Skin Temperature Processes in the Presence of Sea Ice

Monitoring the sea-ice margins of polar oceans and understanding the physical processes at play at the ice-ocean-air interface is essential in the perspective of a changing climate in which we face an accelerated decline of ice caps and sea ice. Remote sensing and in particular InfraRed (IR) imaging offer a unique opportunity not only to observe physical processes at sea-ice margins, but also to measure air-sea exchanges near ice. It permits monitoring ice and ocean temperature variability, and can be used for derivation of surface flow field allowing investigating turbulence and shearing at the ice-ocean interface as well as ocean-atmosphere gas transfer.

Here we present experiments conducted with the aim of gaining an insight on how the presence of sea ice affects the momentum exchange between the atmosphere and ocean and investigate turbulence production in the interplay of ice-water shear, convection, waves and wind. A set of over 200 high resolution IR imagery records was taken at the US Army Cold Regions Research and Engineering Laboratory (CRREL, Hanover NH) under varying ice coverage, fan and pump settings. In situ instruments provided air and water temperature, salinity, subsurface currents and wave height. Air side profiling provided environmental parameters such as wind speed, humidity and heat fluxes.

The study aims to investigate what can be gained from small-scale high-resolution IR imaging of the ice-ocean-air interface; in particular how sea ice modulates local physics and gas transfer. The relationship between water and ice temperatures with current and wind will be addressed looking at the ocean and ice temperature variance. Various skin temperature and gas transfer parameterizations will be evaluated at ice margins under varying environmental conditions. Furthermore the accuracy of various techniques used to determine surface flow will be assessed from which turbulence statistics will be determined. This will give an insight on how ice presence may affect the dissipation of turbulent kinetic energy.

Time: 8:00 AM.
Poster by: Sophia E. Brumer; Christopher J. Zappa; Scott Brown; Wade R. McGillis; Brice Loose
Location: Hall A-C (Moscone South)

Cenozoic sedimentation rates and provenance variations in the South Pacific Gyre

Pelagic clays are traditionally difficult to date due to the scarcity of biogenic deposition and the prevalence of homogenous, altered, very fine-grain sediment. Integrated Ocean Drilling Program Expedition 329 recovered completely oxic, brown, pelagic zeolitic metalliferous clay from the South Pacific Gyre (SPG). Despite post-depositional alteration, the sediment retains enough of its original chemical signature to track
downcore changes in provenance.

Of particular interest is the cosmogenic portion of the sediment (e.g., Co), which we use to determine sedimentation rates and explore the paleoceanographic implications of changing sedimentation in the SPG throughout the Cenozoic. Under the assumption that the flux of extraterrestrial cosmogenic dust is spatially and temporally constant (or can at least be constrained), the concentration of cosmic dust in the sediment is inversely proportional to the sedimentation rate. Previous studies have used this premise to successfully date pelagic clays and Fe-Mn crusts, using Co as a proxy for cosmic dust deposition. The SPG has the slowest marine sedimentation rates in the world (as low as 0.1 m/Myr) and subsequently has the highest concentration of cosmic dust in the seafloor, making it an ideal region to apply this technique.

Building upon Zhou and Kyte (1992, Paleocean., 7, 441-465) at the single location of DSDP Site 596, we are dating SPG pelagic clays and identifying provenance variations throughout the SPG using a combined analytical and statistical approach. We analyze bulk sediment from Exp. 329 for a wide suite of major, trace, and rare earth elements by ICP-ES/MS. We apply multivariate statistical methods to quantify the contributions through time from various sources, aiming to distinguish a cosmogenic component. From the cosmogenic abundances, we produce a high-resolution record of instantaneous sedimentation rates of SPG pelagic clays during the Cenozoic.

Our preliminary constant cosmogenic Co models show variations in pelagic clay sedimentation rates between ~10 to 170 cm/Myr at Site U1366. Site U1370 is positioned closer to the edge of the gyre and more downwind of Australia than Site U1366 and, as expected, yields overall higher sedimentation rates ranging from ~30 cm/Myr at the beginning of the Cenozoic to more recent rates of ~250 cm/Myr. A gradual increase in sedimentation rate throughout the Cenozoic is seen in the pelagic clay portions of multiple Exp. 329 Sites (U1365, U1366, U1369, and U1370) across the SPG. Additional refinements to our mixing models will examine the relative importance of factors contributing to this sedimentation increase, including the aridification of Australia and Antarctica, increased volcanism, and the reorganization of ocean currents caused by the opening of the Drake Passage.

Time: 8:00 AM
Poster by: Ann G. Dunlea; Richard W. Murray; Justine Sauvage; Arthur J. Spivack; Robert N. Harris; Steven L. D'Hondt
Location: Hall A-C (Moscone South)

A possible difference in cooling rates recorded in REE in coexisting pyroxenes in peridotites from supra-subduction ophiolites and mid-ocean ridges

Recently a REE-in-two-pyroxene thermometer was developed for mafic and ultramafic rocks [1]. This new thermometer is based on temperature sensitive REE partition coefficients between coexisting pyroxenes and calibrated against laboratory partitioning
Because REE diffusion rates in pyroxene are relatively slow, the thermometer reads a higher temperature than major element based pyroxene thermometers. The difference between major and trace element derived temperatures depends primarily on cooling rate. Here we report new trace element data for peridotites from Trinity and Josephine ophiolites and a modern supra-subduction zone (SSZ) ophiolite analogue (the Mariana trench) determined by laser ablation ICP-MS. We inverted temperatures from the new data and globally distributed ophiolitic peridotite from eight literature studies (Figure 1). Data quality was carefully monitored leaving temperatures from 65 samples. Individual ophiolites usually have temperatures clustered within a range of a few hundred degrees, but the temperature range for the global dataset is greater than 700°C (688-1401°C). Temperatures calculated for the same samples using the two pyroxene thermometer of Brey and Köhler [2] are considerably lower (564-1049°C).

REE temperatures are plotted against the major element temperatures [2] in Figure 1. Abyssal peridotites reported in [1] are shown by the peach field. Much of the ophiolite data plots farther from the blue 1:1 line than the abyssal peridotites, suggesting SSZ lithospheric mantle may cool more rapidly at those ophiolites. Fast cooling can be attributed to one or more dynamic differences between mid-ocean ridge (MOR) environments and supra-subduction environments, such as enhanced hydrothermal circulation, thinner oceanic crust, or rapid cooling due to basin closure and obduction. We note that several ophiolites appear to cool more slowly than the abyssal peridotites, however in those samples geochemical evidence suggests secondary overprinting by melt-rock reaction. By defining the thermometric extent of the global dataset we demonstrate surprising diversity among ophiolites and the potential utility of REE geothermometry to illuminate the dynamics of ophiolite formation and emplacement.

**Understanding the formation of the Ontong Java Plateau through joint ambient noise earthquake tomography and laboratory modeling**

Current knowledge of the Ontong Java Plateau (OJP) comes from a broad range of research disciplines. Despite decades of work, numerous hypotheses on the origin of the OJP do not fully address all of the geophysical and geochemical observations. A more complete image of the current lower crust and upper mantle seismic structure beneath the plateau will provide a link between the plateau’s 120 Ma complex history and its formation. We investigate the anomalous wave speed structure underlying the OJP using an iterative, full-waveform, joint ambient noise and earthquake tomography approach. A 3-dimensional wave speed model is determined from ambient noise data at periods between 25 and 200 seconds. Data from over 100 earthquakes, recorded between 1990 and 2012, are then added to the inversion to improve data coverage and model resolution. The combination of datasets allows us to best exploit the limited station distribution in the Pacific, resulting in resolution better than 5-degrees beneath the plateau and
extending to depths greater than 350 km.

To improve our sense of expected deformation patterns for sub-plateau mantle through geologic time, a set of laboratory models were run where OJP residuum viscosity is changed relative to the ambient fluid. Models focus on the interaction between OJP residuum and the rollback-driven flow associated with passage of the Tonga subduction system to the south. Model results show dramatic thinning and extraction of the southern portion of sub-OJP fluid due to subduction induced torroidal flows. Significant distortion of the sub-OJP material over roughly the last 40 Ma is predicted in cases where residuum is either stronger or weaker than ambient fluid.

The results of this work confirm an anomalously slow mantle beneath the OJP extending to depths greater than 300 km and provide high-resolution images constraining the magnitude and dimensions of wave speed anomalies that can be used to determine thermal and compositional variations within the mantle. The preliminary geodynamic modeling links the current state of the plateau to its interactions with Pacific plate motions through the last 40 Ma. Model results suggest the southern portion of sub-OJP material to be thinned and entrained towards the distant Tonga subduction zone and are consistent with high-resolution seismic images indicating distinct north-south variations in wave speed anomaly across the plateau.

Time: 8:30 AM
Presenters: Brian M. Covellone; Sara Szwaja; Brian K. Savage; Yang Shen; Christopher R. Kincaid
Location: 303 (Moscone South)

A comprehensive view of the seismic structure of the Cascadia subduction zone from the spreading center to the backarc

We construct a shear-wave velocity model of the crust and uppermost mantle at the Cascadia subduction zone using a full-wave ambient noise tomographic method. The 3D offshore-to-onshore structure provides constraints on the geometry of the oceanic lithosphere prior to and after subduction, and the relationships of multi-mode along-strike variations. In total, we include ~125 ocean bottom seismometers deployed by the Cascadia Initiative community experiment during 2011-2013 and Neptune Canada, and more than 1000 broadband stations onshore. The vertical components of continuous seismic records are normalized with a frequency-time waveform normalization method, and then cross-correlated between each station pair to extract empirical Green’s functions (EGF). The EGFs provide useful Rayleigh waves at 7-50 s period between ocean bottom seismometers and 7-200 s between inland stations. We simulate wave propagation within a 3D Earth structure using a finite-difference method to generate a station Strain Greens Tensor database and synthetic waveforms. Rayleigh wave phase delays are obtained by cross-correlating the observed and synthetic waveforms. The sensitivity kernels of Rayleigh waves on the perturbations of Vp and Vs are calculated based on the Strain Greens Tensor database. We then invert for the velocity perturbation from the reference
model and progressively improve the model resolution. We image a low-velocity anomaly off the axial volcano within 28-40 km depth. There exist three segmented low-velocity anomalies in the crust along the forearc, which are spatially correlated with the pattern of offshore basins. The distribution of pseudofaults at the Juan de Fuca plate defines the seismic velocity heterogeneities. We image three separate low shear-wave velocity anomalies along the back-arc in the upper mantle ~200 km east of the Cascade volcanic arc. These back-arc low-velocity anomalies are spatially correlated with the three arc-volcano clusters. The geometry of the low-velocity volumes relative to the slab and arc is consistent with the pattern of subduction-induced decompressional melting in the back-arc. Their along-strike variation suggests that the large-scale plate-motion-induced flow in the back-arc mantle wedge is modulated by small-scale convection, resulting in a highly 3D process that defines the segmentation of volcanism along the Cascade arc.

Time: 9:45 AM
Presenters: Haiying Gao; Yang Shen
Location: 305 (Moscone South)

Classical Odd-hydrogen Reservoir Species in the Marine Boundary Layer During the California Nexus Program

Hydrogen peroxide, methylhydroperoxide and formaldehyde were measured in the marine boundary layer from on board the R/V Atlantis during the CalNex program along with a suite of other photochemically active gas and aerosol species. The CalNex R/V Atlantis sub-program was focused on improving our understanding of aerosol and gas photochemistry under a variety of mixed maritime and urban air mass conditions. The cruise occurred between May 14 and June 8, 2010, and the ship's track was along the California coast from San Diego, to the Los Angeles bight, to San Francisco and inland up the Sacramento River to the “turn-around basin”. Hydrogen peroxide mixing ratios ranged from below the detection limit (0.02 ppb) to 2.1 ppb. Methylhydroperoxide mixing ratios ranged from below the detection limit (0.04 ppb) to 1.2 ppb. Measurements of peracetic were attempted, however, mixing ratios above the detection limit (0.2 ppb), were not encountered. Formaldehyde was measured using a wet chemical derivatization fluorescence method and by a quantum cascade laser spectral absorption method. The measurements ranged from below the detection limit, nominally 0.020 ppb (QCL) and 50 (WetChem), to greater than 15 ppb; with values typically between 0.2 and 2.0 ppb. A formaldehyde measurement comparison will be presented; the two systems agreed well. Hydrogen peroxide, methylhydroperoxide and formaldehyde will be presented and interpreted in terms of photochemistry, air quality, and meteorological conditions.

Time: 1:40 PM
Poster by: Brian Heikes; Scott Herndon; Mark S. Zahniser
Location: Hall A-C (Moscone South)
Investigating uncultured microbes and their role in a deep subseafloor ammonium sink

The marine deep biosphere is thought to hold a large reservoir of both microbial cells and untapped genetic diversity. One potential driving force behind the vast amount of uncultured organisms are unconventional redox pairs which may not be favorable at benchtop conditions, but can support life in other circumstances. One instance of this is the previously documented thermodynamic favorability of ammonium oxidation with sulfate in sediments such as those investigated here from the Indian Ocean. Using 454 tag sequencing of 16S DNA, we identified uncultured archaea and bacteria potentially playing key roles at the sulfate and ammonium interface. First, the phylogenetic identity of organisms potentially involved in this reaction is inferred, as well as thermodynamic considerations of potential pathways. Several novel phyla, as well as Clostridiales, appear over-represented at the reaction zone. Secondly, to understand the metabolic capability of these target organisms, these sequences have been cross-referenced with assemblies from metagenomic data sets, and connections to functional genes are being elucidated. Finally, we discuss parallels with near-shore coastal sediment from Narragansett Bay, Rhode Island, where geochemical similarities have been found. While the thermodynamic regime is similar to the Indian Ocean, suggesting the potential for a broad geographic distribution, accessibility provides the opportunity to construct bioreactors to test rates and pathways of ammonium and sulfate fluxes. Iron content may be a key factor in determining reaction favorability. We present ongoing work in this area and the pros and cons of different bioreactor designs.

Radiolytic hydrogen production in basaltic basement of the South Pacific Gyre

Water radiolysis is the decomposition of water molecules due to interactions with ionizing radiation from the natural decay of radioactive elements, such as uranium ($^{238}\text{U}$, $^{235}\text{U}$), thorium ($^{232}\text{Th}$) and potassium ($^{40}\text{K}$). This abiotic process produces electron donors (e.g., H$_2$) and acceptors (e.g., O$_2$) that microorganisms can metabolize for energy. Although water radiolysis has been examined in deep continental crust (Lin et al., 2005) and marine sediment (Blair et al., 2007), it has not been rigorously addressed in oceanic basement. The submarine depth to which life extends on Earth, and the potential for life in basaltic aquifers of other worlds (such as Mars and Europa), may depend on radiolytic production of electron donors and acceptors. In order to quantify the extent to which water radiolysis occurs in the subseafloor basaltic basement, we (i) quantified radioactive element concentrations of basement samples from Integrated Ocean Drilling Program (IODP) Expedition 329 and (ii) developed a quantitative model of H$_2$ production by water radiolysis in the basement aquifer. Modeling radiolytic production of H$_2$ in oceanic basement is difficult because the basement is a heterogeneous environment. Microscale changes in physical properties and
chemical composition cause microscale variation in water radiolysis within the basement. During radioactive decay, alpha particles, beta particles and gamma rays are emitted, each with a spectrum of characteristic energies. The distance over which radiation is attenuated depends on the kind of radiation (alpha, beta or gamma), initial energy, and the absorbing material. These properties and the concentration of radioactive elements provide the basis for our preliminary model. We are using inductively coupled plasma emission spectroscopy (ICP-ES), mass spectrometry (ICP-MS) and laser ablation (LA ICP-MS) to map variation in radioelement concentrations from phase to phase (e.g., across successive alteration halos to unaltered rock). The last step in our model combines (i) the rate at which radiation energy is transferred to the water with (ii) published H\textsubscript{2} yields per rate of energy transfer.

Time: 1:40 PM
Poster by: Mary E. Dzaugis, Arthur J. Spivack; Ann G. Dunlea; Richard W. Murray; Katherine A. Kelley; Steven L. D'Hondt
Location: Hall A-C (Moscone South)

ED13D. Educator Professional Development Programs Promoting Authentic Scientific Research I Posters
Convener(s): Constance Walker (Natl Optical Astronomy Observ) and Gail Scowcroft (University of Rhode Island)
1:40 PM - 6:00 PM; Hall A-C (Moscone South)

The Climate Change Education Partnership Alliance: Building a Network for Effective Collaboration and Impact (Invited)

The mission of the Climate Change Education Partnership Alliance (The Alliance), funded by the National Science Foundation (NSF), is to advance exemplary climate change education through research and innovative partnerships. Through six unique regional projects, The Alliance is reaching wide and diverse audiences across the U.S., while linking groups and institutions that might not otherwise be connected by a common focus on climate change education. The goals for The Alliance include building collaborations between projects and institutions, sharing effective practices, and leveraging resources to create a community in which the whole is greater than the sum of its parts. To foster these goals, NSF has funded a central hub, the Alliance Office. Currently, the Alliance Office is building the infrastructure necessary to support activities and communication between the projects. Successful networks need objectives for their interactions and a common vision held by the partners. In the first national meeting of The Alliance members, held in June 2013, the foundation was laid to begin this work. The Alliance now has a common mission and vision to guide the next four years of activities. An initial “mapping” of the network has identified the scope and diversity of the network, how members are connected, current boundaries of the network, network strengths and weaknesses, and network needs. This information will serve as a baseline as the network develops. The Alliance has also identified the need for key “working
groups” which provide an opportunity for members to work across the projects on common goals. As The Alliance evolves, building blocks identified by the field of network science will be used to forge a strong and successful collaborative enterprise. Infrastructure is being established to support widespread engagement; social ties are being fostered through face-to-face meetings and monthly teleconferences; time is provided to build and share knowledge; the sharing of new and diverse perspectives is encouraged; and resources will be leveraged across and beyond the projects. This presentation will provide an overview of The Alliance activities, lessons learned thus far, and plans for the future.

Time: 2:25 PM
Presenter: Gail Scowcroft
Location: 103 (Moscone South)

Towards mapping attenuation and water content in the Transition Zone

The mantle transition zone is suggested to play a significant role in water storage due to the high solubility of H2O in transition zone minerals. However, quantifying the water content of the transition zone has proven difficult. Previous investigations of the transition zone using a variety of techniques have identified variations in water content globally, associated melt at 400 km, and variable thickness. The resulting water distribution models indicate substantially different Earth models and subsequent seismic responses. Water enhances attenuation with minimal change to seismic wave speed in the transition zone. Taken in combination with correlated temperature induced wave speed / attenuation reductions, the water content and temperature in the transition zone can be inferred.

Using upper mantle seismic phases that propagate within the transition zone, we can isolate the effects of attenuation, or anelasticity, and seismic wave speeds. Synthetic seismograms at high frequency, around 1 Hz, from models with a "wet" transition zone show a distinct amplitude reduction and phase delay. Conversely, models with melt on top of the transition zone produce a delayed, secondary arrival with an upper mantle moveout velocity. These diagnostic arrivals, based on synthetic seismic responses, are best identified at the end of the triplicated 660 km branch. Full modeling of the seismic phases from the transition zone will enable a mapping of water content and temperature, while deciphering how water is distributed and transported throughout the mantle.

Time: 5:30 PM
Presenter: Brian K. Savage
Location: 303 (Moscone South)
Mesoscale convective system induced high frequency sea-level oscillations off the coast of the eastern United States

Three large high frequency sea level oscillations were recorded on June 29th, 2012, April 10th, 2013, and June 13th, 2013. These events were not caused by earthquakes and occurred after the passage of eastward propagating pressure disturbances with an amplitude of greater than 3 hPa and a duration of less than 5 hours. Mesoscale Convective Systems (MCS) were responsible for these pressure anomalies. As a MCS moves out over the ocean, atmosphere-water interaction forces a shallow water wave, a meteorological tsunami, that is amplified by Proudman resonance. Waves propagate freely after the atmospheric forcing has dissipated or the ocean wave reflects off the continental shelf. The atmospheric pressure disturbances for these three events were recorded by the UArray Transportable Array and are tracked until the pressure anomaly moved past NOAA tide gauge sensors. This case study demonstrates that it is possible to identify and quantify in detail the MCS pressure disturbances in the interior of the continental United States, suggesting that we can monitor and predict possible meteotsunamis in the future.

Time: 8:00 AM
Poster by: Christina A. Wertman; Yang Shen; John T. Merrill; Richard M. Yablonsky; Christopher R. Kincaid; Robert A. Pockalny
Location: Hall A-C (Moscone South)

A plate-driven model for enigmatic volcanic history of the Cascades-Yellowstone System

The Cascades subduction system in the Pacific Northwest (USA) represents a complex tectonic setting, where rollback subduction of the Juan de Fuca plate beneath the North American plate, back-arc extension, and a possible mantle plume have been proposed to explain the complicated volcanic trends observed over the past 20 Ma. Plume and non-plume models have been developed to reconcile the voluminous Columbia River/Steens Flood Basalts (CSFB) (~20 Ma), the age progressive (15 Ma to present) Snake River Plain (SRP) that terminates at Yellowstone and the opposite, or westward trending High Lava Plains (HLP) volcanic track of eastern/central Oregon. We present results from laboratory experiments designed to test a plate-driven model for reproducing gross spatial-temporal characteristics of these three magmatic features. Models use a glucose fluid with temperature dependent viscosity in representing Earth’s mantle and continuous rubber belts that kinematically reproduce subduction trends for the Cascades system. Experiments begin at 20 Ma with a volume of mantle residuum in the Cascades wedge that is elongated and restricted in the trench-parallel and trench-normal directions, respectively. The underlying assumption is that residuum was created in the wedge during an earlier plate steepening event that caused the flood basalts. Our models characterize dispersion patterns for the melt residuum material as it deforms within four-
dimensional wedge circulation fields driven by rollback subduction (e.g. with a translational component of motion). Results show that residuum viscosity, relative to the ambient fluid, determines whether anomalous fluid can evolve to a morphology that matches the SRP/HLP tracks over ~15-20Ma. A weak residuum (e.g. retained partial melt) deforms over this time scale from the initial north-south oriented feature to an east-west trending morphology that is thin in both depth and north-south extent, material initially beneath CSFB is offset to the south, and is capable of producing opposite age progressions beneath the surface HLP/SRP track locations. The evolution of a high viscosity residuum in rollback-driven flow did not match the observed trends, as the feature deformed into an overly thick and wide morphology in the sub-HLP wedge compared to seismic data. Higher viscosity also produces stress coupling throughout the residuum, causing efficient entrainment from under the SRP towards the trench, leaving only ambient fluid beneath this track. In cases with stronger viscous coupling to the base of the overriding plate, the residuum is not able to deform into a morphology that is consistent with SRP/HLP tracks over the period 15 – 0 Ma. Models show only a limited range of conditions, where a low viscosity residuum is decoupled from the overriding plate, are capable of producing morphologies and offsets that roughly match observed spatial and temporal trends for primary features in the Pacific Northwest. Additional work is needed to understand the vertical heat/mass transfer processes that would enable deforming residuum to continually supply the bimodal magmatic output recorded over ~15Ma along the HLP and SRP tracks.

Time: 8:00 AM
Poster by: Sara Szwaja; Christopher R. Kincaid; Kelsey A. Druken; Julia MacDougall
Location: Hall A-C (Moscone South)

Connecting Soluble Trace Gases and Aerosol Vertical Distributions to Storm Properties

Wet deposition is important because it removes soluble trace gases and aerosols from the atmosphere, thereby affecting ozone photochemistry, visibility, and potentially the radiation budget of the atmosphere. Wet deposition of chemical constituents not only depends on the solubility of the compound, but also on the storm properties, such as liquid and ice water contents, precipitation production and evaporation, and the ice-to-water partitioning. These storm properties, in turn, depend on the storm dynamics and its thermodynamic environment.

We analyze the Deep Convective Clouds and Chemistry (DC3) observations to connect the aircraft measurements of a range of soluble gases (e.g. HNO3, H2O2, HCHO, CH3OOH) to the storm and environment observations. These observations include aircraft measurements of water content, radar reflectivity (including hydrometeor structure), radar vertical velocities, and pre-storm soundings of convective available potential energy and wind shear. We use the 2-component mixture model to estimate scavenging and transport efficiencies. We then compare these efficiencies to various storm properties. Estimates of scavenging efficiencies vary substantially for HCHO
84%) for four different thunderstorms ranging from low shear, moderate CAPE to high shear, high CAPE environments. The preliminary scavenging efficiencies for H2O2 for the same four storms are estimated to be all >90%.

Time: 9:00 AM
Presenters: Mary C. Barth; Megan M. Bela; Meghan Applegate; Alan Fried; Petter Weibring; Thomas F. Hanisco; Heather L. Arkinson; Eric C. Apel; Daniel W. O'Sullivan; Brian Heikes; Paul O. Wennberg; John Crounse; Jason M. St Clair; Athanasios Nenes; Milos Z. Markovic; Jeffrey L. Stith; Teresa L. Campos; Steven A. Rutledge; Brett Basarab; Brody Fuchs; Lawrence D. Carey; Anthony L. Bain; Michael I. Biggerstaff; Armin Wisthaler; Glenn S. Diskin; Pedro Campuzano Jost; Thomas B. Ryerson; Frank M. Flocke; Sara Lance
Location: 3012 (Moscone West)

Delving into the Deep Biosphere

The Census of Deep Life organized an international survey of microbial community diversity in terrestrial and marine deep subsurface environments. Habitats included subsurface continental fractured rock aquifers, volcanic and metamorphic subseafloor sedimentary units from the open ocean, subsurface oxic and anoxic sediments and underlying basaltic oceanic crust, and their overlying water columns. Our survey employed high-throughput pyrosequencing of the hypervariable V4-V6 16S rRNA gene of bacteria and archaea. We detected 1292 bacterial genera representing 40 phyla, and 99 archaeal genera from 30 phyla. Of these, a core group of thirteen bacterial genera occurred in every environment. A genus of the South African Goldmine Group (Euryarchaeota) was always present whenever archaea were detected. Members of the rare biosphere in one system often represented highly abundant taxa in other environments. Dispersal could account for this observation but mechanisms of transport remain elusive. Ralstonia (Betaproteobacteria) represented highly abundant taxa in marine communities and terrestrial rock, but generally low abundance organisms in groundwater. Some of these taxa could represent sample contamination, and their extensive distribution in several systems requires further assessment. An unknown Sphingobacteriales (Bacteroidetes) genus, Stenotrophomonas (Gammaproteobacteria), Acidovorax and Aquabacterium (both Betaproteobacteria), a Chlorobiales genus, and a TM7 genus were in the core group as well but more prevalent in terrestrial environments. Similarly, Bacillus (Firmicutes), a new cyanobacterial genus, Bradyrhizobium and Sphingomonas (both Alphaproteobacteria), a novel Acidobacteriaceae genus, and Variovorax (Betaproteobacteria) frequently occurred in marine systems but represented low abundance taxa in other environments. Communities tended to cluster by biome and material, and many genera were unique to systems. For example, certain Rhizobiales (Alphaproteobacteria) only occurred in groundwater, and select Firmicutes and actinobacterial taxa were specific to rock environments. We continue to investigate the ecological and physiological context of these organisms. By combining deep sequencing of microbial communities and geochemical and physical evaluations of their
environments, we bring to light the diversity and scope of the deep biosphere and insight into the factors that determine the nature of these communities.

Three-dimensional passive-source reverse time migration: A numerical experiment

Reverse time migration (RTM) has been widely used in industry because it accounts for the physics of wave propagation in complex 3D media and offers superior performance compared to traditional methods. As increasingly dense broadband seismic arrays are been deployed and high-performance computational resources are more accessible, 3D passive-source RTM becomes an increasingly practical and powerful tool to image the deep Earth. In this study, we extend the passive-source RTM method from 2D to 3D and explore its advantages and limitations with synthetics experiments. We compare the RTM results with those of common conversion point (CCP) stacking in imaging several structures, including interfaces with different dipping angles. We document the effect of earthquake source distribution and the sensitivity of migrated images to station density and distribution.

Relationship of subseafloor microbial diversity to sediment age and organic carbon content

Our tag pyrosequencing investigation of four globally distant sites reveals sediment age and total organic carbon content to be significant components in understanding subseafloor diversity. Our sampling locations include two sites from high-productivity regions (Indian Ocean and Bering Sea) and two from moderate-productivity (eastern and central equatorial Pacific Ocean). Sediment from the high-productivity sites has much higher TOC than sediment from the moderate-productivity equatorial sites. We applied a high-resolution 16S V4-V6 tag pyrosequencing approach to 24 bacterial and 17 archaeal samples, totaling 602,502 reads. We identified 1,291 archaeal and 15,910 bacterial OTUs (97%) from these reads. We analyzed bacterial samples from all four sites in addition to archaeal samples from our high productivity sites. These high productivity, high TOC sites have a pronounced methane-rich sulfate-free zone at depth from which archaea have
been previously considered to dominate (Biddle et al., 2006). At all four locations, microbial diversity is highest near the seafloor and drops rapidly to low but stable values with increasing sediment depth. The depth at which diversity stabilizes varies greatly from site to site, but the age at which it stabilizes is relatively constant. At all four sites, diversity reaches low stable values a few hundred thousand years after sediment deposition. The sites with high total organic carbon (high productivity sites) generally exhibit higher diversity at each sediment age than the sites with lower total organic carbon (moderate-productivity sites). Archaeal diversity is lower than bacterial diversity at every sampled depth.

Time: 2:10 PM
Presenters: Emily A. Walsh; John B. Kirkpatrick; Mitchell L. Sogin; Steven L. D'Hondt
Location: 2006 (Moscone West)

Distribution and activity of hydrogenase enzymes in subsurface sediments

Metabolically active microbial communities are present in a wide range of subsurface environments. Techniques like enumeration of microbial cells, activity measurements with radiotracer assays and the analysis of porewater constituents are currently being used to explore the subsurface biosphere, alongside with molecular biological analyses. However, many of these techniques reach their detection limits due to low microbial activity and abundance. Direct measurements of microbial turnover not just face issues of insufficient sensitivity, they only provide information about a single specific process rather than an overall microbial activity. Since hydrogenase enzymes are intracellular and ubiquitous in subsurface microbial communities, the enzyme activity represents a measure of total activity of the entire microbial community. A hydrogenase activity assay could quantify total metabolic activity without having to identify specific processes. This would be a major advantage in subsurface biosphere studies, where several metabolic processes can occur simultaneously. We quantified hydrogenase enzyme activity and distribution in sediment samples from different aquatic subsurface environments (Lake Van, Barents Sea, Equatorial Pacific and Gulf of Mexico) using a tritium-based assay. We found enzyme activity at all sites and depths. Volumetric hydrogenase activity did not show much variability between sites and sampling depths, whereas cell-specific activity ranged from 10-5 to 1 nmol H2 cell-1 d-1. Activity was lowest in sediment layers where nitrate was detected. Higher activity was associated with samples in which sulfate was the predominant electron acceptor. We found highest activity in samples from environments with >10 ppm methane in the pore water. The results show that cell-specific hydrogenase enzyme activity increases with decreasing energy yield of the electron acceptor used. It is not possible to convert volumetric or cell-specific hydrogenase activity into a turnover rate of a specific process like sulfate reduction. However, we can use the cell-specific hydrogenase activity to estimate the size of the metabolically active microbial population. The conversion factors vary according to the predominant electron-accepting process. In subsurface sediment standard methods for quantification of the metabolically active microbial population (e.g. CARD-FISH) are at
their lower detection limit. The hydrogenase enzyme activity measurement provides an alternative and sensitive way of quantification.

Time: 3:10 PM
Presenters: Rishi Ram Adhikari; Julia Nickel; Clemens Glombitza; Arthur J. Spivack; Steven L. D'Hondt; Jens Kallmeyer
Location: 2006 (Moscone West)
High resolution hybrid optical and acoustic sea floor maps (Invited)

This abstract presents a method for creating hybrid optical and acoustic sea floor reconstructions at centimeter scale grid resolutions with robotic vehicles. Multibeam sonar and stereo vision are two common sensing modalities with complementary strengths that are well suited for data fusion. We have recently developed an automated two stage pipeline to create such maps. The steps can be broken down as navigation refinement and map construction. During navigation refinement a graph-based optimization algorithm is used to align 3D point clouds created with both the multibeam sonar and stereo cameras. The process combats the typical growth in navigation error that has a detrimental affect on map fidelity and typically introduces artifacts at small grid sizes. During this process we are able to automatically register local point clouds created by each sensor to themselves and to each other where they overlap in a survey pattern. The process also estimates the sensor offsets, such as heading, pitch and roll, that describe how each sensor is mounted to the vehicle. The end results of the navigation step is a refined vehicle trajectory that ensures the points clouds from each sensor are consistently aligned, and the individual sensor offsets.

In the mapping step, grid cells in the map are selectively populated by choosing data points from each sensor in an automated manner. The selection process is designed to pick points that preserve the best characteristics of each sensor and honor some specific map quality criteria to reduce outliers and ghosting. In general, the algorithm selects dense 3D stereo points in areas of high texture and point density. In areas where the stereo vision is poor, such as in a scene with low contrast or texture, multibeam sonar points are inserted in the map. This process is automated and results in a hybrid map populated with data from both sensors. Additional cross modality checks are made to reject outliers in a robust manner.

The final hybrid map retains the strengths of both sensors and shows improvement over the single modality maps and a naively assembled multi-modal map where all the data points are included and averaged. Results will be presented from marine geological and archaeological applications using a 1350 kHz BlueView multibeam sonar and 1.3 megapixel digital still cameras.

Time: 8:00 AM
Presenters: Christopher Roman; Gabrielle Inglis
Location: 3009 (Moscone West)

Redox Controls on the Asthenosphere (Invited)

Mantle oxygen fugacity (fO2) may exert primary control on the depth of melt initiation in the asthenosphere by controlling the depth at which reduced carbon oxidizes to
carbonate. Carbonate will drive flux melting; reduced carbon will not. The extent to which carbon actually works to melt the deep asthenospheric mantle, however, remains unknown. Likewise, while xenoliths from the continental mantle record decreasing fO2 with depth, the extension of this profile to the oceanic upper mantle remains speculative. Assuming that the continental xenolith record broadly mirrors the fO2 of the oceanic upper mantle, then as mantle ascends, fO2 increases and at some depth conditions become oxidizing enough to cause oxidation of carbon and concomitant reduction of iron [Stagno et al., Nature, 2013; Cottrell and Kelley, Science, 2013]. At the same time, Fe3+/ΣFe ratios and fO2 of erupted MORB negatively correlate with proxies for mantle source enrichment [Cottrell and Kelley, Science, 2013], suggesting that regional variations in the oxidation state of the upper mantle are tied to composition. If both the Fe3+/ΣFe ratio and carbon concentration vary regionally in the oceanic upper mantle as a function of its composition, then the interplay between Fe3+/ΣFe ratio, carbon concentration, and fO2 have key implications for the depth and extent of melting beneath mid-ocean ridges. Properties of the asthenosphere presumed to be sensitive to the presence of low degree carbonatitic or kimberlitic melt, such as shear wave velocity and conductivity, should therefore inform our understanding of the mantle’s redox, carbon, and melt budgets, and vice versa. Here, we present a global assessment of the linked chemical and physical properties of the oceanic asthenosphere.

http://mineralsciences.si.edu/staff/pages/cottrell.htm

Time: 8:30 AM
Presenters: Elizabeth Cottrell; Vedran Lekic; Fred A. Davis; Katherine A. Kelley
Location: 303 (Moscone South)

Mantle heterogeneities as revealed by along-axis variations in MORB volatile concentrations

We determined C, H, S, F and Cl concentrations by SIMS in more than 300 mid-ocean ridge basalts from ridges worldwide. Although CO2 contents of MORB glasses are strongly affected by degassing, rapid quenching and confining water pressure during submarine eruptions prevents H2O, S, F and Cl from degassing, allowing us to study volatile-element systematics in relation to variations in the composition of the mantle source. Average compositions are 160±150 ppm CO2, 0.32±0.36 wt% H2O, 190±190 ppm F, 1200±450 ppm S and 140±420 ppm Cl (2σ standard variation). High Cl/Nb can be used as tracer of seawater alteration and/or assimilation of altered materials such as serpentinite. MORB samples that are depleted in Cl (and other incompatible elements) are the ones most affected by Cl addition. Filtering out all samples with Cl/Nb>20 results in lowering the average composition for Cl as well as the range in compositions for all volatiles (2σ standard variation lowered by up to 50%). After filtering, the volatile content for unaltered MORB glasses is 180±130 ppm CO2, 0.33±0.38 wt% H2O, 200±190 ppm F, 1150±250 ppm S and 80±230 ppm Cl. To account for variations in the degree of melting and/or crystallization, we normalize by a trace element with similar compatibility during mantle melting. Average ratios for unaltered MORB are 150±70 for
CO₂/Nb, 10±8 for Cl/Nb, 2.4±1.8 for F/Zr, 240±100 for H₂O/Ce, and 240±80 for S/Dy. For CO₂, the positive correlation with eruption depth at the global scale indicates that the CO₂ content in MORB is mainly controlled by degassing, through a combination of equilibrium degassing (for samples with saturation pressure equals to equilibrium pressure, indicating equilibrium between the melt and the gas phase) and kinetic effects (for samples with saturation pressure greater than eruption pressure, indicating a delay in CO₂ partitioning into the bubbles, thus an excess CO₂ in the melt).

We find that there is no correlation globally between H₂O/Ce or S/Dy ratios and proxies for mantle enrichment, such as La/Sm ratio. In contrast, Cl/Nb and F/Zr ratios both tend to be elevated in enriched MORB (EMORB, with La/Sm>1) relative to normal MORB (NMORB, with La/Sm<1) at the global scale. The F/Zr ratio in particular shows promise as a proxy for variations in the mantle source, increasing along plume-affected segments. F/Zr ratio also correlates with radiogenic isotopes such as ²⁰⁶Pb/²⁰⁴Pb (both increase near the Sierra Leone hotspot for example) and can be tied to processes occurring at subduction zones where mantle heterogeneity is introduced. We will discuss global variations in MORB volatile concentrations in terms of location, nature and age of mantle components.

Tracing the origins of back-arc basin slab-derived fluids

Water is known to be a central component in back-arc basin processes, added through the subducting slab to the back-arc mantle. The relationship between water and trace elements in back-arc basin basalts relate closely to the compositions of the subducted inputs, the conditions and mineralogy of the subducting slab, and fluid pathways through the mantle wedge. These factors combine to create the fluids that modify back-arc mantle sources, yet there are competing ideas for how slab-derived fluids reach the back-arc source. Here, we present new SIMS measurements of magmatic volatiles (H₂O, CO₂, S, Cl, F) and new LA-ICP-MS trace element data for basaltic glasses (>5 wt.% MgO) from the Manus, North Fiji, and Lau Basins. In combination with previously-published data for these basins, the Mariana Trough, and the East Scotia Ridge, we use recent geochemical models of slab conditions based on H₂O/Ce ratios, coupled with geodynamic models of slab surface temperatures (SST), at each subduction zone to provide a robust test of the origination conditions of back-arc slab-derived fluids. The H₂O/Ce ratios of these BABB span a wide range (250-3900) from normal mid-ocean ridge basalt (MORB; 150-250) to high, arc-like ratios. Average SSTs for these global back arc basin spreading segments, referenced to 4 GPa, range from ~775-1000°C, hotter on average than global arc SSTs referenced to the same pressure (730-850°C), suggesting that back-arc basin fluids are derived from hotter domains of the subducted slab than those that supply their respective arcs. Here we explore three possible explanations: (1) back-arc slab-derived fluids are released at greater slab depth, and thus higher temperature, than arc fluids, (2) back-arc fluids come from the same depth as arcs but from the hotter edges of the slab, or (3)
thermal models predict slab surface geotherms that are too cold. The back-arc basin slab-derived fluids may reflect a combination of thermal variations in the slab, resulting from toroidal flow, and an underprediction of slab surface geotherms by 2D thermal models.

Time: 10:50 AM
Presenters: Marion L. Lytle; Katherine A. Kelley; Erik H. Hauri
Location: 301 (Moscone South)

Multibeam Mapping and Remotely Operated Vehicle Exploration of the Puerto Rico and Virgin Islands Region

During October 2013, an ocean exploration project took place off the coast of Puerto Rico and the Virgin Islands. This project, a collaborative effort between the Ocean Exploration Trust, the US Geological Survey, the University of Puerto Rico at Mayaguez, the University of Rhode Island, and NOAA, was aimed at exploring regions of the US exclusive economic zone (EEZ) south of the Puerto Rico Trench axis, and north of Mona Island, Puerto Rico, and the US and British Virgin Islands, and portions of the Anegada Passage. The research vessel E/V Nautilus and the Hercules/Argus ROV system were used to expand the multibeam sonar bathymetric data coverage of the region, collect high definition video footage of seafloor features, and to collect biological and geological samples along selected transects. Particular areas of interest for targeted ROV dives included: the region where a large M7.2 1918 earthquake produced a tsunami that struck northwestern corner of Puerto Rico; a transect up the vertical wall of the Mona Rift (4000 to 1500 m depth); transects along the Septentrional fault system; dives in areas of suspected fluid flow through faults, fissures, and offshore Karst systems associated with the tilted carbonate platform north of Puerto Rico; dives in the Anegada Passage at the entry points for surface Atlantic waters that circulate into the Caribbean; and in regions to investigate and date sedimentary features offset by fault motion and potential tsunamigenic landslides. Biological sampling of many deep-sea benthic organisms (including deep water corals) have never been attempted before in this area. These samples are being used to understand more about the diversity, population dynamics, genetics, and habitat connectivity of these communities, and to provide an age constraint for disturbed sedimentary features. Until this cruise, the location and distribution of deep coral habitats in the US Caribbean was largely unknown. The available information on benthic communities associated with deep coral ecosystems in this region was mostly limited to taxonomic listings from incidental collections by fish traps, shrimp trawls and coral entanglement devices. We present the results of the first direct observations and sampling of these ecosystems.

Time: 1:40 PM
Poster by: Dwight F. Coleman; Uri S. Ten Brink; Roy Armstrong; Jason D. Chaytor; Amanda W. Demopoulos
Location: Hall A-C (Moscone South)
Variation of the upper mantle velocity structure along the central-south Andes

Variations in the subduction angle of the Nazca plate beneath the South American plate has lead to different modes of deformation and volcanism along the Andean active margin. The volcanic gap between the central and southern Andean volcanic zones is correlated with the Pampean flat-slab subduction zone, where the subducting Nazca slab changes from a 30-degree dipping slab beneath the Puna plateau to a horizontal slab beneath the Sierras Pampeanas, and then to a 30-degree dipping slab beneath the south Andes from north to south. The Pampean flat-slab subduction correlates spatially with the track of the Juan Fernandez Ridge, and is associated with the inboard migration of crustal deformation. A major Pliocene delamination event beneath the southern Puna plateau has previously been inferred from geochemical, geological, and preliminary geophysical data. The mechanisms for the transition between dipping- and flat-subduction slab and the mountain building process of the central Andean plateau are key issues to understanding the Andean-type orogenic process.

We use a new frequency-time normalization approach to extract very-broadband (up to 300 second) empirical Green’s functions (EGFs) from continuous seismic records. The long-period EGFs provide the sensitivity needed to constrain the deep mantle structure. The broadband waveform data are from 393 portable stations of eight temporary networks: PUNA, SIEMBRA, CHARCIGE, RAMP, East Sierras Pampeanas, BANJO/SEDA, REFUCA, ANCORP, and 31 permanent stations accessed from both the IRIS DMC and GFZ GEOFON DMC. A finite difference wave propagation method is used to generate synthetic seismograms from 3-D velocity model. We use 3-D traveltime sensitivity kernels, and traveltime residuals measured by waveform cross-correlation to directly invert the upper mantle shear-wave velocity structure. The preliminary model shows strong along-strike velocity variations within in the mantle wedge and the subducting NAZCA slab. Low upper mantle velocities are north of 29°S and south of 35°S, corresponding to the low velocity mantle wedge of dipping-subduction. The upper mantle beneath the Sierras Pampeanas has a higher velocity than that beneath the central and south volcanic zones, which is consistent with the Pampeanas flat-slab. Though we observe substantial heterogeneity within this flat-slab zone.

Time: 1:40 PM  
Poster by: Xiaofeng Liang; Eric A. Sandvol; Yang Shen; Haiying Gao; Zhongjie Zhang  
Location: Hall A-C (Moscone South)

Reconstructing past plate motions with abyssal hill topography

The seafloor spreading history of oceanic plates is primarily reconstructed by using a combination of dated seafloor magnetic anomalies and fracture zone trends to locate Euler poles and determine rotation rates. In some regions, these conventional measures of determining spreading history do not exist and alternative methods are required. Abyssal hills are elongate, topographic highs that are created at and form parallel to the ridge axis of spreading centers. Once formed, the abyssal hills are transported onto the ridge flank.
and provide a record of ridge axis orientation. We propose using the orientation of abyssal hill topography to supplement existing plate motion reconstruction methods and to serve as a stand-alone method for regions where conventional methods will not apply. Our new method uses high-resolution bathymetry grids created with multibeam data with grid-node spacing of 100-200 m, determined by regional water depths. The bathymetric grids are detrended to remove depth-age relationships and spatially filtered to remove anomalous regions where seafloor age is unknown. The detrended grids are then clipped to remove anomalously deep (e.g., fracture zones) or anomalously shallow topography (e.g., seamounts). Abyssal hill orientations are determined by calculating the modal frequencies of slope azimuth for pre-defined sub-regions (e.g., 50 km x 50 km) of these modified grids. The Euler Pole is then found by an iterative least-squares method from a grid of potential Euler Poles; first a coarse grid and then a fine grid are utilized to avoid local minima. At each potential Euler Pole, the sum of the differences between predicted and observed abyssal hill trends is squared and the minimum value identifies the location of the best-fit Euler Pole. Our method was applied to the well-mapped Cocos-Pacific plate boundary along the northern East Pacific Rise for the past 3 Ma and the poorly constrained Mid-Cretaceous seafloor (84 – 120 Ma) in the southwest Pacific Ocean. The results for the northern East Pacific Rise are very encouraging and our calculated Euler Poles are within 4 degrees of the NUVEL 1a and 2 degrees of the MORVEL global relative motion models. We also applied our method to the EMAG2 magnetic anomaly intensity grids with similar encouraging results; 17 degrees NUVEL 1a & 11 degrees MORVEL. The results for the southwest Pacific are still preliminary, but the method effectively identifies regions with similar abyssal hill trends and may be useful for more detailed tectonic reconstructions of the enigmatic region.

Time: 1:40 PM
Poster by: Marah R. Dahn; Robert A. Pockalny; Christina King
Location: Hall A-C (Moscone South)

An Evaluation of Polycyclic Aromatic Hydrocarbon Uptake into Polyethylene Samplers

Polyethylene passive samplers (PEs) are simple reliable tools that have been widely used in the detection of hydrophobic organic compounds. Thick (>200µm or greater) PEs have important applications to specific sampling scenarios including biological assays, deployment on ships and aircraft (towing) and long term sampling, however little is known about their uptake kinetics. This study aimed to develop an accurate understanding of the uptake kinetics of these thick PEs. PE passive samplers of equal surface area, but differing thicknesses were co-deployed in the surface water and air of lower Narragansett Bay in 2013 to characterize differences in their uptake of polycyclic aromatic hydrocarbons (PAHs). PE samplers of approximately 50, 800, and 1600µm thicknesses were analyzed for 38 parent and alkylated PAHs, with replicate sampler reproducibility mostly within 25%. A number of smaller PAHs (typically those with a molecular weight less than 180) analyzed over a 4 week deployment equilibrated, while the larger molecules remained in the linear or curve linear uptake stages. Results from a second, 24 week deployment of 800µm and 1600µm samplers in surface waters suggest
that all 38 compounds studied remained in the linear uptake stage. The PE-weight normalized concentration ratio of 1600µm to 800µm sampler fell below 1 for all analytes, implying equilibrium had not been established.

Time: 1:40 PM
Poster by: Dmitro J. Martynowych; Carrie McDonough; Rainer Lohmann
Location: Hall A-C (Moscone South)

Distribution of tephra from the 1650 AD submarine eruption of Kolumbo volcano, Greece

Kolumbo submarine volcano, located 7 km northeast of Santorini in the Aegean Sea, last erupted in 1650 AD resulting in about 70 fatalities on Thera from gas discharge and significant coastal destruction from tsunamis. Extensive pumice rafts were reported over a large area surrounding Santorini, extending as far south as Crete. Tephra from the 1650 AD submarine eruption has been correlated in sediment box cores using a combination of mineralogy and major element composition of glass shards. The biotite-bearing rhyolite of Kolumbo can be readily discriminated from other silicic pyroclastics derived from the main Santorini complex. In general the tephra deposits are very fine grained (silt to fine sand-size), medium gray in color, and covered by about 10 cms of brown hemipelagic sediment. This corresponds to an average background sedimentation rate of 29 cm/kyr. The distribution of the 1650 AD Kolumbo tephra extends over an area larger than previously inferred from seismic profiles on the volcano’s slopes and in adjacent basins. The cores indicate tephra deposits at least 19 km from the caldera, more than double the approximate 9 km inferred from seismic data. The preferential occurrence of the tephra within basins and sedimentological features such as cross bedding and laminations suggests that emplacement was dominated by sediment gravity flows generated from submarine and subaerial eruption plumes. We suggest that generation of the sediment gravity flows took place by collapse of submarine eruption columns and by Rayleigh-Taylor instabilities that formed on the sea surface as subaerial fallout accumulated from parts of the columns that breached the surface. Additionally, SEM imaging reveals particle morphologies that can be attributed to fragmentation by both primary volatile degassing (bubble wall shards) and phreatomagmatic activity (blocky equant grains). It is likely that phreatomagmatic activity became more important in the latter stages of the eruptive sequence when eruptions columns broke the surface and a small ephemeral island was formed. The fine grain marine tephra deposits surrounding Kolumbo represent the compliment to the very fines-poor proximal pumice sequence exposed in the crater walls and demonstrates the very effective fractionation of fine tephra that can take place during explosive submarine eruptions.

Time: 2:25 PM
Presenters: Sarah A. Fuller; Steven Carey; Paraskevi Nomikou
Location: 308 (Moscone South)
He isotope ratios in the Nankai Trough and Costa Rica subduction zones - implications for volatile cycling

The noble gas \(^{3}\)He is a clear indicator of primordial volatile flux from the mantle, thus providing important insights on the interaction between Earth's interior and exterior reservoirs. Volatile cycling at ridge-crests and its impact on the evolution of seawater chemistry is rather well known as constrained by the \(^{3}\)He flux, whereas the impact of volatile cycling at subduction zones (SZs) on seawater chemistry is as yet poorly known. Constraining chemical and isotopic cycling at SZs is important for understanding the evolution of the mantle-crust and ocean-atmosphere systems.

To gain insights on volatile cycling in SZs, pore fluids were sampled for He concentration and isotopic analyses at two tectonically contrasting SZs, Nankai Trough (offshore Japan, Muroto and Kumano transects), an accretionary SZ, and Costa Rica (Offshore Osa Peninsula), an erosional SZ. Sampling for He was achieved by rapidly subsampling core sediments, cleaning and transferring these samples into Ti squeezers in a glove bag, and storing the squeezed pore fluids in crimped Cu tubes for shore-based He concentration and isotope ratio analyses.

At the Nankai Trough SZ there is a remarkable range of He isotopic values. The \(^{3}\)He/\(^{4}\)He ratios relative to atmospheric ratio (R\(_{A}\)) range from mostly crustal 0.47 R\(_{A}\) to 4.30 R\(_{A}\) which is ~55% of the MORB value of 8 R\(_{A}\). Whereas at the Costa Rica SZ, offshore Osa Peninsula, the ratios range from 0.86 to 1.14 R\(_{A}\), indicating the dominance of crustal radiogenic \(^{4}\)He that is from U and Th decay.

The distribution of the He isotope values at Nankai Trough is most interesting, fluids that contain significant mantle \(^{3}\)He components (\(^{3}\)He/\(^{4}\)He >1) were sampled along and adjacent to fluid conduits that were identified by several chemical and isotopic data (i.e. Cl, B, and Li), including the presence of thermogenic hydrocarbons. Whereas the fluids dominated by \(^{4}\)He (\(^{3}\)He/\(^{4}\)He \(\leq 1\)) were obtained from sediment sections that were between the fluid conduits. At Costa Rica, however, even along conduits, the fluids were not greatly enriched in \(^{3}\)He, hence there is no evidence for fluid advection from the subducting Cocos Ridge and numerous seamounts into the sediments, suggesting greatly diminished hydrothermal activity.

Focused flow along faults, the décollement, splay and out of sequence faults, and fractured and permeable horizons at SZs play a key role in controlling fluid and heat transport, including mantle He, whereas diffuse flow plays a minor role; mud volcanoes and seeps as well play some role in volatile cycling.
Hydrogen peroxide and methylhydroperoxide observations by chemical ionization mass spectrometry on the GV during the Deep Convective Clouds and Chemistry Experiment

Airborne gas phase measurements of hydrogen peroxide and methylhydroperoxide were made on 22 research flights on the NCAR Gulfstream-V using chemical ionization mass spectroscopy (CIMS) during the Deep Convective Clouds and Chemistry Experiment (DC3) in May and June 2012. A multi-reagent ion CIMS method, using O$_2^-$ and CO$_4^-$ reagent ions, and standard additions of hydrogen peroxide and methylhydroperoxide was developed to identify and quantify hydrogen peroxide (H$_2$O$_2$) and methylhydroperoxide (CH$_3$OOH) in ambient air. The DC3 field program characterized a number of active convective systems in three different regions, Colorado, Oklahoma, and Alabama with observations extending from the surface to 13 km. A few flights were also flown to characterize the photochemical aging of lofted chemicals and lightning generated oxides of nitrogen. Peroxide observations will be used to examine transport efficiency and removal in isolated convective storms and larger scale multiple convective systems. Differences in peroxide storm input and transport process will be compared across the three regions. Peroxide observations coupled with other in situ chemical species observations and meteorological parameters will be used to assess the contribution of convective transport to the photochemical budget of hydrogen peroxide and methylhydroperoxide in the upper troposphere over the United States.

Time: 8:00 AM
Poster by: Daniel W. O'Sullivan; Indira Silwal; Victoria Treadaway; Ashley McNeill; Brian Heikes
Location: Hall A-C (Moscone South)

Observations of formic and acetic acid by chemical ionization mass spectrometry in the Deep Convective Clouds and Chemistry Experiment

Formic (HFO) and acetic acid (HAc) are part of the atmospheric processing of carbon and their measurement is relevant to defining oxygenated volatile organic carbon (OVOC) emissions, to examining photochemical processing of volatile organic carbon (VOC) and OVOCs, and to the photochemical processing of organic aerosol. Further, they can serve as photochemical tracers of convective transport, cloud chemical processes, and precipitation scavenging. The addition of HFO and HAc measurements to the Deep Convective Clouds and Chemistry Experiment (DC3) is relevant to the DC3 science objectives and complements the suite of chemicals already observed during DC3. The peroxide chemical ionization mass spectrometer (PCIMS) was flown aboard the NCAR Gulfstream-V platform in DC3 and while its primary function was to observe hydrogen peroxide and methylhydroperoxide it recorded signals attributed to iodide cluster ions of HFO and HAc at mass-charge ratios of 173 and 187, respectively. Post-mission laboratory experiments were performed to determine the CIMS instrument’s sensitivity to these
acids under the varying water vapor and sample flow conditions encountered during DC3 flights. The results of field measurements, laboratory experiments and the HFo and HAc recovery process are reported and HFo and HAc measurement quality assessed. The resultant HFo and HAc data are presented and interpreted with respect to atmospheric chemistry within measurement constraints. The DC3 observations were made in May and June 2012 and extended from the surface to 13 km over the central United States.

Time: 8:00 AM
Poster by: Victoria Treadaway; Ashley McNeill; Brian Heikes; Daniel W. O'Sullivan; Indira Silwal
Location: Hall A-C (Moscone South)

The next generation of ship-to-shore networking from research vessels

As mobile satellite technology has slowly become more readily available over the last decade, an always-online culture aboard research vessels has expanded dramatically and been limited by cost. During the past few years, several science projects have funded additional bandwidth for real-time video outreach and bulk data exchanges between the research vessel and shore. These types of operations are becoming more common throughout the fleet, where nearly every cruise could benefit by having additional bandwidth. Increasing demands for Internet connectivity while at sea, whether for science operations, educational outreach, or other technical communications, will require changes to the research fleet’s cyberinfrastructure. With the next generation of satellite technology poised to dramatically drop in price and increase in capacity, now is the time to shape ship-to-shore/shore-to-ship communications for the future.

http://www.hiseasnet.net

Time: 8:00 AM
Poster by: Steven Foley; Dwight F. Coleman; Jonathan Berger; John A. Orcutt
Location: Hall A-C (Moscone South)

Links between oxygen fugacity, slab fluids, and calc-alkaline differentiation of arc magmas (Invited)

Calc-alkaline differentiation, a process by which magmas become depleted in Fe early in their crystallization history, is observed in magmas at subduction zone settings and is thought to drive arc magmas towards the bulk composition of continental crust. Basaltic arc magmas may achieve calc-alkaline affinity through some combination of high magmatic \( \text{H}_2\text{O} \), which delays the crystallization of silicates (most notably plagioclase), and high magmatic oxygen fugacity \( (fO_2) \), which enhances the onset of magnetite crystallization. The relative importance of \( \text{H}_2\text{O} \), \( fO_2 \), and magmatic bulk composition in generating calc-alkaline magma series, however, is not yet clearly resolved. Here, we present new measurements of the oxidation state of Fe (expressed as \( \frac{\text{Fe}^{3+}}{\text{Fe}} \) ratio; a proxy for magmatic \( fO_2 \)), in combination with previously-published analyses, of mafic
(Mg#≥0.5) olivine-hosted melt inclusions from global arc volcanoes (Galunggung, Paricutin, Cerro Negro, and several volcanoes from the Mariana and Aleutian arcs), acquired using X-ray Absorption Near Edge Structure spectroscopy. We use the Tholeiitic Index (THI) of Zimmer et al., 2010 to quantify the calc-alkaline affinity of arc magma series (<1 is more calc-alkaline, >1 is more tholeiitic). These volcanoes span a range of calc-alkaline affinity, with THI ranging from 0.65 to 1.3. The Fe$^{3+}/\sum$Fe ratios of arc basalts, corrected for fractional crystallization to 6 wt.% MgO (i.e., Fe$^{3+}/\sum$Fe$_{6.0}$) range globally from 0.15-0.31 and all but Galunggung are more oxidized than the more tholeiitic basaltic glasses from the Mariana trough back-arc basin (THI=1.4; Fe$^{3+}/\sum$Fe$_{6.0}$=0.185) or normal MORB (THI=1.6; Fe$^{3+}/\sum$Fe$_{6.0}$=0.167±0.01). Our results show a strong correlation between THI and Fe$^{3+}/\sum$Fe$_{6.0}$ ratios at these volcanoes, such that more calc-alkaline magmas contain a greater proportion of oxidized Fe. At the same time, the maximum dissolved H$_2$O contents of basaltic melt inclusions from these volcanoes also strongly correlate with THI, and with Fe$^{3+}/\sum$Fe$_{6.0}$ ratios (although H$_2$O is not the direct cause of oxidation), which points to a slab-derived origin of both H$_2$O and oxidation and thus potentially links slab-derived fluids to the generation of calc-alkaline magma series. These correlations also illustrate the challenge of separating the effects of H$_2$O and $f$O$_2$ on arc magmatic differentiation, as the two are difficult to isolate in nature. Yet, some volcanoes may shed light on this issue. Arc volcanoes with similar Fe$^{3+}/\sum$Fe$_{6.0}$ or H$_2$O, but significantly different THI, may illustrate most clearly the isolated effects of the other variable.

Time: 9:00 AM
Presenters: Katherine A. Kelley; Elizabeth Cottrell; Maryjo N. Brounce
Location: 302 (Moscone South)

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**Organic geochemical paleoenvironmental and paleoclimatic reconstructions from Argentina Loess/Loessoid deposits**

The loess/loessoid sediments of Argentina have accumulated since the Late Miocene (~10-12 Ma) and are an important terrestrial archive for much of the Late Cenozoic. These sedimentary sequences contain an extensive fossil vertebrate record, which provides the foundation for the South American Land Mammal Ages (SALMA) stratigraphy, and an extensive meteorite impact record. Previous work by our group has focused on using environmental magnetic parameters to characterize changes in depositional and post-depositional processes in relation to meteorite impacts, moisture transport, wind patterns, and temperature over the last ~3.5 Ma. This work has provided the foundation for ocean-atmosphere-terrestrial models to explain paleoenvironmental and paleoclimatic changes associated with several major global climate transitions/states.

Although the environmental magnetic proxies provide a high-resolution record, they are limited in their ability to unambiguously or quantitatively define changes in moisture or temperature, especially when both are changing at the same time. To address these uncertainties, we have used a combination of organic geochemical paleoenvironmental and paleoclimate proxies (carbon isotopes, hydrogen isotopes, and bacterially generated compounds) in order to calibrate the high-resolution environmental magnetic parameters.
These proxies include compound specific hydrogen isotopic ratios (δD) and carbon isotope ratios (δ13C) from plant leaf waxes and the distribution of glycerol dialkyl glycerol tetraethers (branched GDGTs). Our preliminary results show that leaf wax n-alkyl lipids and branched GDGTs are sufficiently abundant for compound specific hydrogen and carbon isotopic analysis as well as paleotemperature reconstructions. Analysis of the most recent interglacial/glacial cycle indicates that interglacial temperature estimates are consistent with mean January temperatures for the region (20-24°C) while the glacial to interglacial temperature change appears to be somewhat unusually large (maximum change >15°C). This is likely due to changes in the production seasonality of branched GDGTs such that interglacial production mainly occurred during the warm and wet summer seasons, whereas the branched GDGT production may occur throughout the year during glacial intervals. Therefore, the GDGT glacial temperature estimates may be more representative of annual mean temperatures due to the reduction in summer moisture. Lower δ13C values for C26 n-alkanoic acid support the transition from a C3-dominated plant ecosystem in the cold glacial interval to a more C4-dominated plant ecosystem in the interglacial. Variable δD values likely represent a mixture of temperature and moisture changes in that interval. This work demonstrates that the combination of organic geochemical and environmental magnetic proxies is a powerful tool for characterizing paleoenvironmental/paleoclimatic changes in a terrestrial environment, providing an environmental framework for the SALMA record and meteorite impact events in Argentina over the last several million years.

Time: 1:40 PM
Poster by: Clifford W. Heil; Yongsong Huang; Pamela Wegener; John W. King; Peter H. Schultz
Location: Hall A-C (Moscone South)

Temporal evolution of fO2 in the Mariana mantle wedge

The elevated oxygen fugacity (fO2) recorded by arc lavas appears to be linked to slab fluid influence globally and locally; however, many details regarding the capacity that slab fluids have to oxidize the mantle wedge remain unknown. At the time of subduction initiation, melts may be produced by a combination of decompression and fluid-fluxed melting and the role of flux melting may increase as the subduction zone matures (Reagan et al., 2010, G3 11(3)). Immediately prior to subduction initiation, the mantle presumably has fO2 and fluid concentrations similar to mid-ocean ridge (MOR) source mantle (near the quartz-fayalite-magnetite buffer, QFM, and relatively dry). As subduction zones mature, slab fluids may become more dominant in melt generation as evidenced by increases in fluid-mobile trace element signatures, but the fO2 of slab fluids and temporal changes in the fO2 of erupted basalt remains undocumented. The Mariana forearc southwest of Guam records the initiation of Pacific plate subduction (Reagan et al., 2010). At the base, fore-arc basalts (FAB) erupted at the immediate onset of subduction (51-52 Ma) show minor traces of slab fluid influence and likely reflect decompression melting that occurred as mantle rose to accommodate the sinking Pacific plate. The FAB are overlain by 37-44 Ma “transitional” basalts whose fluid mobile trace
element enrichments indicate that slab fluids have greater influence in their petrogenesis. These lavas provide the opportunity to directly constrain the timescales of mantle wedge oxidation during the initiation and maturation of an oceanic subduction zone. We present $\text{Fe}^{3+}/\Sigma\text{Fe}$ ratios ($\mu$-XANES) determined on FAB and transitional basalt glasses, paired with previously published major and trace element data. These glasses range in MgO from 2.75 – 7.56 wt% and have $\text{Fe}^{3+}/\Sigma\text{Fe}$ ratios (0.171 – 0.208) that are slightly more oxidized than MORB (0.16), similar to Mariana trough lavas that reflect minor traces of slab fluid influence (Ba/La~10). Melts last in equilibrium with the mantle (i.e. primary melts) are reconstructed from measured compositions with MgO > 5.0 wt% by backtracking along empirical and modeled LLDs to yield primary $\text{Fe}^{3+}/\Sigma\text{Fe}$ ratios. Pressures and temperatures of primary melt equilibration are calculated using Si-thermobarometry. FAB primary melts have $f_{\text{O}_2}$ and Ba/La ratios identical to modern Mariana trough magmas (QFM+0.4, Ba/La~9). This suggests that the first melts formed during subduction initiation come from a mantle source that is already oxidized, perhaps because the volume of mantle that oxidized slab fluids interact with to produce melts is small. Primary transitional melts have $f_{\text{O}_2}$ ~ QFM+0.8 and Ba/La~22, corresponding to an increase of 0.4 log units in 11 Ma. The modern mantle wedge $f_{\text{O}_2}$ is ~QFM+1.4 and Ba/La can exceed 50 (e.g., at Guguan volcano). This increase in mantle wedge $f_{\text{O}_2}$ may be due to the increasing influence of slab fluids on melting processes in the mantle wedge through time, suggesting that oxidation occurs immediately and increases at a rate of 0.04 log units per Ma in the early stages of subduction magmatism.

Elevated nitrogen isotopic composition of nitrate in the deep North Pacific during the last ice age

Fixed nitrogen in the water column is an essential nutrient and its distribution is linked to the cycling of carbon, phosphorus, and oxygen. The history of the isotopic composition of deep water nitrate reflects past variations in the relative magnitude of water column versus sediment denitrification. We determined the isotopic compositions of N ($\delta^{15}\text{N}$) and O ($\delta^{18}\text{O}$) of dissolved nitrate in sedimentary pore fluid in the North Pacific Gyre in order to infer changes in the deep ocean $\delta^{15}\text{N}$ and $\delta^{18}\text{O}$ values. Samples were collected on cruise 195 aboard the R/V Knorr during January-February 2009 from cores recovered below depths greater than 5000 meters at sites EQP 10 and 11. We correct the measured isotopic compositions for in situ nitrate production. In the resulting corrected profiles, both $\delta^{15}\text{N}$ and $\delta^{18}\text{O}$ values increase, by 1.5‰ and 2‰, respectively, between the shallowest and deepest sample (27 mbsf). Water at these depths is relict and has only partially exchanged with deep waters since the last glacial maximum (LGM). These are lower limit estimates of the actual isotopic shifts since the LGM due to the dampening effects of diffusion. We compare the measured (corrected for in situ nitrate production) profiles with predicted profiles based on measured solid phase sedimentary $\delta^{15}\text{N}$ values from sites that are below modern oxygen minimum zones, and the mean deep ocean
nitrate $\delta^{15}N$ estimates of Galbraith et al., (2013). The measured (corrected) $\delta^{15}N$ profile is similar to the predicted profile of solid phase sedimentary $\delta^{15}N$. In contrast, the global $\delta^{15}N$ estimate of Galbraith et al., (2013) does not produce a similar profile. The comparison suggests that regional changes in nitrogen cycling, (i.e. assimilation, remineralization, denitrification) are most likely responsible for the increased $\delta^{15}N$ and $\delta^{18}O$ in the past at our sites. We propose three possible driving mechanisms for the observed changes: 1) expanded water column denitrification in the deep waters of the North Pacific as compared to today, 2) enhanced transfer of a surface/intermediate water N isotopic signal via organic matter export since the LGM, potentially introducing regenerated nitrate with elevated $\delta^{15}N$ (observed in sedimentary $\delta^{15}N$ records), and 3) elevated $\delta^{15}N$ of preformed nitrate. Mechanism 1, expanded denitrification in the deep water, can account for the change observed in $\delta^{15}N$ and $\delta^{18}O$; neither of the other two mechanisms, however, satisfactorily describes the concurrent $\delta^{18}O$ shift. Understanding the changes observed in these pore fluid records could lead to a deeper understanding of the relationship between large scale climate change (glacial/interglacial transitions) and the nitrogen cycle, as well how these changes may impact the distribution of carbon in the ocean.

Time: 2:55 PM
Presenters: Anne M. Hartwell; Rebecca S. Robinson; Arthur J. Spivack
Location: 2008 (Moscone West)  

Mechanism of spontaneous and triggered shallow creep events - Implications for shallow fault zone properties

Slip on tectonic faults take place over a wide range of spatial and temporal scales as earthquakes, continuous aseismic creep, or transient creep events. Shallow creep events on continental strike-slip faults can occur spontaneously, or are coupled with earthquake afterslip, or are triggered by nearby earthquakes. Despite more than five decades of observations, the mechanism of shallow creep events and their implications for seismic hazard are still not fully understood.

To understand the mechanism of creep events, we developed a physics-based numerical model to simulate shallow creep events on a strike-slip fault with rate-and-state frictional properties (Wei et al., 2013). We show that the widely used synoptic model (Scholz, 1998) cannot reproduce both rapid afterslip and frequent creep events as observed on the Superstition Hills fault in the Salton Trough after the 1987 Mw 6.6 earthquake. Rather, an unstable layer embedded in the shallow stable zone is required to match the geodetic observations of the creep behavior.

Using the strike-slip fault model, we studied the triggering process of creep events, by either static or dynamic, or combined stress perturbations induced on the fault by nearby earthquakes. Preliminary results show that static stress perturbations in the effective normal stress on a system with spontaneous creep events can advance or delay creep
events. The magnitude and timing of perturbations determines the clock change of creep events. The magnitude and interval of creep events changes permanently after static stress perturbation. Dynamic stress perturbations in effective normal stress can advance the timings of creep events when the perturbation temporally decreases the effective normal stress. A threshold exists for instantaneous triggering. The size of triggered slip increases as the dynamic perturbation increases in the direction of less normal stress. The system returns to pre-perturbation state after a long period of no slip. The length of the recovery time depends on the size of triggered slip therefore the magnitude and duration of perturbation. Perturbations that temporally increase effective normal stress do not have significant influence on the timings of future creep events.

We applied our theoretical models to the Salton Trough, California, where both shallow creep events and earthquakes are common. We systematically analyzed the level of dynamic and static triggering from nearby earthquakes for the last 30 years, including moderate (> M5) to large (>M6) earthquakes. By incorporating these triggering to our fault model, we are trying to understand 1) which mechanism is dominant, static or dynamic; 2) whether a critical threshold exists, like in the generic model with synthetic dynamic perturbations for the instantaneous triggering of shallow creep events in Salton Trough; 3) the effect of fault orientation with respect to the incoming seismic waves.

By developing state-of-the-art models and constraining parameters with rich datasets from Southern California, we aim to transition from a conceptual understanding of fault creep towards a quantitative and predictive understanding of the physical mechanism of creep events on continental strike-slip faults.

Time: 5:15 PM
Presenters: Meng Wei; Yoshihiro Kaneko; Yajing Liu; Jeffrey J. McGuire
Location: 307 (Moscone South)
**Tectonic reconstruction models for the break-up and divergence of the Manihiki and Hikurangi plateaux**

The plate tectonic history of the Mid-Cretaceous seafloor located between the Manihiki and Hikurangi plateaux is poorly constrained due to the complex pattern of fracture zones and the lack of correlatable magnetic anomalies. Conventional plate reconstruction models suggest the Manihiki, Hikurangi and Ontong Java plateau were once part of a larger igneous complex, which broke up during a major plate reorganization at about magnetic anomaly M0 time (~120 Ma). The divergence between the Manihiki and Hikurangi plateaux continued for an unspecified duration, but likely ceased during another major plate reorganization event in the Late Cretaceous (71-84 Ma). At that time, spreading near the Osbourn Trough relocated to the Pacific-Antarctic divergent plate boundary. To understand the detailed tectonic history of the region bracketed by these plate reorganization events, we have assembled all available high-resolution multibeam data in the region. These data were used to quantify regional trends in abyssal hill orientations and to identify fracture zone locations and offset orientations. Our preliminary results suggest a fairly complex spreading history for the region, which requires multiple Euler Poles and ridge-axis relocation events. We present several tectonic reconstruction scenarios to account for these new observations. These tectonic reconstructions have important implications for the mantle plume-influenced history of the region and the origin/evolution of the Manihiki-Hikurangi-Ontong Java large igneous province.

**Time:** 8:00 AM  
**Poster by:** Robert A. Pockalny; Marah R. Dahn  
**Location:** Hall A-C (Moscone South)

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**Magnetofossils as tracers of oxygenation change: a case study from the stratified Pettaquamscutt River Estuary**

Magnetotactic bacteria (MB) are motile organisms commonly found around the oxic-anoxic-interface (OAI) in sediments and stratified water columns. Magnetite and greigite crystals synthesized by MB intracellularly, termed magnetosomes, can be preserved in sediments as magnetofossils. Changes in OAI thickness (due to changes in temperature, clathrate dissociation & methane oxidation, organic carbon supply/oxidation, or sedimentation rate) would produce proportional changes in MB population and sedimentary magnetofossil concentration. While potentially useful as an oxygenation proxy, magnetofossil quantification techniques and variables controlling their preservation in sediments need to be better understood. Most prior work focused on cultured magnetite-MB and sediment mixtures while studies of greigite-MB (found just below the OAI in the sulfidic hypolimnion) is lacking because axenic cultures do not exist. To address these issues, we study wild magnetite- and greigite-MB from the seasonally stratified Pettaquamscutt River Estuary Upper Basin (RI, USA) as a function of water depth, d. Transmission electron microscope imaging of 21 MB (377...
magnetosomes) revealed a complexity in wild MB not found in cultures. From d=3.9 m-7.0 m, live-cell assays confirmed the presence of multiple MB morphotypes, both north-(majority) and south-seeking (minority), and a few magnetic protists. Based on a previous microscopy study just 1.4 km south of Upper Basin (Bazylinski et al., 1995), magnetite-MB are expected for d<5.0 m, mix magnetite- and greigite-MB for 5.0 m<d<6.0 m, and greigite-MB for d>6.0 m. Coercivity distributions for all depths are characterized by a small variance, reflecting uniformity in magnetosome size. Interestingly, despite changing from dominant magnetite to greigite-MB with increasing depth, the median coercivity remained largely unchanged. Median coercivity is therefore not diagnostic of magnetosome mineralogy. We also report ferromagnetic resonance spectroscopy (FMR) results. The first derivative of the absorption spectra for d<5.6 m typically present multiple low-field maxima, which is consistent with observations from magnetite-MB cultures. In contrast, only one maximum in the spectra was observed for 6.0 m<d<7.0 m (where greigite-MB dominates). While this raises the possibility of using FMR to differentiate between greigite and magnetite magnetosomes, abiogenic samples with a similar FMR spectrum have also been observed. Additionally, in contrast with the sharply defined FMR parameters measured from magnetite-MB cultures, a wide range of parameters was found for the water column samples (asymmetry=0.8-1.3, alpha=0.27-0.34, geff=1.93-2.18, and linewidth=93-152 mT). Caution should therefore be taken when using FMR for magnetosome detection.

Time: 8:00 AM
Poster by: Amy P. Chen; Veronica M. Berounsky; Mun K. Chan; Bruce M. Moskowitz; Eduardo Andrade Lima; Robert E. Kopp; Clyde Cady; Benjamin P. Weiss; Paul P. Hesse
Location: Hall A-C (Moscone South)

A coordinated increase in export production and denitrification on the Costa Rica margin during the early Pleistocene

The oceanic carbon, nitrogen, and oxygen cycles are linked through export production, oxygen consumption, and denitrification. Denitrification, the bacterial reduction of nitrate, is an anoxic process that serves as the primary sink for fixed nitrogen in the ocean. The Eastern Tropical Pacific (ETP) houses an oxygen minimum zone (OMZ) where pelagic denitrification proceeds as a result of both large scale circulation and regionally high export of organic matter that fuels oxygen consumption in the subsurface. Here we present a 2.4 million year long record of denitrification and productivity in the ETP using ODP Site 1242. Site 1242 is located ~70 km off the west coast of Costa Rica, beneath the OMZ. Downcore records of bulk sedimentary nitrogen isotope values (δ15N) and opal and organic matter accumulation rates show near synchronous increases in δ15N values and biogenic sediment accumulation at approximately 1.6 My. The concurrent increase in the denitrification and productivity proxies suggests that regional oxygen demand could be driving the increase in denitrification observed at Site 1242. This is in contrast to what is observed elsewhere, where export productivity and denitrification changes do not appear to be coupled locally. Moreover, the timing of this increase is distinct from a previously observed increase in δ15N at California Margin Site 1012.
which occurred at ~2.1 Ma (Liu et al., G-cubed, 2008) and is also attributed to enhanced denitrification in the OMZ. These differences suggest that the Site 1242 record reflects a purely local or regional process. Interestingly, the later increase in denitrification at 1.6 Ma observed at Site 1242 does not appear to be restricted to the ETP, but rather shows similar timing to a $\delta^{15}$N shift in a site from the Arabian Sea OMZ (Muzuka et al., Proceedings of the ODP, 1991). The new data presented here will help in the development of a mechanistic understanding of relative roles of local and regional processes over global controls on intermediate water OMZ intensity.

Time: 8:00 AM
Post by: Victoria Yuan; Carlisle Bascom Jr.; Rebecca S. Robinson
Location: Hall A-C (Moscone South)

Pushing the Envelope: Ship to Shore Events and High-Bandwidth Telepresence Engages Scientists and the Public

Since 2009, the drillship JOIDES Resolution has engaged in an extensive program of live ship-to-shore events during its two-month scientific expeditions using a range of software applications and formats. The University of Rhode Island’s Inner Space Center has utilized a high bandwidth “telepresence” from ships such as the Ocean Exploration Trust’s E/V Nautilus and the NOAA Ship Okeanos Explorer, to bring live feeds from underwater exploration vehicles directly into museums, aquaria, science centers, boys and girls clubs, and K-16 classrooms. Both of these strategies have employed close partnerships between scientists and educators to bring cutting edge research and the excitement of exploration and discovery directly to the public in close to real time, but telepresence provides unique opportunities. Participants have been able to experience, live, launches of remotely operated vehicle systems including Jason/Medea on R/V Atlantis and Hercules/Argus on Nautilus, see scientific samples come up on deck for the very first time, observe previously- undiscovered shipwrecks at the same time as those on ship, and watch amazing deep sea creatures swim past deep water cameras. There are many benefits from high-bandwidth telepresence, including improved quality of images, video, and sound; the ability to move large data sets and files between ship and shore, allowing collaboration among individuals who are not on the ship; the ability to stage spontaneous "web events" among scientific, educational, and technical personnel at essentially any time; and more intensive interactions through use of social media, such as blogging, posting of multimedia products, and frequent question/answer sessions. These telepresence-enhanced activities assist the public in understanding the significance and excitement of these discoveries, the challenges of working in the deep sea, and the true nature of scientific processes. These interactions have significant impacts on their audiences, and also on the scientists and educators providing them.

Time: 9:30 AM
Presenters: Sharon K. Cooper; Dwight F. Coleman; Andrew T. Fisher; Dean Livelybrooks; Greg Mulder
Location: 103 (Moscone South)
Receiver function analysis of crustal structure beneath northeast Tibet

The Tibetan Plateau has been the prime site to understand the processes of continental collision, mountain building, and the interaction between tectonics. More detailed studies of crustal structure in northeast Tibet can be of great benefit to the understanding of crustal deformation and plateau growth mechanisms. We investigate crustal structure beneath 64 seismic stations in the northeast Tibet using the receiver function method to estimate the crustal thickness by analyzing the collected three-component teleseismic data recorded by 29 stations between June, 2008 and July, 2010 deployed by China University of Geosciences and 35 Ascent stations deployed between May, 2007 and August, 2008. The distributions of the crustal thickness have a good correlation with the known geological tectonic features. The images of Moho depth suggests the lateral variations of the crustal thickness decreasing from the northeastern margin of the Tibet (~70 km) to the Ordos Block (~40 km). The observations disagree with the crustal composition beneath the northeastern margin of the Tibetan plateau. Our results of crustal structure in this study area not only reveal the lateral inhomogeneity of the crustal structure but also provide some constraints on understanding the mechanism of uplift and crustal thickening of the Tibet and insights into the geodynamic process between the Tibet and its adjacent blocks.

Time: 1:40 PM
Poster by: Xinfu Li; Yang Shen; Hongyi Li; Danian Shi; Eric A. Sandvol; Aibing Li
Location: Hall A-C (Moscone South)