AGU Fall Meeting 2017

Monday, 11 December 2017

Monday, 11 December 2017 08:00 – 10:00 Convention Center – 222

S11D: Advances in Full Waveform Modeling, Inversion, and Imaging I

Full-waveform modeling has enabled seismologists to accurately account for complex wave propagation in three-dimensional (3D) heterogeneous, anisotropic, and (an)elastic Earth. This has led to great progress in imaging of the Earth structure and studies of seismic sources. This session provides a forum for developments in full-waveform-based methods and applications, including but not limited to: (1) development and validation of forward modeling techniques and inversion algorithms; (2) automatic full-waveform data processing algorithms; (3) multi-scale imaging of velocity, anisotropy, density, and attenuation structures using earthquake signals, ambient noise, and active-source data; (4) estimation of earthquake source locations, moment tensors, rupture processes, and fault structures; (5) model assessment and validation; (6) full-waveform migration; and (7) wave-prediction and observation of site amplification, surface ground-motion, and seismic hazard. Topics combining full-waveform methods with other geophysical constraints and presentations highlighting new geological/tectonic insights from full-waveform approaches are strongly encouraged.

Conveners
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Yang Shen
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Monday, 11 December 2017 08:30 – 8:45 Convention Center – 222

S11D-03: Foundering of the Lithospheric Mantle under the Eastern Tibetan Plateau Revealed by Full-Wave Pn Tomography

An accurate tomography model of the lithospheric mantle is essential for understanding the dynamics and evolution of the Tibetan Plateau. Using regional earthquake records, we obtain the first full-wave Pn tomography model for the eastern Tibetan Plateau. The resulting three-dimensional model exhibits similarities to and notable differences from the previous models based on ray theory. The juxtaposition of a high-velocity anomaly under the eastern Qiangtang Terrane and a low-velocity anomaly to the south near the Bangong-Nujiang Suture (BNS) provides strong evidence that the underthrusting Indian Plate does not reach the BNS beneath the plateau east of 90°E. The model shows no

evidence for a southward-subducted Qaidam lithosphere. The sandwich-like layering of a low-velocity layer between two high-velocity layers at 80 to 160 km depths, mainly beneath the Qiangtang Terrane, is consistent with the results of S-to-P receiver functions. The observed contact between these two high-velocity layers beneath the Kunlun suggests that the lower high-velocity layer can be identified as the foundering Tibetan lithospheric mantle, which may be caused by gravitational instability. Beneath the eastern Kunlun Fault and the West Qinling orogen, a southward dipping high-velocity anomaly underlies a low-velocity mantle anomaly, is a pattern consistent with a delaminated mantle lithosphere and associated upwelling asthenosphere. Together with the evidence for lithospheric delamination beneath the central and southern Tibetan Plateau in previous studies, our findings suggest that the lithospheric foundering plays an important role in the formation of the Tibetan Plateau.

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Monday, 11 December 2017 8:00 – 12:20 Convention Center – Poster Hall D-F

B11A-1658: Global Distribution of Radiolytic H_2 Production in Marine Sediment and Implications for Subsurface Life

We present the first global estimate of radiolytic H_2 production in marine sediment. Knowledge of microbial electron donor production rates is critical to understand the bioenergetics of Earth's subsurface ecosystems.

In marine sediment, radiolysis of water by radiation from naturally occurring radionuclides leads to production of reduced (H_2) and oxidized (H_2O_2, O_2) species. Water radiolysis is catalyzed by marine sediment. The magnitude of catalysis depends on sediment composition and radiation type. Deep-sea clay is especially effective at enhancing H_2 yields, increasing yield by more than an order of magnitude relative to pure water. This previously unrecognized catalytic effect of geological materials on radiolytic H_2 production is important for fueling microbial life in the subseafloor, especially in sediment with high catalytic power.

Our estimate of radiolytic H_2 production is based on spatially integrating a previously published model and uses (i) experimentally constrained radiolytic H_2 yields for the principal marine sediment types, (ii) bulk sediment radioactive element content of sediment cores in three ocean basins (N. Atlantic, N. and S. Pacific), and global distributions of (iii) seafloor lithology, (iv) sediment porosity, and (v) sediment thickness. We calculate that global radiolytic H_2 production in marine sediment is 1.6E+12 mol H_2 yr^{-1}. This production rate is small relative to the annual rate of photosynthetic organic-matter production in the surface ocean. The globally integrated ratio of radiolytic H_2 production relative to photosynthetic primary production is 4.1E-4, based on electron equivalences.

Although small relative to global photosynthetic biomass production, sediment-catalyzed production of radiolytic products is significant in the subseafloor. Our analysis of 9 sites in the N. Atlantic, N. and S. Pacific suggests that H_2 is the primary microbial fuel in organic-poor sediment older than a few million years; at these sites, calculated radiolytic H_2 consumption rates are more than an order of magnitude higher than organic-matter oxidation rates. Similarly, in subseafloor ecosystems of continental margins, which are depleted in strong oxidants, catalyzed production of radiolytic O_2 and H_2O_2 is a previously unrecognized cryptic source of electron acceptors.

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Monday, 11 December 2017 8:00 – 12:20 Convention Center – Poster Hall D-F

V11B-0343: Calc-Alkaline Liquid Lines of Descent Produced Under Oxidizing Conditions: An Experimental and Petrologic Study of Basaltic Tephras from the Western Aleutians, AK

Buldir, a volcano in the western Aleutian Arc, features eruptive products that form one of the most strongly calc-alkaline compositional trends observed in modern island arcs. Previous studies of Buldir and nearby submarine dredge samples suggest that Buldir's mineral phases and isotopic signatures may be introduced through mixing of two distinct magmas and/or melts, as no experimental study has been able to create a liquid line of descent (LLD) as calc-alkaline as Buldir's whole rock trend. To further test this hypothesis, we present new experimental results and petrographic analysis of tephras from the 2015 field season of the GeoPRISMS shared platform. Tephras (51.4–54.8 wt% SiO_2) have a phenocryst assemblage of olivine + plagioclase + cpx + spinel ± hornblende (hbl). In natural samples, plagioclase comprises most of the crystal volume, followed by either olivine or hornblende. In samples that contain abundant hbl (Hbl Mg#=65-80), olivine and plagioclase span a range of compositions from Fo_{72-86} and An_{60-93}, respectively. In samples without hbl, olivines are more forsteritic (Fo_{79-90}), and plagioclase is less calcic (An_{65-83}). Spinel is ubiquitous; with Cr- rich spinel inclusions in olivine and hbl, and magnetite in the groundmass. Our petrologic observations do not require magma mixing. To determine whether these observations could be consistent with the LLD of a single parental liquid, we conducted a series of phase equilibrium experiments at 100 MPa in a rapid-quench cold-seal (MHC) apparatus on the most primitive natural lava from Buldir (9.34 wt% MgO). Experiments were equilibrated in noble metal capsules pre-saturated with Fe, and buffered at Re-ReO_2 under water-saturated conditions. Spinel [$(Mg_{80}, Fe^{2+}_{20})(Fe^{3+}_{52}, Cr_{83}, Al_{66})O_4$] is the liquidus phase,

followed by olivine, then plagioclase, then cpx, and lastly, hbl. Once cpx and hbl saturate, spinel composition shifts to magnetite. Experimental run products demonstrate that all mineral phases observed in the tephras are plausible phenocrysts. Experimental glass compositions demonstrate that the strongly calc-alkaline trend observed at Buldir can be produced through crystallization of a parental liquid under water-saturated conditions at relatively high oxygen fugacity, where the effect of high fO_2 is to stabilize spinel as a liquidus phase.

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Monday, 11 December 2017 8:00 – 12:20 Convention Center – Poster Hall D-F

PP11B-1034: Penguin Proxies: Deciphering Millennial-Scale Antarctic Ecosystem Change using Amino Acid Stable Isotope Analysis

The Southern Ocean ecosystem is undergoing rapid environmental change due to ongoing and historic anthropogenic impacts such as climate change and marine mammal harvesting. These disturbances may have cascading effects through the Antarctic food webs, resulting in profound shifts in the sources and cycling of organic matter supporting higher-trophic organisms, such as penguins. For example, bulk stable isotope analyses of modern and ancient preserved penguin tissues suggest variations in penguin feeding ecology throughout the Holocene with dramatic isotopic shifts in the last ~200 years. However, it is not clear whether these isotopic shifts resulted from changes at the base of the food web, dietary shifts in penguins, or some combination of both factors. Newly developed compound-specific stable nitrogen isotope analysis of individual amino acids (CSIA-AA) may provide a powerful new tool to tease apart these confounding variables. Stable nitrogen isotope values of trophic amino acids (e.g., glutamic acid) increase substantially with each trophic transfer in the food web, while source amino acid (e.g., phenylalanine) stable nitrogen isotope values remain relatively unchanged and reflect ecosystem baselines. As such, we can use this CSIA-AA approach to decipher between baseline and dietary shifts in penguins over time from modern and ancient eggshells of *Pygoscelis* penguins in the Antarctic Peninsula and the Ross Sea regions of Antarctica. In order to accurately apply this CSIA-AA approach, we first characterized the trophic fractionation factors of individual amino acids between diet and penguin consumers in a long-term controlled penguin feeding experiment. We then applied these values to modern and ancient eggshells from the Antarctic Peninsula and Ross Sea to evaluate shifts in penguin trophic dynamics as a function of climate and anthropogenic interaction throughout much of the Holocene. This work develops a cutting-edge new molecular

geochemistry approach applied to penguins as sensitive indicators of past environmental change in Antarctica.

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Monday, 11 December 2017 9:15 – 9:30 Convention Center – 344-345

PP11E-06: Amino Acid Stable Isotope Applications to Deep-Sea Corals: A Molecular Geochemistry Approach to Reconstructing Past Ocean Conditions

Future climate change is predicted to alter ocean productivity, food web dynamics, biogeochemical cycling, and the efficacy of the biological pump. Proteinaceous deep-sea corals act as "living sediment traps," providing long-term, high-resolution records of exported surface ocean production and a window into past changes in ocean condition as a historical context for potential future changes. Here, we present recent work developing the application of compound-specific stable isotope analysis of individual amino acids to proteinaceous deep-sea corals to reconstruct past changes in phytoplankton community composition and biogeochemical cycling. We present new calibrations for molecular isotope comparisons between metabolically active coral polyp tissue and bioarchival proteinaceous skeleton. We then applied these techniques to deep-sea corals from the North Pacific Subtropical Gyre (NPSG) to reconstruct centennial to millennial time scale changes in phytoplankton community composition and biogeochemical cycling as a function of regional climate change. This work suggests that the NPSG has undergone multiple major phytoplankton regime shifts over the last millennium between prokaryotic and eukaryotic phytoplankton communities and associated sources of nitrogen fueling production. The most recent regime, which started around the end of the Little Ice Age and the onset of the Industrial era, is unprecedented in the last 1000 years and resulted in a 30-50% increase in diazotrophic cyanobacteria contribution to export production and an associated 17-27% increase in N_2-fixation in the NPSG over last century. By offering the first direct phylogenetic context for long-term shifts in isotopic records of exported particulate organic matter, our data represent a major step forward in understanding the evolution of marine plankton community dynamics, food web architecture, biogeochemical cycling, and the climate feedback loops through the biological pump.

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Monday, 11 December 2017 13:40 – 18:00 Convention Center – Poster Hall D-F

S13A: Advances in Full Waveform Modeling, Inversion, and Imaging II - Posters

Full-waveform modeling has enabled seismologists to accurately account for complex wave propagation in three-dimensional (3D) heterogeneous, anisotropic, and (an)elastic Earth. This has led to great progress in imaging of the Earth structure and studies of seismic sources. This session provides a forum for developments in full-waveform-based methods and applications, including but not limited to: (1) development and validation of forward modeling techniques and inversion algorithms; (2) automatic full-waveform data processing algorithms; (3) multi-scale imaging of velocity, anisotropy, density, and attenuation structures using earthquake signals, ambient noise, and active-source data; (4) estimation of earthquake source locations, moment tensors, rupture processes, and fault structures; (5) model assessment and validation; (6) full-waveform migration; and (7) wave-prediction and observation of site amplification, surface ground-motion, and seismic hazard. Topics combining full-waveform methods with other geophysical constraints and presentations highlighting new geological/tectonic insights from full-waveform approaches are strongly encouraged.

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Monday, 11 December 2017 13:40 – 18:00 Convention Center – Poster Hall D-F

S13A-0629: A High-Order Strong Stability Preserving Runge-Kutta Method for Three-Dimensional Full Waveform Modeling and Inversion of Anelastic Models

Accurate and efficient forward modeling methods are important for high-resolution full waveform inversion. Compared with the elastic case, solving anelastic wave equation requires more computational time, because of the need to compute additional material-independent anelastic functions. A numerical scheme with a large Courant-Friedrichs-Lewy (CFL) condition number enables us to use a large time step to simulate wave propagation, which improves computational efficiency. In this work, we apply the fourth-order strong stability preserving Runge-Kutta method with an optimal CFL coeffiecient to solve the anelastic wave equation. We use a fourth order DRP/opt MacCormack scheme for the spatial discretization, and we approximate the rheological behaviors of the Earth by using the generalized Maxwell body model. With a larger CFL condition number, we find that the computational efficient is significantly improved compared with the traditional fourth-order Runge-Kutta method. Then, we apply the scattering-integral method for calculating travel time and amplitude sensitivity kernels with respect to velocity and attenuation structures. For each source, we carry out one forward simulation and save the time-dependent strain tensor. For each station, we carry out three "backward" simulations for the three components and save the corresponding strain tensors. The sensitivity kernels at each point in the medium are the convolution of the two sets of the strain tensors. Finally, we show several synthetic tests to verify the effectiveness of the strong stability preserving Runge-Kutta method in generating accurate synthetics in full waveform modeling, and in generating accurate strain tensors for calculating sensitivity kernels at regional and global scales.

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Monday, 11 December 2017 13:40 – 18:00 Convention Center – Poster Hall D-F

S13A-0630: Three-Dimensional Sensitivity Kernels of Z/H Amplitude Ratios of Surface and Body Waves

The ellipticity of Rayleigh wave particle motion, or Z/H amplitude ratio, has received increasing attention in inversion for shallow Earth structures. Previous studies of the Z/H ratio assumed one-dimensional (1D) velocity structures beneath the receiver, ignoring the effects of three-dimensional (3D) heterogeneities on wave amplitudes. This simplification may introduce bias in the resulting models. Here we present 3D sensitivity kernels of the Z/H ratio to Vs, Vp, and density perturbations, based on finite-difference modeling of wave propagation in 3D structures and the scattering-integral method. Our full-wave approach overcomes two main issues in previous studies of Rayleigh wave ellipticity: (1) the finite-frequency effects of wave propagation in 3D Earth structures, and (2) isolation of the fundamental mode Rayleigh waves from Rayleigh wave overtones and converted Love waves. In contrast to the 1D depth sensitivity kernels in previous studies, our 3D sensitivity kernels exhibit patterns that vary with azimuths and distances to the receiver. The laterally-summed 3D sensitivity kernels and 1D depth sensitivity kernels, based on the same homogeneous reference model, are nearly identical with small differences that are attributable to the single period of the 1D kernels and a finite period range of the 3D kernels. We further verify the 3D sensitivity kernels by comparing the predictions from the kernels with the measurements from numerical simulations of wave propagation for models with various small-scale perturbations. We also calculate and verify the amplitude kernels for P waves. This study shows that both Rayleigh and body wave Z/H ratios provide vertical and lateral constraints on the structure near the receiver. With seismic arrays, the 3D kernels afford a powerful tool to use the Z/H ratios to obtain accurate and high-resolution Earth models.

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Monday, 11 December 2017 14:09 – 14:22 Convention Center – 238-239

NG13A-03: Multiple States and Hysteresis in a Two-layer Loop Current Type System

Rotating table experiments are considered of a two-layer loop current type or gap-leaping system. Such experiments are representative of oceanic regions including the Kuroshio Current crossing the Luzon Strait, the Gulf of Mexico Loop Current, the Northeast Chanel of the Gulf of Maine where Scotian Shelf water leaps directly from Browns Bank to Georges Bank and more. Systems such as these are known to admit two dominant states: leaping across the gap or penetrating into the gap forming a loop current. Which state the system will assume and when transitions between states will occur are open problems. We show that such systems admit multiple steady states with hysteresis when

the strength of the current is varied. When the state of the system is viewed in a parameter space representing inertia and vorticity constraint, the system is found to be characterized by a cusp topology of solutions. The existence of such dynamics in two-layer quasi-geostrophic systems has significant implications for oceanographic predictability.

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Monday, 11 December 2017 16:00 – 16:15 Convention Center – 203-205

DI14A-01: Migrating Toward Fully 4-D Geodynamical Models of Asthenospheric Circulation and Melt Production at Mid-Ocean Ridges

Lateral migration of mid-ocean ridge spreading centers is a well-documented phenomenon leading to asymmetric melt production and the surficial expressions thereof. This form of plate motion has been difficult to incorporate into both numerical and analogue geodynamical models, and consequently, current estimates of time-dependent flow, material transport, and melting in the mantle beneath ridges are lacking. To address this, we have designed and built an innovative research apparatus that allows for precise and repeatable simulations of mid-ocean ridge spreading and migration. Three pairs of counter-rotating belts with adjustable lateral orientations are scaled to simulate spreading at, and flow beneath, three 600km wide ridge segments with up to 300km transform offsets. This apparatus is attached to a drive system that allows us to test a full range of axis-parallel to axis-normal migration directions, and is suspended above a reservoir of viscous glucose syrup, a scaled analogue for the upper mantle, and neutrally buoyant tracers. We image plate-driven flow in the syrup with high-resolution digital cameras and use particle image velocimetry methods to obtain information about transport pathlines and flow-induced anisotropy. Suites of experiments are run with and without ridge migration to determine the overall significance of migration on spatial and temporal characteristics of shallow mantle flow. Our experiments cover an expansive parameter space by including various spreading rates, migration speeds and directions, degrees of spreading asymmetry, transform-offset lengths, and upper mantle viscosity conditions. Preliminary results highlight the importance of modeling migratory plate forces. Mantle material exhibits a significant degree of lateral transport, particularly between ridge segments and towards the melt triangle. Magma supply to the melting region is highly complex; parcels of material do not necessarily move along fixed streamlines, rather, they can be perturbed upwards and left behind as spreading centers continue to move laterally. These results emphasize that observations of seismic anisotropy should be interpreted in light of intricate flow pathlines, and that melt transport models should consider different paths for melt relative to the solid matrix.

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Tuesday, 12 December 2017

Tuesday, 12 December 2017 08:00 – 12:20 Convention Center – Poster Hall D-F

OS21A-1355: Global Distribution of Net Electron Acceptance in Subseafloor Sediment

We quantified the global distribution of net electron acceptance rates (e^-/m^2/year) in subseafloor sediment (>1.5 meters below seafloor [mbsf]) using (i) a modified version of the chemical-reaction-rate algorithm by Wang et al. (2008), (ii) physical properties and dissolved oxygen and sulfate data from interstitial waters of sediment cores collected by the Ocean Drilling Program, Integrated Ocean Drilling Program, International Ocean Discovery Program, and U.S. coring expeditions, and (iii) correlation of net electron acceptance rates to global oceanographic properties. Calculated net rates vary from 4.8 x 1019 e^-/m^2/year for slowly accumulating abyssal clay to 1.2 x 1023 e^-/m^2/year for regions of high sedimentation rate. Net electron acceptance rate correlates strongly with mean sedimentation rate. Where sedimentation rate is very low (e.g., ~1 m/Myr), dissolved oxygen penetrates more than 70 mbsf and is the primary terminal electron acceptor. Where sedimentation rate is moderate (e.g., 3 to 60 m/Myr), dissolved sulfate penetrates as far as 700 mbsf and is the principal terminal electron acceptor. Where sedimentation rate is high (e.g., > 60 m/Myr), dissolved sulfate penetrates only meters, but is the principal terminal electron acceptor in subseafloor sediment to the depth of sulfate penetration. Because microbial metabolism continues at greater depths than the depth of sulfate penetration in fast-accumulating sediment, complete quantification of subseafloor metabolic rates will require consideration of other chemical species.

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Tuesday, 12 December 2017 08:00 – 12:20 Convention Center – Poster Hall D-F

PA21B: Building and Sustaining Successful Communities in Science Posters

Science is increasingly collaborative. Scientists are uniting in national and international communities to focus funding, inter-disciplinary thinking, and public engagement on a variety of research questions. Additionally, scientists are involved in wide-ranging professional or political communities for improving public understanding of science and science-driven decision-making. Few such communities are self-sustaining, and the need for functioning communities in science has created a small but growing profession: the scientific community manager. This session will highlight the roles and responsibilities of community managers in a variety of scientific settings, how these individuals facilitate new connections, and how this translates into impactful discovery, policy, and public engagement outcomes. We will highlight ways of measuring success in community engagement, and how meaningful implementation of metrics and benchmarking impact effective community management. We will build upon the outcomes of the inaugural AAAS Community Engagement Fellowship program, in which all conveners are Fellows.

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Tuesday, 12 December 2017 08:00 – 12:20 Convention Center – Poster Hall D-F

PA21B-0347: Working With and Promoting Early Career Scientists Within a Larger Community

For many scientific communities, engaging early career researchers is critical for success. These young scientists (graduate students, postdocs, and newly appointed professors) are actively forming collaborations and instigating new research programs. They also stand to benefit hugely from being part of a scientific community, gaining access to career development activities, becoming part of strong collaborator networks, and achieving recognition in their field of study — all of which will help their professional development. There are many ways community leaders can work proactively to support and engage early career scientists, and it is often a community manager's job to work with leadership to implement such activities. In this presentation, I will outline ways of engaging early career scientists at events and tailored workshops, of promoting development of their leadership skills, and of creating opportunities for recognizing early career scientists within larger scientific communities. In this talk, I will draw from my

experience working with the Deep Carbon Observatory Early Career Scientist Network, supported by the Alfred P. Sloan Foundation.

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Tuesday, 12 December 2017 08:00 – 12:20 Convention Center – Poster Hall D-F

T21A-0553: Numerical Simulation of Dynamic Triggering of Aseismic Slip Events in Northern Chile and New Zealand

Dynamic triggering of aseismic slip events has been observed in California for several decades. However, it has not been observed much in other parts of the world. Recently, due to increased monitoring networks, more examples have been observed and provide an opportunity to improve our understanding of the mechanism of both aseismic slip events and its triggering mechanism. Here, we use numerical simulations to study the dynamic triggering of aseismic slip events in two regions: the Atacama Fault System in Northern Chile and the Hikurangi subduction zone in New Zealand. On the Atacama Fault, creepmeters have recorded both spontaneous and triggered creep events. On the Hikurangi subduction zone, GPS stations have recorded shallow slow slip events that ruptured the thrust interface near the North Island every 2-5 years. In 2016, the M7.8 Kaikoura earthquake dynamically triggered several shallow slow slip events in this area from 500 km away, which is one of the first observations of such triggering. Here we simulate the dynamic triggering of aseismic slip events in these two areas using a 1D fault model in the framework of rate-and-state friction, constrained by creepmeter, GPS, and seismic data. We focus on identifying the triggering threshold in terms of the amplitude and frequency content of the perturbations imparted by the passing seismic waves. We compare the results with previous studies on the triggering of creep events on the Superstition Hills Fault in Southern California. Our preliminary results suggest that shallow frictional heterogeneity can explain both the spontaneous and dynamically triggered aseismic events in Northern Chile, New Zealand, and California.

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Tuesday, 12 December 2017 11:20 – 11:35 Convention Center – 211-213

T22E-05: Diffuse Extension of the Southern Mariana Margin: Implications for Subduction Zone Infancy and Plate Tectonics

Opening of the southern Mariana margin takes place in contrasting modes: Extension normal to the trench forms crust that is passively accreted to a rigid Philippine Sea plate and forms along focused and broad accretion axes. Extension also occurs parallel to the trench and has split apart an Eocene-Miocene forearc terrain accreting new crust diffusely over a 150-200 km wide zone forming a pervasive volcano-tectonic fabric oriented at high angles to the trench and the backarc spreading center. Earthquake seismicity indicates that the forearc extension is active over this broad area and basement samples date young although waning volcanic activity. Diffuse formation of new oceanic crust and lithosphere is unusual; in most oceanic settings extension rapidly focuses to narrow plate boundary zones—a defining feature of plate tectonics. Diffuse crustal accretion has been inferred to occur during subduction zone infancy, however. We hypothesize that, in a near-trench extensional setting, the continual addition of water from the subducting slab creates a weak overriding hydrous lithosphere that deforms broadly. This process counteracts mantle dehydration and strengthening proposed to occur at mid-ocean ridges that may help to focus deformation and melt delivery to narrow plate boundary zones. The observations from the southern Mariana margin suggest that where lithosphere is weakened by high water content, narrow seafloor spreading centers cannot form. These conditions likely prevail during subduction zone infancy, explaining the diffuse contemporaneous volcanism inferred in this setting.

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Tuesday, 12 December 2017 13:40 – 18:00 Convention Center – Poster Hall D-F

H23G-1763: Contamination Control of Freeze-Shoe Coring System for Collection of Aquifer Sands

We have developed and tested an original device, the freeze-shoe coring system, designed to recover undisturbed samples of water contained in sand-dominated aquifers. Aquifer sands are notoriously difficult to collect together with porewater from coincident depths, as high hydraulic permeability leads to water drainage and mixing during retrieval.

Two existing corer designs were reconfigured to incorporate the freeze-shoe system; a hydraulic piston corer (HPC) and a rotary corer (RC). Once deployed, liquid CO_2 contained in an interior tank is channeled to coils at the core head where it changes phase, rapidly cooling the deepest portion of the core. The resulting frozen core material impedes water loss during recovery.

We conducted contamination tests to examine the integrity of cores retrieved during a March 2017 yard test deployment. Perfluorocarbon tracer (PFC) was added to the drill fluid and recovered cores were subsampled to capture the distribution of PFC throughout the core length and interior. Samples were collected from two HPC and one RC core and analyzed for PFC concentrations.

The lowest porewater contamination, around 0.01% invasive fluid, occurs in the center of both HPC cores. The greatest contamination (up to 10%) occurs at the disturbed edges where core material contacts drill fluid. There was lower contamination in the core interior than top, bottom, and edges, as well as significantly lower contamination in HPC cores that those recovered with the RC.

These results confirm that the freeze-shoe system, proposed for field test deployments in West Bengal, India, can successfully collect intact porewater and sediment material with minimal, if any, contamination from drill fluid.

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Tuesday, 12 December 2017 14:10 – 14:25 Convention Center – 211-213

T23I-03: New Constraints on Subduction Inputs and Volatile Outputs Along the Aleutian Arc

Volatile cycling drives volcanism in subduction zone settings. At arcs, volatiles can originate from the subducted slab, mantle wedge and/or crust. Each region has characteristic isotopic signatures, which can be used to fingerprint volatile provenance. We speculate that differences in subduction parameters, such as convergence angle, plate coupling and subducted sediment fluxes, may lead to differences in volatile provenance, which may in turn influence volcanic eruption style and frequency. Here we combine updated constraints on subduction inputs and volatile outputs to provide new insights into volatile cycling within the Aleutian Arc.

The high proportion of organic carbon (80-100% to total carbon) in sediments subducting at the Aleutian trench stands out globally and predicts a light carbon isotopic composition of recycled volcanic fluids. We assess volatile outputs on volcanic timescales and along the arc by combining carbon (C), nitrogen (N) and helium (He) isotopic compositions of volcanic gases and new analyses of He and, where possible, C isotopes in olivine-hosted fluid inclusions. From our preliminary isotopic analyses of volcanic gases, we find a greater proportion of mantle-derived volatiles released from the Western segment of the Aleutian Arc (>40% mantle) compared with other volcanic arcs around the world (<30% mantle), where volatiles are sourced primarily from subducted or upper crustal carbonates. This trend may be due to the oblique convergence and low subducted sediment input in this region. The Aleutian Arc also exhibits among the lightest carbon isotope ratios of arcs worldwide ($\delta^{13}C$ = -10 to -15‰), especially in the central part of the arc, where organic-bearing terrigneous sediment fills the trench and the convergence rate is high. New constraints on subduction inputs and outputs presented here will help discriminate between upper crustal and subducted carbon sources, and provide further insights into volatile cycling and subduction processes within the Aleutian Arc.

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Wednesday, 13 December 2017

Wednesday, 13 December 2017 8:00 – 12:20 Convention Center – Poster Hall D-F

OS31C-1410: Preparing for Science at Sea - A Chief Scientists Training Cruise on Board the R/V Sikuliaq

As part of their education, marine geology and geophysics students spend time at sea, collecting, processing and interpreting data to earn their degrees. While this is a critical component of their preparation, it is an incomplete introduction to the process of doing science at sea. Most students are unfamiliar with the proposal process. Many students spend their time at sea performing assigned tasks without responsibility or participation in cruise planning and execution. In December 2016, we conducted a two-week-long, NSF-funded "Chief Scientist Training Cruise" aboard the R/V *Sikuliaq* designed to complete their introduction to seagoing science by giving the students the opportunity to plan and execute surveys based hypotheses they formulated.

The educational process began with applicants responding to a request for proposals (RFP), which provided a framework for the scientific potential of the cruise. This process continued training through two days of workshops and presentations at the Hawai'i Institute of Geophysics. The students used existing data to define hypotheses, plan surveys, and collect/analyze data to test their hypothesis. The survey design was subject to the time constraints imposed by the ship schedule and the physical constraints imposed by the ship's equipment. The training and sea time made it possible to address all steps of the scientific process, including proposal writing.

Once underway, the combination of conducting the planned surveys and attending daily presentations helped familiarize the students with at-sea operations, the equipment on board the R/V *Sikuliaq*, and the process of writing proposals to NSF for sea-going science. Questionnaires conducted prior to the cruise and in the final days before arriving in port document the success of this training program for developing the abilities and confidence in identifying significant scientific problems, preparing proposals to secure funding, and planning and directing ship surveys.

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Wednesday, 13 December 2017 13:40 – 18:00 Convention Center – Poster Hall D-F

V33D-0554: Subsolidus Cooling of Mid-ocean Ridge Peridotites and Implications for the Oxygen Fugacity of the Oceanic Upper Mantle

Peridotites dredged from mid-ocean ridges provide a window into the chemistry of Earth's upper mantle. At equilibrium, mineral assemblages within peridotite record intrinsic properties, including oxygen fugacity (f_{O2}). During cooling below the solidus, however, reactions affect the chemical compositions and modal abundances of minerals, directly affecting the f_{O2} recorded by these mineral assemblages. The slow kinetics of subsolidus diffusion also prevent full re-equilibration of peridotite during cooling, and different reactions have different closure temperatures. As a result, peridotites measured at the surface record neither equilibrium nor asthenospheric conditions.

In order to quantify the effect of subsolidus diffusion on f_{O2}, we analyzed minerals from abyssal peridotites dredged from the Southwest Indian Ridge (SWIR), which we then used as a basis for modeling potential subsolidus reactions. We first examined exchange reactions where no modal changes occur. We considered both Fe-Mg exchange between olivine and spinel [1] and Al-Cr exchange between orthopyroxene and spinel [2], and combined these models with spinel oxybarometry [3] to determine the effect of these reactions on f_{O2}. Our results indicate that as peridotites cool from ~1300°C to ~900°C, these exchange processes together increase recorded f_{O2} by ~0.3 log units relative to the approach in which compositional changes are not considered.

Some reactions additionally change mineral modal abundances during cooling, in particular the Tschermak exchange in orthopyroxene [2], which consumes olivine and Al-rich orthopyroxene and produces spinel and Al-poor orthopyroxene as temperature decreases. Depending on partitioning of Fe^{3+} between phases, this reaction may dilute the concentration of Fe^{3+} in spinel and decrease recorded f_{O2} as temperature decreases. Preliminary results suggest that the magnitude of this effect is strongly sensitive to both initial spinel mode and partitioning of Fe^{3+} between orthopyroxene and spinel. Finally, we compare the f_{O2} recorded by SWIR peridotites to the f_{O2} recorded by basalts, projected to source conditions.

[1] Li et al., 1995; [2] Voigt and von der Handt, 2011; [3] Davis et al., 2017

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Wednesday, 13 December 2017 13:40 – 18:00 Convention Center – Poster Hall D-F

S33C-0877: Eastern North American Finite-Frequency, Compressional and Shear Tomographic Models

The Eastern North American margin and continental interior is imaged using a finite-frequency, tomographic method. Each of the P and S teleseismic body wave date sets consists of over 80,000 usable measurements recorded on the Transportable Array (TA). Sensitivity kernels are computed from a 1D model with grid spacing of 50 x 50 x 25 km. Measurements are performed automatically at three individual frequency bands, allowing a more effective use of the available broadband data.

Imaged shear and compressional wave speeds show similar long-wavelength features of reduced wave speeds along the continent-ocean margin and increased wave speeds within the stable interior. Wave speeds throughout the model are highly variable at the scale of 100 to 200 km. Large wave speed reductions are present near New England, the Mid-Atlantic states, and the Gulf Coast states; these variations are present in previous models. Interestingly, the strongly reduced wave speeds near South Carolina are absent at depths greater than 150 km within this model and recent teleseismic body-wave models. This result is contrary to a variety of surface wave models which contain an intense, reduced wave speed anomaly extending past 250 km depth and interpreted as a mantle upwelling associated with edge driven convection. An anomaly along the West Virginia-Virginia border, associated with volcanism and mantle upwelling, is also present, tightly constrained, and extends to 200 km depth.

Moreover, the interior of the continent contains significant, regional wave speed variations. Variation of this style is present in other surface and body-wave models and is not consistent with a massive, homogeneous continent with no internal variations. These internal continental variations suggest a compositional influence as temperature, melt and water are thought to have minimal effect. Unlike surface wave models that include a distinct continental base around 175 km, teleseismic body wave models, including this one, do not show this base. However, this model does include the deep, positive wave speed anomaly within the mantle transition zone interpreted as a slab fragment, agreeing with previous models.

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Wednesday, 13 December 2017 14:55 – 15:10 Convention Center – 271-273

OS33C-06: Correlating Sea-Level Rise Still-Stands to Marine Terraces and Undiscovered Submerged Shoreline Features in the Channel Islands (USA) Using Autonomous and Remotely Operated Systems

In 2017, the Ocean Exploration Trust aggregated onboard and autonomous mapping technologies to identify and explore paleo shorelines and discover previously undocumented submerged shoreline features in and around the Channel Islands offshore of California. Broad area mapping was conducted with the hull-mounted multibeam echosounder aboard the E/V *Nautilus*. This Kongsberg EM302 provided maps at 2-10 m resolution, at depths generally greater than 50 m. From this data marine terraces were identified for higher resolution mapping via an autonomous surface vehicle (ASV). The precision data from the ASV's Kongsberg EM2040p echosounder allowed identification of the knickpoints associated with cliffs on the landward extent of each terrace. Sub-sea cave targets were identified using backscatter and slope maps from a combination of both the broad area and high-resolution multibeam data. To ground-truth the targets identified through mapping, remotely operated vehicles (ROVs) and a highly specialized team of cave divers explored these targets. The results from the visual inspection were then fed back into the analysis fostering the rapid iteration of the onboard identification criteria and resulted in locating submerged shorelines containing numerous large caves, arches, and concretions. Caves were found at still-stands at 8, 33, 66, and 103 m depth at Santa Cruz Island, Santa Barbara Island platform, and Osborn Bank, along the vertical escarpment at the cliff-face and aligned with the strike of fractures in the volcanic rock. These terraces correspond to different sea level still-stands. ROV grab samples of fossiliferous marine terraces will provide ages and aid in reconstructions of sea level change and tectonic history for each location. Finally, caves were mapped in sub-cm resolution using a Kongsberg M3 sonar mounted vertically on the front of the ROV to test the capabilities of the system to provide accurate information about exterior dimensions and morphology.

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Thursday, 14 December 2017

Thursday, 14 December 2017 11:35 – 11:50 Convention Center – 217-219

S42B-06: Investigating Subduction Reversal in Papua New Guinea from Automatic Analysis of Seismicity Recorded on a Temporary Local Network

The area of Papua New Guinea is one of the most seismically active regions on the planet. Seismicity in the region results from oblique convergence between the Pacific and India-Australia plates, with deformation occurring across a broad region involving several microplates. The region gives an excellent natural laboratory to test geodynamic models of subduction polarity reversal, microplate interaction, and to delineate the structure of subducting plates and relic structures at depth. However, a lack of permanent seismic stations means that routine earthquake locations for small to intermediate sized earthquakes have significant location errors.

In 2014, we deployed a temporary network of eight broadband stations on islands in eastern Papua New Guinea to record ongoing seismic deformation. The network straddles a complex region where subduction of the Solomon plate occurs to the south and possible subduction of the Ontong-Java plateau occurs to the north. The stations were installed for 27 months. During the deployment period, there were 13 M>6.5 earthquakes in the area, including M7.5 doublet events in 2015, giving a rich seismic dataset. A high-quality catalogue of local events was formed by a multi-step process. Using the scanloc module of SeisComp3, we first detect P-onsets using a STA/LTA detection. Once clusters of P onsets are found, S-wave picks are incorporated based on a pre-defined window length of maximum S-P time. Groups of onsets are then associated to events, giving us a starting catalogue of 269 events (1765 P-onsets) with minimum magnitude of M~3.5. In a second step, we refine onset times using a Kurtosis picker to improve location accuracy. To form robust hypocentral locations using an appropriate structural model for the area and to constrain crust and mantle structure in the region, we derive a minimum 1-D velocity model using the VELEST program. We use a starting model from Abers et al. (1991) and we restrict our catalogue to events with an azimuthal gap of <270°, leaving 147 well-located events.

This new seismic catalogue gives a detailed insight into the plate boundary structures at depth in the Papua New Guinea region. We are also able to delineate

Wadati-Benioff seismicity to 600 km depth in the subducting Solomon Sea plate beneath the New Britain arc.

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Thursday, 14 December 2017 13:40 – 18:00 Convention Center – Poster Hall D-F

V43E-0573: Anisotropic Full Waveform Ambient Noise and Earthquake Tomography of the Ontong Java Plateau and Surrounding Pacific Upper Mantle

The Ontong Java (OJP) and Manihiki plateau (MP) large igneous provinces (LIP) of the Southwest Pacific took shape from a complicated, but poorly understood geological history. Unraveling the formation and deformation of these Pacific LIPs is not straightforward due to limited available data, remote location, and atypical geology. Origin hypotheses include melting of a plume or a fast-spreading triple junction, but distinguishing between these requires a further understanding of 120 Ma of deformation of each LIP. A previous tomographic model of OJP observed highly abnormal Rayleigh shear wave speeds, >4.75km/s, and attributed these to an unusual composition, garnet and clinopyroxene residual from melting pyroxenite entrained within a rising plume. Unfortunately, this model lacks constraints on the horizontally polarized shear wave speeds, SH or Love waves, anisotropy, and attenuation.

We therefore perform a transverse-isotropic, scattering-integral, full-waveform tomography between periods of 25 and 200 seconds, utilizing both ambient noise empirical Green's functions and seismic data from regional earthquakes. Our tomographic model improves upon previous work using permanent and temporary seismic stations, increased model space, and utilizing three components of seismic data (vertical, radial, and tangential). Included is also an assessment of the anelastic attenuation in the western Pacific using both surface waves and multiple core reflections. Our results will improve the tomographic resolution around OJP and the Pacific upper mantle between 35 and 300

km depth. This improved model will enhance our understanding of the tectonic history of the OJP and MP regions, and the Pacific Indo-Australian plate boundary.

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Thursday, 14 December 2017 13:40 – 18:00 Convention Center – Poster Hall D-F

S43H-2974: InSAR Observation of the September 3rd Nuclear Test in North Korea

InSAR data from ALOS-2 and Sentinel-1B satellites show significant loss of coherence in phase images covering the September 3rd event at Mt. Mantap, which provide strong evidence that the nuclear test occurred there. The area with low coherence is consistent with several seismic-determined locations. The loss of coherence is much more significant than that of the January 6, 2016 event, which also has good InSAR data coverage and shows surface displacement. For regions that stay coherent at peripheral area of Mt. Mantap, the data show line-of-sight displacement up to 10 cm. In comparison, TerraSAR-X InSAR data (generated by Dr. Teng Wang) show subsidence up to 2 m and horizontal displacement up to 4 m in the area that ALOS2 and Sentinel-1B lost coherence. The large displacement is calculated from the shift of pixels in amplitude images, which does not work for ALOS and Sentinel-1B data. Nevertheless, all InSAR data suggest that the event occurred at Mt. Mantap. We conclude that InSAR provides a powerful, independent tool for monitoring and characterizing nuclear tests, whether announced or not, to complement the seismic method.

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Friday, 15 December 2017

Friday, 15 December 2017 08:00 – 12:20 Convention Center – Poster Hall D-F

A51A-2026: Viscous and Turbulent Stress Measurements over Wind-driven Surface Waves

In recent years, the exchange of momentum and scalars between the atmosphere and the ocean has been the subject of several investigations. Although the role of surface waves on the air-sea momentum flux is now well established, detailed quantitative measurements of the turbulence in the airflow over surface waves remain scarce. The

current incomplete physical understanding of the airflow dynamics impedes further progress in developing physically based parameterizations for improved weather and sea state predictions, particularly in high winds and extreme conditions.

Using combined particle image velocimetry (PIV) and laser induced fluorescence (LIF) in the laboratory, we have acquired detailed quantitative measurements of the airflow over wind-driven waves and down to within the viscous sub-layer. Various wind-wave conditions are examined with mean wind speeds ranging from 0.86 to 16.63 m s^{-1}. The mean, turbulent, and wave-induced velocity fields are then extracted from instantaneous two-dimensional velocity measurements. Individual airflow separation events precipitate abrupt and dramatic along-wave variations in the surface viscous stress. In the bulk flow above the waves, these separation events are a source of intense vorticity. Phase averages of the viscous stress present a pattern of along-wave asymmetry near the surface; it is highest on the upwind of wave crest with its peak value about the crest and its minimum occurs at the middle of the leeward side of waves. The contribution of the viscous stress to the total momentum flux is not negligible, particularly for low to moderate wind speeds, and this contribution decreases with increasing wind speed. Away from the surface, the distribution of turbulent Reynolds stress forms a negative-positive pattern along the wave crest with a separation-induced maximum above the downwind side of the wave. Our measurements will be discussed in the context of available previous results.

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Friday, 15 December 2017 08:00 – 12:20 Convention Center – Poster Hall D-F

T51G-0566: Transpressional Tectonics Across the North American-Caribbean Plate Boundary: Preliminary Results of a Multichannel Seismic Survey of Lake Azuei, Haiti

On January 12, 2010, a Mw 7.0 earthquake struck Haiti, killing over 200,000 people and devastating the capital city of Port-au-Prince and the surrounding regions. It ruptured a previously unknown blind-thrust fault that abuts the Enriquillo Plantain Garden Fault (EPGF), one of two transform faults that define the North American-Caribbean plate boundary. That earthquake highlighted how transpression across this complex boundary is accommodated by slip partitioning into strike-slip and compressional structures. Because the seismic hazard is higher for a rupture on a reverse or oblique-slip fault than on a vertical strike-slip fault, the need to characterize the geometry of that fault system is

clear. Lake Azuei overlies this plate boundary ~60 km east of the 2010 epicenter. The lake's ~23 km long axis trends NW-SE, parallel to the Haitian fold-and-thrust belt and oblique to the EPGF. This tectonic context makes it an ideal target for investigating the partitioning of plate motion between strike-slip and compressional structures. In January 2017, we acquired 222 km of multichannel seismic (MCS) profiles in the lake, largely concurrent with subbottom seismic (CHIRP) profiles. The MCS data were acquired using a high-frequency BubbleGun source and a 75 m-long, 24-channel streamer, achieving a 24 seismic fold with a penetration of ~200 m below lakebed. With the goal of resolving tectonic structures in 3-D, survey lines were laid out in a grid with profiles spaced 1.2 km apart. Additional profiles were acquired at the SE end of the lake where most of the tectonic activity is presumably occurring. The co-located CHIRP and MCS profiles document the continuity of tectonic deformation between the surficial sediments and the deeper strata. Preliminary processing suggests that a SW-dipping blind thrust fault, expressed updip as a large monocline fold, may control the western edge of the lake. Gentle, young folds that protrude from the flat lakebed are also imaged with the CHIRP data. No obvious strike-slip faults are revealed in the MCS or CHIRP imagery. This result is consistent with a published analysis of GPS measurements that suggests oblique convergence on a south-dipping reverse fault along the southern shore of the lake.

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Friday, 15 December 2017 08:00 – 12:20 Convention Center – Poster Hall D-F

T51G-0567: Subbottom Seismic Profiling Survey of Lake Azuei, Haiti: Seismic Signature of Paleo-Shorelines in a Transpressional Environment and Possible Tectonic Implications

The left-lateral Enriquillo-Plantain Garden Fault (EPGF) is one of two major transform faults that form the North American-Caribbean plate boundary. GPS measurements indicate that relative motion evolves from nearly pure strike-slip in western Haiti to highly transpressional near Lake Azuei in eastern Haiti, where the EPGF may terminate against a south-dipping oblique reverse fault. Lake Azuei, one of the largest lakes in the Caribbean region (10 km x 23 km), is surrounded by two high-elevation sierras (> 2,000 m). Because the lake has no outlet to the sea, its level is sensitive to variations in precipitation and is thought to have fluctuated by 10's of meters during the Holocene. A rise of ~5 m over the past 10 years has had a devastating impact, submerging villages, farmland, and roads. A grid of high-resolution (~10 cm) subbottom seismic (CHIRP) profiles acquired in January 2017 captures the subtle signature of the ~5 m-deep shoreline and also images a prominent paleo-shoreline at ~10 m water depth. This 10 m paleo-shoreline is well expressed in the CHIRP data, suggesting it was occupied for a long period of time. It is buried beneath a thin (< 20 cm-thick) veneer of sediments, indicating that it was submerged centuries to millennia ago. This paleo-shoreline represents a key horizontal marker that may have been warped by local transpressional tectonics. We therefore catalogued its varying seismic signature with the goal of detecting any subtle but systematic depth variations of the associated shoreline angle around the periphery of the lake. Two sediment cores, collected in water depths of 14 m and 17 m, each bottomed 80-90 cm below the lakebed into a distinctively coarser bed. On-going radiometric dating is expected to constrain the age of this distinctive layer. Should this layer be tied to the perduring 10-m lowstand of the lake, determining its age could help quantify vertical deformation rates around Lake Azuei.

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Friday, 15 December 2017 08:00 – 12:20 Convention Center – Poster Hall D-F

T51G-0568: Signature of Transpressional Tectonics in the Holocene Stratigraphy of Lake Azuei, Haiti: Preliminary Results From a High-Resolution Subbottom Profiling Survey

The left-lateral Enriquillo-Plantain Garden Fault (EPGF) is one of two transform systems that define the Northern Caribbean plate boundary zone. Relative motion across its trace (~ 10 mm/yr) evolves from nearly pure strike-slip in western Haiti to transpressional in eastern Haiti, where the fault system may terminate against a south-dipping oblique reverse fault. Lake Azuei is a large (10 km x 25 km) and shallow (< 30 m deep) lake that lies in the direct extension of the EPGF in eastern Haiti. A single core previously collected in the lake suggests high sedimentation rates at its depocenter (~6 mm/yr). The shallow lake stratigraphy is therefore expected to faithfully record any tectonic deformation that occurred within the past few thousand years. In January 2017, we acquired a grid of high-resolution (~10 cm), shallow penetration (~4 to 5 m) subbottom seismic (CHIRP) profiles spaced 1.2 km apart across the entire lake. A new bathymetric map compiled from these CHIRP data and some prior echosounder survey reveals a flat lake floor (<0.01°) surrounded by steep (~5°) shoreline slopes. The CHIRP profiles highlight several gentle folds that protrude from the flat lakebed near the southern shore, an area where transpressional deformation is presumably focused. Thin (< 20 cm) horizontal strata from the lakebed can be traced onto the flanks of these gentle folds and pinch out in an upward curve. They also often pinch upward onto the base of the

shoreline slopes, indicating that young sediments on the lakebed bypassed the folds as well as the shoreline slopes. We interpret this feature as diagnostic of sediments deposited by turbidity currents. The fact that young turbidites pinch out in upward curves suggests that the folds are actively growing, and that active contractional structures (folds and/or blind thrust faults) control much of the periphery of the lake. A few sediment cores were strategically located where beds are pinching out in order to maximize stratigraphic records. Two of these cores successfully penetrated strata imaged by the CHIRP profiles. On-going Pb210 dating of sediment samples from the cores should constrain sedimentation rates and thus help quantify the rates of the tectonic deformation.

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Friday, 15 December 2017 08:00 – 12:20 Convention Center – Poster Hall D-F

V51D-0385: Major and Trace Element and Volatile Constraints on Magma Systematics of Seamounts and Axial Ridge Glasses from the East Pacific Rise Between 8°N and 12°N

The East Pacific Rise is a fast spreading mid-ocean ridge system (6-16cm/yr) consisting of many spreading ridges and transform faults. Focusing on a well-studied segment between 8-12°N, we present new SIMS measurements of magmatic volatiles (H_2O, CO_2, S, Cl, F) and new LA-ICP-MS trace element data in both on-axis and off-axis glasses, coupled with previously published data and use these data to relate melt composition to crystallization and melting processes. The seamounts range in composition from evolved (MgO = 5.54 wt%) to fairly primitive (MgO = 9.70 wt%), whereas on-axis samples have a narrower range of MgO (5.85 – 8.83 wt%). Seamounts span a wide range of enrichment in trace element compositions (La/Sm 0.45 – 4.63; Th/La 0.02 – 0.14; K/Ti 0.02 – 0.66), whereas on-axis glasses reflect NMORB compositions (La/Sm 0.5 – 1; Th/La 0.035 – 0.07; K/Ti 0.05 – 0.15). Light rare earth elements in the seamounts vary from depleted to enriched and have variable Eu anomalies (0.79 – 1.10), while on-axis samples have NMORB patterns with more negative Eu anomalies (0.74 – 1.00). The H_2O content of the seamounts ranges from dry (0.05 wt%) to fairly wet (0.96 wt%), whereas on-axis samples have a narrower range (0.15 – 0.31 wt%). Cl contents show variable mixing between seawater and a magmatic component, with seamounts assimilating more seawater. Magmatic liquid lines of descent (LLD), recorded in glass, reflect fractional crystallization of olivine, plagioclase, and clinopyroxene, consistent with modal phenocryst abundances of the rocks. A multi-element approach (e.g., MgO vs. Al_2O_3, CaO, CaO/Al_2O_3), constrains LLDs, providing fractionation slopes, allowing mafic basalt compositions to be accurately corrected back to primary melts in equilibrium with Fo_{90}. Using these melts, pressures and temperatures of melt equilibration can be constrained using melt thermobarometry. On-axis samples reflect higher PT conditions (1371°C; 1.37 GPa), although within error of seamounts (1340°C; 1.25 GPa). Overall, on-axis samples are more homogeneous, likely reflecting residence and homogenization of magma batches in an axial magma chamber, whereas off-axis seamounts reflect greater heterogeneity that arises from the localized nature of seamount magmatic systems and extraction of smaller-volume, discrete magma batches from the ridge mantle.

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Friday, 15 December 2017 08:00 – 12:20 Convention Center – Poster Hall D-F

T51G-0557: Offshore Earthquake 2012 in the California Borderlands: Possible Extension of Seismically Active Area Offshore

The California Borderlands is a tectonically active region with abundant seismic activity. In 2012, an earthquake epicenter was located on the eastern Pacific Plate west of the Patton Escarpment (31.08N, 119.61W). The earthquake was a magnitude 6.3 with a normal focal mechanism. In the past, seismic activity was thought not to extend past the Patton Escarpment. With this offshore earthquake, the extent of seismically active structures past the Patton Escarpment has been brought into question. On a recent Marine Geology and Geophysics Chief Scientists Training Cruise, early career scientists worked together to develop projects that could be completed aboard the R/V *Sikuliaq*. A survey was completed of the earthquake area collecting gravity, multibeam, and sub-bottom profiler data. The survey was designed to identify seafloor morphology or internal structure that could have localized the unexpected offshore seismic activity. Possible mechanisms for the earthquake are a structure linked to the fault system within the California Borderlands that was extinct but reactivated. Another possibility is that a structure in the oceanic lithosphere may have reactivated to accommodate movement. Establishing the possible mechanism of the 2012 earthquake can determine the possibility of other seismic activity offshore the Borderlands.

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Friday, 15 December 2017 11:50 – 12:05 Convention Center – 242

ED52A-07: Increasing Communities Capacity to Effectively Address Climate Change Through Education, Civic Engagement and Workforce Development (Invited)

Understanding the causes, effects, risks, and developing the social will and skills for responses to global change is a major challenge of the 21st century that requires coordinated contributions from the sciences, social sciences, humanities, arts, and beyond. There have been many effective efforts to implement climate change education, civic engagement and related workforce development programs focused on a multitude of audiences, topics and in multiple regions. This talk will focus on how comprehensive educational efforts across our communities are needed to support cities and their primary industries as they prepare for, and embrace, a low-carbon economy and develop the related workforce. While challenges still exist in identifying and coordinating all

stakeholders, managing and leveraging resources, and resourcing and scaling effective programs to increase impact and reach, climate and energy literacy leaders have developed initiatives with broad input to identify the understandings and structures for climate literacy collective impact and to develop regional/metropolitan strategy that focuses its collective impact efforts on local climate issues, impacts and opportunities. This Climate Literacy initiative envisions education as a central strategy for community's civic actions in the coming decades by key leaders who have the potential to foster the effective and innovative strategies that will enable their communities to seize opportunity and prosperity in a post-carbon and resilient future. This talk discusses the advances and collaborations in the Climate Change Education community over the last decade by U.S. federal and non-profit organization that have been made possible through the partnerships of the Climate Literacy & Energy Awareness Network (CLEAN), U.S. National Science Foundation–funded Climate Change Education Partnership (CCEP) Alliance, and the Tri-Agency Climate Change Education Collaborative.

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Friday, 15 December 2017 13:40 – 18:00 Convention Center – Poster Hall D-F

IN53B-0083: Basic to Advanced InSAR Processing: GMTSAR (Invited)

Monitoring crustal deformation using InSAR is becoming a standard technique for the science and application communities. Optimal use of the new data streams from Sentinel-1 and NISAR will require open software tools as well as education on the strengths and limitations of the InSAR methods. Over the past decade we have developed freely available, open-source software for processing InSAR data. The software relies on the Generic Mapping Tools (GMT) for the back-end data analysis and display and is thus called GMTSAR. With startup funding from NSF, we accelerated the development of GMTSAR to include more satellite data sources and provide better integration and distribution with GMT. In addition, with support from UNAVCO we have offered 6 GMTSAR short courses to educate mostly novice InSAR users. Currently, the software is used by hundreds of scientists and engineers around the world to study deformation at more than 4,300 different sites. The most challenging aspect of the recent software development was the transition from image alignment using the cross-correlation method to a completely new alignment algorithm that uses only the precise orbital information to geometrically align images to an accuracy of better than 7 cm. This development was

needed to process a new data type that is being acquired by the Sentinel-1A/B satellites. This combination of software and open data is transforming radar interferometry from a research tool into a fully operational time series analysis tool. Over the next five years we are planning to continue to broaden the user base through: improved software delivery methods; code hardening; better integration with data archives; support for high-level products being developed for NISAR; and continued education and outreach.

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Friday, 15 December 2017 15:10 – 15:25 Convention Center – 203-205

DI53A-07: Light Stable Isotopic Compositions of Enriched Mantle Sources: Resolving the Dehydration Paradox

An outstanding puzzle in mantle geochemistry has been the origin and evolution of Earth's volatile components. The "dehydration paradox" refers to the following conundrum: Mantle compositions for some enriched mid-ocean ridge basalts (MORB) and ocean island basalts (OIB) require involvement of a mostly dehydrated slab component to explain the trace element ratios and radiogenic isotopic compositions, but a fully hydrated slab component to explain the stable isotopic compositions. Volatile and stable isotopic data on enriched MORB show a diversity of enriched components. Pacific PREMA-type basalts ($H_2O/Ce = 215 \pm 30$, $\delta D_{SMOW} = -45 \pm 5$ ‰) are similar to those in the North Atlantic ($H_2O/Ce = 220 \pm 30$; $\delta D_{SMOW} = -30$ to -40 ‰). Basalts with EM-type signatures have regionally variable volatile compositions. North Atlantic EM-type basalts are wetter ($H_2O/Ce = 330 \pm 30$) and have isotopically heavier hydrogen ($\delta D_{SMOW} = -57 \pm 5$ ‰) than North Atlantic MORB. South Atlantic EM-type basalts are damp ($H_2O/Ce = 120 \pm 10$) with intermediate δD_{SMOW} (-68 ± 2 ‰), similar to dD_{SMOW} for Pacific MORB. North EPR EM-type basalts are dry ($H_2O/Ce = 110 \pm 20$) and isotopically light

(δD_{SMOW} = -94 ± 3 ‰). Boron and lithium isotopic ratios parallel the trends observed for dD_{SMOW}.

A multi-stage metasomatic and melting model accounts for the origin of the enriched components by extending the subduction factory concept down through the mantle transition zone, with slab temperature a key variable. The dehydration paradox is resolved by decoupling of volatiles from lithophile elements, reflecting primary dehydration of the slab followed by secondary rehydration and re-equilibration by fluids derived from subcrustal hydrous phases (e.g., antigorite) in cooler, deeper parts of the slab. The "expanded subduction factory" model includes melting at several key depths, including 1) 180 to 280 km, where EM-type mantle compositions are generated above slabs with average to hot thermal profiles by addition of <1% carbonated sediment-derived supercritical fluids/melts to depleted asthenospheric or subcontinental lithospheric mantle, and 2) 410 to 660 km, where PREMA-type mantle sources are generated, above slabs with average to cool thermal profiles, by addition of <1% carbonated eclogite ± sediment-derived supercritical fluids to depleted mantle.

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Friday, 15 December 2017 16:45 – 17:00 Convention Center – 208-209

V54A-04: Full-Wave Ambient Noise Tomography of the Long Valley Volcanic Region (California)

In the late 1970s, and throughout the 1990s, Long Valley Caldera (California) experienced intense periods of unrest characterized by uplift of the resurgent dome, earthquake swarms, and CO_2 emissions around Mammoth Mountain. While modeling of the uplift and gravity changes support the possibility of new magmatic intrusions beneath the caldera, geologic interpretations conclude that the magmatic system underlying the caldera is moribund. Geophysical studies yield diverse versions of a sizable but poorly resolved low-velocity zone at depth (> 6km), yet whether this zone is indicative of a significant volume of crystal mush, smaller isolated pockets of partial melt, or magmatic fluids, is inconclusive. The nature of this low-velocity zone, and the state of volcano's magmatic system, carry important implications for the significance of resurgent-dome inflation and the nature of associated hazards. To better characterize this low-velocity zone we present preliminary results from a 3D full-waveform ambient-noise seismic tomography model derived from the past 25 years of vertical component broadband and short-period seismic data. This new study uses fully numerical solutions of the wave equation to account for the complex wave propagation in a heterogeneous, 3D earth model, including wave interaction with topography. The method ensures that wave propagation is modeled accurately in 3D, enabling the full use of seismic records. By

using empirical Green's functions, derived from ambient noise and modeled as Rayleigh surface waves, we are able to extend model resolution to depths beyond the limits of previous local earthquake studies. The model encompasses not only the Long Valley Caldera, but the entire Long Valley Volcanic Region, including Mammoth Mountain and the Mono Crater/Inyo Domes volcanic chain.

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