## Monday, 15 December, 2014

PP11D: Ocean Climate Dynamics: Carbon Cycle and Oxygenation Perturbations I

8:45 AM-09:00 AM, Moscone West 2010

*A New Approach to Reconstruct Ancient Bottom Water Oxygen Levels*

Anthony Earl Rathburn1, Jake Willingham1, **Bruce H Corliss[2]**, Ashley M Burkett3 and Wiebke Ziebis4, (1) Indiana State University, Terre Haute, IN, United States, (2)University of Rhode Island Narragansett Bay, Narragansett, RI, United States, (3)Indiana State University, Earth and Environmental Systems, Terre Haute, IN, United States, (4)University of Southern California, Biological Sciences, Los Angeles, CA, United States

Abstract:

Oxygen availability controls many biological and geochemical processes, and serves as an important indicator of paleoceanographic characteristics. Recent work has demonstrated a direct relationship between oxygen acquisition and pores on benthic foraminiferal tests. Epifaunal foraminifera (living near or above the sediment-water interface) are directly exposed to bottom water, and can occur in abundance in a wide range of seafloor environments. In this study, a novel approach using ArcGIS and image analysis techniques was used to determine the percentage of test chamber surface area covered by pores in living and recently living (Rose Bengal stained) epifaunal taxa (*Cibicides*, *Cibicidoides* and *Planulina*). Analyses of Scanning Electron Microscope images of 97 specimens collected from 20 deep-sea locations having different bottom water oxygen concentrations (0.04 to 6.20 ml/L) revealed a robust ($R^2$= 0.729; $p < 0.001$), negative relationship between pore surface area on test chambers and ambient bottom water oxygen concentration. The resulting calibration curve serves as new, quantitative proxy to assess bottom water oxygen of ancient oceans.

---

V11E: Dynamics of Continental and Submarine Hydrothermal Systems I

8:30 AM-08:45 AM, Marriott Marquis, Salon 8

*Hydrothermal Venting at Kick'Em Jenny Submarine Volcano (West Indies)*

**Steven Carey[1]**, **Katherine Lynn Croff Bell**[2], Frederic Jean-Yves Dondin3, **Christopher Roman**[1], Clara Smart1, Marvin D Lilley4, John E Lupton5 and **Robert D. Ballard**[2], (1) University of Rhode Island, Graduate School of Oceanography, Narragansett, RI, United States, (2) Ocean Exploration Trust, Narragansett, RI, United States, (3)University of the West Indies, Seismic Research Center, St. Augustine, Trinidad and Tobago, (4)Univ Washington, Seattle, WA, United States, (5)NOAA/PMEL, Newport, OR, United States

Abstract:

Kick'em Jenny is a frequently-erupting, shallow submarine volcano located ~8 km off the northwest coast of Grenada in the West Indies. The last eruption took place in 2001 but did not breach the sea surface. Focused and diffuse hydrothermal venting is taking place mainly within a small (~100 x 100 m) depression within the 300 m diameter crater of the volcano at depths of about 265 meters. Near the center of the depression clear fluids are being discharged from a focused mound-like vent at a maximum temperature of 180$^{o}$ C with the simultaneous discharge of numerous bubble streams. The gas consists of 93-96% $CO_2$ with trace amounts of methane and hydrogen. A sulfur component likely contributes 1-4% of the gas total. Gas flux measurements on individual bubble streams ranged from 10 to 100 kg of $CO_2$ per day. Diffuse venting with temperatures 5 to 35$^{o}$ C above ambient occurs throughout the depression and over large areas of the main crater. These zones are extensively colonized by reddish-yellow bacterial mats with the production of loose Fe-oxyhydroxides largely as a surface coating and in some cases, as fragile spires up to several meters in height. A high-resolution photo mosaic of the crater depression was constructed using the remotely operated vehicle Hercules on cruise NA039 of the *E/V Nautilus*. The image revealed prominent fluid flow patterns descending the sides of the depression towards the base. We speculate that the negatively buoyant fluid flow may be the result of second boiling of hydrothermal fluids at Kick'em Jenny generating a dense saline component that does not rise despite its elevated temperature. Increased density may also be the result of high dissolved $CO_2$ content of the fluids, although we were not able to measure this directly. The low amount of sulphide mineralization on the crater floor suggests that deposition may be occurring mostly subsurface, in accord with models of second boiling mineralization from other hydrothermal vent systems.

---

B11F: The Thermodynamics of Life Posters

8:00 AM-12:20 PM, Moscone West

*Energetic Constraints of Subseafloor Life*

**Steven D'Hondt**[1], **Arthur J Spivack**[1] and Guizhi Wang[2], (1)University of Rhode Island, Narragansett, RI, United States, (2)Xiamen University, Xiamen, China

Abstract:

Mean per-cell rates of catabolic activity, energy flux, and biomass turnover are orders of magnitude slower in subseafloor sediment than in the surface world. Despite extreme scarcity of electron donors, competing metabolic pathways co-occur for hundreds of meters deep in subseafloor sediment deposited over millions of years. Our study of an example site (ODP Site 1226) indicates that the energy yields of these competing reactions are pinned to a thermodynamic minimum (Wang et al., 2010). The simplest explanation of this long-term co-existence is thermodynamic cooperation, where

microorganisms utilize different but co-existing pathways that remove each other's reaction products.

Our Site 1226 results indicate that the energy flux to subseafloor sedimentary microbes is extremely low. Comparison to biomass turnover rates at other sites suggests that most of this flux may be used for building biomolecules from existing components (*e.g.*, amino acids in the surrounding sediment), rather than for *de novo* biosynthesis from inorganic chemicals.

Given these discoveries, ocean drilling provides a tremendous opportunity to address several mysteries of microbial survival and natural selection under extreme energy limitation. Some of these mysteries are centered on microbial communities. To what extent do counted cells in subseafloor sediment constitute a deep microbial necrosphere? How do different kinds of microbes interact to sustain their mean activity at low average rates for millions of years? Other mysteries relate to individual cells. How slowly can a cell metabolize? How long can a cell survive at such low rates of activity? What properties allow microbes to be sustained by low fluxes of energy? In what ways do subseafloor organisms balance the benefit(s) of maximizing energy recovery with the need to minimize biochemical cost(s) of energy recovery?

References

Wang, G., et al., 2010. *Geochimica et Cosmochimica Acta* 74, 3938-3947.

---

B11H: Wanted, Dead or Alive: Microbes in the Subsurface I Posters

8:00 AM-12:20 PM, Moscone West

*Bacterial Diversity, Sediment Age and Organic Respiration in the Marine Sedimentary Environment*

**Emily A Walsh**[1], **John B Kirkpatrick**[2], **Robert A Pockalny**[2], **Justine Sauvage**[2], Mitchell L Sogin[3] and **Steven D'Hondt**[2], (1) University of Rhode Island, Kingston, RI, United States, (2)University of Rhode Island, Narragansett, RI, United States, (3)Marine Biological Laboratory, Woods Hole, MA, United States

Abstract:

Subseafloor sediment hosts to a large[1], taxonomically rich[2] and metabolically diverse[3] microbial ecosystem. However, the factors that control microbial diversity in subseafloor sediment have rarely been explored. Here we show that subseafloor bacterial richness varies directly with sediment age and net rate of organic-fueled respiration. We examined three open-ocean sites (in the Bering Sea and equatorial Pacific) and one continental margin site (Indian Ocean), with sediment depths to 404 meters below seafloor. At all locations, taxonomic richness decreases exponentially with increasing sediment age.

Richness declines most rapidly for a few hundred thousand years after sediment deposition. This profile generally matches the canonical relationship between rates of organic oxidation and sediment age [4]. To examine the potential link between organic oxidation and taxonomic richness we used pore-water chemical profiles to quantify net rates of organic respiration at the three open-ocean sites (the chemical profiles of the ocean-margin site are not in diffusive steady state). Taxonomic richness and total rate of organic-fueled respiration are highest at the high productivity Bering Sea site and lower at the moderate productivity equatorial Pacific sites. At each of these sites, organic-fueled respiration rate and taxonomic richness are highest at the surface and decline together as sediment depth and age increase. To our knowledge, this is the first evidence that taxonomic richness is closely linked to organic-fueled respiration rate and sediment age in subseafloor sediment.

**References**

1. Kallmeyer, J., Pockalny, R., Adhikari, R. R., Smith, D. C. & D'Hondt, S. Proceedings of the National Academy of Sciences, doi:10.1073/pnas.1203849109 (2012).

2. Inagaki, F. et al. Proceedings of the National Academy of Sciences 103, 2815-2820 (2006).

3. D'Hondt, S. et al. Science 306, 2216-2221, doi:10.1126/science.1101155 (2004).

4. Middelburg, J. J. *Geochimica et Cosmochimica Acta* **53**, 1577-1581, doi:http://dx.doi.org/10.1016/0016-7037(89)90239-1 (1989).

---

B11H: Wanted, Dead or Alive: Microbes in the Subsurface I Posters

8:00 AM-12:20 PM, Moscone West

*Boosting subsurface life: is subseafloor sediment a natural catalyst for radiolytic hydrogen production?*

**Justine Sauvage**[1], **Dennis Graham**[1], **Arthur J Spivack**[1], Ann G Dunlea[2], Richard W Murray[3] and **Steven D'Hondt**[4], (1) University of Rhode Island - GSO, Oceanography, Narragansett, RI, United States, (2) Boston University, Boston, MA, United States, (3)Boston Univ, Boston, MA, United States, (4) University of Rhode Island, Narragansett, RI, United States

Abstract:

Naturally occurring production of molecular hydrogen ($H_2$) by water radiolysis may be a fundamentally important source of electron donors (energy) for life in subsurface environments where organic matter is scarce. Previous studies with very high gamma radiation rates and wet mineral phases have reported high $H_2$ production relative to

production from water radiolysis in the absence of solid phases. Numerical calculations by other previous studies have predicted enhanced $H_2$ production from seawater radiolysis relative to pure water radiolysis, due to the interaction of anions with hydroxyl radicals.

Given these reports, the potential catalytic influences of solid and dissolved chemical phases on radiolytic $H_2$ production need to be carefully quantified in order to fully evaluate the role of radiolytic $H_2$ as a microbial energy source.

For such quantification, we undertook gamma-irradiation experiments with pure water, deep ocean water and mixtures (slurries, $\varphi = 0.85$) of seawater with: North Pacific abyssal clay and calcareous oozes, coastal sediment, zirconium dioxide, and zeolite. We carried out our experiments at the Rhode Island Nuclear Science Center using a $^{37}$Cesium source at low dose rates (up to 0.1 Gy/hr).

Our results to date include the following. First, the per-dose radiolytic $H_2$ yield of pure water at low dose rates is directly comparable to the per-dose yield at much higher dose rates (ca. 1 kGy/hr); this result indicates that $H_2$ production rate is linearly related to radiation dose rate across four orders of magnitude. Second, there is no statistically significant difference (90% confidence limit) between the radiolytic $H_2$ yield from pure water and that from seawater; this result rules out influence of abundant seawater salts on $H_2$ yield from water radiolysis. Third, $H_2$ production from a mixture of abyssal clay and seawater is 25% higher than the yield from pure water. This enhanced yield is consistent with catalysis of radiolytic $H_2$ production by zeolite.

---

C11A: Marginal Ice Zone Processes I Posters

8:00 AM-12:20 PM, Moscone West

*Radon and radium in the ice-covered Arctic Ocean, and what they reveal about gas exchange in the sea ice zone.*

**Brice Loose[1], Roger P Kelly[1], Arash Bigdeli[1] and Stephen Bradley Moran[1,2]**, (1)URI GSO, Narragansett, RI, United States, (2)White House Office of Science and Technology Policy, Washington DC, United States

Abstract:

The polar sea ice zones are regions of high primary productivity and interior water mass formation. Consequently, the seasonal sea ice cycle appears important to both the solubility and biological carbon pumps. To estimate net $CO_2$ transfer in the sea ice zone, we require accurate estimates of the air-sea gas transfer velocity. In the open ocean, the gas transfer velocity is driven by wind, waves and bubbles - all of which are strongly altered by the presence of sea ice, making it difficult to translate open ocean estimates of

gas transfer to the ice zone. In this study, we present profiles of $^{222}$Rn and $^{226}$Ra throughout the mixed-layer and euphotic zone. Profiles were collected spanning a range of sea ice cover conditions from 40 to 100%. The profiles of Rn/Ra can be used to estimate the gas transfer velocity, but the 3.8 day half-life of $^{222}$Rn implies that mixed layer radon will have a memory of the past ~20 days of gas exchange forcing, which may include a range of sea ice cover conditions. Here, we compare individual estimates of the gas transfer velocity to the turbulent forcing conditions constrained from shipboard and regional reanalysis data to more appropriately capture the time history upper ocean Rn/Ra.

---

ED11C: Pioneering Innovative Approaches for Remote Science, Education, and Outreach

8:00 AM-12:20 PM, Moscone South

Chairs: Allison Fundis, Ocean Exploration Trust, Narragansett, RI, United States and **Katherine Lynn Croff Bell**, Ocean Exploration Trust, Narragansett, RI, United States
Primary Conveners: Allison Fundis, Ocean Exploration Trust, Narragansett, RI, United States
Co-conveners: **Katherine Lynn Croff Bell**, Ocean Exploration Trust, Narragansett, RI, United States, Catherine Coleman, NASA Johnson Space Center, Houston, TX, United States and Liz Warren, Barrios Technology, Houston, TX, United States

*Expanding the Telepresence Paradigm to the UNOLS Fleet*

**Dwight Coleman**, University of Rhode Island Narragansett Bay, Narragansett, RI, United States and **Gail Scowcroft**, University of Rhode Island, Narragansett, RI, United States

Abstract:

The Inner Space Center (ISC) at the University of Rhode Island Graduate School of Oceanography (URI-GSO) has been at the forefront of developing the tools, techniques, and protocols for telepresence-enabled ocean science exploration and education programs. Working primarily with the Ocean Exploration Trust's *E/V Nautilus* and the NOAA Ship *Okeanos Explorer*, the ISC facility and staff have supported dozens of research cruises with significant shore-based support, while delivering related educational programming across the globe. Through a partnership with the University National Oceanographic Laboratory System (UNOLS), the ISC is broadening its reach and capabilities to serve vessels in the U.S. academic research fleet, managed by UNOLS. The ISC has developed and used a portable shipboard "mobile telepresence unit" (MTU) on several UNOLS ships to support projects led by ocean scientists that employed the telepresence paradigm as part of their research and outreach programs. Utilizing the ISC facilities provides opportunities for effective, successful broader impact activities and shore-based remote science connectivity. With new UNOLS ships coming online, including the *R/V Sikuliaq*, the *R/V Neil Armstrong*, and the *R/V Sally Ride*, in addition to

future Regional Class Research Vessels (RCRVs), telepresence capability has become a technical requirement for a variety of reasons. Older vessels are being retrofit with this forward-looking technology, and URI's research vessel, the *R/V Endeavor*, has been recently configured with technology to support telepresence operations. This presentation will provide an overview of the future of telepresence technology, its use in ocean science research and education, and advantages for using this capability to support broader impact activities. In addition, ISC successes, challenges, and lessons learned in employing telepresence technologies and methodologies onboard the academic research fleet will be discussed.

---

ED11C: Pioneering Innovative Approaches for Remote Science, Education, and Outreach Posters

8:00 AM-12:20 PM, Moscone South

*NOAA Ship Okeanos Explorer: Evolving Models Enabling Remote Science Participation via Telepresence*

Kelley Elliott1, Jeremy Potter2, **Catalina Martinez**[3], Webb Pinner4, Craig W Russell5 and Nicola Verplanck5, (1)Acentia/2020 Company, LLC, Falls Church, VA, United States, (2)NOAA Office of Ocean Exploration and Research, Silver Spring, MD, United States, (3)NOAA Office of Ocean Exploration and Research, Narragansett, RI, United States, (4)Capable Solutions, Wakefield, RI, United States, (5)NOAA Office of Ocean Exploration and Research, Seattle, WA, United States

Abstract:

Since 2005 NOAA's Office of Ocean Exploration and Research (OER) and partners have tested and developed uses of telepresence to extend ocean exploration expeditions to shore-based scientists and students in real-time. Telepresence increases the potential pace and scope of ocean exploration by enabling experts to join an expedition from anywhere, providing unlimited access to intellectual capital, while simultaneously expanding the reach of ocean science expeditions to public audiences worldwide. "America's Ship for Ocean Exploration", NOAA Ship *Okeanos Explorer*, is the first and only federal vessel purpose-outfitted for conducting telepresence-enabled ocean exploration. As a platform for testing new technologies and methodologies, her primary operating paradigm focuses on using telepresence to enable the majority of expedition scientists to participate and guide explorations from shore in real-time. Between 2010-2014, NOAA and partners implemented different models to conduct telepresence-enabled ocean exploration on NOAA Ship *Okeanos Explorer*, all with the majority of the participating expedition scientists located on shore. These expeditions tested different scientist participation models, communication technologies, operating procedures, internet video streams, data distribution methods, and internet-based collaboration tools, and provided varying levels of real-time access to ongoing expeditions. Each expedition provided new insights into

what makes remote science participation "work", and identified challenges that remain to be overcome. This presentation will provide an overview of the different methods and tools used by NOAA's *Okeanos Explorer* Program to enable remote science participation in expeditions over the last five years, highlighting successes, lessons learned, and challenges for the future.

---

S11E: Outstanding Challenges in the Seismological Study of Volcanic Processes I

8:00 AM-12:20 PM, Moscone South

*Full waveform ambient noise tomography of Mount Rainer*

**Ashton F Flinders**, University of Rhode Island, Kingston, RI, United States and **Yang Shen**, Univ Rhode Island, Narragansett, RI, United States

Abstract:

Mount Rainier towers over the landscape of western Washington, ranking with Fuji-yama in Japan, Mt. Pinatubo in the Philippines, and Mt. Vesuvius in Italy, as one of the great stratovolcanoes of the world. Notwithstanding its picturesque stature, Mt. Rainier is potentially the most devastating stratovolcano in North America, with more than 3.5 million people living beneath its shadow in the Seattle-Tacoma area. The primary hazard posed by the volcano is in the form of highly destructive volcanic debris flows (lahars). These lahars form when water and/or melted ice erode away and entrain preexisting volcanic sediment. At Mt. Rainier these flows are often initiated by sector collapse of the volcano's hydrothermally rotten flanks and compounded from Mt. Rainier's extensive snow and glacial ice coverage. It is therefore imperative to ascertain the extent of summit hydrothermal alteration within the volcano, and determine areas prone to collapse. Despite being one of the sixteen volcanoes globally designated by the International Association of Volcanology and Chemistry of the Earth's Interior as warranting detailed and focused study, Mt. Rainier remains enigmatic both in terms of shallow internal structure and the degree of summit hydrothermal alteration. We image this shallow internal structure and areas of possible summit alteration using ambient noise tomography. Our full waveform forward modeling includes high-resolution topography, allowing us to accurately account for the effects of topography on the propagation of short-period Rayleigh waves. Empirical Green's functions were extracted from 80 stations within 200 km of Mount Rainier and compared with synthetic greens functions over multiple frequency bands from 2-28 seconds. The preliminary model shows a broad (60 km wide) low shear-wave velocity anomaly in the mid-crust beneath the volcano. The mid-crust low-velocity body extends to the surface beneath the volcano summit in a narrow near-vertical conduit, the likely path of magma ascent. There is a peculiar aseismic high Vs and low Vp/Vs zone (possibly indicative of a high quartz bearing lithology) beneath the eastern edifice. We interpret it as a possible remnant of a more felsic (and perhaps more explosive) proto Mount Rainier volcano.

T11A: Active Tectonics and Magmatism of Alaska, the Aleutians, and Northwest Canada Posters

8:00 AM-12:20 PM, Moscone South

*Roles of magmatic oxygen fugacity and water content in generating signatures of continental crust in the Alaska-Aleutian arc*

**Katherine A Kelley**[1], Elizabeth Cottrell2, **Maryjo N Brounce**[1,2] and **Zoe Gentes**[1], (1)University of Rhode Island Narragansett Bay, Narragansett, RI, United States, (2)Smithsonian, NMNH, Washington, DC, United States

Abstract:

Early depletion of Fe during magmatic differentiation is a characteristic of many arc magmas, and this may drive them towards the bulk composition of continental crust. In the Alaska-Aleutian arc, magmas are strongly Fe-depleted both in the east, where the arc sits atop pre-existing continental crust, and in the west, where the system is oceanic but convergence is highly oblique. Primary basaltic arc magmas may achieve early Fe depletion through a combination of high magmatic $H_2O$, which delays silicate saturation, and high oxygen fugacity ($fO2$), which promotes early onset of Fe-oxide crystallization. Alternatively, low-Fe, high Mg# magmas may emerge directly from the arc mantle, possibly due to slab melting, driving mixing with Fe-rich basaltic magmas. Yet, the relative importance of $H_2O$, $fO_2$, and magmatic bulk composition in generating Fe-depletion is not clearly resolved. Here, we present new measurements of the oxidation state of Fe ($Fe^{3+}/\Sigma Fe$ ratio; a proxy for magmatic $fO_2$), in combination with major element and volatile data, of olivine-hosted melt inclusions from four Alaska-Aleutian arc volcanoes (Okmok, Seguam, Korovin, Augustine), acquired using XANES spectroscopy. We use the Tholeiitic Index (THI) of Zimmer et al., 2010 to quantify the behavior of Fe in each volcano magma series (<1 is Fe-depleted, >1 is Fe-enriched). These volcanoes span a range of THI, from 0.9-0.65. The $Fe^{3+}/\Sigma Fe$ ratios of Aleutian basalts, corrected for fractional crystallization to 6 wt.% MgO (i.e., $Fe^{3+}/\Sigma Fe_{6.0}$) range from 0.22-0.31 and correlate strongly with THI ($r^2$>0.99), such that more Fe-depleted magmas contain a greater proportion of oxidized Fe. The maximum dissolved $H_2O$ contents of basaltic melt inclusions from these volcanoes also strongly correlate with THI ($r^2$>0.96), and with measured $Fe^{3+}/\Sigma Fe$ ratios (although $H_2O$ is not the direct cause of oxidation). These links point to a slab-derived origin of both $H_2O$ and oxidation and thus relate slab fluxes to the Fe-depletion trends of arc magmas. These correlations also illustrate the difficulty of separating the effects of $H_2O$ and $fO_2$ on arc magmatic differentiation, as the two are challenging to isolate in nature. Analysis of experimental data, however, suggest that $fO_2$ exhibits stronger control than H2O on the relative appearance of spinel and silicates on the liquidus.

V11B: Physical Volcanology and Volcano Development in Aqueous and Terrestrial Environments Posters

8:00 AM-12:20 PM, Moscone South

*New Insights into Basaltic Balloon Formation during Submarine Eruptions*

**Steven Carey[1], Joshua Kelly[1]**, Mauro Rosi2, Marco Pistolesi3, Michael Marani4, **Christopher Roman[1]** and **Katherine Lynn Croff Bell[5]**, (1) University of Rhode Island, Graduate School of Oceanography, Narragansett, RI, United States, (2)Italian Civil Protection, Roma, Italy, (3)University of Pisa, Pisa, Italy, (4)Istituto Geologia Marina-CNR, Bologna, Italy, (5)Ocean Exploration Trust, Narragansett, RI, United States

Abstract:

Remotely operated vehicle (ROV) explorations in the area of the 1891 Foerstner submarine eruption (Pantelleria, Italy) during cruise NA-018 of the *E/V Nautilus* has provided the first examination of the vent site of a basaltic balloon-forming eruption. Ultra high-resolution bathymetric mapping defined a mound-like vent morphology in water depths of ~250 meter, constructed dominantly of highly vesicular scoriaceous fragments with minor pillow lava flows. The formation of floating basaltic balloons that reached the surface of the Strait of Sicily during the eruption is attributed to a hybrid Strombolian eruption mechanism that involved pre-concentration of volatiles into gas-rich portions of magma beneath the vent. An important difference of this Strombolian mechanism compared to its subaerial counterpart is the occurrence of buoyant magma discharge in the submarine environment caused by localized high gas contents. The added buoyancy flux modifies the fluid dynamic configuration of magma venting on the seafloor allowing for detachment of highly-inflated parcels of gas-rich magma. Some of these parcels contain large gas cavities that are enveloped in a partially quenched shell and maintain sufficient buoyancy to rise to the sea surface as a basaltic balloon. The majority of the vesicular magma maintains only partial positive buoyancy or negative buoyancy and is explosively fragmented to form large quantities of decimeter-scale fragments that accumulate close to the vent. Formation of the basaltic balloons is thus considered a somewhat accidental process that involves a subset of the total erupted volume of magma during the eruption. Suitable conditions for balloon formation include low magma viscosity, pre-concentration of gas, and moderate pressures (*i.e*. water depth). The dampening effect of seawater greatly reduces the dispersal of pyroclasts resulting in a mound-like vent morphology compared to subaerial scoria cones typically associated with Strombolian activity.

---

V11B: Physical Volcanology and Volcano Development in Aqueous and Terrestrial Environments Posters

8:00 AM-12:20 PM, Moscone South

*Geomorphological characteristics of the onshore/offshore volcanic edifices with respect to their evolutionary stage in the South Aegean Sea, Greece.*
Paraskevi Nomikou1, Dimitrios Papanikolaou1, Matina Alexandri2 and **Steven Carey**[3], (1)National and Kapodistrian University of Athens, Athens, Greece, (2)Hellenic Center for Marine Research, Anavyssos, Greece, (3)University of Rhode Island Narragansett Bay, Narragansett, RI, United States

Abstract:

Volcanism in the South Aegean Sea first occurred about 3-4 million years ago, along four different volcanic island groups, including both onshore and recently discovered offshore volcanoes: 1) Starting from the west, the Methana group consists of the Methana stratovolcano, composed exclusively of volcaniclastics and lavas, creating cones and domes onland and the Paphsanias submarine cone in the Epidavros tectonic graben, bordered by E-W normal faults. It has a 2 km basal diameter at 400 m depth and its top rises to 150 m. 2) The Milos-Antimilos group consists of volcanic domes and calderas onland and three submarine domes to the east of Antimilos. A hydrothermal vent field is limited in the SE coastal zone of Milos, 3) The Santorini group consists of: (i) the older volcanic cones of Christianna islets and three submarine domes east of them, (ii) Santorini volcano which during the last 500 ka experienced repeated caldera collapses following Plinian eruptions and edifice rebuilding, represented by the growth of the Kamenes islands after the last catastrophic Late Bronze age eruption. (iii) a chain of about twenty submarine volcanic domes and craters in the Kolumbo zone northeast of Santorini. Kolumbo volcano is a 3 km diameter cone with a 1500 m wide crater, a crater rim as shallow as 18 m depth and a flat crater floor at 505 m depth containing an active hydrothermal vent field degassing 99% of $CO_2$. 4) The Kos-Nisyros group at the eastern edge of the Hellenic Volcanic arc, comprises several domes and craters offshore and Nisyros volcano consists exclusively of alternating lava and pyroclastic deposits following several phases of reconstruction and caldera collapse. The rhyodacitic domes of Profitis Ilias are the latest evolutionary stage of Nisyros volcano which disrupted a pre-existed caldera and may be regarded as an earlier reconstruction phase similar to the Kameni islands at Santorini.

The volcanic relief reaches 1100-1200 m in most cases. This is produced from the outcrops of the volcanic centers emerging usually at 400-600 m depth and ending either below sea level or at high altitudes of 600-700 m on the islands. All volcanic edifices are located within neotectonic grabens formed by normal faulting, sometimes overprinted by subvertical strike-slip structures.

---

V11C: Volatile Elements and the Oceanic Crust Posters

8:00 AM-12:20 PM, Moscone South

*Undegassed Carbon Content from a Highly Depleted Segment of the Mid-Atlantic Ridge (1-5°S): Evidence from Melt Inclusions*

Marion Le Voyer1, **Katherine A Kelley[2]**, Elizabeth Cottrell3 and Erik H Hauri1, (1) Carnegie Institution, Washington, DC, United States, (2)University of Rhode Island, Kingston, RI, United States, (3)Smithsonian, NMNH, Washington, DC, United States

Abstract:
As carbon solubility is low in basalts, MORB contain little dissolved $CO_2$ (189±61 ppm, 1 σ , n=600 [1]). A global negative correlation between $CO_2$/Nb (proxy for amount of $CO_2$ lost by degassing) and Ba/La (proxy for source enrichment) indicates that depleted MORB are less affected by degassing than enriched MORB: $CO_2$/Nb ratios range from 0-100 for samples with Ba/La>4, while $CO_2$/Nb range from 50 to 400 for samples with Ba/La<4 [1]. To assess the $CO_2$ content of undegassed MORB, we analyzed the volatile content of 70 olivine-hosted, glassy melt inclusions (MIs) from four basalts dredged along MAR 1-5°S, a ridge segment that produces highly depleted MORB in terms of trace element enrichment and radiogenic isotopes [2, 3]. MIs contain $CO_2$ contents (180-1420 ppm) that are higher than their respective matrix glasses (130-220 ppm, typical for vapor-saturated melts erupted at 3-5 km b.s.l.).

One of the four dredges (EN061 5D-3Ag) contains MIs that do not exhibit shrinkage bubbles. For this sample only, we find a positive correlation between the $CO_2$ content (240-770 ppm) and the Cl content (6-20 ppm) of the MIs that is not found in the matrix glasses (see Fig.). We infer that the correlation between $CO_2$ and Cl, both highly incompatible in silicate minerals during fractional crystallization, is strong evidence for vapor-undersaturation, as any $CO_2$ degassing would have erased the correlation. Together with MIs from the Siqueiros Fracture Zone [4] and from northern Iceland [5], the MIs from EN061 5D-3Ag may represent another occurrence of carbon-undersaturated MORB. Our results will be used to model the primary carbon content of MORB and of the depleted upper mantle. Note that the average Cl content of the matrix glasses (20±1 ppm) is higher than those of the MIs (12±3 ppm, see Fig.). This indicates either that the matrix glasses assimilated a small amount of seawater Cl, or that the MIs are all more depleted than the matrix glass. We will acquire major and trace element data in order to further investigate the origin of the low Cl and high $CO_2$ contents in these MIs.

Ref. [1] Le Voyer et al. 2014 Goldschmidt abstr. [2] Schilling et al. 1994 JGR 99 [3] Kelley et al. 2013 G3 [4] Saal et al. 2002 Nature 419 [5] Hauri and Saal 2009 EOS Fall suppl. AGU abstr.

---

NH12A: Advances in Tsunami Hazard Mitigation and Response II

11:05 AM, Marriott Marquis, Salon 7

*Tsunami Inundation Mapping for the Upper East Coast of the United States*

Babak Tehranirad1, James T Kirby Jr2, John A Callahan3, Fengyan Shi1, Saeideh Banihashemi1, **Stephan T Grilli**[4], Annette R Grilli4, Tayebeh S Tajalli Bakhsh5 and Christopher O'Reilly5, (1)University of Delaware, Center for Applied Coastal Research, Newark, DE, United States, (2)Univ Delaware, Newark, DE, United States, (3)Delaware Geological Survey, Geology, Newark, DE, United States, (4)Univ Rhode Island, Narragansett, RI, United States, (5)University of Rhode Island, Narragansett, RI, United States

Abstract:

We describe the modeling of tsunami inundation for the Upper US East Coast (USEC) from Ocean City, MD up to Nantucket, MA. and the development of inundation maps for use in emergency management and hazard analysis. Seven tsunami sources were used as initial conditions in order to develop inundation maps based on a Probable Maximum Tsunami approach. Of the seven, two coseismic sources were used; the first being a large earthquake in the Puerto Rico Trench, in the well-known Caribbean Subduction Zone, and the second, an earthquake close to the Azores Gibraltar plate boundary known as the source of the biggest tsunami recorded in the North Atlantic Basin. In addition, four Submarine Mass Failure (SMF) sources located at different locations on the edge of the shelf break were simulated. Finally, the Cumbre Vieja Volcanic (CVV) collapse, located in the Canary Islands, was studied.

For this presentation, we discuss modeling results for nearshore tsunami propagation and onshore inundation. A fully nonlinear Boussinesq model (FUNWAVE-TVD) is used to capture the characteristics of tsunami propagation, both nearshore and inland. In addition to the inundation line as the main result of this work, other tsunami quantities such as inundation depth and maximum velocities will be discussed for the whole USEC area. Moreover, a discussion of most vulnerable areas to a possible tsunami in the USEC will be provided. For example, during the inundation simulation process, it was observed that coastal environments with barrier islands are among the hot spots to be significantly impacted by a tsunami. As a result, areas like western Long Island, NY and Atlantic City, NJ are some of the locations that will get extremely affected in case of a tsunami occurrence in the Atlantic Ocean. Finally, the differences between various tsunami sources modeled here will be presented. Although inundation lines for different sources usually follow a similar pattern, there are clear distinctions between the inundation depth and other tsunami features in different areas. Figure below shows the inundation depth for surrounding area of the Ocean City, MD. Figure (a) and (b) are the envelope inundation depth for SMF and coseismic sources. Figure (C) shows the inundation depth for CVV source, which clearly has the largest magnitude amongst the sources studied for this work.

---

12:05 PM, Marriott Marquis, Salon 7

*Development of algorithms for tsunami detection by High Frequency Radar based on modeling tsunami case studies in the Mediterranean Sea*

**Stephan T Grilli**, Univ Rhode Island, Narragansett, RI, United States, Charles-Antoine Guérin, Université de Toulon, Institut Méditerranéen d'Océanologie, F-83957 La Garde cedex, France and Samuel Grosdidier, Diginext Inc., Toulouse, France

Abstract:
Where coastal tsunami hazard is governed by near-field sources, Submarine Mass Failures (SMFs) or earthquakes, tsunami propagation times may be too small for a detection based on deep or shallow water buoys. To offer sufficient warning time, it has been proposed by others to implement early warning systems relying on High Frequency Radar (HFR) remote sensing, that has a dense spatial coverage far offshore.

A new HFR, referred to as STRADIVARIUS, is being deployed by Diginext Inc. (in Fall 2014), to cover the "Golfe du Lion" (GDL) in the Western Mediterranean Sea. This radar uses a proprietary phase coding technology that allows detection up to 300 km, in a bistatic configuration (for which radar and antennas are separated by about 100 km). Although the primary purpose of the radar is vessel detection in relation to homeland security, the 4.5 MHz HFR will provide a strong backscattered signal for ocean surface waves at the so-called Bragg frequency (here, wavelength of 30 m). The current caused by an arriving tsunami will shift the Bragg frequency, by a value proportional to the current magnitude (projected on the local radar ray direction), which can be easily obtained from the Doppler spectrum of the HFR signal.

Using state of the art tsunami generation and propagation models, we modeled tsunami case studies in the western Mediterranean basin (both seismic and SMFs) and simulated the HFR backscattered signal that would be detected for the entire GDL and beyond. Based on simulated HFR signal, we developed two types of tsunami detection algorithms: (i) one based on standard Doppler spectra, for which we found that to be detectable within the environmental and background current noises, the Doppler shift requires tsunami currents to be at least 10-15 cm/s, which typically only occurs on the continental shelf in fairly shallow water; (ii) to allow earlier detection, a second algorithm computes correlations of the HFR signals at two distant locations, shifted in time by the tsunami propagation time between these locations (easily computed based on bathymetry). We found that this second method allowed detection for currents as low as 5 cm/s, *i.e.*, in deeper water, beyond the shelf and further away from the coast, thus allowing an earlier detection.

---

S13C: Seismology Contributions: Advances in Instrumentation and Installation II Posters

1:40 PM-6:00 PM, Moscone South

*A high-precision, distributed geodetic strainmeter based on dual coaxial cable Bragg gratings*

Jihua Fu, Institute of Crustal Dynamics, China Earthquake Administration, Beijing, China, Tao Wei, University of Rhode Island, Electrical, computer, & biomedical engineering, Kingston, RI, United States, **Meng Wei**, University of Rhode Island Narragansett Bay, Narragansett, RI, United States and **Yang Shen**, Univ Rhode Island, Narragansett, RI, United States

Abstract:

Observations of surface deformation are essential for understanding a wide range of geophysical problems, including earthquakes, volcanoes, landslides, and glaciers. Current geodetic technologies, such as GPS, InSAR, borehole and laser strainmeters, are costly and limited in their temporal or spatial resolution. Here we present a new type of strainmeter based on coaxial cable Bragg grating (CCBG) sensing technology that provides high-precision, distributed strain measurements at a moderate cost. The coaxial-cable-based strainmeter is designed to cover a long distance (~ km) under harsh environmental conditions such as extreme temperatures. To minimize the environmental noises, two CCBGs are introduced into the geodetic strainmeter: one is used to measure the strain applied on it, and the other acts as a reference only to detect the environmental noises. The environmental noises are removed using the inputs from the strained CCBG and the reference CCBG in a frequency mixer. The test results show that the geodetic strainmeter with dual CCBGs has micron-strain accuracy in the lab.

## Tuesday, 16 December 2014

IN21D: Using Open Source Software to Enable Scientific Analysis and Reuse of Data I

08:45 AM

*Use Cases for Server Operators Extending the Open-Source Data-Access Protocol (DAP)*

James H R Gallagher, OPeNDAP, Inc., Butte, MT, United States, David W Fulker, OPeNDAP, Inc., Boulder, CO, United States, Brian Blanton, Renaissance Computing Institute, Chapel Hill, NC, United States, Steven Businger, University of Hawaii at Manoa, Honolulu, HI, United States and **Peter Cornillon**, University of Rhode Island Narragansett Bay, Narragansett, RI, United States

Abstract:

On the premise that EarthCube must incorporate data-access (Web) services that are effective even in big-data contexts, we articulate three use cases where a common form of data reduction, namely array-subset selection, falls short. These cases—addressing climate-model downscaling for native-Hawaiian use, real-time storm-surge prediction for U.S. coastal areas, and analysis of sea-surface-temperature (SST) fronts using satellite imagery—share three traits: a) each requires access to vast and remote volumes of source data, though the end-user applications need much less (by orders of magnitude); b) the volume reduction cannot be realized solely via subsetting, especially if limited to subarray-specification via index constraints; c) each data-reduction need can be met by extending a well-used data-access protocol (DAP) to embrace new data-proximate (I.e., pre-retrieval) server functions; and d) the required new functions will be useful across many geoscience (EarthCube) domains. Reflecting OpenDAP progress on designing this extension—dubbed ODSIP for Open Data-Services Protocol, to be prototyped under an NSF/EarthCube award—this talk sketches the near-source operations needed for the three use-cases, highlighting potential for abstraction and thus broad applicability.

---

B21L: Wanted, Dead or Alive: Microbes in the Subsurface II

09:45 AM, Moscone West 2004

*Microbial Cells and Aerobic Respiration from Seafloor to Basement in the South Pacific Gyre*

**Steven D'Hondt**[1], Fumio Inagaki[2], Carlos A Alvarez Zarikian[3], Yuki Morono[2], **Robert A Pockalny**[1], **Justine Sauvage**[1], **Arthur J Spivack**[1] and IODP Expedition 329 Shipboard Science Party, (1)University of Rhode Island, Narragansett, RI, United States, (2)JAMSTEC Japan Agency for Marine-Earth Science and Technology, Kanagawa, Japan, (3)Integrated Ocean Drilling Program, College Station, TX, United States

Abstract:

The seafloor is broadly divided into two regions (Emerson et al., 1985): one where sedimentary microbial respiration is high and oxygen ($O_2$) penetrates only millimeters to centimeters into the sediment (Revsbech et al., 1980), and another where sedimentary respiration is low and $O_2$ penetrates much deeper (Murray& Grundmanis, 1980; D'Hondt et al., 2011; Røy et al, 2012; Orcutt et al., 2013). Active anaerobic microbial communities persist for hundreds of meters or more in subseafloor sediment of the high-respiration region. In the low-respiration region, the existence of microbial communities is previously unknown throughout most of the sedimentary sequence (Morita & Zobell, 1955; D'Hondt et al., 2009; Røy et al., 2012). Here we show that microbial cells and aerobic respiration persist through the entire sediment sequence (to depths of at least 75 m below seafloor) throughout the vast expanse of the oligotrophic South Pacific Gyre. This sediment and underlying basalt may be continuously exposed to $O_2$ for its entire history (up to 120 myrs at our sites). Redfield stoichiometry of dissolved $O_2$ and nitrate indicates that net sedimentary $O_2$ reduction is coupled to oxidation of marine organic

matter. Oxygen and aerobic communities may occur throughout the entire sediment sequence in 15-44% of the Pacific and 9-37% of the global ocean. This result has major implications for the nature and distribution of subseafloor life. It may ultimately affect the chemical evolution of Earth's mantle and subduction-related volcanic systems.

References

D'Hondt, S., et al., 2009. *Proc. Nat. Acad. Sci. U.S.A.* **106**, 11651-11656, doi:10.1073/pnas.0811793106.

D'Hondt, S., et al., 2011. *Proc. IODP* **329**, doi:10.2204/ iodp.proc.329.2011.

Emerson, S., et al., 1985. *Deep-Sea Research* **32**, 1–21.

Morita, R.Y. & Zobell, C.E., 1955. *Deep-Sea Research* **3**, 66-73.

Murray, J.W. & Grundmanis, V., 1980. *Science* **209**, 1527-1530.

Orcutt, B.N., et al., 2013. *Nature Communications* **4**, 2539, DOI: 10.1038/ncomms3539.

Revsbech N.P. et al., 1980. *Science* **207**, 1355-1356.

Røy, H. et al., 2012. *Science* **336** (6083), 922-925, DOI: 10.1126/science.1219424.

---

ED21E: Climate Literacy: Effective Responses and Solutions through Best Practices in Communication, Partnerships, and Networks I

08:00 AM-10:00 AM, Moscone South 102

Chairs: **Gail Scowcroft**, University of Rhode Island, Graduate School of Oceanography, Narragansett, RI, United States, Mona Behl, Texas A & M University, College Station, TX
Primary Conveners: **Gail Scowcroft**, University of Rhode Island, Graduate School of Oceanography, Narragansett, RI, United States
Co-conveners: Jennifer Saltzman, Stanford University, Stanford, CA, United States, Mona Behl, Texas A & M University, College Station, TX, United States and Joshua Sneideman, Department of Energy Washington DC, Einstein Fellow, Washington, DC, United States

---

NH21B: Tsunami Hazards and the Responses of Human and Physical Environmental Systems to Tsunami Forcing I Posters

8:00 AM-12:20 PM, Moscone South

*Survey of Tsunamis Formed by Atmospheric Forcing on the East Coast of the United States*

**John Lodise**[1]**, Yang Shen**[2] and **Christina A Wertman**[1], (1)University of Rhode Island Narragansett Bay, Narragansett, RI, United States, (2)Univ Rhode Island, Narragansett, RI, United States

Abstract:

High-frequency sea level oscillations along the United States East Coast have been linked to atmospheric pressure disturbances observed during large storm events. These oscillations have periods similar to tsunami events generated by earthquakes and submarine landslides, but are created by moving surface pressure anomalies within storm systems such as mesoscale convective systems or mid-latitude cyclones. Meteotsunamis form as in-situ waves, directly underneath a moving surface pressure anomaly. As the pressure disturbances move off the east coast of North America and over the continental shelf in the Atlantic Ocean, Proudman resonance, which is known to enhance the amplitude of the meteotsunami, may occur when the propagation speed of the pressure disturbance is equal to that of the shallow water wave speed. At the continental shelf break, some of the meteotsunami waves are reflected back towards the coast. The events we studied date from 2007 to 2014, most of which were identified using an atmospheric pressure anomaly detection method applied to atmospheric data from two National Data Buoy Center stations: Cape May, New Jersey and Newport, Rhode Island. The coastal tidal records used to observe the meteotsunami amplitudes include Montauk, New York; Atlantic City, New Jersey; and Duck, North Carolina. On average, meteotsunamis ranging from 0.1m to 1m in amplitude occurred roughly twice per month, with meteotsunamis larger than 0.4m occurring approximately 4 times per year, a rate much higher than previously reported. For each event, the amplitude of the recorded pressure disturbance was compared to the meteotsunami amplitude, while radar and bathymetry data were analyzed to observe the influence of Proudman resonance on the reflected meteotsunami waves. In-situ meteotsunami amplitudes showed a direct correlation with the amplitude of pressure disturbances. Meteotsunamis reflected off the continental shelf break were generally higher in amplitude when the average storm speed was closer to that of the shallow water wave speed, which suggests that Proudman resonance has a significant influence on meteotsunami amplitude over the continental shelf. Through the application of these findings the frequency and severity of future meteotsunamis can be better predicted along the east coast of the United States.

---

PP21A: Cenozoic through Modern Climate and Glacial Records and Processes at High-Latitude Margins I Posters

8:00 AM-12:20 PM, Moscone West

*Paleoceanography in Pelagic Clay of the South Pacific Gyre*

Ann G Dunlea1, Richard W Murray2**, Justine Sauvage**[3], **Arthur J Spivack**[3], Robert N Harris4 and **Steven D'Hondt**[5], (1)Boston University, Boston, MA, United States, (2)Boston Univ, Boston, MA, United States, (3)University of Rhode Island - GSO, West Warwick, RI, United States, (4)Oregon State University, Corvallis, OR, United States, (5)University of Rhode Island, Narragansett, RI, United States

Abstract:

A spatially and temporally expansive record of early Cenozoic high-latitude ocean history resides in the pelagic clay of the South Pacific Gyre (SPG). At the beginning of the Cenozoic, four sites drilled during IODP Expedition 329 were located between 40-62°S, which may have been the center of an ancient polar gyre. As the Pacific Plate migrated northward, these sites were subjected to major paleoceanographic changes including the onset of the Antarctic Circumpolar Current, Australian desertification, and Southern Hemisphere volcanism.

The SPG sediment is homogenous brown, zeolitic, metalliferous pelagic clay. Such sediment can be challenging for paleooceanographic research due its ultrafine grain size, slow accumulation rate, post-depositional alteration, and lack of biogenic material. However, our geochemical techniques embrace the authigenic nature of SPG clay to develop a constant-Co age model and track variations in sediment origin and accumulation. By combining sedimentation patterns with backtracked site paths, we produce an unprecedented characterization of the Cenozoic paleoceanographic evolution of the SPG.

We analyzed 47 major, trace, REE concentrations in 206 bulk sediment samples from 7 sites across the SPG, deposited as long ago as 100 Ma. For each sample, traditional geochemical partitioning techniques, Q-mode factor analyses, and multiple linear regressions allowed us to quantify contributions of six end-members: post-Archean average Australian shale (PAAS), Fe-Mn-oxyhydroxides, apatite, biogenic Si, and two distinct types of altered volcanic ash.

Mass accumulation of the PAAS end-member increased 12-18% throughout the Cenozoic, with the most rapid increase occurring just after the mid-Miocene when Australia became more arid. The Paleogene/Neogene boundary also marks a change in sedimentation, likely caused by a change in eolian activity and/or a change in authigenic processes due to changing bottom water conditions. Contributions from one kind of altered ash decreased throughout the Cenozoic while the second kind of altered ash increased in importance. This volcanic shift reflects either a large-scale change in the source of volcanic ash and/or different alteration of ash from the same source, possibly from changes in bottom water conditions or sedimentation rate.

---

PP21A: Cenozoic through Modern Climate and Glacial Records and Processes at High-Latitude Margins I Posters

8:00 AM-12:20 PM, Moscone West

*Record of Earliest West Antarctic Ice Sheet Beneath Ross Sea?*

**Sierra Madeline Davis**[1], **(SURFO)** Christopher C Sorlien[2], Laura De Santis[3], Bruce P Luyendyk[2], Chiara Sauli[3], Nigel Wardell[3] and Philip J Bart[4], (1)Indiana Univ of PA, Indiana, PA, United States, (2)University of California Santa Barbara, Earth Research Institute, Santa Barbara, CA, United States, (3)Ist Nazionale Oceanografia, Sgonico, Italy, (4)Louisiana State Univ, Baton Rouge, LA, United States

Abstract**:**

Recent Global Climate Models, utilizing topography restored for rift-related subsidence and glacial erosion, produce a West Antarctic Ice Sheet for earliest Oligocene (~34 Ma) conditions. Additionally, global isotopic records indicate an Antarctic ice sheet larger than today's at ~34 Ma. However, evidence for a pre-30 Ma major glaciation has been lacking in seismic stratigraphic studies of Ross Sea.

Utilizing deep scientific core holes and all available seismic reflection profiles, we investigated subsidence, sedimentation, and glacial erosion in the Ross Sea. These data image a smooth, tilted and laterally continuous (>200 km) unconformity interpreted as metamorphic basement eroded by waves and subaerial processes. At ~34 Ma, much of the central proto-Ross Sea's ground surface was composed of this basement.

In the western Ross Sea, a pre-30 Ma trough >50 km-wide cuts downward as much as 2 km into acoustically reflective strata. These reflective strata are interpreted to be 80-55 Ma syn-rift sedimentary rocks cut by faults. The trough fill is unfaulted; therefore erosion postdates the rifting. Using the current depth of the top basement and the age of initial aggrading marine strata, post-~30 Ma to post-~25 Ma subsidence rates are easily calculated. Projecting these rates using tilts of 30 Ma and younger strata, Central Trough has subsided 2-3 km since 30 Ma, similar to published values for this trough. The unconformity flooring the trough currently is as deep as 6 km with shallower sills downflow. If backstripping and thermal modeling also indicate a reverse gradient of the trough axis at ~34 Ma and ~55 Ma, the erosion must have been due to ~34 Ma ice. In the event that the trough was eroded soon after cessation of rifting at 55 Ma, then total differential subsidence might explain both the current depth and reverse gradient. Projecting the known rates of sediment deposition between ~25 Ma and ~30 Ma, the trough fill can easily be post-~34 Ma. Therefore, one of the possible explanations is that the erosional trough comprising deep Central Trough may be evidence of the first advance of the West Antarctic Ice Sheet. However, since we have not yet done the modeling, we cannot yet rule out the trough being an early Cenozoic river valley or a submarine canyon.

---

ED22A: Climate Literacy: Effective Responses and Solutions through Best Practices in Communication, Partnerships, and Networks II

10:20 AM-12:20 PM, Moscone South 102

Chairs: Jennifer Saltzman, Stanford University, Stanford, CA, United States and Olivia Ambrogio, American Geophysical Union, Washington, United States
Primary Conveners: **Gail Scowcroft**, University of Rhode Island, Graduate School of Oceanography, Narragansett, RI, United States
Co-conveners: Jennifer Saltzman, Stanford University, Stanford, CA, United States, Mona Behl, Texas A & M University, College Station, TX, United States and Joshua Sneideman, Department of Energy Washington DC, Einstein Fellow, Washington, DC, United States

---

V23G: The Geochemical Diversity of the Mantle Inferred from Hotspots: Five Decades of Debate II

1:55 PM, Marriott Marquis, Salons 1-3

*Redox Heterogeneity of the Mantle Inferred from Hotspots*

Elizabeth Cottrell, National Museum of Natural History, Smithsonian Institution, Department of Mineral Science, Washington, DC, United States and **Katherine A Kelley**, University of Rhode Island, Kingston, RI, United States

Abstract:

Hotspots provide a unique opportunity to sample mantle heterogeneities and thereby gain insight into the geodynamic history of our planet. Well-documented excursions in isotopic ratios from values typical of normal mid-ocean ridge basalt (MORB) classically underpin our understanding of geochemical heterogeneity. Major elements too appear to record litholoigcal heterogeneity and thus deepen our understanding of the processes responsible for creating heterogeneity. Here we report the $Fe^{3+}/\Sigma Fe$ ratios of submarine glasses dredged from ocean islands (Samoa, Hawaii, Pitcairn, Societies) and plume-affected ridge segments (Azores, Galapagos). When corrected for low-pressure crystal fractionation to 8 wt.% MgO, $Fe^{3+}/\Sigma Fe_{(8)}$ratios of ocean island basalts (OIB) from Samoa, Loihi, and Pitcairn extend to higher values than normal MORB (0.16±0.01) and, with one exeption, overlap with the range observed in back arc basin basalts (0.16 to 0.21 at Samoa, 0.17 to 0.19 at Loihi, and 0.19 to 0.27 at Pitcairn). Plume-affected samples are among the most oxidized MORBs (~0.168 at Azores and ~0.175 at Galapagos).

Basalt $Fe^{3+}/\Sigma Fe$ ratios provide one proxy for the oxygen fugacity ($fO_2$) of the mantle from which they derive. The higher oxidation state of Fe in OIB relative to MORB may reflect higher $fO_2$ in the source mantle of OIB relative to MORB, and may further explain major element systematics in OIBs as well as their more calc-alkaline nature. We also report that $Fe^{3+}/\Sigma Fe_{(8)}$ ratios correlate with isotopic ratios, such as $^{87}Sr/^{86}Sr$, which may trace recycled continental crust (Samoa: R=0.57, n=8; Galapagos: R = 0.94, n=8). Strikingly, these positive correlations are opposite to those observed in MORB away from plumes, where $Fe^{3+}/\Sigma Fe_{(8)}$ ratios correlate negatively with indicies of enrichment (e.g. $^{87}Sr/^{86}Sr$, R = -0.71, n=31 and Ba/La, R = -0.72, n=19, Cottrell and Kelley, Science, 2013 and unpub.). Yet, these new OIB data support conclusions drawn from MORB: redox heterogeneities reflect large-scale geodynamic processes acting over long time periods and are not overprinted by melting and differentiation (C&K, Science, 2013). We infer that a variety of procesess, including recycling of surface-derived materials, generate redox heterogeneities in the mantle that persist and influence OIB petrogenesis.

---

ED23B: Climate Literacy: Effective Responses and Solutions through Best Practices in Communication, Partnerships, and Networks III Posters

1:40 PM-6:00 PM, Moscone South

Chairs: **Gail Scowcroft**, University of Rhode Island, Narragansett, RI, United States and Jennifer Saltzman, Stanford University, Stanford, CA, United States
Primary Conveners: **Gail Scowcroft**, University of Rhode Island, Graduate School of Oceanography, Narragansett, RI, United States
Co-conveners: Jennifer Saltzman, Stanford University, Stanford, CA, United States, Mona Behl, Texas A & M University, College Station, TX, United States and Joshua Sneideman, Department of Energy Washington DC, Einstein Fellow, Washington, DC, United States

---

H23D: Linking Surface and Subsurface Hydrologic Processes to Understand Flow from Continents and Islands to the Ocean Posters

1:40 PM-6:00 PM, Moscone West

*Submarine groundwater discharge is an important source of REEs to the coastal ocean*

Karen Haley Johannesson[1], Darren Andrew Chevis[1], C. Dianne Palmore[1], Katherine Telfeyan[1], David Burdige[2], Jaye Ellen Cable[3], Sidney R Hemming[4], Troy Rasbury[5], **S Bradley Moran**[6], Nancy Prouty[7] and Peter W Swarzenski[8], (1)Tulane Univ Earth&Environ Sci, New Orleans, LA, United States, (2)Old Dominion University, Dept. of Ocean, Earth and Atmospheric Sciences, Norfolk, VA, United States, (3)University of North Carolina at Chapel Hill, Chapel Hill, NC, United States, (4)Lamont-Doherty Earth Observ, Palisades, NY, United States, (5)Stony Brook University, Stony Brook, NY, United States, (6)University of Rhode Island, Graduate School of Oceanography,

Narragansett, RI, United States, (7)USGS, Pacific Coastal and Marine Science Center, Baltimore, MD, United States, (8)USGS, Pacific Coastal and Marine Science Center, Santa Cruz, CA, United States

Abstract:

Rare earth element (REE) concentrations of submarine groundwater discharge (SGD) were measured in three subterranean estuaries (i.e., Indian River Lagoon, Florida; Pettaquamscutt estuary, Rhode Island; Kona Coast, Hawaii). Using site-specific SGD estimates previously obtained by a variety of techniques (e.g., seepage meters, Ra, and Rn), we estimated SGD-derived fluxes of REEs to the coastal ocean using simple, one-dimensional modeling techniques. Our results indicate that the SGD fluxes of REEs are either of the same magnitude as riverine REE fluxes (Indian River Lagoon; Pettaquamscutt estuary), or far exceed surface runoff sources of REEs to the coastal ocean (Kona Coast). At each site important biogeochemical reactions occurring in the subterranean estuary, such as redox reactions, sediment bioirrigation, mineral dissolution and re-precipitation, and salt-induced mobilization from "nano-colloids", appear to facilitate release of REEs into solution, which are then advected to the coastal ocean via SGD. Neodymium isotope analysis of SGD and aquifer sediment are consistent with sediment diagenesis and redox transformations of Fe(III) oxides/oxyhydroxides, as well as preferential weathering of REE-bearing minerals like apatite, as being important sources of REEs to coastal seawater. Our investigations demonstrate that geochemical reactions occurring in the studied subterranean estuaries represent a net source of light and middle REEs to coastal seawater, whereas the heavy REEs appear to be sequestered in the subterranean estuary sediment.

## Wednesday, 17 December 2014

T31D: Crustal and Lithospheric Structure of Cratons Inferred with Geophysical Methods II

8:15 AM, Moscone South 304

*Constraints on Shear Velocity in the Cratonic Upper Mantle From Rayleigh Wave Phase Velocity*

**Aaron C Hirsch**, Boston University (**now GSO**), Department of Earth and Environment, Boston, MA, United States and Colleen A Dalton, Brown University, Department of Earth, Environmental, and Planetary Sciences, Providence, RI, United States

Abstract**:**

In recent years, the prevailing notion of Precambrian continental lithosphere as a thick boundary layer (200-300 km), defined by a depleted composition and a steady-state conductively cooled temperature structure, has been challenged by several lines of

seismological evidence. One, profiles of shear velocity with depth beneath cratons exhibit lower wave speed at shallow depths and higher wave speed at greater depths than can be explained by temperature alone. These profiles are also characterized by positive or flat velocity gradients with depth and anomalously high attenuation in the uppermost mantle, both of which are difficult to reconcile with the low temperatures and large thermal gradient expected with a thermal boundary layer. Two, body-wave receiver-function studies have detected a mid-lithospheric discontinuity that requires a large and abrupt velocity decrease with depth in cratonic regions that cannot be achieved by thermal gradients alone. Here, we used forward-modeling to identify the suite of shear-velocity profiles that are consistent with phase-velocity observations made for Rayleigh waves that primarily traversed cratons in North America, South America, Africa, and Australia. We considered two approaches; with the first, depth profiles of shear velocity were predicted from thermal models of the cratonic upper mantle that correspond to a range of assumed values of mantle potential temperature, surface heat flow, and radiogenic heat production in the crust and upper mantle. With the second approach, depth profiles of shear velocity were randomly generated. In both cases, Rayleigh wave phase velocity was calculated from the Earth models and compared to the observed values. We show that it is very difficult to match the observations with an Earth model containing a low-velocity zone in the upper mantle; instead, the best-fit models contain a flat or positive velocity gradient with depth. We explore the implications of this result for the thermal and compositional properties and long-term stability of the cratonic upper mantle.

---

ED31H: Climate Literacy: Culture of Science AND Broader Impacts Done Well I

8:45 AM

*Effective Broader Impacts - Lessons Learned by the Ocean Science Community*

**Gail Scowcroft**, University of Rhode Island, Narragansett, RI, United States (Invited)

Abstract:

Effective broader impact activities have the potential for scientists to engage with educators, students, and the public in meaningful ways that lead to increased scientific literacy. These interactions provide opportunities for the results and discoveries of federally funded research projects, along with their implications for society, to reach non-scientist audiences. This is especially important for climate, ocean, and environmental science research that will aid citizens in better understanding how they affect Earth's systems and how these systems affect their daily lives. The National Centers for Ocean Sciences Excellence (COSEE) Network has over 12 years of experience in conducting successful broader impact activities and has provided thousands of ocean scientists the opportunity to share the fruits of their research well beyond the scientific enterprise. COSEE evaluators and principal investigators collaborated over several years to

determine the impacts of COSEE broader impact activities and to identify best practices. The lessons learned by the ocean science community can help to inform other disciplines. Fruitful broader impact activities require key elements, no matter the composition of the audience. For example, a high degree of success can be achieved when a "bridge builder" facilitates the interactions between scientists and non-science audiences. This presentation will offer other examples of best practices and successful strategies for engaging scientists in broader impact activities, increasing societal impacts of scientific research, and providing opportunities for collaboration on a national scale. http://www.cosee.net

---

V31G: Arcs from the Inside Out I

9:15 AM, Moscone South 310

*The Redox Budget of the Mariana Subduction System*

**Maryjo N Brounce**, University of Rhode Island Narragansett Bay, Narragansett, RI, United States, Elizabeth Cottrell, Smithsonian, NMNH, Washington, DC, United States and **Katherine A Kelley**, University of Rhode Island, Kingston, RI, United States

Abstract:

Oceanic lithosphere is altered and oxidized as it spreads, until it subducts and fluids and melts from the subducting plate contribute to the composition of arc and back-arc basalts. The oxidized nature of Mariana arc magmas is likely acquired through the transfer of oxidized species from the slab to the mantle wedge via aqueous fluids [1]. Despite its critical role in the relationship between material recycling at subduction zones and oxidation, it is unclear what percentage of the oxidized material is transported into the mantle wedge and output during volcanism and what percentage is transported past subduction zones, into the deep mantle. We present $Fe^{3+}/\Sigma Fe$ ratios determined on bulk sediments and altered oceanic crust recovered from ODP Site 801 in the western Pacific in order to constrain the bulk oxidation state of the Pacific plate prior to subduction. We performed micro-colorimetric determinations of the $Fe^{2+}O$ contents of 9 sediment samples, 8 variably altered MORBs, 5 alteration products, and 8 mixed composite powders from the sediment and upper 500 m of altered oceanic crust at ODP Site 801. Site 801 sediments have $Fe^{3+}/\Sigma Fe$ ratios >0.69 and the altered oceanic crust (801 Super Composite) has $Fe^{3+}/\Sigma Fe$=0.51. Bulk $Fe^{3+}/\Sigma Fe$ ratios of altered oceanic crust at Site 801 increase from 0.16 (pristine MORB glass measured by XANES, [2]) to 0.78 with increasing extent of alteration. Using bulk $Fe^{3+}/\Sigma Fe$ ratios determined here, and Fe redox information from [1] and [2], we calculated a mass balance of $Fe^{3+}$ and $O_2$ equivalent through the Mariana subduction zone. We subtracted the $Fe^{3+}$ of pristine oceanic crust from that of altered oceanic crust to estimate the amount of $Fe^{3+}$ taken up by oceanic crust during alteration on the seafloor. Comparing this value to the output of $Fe^{3+}$ from Mariana arc and back-arc lavas, we find that 50-70% of the $O_2$ equivalent added to the

oceanic crust by alteration on the seafloor is not output by arc or back-arc magmas. If this oxygen is retained in the slab that subducts into the deep mantle, it may contribute to mantle redox heterogeneity.

[1] Brounce, M.N., Kelley, K.A., and Cottrell, E. in revision. Variations in $Fe^{3+}/\sum Fe$ of Mariana arc basalts and mantle wedge $fO_2$.

[2] Brounce, M.N., Kelley, K.A., and Cottrell, E. in prep. Temporal evolution of mantle wedge oxygen fugacity during subduction initiation.

---

ED31F: Undergraduate Earth, Atmospheric, Ocean, and Space Science Research and Outreach Showcase Posters

8:00 AM-12:20 PM, Moscone South

*Revisiting Antarctic Circumpolar Current Transport Estimates*

Lauren Ann Sommers1, **Kathleen A Donohue**[2] and **Kellen Rosburg**[2], (1)California State University Monterey Bay, Seaside, CA, United States, (2)Univ Rhode Island, Narragansett, RI, United States

Abstract:

The Antarctic Circumpolar Current (ACC) is the world's strongest current, and acts as a conduit that transports water between Atlantic, Pacific, and Indian Oceans. ACC transport is a key metric used to evaluate the accuracy of ocean and climate models. The canonical transport of 134 Sv through Drake Passage, the narrowest choke point of the ACC, derives from a year-long experiment conducted in 1979 (DRAKE79). Recent studies suggest that this historical value may be biased low by as much as 20%. DRAKE79 transport estimates resulted from a complicated synthesis of historical data and in-situ measurements, and relied heavily on the outcome of referencing three hydrographic sections with directly measured currents. This study focuses on evaluating DRAKE79's geostrophic referencing technique. We hypothesized that the horizontal spacing and temporal averaging of current meters led to a bias in the historical estimate. Southern Ocean State Estimate (SOSE) was used as a test bed to evaluate DRAKE79 methods. A mean AAC transport of 181.5 ± 17.6 Sv was obtained by applying DRAKE79 methods to 2005 SOSE output. This value is greater than SOSE's "true" geostrophic transport (153.0 ± 5.7) by 29 Sv. This difference resulted primarily from linear interpolation between two lost moorings; however the horizontal spacing of the current meters did not resolve the narrow jets of the ACC regardless of mooring loss. Within SOSE, geostrophic transports referenced with velocities at all mooring locations resulted in a mean transport of 161.0 ± 10.2 Sv. Temporal smoothing of the reference velocities, using up to a 20-day running mean, had minimal impact on the mean transport

estimate. A next step would evaluate whether the mooring positions should be modified within SOSE to capture the same circulation features as DRAKE79.

---

OS31D: Ocean Submesoscale Processes and Potential Scientific Breakthrough: Simulations, Observations, and Applications II Posters

8:00 AM-12:20 PM, Moscone West

*Spectral Analysis of Submesoscale Energy Cascades Using Subtropical North Atlantic Sea Surface Temperature Fields*

**Emily Iskin**, University of Rhode Island Narragansett Bay, Narragansett, RI, United States, **Fabian Schloesser**, IPRC, Hawaii & GSO, Rhode Island, Narragansett, RI, United States and **Peter C Cornillon**, University of Rhode Island, Kingston, RI, United States

Abstract**:**

Mixing parameterizations of current climate models could be improved by a better understanding of energy cascades in the submesoscale ocean (1 – 10 km). This study uses spectral analysis to compare energy cascades in two different data sets that resolve processes of about 1 km scale. The first data set consists of 20 years of in situ measurements from an acoustic Doppler current profiler (ADCP, temperature and velocity) and about 10 years of in situ data from a thermosalinograph (TSG, temperature and salinity) both mounted on the *Oleander*, a container vessel that makes weekly trips from New Jersey to Bermuda. The second data set consists of global sea surface skin temperature data from the Visible-Infrared Imager-Radiometer Suite (VIIRS) mounted on the Soumi-NPP NASA spacecraft. The slopes of the ADCP and TSG potential energy spectra are between -2.4 and -2.6, the similarity suggesting they represent the same physical processes. Because the TSG produces higher resolution data than the ADCP, the TSG energy spectrum better resolves processes at scales < 10 km. When separated by region, the TSG energy spectra have different slopes in three distinct regions along the *Oleander* track: on the continental shelf and in the Gulf Stream the slopes are about -2.7, and in the Sargasso Sea the slope is about -2.5. All slopes determined from the temperature structure functions for the same regions are between 1.0 and 1.3, with the Sargasso Sea slope being the lowest of the four (the three separated regions and the entire *Oleander* track). In theory, the energy spectrum slope ($n$) and the structure function slope ($p$) should be related by $n = p + 1$ if the underlying physical processes are both isotropic and homogeneous. The deviations from theory may result from failure of this assumption and/or from the contribution of multiple processes to the spectra, which are combined differently for structure functions than for energy spectra. Of interest here is that our estimates show consistent differences in slopes in the different regions. Comparisons will be made between TSG and VIIRS temperature structure functions to determine if surface properties are consistent with in situ data.

---

T31B: Oblique Deformation: The 3D Challenge I Posters

8:00 AM-12:20 PM, Moscone South

*Activity on the multi-stranded Central Branch of the North Anatolian Fault along the southern shelf of the Marmara Sea, Turkey*

Seda Okay1, Christopher C Sorlien2, Gunay Cifci1, **Marie-Helene Cormier**[3], Derman Dondurur1, Michael S Steckler4, Burcu Barin1 and Leonardo Seeber4, (1)Dokuz Eylül University, Izmir, Turkey, (2)Univ California Santa Barbara, Santa Barbara, CA, United States, (3)University of Rhode Island, Graduate School of Oceanography, Kingston, RI, United States, (4)Lamont-Doherty Earth Obs, Palisades, NY, United States

Abstract:

The North Anatolian Fault (NAF), a major continental transform boundary, splays westward into three branches in the Sea of Marmara region of NW Turkey. The main northern branch passes only ~20 km from Istanbul and has been the subject of intense investigation, The central branch enters the sea of Marmara in Gemlik Bay and extends westeward along the southern shelf of the Sea of Marmara. However, its detailed offshore geometry as well as its level of seismic activity have remained controversial. Under the SoMAR Project, two geophysical cruises were carried out in 2013 and 2014 to map the major sedimentary basins and shallow fault patterns of the southern shelf of the Marmara Sea. Including our 2008 and 2010 acquisition, we acquired 4,430 km of high-resolution multichannel seismic, sparker, multibeam bathymetric and CHIRP data. We used the new data to correlate our published late Quaternary stratigraphic age model across the outer shelf, and a ~1/4 Ma horizon across the Inner Shelf, thus providing a chronology that can be applied to the tectonic history of the central branch.

As it exits Gemlik Bay, the central branch itself diverges westward into strands in a fan pattern. A half dozen southern strands strike WSW and W, with one continuing onland near the Kocasu River delta between Bandırma and Mudanya, and others dying out offshore. The northern strand strikes WNW and splays again into the İmrali Ridge Fault and the Imrali Fault across respectively the mid-shelf and the shelf break. A middle fault, the Kapidag fault, is present between Kapidag Peninsula and Marmara Island.

Most of the faults increase their vertical component with depth, suggesting activity during Pliocene through Holocene time. The Kapidag fault and Imrali Ridge fault each exhibit between 1 and 2 km of vertical separation of acoustic basement. Late Quaternary rates of vertical separation on these faults can accumulate the total vertical component after Miocene time. Thus, steady-state activity is possible. Alternatively, the late Quaternary activity could represent reactivation. High-resolution CHIRP seismic profiles confirm that tilting is ongoing and that most of the faults offset the Last Glacial Maximum unconformity.

Keywords: Marmara Sea, North Anatolian Fault; central branch; strike slip fault; erosional unconformity, seismic hazard; transform fault;

---

OS33A: Marine Geohazards III Posters

1:40 PM-6:00 PM, Moscone West

*Windward Passage and Jamaica Channel: New Insights About two Tectonic Gateways of the Northern Caribbean*

**Marie-Helene Cormier**[1], Ruth Elaine Blake[2], **Dwight F. Coleman**[1], Kelly Guerrier[3], Nicole Raineault[4], Nixon Saintilus[5], Sharon L Walker[6], Steven Auscavitch[7] and Jamie Wagner[8], (1)University of Rhode Island, Graduate School of Oceanography, Narragansett, RI, United States, (2)Yale University, Dept. Geology and Geophysics, New Haven, CT, United States, (3)State University of Haiti, URGeo-FDS, Port-au-Prince, Haiti, (4)Ocean Exploration Trust, Graduate School of Oceanography - University of Rhode Island, Narragansett, RI, United States, (5)SEMANAH (Haiti maritime and Navigation Service), Delmas, Haiti, (6)NOAA/PMEL, Seattle, WA, United States, (7)University of Maine, Orono, ME, United States, (8)Duke University, Durham, NC, United States

Abstract**:**

This August 2014, a 14-day expedition of the *E/V NAUTILUS* of the *OCEAN EXPLORATION TRUST* will explore the region delimited by two deep straits of the northern Caribbean, the Windward passage and the Jamaica Channel. The morphology of these straits is controlled by two transform faults: The Septentrional fault, which stretches between Cuba and Haiti (slip rate: ~13 mm/yr), and the Enriquillo-Plantain Garden Fault (EPGF), which stretches between Jamaica and Haiti (slip rate: ~9 mm/yr). Together, these faults bound the Gonave microplate, an elongated platelet caught between the North America plate and Caribbean plates. The Septentrional fault ruptured in 1842, devastating the town of Cap Haitien. The EPGF ruptured catastrophically in 2010 near Port-au-Prince (death toll > 100,000). Tsunamis were associated with both earthquakes. Oblique slip on these two faults is presumably controlling the history of uplift and subsidence of the seafloor, and has therefore also been regulating the water exchanges between the north central Atlantic and the Caribbean Sea. New multibeam bathymetric and CHIRP sub-bottom profiling data will be acquired with the *E/V NAUTILUS*, while the ROV HERCULES will be used to collect video, water and rock samples, as well as water column physical properties.

We anticipate that this survey will document the following: (1) The nature of drowned carbonate platforms, which in turn may provide useful markers to assess rates of vertical deformation along the two faults. (2) The extent of major landslides detected on the steep fore reefs from existing multibeam bathymetric data. (3) Whether fluids are actively seeping along the fault traces or in association with the landslides, as has been reported

elsewhere around the World. (4) If cold seeps are indeed present, to what extent their associated ecosystems are affected by the bottom currents that flow through these gateways. Altogether, the new findings should contribute to a better understanding of the natural hazards associated with two major transform faults.

---

V33B: Arcs from the Inside Out III Posters

1:40 PM-6:00 PM, Moscone South

*The Melt Segregation During Ascent of Buoyant Diapirs in Subduction Zones*
Nan Zhang, Woods Hole Oceanographic Institution, Geology & Geophysics, Woods Hole, MA, United States, Mark D Behn, Woods Hole Oceanographic Inst, Woods Hole, MA, United States, E Marc Parmentier, Brown University, Geological Sciences, Providence, RI, United States and **Christopher R Kincaid**, Univ Rhode Island, Narragansett, RI, United States

Abstract:

Cold, low-density diapirs arising from hydrated mantle and/or subducted sediments on the top of subducting slabs may transport key chemical signatures from the slab to the shallow source region for arc magmas. These chemical signatures are strongly influenced by melting of this buoyant material during its ascent. However, to date there have been relatively few quantitative models to constrain melting and melt segregation in an ascending diapir, as well as the induced geochemical signature.

Here, we use a two-phase Darcy-Stokes-energy model to investigate thermal evolution, melting, and melt segregation in buoyant diapirs as they ascend through the mantle wedge. Using a simplified 2-D axi-symmetric circular geometry we investigate diapir evolution in three scenarios with increasing complexity. First, we consider a case without melting in which the thermal evolution of the diapir is controlled solely by thermal diffusion during ascent. Our results show that for most cases (e.g., diapir radius $\leq$ 3.7 km and diapir generation depths of ~ 75 km) thermal diffusion times are smaller than the ascent time—implying that the diapir will thermal equilibrate with the mantle wedge. Secondly, we parameterize melting within the diapir, but without melt segregation, and add the effect of latent heat to the thermal evolution of the diapir. Latent heat significantly buffers heating of the diapir. For the diapir with radius ~3.7 km, the heating from the outside is slowed down ~30%. Finally, we include melt segregation within the diapir in the model. Melting initiates at the boundaries of the diapir as the cold interior warms in response to thermal equilibration with the hot mantle wedge. This forms a high porosity, high permeability rim around the margin of the diapir. As the diapir continues to warm and ascend, new melts migrate into this rim and are focused upward, accumulating at the top of the diapir. The rim thus acts like an annulus melt channel isolating the central part of diapir from the hot exterior and leading to even slower heating rates compared to cases without melt segregation.

These model results suggest that the melting and melt migration in an ascending diapir will segregate the interior from the outer rim, and may generate strong chemical gradients across the diapir.

---

V33B: Arcs from the Inside Out III Posters

1:40 PM-6:00 PM, Moscone South

*Laboratory experiments on subduction-induced circulation in the wedge and the evolution of mantle diapirs*

**Christopher R Kincaid**[1], **Richard Tucker Sylvia**[1], Mark D Behn2 and Nan Zhang2, (1) Univ Rhode Island, Narragansett, RI, United States, (2)Woods Hole Oceanographic Inst, Woods Hole, MA, United States

Abstract:

Circulation in subduction zones involves large-scale, forced-convection by the motion of the down-going slab and small scale, buoyant diapirs of hydrated mantle or subducted sediments. Models of subduction-diapir interaction often neglect large-scale flow patterns induced by rollback, back-arc extension and slab morphology. We present results from laboratory experiments relating these parameters to styles of 4-D wedge circulation and diapir ascent. A glucose fluid is used to represent the mantle. Subducting lithosphere is modeled with continuous rubber belts moving with prescribed velocities, capable of reproducing a large range in downdip relative rollback plate rates. Differential steepening of distinct plate segments simulates the evolution of slab gaps. Back-arc extension is produced using Mylar sheeting in contact with fluid beneath the overriding plate that moves relative to the slab rollback rate. Diapirs are introduced at the slab-wedge interface in two modes: 1) distributions of low density rigid spheres and 2) injection of low viscosity, low density fluid to the base of the wedge. Results from 30 experiments with imposed along-trench (y) distributions of buoyancy, show near-vertical ascent paths only in cases with simple downdip subduction and ratios (W*) of diapir rise velocity to downdip plate rate of W*>1. For W* = 0.2-1, diapir ascent paths are complex, with large (400 km) lateral offsets between source and surfacing locations. Rollback and back-arc extension enhance these offsets, occasionally aligning diapirs from different along-trench locations into trench-normal, age-progressive linear chains beneath the overriding plate. Diapirs from different y-locations may surface beneath the same volcanic center, despite following ascent paths of very different lengths and transit times. In cases with slab gaps, diapirs from the outside edge of the steep plate move 1000 km parallel to the trench before surfacing above the shallow dipping plate. “Dead zones” resulting from lateral and vertical shear in the wedge above the slab gap, produce slow transit times. These 4-D ascent pathways are being incorporated into numerical models on the thermal and melting

evolution of diapirs. Models show subduction-induced circulation significantly alters diapir ascent beneath arcs.

---

V33B: Arcs from the Inside Out III Posters

1:40 PM-6:00 PM, Moscone South

*Near-Primary Oxidized Basalts from the Submarine Vanuatu Arc*

**Zoe Gentes**, University of Rhode Island Narragansett Bay, Narragansett, RI, United States, **Katherine A Kelley**, University of Rhode Island, Kingston, RI, United States, Elizabeth Cottrell, Smithsonian, NMNH, Washington, DC, United States and Richard J Arculus, Australian National University, Canberra, Australia

Abstract:

Near-primary melt compositions (i.e., in equilibrium with >$Fo_{89}$ olivine) are rare in arc systems. Yet, such melts provide essential views of mantle-derived melts, without further modification by fractional crystallization or other crustal processes, and reveal the diversity of melt compositions that exist in the arc mantle wedge. Here, we present new measurements of naturally glassy, near-primary olivine-hosted melt inclusions from one dredge of Evita seamount (SS07/2008 NLD-02) in the southern Vanuatu arc system. Two distinct basalt types were identified in hand sample upon collection, based on contrasting phenocryst assemblage (Type 1: 1% phenocrysts; Type 2: 15% phenocrysts). We selected melt inclusions from each type and determined major elements, S, and Cl by EMP, $H_2O$ and $CO_2$ by FTIR, trace elements by LA-ICP-MS, and $Fe^{3+}/\Sigma Fe$ ratios by XANES. Melt inclusions from both lava types show equilibrium with ≥$Fo_{90}$ olivine, consistent with host olivine compositions, and thus are near-primary melt compositions that have escaped major modification since departing the mantle wedge. Both have similar maximum dissolved $H_2O$ (~2.3 wt.%), high Mg# (48-75), and are basalt to basaltic andesite ($SiO_2$ 49-55 wt.%). However, the two lava types have very different major and trace element compositions. Inclusions from Type 1 show relatively flat REE patterns and classic negative anomalies in Nb and Ta, and positive anomalies in Pb and Sr typical of normal arc basalts, and have $Fe^{3+}/\Sigma Fe$ ratios similar to global arc basalts (~0.24). In contrast, melt inclusions from Type 2 exhibit steeply sloped REE patterns with strong depletions in the HREE that suggest garnet in the source lithology for these magmas, either in the subducting slab or the mantle wedge. Moreover, the Type 2 inclusions have high La/Yb (29.5-43) and Sr/Y (50-58), which are classically attributed to partial melting of the basaltic slab, although these inclusions are basaltic, not andesitic. Type 2 inclusions also have $Fe^{3+}/\Sigma Fe$ ratios that are among the highest measured in natural terrestrial glasses (~0.32). The compositions of these near-primary basalts indicate that melts of the mantle wedge, and perhaps melts of the slab, form under oxidizing conditions.

---

B34A: Atmosphere-Surface Exchangeable Pollutants: Emissions, Environmental Processing, Governance, and Perturbations Related to Global Change II

4:00 PM-6:00 PM, Moscone West

*Air-Water Exchange of Legacy and Emerging Organic Pollutants across the Great Lakes*

**Rainer Lohmann**[1], **Zoe Ruge**[1], **Mohammed Khairy**[1], Derek CGM Muir2 and Paul Helm3, (1)Univ of Rhode Island, Narragansett, RI, United States, (2)Environment Canada Toronto, Toronto, ON, Canada, (3)Ontario Ministry of the Environment, Etobicoke, ON, Canada

Abstract:

Organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs) are transported to great water bodies via long-range atmospheric transport and released from the surface water as air concentrations continue to diminish. As the largest fresh water bodies in North America, the Great Lakes have both the potential to accumulate and serve as a secondary source of persistent bioaccumulative toxins. OCP and PCB concentrations were sampled at 30+ sites across Lake Superior, Ontario and Erie in the summer of 2011. Polyethylene passive samplers (PEs) were simultaneously deployed in surface water and near surface atmosphere to determine air-water gaseous exchange of OCPs and PCBs. In Lake Superior, surface water and atmospheric concentrations were dominated by $\alpha$-HCH (average 250 pg/L and 4.2 pg/m3, respectively), followed by HCB (average 17 pg/L and 89 pg/m3, respectively). Air-water exchange varied greatly between sites and individual OCPs, however $\alpha$-endosulfan was consistently deposited into the surface water (average 19 pg/m$^2$/day). PCBs in the air and water were characterized by penta- and hexachlorobiphenyls with distribution along the coast correlated with proximity to developed areas. Air-water exchange gradients generally yielded net volatilization of PCBs out of Lake Superior. Gaseous concentrations of hexachlorobenzene, dieldrin and chlordanes were significantly higher ($p < 0.05$) at Lake Erie than Lake Ontario. A multiple linear regression that incorporated meteorological, landuse and population data was used to explain variability in the atmospheric concentrations. Results indicated that landuse (urban and/or cropland) greatly explained the variability in the data. Freely dissolved concentrations of OCPs (<LOD-114 pg/L) were lower than previously detected concentrations. Nonetheless, concentrations of p,p'-DDE and chlordanes were higher than water quality guidelines for the protection of human health from the consumption of fish. Spatial distributions of freely dissolved OCPs in Lakes Erie and Ontario were influenced by loadings from areas of concern and the water circulation patterns. Air-water exchange calculations indicated that the majority of OCPs were volatilizing from the water; therefore the lower Great Lakes were acting as a secondary source to the atmosphere.

OS34A: New Perspectives on Seafloor Morphology from High-Resolution Ocean Mapping IV

4:00 PM-6:00 PM, Moscone West

*Quantitative characterization of abyssal seafloor with transit multibeam backscatter data*

**Robert A Pockalny**, Univ Rhode Island, Narragansett, RI, United States and Vicki Lynn Ferrini, Lamont -Doherty Earth Observatory, Marine Geology and Geophysics, Palisades, NY, United States

Abstract**:**

The expanding volume of deep-water multibeam echosounder data provides emerging opportunities for the improved characterization of the abyssal seafloor. Nearly 500 cruises criss-cross the oceans with modern wide-swath multibeam systems, and these cruise tracks have imaged a variety of morphologic, tectonic and magmatic environments. The qualitative analysis of the seafloor backscatter data strongly suggests a local and regional variability that correlates with sediment thickness, sediment type and/or depositional environment. We present our initial attempts to develop a method that quantifies this observed seafloor backscatter variability and to explore the causes and potential implications of this variability. Our approach is rooted in the Angular Range Analysis methodology, which utilizes changes in backscatter amplitude observed as a function of grazing angle, to characterize the seafloor. The primary difference in our approach is that we do not invert for geo-acoustical parameters, but rather explores empirical relationships between geological observations and stacked slope and y-intercept values. In addition, we also include the mean and the variance of detrended backscatter measurements. Our initial results indicate intriguing relationships between backscatter parameters and the $CaCO_3$ content of surface sediments. Seafloor regions reported to have high manganese nodule concentrations also tend to have characteristic trends in backscatter parameters. We will present these regional correlations as well as some preliminary statistical analyses of the backscatter parameters and key environmental factors.

---

OS34B: Ocean Submesoscale Processes and Potential Scientific Breakthrough: Simulations, Observations and Applications IV

4:00 PM-6:00 PM, Moscone West

*The Submesoscale from VIIRS Imagery-Band (375 m) Sea Surface Temperature Fields*

**Peter C Cornillon**, University of Rhode Island, Kingston, RI, United States, Gang Pan, SCSIO South China Sea Institute of Oceanology, Chinese Acaademy of Sciences, Guangzhou, China and **Fabian Schloesser**, IPRC, Hawaii & GSO, Rhode Island, Narragansett, RI, United States

Abstract**:**

The Visible-Infrared Imager-Radiometer Suite (VIIRS) carried on the Suomi National Polar-orbiting Partnership (Suomi NPP) spacecraft makes measurements in spectral bands in the infrared at a nadir spatial resolution of 750 m, in what are referred to as the Moderate Resolution Bands (M-Bands), and at a nadir spatial resolution of 375 m in "Imagery Bands" (I-Bands). The spectral coverage of M-Bands allows for the high quality retrieval of sea surface temperature (SST) under cloud-free conditions. In particular, the M-Band suite includes a "split window" in the 10 to 12 micrometer range with which correction for atmospheric water vapor can be made while avoiding issues associated with solar reflection, which afflicts observations in some of the shorter wave-length spectral windows during daylight hours. Unfortunately, there is only one I-Band channel in the 10 to 12 micrometer range precluding the same approach used for M-Band retrievals. In this presentation, we discuss an algorithm developed at the University of Rhode Island that makes use of the atmospheric correction available from M-Band retrieval algorithms together with I-Band radiances to produce a high quality 375 m SST product. The M-Band retrievals used are those from NOAA's Advanced Clear Sky Processor for Oceans (ACSPO) program. In comparisons with ship-borne radiometer SST retrievals, we show that the I-Band retrievals are of similar quality to the underlying M-Band retrievals. We then go on to demonstrate the sub-kilometer scale of the features resolved in the I-Band retrievals as well as how these data may be used to infer near-surface currents on a spatial grid of order 10 kilometers.

---

PP34A: Recent Advances in Terrestrial (Lacustrine) Climate Archives II

4:00 PM-6:00 PM, Moscone West

*Stromatolites provide a terrestrial record of a ~35ka warming event in Walker Lake, a remnant of the Pleistocene Lake Lahontan (Western Nevada, USA)*

Marisol Juarez Rivera, University of California Davis, Earth and Planetary Sciences, Davis, CA, United States, Heda Agić, Uppsala University, Department of Earth Sciences, Uppsala, Sweden, Lewis Ward, California Institute of Technology, Division of Geological and Planetary Sciences, Pasadena, CA, United States, **Zak Kerrigan**, University of Rhode Island, Graduate School of Oceanography, Kingston, RI, United States, Victoria A Petryshyn, University of California Los Angeles, Los Angeles, CA, United States, Carie Marie Frantz, Applied Physics Laboratory University of Washington, Kenmore, WA, United States, Aradhna Tripati, UCLA, Los Angeles, CA, United States, Frank A Corsetti, University of Southern California, Department of Earth Sciences, Los Angeles, CA, United States and John R Spear, Colorado School of Mines, Golden, CO, United States

Abstract:

Walker Lake is a closed-basin remnant of the large Pleistocene glacial Lake Lahontan that has experienced drastic changes in water level. Carbonate structures, such as stromatolites, precipitated from the lake and were studied as potential sources for historical climate change. A 16.7 cm long stromatolite was collected from a paleoshoreline approximately 58 meters above the present Walker Lake surface elevation. Radiocarbon dating revealed that the stromatolite spans approximately 2,000 years of growth, from 35,540 to 33,580 Calibrated YBP (IntCal13). Distinct laminae were drilled along the growth axis, and the resulting powders were collected for clumped isotope analyses, which uses the amount of heavy $CO_2$ "clumps" ($^{13}C$-$^{18}O$-$^{16}O$, or $\Delta_{47}$) generated from the dissolution of carbonate in acid to measure the temperature of formation of a rock. Using this method, we tracked the change in lake temperature and $\delta^{18}O_{fluid}$ during stromatolite formation. Our results show that the stromatolite experienced an overall increase in temperature and $\delta^{18}O_{fluid}$ values during the course of accretion. The resulting data were input to a Rayleigh distillation model for water evaporation in order to estimate the magnitude of lake level and volume fluctuations. Our modeling results show that, during the course of stromatolite accretion, the lake experienced a volume decrease of ~5 $Km^3$, corresponding to lake level fall of ~14 meters. This study shows that lacustrine material (such as stromatolites or other tufas) can potentially be used to reconstruct the timing and magnitude of terrestrial climate change during important transitions in Earth history.

## Thursday, 18 December 2014

OS41A: Airborne Systems in Support of Oceanographic and Atmospheric Research I Posters

8:00 AM-12:20 PM Moscone West

*Access to the Sea: A Roadmap for Expedition Planning*

**Annette M DeSilva**, University-National Oceanographic Laboratory System (UNOLS), University of Rhode Island, Graduate School of Oceanography, Narragansett, RI, RI, United States and Peter R Girguis, Harvard University, Cambridge, MA, United States

Abstract:

The planning process for expeditionary oceanography often spans many years and involves multiple steps, starting from the initial proposal, to logistics planning, cruise execution, post-cruise and scientific reporting. Each year the University-National Oceanographic Laboratory System (UNOLS) Fleet supports a broad spectrum of research operations and their associated logistics support requirements. Operations can vary from single Principle Investigator (PI) cruises to multi-investigators field programs with multi-disciplinary research objectives in locations all over the world.

Over the past decade, the process for access to the sea has evolved and continues to be refined through the critical feedback of scientists, marine technicians, and ship operators.

Under UNOLS guidance, key guidelines have been identified for all phases of cruise planning; from pre-award to post-expedition to help ensure that the research objectives of programs can be met and that optimal use of our Nation's oceanographic facilities is maintained.

An expeditionary roadmap has been created that captures the major milestones essential to executing a research cruise. The roadmap has been introduced during early career scientist workshops and also during the Chief Scientist Training Cruise programs of recent years. It is a useful planning tool not only for early career scientists and new ship users, but also for experienced sea-going scientists. The roadmap will soon be available as a resource tool on the new UNOLS website. This poster will feature the roadmap for expeditionary planning and offer key information about requirements and tips for a successful, safe, research cruise experience. In addition, existing and new requirements associated with custom clearances, export licensing requirements and additional planning considerations also needed when the research requires special facilities such as aircraft or deep submergence vehicles will be discussed.

---

T41B: Structure, Evolution, and Seismic Behavior of Oceanic Strike-Slip Faults Posters

8:00 AM-12:20 PM, Moscone South

*Spatial-temporal clustering of large earthquakes on Oceanic Transform Faults*

**Meng Wei**, University of Rhode Island Narragansett Bay, Narragansett, RI, United States

Abstract:

Progress towards a quantitative and predictive understanding of the earthquake behavior can be achieved by improved understanding of earthquake cycles. However, it is hindered by the long repeat times (100s to 1000s of years) of the largest earthquakes on most faults. At fast-spreading oceanic transform faults (OTFs), the typical repeating time ranges from 5-20 years, making them a unique tectonic environment for studying the earthquake cycle.

One striking observation on OTFs is the quasi-periodicity and the spatial-temporal clustering of large earthquakes: same fault segment ruptured repeatedly at a near constant interval and nearby segments ruptured during a short time period. This has been observed on the Gofar and Discovery faults in the East Pacific Rise (EPR). Between 1992 and 2014, five clusters of M6 earthquakes occurred on the Gofar and Discovery fault system with recurrence intervals of 4-6 years. Each cluster consisted of a westward migration of

seismicity from the Discovery to Gofar segment within a ~ 2-year period, providing strong evidence for spatial-temporal clustering of large OTFs earthquakes.

Motivated by the observations at EPR, we conducted a global search for more repeating large earthquakes on OTFs, using surface-wave based determinations of the relative separations between earthquake centroids. We found that there are many more cases of repeating earthquakes on OTFs than previously reported.

We also built a numerical model with multiple fault segments in the frame of rate-and-state friction to understand the role of stress transfer on the spatial-temporal clustering of large earthquakes on OTFs. We used the Gofar and Discovery faults as a model. We found that static stress transfer alone can explain the clustering of earthquakes if these fault segments are close (< a few km). Otherwise, viscoelastic or dynamic stress transfer will play a more important role.

---

OS43D: The Atlantic Meridional Overturning Circulation, Climate Variability, and Change III Posters

1:40 PM-6:00 PM, Moscone West

*Overturning Circulations Driven by Dense Water Formation in the Interior of an Ocean Basin*

**Fabian Schloesser**, University of Rhode Island, Graduate School of Oceanography, Narragansett, RI, United States, Julian P McCreary Jr, Univ of Hawaii, Honolulu, HI, United States, Ryo Furue, IPRC Univ of Hawaii, Honolulu, HI, United States and **Lewis M Rothstein**, University of Rhode Island- Narragansett Bay, Narragansett, RI, United States

Abstract**:**

Numerous conceptual and dynamical models relate the large-scale meridional overturning circulation (MOC) to the meridional surface-density difference. In our study, we obtain and analyze two types of analytic solutions to a variable-density 2-layer model, one where the densest water is formed in the interior of an ocean basin, and the other one where it is formed near the northern boundary. We discuss the fundamental changes in strength and structure of the MOC between the different solutions. In the case with interior cooling, we report similarities and differences to a beta-plume circulation.

## Friday, 19 December 2014

T51C: Constructing Crust from the Backarc to the Forearc in the Izu-Bonin-Mariana (IBM) and Other Arc Systems I

9:00 AM, Moscone South 306

*The Southern Mariana Forearc: An Active Subduction Initiation (SI) Analogue*

Robert J Stern, Univ Texas Dallas, Richardson, TX, United States, Sherman H Bloomer, Oregon State University, Corvallis, OR, United States, **Maryjo N Brounce**, California Institute of Technology, Pasadena, CA, United States, Teruaki Ishii, Fukuda Geological Institute, Tokyo, Japan, Osamu Ishizuka, Geological Survey of Japan, Tsukuba, Ibaraki, Japan, **Katherine A Kelley**, University of Rhode Island, Kingston, RI, United States, Fernando Martinez, Univ of Hawaii-SOEST/HIGP, Honolulu, HI, United States, Yasuhiko Ohara, JAMSTEC Japan Agency for Marine-Earth Science and Technology, Kanagawa, Japan, Ignacio Pujana, University of Texas at Dallas, Richardson, TX, United States, Mark K Reagan, University of Iowa, Iowa City, IA, United States and Julia Ribeiro, University of Texas at Dallas, Dallas, TX, United States

Abstract:

It is important to understand how new subduction zones form. Some subduction zones begin spontaneously, with sinking of dense oceanic lithosphere adjacent to a lithospheric weakness. The Eocene evolution of the Izu-Bonin-Mariana convergent margin is the type example of this process, with an increasingly well-documented evolution including results from IODP 352 drilling. A lack of any active examples of spontaneous SI hinders our understanding, but our studies of the evolution of the southernmost Mariana convergent margin provides important insights. Here the Mariana Trough backarc basin terminates against the Challenger Deep trench segment, where it has opened ~250 km in the past ~4 Ma. This corresponds to GPS opening rate of ~4.5cm/y at the latitude of Guam (Kato et al., 2003). This newly formed and rapidy widening margin faces the NW-converging Pacific plate and causes it to contort and tear. Pacific plate continues to move NW but the upper plate response is illustrative of a newly formed subduction zone. Slab-related earthquakes can be identified to ~200 km deep beneath this margin; with convergence rate of 3cm/yr, this may reflect no more than 7 Ma of subduction. The usual well-defined magmatic arc is missing; its position ~100 km above the subducted slab is occupied by the magma-rich (inflated) Malaguana-Gadao Ridge (MGR), and hydrous MORB-like basalts with ~2 wt. % $H_2O$ have erupted unusually close to the trench where they overly mantle peridotites ~6 km water depth. HMR-1 sonar backscatter mapping reveals a chaotic fabric that is at a high angle to the trend of the MGR to the east but is concordant to the west. This unusual spreading fabric may have formed by chaotic upper plate extension in response to rapid rollback of the short, narrow Pacific slab in a manner similar to that thought to occur during SI. Further interdisciplinary studies are needed to understand this rapidly-evolving tectono-magmatic province and what it can teach us about SI.

---

T52A: Advances in Subaqueous Paleoseismology and New Insights from the Sedimentary Records into Earthquake Recurrence and Deformation throughout the Earthquake Cycle II

10:35 AM, Moscone South 302

*Sedimentation Triggered by the 2011 Tohoku Megathrust Earthquake along the Japan Trench*

Cecilia M McHugh1,2, Toshiya Kanamatsu3, **Marie-Helene Cormier**[4], Leonardo Seeber2, Richard Bopp5, Ken Ikehara6 and Kazuko Usami6, (1)CUNY Queens College, School of Earth and Environmental Sciences, Flushing, NY, United States, (2)Lamont-Doherty Earth Obs, Palisades, NY, United States, (3)JAMSTEC Japan Agency for Marine-Earth Science and Technology, Kanagawa, Japan, (4)University of Rhode Island, Graduate School of Oceanography, Narragansett, RI, United States, (5)Rensselaer Polytechnic Institute, Troy, NY, United States, (6)Marine Geology Research Group, Geological Survey of Japan, AIST, Tsukuba, Japan

Abstract:

Recent developments in the field of subaqueous paleoseismology have provided information about the sedimentation record of earthquakes and about the long-term seismicity of fault systems. In 2013, the Japan Agency for Marine-Earth Science and Technology conducted expeditions NT13-02 and NT13-19 to the 2011 Tohoku Mw 9.0 megathrust earthquake and tsunami source, with *R/V Natushima* in 800-5,900 m water depth. The goal was identifying earthquake-triggered deposits and mapping their spatial and temporal distribution, as a strategy to recognize the sedimentary signature of Tohoku-like events and measure recurrence intervals for seismic hazard assessment. Twenty-four piston cores, 3 to 6 m long, were recovered during the NT13-19 expedition along a 300 km-long portion of the mid-slope terrace. This elongated structure is parallel to the strike of the Japan Trench, and located landward of the frontal prism where deformation is most intense. Faults, sometimes forming steep scarps, define small (5km long) confined basins that were targeted for coring.

Radioisotopes $^{137}$Cs and xs$^{210}$Pb measured in the cores mark the 2011 Tohoku earthquake-related sedimentation. Detection of $^{134}$Cs and enrichment of $^{137}$Cs provided a 2011 Fukushima reactor signature, which was found in the upper 5cm of several cores and was buried 10-15cm in others. Very high activities of xs$^{210}$Pb were measured in the upper half-meter of the majority of the cores providing evidence of very recent depositional events that we are linking to the 2011 earthquake. We envision the shaking by the earthquake fluidized a layer of surface sediment, which then moved downslope and was deposited where surface slope decreased. These sediments also incorporated $^{137}$Cs derived from global fallout over the past half century. These deposits can be recognized in the cores because they are homogeneous and lack bioturbation. The thickest ones (~1m) have soft sediment deformation features at their base. Along the mid-slope terrace, they are thicker in the region where maximum 2011 rupture displacement

was documented. Several older event horizons separated by bioturbated sediments are recognized in the cores. Usami et al. (2014) used tephra chronology to estimate an average recurrence interval of 100-500 yrs in most cores, although some cores suggest recurrence of 1500-2000 yrs.

---

T52B: Constructing Crust from the Backarc to the Forearc in the Izu-Bonin-Mariana (IBM) and Other Arc Systems II

10:50 AM, Moscone South 306

*Hydrous lithosphere and diffuse crustal accretion and tectonics in the southern Mariana margin: a possible analog for subduction zone infancy and ophiolites*

Fernando Martinez1, Patricia B Fryer1, Jonathan D Sleeper1, Robert J Stern2, **Katherine A Kelley**[3], Yasuhiko Ohara4,5 and Julia M Ribeiro2, (1)Univ of Hawaii-SOEST/HIGP, Honolulu, HI, United States, (2)University of Texas at Dallas, Richardson, TX, United States, (3)University of Rhode Island, Kingston, RI, United States, (4)Hydrographic and Oceanographic Department of Japan, Tokyo 135-0064, Japan, (5)Japan Agency for Marine-Earth Science and Technoloty, Yokosuka 237-0061, Japan

Abstract:

The mode of extension and crustal accretion may vary significantly during subduction margin evolution. Mantle water content likely has a strongly influence on this evolution as it strongly affects the mantle solidus and rheology. Effects of mantle hydration on volcanism and tectonics were examined in the southern Mariana margin in 2012 on a *R/V Thompson* cruise. The southern Mariana margin is actively rifting sub-parallel to the trench forming new crust and lithosphere directly above the de-watering slab (see Ribeiro et al. session T011). Shallow seismicity shows broadly distributed active deformation in the upper plate. Shallow-towed and near-bottom sidescan sonar data map a highly faulted terrain with rotated crustal blocks and distributed volcanic emplacements. The near-bottom sidescan sonar data also image an apparent corrugated core complex structure, the first such described from a convergent margin setting, indicating low-angle normal faulting during the extension. Water content in sampled volcanics is ~2 %, approaching that of the volcanic arc itself. Volcanic rocks from the eastern margin are mostly ~2-4 m.y. old, but younger basaltic volcaniclastics were recovered farther west suggesting that active volcanism may continue. We hypothesize that the broadly distributed volcanism and tectonic activity is due to high mantle water content that weakens the margin lithosphere. Continual water addition from the subducting slab inhibits melting-related dehydration and strengthening as has been proposed for lithosphere formed at mid-ocean ridges. A consequence of a broadening zone of rifting is that extension-related mantle upwelling rates will decrease with time. Surface cooling will thus progressively depress the mantle solidus, perhaps explaining the paucity of current observed volcanism at the

margin. The volcano-tectonic processes active today in the southern Mariana margin may be modern analogs of those inferred at subduction zone infancy where broadly distributed contemporaneous extension and volcanism above the initially subducting and de-watering slab have been proposed. If so, and if ophiolites are relicts of early crust formed at subduction settings, they may reflect crustal accretion processes that differ significantly from those at mid-ocean ridges.

---

DI53B: Dynamic Evolution of the Lithosphere-Asthenosphere Boundary System in Diverse Geological Settings: An Integrated Approach II Posters

1:40 PM-6:00 PM, Moscone South

*Edge Driven Convection along the Eastern North American Margin from Ambient Noise Tomography*

**Brian Kirk Savage**[1], **Brian M Covellone**[1] and **Yang Shen**[2], (1)University of Rhode Island, Kingston, RI, United States, (2)Univ Rhode Island, Narragansett, RI, United States

Abstract:

The eastern North American margin is the result of nearly a billion years of continental collision and rifting. Here we present a new wave speed model of the eastern North American margin from full-wave ambient noise tomography with the USArray data. Transitions in lithosphere thickness occur at the intersection of the North American craton to the west and the Atlantic Ocean basin. We observe a continuous low wave speed feature at the edge of the continent between depths of 120 and 190 km into the Earth. The dramatic change in lithosphere thickness at this boundary may drive asthenosphere upwelling along the edge of the continent. Edge driven convection is hypothesized as the result of induced mantle convection due to plate motions and abrupt thickness changes in the lithosphere. Additionally, the insulating effect of large continents has been hypothesized to result in the formation of “hot” convection cells along their boundaries. Localized higher amplitude slow anomalies are seen adjacent to Maryland and Virginia and offshore of South Carolina and Georgia; these may be the locales of enhanced edge driven convection that exploits weaknesses in the lithosphere from past episodes of volcanism. Additionally, a large slow wave speed anomaly beneath New England continues offshore aligned with the New England Seamount chain, and is possibly a remnant of the Monteregian hot spot active 100 - 120 Ma. Slow wave speeds extending to depths greater than 50 km reflect thickened continental crust in the Appalachians.

---

PP53C: Productivity Proxies: New Developments and Records II Posters

1:40 PM-6:00 PM, Moscone West

*Proxy Applications of Pa/Th Investigated with Scavenging Chemistry in the North Atlantic*

Martin Q Fleisher1, Christopher T Hayes2, Robert F Anderson1, Phoebe J Lam3, Daniel Ohnemus4, Kuo-Fang Huang5, Laura F Robinson6, Yanbin Lu7, Hai Cheng7,8, R. Lawrence Edwards7 and **S Bradley Moran**[9], (1)Lamont -Doherty Earth Observatory, Palisades, NY, United States, (2)Massachusetts Institute of Technology, Cambridge, MA, United States, (3)Woods Hole Oceanographic Inst, Department of Marine Chemistry and Geochemistry, Woods Hole, MA, United States, (4)Bigelow Lab for Ocean Sciences, East Boothbay, ME, United States, (5)Woods Hole Oceanographic Inst, Woods Hole, MA, United States, (6)University of Bristol, Bristol, United Kingdom, (7)University of Minnesota, Minneapolis, MN, United States, (8)Xi'an Jiaotong University, Xian, China, (9)University of Rhode Island, Kingston, RI, United States

Abstract:

The natural radionuclides $^{231}$Pa and $^{230}$Th have potential value as proxies of past biological productivity in the marine sediment record. In addition to its use as a circulation proxy, the particulate Pa/Th ratio has been suggested to monitor total particle flux and/or diatom productivity via processes related to the scavenging, or the adsorptive removal of these elements onto particles. We investigate the nature of scavenging using trans-Atlantic measurements from GEOTRACES of dissolved (<0.45 μm) and particulate (0.8-51 μm) $^{231}$Pa and $^{230}$Th, together with major particle composition. We find widespread impact of intense scavenging by authigenic Fe/Mn oxides, in the form of hydrothermal particles emanating from the Mid-Atlantic ridge and particles resuspended from reducing conditions near the seafloor off the coast of West Africa. Biogenic opal was not a significant scavenging phase for either element, essentially because of its low abundance at the studied sites.

In the context of the paleo-record, the particulate Pa/Th ratio responds most significantly to scavenging intensity, caused by either biotic or abiotic processes. In the modern setting at least, the influence of North Atlantic Deep Water circulation on Pa/Th is apparently outweighed. The Pa/Th proxy, therefore, is best used in conjunction with other information to support the cause for past changes in scavenging intensity.

---

T53C: Tectonics and Geodynamics of the Southwest Pacific and Banda Sea Regions II Posters

1:40 PM-6:00 PM, Moscone South

*The seismic wave speed structure of the Ontong Java Plateau determined from joint ambient noise and earthquake waveform data*

**Brian M Covellone**[1], **Brian Kirk Savage**[1] and **Yang Shen**[2], (1) University of Rhode Island, Kingston, RI, United States, (2)Univ Rhode Island, Narragansett, RI, United States

Abstract:

The Ontong Java Plateau (OJP) represents the result of a significant event in the Earth's geologic history. Limited geophysical and geochemical data, as well as the plateau's relative isolation in the Pacific Ocean, have made interpretation of the modern day geologic structure and its 120 Ma formation history difficult.

Here we present the highest resolution images to date of the wave speed structure of the OJP region. We use an iterative finite-frequency tomography methodology and a unique data set that combines empirical Green's functions extracted from ambient noise and earthquake waveforms. The uniqueness and combination of datasets allow us to best exploit the limited station distribution in the Pacific and image wave speed structures between 35 km and greater than 250 km into the Earth.

We image a region of fast shear wave speeds, greater than 4.75 km/s, that extends to greater than 100 km beneath the plateau. The wave speeds are similar to as observed in cratonic environments and are consistent with a compositional anomaly likely a result of eclogite entrainment during the plateau's formation.

---

V53B: Melt, Volatiles, and the Oxidation State of Iron in Planetary Mantles III Posters

1:40 PM-6:00 PM, Moscone South

*Iron Stable Isotopes, Magmatic Differentiation and the Oxidation State of Mariana Arc Magmas*

Helen M. Williams, University of Durham, Durham, DH1, United Kingdom, Julie Prytulak, Imperial College London, London, SW7, United Kingdom, Terry A Plank, Lamont Doherty Earth Obs., Palisades, NY, United States and **Katherine A Kelley**, University of Rhode Island, Kingston, RI, United States

Abstract:

Arc magmas are widely considered to be oxidized, with elevated ferric iron contents ($Fe^{3+}/\Sigma Fe$) relative to mid-ocean ridge lavas (1, 2). However, it is unclear whether the

oxidized nature of arc basalts is a primary feature, inherited from the sub-arc mantle, or the product of magmatic differentiation and/or post eruptive alteration processes (3).

Iron stable isotopes can be used to trace the distribution of Fe during melting and magmatic differentiation processes (4, 5). Here we present Fe isotope data for well-characterized samples (6-8) from islands of the Central Volcanic Zone (CVZ) of the intra-oceanic Mariana Arc to explore the effect of magmatic differentiation processes on Fe isotope systematics.

The overall variation in the Fe isotope compositions ( $\delta^{57}$Fe) of samples from the CVZ islands ranges from -0.10 $\pm$0.04 to 0.29 $\pm$ 0.01 ‰. Lavas from Anatahan are displaced to lower overall $\delta^{57}$Fe values (range -0.10 $\pm$0.04 to 0.18 $\pm$0.01 ‰) relative to other CVZ samples. Fe isotopes in the Anatahan suite (range -0.10 $\pm$0.04 to 0.18 $\pm$0.01 ‰) are positively correlated with $SiO_2$ and negatively correlated with Ca, $Fe_2O_3$(t), Cr and V and are displaced to lower overall $\delta^{57}$Fe values relative to other CVZ samples. These correlations can be interpreted in terms of clinopyroxene and magnetite fractionation, with magnetite saturation throughout the differentiation sequence. Magnetite saturation is further supported by negative correlations between V, $Fe_2O_3$(t), Cr and MgO (for MgO <3.5 wt%). The early saturation of magnetite in the Anatahan and CVZ lavas is likely to be a function of high melt water content (9, 10) and potentially elevated melt oxidation state. Future work will focus on determining the relationships between mineral Fe isotope partitioning effects and melt composition and oxidation state.