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We conducted a detailed study of the textures of a 70 m stratigraphic section of gabbroic cumulates in the Upper Banded Series of the Stillwater complex, Montana. The lower cumulates have a variably developed and locally strong foliation and fine-scale modal layering alternating on scales as small as 10 cm and are interpreted to have compaction as their main fabric forming process. They are overlain by a modally uniform gabbronorite that hosts anorthositic and pyroxenitic lenses whose fabric is believed to be related to slumping of a crystal mush. This gabbronorite lacks any continuous modal layering and while it has a well-developed foliation the orientation of this fabric is not as uniform as in the lower cumulates. We characterized the fabrics of the cumulates by measuring (1) the silicate fabric on orthogonal sections of 18 oriented blocks and (2) the Anisotropy of Magnetic Susceptibility (AMS) and Anisotropy of Anhysteretic Remanence (AARM) on minicores from the blocks and from sites spaced an average of 50 cm apart. Fabric data from the blocks agrees with the AMS and AARM of their minicores. The foliation planes and lineation directions indicated by the stratigraphic sampling, show good serial correlation and provide insight into where fabric-forming processes differed. The AMS data reveal a strong change in the magnetic character of the cumulates that corresponds with the transition from modally layered to modally uniform cumulates. Samples from the upper section are more magnetically anisotropic than would be inferred from their silicate fabrics. This difference may be related to textural variations present at scales too large to be sampled by minicores.

V12A-0569 1330h POSTER

Three-dimensional fabric and texture analysis in granitic rocks using microfocus Xray-CT

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Microstructure of geomaterials, which are granular sand and/or rocks, has the three-dimensional (3D) structure associated with pore, void and crack, and these structures have induced mechanical and hydrological anisotropy. In order to construct microstructure-based geomechanics for such an anisotropic geomaterials, we need the detail 3D microstructural information. Stereological analysis is one of estimate method for 3D structure and this method can obtain geometrical properties such as orientation, density and size distribution. Recently, Takemura & Oda (2002) have show that the geometrical property estimated by stereology is in agreement with the optical microscopic observation result using universal-stage. Stereologically method using thin section can obtain useful information about the 3D microstructure, however, it is time-consuming and tedious work. In the past decay, X-ray computed tomography (CT) is available to investigate the 3D microstructure of geomaterials (Fredrich et al., 1995; Ohtani et al., 2001). However, such a conventional X-ray CT is not enough in spatial resolution to observe individual particle and associated void in granular sand and microcrack in rock. Recently, microfocus X-ray CT was developed basis of computer technology, and this equipment can be clearly distinguished particle and microcrack even if it is a few microns in size under. In this study, we observed the 3D microstructure associated with pore and microcrack in rocks using such a microfocus X-ray CT. Using 3D image, and we can measure pore and microcrack aperture and shape under air pressure and confining pressure. Furthermore, the texture of granite expresses tensorial measurement using directional change of scanning line for reconstructed 3D image.

V12A-0570 1330h POSTER

3D X-Ray Imaging Study of Fe-Ti-Oxides of Experimental Partially Molten High-Temperature Pelite Cores

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We present 3D X-ray computer tomography of shape and distribution of oxide minerals in pelite cores which were partially molten at P = 2kbar, T = 700° C, 750° C and 800° C for different run durations (76-508hrs). X-ray absorption images were obtained of the sample in steps of 0.68 and 0.90° for a total rotation of 360°. X-ray tube conditions of 40 kV / 250 μA with a conical x-ray spot size of 5.5 μm was used. The image voxel size is 7 μm^3. Computed tomography images are recorded in 8-bit grayscale. Image analysis was accomplished with the Aphelion^{TM} software. The results demonstrate prolific nucleation of oxides in all partial melting experiments. The original pelite sample contains a total of 2.3* 10^5 grains per 1 ccm of rock; 81.5 % of grains have a radius smaller than 20 μm. A sample melted at T = 800° C for 76 hrs contains a total number of 6.5 * 10^5 oxide grains per ccm, where the majority of grains (89.7%) are smaller than 20 μm. This demonstrates nucleation of opaque crystals for this short run condition. An experimental run at T = 750° C, and 170 hrs run duration, shows an intermediate number of crystals (total number of 4.1 * 10^5 crystals per ccm, with 85.7% smaller than 20 μm. It shows clear evidence of recrystallization; a maximum in a grain size histogram is observed for a radius of about 50 μm. The reaction leading to oxide nucleation and growth is muscovite + biotite (1) + quartz + andalusite + albite = melt + sillimanite + biotite (2) + k-feldspar + Fe-Ti-oxides at 700° C; at 800° C hercynite is also produced. These initial results demonstrate the usefulness of X-ray tomography in determining nucleation and recrystallization for experimental materials.

V12B MCC: Level 1 Monday 1330h

The Origins of Hot Spots, LIPs, Seamount Chains, and Volcanic Ridges I Posters *(joint with OS, T)*

Presiding: **G R Foulger,** University of Durham**; J H Natland,** Rosenstiel School of Marine and Atmospheric Science, University of Miami

V12B-0571 1330h POSTER

Plume or no Plume, the Case of the Siberian Trap Formation

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The generation mechanism of continental large igneous provinces, such as the Siberian Traps, are matters of recent debate, particularly their relation to mantle plumes derived from the Earth's interior. Alternative models relate the formation of large igneous provinces to bolide impacts or small-scale convection at the boundary of asymmetric lithospheres. Neither of these models is without criticism and each model cannot explain all characteristics of continental flood basalt formation alone. However, strong support for the involvement of a mantle plume comes from the observation that large volumes of basaltic melts ($\sim$3 x 10^6 km^3) erupted within a short period of time (< 1 My). Such high magma flux rates can only realistically be produced by decompression melting in the head of an uprising mantle plume. Although several areas surrounding the Siberian craton have been attributed to the Siberian Traps volcanic activity, the entire extent remains conjectural. Basaltic and gabbroic rocks occur throughout the West Siberian Basin (WSB) beneath a thick succession of Mesozoic and Cenozoic sediments. Further to the north of the Siberian craton, on the Taimyr Peninsula, are also basalt and dolerite rocks. We have obtained more than 100 samples from both areas and compared chemical data with data from the Siberian Traps. The basalts have chemical characteristics typical of fractionated, contaminated continental flood basalts (e.g. low Mg#, negative Nb anomaly). Trace element modelling suggests that the basalts represent different degrees of partial melting and crustal contamination. The major and trace element data from the WSB and Taimyr basalts show strong affinities with Siberian Trap basalts that precede the main pulse of volcanism extruded over large areas of the Siberian craton. Although the major and trace element data are consistent with a plume origin for the Siberian Traps, they cannot prove it; however, magma volume and timing constraints do strongly suggest that a mantle plume was involved in the formation of the Earth's largest continental flood basalt province.

V12B-0572 1330h POSTER

Modeling Anomalous Crustal Accretion at Spreading Zones

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The thermal and seismic structure of normal oceanic crust or anomalous crust such as Iceland depends on the mode of melt extraction from the mantle and its emplacement within or on top of the crust. We model crustal accretion by a two fold approach. In a 2D spreading model with anomalous mantle temperature beneath the ridge we solve the Navier-Stokes-, the heat tansport, the mass conservation and the melting equations to determine the enhanced melt production beneath the ridge. This melt is extracted and emplaced on top of the model to form the crust. Two cases are distinguished: a) Extruded crustal material is taken out of the model and is only advected according to the spreading of the plate, b) extruded material is fed back into the model from the top to mimic isostatic subsidence of extruded crust. We find that the feed back of case b) is only moderate. For example, if extruded crustal material as thick as 40 km is fed back into the model, the melting region is depressed downward only by as much as 10km, and the total amount of generated melt is reduced by about 20 %. On the other hand, the upper 30 km of the model is cooled considerably by several 100 degrees. A second set of models focuses on the details of crustal accretion without explicitly solving for the melting and extraction. Knowing the spreading rate, the rate of crustal production can be estimated, but the site of emplacement is not obvious. For an anomalous crust such as Iceland we define four source regions of crustal accretion: surface extrusion, intrusion in fissure swarms at shallow depth connected to volcanic centres, magma chambers at shallow to mid-crustal level, and a deep accretion zone, where crust is produced by widespread dyke and sill emplacement and underplating. We solve the Navier-Stokes-, the heat tansport and the mass conservation equations and prescribe different functions in space and time for crustal production in the four defined regions. The temperature of the imposed material depends on the source region and the process of accretion is monitored by identifying material from different source regions by a marker approach. After some time of spreading and accretion, a characteristic temperature distribution and crustal layering evolves, which is compared to observation data.

URL: http://www.geophysik.uni-frankfurt.de

V12B-0573 1330h POSTER

The Effect of a Major Change in Plate Motion on Hotspot Volcanism

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Noticeable changes in Pacific hotspot volcanic edifice construction appear to have occurred following the change in Pacific plate motion that produced the Hawaiian Emperor bend (HEB). In addition to the Hawaiian Emperor trail, the same bend is also visible in seven other seamount trails across the Pacific Basin. Shortly after the HEB, volcanic edifice construction abruptly decreased along the Hawaiian trail, followed by a gradual increase over the next 10 myrs. Whereas, after the bends in the three collinear Marshall-Gilbert-Tuvalu trails and the two Tokelau trails, edifice construction completely stopped and never restarted. In contrast, after the bend in the Louisville trail, which was only a slight bend because of its distance from the stage pole, volcanic edifice construction actually increased. After the bend in the Tuamoto trail, which formed close to the spreading ridge, the Tuamoto plateau was emplaced. Modern hotspot volcanism appears to be located in upwelling regions formed between upper mantle rolls that are visible as geoid undulations, which are aligned parallel to plate motion. Assuming that plate motion parallel upper mantle rolls were also

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present prior to the HEB, the concurrence of the above events following the change in plate motion may indicate a disruption in the upper mantle convective flow pattern caused by the change, particularly in regions where the change was pronounced. Strong hotspots, such as Hawaii, continued to construct edifices, albeit more sparsely, until the convective flow pattern became reestablished. Weak hotspots, such as those forming the Marshall-Gilbert-Tuvalu and the Tokelau trails, were completely shut down. The time frame for the return to robust Hawaiian edifice construction, i.e. about 10 myrs., is in agreement with three dimensional modeling studies of planforms of convection required for the establishment of mantle rolls.

V12B-0574 1330h POSTER

Anomalous Subsidence of the Ontong Java Plateau (ODP Leg 192)

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The Ontong Java Plateau (OJP) in the western Pacific is the largest volcanic oceanic plateau and is anomalous compared to other oceanic large igneous provinces like the Kerguelen plateau in that it never formed a subaerial landmass. To estimate paleoeruption depths and thus better constrain the subsidence history of the OJP, we analyzed dissolved H_2O and CO_2 concentrations in glasses from basaltic pillow rims recovered during ODP Leg 192. The glasses are from four sites (1183, 1185, 1186, 1187) in the central and eastern parts of the plateau. In addition, we analyzed non-vesicular glass shards in volcaniclastic rocks from Site 1184 located on the southeastern part of the OJP. Using the pressure-dependent solubilities of H_2O and CO_2, our data suggest original eruption depths (at 122 Ma) varying from ∼1100 m below sea level (mbsl) on the central part of the plateau to 2200-2600 mbsl on the eastern edge. The glass shards from Site 1184 suggest a quenching depth of 700 mbsl. These estimated depths must be viewed with caution, however, because submarine basaltic pillows (MORB) are typically supersaturated with CO_2, and in the case of Site 1184, because equilibrium degassing may not occur during ascent and quenching in shallow-water hydrovolcanic eruptions. By correcting the present-day depth of the top of the igneous basement for sediment loading, we use our eruption depths to estimate how much subsidence has occurred on the OJP since the time it formed. The results suggest subsidence of 1500 ± 300 m over much of the OJP since 122 Ma. Given the consistency of the subsidence estimates between different sites, we think it unlikely that the CO_2 values reflect strong supersaturation as is found in MORB. The much larger volumes and likely long flow distances on the OJP compared with MORB flows probably allow dissolved CO_2 to reach equilibrium values for the appropriate seafloor depth before final quenching. Our estimates of subsidence for the OJP are significantly less than predictions from thermal models of hotspot-affected lithosphere. These results are paradoxical because partial melting models based on data for high-Mg basalts from Sites 1185 and 1187 indicate melting of peridotitic mantle with a high (∼1500°C) potential temperature.

V12B-0575 1330h POSTER

Impact Origin for the Greater Ontong Java Plateau? Geochemical and Petrologic Evidence.

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Voluminous basaltic magmatism at ∼120 Ma created Earth's biggest large igneous province (LIP), the Greater Ontong Java Plateau (OJP) in the west Pacific Ocean. This volcanic event has been generally attributed to a large mantle plume. However several important lines of geochemical and petrologic evidence are at odds with a plume origin. High concentrations of heavy rare earth elements (HREE) indicate melting at shallow mantle depths, and major and trace element systematics for OJP basalts are consistent with >30% batch melting. These conditions and extents of melting are typical at mid-ocean ridges influenced by hot or wet mantle plumes, but pelagic sediments overlie mostly vesicle-free basalts, implying a deep-water environment of emplacement away from a spreading center. H_2O contents of these basalts are very low indicating that melting was not facilitated by a wet plume. Radiogenic isotopes vary little considering the large size of OJP. Platinum group elements (PGE) are enriched relative to predicted values assuming a primitive mantle source, but OJP basalts are also sulfide-free, leaving PGE levels difficult to explain. An extraterrestrial impact model for OJP seems more consistent with existing data. A bolide ∼20 km in diameter would remove >60 km of overburden, and instigate extensive decompression melting. High extents of melting in the shallow mantle would explain the geochemical homogeneity of the basalts, high HREE contents and low H_2O%. Magmas might also entrain residual bolide which would create basalts with relative PGE enrichment. In the impact scenario, OJP was not heated from below by a mantle plume, so neither uplift nor subsidence would have been extensive, thus explaining the submarine emplacement of the lavas. A major bolide impact could have also caused or contributed to some unexplained phenomena coincident with the timing of OJP emplacement including: onset of the Cretaceous normal magnetic polarity superchron, the Selli oceanic anoxic event, marine faunal extinctions and worldwide radiogenic isotopic excursions that suggest a rapid change from terrigenous-dominated values to mantle-dominated values in marine sediments (Sr and Hf).

V12B-0576 1330h POSTER

Impact Origin for the Greater Ontong Java Plateau? Geophysical and Geodynamic Evidence.

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The ∼120 Ma Greater Ontong Java Plateau (OJP), Earth's most voluminous large igneous province (LIP), encompasses ∼5.7 x 10^7 km^3 of crust in the west Pacific Ocean. OJP defies explanation by extant plume models, and cannot be easily linked to any hotspot track. The arrival and decompression melting of a hot plume at the base of oceanic lithosphere, should have resulted in buoyancy and crustal growth capable of maintaining OJP above sea level. Yet all sampled OJP basalts erupted below sea level. Plateaus within oceanic lithosphere should subside via either thermal conduction or continuous viscous spreading, but interpreted paleoenvironments show that total OJP subsidence was much less than that of other oceanic LIPs or normal oceanic crust. A cylindrical, ∼300 km deep, low velocity root is centered beneath OJP's thickest crust. Its slow shear wave velocities could indicate a thermal anomaly sufficient to cause continued volcanism, but OJP shows no evidence of recent volcanism. Thus key geophysical and geodynamic results are at odds with a plume model for OJP's origin, and an extraterrestrial impact model seems much more consistent with existing data and results. A bolide ∼20 km in diameter, impacting young oceanic lithosphere would instantaneously remove >60 km of overlying crust and mantle, and extensive decompression melting would follow. Melt would flow into the crater, and would also exploit concentric and radial fractures beyond the crater, resulting in emplacement of the plateau and nearby ocean basin flood basalts. Anomalous mantle would fill space created by decompression melt beneath and proximal to the crater, creating a low-velocity mantle root rigidly coupled to OJP crust. In the impact scenario, OJP formed under conditions of isostatic equilibrium, and thus neither rose above sea level nor subsided as would typical oceanic lithosphere. Aptian time is marked by major global events that include onset of the Cretaceous normal magnetic polarity superchron, the Selli oceanic anoxic event, marine faunal extinctions and worldwide radiogenic isotopic excursions (Sr and Hf) in marine sediments. A major bolide impact could have caused or contributed to such phenomena.

V12B-0577 1330h POSTER

Antipodal Hotspots on the Earth: Vestiges of Major Oceanic Bolide Impacts?

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The distribution of hotspots on the Earth has a distinct antipodal character, which has previously been shown to be statistically significant ($p<0.05$) for one long (117) and two short (∼40-50) hotspot lists [1]. One possible mechanism for the creation of antipodal hotspot pairs is the focusing of seismic energy from a major bolide impact at its antipode. Reflected tensile body waves would converge along the axis beneath the antipode possibly causing fracturing to depth [2], and the greatest focusing of seismic energy from fundamental-mode surface waves has been shown to occur in the antipodal asthenosphere where seismic attenuation is greatest [3]. A major impact, therefore, might produce hotspot volcanism at the impact site (particularly on oceanic crust [4]), and produce flood basalts and a second hotspot from the focused disruption at its antipode. In this study, three predictions of this model are tested. (1) All primary' hotspots on Earth initially had near-antipodal hotspots or impact structures. (2) Volcanic activity at both antipodal hotspots of a given pair began at about the same time. And (3), antipodal hotspot pairs have only one flood basalt province and/or impact site between them. A list of 54 primary hotspots is constructed from five commonly cited short hotspot lists. Of these, 28 form near-antipodal pairs mostly within conservative limits for hotspot drift rates from initial antipodality (∼20 mm/yr). Of the remaining 26, 14 are nearly antipodal to secondary' hotspots from the long (117) hotspot list [5] or other volcanic features. Another primary hotspot (Comores, ∼10 Ma) was antipodal to the proposed Ewing impact structure (∼7-11 Ma) in the Pacific Ocean. Many antipodal hotspots have similar ages (e.g. Galápagos, ∼85 Ma; Nikitin, ∼80 Ma), and no contradictions to this prediction have been found. Only two primary hotspots (Hawai'i, Louisville) have continental antipodal sites where no volcanic features exist. These two hotspots, however, are among the oldest (>100 Myr) and could have drifted quite far from antipodality with their opposite hotspots. The remaining 9 primary hotspots have antipodes in the Pacific Ocean where submerged hotspots or impact structures could yet be identified. All hotspots antipodal to those associated with flood basalt provinces or formed in continental crust are, or were, in oceanic crust suggesting links between major deep-ocean impacts, greater impact/seismic efficiency, and the creation of antipodal hotspot pairs. In general, spotless' areas [5] occur opposite to continental masses, and no hotspot volcanism is found at or antipodal to known continental impact structures. [1] Rampino and Caldeira, GRL (1992) 2011; [2] Schultz and Gault, The Moon (1975) 159; [3] Boslough et al., GSA Spec. Pap. 307 (1996) 541; [4] Roddy et al., Int. J. Impact Eng. (1987) 525; [5] Vogt, JGR (1981) 950.

V12B-0578 1330h POSTER

Crustal Structure Beneath the Gravity Lineations in the South Pacific from Seismic Refraction Data

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The GLIMPSE (Gravity Lineations, Intraplate Melting, Petrologic and Seismic Expedition) Experiment explores the origin of cross grain gravity lineations and associated volcanic ridges in the central South Pacific. The active-source seismic refraction component of GLIMPSE Experiment investigated the crustal thickness and velocity structure beneath the Sojourn Ridge and Hotu Matua Ridge systems (116.5-115.5 W, 16.0-12.5 S). The SSE trending 450 km long refraction line crossed over sixteen three-component ocean bottom seismometers (OBSs) sampling at a rate of 128 Hz . Throughout the survey, shots were triggered every two minutes for the 5-gun, 3625 cubic inch airgun array, while the R/V Melville maintained a ship speed between 4-5.5 knots to obtain a shot spacing of approximately 250 m. We will report on the crustal thickness, velocity structure, and upper mantle velocity determined from picks of the primary crustal and mantle phases (Pg, PmP, and Pn) recorded on the thirteen OBSs that returned viable data. Seabeam2000 sidescan measurements suggest fresh lava flows in the vicinity of the Matua ridge, possibly indicative of a robust and active magma system underlying the Hotu Matua volcanic system. High reflectivity along the eastern section of the Sojourn Ridge also suggests a recent eruptive history. The resultant velocity model will help to clarify the extent to which these ridges overlie partially molten material. In addition, the results of this investigation will provide evidence to aid in distinguishing between the competing hypotheses on the origins of the Sojourn, Hotu Matua, and similar anomalous ridge systems. In particular, the lithospheric boudinage and convective roll models predict opposing crustal thickness trends beneath the intraplate ridges, which will be resolvable in the results from the current study.

V12B-0579 1330h POSTER

Analysis of Gravity in the GLIMPSE study region: evidence for deeper mantle processes in the formation of the Sojourn and Hotu Matua ridge systems.

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There are series of intraplate volcanic ridges in the south Pacific that are not the product of hot spot activity. The GLIMPSE (Gravity Lineation Intraplate Melting Petrologic and Seismic Expedition) experiment sought to investigate the formation of these ridges. Using shipboard gravity measurements, we have calculated estimates of effective elastic plate thickness and volcanic edifice density forof the major bathymetric featuresregions in the GLIMPSE study area using a simple elastic flexure model with a grid search method over reasonable values of elastic thickness and load density. The grid search inversion revealed effective elastic thickness that ranged from ~ 2 km beneath the Sojourn Ridge to a maximum of ~ 7 km beneath the Southern Cross Seamount, with the average range of estimates of 2-4 km. The elastic thickness estimates are lower than the thickness predicted for 3-6 Ma seafloor and might be due to the flexural character of the volcanic edifices being "frozen in" after formation near the East Pacific Rise. The seamount densities averaged 2500 kg/m^3. Notably, the Matua and Southern Cross seamounts produced anomalously low estimates for load densities, approximately 2050 and 2250 kg/m^3 respectively, which could reflect an actual low-density seamount derived from an enricheddepleted mantle source with high volatile content or subsurface loading of lower density mantle material, perhaps underplated crust or a deep magma chamber. Using satellite free air gravity and shipboard bathymetry, we calculated the residual mantle Bouguer Anomaly (RMBA) for the entire GLIMPSE study region. The RMBA reveals a negative gravity anomaliesy (~ 40 mGals) in the vicinity of regions beneath the volcanic ridges indicating uncompensated downward flexure in the surrounding moats and crustal thickening beneath the ridges and seamounts themselves. After removing an optimal estimate of this flexural component, significant gravity lineations remain that are oriented approximately perpendicular to the East Pacific Rise in the absolute plate motion direction and which extend to seafloor less than 2 Ma old. These residual gravity anomalies may be caused by compositional or thermal anomalies in the underlying mantle at wavelengths that are too short to flex the surface of the plate, thus creating gravity anomalies but no obvious, associated bathymetric anomaly. that there is a significant flexural component to the gravity signature of the study area. An inversion was performed to determine the extent of the flexural component in the MBA. The inversion accounted for a majority of the MBA; however, a clear negative anomaly remained suggesting that more than simple flexure is required to produce the observed MBA. The residual gravity may be due to other processes such as thermally or compositionally low-density mantle underlying the volcanic edifices or subsurface loading of the plate.

V12B-0580 1330h POSTER

P and S wave delay times and SKS splitting results from the GLIMPSE experiment: comparison with gravity anomalies and recent volcanism.

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The Gravity Lineations Intraplate Melting Petrologic and Seismologic Expedition (GLIMPSE) is investigating the origin of a series of intraplate en echelon volcanic ridge systems in the South Pacific that are not the product of hot spots. The long-term ocean bottom seismometer (OBS) deployment of the experiment has measured P and S wave delay times as well as shear wave splitting from SKS phases. Average P wave delay times at individual OBSs ranged from -.59 s to .45 s with an average standard deviation of .05 s. S wave delays ranged from -.96 s to 1.12 s with an average standard deviation of .16 s. The late arrivals (positive delay) are generally associated with regions of recent volcanism (as inferred from side scan sonar images of the seafloor) indicating that there is anomalous seismic structure beneath the Sojourn and Hotu Matua volcanic ridges. Estimates of lithospheric thinning required to produce the observed delay times yield upwards of 50 km of thinning, which seems very unlikely for even the oldest (~ 9 Ma) seafloor in the region. Therefore, the anomalous structure probably involves the asthenosphere and partial melting. The fastest P-wave anomaly lies within a region of positive residual gravity anomaly and the slower times generally fall within areas of negative residual anomalies. Splitting times ranged from 1.1 to 2.2 s with fast direction azimuths trending within error in the direction of absolute plate motion for the Pacific plate near the East Pacific Rise (EPR). Shear wave splitting in the GLIMPSE study region may be attributable to three components of anisotropy: lattice-preferred orientation (LPO) of olivine crystals in the shallow mantle due to spreading induced strain from the EPR; LPO due to deeper channelized return flow in the asthenosphere from the Pacific Superswell to the EPR; and melt filled lithospheric cracks aligned in the direction of absolute plate motion resulting in shape preferred orientation (SPO) anisotropy. However, calculations of splitting times for penny shaped melt inclusions indicate that a high melt volume fraction (> .05) must be present for SPO in the lithosphere to be a major contributor to the observed splitting times, making the SPO component very unlikely. The greatest splitting delays in both GLIMPSE and the MELT Experiment were associated with areas of anomalously slow S wave velocity to the west of the East Pacific Rise, suggesting strong anisotropy in the shallow asthenosphere.

V12B-0581 1330h POSTER

Rayleigh Wave Tomography Study of the Oceanic Upper Mantle Beneath Intraplate Volcanic Chains West of the East Pacific Rise

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In order to investigate the origin of intraplate volcanic ridges in the GLIMPSE study area on the Pacific plate west of the East Pacific Rise and their possible association with cross-grain gravity lineations, we conducted a passive seismic experiment employing a year-long deployment of ocean bottom seismometers. We present Rayleigh wave tomography results for periods between 16 and 100 s, with more abundant observations below 60 s. The average phase velocity as a function of frequency in the study area falls between dispersion curves for 0 - 4 Ma and 4 - 20 Ma from previous studies (Nishimura and Forsyth, 1988), consistent with seafloor age in this region. Phase velocities decrease from 20 to 33 s, indicating the presence of a thin lithosphere. Velocities increase sharply at periods beyond 40 s as the bottom of the low velocity zone is detected. Two-dimensional phase velocity maps indicate anomalously low phase velocities beneath the eastern end of the Sojourn ridge extending eastward beneath the smaller, newly mapped Brown ridge. In this area of recent, off-axis volcanic activity, anomalous shear wave velocities in the mantle must extend nearly to the base of the crust. The velocities are much less anomalous beneath the other recently active region, the Hotu-Matua volcanic complex, where melting must be deeper and/or confined to a narrower region to avoid detection. High velocities are observed northwest of the Sojourn ridge associated with an offset in seafloor age across the Garrett fracture zone. High velocities are also observed between the Sojourn ridge and Hotu-Matua in the western part of the study area. Azimuthal anisotropy averaged over the study area is well resolved, with Rayleigh waves for periods between 16 and 40 s traveling 3.5% faster perpendicular to the ridge than parallel to it. With this degree of anisotropy, the anisotropic layer must be on the order of 200 km thick to explain the shear wave splitting delays.

V12B-0582 1330h INVITED POSTER

Distribution of Recent Volcanism and Morphology of Volcanic Features in the GLIMPSE Study Area west of the East Pacific Rise

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The existence of seamounts and volcanic ridges west of the East Pacific Rise (EPR), perhaps associated with cross-grain gravity lineations, was initially revealed by detailed satellite altimetry. Multibeam bathymetry and sidescan reflectivity measurements made on board the R/V Melville in 2001 and 2002 as part of the GLIMPSE Experiment, plus additional data gathered on other cruises including those of the MELT Experiment, have allowed us to map the distribution of recent, off-axis volcanic activity west of the EPR and south of the Garrett Fracture Zone and to more precisely define the form of the volcanic features. The Southern Cross Seamount, Sojourn Ridge and Brown Ridge combine to form a linear feature nearly 500 km long, oriented perpendicular to the EPR about 80 km south of the Garrett FZ. Both the Sojourn and Brown ridges comprise several en echelon segments, each about 30 km long, linked together to form continuous topographic highs standing 2000 m or more above the surrounding seafloor. Side-scan data reveal reflective patches along the Brown Ridge at the eastern end of this feature that appear to be recent lava flows. Dredging of fresh basalts dated by Ar/Ar methods at about 0.3 Ma confirm this interpretation. The Southern Cross Seamount, at the western end of the chain, is the largest individual feature, standing more than 3.5 km above the surrounding seafloor and shoaling to depths less than 200 m below sealevel. The Hotu-Matua volcanic complex also extends for several hundred km, but is much more varied in its morphology. The western end has some very small, very linear ridges, flanked on the south by an extensive region of resurfaced, hummocky seafloor. This area is more reflective and presumably younger than the surrounding seafloor, but less reflective than the areas interpreted as recent flows. Roughly midway along this complex are the Hotu and Matua seamounts. Surrounding Matua is an extensive region of highly reflective, recent lava flows, some of which seem to have been dammed against pre-existing, small seamounts. Age dates in this area are highly variable, ranging from <0.6 to about 6 Ma, also suggesting a mixture of pre-existing and resurfaced seafloor. Reflective flows are scattered over a roughly linear region extending another 150 km to the east of Matua, sometimes associated with very small seamounts and sometimes appearing just to fill topographic lows. We find no evidence in the detailed bathymetry or sidescan in this region for any pre-existing tectonic features or cracks extending along the line of volcanic activity.

V12B-0583 1330h POSTER

Microearthquakes Near Matua Seamount, GLIMPSE Study Area

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As part of the GLIMPSE Experiment, we deployed five ocean-bottom seismometers (OBS) in an array on the flanks of Matua Seamount, about 400 km west of the East Pacific Rise. Matua stands about 2000 m above the surrounding seafloor and is surrounded by a number of smaller volcanic cones and recent lava flows, as indicated by highly reflective seafloor imaged by side-scan sonar and by fresh basalt samples dredged from the flows. The array, measuring about 20 km across, was deployed for about 30 days in November and December, 2001. Record quality varied; two of the three-component OBSs were much noisier than the others, but the largest events were recorded at all 5 stations. One event was recorded by a sixth OBS, deployed for a short time as part of a nearby refraction experiment. The microearthquake activity confirms the impression given by the side-scan sonar data that Matua Seamount is still an active volcano. P and S waves from sixteen events were recorded well enough by three or more stations to obtain hypocentral estimates. We

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used a grid-search technique to both locate the earthquakes and to obtain full, non-linear estimates of the uncertainty in location. All of the events are located north or east of Matua, most in the vicinity of recent lava flows. None are beneath the primary edifice itself. Nine of the earthquakes are in very shallow, upper crust. Two are near the base of the crust and five are in the mantle at depths of 12 km or more below the seafloor. The relatively great depths of the mantle events provide an important constraint on the mechanical properties of the 6 Ma old lithosphere on which Matua is constructed.

V12B-0584 1330h POSTER

Age Progression and Changes in Mantle Source Composition With Time in the Rano Rahi Seamount Field, East Pacific Rise Flank, 15°-19°S

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The Rano Rahi seamount field, located on the flanks of the East Pacific rise at 15°-19°S, has unusually long chains of numerous seamounts in its southern half (17°-19°S), extending south and east from the eastern end of the Pukapuka ridge (17.2°S, 118.5°W) to the ridge. To examine the variation in space and time of the seamounts' mantle source composition, Sr, Nd, and Pb isotopic ratios, ^{40}Ar-^{39}Ar ages, and incompatible element concentrations of representative lavas were measured. Isotopic and incompatible element ratios overlap the linear trends of ratios from both the nearby ridge and the Pukapuka ridge (Mahoney et al., 1994; Janney et al., 2000), implying that seamount lavas' mantle sources were composed of varying proportions of the same two components (N-MORB and C-type mantle) making up the sources of Pukapuka ridge and axial lavas. ^{40}Ar-^{39}Ar incremental-heating plateau ages of seamount lavas range from 0.23 - 4.38 Ma. Lavas recovered farther from the ridge are generally older than near-ridge lavas, implying that the seamount field represents a time sequence, rather than a current map, of mantle source compositions. Fewer samples were dated than were analyzed for composition, but the increasing ages of dated samples with distance from the ridge allowed the ages of many of the undated lavas to be estimated using the seamounts' current distance from the ridge, the spreading rate, and the dated lavas' average distance at eruption. This in turn allowed the use of most of the undated lavas to asssess changes in composition with time. In the southernmost seamount chains, about 18°-19°S, isotopic and incompatible element ratios did change with time: ratios in seamount lavas older than 4 Ma are similar to those of the youngest Pukapuka ridge lavas; from about 4 Ma seamount Sr and Pb isotopic ratios increased (ϵ_{Nd} decreased), culminating at 1-2 Ma, while ratios such as Nb/Zr decreased slightly (i.e., isotopic and incompatible element ratios were decoupled in these lavas). These samples have some of the most C-like isotopic ratios in the seamount field. In contrast, lavas from seamount chains at 17°-18°S have no compositional trend with time. Instead, compositions of these lavas tend to be less C-like toward the north, in spite of evidence that the mantle source under the ridge at about 17.3°S is currently the most C-like (Mahoney et al., 1994). In addition, although the long seamount chains occur south of 17°S, geophysical indications of the presence of melt in the mantle are greatest at about 16°-17°S (Forsyth et al., 1998). We suggest that this mismatch between the seamount chains and the current region of high melt production may be reconciled by a scenario in which the seamount chains are the result of two phenomena, the intersection of the Pukapuka ridge with the East Pacific Rise at about 7 Ma, and subsequent extension of the Pacific plate at its thin edge near the ridge. We examine two possible causes of extension: asthenospheric pressure exerted from the west by the South Pacific Superswell (Toomey et al., 2002), and stress caused by a new northward component of Pacific plate motion since 6 Ma (Wessel and Kroenke, 2000).

V12B-0585 1330h POSTER

Regional and Residual Bathymetry and Flexure Modeling of the Nazca Plate

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We investigate the thermo-mechanical properties of the lithosphere along the Easter Seamount Chain and Nazca Ridge, whose bathymetric features are delineated by a broad chain of seamounts in the southeastern Pacific. These properties can be expressed in terms of flexural rigidity or, equivalently, the thickness of an elastic plate that indicates the strength of the lithosphere at the time the seamounts were formed. We can use elastic thickness as indicator of thermal structure or age of the lithosphere at time of loading to understand the origin of seamounts. As a first step, a 30-sec gridded blend of observed and predicted topography was separated into regional and residual components in order to isolate seamount loads from the seafloor. To get robust and objective residuals, we employed spatial median filters with the optimal filter width, 650 ± 50 km, found for this study area. The estimated regional trend detects successfully long-wavelength swelling effects from the East Pacific, Galapagos, and Roggeveen Rises. The uncertainties in the regional and residual separation will be estimated to provide upper and lower bounds on the seamount load. Next, we examine the effective elastic thickness of the lithosphere supporting the seamounts in our study area, based on the relationship between the residual bathymetry and gravity (both shipboard and satellite derived).

V12B-0586 1330h POSTER

Rodriguez, Darwin, Wolf,...,A Third Type of Hotspot Island

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Hotspot-ridge interactions are associated with broad seafloor swells as well as localized volcanic features such as island chains and volcanic lineaments. In several cases, notably the Galapagos, Reunion, and Kerguelen hotspots, volcanic lineaments extend from presumed off-axis hotspot centers toward nearby mid-ocean ridges. It has been proposed that such lineaments are caused by channeling of hot asthenosphere from off-axis mantle plumes toward mid-ocean ridges. Besides the classical concept of a hotspot island chain, this is a second mechanism to form volcanic lineaments [Morgan, 1978]. Alternatively, other workers suggest that these lineaments are controlled by the pattern of stress in the lithosphere. We examine this latter hypothesis by considering the effects of buoyant uplift and asthenospheric shear on the base of the lithosphere induced by a mantle plume. We simplify this 3-D problem by treating the lithosphere as a thin plate and calculating the plan view pattern of depth-integrated stresses, or stress resultants. The effects of plume shear and uplift are treated as horizontal loads on the plate. We calculate the contributions to stress resultants by approximating these loads as point forces distributed over the plate and superposing the associated Kelvin solutions. The ridge is simulated as a line experiencing uniform tension in the direction of seafloor spreading using a boundary element method. Final stress resultants are thus the combined effects of plume uplift and shear subject to the ridge boundary conditions. Results show that plume-ridge interaction can introduce anomalous tension in the lithosphere with trajectories of least tensile stress resultants radiating away from the plume center toward the ridge. We propose that magma below the lithosphere will exploit this stress resultant pattern, tending to form dikes and volcanic lineaments along these stress resultant trajectories. This is yet a third possible mechanism to form volcanic chains or lineaments over hotspots.

V12B-0587 1330h POSTER

Penetration of mantle plumes through the lithosphere.

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Many theories have emerged these last years in order to explain the many forms of melt anomalies. The traditional plume theory has to deal with the interaction of a thermally driven plume with the lithosphere which is still poorly known. Oceanic and continental lithospheres differ by their composition and thickness, implying differences of rheology and density. Continental lithosphere is thicker, chemically distinct from the underlying mantle and probably more viscous and less dense. In order to quantify the effect of these differences, we have used both laboratory experiments and numerical calculation. A thermal plume is generated by a point source of heat at the base of a layer and rises towards an upper layer which is buoyant and more viscous. We study the effects of the energy flux, the density difference, the viscosity ratio, and the thickness of the upper layer. Numerical simulations are made with the STAG3D program developed by Paul Tackley. We solve the equations governing the convective motion in a non-compressible viscous fluid and use active tracers to model the upper layer. Simulations allow to vary all the parameters in a wide range and show good agreement with the experiments. Both experiments and numerical simulations show a wide range of behaviors: the mantle plume can spread laterally at the interface or penetrate through the lithosphere. Moreover, the lithosphere is heated from below by the plume and can become convectively unstable. The thickness and viscosity of the lithosphere are key parameters. The difference of thickness and composition between continental and oceanic lithosphere can lead to very different end-results at the surface.

V12B-0588 1330h POSTER

Modeling the Effects of the 670 km Boundary on the Dispersion of Plume Heads Within the Upper Mantle.

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The large, leading head of a mantle plume has been suggested as the source for large igneous provinces (LIPs). We present results from a finite element numerical model, which looks at the growth and rise of mantle plumes from the core mantle boundary. We look specifically at how the nature of the 670 km interface (e.g. chemical versus phase boundary) modulates the passage of plume heads and their eventual dispersion beneath the lithosphere. Models begin with initial thermal boundary layers at the base (D′′) and the surface (lithosphere) of the domain and, in some cases, at the 670 km interface. We track three distinct chemical fields including the upper and lower mantle and a recycled slab component residing within the D′′) layer. Primary variables include the compositional values for the slab component and both the upper and lower mantle components. For the phase boundary, we vary the clapeyron slope and density difference associated with the phase change. The results show that when the 670 km discontinuity marks only a compositional change between upper and lower mantle, plumes either stagnate below this interface or trigger a complete mantle overturn, depending on the magnitude of the density contrast. With the addition of a phase boundary, there exists an intermediate regime represented by stable layering with short-lived pulses of plume penetration through the 670 and melting beneath the lithosphere. Within this regime, the 670 km interface acts as an effective filter by modulating the relative proportions of recycled slab and entrained lower mantle components, which ultimately rise through to the melting region beneath the lithosphere.

V12B-0589 1330h POSTER

Late Mesozoic-Cenozoic Evolution of the North American Cordillera: Lithospheric Response to Plume-Slab Interaction

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Throughout the late Mesozoic and Cenozoic eras, western North America experienced widespread deformation and volcanism. The nature and extent of this activity does not fit conveniently into the plate tectonic framework for crustal evolution. To date, there is no satisfying explanation that integrates the Laramide Orogeny, Basin and Range extensional activity, and the rise of the Colorado Plateau with the voluminous Tertiary volcanism including Eocene high-K magmatism, the mid-Tertiary ignimbrite flare-up' in and around the Great Basin, and the more recent outpouring of the Columbia River flood basalts (CRB). In fact, the unusual spatial and temporal relationship between the CRB and the on-going time-progressive basaltic and rhyolitic volcanism associated with the Yellowstone hot-spot track has led some researchers to question whether upwelling plumes do, indeed, exist. We note that magmas produced in western North

America throughout the Cenozoic were derived from two compositionally distinct source regions: the subcontinental lithosphere (representing >95% of the magmatism) and the OIB source region (<5%). The two magma types occur at the same place and time throughout the province. We propose that the impingement of the positively buoyant plume head of the Yellowstone hot spot with the underside of the negatively buoyant, subducting Farallon plate at 80 My is responsible for the widespread Tertiary deformation and magmatic activity in the North American Cordillera. The dynamics of mantle flow required to accommodate the mutual passing of the two bodies led to a crisis in the normal mantle flow regime. Upwelling of the plume head was accommodated by shallowing both the Farallon slab and the overlying mantle wedge. This activity drove the subsequent tectonics of the over-riding continental lithosphere for nearly 80 My. We argue that this model is consistent with existing geological, geochemical and geophysical observations of the Cordillera; it provides a new framework in which to view several present-day features of the Cordilleran province, including the observed broad regional uplift, high heat flow, and the anomalous slow propagation of P and S waves through the underlying upper mantle.

V12B-0590 1330h POSTER

Receiver Function Analysis Beneath the CD-Yellowstone Array

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The existence of a mantle plume beneath Yellowstone National Park is controversial, and the study of mantle discontinuities beneath this region will provide insight into the thermal structure of the mantle. The Continental Dynamics Yellowstone (CD-Yell) broadband PASSCAL Array consisted of 78 broadband seismometers deployed within a 250 km radius of Yellowstone Park. Receiver function analysis using a common conversion point stacking technique is being used to examine the shear wave velocity discontinuities of the upper mantle and crust beneath these arrays. Corrections for lateral velocity heterogeneity, that may create false mantle discontinuity topography, are applied using the local P and S-wave upper mantle velocity models produced from the array travel-time data. A primary scientific question is to constrain the thermal structure of the transition zone via correlation of transition zone topography with tomographic velocity models. Preliminary results show 30 km of variation in the transition zone thickness indicative of substantial transition zone thermal heterogeneity. The region of thinnest transition zone (220 km) is located 100 km east of the Yellowstone Caldera. In addition, a potential discontinuity northwest of the park exists around 800 km depth. More detailed results will be presented at conference.

V12B-0591 1330h POSTER

Anisotropic Surface Wave Tomography of the Yellowstone Hotspot

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Yellowstone is the most prominent continental hotspot. Over the last 17Ma, it has tracked from the Oregon-Nevada-Idaho region (also the source of flood basalts and the beginning of the Newberry hotspot), to its current location within the Wyoming Craton. Whether it is a mantle plume or caused by some sort of upper mantle convection is a matter of debate; however, the upper mantle has certainly been dramatically altered by the hotspot, and significant amounts of melt have been released. Despite this, regional SKS splitting measurements are mostly aligned in the direction of absolute plate motion, and do not show any Yellowstone signature. That SKS splitting is unaffected by the profound mantle disturbance causing Yellowstone is perplexing, especially as earlier tomography suggests small-scale convection is occurring. It may be that SKS splitting is averaging out the effects of depth-varying anisotropic fabrics caused by Yellowstone flow; that Yellowstone mantle is unexpectedly flowing more or less uniformly in the direction of plate motion; or that the anisotropy seen by the SKS lies deeper than the mantle perturbed by the Yellowstone system. We will present the results of anisotropic surface wave tomography. using array processing techniques to extract inter-station phase and amplitude variations. This will provide relatively high resolution results. Preliminary inversions show that ray coverage is excellent, and should provide reasonable constraints on the depth-dependence of radial anisotropy to 200 km depth. Results will be used to constrain Yellowstone mantle flow fields, temperature, melting, and composition, which will be compared to existing plume and non-plume models for Yellowstone.

V12B-0592 1330h POSTER

Crustal and Uppermost Mantle Structure Beneath Iceland From Local Earthquake Tomography

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The Iceland hotspot has been a site of extensive seismological investigation. The recent shear-velocity crustal model constructed from surface waves shows a broad low velocity zone in the upper crust near 10-15 km depth along the Icelandic neovolcanic zones, and a low velocity anomaly confined to a circular region in the lower crust (> 15 km) beneath central Iceland. These features are suggestive of broad regions of high temperature and perhaps the presence of partial melt in the crust, and lateral transport of magma along the volcanic zones from the presumed plume center. However, the extensive presence of partial melt in the crust contradicts several other lines of evidence suggesting that the entire Icelandic crust is subsolidus (except for small volumes beneath central volcanoes). Independent measurements of compressional and shear velocities in the crust and uppermost mantle would help to resolve this controversy, which is important for understanding the thermal structure of and mechanisms of magma transfer in the crust and uppermost mantle. We present a three-dimensional P-wave velocity model of the Icelandic crust and uppermost mantle from tomographic inversions of over 6000 first-arrival P waves from local earthquakes recorded by two broadband seismic arrays in Iceland. The model shows low-velocity regions in the upper crust beneath active volcanic regions and in the middle and lower crust beneath central Iceland, in general agreement with the S-wave model. In addition, P waves traversing below the crust provide constraints on the uppermost mantle structure. A pronounced P-wave velocity reduction, 5% or about 2 times that in the 100-400 km depth range imaged by teleseismic tomography, is found in the uppermost mantle beneath central Iceland. The large velocity reduction requires an elevated temperature of up to 500 degrees or, more likely, a combination of an excess temperature and partial melt. The result provides further support for the hypothesis of a relatively focused melt supply of the Iceland hotspot.

V12B-0593 1330h POSTER

Structure of Crust and Upper Mantle Beneath Iceland from Rayleigh Wave Tomography

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We have imaged the 3-D velocity structure in the crust and upper mantle beneath Iceland using Rayleigh waves recorded at the HOTSPOT and ICEMELT broadband seismic stations. The two-plane-wave inversion technique was adopted to obtain 2-D phase velocities at eleven frequencies from 0.01 to 0.05 Hz. These phase velocities were subsequently inverted for shear wave structure. A 1-D velocity model of Iceland was constructed using the average phase velocities. Crustal thickness was fixed at 29 km in this model. The velocity is significantly lower (> 4%) than that in the global model of AK135 to at least 200 km depth. A strong low velocity layer with a shear velocity of 3.9-4.0 km/s appears at depths of 50 to 110 km. Both crustal thickness and velocity are solved in obtaining the 3-D structure of Iceland. The crust is generally thick in eastern Iceland and thin in western Iceland, while the thickest crust of ∼38 km is found in central Iceland rather than beneath the current hotspot in southeastern Iceland. Low velocity anomalies in the crust follow the trend of Icelandic rift zones in the south and appear slightly west off the rift zones in the north. In the shallow upper mantle (<90 km), low velocity anomalies are generally observed under the Icelandic rift zones and high velocities beneath western and eastern Iceland, reflecting the variation of lithosphere thickness across Iceland. The slowest area is imaged from the northern part of the hotspot to the northern rift zones, which is probably associated with the presence of partial melt. At depths of 100 to 200 km, velocity images are dominated by two distinctive anomalies, a low velocity area in southwestern Iceland and a high velocity region in southeastern Iceland. Surprisingly, this high velocity anomaly is under the location of the current hotspot, which may reflect a strong radial anisotropy associated with the upwelling flow in the plume conduit and/or a more-depleted mantle due to the extensive melt extraction under the hotspot.

V12B-0594 1330h POSTER

Formation and Significance of the Greenland-Iceland-Faores Ridge: Importance of Crustal Flow.

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The Greenland-Iceland-Faroes Ridge (GIFR) is regarded as a classic hotspot track, built by interaction between the Iceland Plume and the Mid-Atlantic Ridge. However, the GIFR-plume link remains poorly understood beyond this general concept because of uncertainty over the mantle, crustal and plate tectonic processes that govern GIFR morphology via crustal thickness. The main mantle processes controling crustal thickness are thought to be plate-driven vs plume-driven upwelling and variations in asthenosphere temperature and composition. The most important tectonic events are the ridge jumps that progressively relocate the spreading axis within the GIFR eastwards relative to the Mid-Atlantic Ridge. Here, we argue that lower crustal flow is an equally important process that governs many major morphological features of the GIFR. Theoretical and experimental studies suggest that when crust is hotter than about 750°C, variations in crustal thickness drive ductile flow within a channel bounded by the brittle upper crust and the top of the mantle. Controlled source and earthquake seismology results show that Icelandic crust varies in thickness between 20 and 40km, and suggest that the 750°C isotherm lies at a depth of a few km beneath the spreading axes and no deeper than 15km across Iceland. Conditions are therefore ideal for crustal flow, and several observations strongly suggest that it occurs. First, there is topographic asymmetry about both the Reykjanes and Kolbeinsey Ridges where they intersect the GIFR. Secondly, axis-parallel variation in crustal thickness differs markedly between zero-age crust within the Eastern Volcanic Zone and off-axis crust adjacent within 100km. Thirdly, spreading ridge segments are linked by zones of en-echelon fractures rather than by 'hard' transform faults. Lower crustal flow can also explain the sharp topographic step bounding the Iceland Shelf, the roughly circular plateau of average diameter ∼ 600km encompassing Iceland itself. This sharp egde corresponds neither to the seismic low velocity anomaly of diameter 100–200km beneath SE Iceland, often interpreted as a plume conduit, nor to regional anomalies in topography, gravity, crustal thickness and geochemistry, which have diameters of ∼ 2000km. However, a topographic step similar to the Iceland Shelf edge is predicted to develop when relatively large crustal thickness variations drive viscous flow into a relatively thin lower crustal channel. An important consequence of crustal flow is that the crustal 'memory' of ridge-plume interaction has likely been erased in all parts of the GIFR except the active spreading ridges. Hence crustal thickness maps of the GIFR can be used neither to derive a plume flux history, nor to test in detail whether the present-day Iceland Plume centre is fixed relative to other hotspots.

V12B-0595 1330h POSTER

Anisotropy Beneath Iceland: Using Splitting Observations To Constrain Mantle Flow

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Anisotropy beneath Iceland provides important clues to the interaction of the Iceland plume and Mid-Atlantic ridge. In this study, we combine the HOTSPOT and SIL datasets and select 28 events for SKS splitting analysis. Measurements were made at 35 stations using Wolfe and Silver (1998)'s multi-event stacking procedure. Our observed splitting directions are generally consistent with those of Bjarnason and Silver (2002) from the ICEMELT experiment. However the denser station coverage reveals a different anisotropic signature in central Iceland. Our splitting results fall into three groups: (1) Eastern Iceland: the average fast polarization directions is N17°W with an average delay time of 1.21 sec; (2) Central Iceland: the average fast polarization directions is N43°W with

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an average delay time of 1.60 sec; (3) Western Iceland: weaker anisotropy (average delay time 0.57 sec) with less well-constrained fast polarization directions. These observations suggest that the plume-ridge interaction does not dominate the anisotropic pattern; instead the splitting results are mainly attributed to shear of the North American and Eurasian plate motion relative to a background mantle flow with a direction of S10°E and a magnitude of approximately 20 mm/yr in the hotspot reference frame. The absence of anisotropy in western Iceland may suggest a strong vertical heterogeneity beneath western Iceland, and the splitting observations may be more reflective of the fast polarization directions of the lithosphere or crust. This heterogeneity may be caused by the complex lithosphere-asthenosphere boundaries that disturb the asthenosphere flow beneath Western Iceland.

V12B-0596 1330h POSTER

Constraining the Temporal and Spatial Evolution of Mantle Plumes Using the Stratigraphic Record

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Gravitational and tomographic studies provide a snap-shot of mantle plumes at the present day. However, these techniques are unable to constrain how mantle plumes have evolved, temporally and spatially, to their present day structures. A mantle plume will generate vertical motions in the overlying plate. These vertical motions will be recorded in the stratigraphic record of the region, enabling the size and planform of the mantle plume to be mapped out over time. During Cenozoic times, anomalous uplift and subsidence occurred throughout the North Atlantic region. These vertical motions most likely result from temporal and spatial variations of Iceland Plume activity. Quantifying uplift generated by the convective support of the Iceland Plume enables the extent of the Iceland Plume head to be mapped out. Here, we describe the record of activity of the southern half of the Iceland Plume head, which affected a region encompassing the British Isles, southern Greenland and eastern Canada. This record is based on stratigraphy along the extensional margins which fringe the North Atlantic Ocean. A detailed study has been carried out on the Moray Firth Basin, part of the North Sea rift system, using backstripped well-log data. The effect of tectonic subsidence has been removed from the basement subsidence profiles of 50 wells, enabling anomalous residual uplift and subsidence to be isolated. A transient Paleocene uplift-subsidence event, with a duration of approximately 15 Ma, is recorded throughout the Moray Firth Basin. The magnitude of peak uplift is 150–500 m. This transient uplift event has previously been identified in basins surrounding the British Isles, including the Faroe-Shetland Basin, the Porcupine Basin and the North Viking Graben. The initiating Iceland Plume provided dynamic support to the overlying plate and generated uplift. As the effect of the Iceland Plume in the British Isles region waned, subsidence occurred. These results from subsidence analysis agree with estimates of dynamic support from the palaeotopographic reconstruction of the coastline of the British Isles at the Paleocene/Eocene boundary. The stratigraphic record of the North Atlantic region yields information about the temporal and spatial evolution of the Iceland Plume during Cenozoic time. Such records of mantle plume evolution will provide important new constraints for models of mantle convection.

V12C MCC: Level 1 Monday 1330h

Melting of the Mantle and Formation of Basalt Magmas: Experiments, Field Studies, and Models I Posters *(joint with OS)*

Presiding: **G Gudfinnsson,** Carnegie Institution of Washington**; S Keshav,** Florida International University

V12C-0597 1330h POSTER

Ocean Island Lavas: Garnet Clinopyroxenite or CO2-bearing Mantle Lherzolite?

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We combine new results of an experimental melting study of a Hawaiian garnet clinopyroxenite (SL) at 2.0-2.5 GPa pressure with data from lherzolite (+CO2) in the CMAS and natural systems to evaluate the origin of alkalic basalts (AB) that erupt at oceanic islands. The experimental data on SL are also used to map the behavior of partial melts as a function of pressure (P), temperature (T), and degree of melting (F). The solidus of SL, a tholeiitic picrite with 1wt% Na2O, is bracketed at 1295±15 and 1335±15 degree Celsius at 2.0 and 2.5 GPa, respectively. These brackets are slightly lower than those of anhydrous mantle lherzolite at identical pressures. Chemically, the high and low-F melts are ol-hy normative and moderately to strongly ne-normative, which can be ascribed to the effect of Na and Fe in expanding the "eclogite surface" in natural systems. There is very little overlap between primitive AB and partial melts of SL. These differences are most pronounced for MgO, Al2O3, CaO, CaO/Al2O3, and CaO/MgO. SL melts partially resemble AB only in terms of SiO2 and Na2O+K2O. Partial melts of anhydrous mantle lherzolite also partially overlap AB, but even the lowest degree melts analyzed are far removed from most of the AB. However, partial melts generated at 3-6 GPa from carbonated mantle lherzolite in CMAS-CO2 and natural systems can generate the AB clan of lavas from oceanic islands. Experimental melting studies in simple CMAS-CO2 and natural lherzolitic systems demonstrate that isobaric increases in F lead to a moderate decrease in CaO+MgO in partial melts. With increasing F, CaO/MgO and CaO/Al2O3 drop sharply in the partial melts. Based on CaO/Al2O3, CaO, CaO+MgO, Al2O3, and Mg# systematics, it is proposed that the Hawaiian, Samoan, and Polynesian lavas have tapped the shallowest (3.0-3.5 GPa) part of the melting column within the garnet stability field in the presence of a low-to-moderate amount of CO2 in their respective mantle sources. In addition, on the basis of CaO and CaO/MgO systematics, Hawaiian, Samoan, and Polynesian lavas appear to be produced by relatively high F. Within Hawaii, lavas from Oahu may have equilibrated at a slightly higher pressure than those from Koloa. On the other hand, based on higher CaO, CaO/Al2O3, and CaO+MgO, coupled with lower CaO/MgO, and Al2O3, it is inferred that lavas from the Gran Canaria have equilibrated at a slightly higher pressure (3.5-4.5 GPa) in the presence of slightly higher CO2. Chemical systematics also suggest that lavas from Gran Canaria may have been products of relatively lower F. It is proposed here that major element systematics of AB and also nephelinites/melilitites cannot be modeled by garnet clinopyroxenite (with anhydrous mantle lherzolite) at the pressures of investigation. CO2 is required in the mantle source regions of AB on ocean islands.

V12C-0598 1330h POSTER

Melting experiments of a peridotite from Penghu area, Taiwan, at pressures up to 2 GPa.

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A peridotite occurred as a xenolith in alkali basalt of Penghu, Islands, in Taiwan Strait, Taiwan, was studied with a quenching furnace and a piston-cylinder apparatus. The compositions of melting products showed the trends as the decreasing of Al2O3, CaO, Na2O, and K2O and the increasing of MgO as the melting temperature increased at specific pressure. At the specific temperature, the SiO2 of melting products decreased as the pressure increased. The basalts of Penghu can be classified as alkali basalt, olivine tholeiite, and quartz tholeiite based on the classification of basalt tetrahedron. The quartz tholeiite of Penghu could be modeled as 10% to 24% partial melt product from the peridotite at 0.5 GPa. The olivine tholeiite of Penghu was proposed to be the partial melting, up to 23%, products from the peridotite at 1.0 and 1.5 GPa. Comparing the compositions of melting products with the basalts of Penghu, we proposed that the primitive basaltic magmas of Penghu had been fractional crystallized to produce the basalts of Penghu.

V12C-0599 1330h POSTER

Long-term Rates of Mafic Magma Emplacement and Implications for Heat Advection

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Rates of magmatism (magma emplacement rate) including both volcanic products and intrusive bodies were obtained for terrestrial petrotectonic systems where reliable volumes can be estimated and geochronological data exist. Approximately 50 estimates of magma emplacement rates have been extracted from the literature published between 1982 and 2003 for persistent basaltic systems with durations from 1 ka to 5 Ma. Although the volcanic output is highly episodic, the data indicate that the mass output rate at individual hotspot volcanoes is on the order of 10^{-3} km^3/yr when averaged over several thousand years. This differs from the estimated output rates of large igneous provinces, such as continental flood basalts and oceanic plateaus, which have maximal output rates on the order of 1 km^3/yr per province. For globally averaged mid-ocean ridges, the total volcanic emplacement rate is only 10^{-6} km^3/yr/100 km of ridge. Ratios of intrusive to extrusive emplacement are subject to much uncertainty, but generally lie in the range 6:1 to 10:1 for most crustal mafic magma systems. Recent seismic, geodetic, and gravity work suggests that there may be large regions of underplating and storage in subcrustal magma chambers in areas of basaltic volcanism previously not widely considered in intrusive volume estimates that may increase most of these ratios to 10:1. Rates of magmatism may be translated into excess heat flows for specific magmatic provinces to obtain estimates of advected heat transport via magmatism at regional scales over magmatic province timescales. For mafic eruption rate V and an intrusive/extrusive ratio of R, the volumetric rate of magma flow into the crust is RV. The excess heat power (J/yr) associated with magma transport from mantle to crust is $RV\rho\delta T$ [$Cp + \delta h/(T_{liquidus}-T_{solidus})$] where δT is the temperature difference between the magma and host crust, δh is the enthalpy of crystallization (250-400 kJ/kg dependent on magma composition), ρ is magma density, Cp is the isobaric heat capacity of the magma, and the liquidus to solidus temperature interval is pressure and composition dependant but typically equals 300 K. The excess heat power into the crust due to mafic magmatism is roughly 2e+19 J/yr for a volumetric eruption rate of 1 km^3/a. As an example, consider the Skye sub-province (area 1600 km^2) of the British Tertiary Igneous Province (BTIP). For the estimated volume eruption rate of 2e-3 km^3/a and R=5 the average excess heat flow is 3 e+7 J/m^2a or 1 W/m^2. The excess heat flux is a factor of ten greater than the average terrestrial global heat flux 0.09 W/m^2. The 'excess' heat flux is associated with a crustal thickening rate of 3 km/Ma in the time interval 60-53 Ma. We conclude that the volume flux of magma in the active years of this part of the BTIP focused heat flow about an order of magnitude above background at the regional scale for 5 Myr. The regional energy/mass balance estimate is consistent with geochemical modeling of Skye intrusive and volcanic rocks that point to significant magma recharge during the magmatic evolution at Skye.