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 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.

T41C-0873 0830h POSTER

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.

T41C-0874 0830h POSTER

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

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After more than 100 m.y. of continuous subduction, only small parts of the Farallon plate are still subducting below the northwestern U.S. and central America today. Under the southwestern U.S. a window in the subducting plate has been forming since the Pacific-Farallon ridge reached the trench about 30 Ma. Due to the young age of the last parts of the Farallon plate and its high rates of subduction it has been proposed that much of the slab in the upper mantle would have thermally equilibrated. However, seismic tomography has imaged high velocity anomalies in the transition zone below the southwestern U.S. not far from the previous location of the trench. Our objective is to determine the strength and possible location of the seismic anomalies associated with Farallon subduction based on thermal modeling and the plate tectonic history. The location of the slab in the upper mantle is not easy to predict as its path through the mantle is unknown and it may have deformed and/or broken after subduction of the ridge. However, a composite image of the velocity models of Van der Lee and Nolet (1997) and Grand (1997) shows anomalies that are continuous from the upper to lower mantle. Assuming a continuous and not internally deformed slab, the material at the top of the lower mantle would have been subducted around 40 Ma. A three-dimensional thermo-kinematic model for such a slab shows that in spite of the young age, most of the subducted Farallon plate should still have a thermal signature. At 200 km depth, thermal anomalies range from about -800^{o}C in the currently still subducting part of the plate to 0^o in the slab window. At deeper levels, including the transition zone, thermal anomalies of -200^o to -500^{o}C are preserved which is sufficient for a resolvable seismic velocity anomaly. A comparison of the volume of upper mantle slab material imaged seismically and the volume thermally modeled will allow us to determine whether the material subducted since 40 Ma is sufficient to account for the large-scale anomalies in the transition zone, or whether significant internal deformation of the slab is required.

T41C-0875 0830h POSTER

Slab Detachment, Flat Subduction and Slab Rollback in Central Mexico: Fitting the Neogene Evolution of the Trans-Mexican Volcanic Belt into the History and Dynamics of Subduction

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I present a comparative analysis of the volcanic record of the Trans-Mexican Volcanic Belt (TMVB) and the plate tectonic history since 16 Ma in central Mexico that has important implications for the dynamic of the Cocos-Rivera subduction system. The TMVB volcanism has occurred in episodes characterized by across-arc and along strike variation and/or migration. In its first stage (16 to 10 Ma) the TMVB consisted of a broad andesitic arc emplaced between Long. 102° and 97°30$'$ (central Mexico). During this period volcanism was absent in the western and eastern TMVB. Between 11 and 6 Ma a voluminous mafic volcanism was emplaced to the northof the previous arc with ages progressively younger from west (Tepic-Guadalajara) to east (Queretaro-Hidalgo). Large calderas and silicic dome complexes developed in latest Miocene and early Pliocene (7.5 to 3.5 Ma) west of the Taxco-San Miguel de Allende fault system (TSMA). East of the TSMA a volcanic gap is clearly observed between ~9 and 3.5 Ma. In the western TMVB small amount of lavas with an intra-plate affinity started to be emplaced since 5 Ma. At the same time the volcanic front migrated to the south by about 70 km. East of the TSMA volcanism resumed at about 3.5 Ma in the Mexico City region and at the end of Pliocene in the eastern TMVB (excluding the Palma Sola area). In the Toluca Mexico City area the volcanic front migrated trenchward in the Quaternary. No southward migration of the volcanic front is observed in the eastern TMVB. The Middle Miocene volcanism represent a normal volcanic arc developed after a gap of ~15 Ma following the formation of the Acapulco trench. I propose that the following unusual volcanic evolution was controlled by the detachment of the deeper part of the Cocos slab and the resulting variation in slab inclination. Slab must have detached after 12.5 following the end of subduction off Baja California. This is a kinematic-dynamic requirement, also supported by the fact that the present seismic slab is short. The slab detached from the Gulf of California toward the ESE from ~12 to 7.5 Ma producing a migrating mafic pulse along the propagating tear. Once deprived by its deeper part the slab started to decrease its dip, due to the buoyancy of the young crust. This is the most likely cause for flat subduction of the Cocos plate. No oceanic plateau is obvious on the mirror image on the Pacific plate and the absence of a subducted thickened crust explains why there is no seismic coupling between the two plates and no shortening occurred in the upper plate. The ~9 to 3.5 to volcanic gap in the central TMVB marks the period of flat subduction of the Cocos plate. Indeed, Pacific-Cocos relative motion decrease by 70% after 10 Ma. Flat subduction delays the basalt/gabbro to eclogite transition for some Ma. However the resuming of volcanism in late Pliocene indicate that the leading edge of the Cocos plate completed its transformation to eclogite and started to rollback. The slab rollback enhances the advection of geochemically enriched material into the mantle wedge, which is the most likely cause for the occurrence of intraplate-type volcanism in the TMVB.

T41C-0876 0830h POSTER

In Situ Determination of the Growth Rates of Wadsleyite During the Phase Transformation of San Carlos Olivine

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The growth rates of wadsleyite during the phase transformation of olivine to its high-pressure polymorph are key parameters in modeling the extent of metastable olivine in subducting slabs. Previous measurements have been mainly conducted on analog materials. We report here the first in-situ determination of the growth rates of wadsleyite in natural (Mg, Fe)$_2SiO_4$ system.

The experiments were carried out using T-cup devices coupled with synchrotron radiation at beamline X17B1 of NSLS and beamline 13-BM of APS. The powdered olivine sample and pressure standard (NaCl mixed with BN) were dried in a vacuum oven for several hours prior to loading. The pressure medium for experiments was a MgO octahedron. Four experiments have been performed at different pressure and temperature conditions. In all runs, the sample was first compressed to about 12 GPa at room temperature and annealed at 1200-1250 $^\circ$C in the olivine stability field for at least two hours. After the annealing stage, temperature was decreased to 550 $^\circ$C and kept constant while pressure was gradually increased to the target value. No reaction was observed during the compression stage. Temperature was then increased rapidly to induce the phase transformation. Diffraction data were collected every 2 to 5 minutes while temperature and pressure load remained constant. The relationship between the volume fraction transformed, which was estimated from the integrated intensities of diffraction peaks, and the reaction time was obtained for each run taking into account the decay of synchrotron current during experiment. The data can be explained well by grain boundary nucleated transformation with very high nucleation rates. The growth rate of wadsleyite in each run has been obtained: (4.78 $\pm$ 0.05) x 10^{-11} m/s at 1050 $^\circ$C and 14.7 GPa; (2.52 $\pm$ 0.06) x 10^{-10} m/s at 1110 $^\circ$C and 15.1 GPa; (1.29 $\pm$ 0.09) x 10^{-9} m/s at 1160 $^\circ$C and 15.6 GPa; (3.85 $\pm$ 0.13) x 10^{-9} m/s at 1207 $^\circ$C and 15.7 GPa.

The growth rates of wadsleyite determined in the current study are significantly lower than those previously calculated based on data for analog materials. If assuming the same transformation mechanism applies in the subduction zones, one could expect even larger metastable wedges than previously suggested in subducting slabs consisted predominantly of olivine.

T41C-0877 0830h POSTER

Seismic Structure of the Uppermost Mantle Near the Kamchatka-Aleutian Junction

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At the Kamchatka-Aleutian junction a transcurrent plate boundary connects at the right angle to a steeply-dipping subduction zone. The state of the Pacific slab edge at the junction, and its relation to present-day tectonics and volcanism remains poorly understood. It is particularly important to understand whether this junction evolved by steady-state processes, or whether subduction in the northwestern Pacific has changed recently. Both hypotheses depend on an understanding of past and present tectonics in the vicinity of the Kamchatka-Aleutian junction: e.g., in the Sea of Okhotsk, the Kamchatka Isthmus, and the Komandorsky Basin.

We present a new shear-velocity model of the crust and uppermost mantle beneath and adjacent to Kamchatka peninsula, from joint inversion of broad-band surface-waves and teleseismic body wave receiver functions. We use data from a recent portable broadband seismic deployment in Kamchatka, together with data from permanent seismic stations in the region. Inclusion of receiver function parameters in the surface-wave inversion reduces the uncertainty of the final results.

Some noteworthy features of the new model are: 1) A high-velocity Vs anomaly (+2% relative to global average) in the mantle beneath southern Kamchatka, corresponding to shallow subducted oceanic lithosphere. In our inversion of surface-wave dispersion data the shape and geometry of the subducted slab anomaly are not affected by the distribution of local seismicity. 2) Low (4.3 km/s) upper mantle velocities beneath Kamchatka. A pronounced low-velocity feature (-5% relative to global average) is located in the shallow mantle beneath the northern part of the peninsula. 3) A relatively thin high-velocity lid underlain by low-velocity asthenosphere beneath the Sea of Okhotsk and the Komandorsky Basin, consistent with a recent extension.

According to our new model, the uppermost mantle of the Kamchatka peninsula appears to be mobile, and shows no evidence of a pre-existing continental fragment. Lateral variation in mantle structure from south to north beneath the Kamchatka peninsula is consistent with recent (last 5 Ma) rearrangement of the subduction geometry. Specifically, a pronounced low-velocity feature northwest of Kamchatka-Aleutian juction likely delineates a region where an influx of asthenospheric material followed the cessation of subduction and the progressive loss of the slab under northern Kamchatka.

T41C-0878 0830h POSTER

Upper Mantle Deformation Beneath Intraoceanic Island Arcs: the Talkeetna arc, South Central Alaska

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We are investigating the behavior of the upper mantle beneath the accreted intraoceanic Talkeetna arc, south central Alaska, using U-stage measurements, electron back-scatter diffraction, and thermobarometry. The objectives of this study are to characterize the deformation conditions (pressure, temperature, and H2O activity) of the uppermost, subarc mantle. This information can be used to i) aid in the interpretation of the seismic anisotropy beneath active magmatic arcs worldwide, ii) assess whether a gravitationally unstable lower crust or mantle lithosphere delaminated beneath the Talkeetna arc, iii) constrain the mechanisms by which the Talkeetna arc was accreted onto the Alaska margin in the mid to Late Cretaceous.

Exposures at the base of the arc near Tonsina provide a unique transect from residual upper mantle harzburgites and dunites upward through mixed websterites and dunites, into cumulate garnet-bearing gabbros. Pressures were calculated using Al net-transfer reactions between garnet and orthopyroxene and garnet and clinopyroxene in gabbronorites immediately overlying the mantle section. Determinations of 850-1000 MPa indicate a maximum crustal thickness of 25-30 km.

At least two types of deformation fabrics (lattice-preferred orientation) are present in samples from a transect through the 2 km thick peridotite section; deformation accommodated by slip on (010)[100] and (001)[100]. The (010)[100] fabric is similar to those observed in many natural environments. The (001)[100] fabric is much less commonly reported, but similar fabrics have been observed in other peridotites that were interpreted to deform under high temperature conditions (e.g., Tommasi et al., 2000). Neither of these fabrics are similar to those reported by Jung and Karato (2001) for experimental samples deformed in the presence of H2O, however, the activation of mixed (010)[100] and (001)[100] glide may imply the presence of H2O derived from devolatilization of the slab subducting beneath the arc.

T41C-0879 0830h POSTER

Trace Element Features of Subduction-Related Metasomatism from Ultramafic Xenoliths of the Kamchatka arc

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Ultramafic xenoliths from Shiveluch and Kharchinsky volcanoes in Kamchatka appear to provide a unique opportunity to directly observe the effects of subduction-related metasomatism on depleted mantle peridotite. At Shiveluch Volcano, the common xenolith type is a tectonized dunite that contains abundant kink-banded olivine and displays textural variation from protogranular to porphyroclastic and mosaic equigranular. These xenoliths are cut by millimeter-scale veins and are invaded by irregular spots of metasomatic pyroxene and phlogopite (+/- trace amphibole). At nearby Kharchinsky Volcano, the hydrous, metasomatic mineral in the deformed dunite xenoliths is amphibole. All samples are enriched in the light rare-earth elements (REE), with La/Yb from 1.80 to 14.8-times chondritic. Samples with low REE concentrations have concave-upward heavy REE patterns (low Dy/Yb), similar to published data on harzburgite and dunite xenoliths interpreted to be the highly depleted residue left after fractional melting. The most strongly metasomatized xenoliths (based on phlogopite abundance) have relatively high concentrations of incompatible elements and light REE-enriched patterns similar to those in common volcanic rocks from oceanic arcs (e.g., La/Yb=3.5 with Dy/Yb=2.1). Trace element ratios such as Ba/La, Th/La and Ba/Th are widely variable in the xenoliths (e.g., Ba/La=5-100), but most samples fall within the range of common arc rocks (Ba/La= 25-50; Th/La=0.08-0.14; Ba/Th = 250-500). In contrast, relative Sr concentrations in the xenoliths are low (e.g., Sr/Nd=5-21) compared to common arc rocks (Sr/Nd = 20-60). Most of the preliminary trace element data thus appear to support recently reported 3He/4He and CO2/He observations (N. Basu et al., 2001, GSA annual meeting) which point toward subduction-related fluids as the likely metasomatic agent in the dunite xenoliths from Shiveluch and Kharchinsky volcanoes, Kamchatka.

T41C-0880 0830h POSTER

Experimental Study on Fluid Distribution at Ultra-High Metamorphic Conditions

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Ultra-high pressure (UHP) metamorphic rocks record deep subduction of continental crust. Insight into their rheological behavior at UHP metamorphic conditions is important for the understanding of the mechanical state and the kinematics within subduction zones. Amazingly, many exhumed UHP metamorphic rocks do not show evidence of significant deformation. Thus, it has been proposed that deformation is localized in low-strength zones controlled by partially wetting interstitial fluids [1]. Experimental results [2] show that at UHP metamorphic conditions only one homogenous fluid phase with variable composition exists, whose density and viscosity should be intermediate between those of conventional aqueous solutions and hydrous melts. Inclusions of such supercritical fluid have been recently described from a natural UHP metamorphic rock [3].

Motivated by these findings, experiments using a piston-cylinder apparatus were performed to study the fluid distribution in various rock types at pressures of 3.5 GPa and temperatures between 900 °C and 600 °C. Starting materials were natural UHP metamorphic specimens of (1) S-type granitic biotite-phengite-gneiss and (2) pyrope-quartzite, both from the Dora Maira Massif (Western Alps, Italy) and (3) a diamond-bearing garnet-mica-gneiss with granodioritic bulk composition from the Saxonian Erzgebirge (Germany), all with 2 wt.% water added. The supercritical fluids formed in these experiments can be quenched to form a silicic glass with demixing of an aqueous solution without changing the UHP fluid topology significantly. The shape of the fluid-filled interstices is irregular and complex, resulting in a low volume/interface area ratio and a potential of high stress concentration at the edges of wedge-shaped offshoots.

We propose that the distribution of supercritical fluids has a pronounced effect on the strength of cool subducted crust, allowing deformation by grain boundary sliding and dissolution precipitation creep, or granular flow with grain shape accommodation by material transfer via an intergranular fluid [4], possibly localized in specific rock types.

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T41C-0881 0830h POSTER

Adakites Along Oceanic Transforms ?

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Pliocene-Pleistocene adakite-type trachytes and dacites from Papua New Guinea are among those classically referenced as typical melts from subducting oceanic crust, yet their origin by subduction zone processes is controversial. Unclear is, if the Lusancay Islands are due to melting of the presumably subducting Solomon microplate beneath the Indo-Australian Plate, or if they are associated with rift processes as they occur along the trace of an oceanic transform fault zone linked to a propagating rift-system (Woodlark Rift). They are temporally associated but spatially separated from island-arc type volcanoes. Even if the Lusancay Islands may be melts from presently subducting oceanic crust, the Aird Hills dacites are not as they are located remotely from any active convergent plate margin. Another problem arises from their high LREE contents, as geochemical modelling requires a more evolved source than oceanic basalt or disequilibrium melting. Given the ambiguous tectonic setting of these rocks, we propose that dacites/trachytes with adakite-like geochemical characteristics may be produced by rift-related melts encountering eclogite fragments while rising through a previously subduction modified mantle. Own trace element modelling indicates that explaining their low Yb and most of the high La contents requires small partial melting degrees (less than 10 vol. percent) of an eclogite source (30-42 vol. percent garnet). Reheating and melting of remnant slab eclogite "frozen" in enriched subduction-modified mantle may explain both the geochemical characteristics and occurrence in a propagating rift-system. Rift-related leaky oceanic transfer faults may have provided pathways for these ascending melts. The presence of such slab remnants is consistent with rapid creation and destruction of oceanic microplates since Mesozoic times. Earlier studies on ophiolites documented trondhjemitic rocks along oceanic paleotransforms, explaining their occurrence in non-convergent tectonic regimes nearby MORB- and OIB-magmatic suites. We will test our model at a field campaign starting March 2002 and the results may challenge existing models on Archean crustal growth as adakites are inferred to be modern analogues of Archean crust.

T41C-0882 0830h POSTER

Spatial Variation of Mantle Characteristics Beneath the Izu-Bonin arc -Constraints from High-precision Pb Isotopic Study-

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New high precision Pb isotopes measured by Tl spike and Pb double spike multi-collector ICP-MS are presented from the back-arc region of the Izu-Bonin arc. This oceanic arc has a broad volcanic zone aligned N-S along the northeastern margin of the Philippine Sea plate. This arc exhibits wide variation in volcanotectonic features in both along- and across-arc directions. Both the northern and middle sections of the arc have back-arc seamount chains extending for over 150 km in an ENE-WSW direction. However, back-arc rifting occurs only in the middle part of the arc.

Systematic along-arc variation in magma chemistry is a notable feature of the Izu-Bonin frontal arc and back-arc region. In contrast to Sr isotopes, which are more radiogenic in the north, Pb isotopes are less radiogenic in the north compared to the middle part of the arc. This is particularly apparent in the back-arc seamount chains. Decoupling of Pb and Sr isotopes implies that along-arc variation of Pb isotopes is not dominated by slab-derived fluid which controls the variation of Sr isotopes. The lack of correlation of Pb isotopes with sediment signatures (e.g., Th/Nb) rules out the possibility of significant involvement of subducted sediment to the source mantle. Along-arc variation of Pb isotopes implies the along-arc mantle heterogeneity.

Each back-arc seamount chain forms a consistent trend in which the Pb isotope ratios decrease (i.e. become less radiogenic) towards the back-arc. However, each seamount chain has distinct Pb-Nd and Pb-Pb isotope trends. This is difficult to explain in terms of slab-derived fluid component. Our interpretation is that the difference between these trends is due to heterogeneity of source mantle rather than heterogeneity of the slab-derived component. Hence, each seamount chain might correspond to a specific zone of melt production with an isotopically distinct mantle source on which slab-derived component is superimposed.

T41C-0883 0830h POSTER

A New Parameterization of Hydrous/Anhydrous Melting For Use in Numerical Models of Magma Genesis in Subduction Zones

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The chemistry of arc lavas imposes important constraints on the dynamics of the subduction process. To relate arc chemistry to dynamics, however, requires models that can calculate coupled solid/fluid flow and chemical transport in the mantle wedge. These models, in turn, depend on an accurate and computationally efficient description of wet melting of mantle peridotite. Here we present a new parameterization for both hydrous and anhydrous melting of mantle peridotite and show results of some simplified model calculations using this parameterization.

The parameterization is of the form $F = F(P, T, X, M)$ where F is the degree of melting and P, T, X, and M are the pressure, temperature, bulk water content in weight percent and modal clinopyroxene of the system, respectively. It incorporates features suggested by recent thermodynamic models of melting and observed in experiments. These include: 1) isobaric productivity, $\frac{\partial F}{\partial T}|_{P,X,M}$, that is a monotonic increasing function (*i.e.* $F(T)$ is concave upwards), 2) discontinuous changes in productivity due to phase exhaustion (particularly cpx-out), 3) a degree of melting that increases nearly linearly with increasing bulk water content (but the rate of increase is temperature dependent), 4) a reduction in solidus temperature with the addition of water that extends the "low-F tails" to lower temperatures. The parameterization is calibrated against a compilation of current experimental results on hydrous and anhydrous melting. However, the significant variability between experiments (many nominally at the same conditions) precludes the use of direct inversion techniques. We compare our parameterization to the full experimental database as well as other parameterizations and thermodynamic models and discuss their differences. Finally, we use it to calculate melting curves for isentropic upwelling columns, and are beginning to incorporate it into 1-D reactive melt-transport models with applications to arcs.

T41C-0884 0830h POSTER

A Large Range of Sr and Nd Isotope Ratios in a Small Deep-Crustal Exposure of the Cretaceous Cordilleran Arc, Implications for Arc Magma Evolution

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Deep crustal terranes of arc origin are rare in the Cordillera but are important in developing a full understanding of continental lithospheric composition, evolution, and magmatism. This report emphasizes the results and implications of Sr and Nd isotopic work in a broader study of the Salinian Western Block aimed at understanding lower crustal processes in continental arcs. Located in the Santa Lucia Mountains near Big Sur, California, the Salinian Western Block contains the deepest exposures of the Salinian Terrane, a large allochthonous Mesozoic granitic body with a predominantly quartzo-feldspathic metasedimentary framework. The isotopic characteristics and ages (~110 Ma to ~76 Ma) of widespread granitic magmatic products in the Salinian basement suggest an origin as a west-facing arc which straddled the cratonic margin (Mattinson, 1990). The Western Block is located near the center of Salinian arc reconstructions and underwent extensive intrusion and deformation from at least 104 Ma (Mattinson, 1978) to later than 92 ± 3 Ma, a new orthogneiss U/Pb zircon age. Thermobarometric estimates indicate peak temperatures of 700-800 degrees at 7-8 kbar in the small (~10^2 km) study area near Cone Peak.

Two small and relatively undeformed gabbros ($^{87}Sr/^{86}Sr$ .7072 to .7089) and a quartz diorite ($^{87}Sr/^{86}Sr$ .7060 to .7074, ϵNd 1.2 to -2.4) are interpreted as the youngest Western Block intrusions in the study area. Together with a large pyroxene tonalite (~104 Ma, Mattinson, 1978; $^{87}Sr/^{86}Sr$ .7068 to .7092, ϵNd -1.7 to -6.8) in the Western Block 30 km to the northwest, these rocks display a wide range of $^{87}Sr/^{86}Sr$ (.7060 to .7092) and ϵNd (1.2 to -6.8). The isotope ratios show no overall correlations with La/Yb or major oxides such as SiO_2 and MgO and span a range similar to the entire reported range for Salinian granitoids in the Central, Northern and Western blocks (.7057 to .7092 and -4.4 to -9.6 respectively; Mattinson, 1990). Our results reveal that the deep crust of the arc was isotopically and compositionally heterogeneous at a very fine scale and suggest that a more complex model is needed to explain the generation of Salinian magmas than simple mixing between a primitive, mafic end member and a continental crustal end member.

T41C-0885 0830h POSTER

Understanding Island Arc Evolution Through U/Pb and $^{40}Ar/^{39}Ar$ Geochronology of the Talkeetna Arc, South-Central Alaska

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Mineralogy, geochemistry, and field relations suggest that the Talkeetna section, south-central Alaska, is an accreted Jurassic intra-oceanic arc. The section includes ultra-mafic to intermediate composition rocks and extends from below the crust-mantle boundary (Moho) up through surficial volcanic flows. The rare exposures of middle and lower crust provide an opportunity to examine the processes of by which island arcs form, evolve, and morph into continental crust. This study focuses on the geochronology of the Talkeetna section to constrain crystallization history and the evolution of the thermal history. Understanding the crystallization history of the arc will help constrain rates of crust formation, and characterizing the thermal history of the Talkeetna arc will lend insight into such issues as whether P-T conditions might have favored the phase transformations necessary to trigger lower crustal delamination.

We have begun $^{40}Ar/^{39}Ar$ and U/Pb dating of an extensive suite of metamorphic and magmatic rocks that span a range of geologic settings and relative ages within the Talkeetna arc. Two amphibolites, a spinel pyroxene hornblende norite and a hornblende quartz diorite yield $^{40}Ar/^{39}Ar$ ages of 171.7 ± 2.2 Ma, 181.5 ± 1.8 Ma, 177 ± 8.6 Ma, and 181.6 ± 0.9 Ma (2 sigma uncertainties), respectively. These ages overlap with, and range to slightly younger than, seven existing $^{40}Ar/^{39}Ar$ hornblende ages of 175-181 Ma, indicating a ~10 Myr span over which different parts of the arc cooled through hornblende closure to Ar loss. Our new sensitive high-resolution ion microprobe (SHRIMP) zircon analyses of a granodiorite, a hornblende gabbro and the same hornblende quartz diorite sample discussed above yield crystallization ages of 186 ± 3 Ma, 190.4 ± 2.3 Ma, and 194.1 ± 1.9 Ma (2 sigma uncertainties), respectively. These dates indicate an ~8 ± 4 Myr range in crystallization ages that is similar to some other exhumed intra-oceanic arcs, but notably shorter than the lifetime of the Mariana arc, for example. The difference between the zircon and hornblende ages–considering either only the hornblende quartz diorite or the entire suite of samples–imply approximately ~12 Myr of post-magmatic cooling to temperatures of ~500 C. Analyses to resolve whether this interval resulted from protracted, single stage cooling following the end of arc magmatism, or whether the $^{40}Ar/^{39}Ar$ ages reflect reheating by an as yet undated magmatic event are in progress.

T41C-0886 0830h POSTER

Chemical versus temporal controls on evolution of tholeiitic and calc-alkaline volcanoes in the Aleutian arc

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The Aleutian arc is characterised by adjacent tholeiitic and calc-alkaline volcanoes and there is debate as to the origin of this magmatic diversity. Possible explanations include a progression from tholeiitic to calc-alkaline volcanism through time as the plumbing system matures thermally and chemically or tectonic control on chemical affinity in response to varying ambient stress regimes along arc segments. These models imply that tholeiitic magma systems have shorter crustal residence times and less complex differentiation paths than calc-alkaline ones. Alternatively, it has been argued that contamination is important in calc-alkaline differentiation. In this study we compare magmatic evolution and time scales at Akutan, a tholeiitic oceanic volcano, with Aniakchak, a calc-alkaline volcano from the continental sector.

Whole-rock Sr isotopes vary little in the tholeiitic Akutan suite (0.7034-0.7035) but at Aniakchak, Sr isotopes increase from 0.7032 to 0.7035 with increasing differentiation, suggesting that assimilation processes were more important for calc-alkaline evolution. Given evidence for similar source regions, the Aniakchak lavas may represent smaller melt fractions than the Akutan lavas. The Akutan lavas have up to 20 per cent U-excesses consistent with fluid addition whereas the Aniakchak lavas straddle the equiline, some having Th excesses which may reflect melting effects. However, U-Th disequilibria do not vary with silica in either suite. In contrast, Ra-excesses decrease from 10 per cent excesses to 6 per cent deficits as silica increases at Akutan, and from 4 per cent Ra-excesses to 15 per cent deficits at Aniakchak. This is consistent with the time scale of differentiation of moderate-volume magma bodies being on the order of thousands of years. The transition from Ra excesses to deficits requires plagioclase fractionation and means the inferred time scales are maxima. Thus, the data suggest that the role of contamination is more critical than differentiation time scales in determining whether magmas follow a tholeiitic or calc-alkaline differentiation path in the Aleutian arc.

T41C-0887 0830h POSTER

Contrasts in Subduction Signal Between Southeastern and Northwestern Nicaragua

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The slab signature exhibits a robust regional variation in Central America with a maximum in central Nicaragua. The Nicaraguan arc segments southeast and northwest of this maximum contrast in both slab and sediment signals. Southeastern Nicaragua shows a strong gradient in slab signal while the northwest retains a high slab signal. Low-Ti samples from the southeast display a variation in total subducted sediment signal contrasting with northeastern samples, which have a continuously high subducted sediment signal but show an apparent mixing between hemipelagic rich and poor sediments. High-Ti lavas from the two segments have distinctly different U/La contents both from each other and from their low-Ti counterparts. The southeast has lower U/La than both the its low-Ti counterparts and northwestern samples while Ba/Th remains fairly constant. The northeast shows similar U/La and lower Ba/Th compared to its low-Ti counterparts. It may be that the high-Ti lavas of the northwest have interacted with a metasomatic fluid rich in U/La whereas the southeastern lavas have not. Differences in subduction components may explain signal contrasts. The southeastern segment has a persistent hemipelagic component regardless of a weak or strong slab signature while the northwestern segment is highly variable in its hemipelagic component with a continuously high slab signature.

T41C-0888 0830h POSTER

Genetic linkage between calc-alkalic andesites and continental crusts: contributions from NE Japan

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The occurrence of two types of andesites, calc-alkalic and tholeiitic, typifies magmatism in subdcution zones. Examination of geochemical characteristics of those andesites in the NE Japan arc and the bulk continental crusts reveals marked compositional similarity between calc-alkalic andesites and continental crusts. One of the principal mechanisms of calc-alkalic andesites, at least those on the NE Japan arc, is mixing of two magmas, having basaltic and felsic compositions and being derived from partial melting of the mantle and the basaltic crust, respectively. It may be thus suggested that this process would also have contributed greatly to continental crust formation. If this is the case, then the melting residue after extraction of felsic melts should be removed and delaminated from the initial crust in order to form ?andesitic? crust compositions. These processes are examined by geochemical modeling of dehydration, partial melting, and fluid-solid reactions, suggesting that such processes can explain both the major and trace element compositions of the andesitic bulk continental crust. Isotopic modeling further shows that an inferred pyroxenitic delaminated component produced at 3-4 Ga possesses Sr-Nd-Pb isotopic compositions similar to those of the EMI reservoir in the mantle. Continental crust formation and complementary accumulation of the EMI reservoir in the deep mantle may thus have taken place simultaneously in Archean subduction zones.

T41C-0889 0830h POSTER

Pb Isotopic Ratios in Volcanic Rocks From ODP Leg 195, Site 1201, West Philippine Basin

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Site 1201, ODP Leg 195, was drilled in the West Philippine Basin, ~ 100 km west of the Palau-Kyushu ridge at latitude 19 degrees North. The cored section included ~ 400 m thick sequence of volcaniclastic turbidites overlying a section of basaltic pillow lavas. Based on basalt petrography and trace element geochemical affinities, the lower unit is interpreted as West Philippine basin basement, while the volcaniclastic sequence formed from debris shed from the early Izu-Bonin-Mariana (IBM) island arc to the east. Site 1201 lies on Chron 21, suggesting the basement age may be as old as 49 Ma.

Pb-isotope ratios were determined for 9 basement basalts and 3 large clasts. Excluding two samples, basement basalts have a narrow range of variation: 17.87-18.18 ($^{206}Pb/^{204}Pb$), 15.45-15.52 ($^{207}Pb/^{204}Pb$) and 37.7-37.9 ($^{208}Pb/^{204}Pb$). These values are similar to those of basalts recovered from DSDP Site 447 in the West Philippine basin floor to the southwest. Two of the basement samples and the three arc derived clasts have higher and more scattered Pb-isotope ratios. The new data show that even early formed West Philippine basin floor basalt typically has an "Indian Ocean" rather than a "Pacific Ocean"-type Pb-isotopic character. Pb-isotopic compositions of the clasts overlap with

values reported for volcanic rocks from other early IBM arc locations.

T41C-0890 0830h POSTER

New Ages on Old Arc Rocks, Preliminary Results From the Southern IBM Arc

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The first results of our reevaluation of the geochemistry and geochronology of Eocene to Miocene volcanic rocks from the southern Izu-Bonin-Mariana (IBM) arc include preliminary $^{40}Ar/^{39}Ar$ ages on rocks from Guam, and DSDP sites 447, 448, 458, 459B. Our new $^{40}Ar/^{39}Ar$ age of 44 Ma on a boninite series basalt from the Facpi formation, supports earlier work by Meijer et al. (1983, AGU Mono. 27, p349) who obtained a 44 Ma K-Ar age on a similar basalt from the same area in western Guam. Our $^{40}Ar/^{39}Ar$ age of 20 Ma age on a tholeiite dike in the southern portion of the Facpi formation is in the range of K-Ar ages in Cosca et al. (1998 Is. Arc 7 p.579) and Meijer et al. (1983) of 36 Ma to 16 Ma for the Facpi. These ages are younger than the Late Middle Eocene age assigned to the Facpi, and indicates either that a previously unrecognized unit of tholeiitic arc volcanics exists in southern Guam, or that zeolite facies metamorphism reset the ages. If the former is true, then this unit has ages within the gap in arc volcanism previously postulated for the late Oligocene and early Miocene on Guam. Our preliminary results on DSDP cores when combined with $^{40}Ar/^{39}Ar$ and K-Ar dates from Cosca et al. (1998,), and older K-Ar ages from Meijer et al. (1983) suggest that tholeiitic to boninitic volcanism occurred at site 458 and perhaps 459 to east of Guam at about 50 Ma. Similarly, Cosca et al. (1998), showed that volcanism along the Palau-Kyushu ridge dates back to about 50 Ma. Thus, magmatism appears to have occurred around 5 Ma later on Guam than to the east and west, which is consistent with a center of Eocene forearc spreading near Guam. A single preliminary $^{40}Ar/^{39}Ar$ age of 20 Ma for a relatively intact diabase at site 447 and dates reported in Fujioka et al., (1999, Geology 27, p.1135) and Hickey-Vargas (1998 JGR 103, p. 20963) presents the possibility that volcanism continued in the West Philippine Basin into the early Miocene.

T41C-0891 0830h POSTER

Crustal transect of the Kuril arc-trench system -Results from the onshore-offshore wide-angle seismic study-

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The Kuril Trench is the oblique convergent boundary located in the northwestern margin of the Pacific plate. The Kuril arc collides with the northeastern Japan Island arc northwest of the Kuril Trench. Historic great earthquakes were generated repeatedly along the trench. These events are attributed to the subduction of the Pacific plate beneath the overriding North American plate. However, little is known about the deep crustal structure down to the Kuril subduction seismogenic zone. To obtain a complete image of the seismogenic zone, an onshore-offshore wide-angle seismic survey was performed from the Kuril Trench to the sea of Okhotsk through the northeastern Hokkaido (the Kuril arc). In June-August of 2000, JAMSTEC and Univ. of Tokyo performed a seismic survey across the Kuril arc-trench system using R/V KAIYO and KAIREI of JAMSTEC. Forty-six ocean bottom seismographs (OBS) (3.6km interval in the Pacific ocean; 12km interval in the sea of Okhotsk) and seventy-four land stations (1.5-2km interval) were deployed along a 500 km long profile. The multi-channel seismic (MCS) reflection data were acquired using a 156-channel hydrophone streamer (ca. 4000m long). We used a 200 liter airgun array as controlled source. They were shot every 50m for the MCS survey and 150 m for the wide-angle survey. Four explosives (300kg x 2, 100kg x 2) were blasted on land. From the OBS data of the Pacific Ocean, the crustal structure down to the depth of about 25km shows the subducting oceanic crust, the sedimentary wedge and the Kuril island arc crust. This profile was selected to across the presumed coseismic rupture zone of the 1973 Nemuro-oki earthquake (M7.4). Comparing the rupture zone with the crustal model, it is obvious that the coseismic rupture had occurred deeper than the island arc upper crust. Moreover, the thickness of the crust beneath the sea of Okhotsk can be estimated to be about 20 km. A problem to be solved hereafter is to reveal the structural image of the asperity of the great earthquakes, and formation process of the Kuril arc-trench system combining results of the onshore-offshore seismic survey.

T41C-0892 0830h POSTER

A Slice of Intra-oceanic Arc: Insights from the First Multichannel Seismic Reflection Profile Across the South Sandwich Island Arc.

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Seismic reflection profiling across modern arc-trench systems can provide important evidence relating to strain regime and the balance between accretion and erosion. The South Sandwich island arc is a classic intra-oceanic arc in the southernmost part of the Atlantic Ocean. The arc is situated on the small Sandwich plate, which is overriding the South American plate at the South Sandwich Trench at about 80 mm/yr.

A 600-km-long multichannel seismic (MCS) reflection line provides a first cross-section of the entire South Sandwich subduction system from the outer rise in the east to the western flank of the backarc basin. This line was collected as part of the Sandwich Lithospheric and Crustal Experiment (SLICE). The MCS data show that the 27-Myr-old oceanic crust east of the southern part of the trench has a sediment cover up to 200 m thick, but that there appears to be almost no sediment fill in the trench. The outer forearc slope is draped by a sediment apron which increases in thickness towards the trench. An accretionary wedge extends less than 20 km from the trench. A fairly continuous reflection beneath the outer forearc slope and accretionary wedge probably represents the top of subducted oceanic basement. The outer forearc slope has a stepped appearance. In particular, a 1.2-km-high fault scarp and 20-km-wide arcward tilted block east of a mid-forearc high suggest that the outer forearc is subject to large-scale rotational block faulting.

Earthquake focal mechanisms from the Harvard centroid moment tensor catalogue associated with well-located hypocentres within a 100-km-wide corridor centred on the MCS line suggest extensional faulting in the mid-forearc to a depth of 17 km. In contrast, neither the MCS data nor earthquake data show any evidence of extensional faulting affecting the arc itself. Therefore extension in the forearc is probably caused by gravitational instability resulting from subduction erosion of the outer forearc, rather than by regional stress affecting the Sandwich plate as a whole. These observations indicate that sediment subduction and subduction erosion are important processes at the South Sandwich Trench.

T41C-0893 0830h POSTER

Isotopic Characteristics of Basalts From the Central Basin Fault, West Philippine Basin

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The Central Basin Fault (CBF) of the West Philippine Basin (WPB) marks the location of an extinct seafloor spreading center that was disrupted by shearing and amagmatic extension. Basaltic rocks recovered from the rift by dredging and Shinkai 6500 submersible have K-Ar and Ar-Ar ages as young as 26-28 Ma and 15 Ma and probably include the final products of magmatism related to the Central Basin spreading center. The relationship between this spreading center and early arc magmatism along the Izu-Bonin-Mariana arc is an important question.

Nd and Pb isotopic ratios of basalts from the CBF are similar to those found in older West Philippine Basin basalts and they have the same "Indian Ocean" isotopic signature that characterizes basin basalts from throughout the Philippine Sea plate. $^{143}Nd/^{144}Nd$ varies from 0.51294 to 0.51308 and Pb isotope ratios are: $^{206}Pb/^{204}Pb$ = 18.15-18.62, $^{207}Pb/^{204}Pb$ = 15.47-15.57 and $^{208}Pb/^{204}Pb$ = 37.80-38.63. The Pb isotope ratios span a range from low values similar to normal MORB-like WPB basalts to high values typical of highly incompatible element-enriched, OIB-like basalts from the Benham Rise. However, Pb isotopic ratios are not coupled with incompatible element enrichment among the CBF basalts. Instead, there is an apparent geographic pattern, with higher $^{206}Pb/^{204}Pb$ in basalts from westernmost sites, near the junction of the Benham seamount chain with the CBF, and lower values in basalt from the easternmost site near the Palau-Kyushu ridge, a remnant of the early Izu-Bonin-Mariana arc. The decoupling of trace element and isotopic ratios may indicate that late stage magmatism involved generation and extraction of small melt volumes resulting in extreme fractionation of trace elements.

T41C-0894 0830h POSTER

Mantle Inputs to the Subduction Factory: Detailed Studies of the Southern Mariana Seamount Province

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The southern Mariana Arc system has been studied intensively, with a focus on volcanoes along the magmatic arc and associated cross-chains. Sonar backscatter imagery of about 50,000 square kilometers imaged 28 submarine volcanoes of the Mariana arc system that had not been previously studied. We also imaged the spreading axis of the Mariana Trough from 13o45 to 17 o 30, about half the length of this slow-spreading ridge.

Our survey of 450 km along the arc magmatic axis, from 13 o 30N to 17 o 20N, indicates that these volcanoes vary widely in volume, from a third to 1000 km3. The average volcano from along the Mariana magmatic front is spaced 20km from its neighbor, is built on a platform that lies at 1800m below sealevel, rises 1000m above this platform, and occupies a volume of about 200 cubic kilometers. Lavas collected from 24 edifices along the magmatic front include abundant basalt and dacite; we also collected several cumulate gabbroic xenoliths. Phenocryst phases are dominated by plagioclase, olivine, pyroxene, and hornblende. Five of the volcanoes in the study area the islands of Guguan, Sarigan, and Anatahan, and the submarine edifices of S. Ruby and Esmeralda are active. Other volcanoes are extinct, and our study shows that, to a first approximation, the smaller the edifice, the less likely it is to be active. Some extinct edifices have flat summits at depths that range from 40 to 300 m which are capped with coral, or, farther north in the study area, shelly material or carbonate sand.

A major cross-chain of small volcanoes along 14 o 40N was studied and sampled for the first time. These volcanoes yielded a range of lavas, from basalt to dacite. Volcanoes from another cross-chain, extending along 17 o 20N latitude west of Guguan, yielded only basalt. Shorter cross-chains were also studied in the Diamantes and near Sarigan.

We recovered abundant pumice from 6 volcanoes in the northernmost 100km of the arc and one volcano in the south. Each volcano yielded a homogeneous and compositionally distinctive suite. This fact, coupled with the large size and angular shape of pumice blocks, indicates that these pumice hauls are in situ. These dredges were made at depths of 800 to 1700m, indicating that vesiculation to form pumice can happen when felsic lavas erupt at relatively high pressures. These hauls also reinforce the idea that felsic magmas are a much more important part of the Mariana arc system than previously appreciated.

Sampling in the back-arc basin spreading axis recovered fresh glassy basalts from ridge segments shallower than 4000m but was largely unsuccessful for deeper

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ridge segments, where the igneous basement appears to be buried beneath sediments. Serpentinites and metagabbros were recovered from rift wall exposures near 14 o 36N.

Geochemical characteristics (including fluid inclusion studies) of the back-arc and associated arc and cross-chain compositions will be used to examine hypotheses for mantle flow under the arc system.

T41C-0895 0830h POSTER

Seafloor Spreading in the Southern Mariana Trough Inferred From 3-component Magnetometer Data

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The Mariana Trough is an active backarc basin in the western Pacific, but its detailed tectonics are not yet fully understood. We collected 3-component magnetometer data and MR-1 bathymetry and other geophysical data during COOK06 and COOK07 legs of the R/V Melville cruise in the southern Mariana Trough in February and March 2001, which reveal new details of the extensional tectonics.

Although magnetic anomalies from volcanic arc seamounts interfere near the eastern end of the Mariana Trough, we could identify Brunhes (0-0.78Ma) and Gauss (2.60-3.58Ma) normal-polarity chrons, Matuyama reversed-polarity chron and Olduvai subchron (1.87Ma) in Z-component magnetic anomaly profiles between 17°30'N and 14°N in the eastern half of the trough. The seafloor spreading in this area is approximately in an E-W direction, and its initiation was probably older than the Gauss/Gilbert boundary (3.58Ma). The calculated half spreading rate for the eastern half is generally 1.5-1.7 cm/yr with a slightly higher rate of 2.5 cm/yr at about 15°N. The bathymetry from the MR-1 system suggests that recent spreading is propagating northward from about 14°N. We interpret that two Brunhes positive anomaly zones with apparent average half spreading rates less than 1 cm/yr run parallel between 14°10'N and 14°45'N: the eastern dying zone and the western propagating zone. The spreading rate of the eastern zone increases northward to 2.9 cm/yr at about 15°N, while that of the western zone also increases southward to 2.8 cm/yr at 13°50'N.

We also collected data in the southwestern part of the trough at about 13°N. Here, the spreading is in a NW-SE direction, and the half spreading rate is about 3.0 cm/yr. The spreading probably began during Gauss normal-polarity chron at about 3.0 Ma, because the Gauss/Gilbert boundary was not observed.

An ENE trending trough with depths greater than 5000 m occurs at about 12°20'N just south of the West Mariana Ridge. No lineated magnetic anomalies were observed there. This trough is probably still in an amagmatic extensional stage.

T41C-0896 0830h POSTER

Anelastic Mantle Structure beneath the Northern Philippine Sea from Phase Pair Method

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Anelasticity of the mantle provides important constraints on its dynamics, in complement to elasticity, however, studies of lateral variation in attenuation are few, especially at short periods.

In this study, we determine the body wave attenuation structure of the mantle beneath the northern part of the Philippine Sea. Elastic tomography studies [e.g. van der Hilst et al., 1991; Fukao et al., 1992] show a stagnant Pacific lithosphere just above the 660 km discontinuity in this region. This stagnation was caused by the trench retreat due to the back arc spreading during the past 17 - 30 Ma [Seno et al., 1993; van der Hilst, 1995; Shito and Shibutani, 2001]. Anelastic properties of the mantle and lithosphere may play important roles in the interaction of the slab and mantle of this area.

To study the attenuation structure, we examine the difference of the observed attenuation between P and S waves. The S-P phase pair method measures $\delta t^{\star}$ using the differential spectral decay between S and P waves arriving at the same station, assuming a constant Q_α/Q_β over the frequency band of 0.5 to 1.25 Hz.

We use 20 earthquakes in the Izu-Bonin slab which were recorded at 43 broad-band stations of the J-array and FREESIA networks in Japan. About 700 phase pairs are used to invert for the 2-D attenuation structure.

The resultant preliminary Q model shows the local variations of attenuation in the subduction zone. The slab is imaged as a low attenuation area ($Q_\alpha > 1000$), while Q_α values in the range of 100 - 350 are found in the mantle wedge.

T41C-0897 0830h POSTER

Constraints on the Dip of the Anisotropic Symmetry Axis Beneath Japan From Shear Wave Splitting

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Shear wave splitting is widely used as a tool to characterize deformational signatures in the upper mantle. However, we nearly always make the simplifying assumption that the axis of symmetry of the anisotropy is horizontal, which may not always be correct. Due to the nearly vertical incidence angles of the SKS phases typically used in splitting studies, the dip of the symmetry axis is difficult to characterize. However, if phases with varying angles of incidence are used, constraints may be placed on the dip of the symmetry axis. Splitting measurements made on upgoing shear waves with different incidence angles should exhibit discrepancies if the axis of symmetry is not horizontal. Therefore, recordings of SKKS, S, and ScS phases in addition to SKS may be used to constrain the dip of the axis of anisotropic symmetry. Japan is an excellent candidate region to potentially exhibit such discrepancies; deformation associated with the subduction beneath Japan could reasonably be expected to produce a dipping axis of symmetry. In addition, Japan is favorably located with respect to suitable source regions and data from several dense broadband seismic networks are available.

We examine data from several high-quality, low-noise stations from the FREESIA network, a network of 62 broadband stations in Japan. We search for good recordings of events in the 0°-60° distance range for ScS, from 40°-80° for S, from 90°-130°for SKS, and beyond 105° for SKKS. Only deep (>200km) events are used for S and ScS to eliminate contamination from source-side anisotropy. The multichannel method of Chevrot (JGR 2000) is used to determine splitting parameters (ϕ, δt) at each station for each phase. Splitting parameters are determined from the azimuthal dependence of the splitting intensity; the method is therefore limited by the azimuthal coverage. Japan has relatively poor azimuthal coverage for SKS and SKKS, and this limits the usefulness of the multichannel method for this dataset. Splitting parameters for SKS and SKKS phases may also be determined using the method of Silver Chan (JGR 1991). Azimuthal coverage for deep events in the distance ranges associated with S and ScS, however, is quite good and this favorable coverage makes Japan a good place to carry out such a study. We investigate the discrepancies between measured splitting parameters for S, ScS, SKS, and SKKS. We will present preliminary results of the modeling of such discrepancies in terms of a dipping axis and discuss to what extent this can be explained by the presence of a dipping slab.

T41C-0898 0830h POSTER

The Upper Mantle Velocity Structure Beneath the Sea of Okhotsk

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We use Rayleigh-wave tomography to explore the velocity structure of the upper mantle beneath the Sea of Okhotsk. The Sea of Okhotsk is a complex geologic region, frequently defined as an independent plate, with large variations in crustal structure and an unresolved tectonic history. Upper mantle tomography provides constraints on the tectonic evolution of a region by imaging fast and slow velocity anomalies associated with structures that may result from recent tectonic activity (i.e. remnant slabs). Using long-period waveforms recorded by IRIS, Michigan State University, and the Northeast Interdisciplinary Scientific Research Institute, we find the best-fitting multi-mode synthetics along a variety of regional source-receiver paths. The multi-mode synthetics produce path-averaged velocity profiles that act as model parameter constraints when the paths are combined and inverted to produce a 3-D tomographic model.

Our model shows high and low-velocity anomalies, primarily associated with the modern slab and mantle wedge. Both anomalies vary vertically and laterally as the angle of the Wadati-Benioff zone changes. In general, the depth to the Moho discontinuity in our model agrees well with the interpretation of refraction and reflection surveys in this region (e.g. Pavlenkova, 1996). Thicker crustal structures and a deeper Moho boundary are present in the shallow central and northeastern portions of the Okhotsk Sea, while the Moho is shallower in the Kuril Basin. Measurements of residual travel times for multiple ScS waves agree with the velocity structure of the 3-D model. We find positive (slow) residuals in the central portion of the Okhotsk Sea, and negative (fast) residuals in regions where the modern slab is present. The most negative (fastest) ScS residual is located north of Sakhalin Island. As revealed by the 3-D model, this fast residual appears to be the result of a shallower Moho depth and a high-velocity zone extending down from approximately 150 km depth. This high velocity anomaly corresponds with similar anomalies interpreted as remnant slabs from earlier subduction of the Okhotsk plate west of the modern subduction zone (Gorbatov et al., 2000). A high spectral ratio measurement of Q_{ScS} further supports the possible existence of a remnant slab in the upper mantle of this region.

T41C-0899 0830h POSTER

A Detailed Waveform Modeling for Remarkable Upper Mantle Phases of Receiver Functions Observed at a Broadband Station TMR, Northeast Japan

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We are examining receiver functions observed at a large number of broadband and short-period stations closely installed over the whole Japan Islands to reveal the detailed structure of the crust and the upper mantle including velocity discontinuities through waveform tomography. The number of stations amounts to more than 500. So far we have got receiver function imaging of crust and upper mantle structure using a large number of depth migrated receiver functions. Now, we are constructing the 3-D velocity structures from these receiver function images. In this study, we present a detailed waveform modeling of receiver functions observed at a broadband station TMR, northeast Japan, whose receiver functions have several remarkable phases and provide us with rich information on the upper mantle velocity discontinuities. Beneath this station, the Pacific slab is subducting westwards with a dip of 20 degrees at a depth of 80 km. Therefore we need to consider a model including inclined layers for waveform modeling. For this purpose, we use a generalized ray theoretical approach. First targets for modeling are strong PS converted phases at the upper and the lower boundaries of the descending Pacific slab. These phases have delay times dependent on azimuths, which clearly support the PS conversion phases at the inclined slab boundaries. The amplitudes are also dependent on azimuths, but the dependence is completely different from the synthetics based on a model including the 20 degrees inclined slab with the thickness of 80 km. But, in this modeling of waveforms, we did not consider the attenuation structure. Consideration of the low-Q structure in the mantle wedge portion would solve this problem. Second, we can see remarkable phases originating from the upper mantle discontinuities at depths of 410, 520 and 660km. Based on the waveform modeling, we conclude that the 410 one is very sharp and has

strong velocity contrast. The 520 is rather weak but clearly recognized. The 660 km discontinuity does not seem to be a single discontinuity but seems to be separated into two or three ones. Several multiple converted phases can be usually seen in the receiver functions, which produce false images or artifacts. However, the comparison of the observed with the synthetic receiver functions confirms that the image of multiple discontinuities around 600 km can be real.

T41C-0900 0830h POSTER

Distribution of Attenuation Factor Beneath the Japanese Islands

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In this research, we tried to estimate the distribution of attenuation factor of seismic wave, which is closely related to the above-mentioned inelastic parameters. Here the velocity records of events from the Freesia network and the J-array network were used. The events were selected based on the following criteria: (a) events with JMA magnitudes from 3.8 to 5.0 and hypocentral distance from 20km to 200km, (b) events with JMA magnitudes from 5.1 to 6.8 and hypocentral distance from 200km to 10?, (c) Depth of all events is greater than 30km with S/N ratio greater than 2. After correcting the instrument response, P-wave spectra were estimated. Following Boatwright (1991), the observed spectra were modeled by the theoretical spectra by assuming the following relation; Aij(f) = Si(f) Pij(f) Cj(f). Brune's model (1970) was assumed for the source model. Aij(f), Si(f), Pij(f), and Cj(f) are defined as observed spectrum, source spectrum, propagation effect, and site effect, respectively. Frequency dependence of attenuation factor was not assumed here. The global standard velocity model (AK135) is used for ray tracing. Ellipticity corrections and station elevation corrections are also done. The block sizes are 50km by 50km laterally and increase vertically. As the results of analysis, the attenuation structure beneath Japanese Islands up to the depth of 180km was reconstructed with relatively good resolution. The low Q distribution is clearly seen in central Hokkaido, western Hokkaido, Tohoku region, Hida region, Izu region, and southern Kyushu. The relatively sharp decrease in Q associated with asthenosphere can be seen below the depth of 70km.

T41C-0901 0830h POSTER

Receiver Function Imaging of Crust and Uppermost Mantle Structure beneath the Japan Islands -Inclusion of Hi-net Data-

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We are examining a large number of teleseismic waveforms observed at stations closely distributed over the Japan Islands to construct body-wave waveform tomography data for determining 3-D crust and upper mantle structure including velocity discontinuities. As one of preparatory studies toward this final goal, we are executing array analyses of Receiver Functions (RF). RF analyses of J-array data (32 broad band stations and 269 short period stations) and Freesia data (15 broad band stations), whose stations are closely distributed, have provided us with new information on the structure including velocity discontinuities beneath the Japan Islands (Tada et al, 2001). In their study, for crustal imaging, RFs transformed from time to depth domain after SVD filtering (Chevrot and Giardin, 2000) are projected onto 2-D profiles, which show average values for cells within ±50km from each cross section. However, this cell size does not satisfy our demand to draw the detailed image beneath the Japan Islands. In addition, J-array short period RFs available for the analyses are limited because of high frequency noises.

In this research, Hi-net data (short period), whose stations are far more closely distributed, are newly included into our data. We make RF image with $\alpha = 3$ of short period J-array data and Hi-net data for events observed during a period from September, 2000 to July, 2001 with the magnitudes larger than 5.5. The total number of the stations with their average spacing of 10km is about 800 (J-array; 270, Hi-net; 500), which enables to reduce the cell size to ±20km at most. We show a new 3-D RF image of the crust and the uppermost mantle, whose best spatial resolution is reaching less than 5km. Therefore we can obtain much more detailed 3-D RF image beneath the whole Japan Islands.

T41C-0902 0830h POSTER

Stress Fields Along Okinawa Trough and Ryukyu Arc Inferred From Regional Broadband Moment Tensors

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Most shallow earthquakes along Okinawa trough and Ryukyu arc are relatively small (M<5.5). Focal mechanism estimations for such events were difficult due to insufficient dataset. However, this situation is improved by regional broadband network (FREESIA). Lower limit of magnitude of the earthquakes determined becomes 1.5 smaller in M_w than that of Harvard moment tensors. As a result, we could examine the stress field in more detail than Fournier et al.(2001, JGR, 106, 13751-) did based on surface geology and teleseismic moment tensors. In the NE Okinawa trough, extension axes are oblique to the trough strike, while in SW Okinawa trough, they are perpendicular to the trough. Fault type in SW is normal fault and gradually changes to mixture of normal and strike slip toward NE. In the Ryukyu arc, extension axes are parallel to the arc. Although this feature is not clear in the NW Ryukyu arc, arc parallel extension may be a major property of entire arc. Dominant fault type is normal fault and several strike slips with the same extensional component are included. The volcanic train is located at the edge of arc parallel extension field faced A simple explanation of the arc parallel extension is the response to the opening motion of the Okinawa trough. Another possible mechanism is forearc movement due to oblique subduction which is enhanced in SW. We consider that the Okinawa trough and the Ryukyu arc are independent stress provinces.

T41C-0903 0830h POSTER

3D Wave Effects of Sources inside Subduction Zones

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Subduction zones (SZ) contain the largest earthquakes on Earth. Knowledge of their structural details not only is important for hazard assessment but also for the understanding of the dynamics of subduction and mantle convection. The structure of SZs may show strong lateral variations in seismic velocities and contain - on top of the overall positive velocity anomaly - low velocity zones (LVZ). These heterogeneities may severely alter the seismic waves radiated from large ruptures inside the seismogenic zone. Ignoring these effects may lead to errors in determining location, magnitude and source parameters for deep subduction events. Therefore, 3D large scale modelling is a useful tool to simulate the seismic wave field for such cases and their effects observable at the surface. A finite- difference solution to the elastic wave equations in spherical coordinates based on a high-order staggered-grid approach was developed and implemented on a large supercomputer. The physical model is limited to a spherical section centred around the equator thereby omitting problems with the singularities in the wave equation. Comparison with analytical solutions showed that wave propagation can be accurately modelled for epicentral distances up to 60 degrees. We simulate waves emanating from sources inside a simplified slab structure with and without low-velocity layers on top of the slab. The ground motion for dip-slip point sources situated inside the low velocity layer is significantly influenced as a function of azimuth compared to layered models (PREM) or models without LVZ. Secondary body waves are initiated by the low velocity channel and may propagate as guided energy within this layer. Synthetic seismograms from receivers located circularly around the source reveal phases reflected from the top of the slab towards the back-arc region at high azimuths. Wave field visualization is used to depict and interpret the observed effects.

T41C-0904 0830h POSTER

Three-dimensional P and S wave velocity structure of the Alaskan subduction zone

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The three-dimensional P and S wave velocity structure of the Alaskan subduction zone, to depths of 200km, is determined with nearly 300000 P wave and 140000 S wave first arrival times from 14129 earthquakes, recorded by 67 stations around the Cook Inlet, and operated by the AEIC, AVO and USGS. First-arrival times are calculated using a finite-difference technique, which allows for flexible parameterization of the slowness model and easy inclusion of topography and source-receiver geometry. The three-dimensional P wave velocity structure and hypocenters are determined simultaneously, while the three-dimensional S wave velocity model is determined using the relocated seismicity and an initial S wave velocity model derived from the P wave velocity model assuming an average Vp/Vs ratio of 1.78. The most prominent feature observed in both three-dimensional velocity models is a northwest dipping, high-velocity anomaly that aligns with the seismicity of the Wadati-Benioff zone and is interpreted to be the Pacific Slab subducting beneath the Cook Inlet. Significantly lower velocities at depths 40-70 km, adjacent to the subducting slab, are attributed to melting of mantle-wedge peridotites, caused by fluids liberated from the subducting oceanic crust and sediments.

T41C-0905 0830h POSTER

Regional faulting associated with the southern Alaska orocline

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Among the most prominent physiographic features of southern Alaska are a series of nested arcuate lineations, including the Denali fault, that parallel the convex-southward coastline of the state. These features are generally interpreted as major dextral shear zones that respond to stresses imposed on the western edge of North America by transcurrent motion and oblique subduction of the Pacific plate past the North American plate. Southcentral Alaska consists of a collage of Paleozoic and Mesozoic tectonostratigraphic terranes and overlap assemblages. Following obduction to the continent, these terranes were transported northward along the continental margin via strike slip faults like the ancestral Denali fault that formed by oblique subduction. They would have arrived approximately at their present position by Eocene time. It is commonly held that soon after, southern Alaska rotated into its present configuration in response to impingement of northeast Asia on western Alaska. Subsequent to this rotation, during middle and late Tertiary time, southern Alaska terranes were presumably transported through the Alaska orocline due to continued dextral movement along faults like the Denali and Tintina. Both the initial bending of the crust to form the orocline, and subsequent advection of crust through the orocline would result in significant shortening within parts of the bend. We suggest that this shortening is accommodated along secondary northeast trending thrust faults, resulting in a distinct pattern of uplift. An example of this is the pronounced uplift in the Mt. McKinley region in the central Alaska range. The distribution of northeast trending faults shows a consistent pattern within the bend: the faults appear to splay off, or near the major dextral shear zones and generally occur west of the axis of the Alaska orocline. That these faults occur where deformation would be greatest as crust advects through the bend, suggests that the faults are directly related to crustal dynamics within the bend. Faults like the Talkeetna (TK) and West Fork (WF), generally considered major sutures formed during accretion of the Wrangelia and Peninsular terranes to North America in the Mesozoic, fall within this family of 'west-limb', northeast trending faults. They may, therefore, have rotated into a position favorable to accommodate strain, and thus reactivated in the Cenozoic in response to bending. The present northeast trend of faults like TK and WF may be primarily dynamic features whose trends are related to the geometry of the bend, plate dynamics, and crustal deformation. This interpretation does not preclude the formation of these faults along pre-existing sutures, but does suggest that their present trends mainly result from dynamics within the bend to accommodate confining stresses.

T41C-0906 0830h POSTER

Preliminary results of a high-resolution seismic imaging investigation on St. Paul Island, Pribilof Islands, Alaska

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St. Paul Island, one of the Alaskan Pribilof Islands, is located in the Bering Sea about 1100 km WSW of Anchorage, Alaska. Geologically, St. Pauls nearsurface lithology consists of basaltic lava flows and sills, with minor amounts of glacial sediments. To better understand the subsurface structure of St. Paul island, the U.S. Geological Survey acquired a series of high-resolution seismic imaging profiles across the island in June, 2000. The longest seismic profile is approximately 1.8-km-long and trends ENE. Shot and geophone spacing was 5 m, recorded with 162 channels. Seismic sources were generated using a Betsy Seisgun in ∼0.3 m-deep holes. Approximately 2 s of data were recorded at a 0.5-ms sampling rate. Our study was designed to investigate the relationship between groundwater flow, basement rocks, and faults on St. Paul Island in an attempt to mitigate the effects of subsurface chemical contaminants. Seismic velocities range from about 500 m/s in the near surface to about 5000 m/s at varying depths, some of the high velocity layers appear as shallow as 40 m below the surface. The reflection data show a thin vaneer of sediments overlying layered basalts. Layered basalts vary in thickness from about 5 to 40 m near the surface, and these layers are faulted in places. The groundwater supply for St. Paul is derived from a shallow-depth water table that is, in places, a mixture of seawater and freshwater (Anderson, 1976). Vertical and lateral flow of ground-water is affected by the depth to basement rocks, which are believed to be largely impermeable and thus restrict the flow of ground-water. In addition, a series of observed faults that have vertically displaced basement rocks may act as barriers or as conduits to the flow of ground-water. In unconsolidated sediments, the ground-water table typically has velocities of ∼1500 m/s. Using this velocity criteria, our data suggest that the ground-water table varies between 0 and 25 m depth along the profile. This result was supported by well log data.

T41C-0907 0830h POSTER

Crustal Thickness Across the Alaska Range

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Subduction of the Pacific plate beneath the North American plate dominates the tectonics of southern and central Alaska. One expression of this convergence is the Alaska Range, including Mount McKinley, the highest point in North America. The Broadband Experiment Across the Alaska Range (BEAAR) three year data acquisition phase is now complete. BEAAR utilized IRIS/PASSCAL instrumentation for thirty-six closely (∼ 10 km) spaced broadband stations along roughly north-south and east-west lines. The large quantity of data produced provides ample opportunity to examine the structure and tectonic setting of the Alaska Range. This study uses teleseismic receiver function analysis to determine Moho depths beneath the Alaska Range.

Teleseismic events recorded in 1999 and 2000 were processed individually, and events with similar back-azimuths were stacked to reduce noise and enhance phase information. Synthetic receiver functions were generated for each station using plane layered models, and Moho depths were determined using minimum root-mean-square misfits between data and synthetics. Moho depths from stacked traces range from 34 km deep north of the range, to 46 km deep beneath the heart of the range, and in general show crustal thickening beneath the mountains. In addition to the Ps conversion from the continental Moho, we also observe a conversion from the subducting Pacific plate. This slab phase can be correlated across the southern portion of the network, where the mantle wedge gradually pinches out. To incorporate as many events as possible, including the most recent data and smaller events, we are automating BEAAR receiver function analysis. Our automation efforts include quality control to eliminate anomalous receiver functions, and smoothed plots showing azimuthal variations beneath stations.

T41D MC: 309 Thursday 0830h

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

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

T41D-01 0830h INVITED

The 140 Ma (?) Evolution of the Galpagos Hotspot

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The Galpagos Islands and hotspot tracks on the Cocos and Nazca Plates (Cocos, Carnegie, Malpelo and Coiba Ridges) extend the activity of the Galpagos hotspot to nearly 20 Ma (Malpelo and Carnegie Ridges). The complex spatial zonation in trace element and isotopic composition found at the Galpagos Islands is also preserved in the hotspot tracks. Older parts of the hotspot tracks have presumably been subducted beneath South and Central America and therefore are not directly available for sampling. Detailed field, geochemical and 40Ar/39Ar age dating studies of accreted volcanic terranes in Costa Rica and Panama, however, show that they represent parts of the subducted history of the Galpagos hotspot. Samples from accreted ocean island, seamount and submarine ridge volcanoes range in age from 20-70 Ma and have intraplate major element, trace element and Sr-Nd-Pb isotopic compositions consistent with their derivation from the Galpagos hotspot. Our preliminary geochemical data also suggests that the unique spatial zonation of the Galpagos hotspot can be traced as far back as 65 Ma. Outcrops of radiolarian chert, which have been intruded by gabbros or basaltic dikes and sills or are overlain by basaltic sheet flows and pillow lavas, are also common along the Pacific margin of Central American. These rocks are tholeiitic in composition, have very uniform trace element and Sr-Nd-Pb isotopic characteristics, which are identical to other basalts from the Caribbean Large Igneous Province (CLIP). Despite their homogeneous geochemistry, 40Ar/39Ar dating yields a surprisingly large age range of 70-140 Ma. The oldest ages (133-139 Ma) are derived from pristine glasses from pillow rinds from three separate outcrops in North Nicoya. Questions posed by these data include: 1) Has the Galpagos hotspot been active for the last 140 Ma? and 2) Over what age span was the CLIP formed?

T41D-02 0845h INVITED

Correlated Geophysical, Geochemical and Volcanological Manifestations of Plume-Ridge Interaction Along the Galapagos Spreading Center, 90.5-98°W

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As the Galapagos plume is approached from the west along the Galapagos Spreading Center there are systematic increases in crustal thickness, and K/Ti and H_2O content of recovered lavas. These increases correlate with progressive transitions from axial deep to axial high morphology along with decreases in axial depth, residual mantle Bouguer gravity anomaly (MBA), average swell depth, average lava Mg # (atomic MgO/(MgO+FeO)), and the frequency of isolated axial seamounts. Although K/Ti, H_2O and Nb/Zr (likely indicators of plume source enrichment) show step-wise increases across the 95.5°W propagating offset, trends in crustal thickness, axial bathymetry, MBA, swell depth, and seamount frequency generally show either no effect or only local perturbations to regional trends. East of ∼92.7°W, sharp increases in K/Ti, Nb/Zr, H_2O, and Na8 (Na2O corrected for fractionation to 8 wt % MgO) coincide with the transition to axial high morphology, a rapid shoaling of axial magma chamber (AMC) seismic reflectors, and thinning of seismic layer 2A. Maximum values in K/Ti (>0.4), Nb/Zr (>0.10), H_2O (>1.0 wt %), Na8 (∼3.2) and crustal thickness (7.9 km), and minima in axial depth (<1700 m), Mg # (<40), and Ca8/Al8 (<0.7) all occur between 91.25°W and 92°W, whereas the minimum MBA (-25 mGal) and AMC depth (∼0.5 sec 2-way travel time) are found near 92.25°W. These general correlations can be modeled by the combined effects of changes in source composition and melt generation processes on the thickness, composition and structure of the oceanic crust. Key elements of this model include: (1) compensation of the swell is partitioned between crustal thickening (2.3 km) between 98°W and 90.5°W [*Ito et al.*, this meeting] and thermal and compositional buoyancy of the mantle [*Canales et al.*, this meeting]; (2) increased melt production near the hotspot is associated with lower mean extents of melting from a larger region of an increasingly hydrous, and other incompatible element-enriched mantle [*Cushman et al.*, this meeting]; and (3) higher magma supply results in stabilization of axial magma chambers at increasingly shallow crustal depths [*Blacic et al.*, this meeting] and the dominance of fissure-fed rather than point-source volcanism. The hotspot-related effect of increased magma supply on axial morphology, AMC depth and volcanic style along this intermediate-spreading ridge is similar to that between slow and faster spreading mid-ocean ridges.

T41D-03 0900h INVITED

Geophysical constraints on the compensation mechanism of the Galápagos swell

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We use geophysical observations such as bathymetry, gravity, and seismic crustal thickness to understand the origin of the Galápagos swell. Wide-angle refraction and multichannel reflection seismic data show that the crust along the Galápagos Spreading Center (GSC) between 97.5°W and 91°W thickens by 2.3 km as the Galápagos plume is approached from the west [*Ito et al.*, this meeting]. Axial depth along the GSC shoals by 1800 m, 60% of which is due to dynamic topography and changes in axial morphology. The remaining 700 m correspond to the amplitude of the Galápagos bathymetric swell, 75% of which is explained by crustal thickening. The eastward shoaling of the swell and increase in crustal thickness along the GSC is accompained by a progressive decrease in mantle Bouguer gravity anomaly (MBA). Assuming a constant crustal thickness model, the MBA reaches a minimum value of -70 mGal near 91.25°W. After correcting for changes in crustal thickness, however, the gravity anomaly shows a minimum of -25 mGal near 92.2°W, the area where the GSC is intersected by the Wolf-Darwin volcanic lineament.