrated over all of the local hot sources below the hotspots and the total negative buoyancy beneath the subduction zones.

T42A-0917 1330h POSTER

The History of the Pacific Superplume

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To understand the birth place and episodic activity of the Pacific superplume, we reconstructed the paleogeograhy of continents and oceanic plates from 1.0 Ga supercontinent Rodinia until now by adopting the most confident available data set to determine paleopositions of oceanic plateaus, seamounts, and oceanic arc, in addition to major continents, by using plate trajectory for the last 150Ma and for the farther back to 1.0Ga, by the paleomagnetic constraints tied with geologic connections. Our main focus is the frequency change of ancient activity of plume rocks that are now preserved in the accretionary complex around the circum-Pacific orogenic belts. Several conclusions are led through our reconstruction. (1) Cretaceous oceanic plateaus which present widespread in western Pacific (e.g., Manihiki Plateau, Shatsky Rise, Hess Rise, Mid-Pacific Mountain, Nauru Basin) are traced back and concentrated to the present active region of the Pacific superplume. This suggests that those were once formed a huge composite volcanoes as large as 4000 km x 2400 km across during the Cretaceous by superplume activity. These are equivalent to Australia or Tharsis bulge volcanic complex on Mars. The estimated thickness of oceanic crust ca. 30-40 km suggests that major parts may have been above sea-level during the Cretaceous time. The Cretaceous global warming may be related to this hyper-active superplume event which have carried mantle CO_2 to the surface of 3.2 x 10^{21} g, assuming 0.3 wt% x 350 million km^3 (magma volume) x 3.07 g/cm^3 during 150-75 Ma. This CO_2 output amount occupies as much as 37 wt% among the total output from mantle estimated by using erupted basaltic volume estimated by Larson (1991, Geology, 549-550) and present output rate of CO_2. The similar episodic activity of Pacific superplume seems to have occurred at 750-700 Ma, 550-500Ma, 300-250Ma by considering the frequency of occurrences of greenstones in the accretionary complexes of the world. (2) Rodinia rifted and separated at 750Ma on the similar latitude to present active region of the Pacific superplume. This suggests that Pacific superplume may be born at 750Ma to break-up supercontinent Rodinia to support the original idea by Maruyama (1994, J. Geol. Soc. Japan, 100, 24-49) as African superplume may be born at 250-200 Ma to break-up Pangea. (3) At 1000Ma, the Grenvillian orogens cemented amalgamated collisional continents to form the supercontinent Rodinia. This suggests that the large amounts of oceanic slab must have subducted along the Grenvillian sutures and might have caused the birth of Pacific superplume.

T42A-0918 1330h POSTER

Preliminary evidence for low S-velocity in the D" under the south Pacific superswell

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S-wave heterogeneity in the D" region under the South Pacific Superswell is examined using SKKS-SKS differential travel times observed by a temporary broad-band seismometer networks of the SPASE (Wiens, 1995) and a new permanent network of the SPANET (Ishida et al., 2000).

Seismograms of deep earthquakes in the south America were collected. SKKS-SKS differential travel times were measured by the cross-correlation between band-passed (10 s to 100 s) waveforms of SKS and SKKS on the radial component after correction of phase shift and polarity reverse. The residuals of the differential travel times were calculated with respect to PREM. The SKKS rays pass across the core-mantle boundary (CMB) under the receiver side distribute evenly around the central point of (30°S, 150°W) within 500 km radius, whereas those under the source side concentrate around the two points of (20°S, 100°W) and (35°S, 90°W). The SKKS-SKS residuals vary from 1 s to 6 s. This variation is reflected mainly the lateral variation of S-velocity under the receiver-side because that ray paths of SKS and SKKS under the source side are very close each other with respect to the wavelength.

The SKKS-SKS residuals, of which SKKS rays pass across the CMB in west of 150°W longitude lines, are around 2s consisted with prediction from 3D S-wave heterogeneity models of SKS12WM13 by Dziewonski et al. [1997] and S16U6L8 by Liu and Dziewonski [1998]. However, the SKKS-SKS residuals of which SKKS rays pass the CMB in east of 150°W longitude lines are approximately 4 s, and some ones reach to 6 s. They are much larger than those predicted by the above models. When the S16U6L8 are considered, the residuals of 3 to 5 s are remained. These SKKS passing points with the large positive residuals are distributed beneath the South Pacific superswell including the hot spots of Tahiti and Macdonald. S-wave heterogeneity models by SKS12WM13 and S16U6L8, SB4L18[Masters et al., 2000] and SAW24B16[Megnin and Romanowicz, 2000] do not show an extreme of a low-velocity anomaly in the D" region under this region, this is probably due to the lack of sampling. A new data set suggests strongly the existence of a very slow anomaly in D" region under the South Pacific superswell.

T42A-0919 1330h POSTER

A newly found fragment of Cretaceous oceanic Lip derived from Pacific superplume; an example from the Sanbagawa eclogite-peridotite mass in Shikoku, Japan

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It is well-known that the Pacific superplume has been episodically active to form a number of oceanic Lips in the Pacific. During the middle Cretaceous time, it has formed Ontong-Jawa, Caribbean plateau, Mid-Pacific seamount chains and others. Moreover, several accreted fragments of those equivalents have been recently recognized as accreted fragments in accretionary orogens around the Pacific rims. Here, we list up a possible candidate which appears as a small piece now but it must have been a huge one equivalent to Ontong-Java size.

The Cretaceous Sanbagawa belt in SW Japan is an accretionary complex metamorphosed at high-P/T conditions from 300-900°C and 0.5-2.6 GPa. We have recently completed a new lithotectonic map at 1:5000 scale for the highest grade areas, central Shikoku, with special attention on duplex structure and protolith occurrences. The mapped area consists of pelitic, basic and quartz schists with epidote-amphibolite facies grade, which enclose the Iratsu- and Higashi-Akaishi eclogite-peridotite masses. The eclogite-peridotite masses are composed of ultramafic rocks, eclogitic metabasites with basalt and gabbro origin, metacarbonate, metachert and pelitic gneiss (trench turbidite) in ascending order, and are divided into 4 horses consisting of those lithologies. These are separated on the top by the roof thrust and on the bottom by the floor thrust, indicating duplex. Based on duplex occurrences of oceanic materials within trench turbidite and reconstructed oceanic plate stratigraphy, we reconstruct the subduction polarity as always northwards, and directional change with time. The reconstructed oceanic plate stratigraphy suggests their origin of oceanic plateau covered by pelagic limestone with minor cherts on their flank before the arrival time at trench. The petrological thickness of plateau may exceed 30km, because high-pressure granulite facies assemblage remained in metagabbro in the Iratsu eclogite mass (Yokoyama, 1980), indicating huge oceanic plateau in origin. Moreover, the relative convergence motion of plate was estimated to be changed from NW to NE during the accretion of huge oceanic plateau.

The Cretaceous paleogeography in the Pacific Ocean, based on paleo-plate reconstruction and the accreted oceanic crusts and plateaus around the circum-Pacific orogenic belts, has drawn the huge composite volcanoes formed at South Pacific Superplume around the earliest Cretaceous, named 'Gossira continent' (Suzuki et al., 2000, AGU abstract). Our reconstructed oceanic plateau would have constituted a part of the Gossira continent.

URL: http://www.geo.titech.ac.jp/maruyamalab/f_maruyamalab.e.html

T42A-0920 1330h POSTER

Evidence of thick mantle transition zone beneath the Philippine Sea as inferred multiple-ScS waves recorded by new broadband network JISNET

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In 1997, we deployed a regional-scale broadband seismic network (JISNET) in Indonesia to elucidate seismic structure in the transition zone and uppermost lower mantle in the subduction zone and back-arc basin beneath around Indonesia.

Following Niu et al. [2000], we analyzed the ScS reverberated waves recorded at the JISNET, OHP and IRIS to investigate the thickness of the mantle transition zone beneath the Philippine Sea. We select the waveforms for a deep USSR - N.E. China boarder event (April 8, 1999). The thickness obtained at stations in western Indonesia is about 240 km, indicating that the thickness beneath the continental part of East and Southeast Asia is thinner than that of the IASP91 model. The thickness increases towards east and reaches 280-290 km for a corridor between the earthquake and the JISNET stations in eastern Indonesia, passing the western edge of the Philippine Sea. The thickness decreases towards further east to 260-280 km beneath the mid part of the Philippine Sea and about 260 km beneath the Izu-Bonin arc.

The high velocity anomaly in the transition zone obtained by the tomographic studies and the present result of the thick transition zone suggest that the transition zone beneath the Philippine Sea and Indonesian region are cooled possibly by cold slabs subducted from the Pacific Ocean, the Philippine Sea, and the Indian Ocean. Another possible cause of the thick transition zone arises from recent rock experiments, suggesting that the spinel in the transition zone can be a reservoir of water carried by subducted slabs and the hydrated spinel has wider stability range than dry spinel [Inoue et al., 1995]. The contribution of hydrated spinel to the thick transition zone is still to be studied.

T42A-0921 1330h POSTER

Short Wavelength Tomography as a Constraint on the Mineralogical Heterogeneity of the Subcrustal Lithosphere beneath Stable Continents

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A recurrent question when interpreting lateral variations of velocity in the lithosphere is to know if their origin is thermal or mineralogical. On a large scale, the 10-15% velocity variations deduced from tomography is explained by changes in temperature and by partial melting. For Jordan (1978), Archean cratons are chemically distinct from the oceanic mantle but mineralogy only explains 1-2% velocity changes. For stable regions, one way P-vertical travel times are 1.5s faster (6%) through a craton than through a Paleozoic platform. We present several examples of tomographic studies - from teleseismics and from surface waves - which are difficult to reconcile with a thermal interpretation, as if short wavelength and long wavelength tomography results were contradictory. In many sites, velocity changes laterally within 20-50km on the entire thickness of the lithosphere. Some of these sutures have been inactive for a very long duration. In the Western Urals, a contrast in velocity has been preserved over more than 1.5 Ga. From a refraction survey recording 2 distant events, Masson et al. (1998) report abrupt local velocity variations beneath the moho of the Iapetus suture in Ireland. Any temperature effect should be smoothed and should not be preserved over several hundred million years. At a small scale, the subcrustal continental lithosphere appears as an assemblage of 50-200 km wide blocks with 2-3% different velocity and sharp subvertical or tilted limits. Subcrustal anisotropy is difficult to measure; but anisotropy is preserved with age and introduces local asymmetry (Babuska et al., 1993). The widespread observation of sharp and permanent lateral velocity gradients within stable continents implies chemical heterogeneity. At a larger scale, the seismic characteristics of subcontinental lithosphere can be related to the age of the overlying continents. The oldest > 3 Ga cratons have 200-250 km lithospheric roots with very high velocity. Peridotite xenoliths from this lithosphere have compositions different from those from younger lithosphere, being composed of unusually Fo-rich olivine and abundant orthopyroxene. The low density and high viscosity of this assemblage results in a buoyant, rigid lithosphere that has survived since the formation of continents. The origin of this lithosphere is related to high temperatures in the Archean mantle and efficient processes that extracted the low-density residual phases produced during high-degree mantle melting from denser normal mantle minerals. The secular variation in the seismic and chemical character of the continental lithosphere is thus related to the progressive cooling of the mantle.

T42A-0922 1330h POSTER

Three-Dimensional Structure of the Upper Mantle Beneath Fennoscandia (Baltic Shield) by High-Resolution Teleseismic Tomography

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SvekalapkoSeismic Tomography Wkg Grp

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We present new tomographic images of the upper mantle beneath the Baltic Shield down to 400 km. The input dataset is composed of 5127 handpicked first P arrivals that were recorded at 146 evenly spaced recorders covering an area of 1000 km by 800 km. A three-dimensional crustal model was constructed based on controlled-source seismology experiments following the principle of simplicity in order to determine the traveltime effects produced by the crust. The model obtained is in good agreement with previously published crustal models with a maximum Moho depth of 64 km and an anomalous high velocity lower crust. The associated teleseismic traveltime differences range between +0.3 s and -0.4 s for P-waves when compared with the standard reference crustal model of IASP91. The crustal-corrected teleseismic traveltimes were then inverted for upper mantle structure maintaining the crust fixed. The results show P-wave velocity variations between -4 % to +4 % relative to IASP91. Anomalies associated with the NW-SE Proterozoic suture in the north (Karelian-Svecofennian) extend down to the lower lithosphere at 150 km depth. Another even more remarkable feature in the south is a SW-NE trending boundary that separates a fast velocity zone in the center of the study area from a negative anomaly area in the Ladoga region. At present, the tectonic origin and significance of this deep seated, rather strong lateral velocity variation beneath the craton is not yet known. According to the tomographic images, however, no seismic asthenosphere in P-wave velocities exists beneath the central part of the study region.

T42A-0923 1330h POSTER

Insights Into Baikal Rift Lithospheric Structures From Joint Gravity and Tomography Study

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The causes and the localisation of extension in the Baikal rift area still remain a source of debate. The lithospheric structures beneath this region are not well defined, though they could give strong constrains on the geodynamical scheme of this area. In this study, we propose a multidisciplinary method, based on joint inversion of gravity and teleseismic data, to improve our understanding of this continental break-up. This method, tested on numerous synthetic tests, is able to discriminate between several models, and is a way to reduce the problems of non-unicity and smearing effects in both gravity and seismological inversions.

Our work is based on previously teleseismic studies and gridded gravity data. The first interpretation of teleseismic data seems to enlight an asthenospheric upwards just beneath the rift, whereas the results of various studies are not so conclusive about such a feature. We correct the gravity data from effects of outside structures and sediments, which are important in the central part of the rift. We first reprocess teleseismic and gravity inversion seperatly, with different initial models. Second, the combination of both data sets in a joint inversion is proceeded with an initial model deduced from geological and geophysical informations. We present here the preliminary results.

T42A-0924 1330h POSTER

Solubility of Water in Lower Mantle Minerals

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Water in the Earth's interior plays key roles in geodynamics since the presence of water dramatically influences the physical properties (ca. viscosity and melting temperature) of the mantle. It is well accepted that dense hydrous magnesium silicate (DHMS) phases, hydrous wadsleyite and hydrous ringwoodite are candidates for water reservoirs in the mantle. However, the possible sites for water in lower mantle minerals have been controversial. The lower mantle is believed to consist predominantly of Mg-perovskite with 20% magnesiowustite and Ca-perovskite by volume. To elucidate the water contents in these phases leads to an understanding the most promising strage site of hydrogen in lower mantle.

We measured the abundance of hydrogen in Mg-perovskite, magnesiowustite, and Ca-perovskite synthesized in the natural peridotitic composition. The synthesis was made at a pressure of 25.5 GPa and at temperature of 1600-1650 C* in a multi-anvil apparatus. Hydrogen measurements in three phases were performed with SIMS. SIMS measurements showed that both Mg-perovskite and magnesiowustite contain about 0.2 wt% H2O, and Ca=perovskite contains about 0.4 wt% H2O. We have also confirmed the OH absorption bands in Mg-perovskite and magnesiowustite by using FT-IR. Solubility of water estimated from IR measurements were consistent with that of SIMS analyses. These amounts are much higher than the previous estimates for the same minerals but with simple end-member compositions. It can be deduces that chemical impurities such as Al or Fe would promote the solubility of water in these phases dramatically.

Our results suggest that the lower mantle can potentially store considerable amounts of water. When the capacity of water in three phases is integrated over the mass of the lower mantle, the total mass of water is about 5 times that of seawater. This amount is comparable to that in the transition zone. The high solubility of water in representative lower mantle minerals also has implications for the rheological properties of the lower mantle.

T42A-0925 1330h POSTER

In-Situ X-ray Measurements of the Phase Relation of Antigorite

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The stability of antigorite (serpentine) in subducting lithosperic mantle is of great geological significance, for example, in relation to origins of arc magmatism (Ulmer & Trommsdorff, 1995) and of intra-slab double seismic zone (Seno & Yamanaka, 1996). In the model MSH system, one important invariant point (IP hereafter) defined as coexistence of antigorite, phase A, enstatite, forsterite and water occurs at P = 4-6 GPa, T = 550-600°C. From this IP, 5 univariant reaction curves radiate. The phase boundary Fo + H_2O (low P) = phA + En (high P) originates from this IP toward higher P-T side. For subducting slab, higher temperature side of this IP is occupied by dry region (no hydrous mineral is stable), whereas lower temperature side is hydrous region (phase A is stable). The fate of hydrated slab peridotite in deeper mantle depends on this IP. If the geotherm passes to lower T side of that IP, water would be transported into mantle transition zone. Therefore, the accurate position of this IP should be determined. However, the previous experimental results on antigorite stability (Ulmer & Trommsdorff, 1995; Wunder & Schreyer, 1997; Bose & Navrotsky, 1998) show large discrepancies in pressure. The discrepancy reaches to 2 GPa on the position of the IP. This may be due to the difficulty in pressure calibration at low temperature (below 600°C) and/or the differences in the compositions of antigorite as starting materials. Solving these problems, we operated high P-T in-situ experiments at SPring-8 (Japan) to determine the accurate phase relation of antigorite, particularly the location of the IP. Pressure-temperature conditions are 4.0-9.0 GPa and 520-800°C. The starting materials were both synthesized Mg-end and natural (MgO: 43.56, Al_2O_3: 1.86, FeO: 1.65, Fe_2O_3: 1.52, SiO_2: 43.56 wt.%) antigorites. Equation of state of NaCl (Decker, 1971) was used as a pressure scale. First, we determined the breakdown curve of antigorite. The results of two kinds of antigorite starting composition showed no difference. Antigorites were stable up to 6.5 GPa at 520°C and decomposed at 6.5 GPa, 550°C and at 4.0 GPa, 600°C. Second, the phase boundary Fo + H_2O = phA + En were bracketed. This reaction curve is almost linear and has a compositional dependence. This boundary in Mg-end composition locates at lower pressure than in natural composition and the Clapeyron slope in Mg-end composition of 10.52 MPa/K is steeper than that in natural composition. The intersection of antigorite breakdown curve with the reaction Fo + H_2O = phA + En defines the IP. The IP is concluded to be located at 5.5 GPa, 550°C in Mg-end composition and 6.8 GPa, 530°C in natural composition.

T42B MC: Hall D Thursday 1330h

Structure and Evolution of the Galapagos Volcanic Province II *(joint with OS, S, V)*

Presiding: **J P Canales,** Woods Hole Oceanographic Institution**; K S Harpp,** Colgate University

T42B-0926 1330h POSTER

The Influence of the Galapagos Hotspot on the Development of the Cocos-Nazca Spreading Center

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