f-ratio on the transfer efficiency of carbon is tentatively attributed to greater biodegradability of organic matter exported from regions with high f-ratios, seasonality and cold SST. In high latitude opal-dominated regions, while a higher fraction of net production is exported, a higher fraction of the exported organic matter is remineralized before reaching bathypelagic depths. On the other hand, in low latitude, carbonate-dominated regions with low f-ratios, a higher fraction of the exported organic matter sinks to the deep-sea. Increasing the f-ratio or inducing diatom blooms by Fe fertilization may not result in a proportionally higher carbon flux to the deep-sea.

OS31F HC: Hall III Wednesday 0830h

Physical, Chemical, and Biological Processes Associated With Active Submarine Volcanism in the Pacific I

Presiding: **B Embley,** NOAA/Pacific Marine Environmental Laboratory**; M Kinoshita,** JAMSTEC

OS31F-100 0830h POSTER

Hydrothermal Microbial Ecosystem at the Suiyo Sea Mount on the Izu-Ogasawara Arc

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Microbial population and composition in hydrothermal fluid, plume and in situ incubation samples collected from the Suiyou Sea Mount caldera using Japanese submersibles in 2001 were estimated by recent bio-techniques for creating a microbial ecosystem model in this very active arc-type hydrothermal system, as well as finding new bio/gene resources. The Japanese Archaean Park Project supported this study.

In almost all samples including high temperature fluids emitted from drilled bore holes, microbial cells were detected and counted more than 10000 cells/ml, showing the predominance of the domain Bacteria in both molecular and cellular quantification analyses. Dense population was detected at the central region of the caldera, where Bathymodiolus bivalve-rice benthic animals colonized and made lots of patchy shell mounts, than the surrounding sandy seafloor. In hot subsurface samples obtained from a catheter-type incubator and others, many environmental gene clones assigned to new members within the epsilon-proteobacteria, and a few in archaea. Remarkable number of microbes was also detected in plume layer above the seafloor of the 1380 m depth, corresponding to anomaly in vertical nephelometric profiles (ca.1100-1200 m). Undeniable that a hydrothermal energy-driven, highly productive ecosystem is present in this isolated aphotic region, even in a hot sub-vent environment.

OS31F-101 0830h POSTER

Very High Productivity of Microbes in Hydrothermal Vent Unveiled with In Situ Measurement

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In deep-sea hydrothermal vent ecosystem, bacterioplankton exist usually 2 to 5 order of magnitude higher than in the ambient. As is generally suggested, these environments O'are in effect chemostatOL, where concentration of reduced compounds are continuously maintained in supersaturated level by the effluent of chimney. Our recent observation at Dai-Yon Yonaguni and Hatoma Knolls located in the southern part of Okinawa Trough, 1330 <ETH> 1530 m bsl supported that and moreover we first found directly that the microbial production was unexpectedly high in the vicinity of the plume. We succeeded to carry out incubation of near plume water under in situ condition near the dense colonies of the bivalve Bathymodiolus platifrons, using a diffusion chamber, which did not obstruct the supply of dissolved gases and elements. We detected 12-14% FDC, 22-26 hours generation time in number of bacteria and less than 1 hour of their biomass turnover time. Image analysis revealed significant increase in cell size of existing bacteria during 7 <ETH> 9 days incubation. Those belonged to domain Eubacteria according to in situ RNA hybridization.

OS31F-102 0830h POSTER

Hydrothermal Plume Processes in the Indian Ocean (Kairei and Edmond Vent-Sites, Central Indian Ridge)

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CD128 Science Party

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During May and June 2001, RRS Charles Darwin cruise CD128 conducted a detailed investigation of the physical dispersion of, and biogeochemical cycling within, non-buoyant hydrothermal plumes overlying the recently-discovered Kairei and Edmond ventsites on the Central Indian Ridge near 25 deg 19 min South and 23 deg 53 min South, respectively. The cruise combined detailed investigations into plume dispersion and biogeochemistry with deep-tow biological investigations in which RMT 1+8 nets were used to fish the identified plumes. In this talk we will provide an overview of the range of investigations conducted. Details of many of these will be presented in additional talks and/or posters. A total of 24 CTD stations were occupied for conventional water column sampling. These stations included a tow-yo directly across the Kairei vent-site to map out the dispersion characteristics of the plume and ten detailed "process" stations (8 at Kairei and 2 more, for intercomaprison, directly above the Edmond field) to investigate plume evolution characteristics. These process stations included simultaneous large-volume in situ filtration sampling of suspended particulates through three different pore-size filters coupled with time-series sampling of unfiltered water from the same locations, over 2-4 hour time intervals, using Niskin bottles. This novel approach allows us to investigate the kinetics of key reactions at plume height and the partitioning of different materials into coarse, fine and colloidal particulates as well as truly dissolved phases. Additional CTD operations included a time-series yo-yo directly above the Kairei site to investigate plume-tidal interactions and determine heat-flux from the site and a background station, approximately 200km off-axis, to provide first detailed trace-element geochemical profiles in East Indian Ocean basins. Water column sampling was completed with the collection of a suite of 10 further large volume in situ filtration samples, collected from the Edmond hydrothermal plume to investigate vertical cycling using combined radiochemical and geochemical techniques. For biological sampling, a key focus was the use of the RMT 1+8 nets for which 34 samples were collected within and above the Kairei and Edmond plumes. As with CTD operations, principal focus was at the Kairei site (22 of 34 deployments) with the remaining trawls conducted at Edmond. As with previous experience from the Mid-Atlantic Ridge, larval vent-shrimp were successfully recovered from the water column overlying both sites.

OS31F-103 0830h POSTER

Particle geochemistry and radionuclides in the Edmond and Kairei hydrothermal plumes, Indian Ocean: Preliminary results

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RRS Charles Darwin cruise 128 (May-June, 2001) was a detailed investigation of the chemistry and biology of the hydrothermal plumes overlying the newly discovered Kairei and Edmond vent sites on the Central Indian Ridge. As part of this study we collected large volume samples of particulate material for elemental and isotopic analysis using in situ filtration. A total of nine particulate samples were collected from the Kairei plume and thirteen from the Edmond plume. Of these, eight and five respectively have associated samples (in the form of manganese absorber cartridges) for measurement of dissolved thorium isotopes. With these samples, we will test hypotheses regarding the influence of hydrothermal plume processes on marine geochemical budgets via particle formation and scavenging.

We will present dissolved and particulate thorium-234, particulate lead-210, particulate Fe, and dissolved uranium data from these two plumes. Particulate Pb-210 activities are greater than 3 dpm/L in most of the samples from both plumes, which is high relative to previous results from the Rainbow plume on the Mid-Atlantic Ridge but comparable to or perhaps lower than values at TAG. Particulate Pb-210 activities are higher in the Edmond plume samples than in those from Kairei. Particulate Th-234 activities are generally quite low (only two samples with greater than 0.3 dpm/L, one from each site). Total (dissolved + particulate) Th-234 activities are in equilibrium (2.5 dpm/L) with the parent U-238 except for two samples at the Kairei site for which total activities are less than 2 dpm/L, indicating significant scavenging removal of Th-234. We will discuss the data in the context of our previous results from the Mid-Atlantic Ridge and available data from the Pacific Ocean as well.

OS31F-104 0830h POSTER

Iron (II) Oxidation Rates in Hydrothermal Plumes at the Kairei and Edmond Vent Sites in the Indian Ocean

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During Cruise 128 of RRS Charles Darwin to the Rodriguez Triple junction area of the Indian Ocean Ridge system, water samples were taken at the Kairei and Edmond vent sites. Both the neutrally buoyant plume (as identified by light scattering sensor anomalies) and the adjacent, background, water column were sampled. Where Fe (II) concentrations were too low to detect, a spike of Fe(II) was added to the water sampling bottle, and the loss of Fe II monitored with time. These incubation experiments were done at ambient deep-water temperature within the sampling bottles. Reactive Fe was determined by complexation with Fe II-specific Ferrozine, and molecular spectrophotometry. The average pseudo first-order rate constant for oxidation of Fe(II) for 11 experiments was 0.303(standard deviation 0.029)h-1 which equates to a half life of Fe II in these waters of 2.31h. This half-life is of the same magnitude as that predicted by Field and Sherrell (2000) for Indian Ocean waters, who argued that Fe oxidation rates should change through the major ocean basins as a result primarily of variations in oxygen concentration. The oxidation rate of Fe II naturally present in samples from the neutrally buoyant plumes was not detectably different to that of Fe II added to deep water collected from outside the plume, suggesting that no components in the plume significantly influenced the rate. These first data investigating rates using incubation of plume waters thus support the general argument of Field and Sherrel that there are substantial differences in Fe II oxidation rates in hydrothermal plumes between ocean basins. This slower formation of element scavenging iron (III) hydroxy-oxide phases in older waters with lower concentrations of oxygen will allow more time for effective mixing of background and hydrothermal waters and possible enhanced removal of some trace elements. Field, M.P. and R.M. Sherrell, Geochim. et Cosmochim. Acta, 2000. 64(4) 619-628.

OS31F-105 0830h POSTER

Total Dissolvable Manganese Anomalies Over the Knipovich Ridge: Evidence for Hydrothermal Activity

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The Knipovich Ridge extends between 73 'deg 50'N and 78 'deg (northern Norwegian-Greenland Sea) and spreads at just 8mm/year, full-rate (Crane et al., 1991). The ridge exhibits a single continuous rift-valley, ca. 500km in length, which lies at a water depth of >3000m

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and which is punctuated, every 50-100km along axis, by >500m bathymetric highs (Crane et al., in press). Recent research using the RV Professor Logachev with deep-tow sidescan sonar imaging indicates that these discrete axial highs represent centres of fresh neovolcanic activity which are separated by uniformly flat, sediment-covered rift-valley basins. During the same cruise samples of water were collected by CTD rosette, for the analysis of a number of variables including Helium, methane, dissolved trace metals, ATP and total manganese. A series of 9 vertical CTD profiles were occupied, above axial volcanic highs along the ridge crest from 74-78N, including one site directly above a deep-tow particle anomaly. Analysis of all 9 CTD profiles at SOC for total dissolvable manganese has revealed evidence of total manganese enrichment in discrete areas of the ridge system. Concentrations in the upper water column (<500m) are comparable to reported concentrations (circa 1nM, Yeats and Westerlund, 1991). Background concentrations in the deeper water column are of the order of 0.5-1 nM, but 5 CTD profiles show higher concentrations of TDMn (up to 3.5 nM) and an associated distribution in the water column which, together, are indicative of hydrothermal activity. The results presented here for total dissolvable manganese, combined with the results of the other analytical variables studied, provides evidence for the presence of hydrothermal activity along the Knipovich Ridge. The presence of hydrothermal activity at the ultra slow spreading Knipovich Ridge, in turn, suggests that hydrothermal activity can occur at all spreading ridges, world-wide.

OS31F-106 0830h POSTER

Modern seawater intrusion in a coastal aquifer of Jeju vocanic island, Korea: Geochemical and isotopic evidences

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We present here geochemcal and isotopic evidences of modern seawater intrusion in the coastal aquifer of Jeju volcanic island, Korea. The total dissolved solid (TDS) contents of groundwaters, collected from east and southeast coastal regions in Jeju island, are very high (up to 22,000 mg/L). Most of these waters are classified into Na-Cl type. Geochemical characteristics of major ions show that the changes of chemical compositions of ground waters were mainly controlled by the salinization process linked to cation-exchange reactions. Oxygen, hydrogen, sulfur, and strontium isotopic data clearly show a simple mixing relation between freshwater and seawater. Strontium isotopic compositions and Br/Cl ratios strongly suggest that the source of salinity is modern seawater intrusion rather than old seawater or formation water, this is also supported by the I/Cl ratio data. The highly permeable aquifers at the east coastal region are characterized by low hydraulic gradient and discharge rate and high hydraulic conductivity as compared with other regions. These properties create conditions that are advantageous to the salinization observed in the study area. Based on the chloride, oxygen, strontium isotopic data, seawater was determined to have intruded inland some 2.5 km from coastline. Considering the poor correlation of sampling depth and Cl concentrations observed, the position of seawater-freshwater interface is not uniformly distributed in the study area, reflecting that the distribution of permeable zones of the basaltic aquifers was controlled by the characteristics of lava flow and is very heterogeneous. The combined use of geochemical and isotopic data can provide useful information on the groundwater salinization process in coastal aquifers and assist in the design of effective freshwater resource management strategies.

OS31F-107 0830h POSTER

Distinction Between Hydrothermal vs. Diagenetic Contributions to Sediment Porewater Characteristics in Yellowstone Lake, Wyoming

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Dissolved mineral inputs to Yellowstone Lake come from a variety of sources, including hydrothermal vents, ground water, rain water, flux from sediments and direct runoff. One third of Yellowstone Lake, within the caldera, is directly influenced by hydrothermal activity (hot water vents and fumaroles). Geothermally heated water emanating from vents and fissures is highly enriched in carbonate, silicate, and chloride, with some locations additionally rich in methane, iron, and sulfide.

Microorganisms that live in high temperature ecosystems are tightly coupled to their environment. A detailed understanding of the geochemistry of hydrothermal environments can be an important component in deciphering critical characteristics for the presence of microbial life under changing conditions in this lake geoecosystem.

Vent waters in West Thumb typically contained submicromolar concentrations of Fe while those in Mary Bay and off Stevenson Island contain up to 10μM. The water column concentrations of dissolved Fe range from 250 to 450 nM in Mary Bay, but were <180 nM in the waters of South East Arm (outside of the caldera), West Thumb, and off Stevenson Island.

Pore water and vent water chemistry provide evidence for lake water dilution of vents below the sediment-water interface. Significant fracturing of source water conduits was indicated by extreme differences in pore water profiles from cores less than 5m apart in geothermally vigorous West Thumb. Some samples approached theoretical reservoir composition for conservative geochemical tracers. Likewise, pore water results from the geothermally active areas of Mary Bay and West Thumb show Cl^- enrichments reaching several mmolar and, in the case of Mary Bay, extrapolate to the geothermal end member ($\sim$ 20 mM) at a depth of only 2-3 m. These steep concentration gradients support diffusive Cl^- fluxes across the sediment-water interface 3 orders of magnitude higher than those in non-venting depositional areas.

OS31F-84 0830h POSTER

Ocean Currents at Axial Volcano, a Northeastern Pacific Seamount

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Analyses of year-long observations of currents and results from analytic and numerical models confirm that the principal subinertial motions around Axial Volcano are mode-one azimuthal trapped waves. Spectra of currents show tidal, inertial, and weather-band period (3-7 day) peaks. For K1, O1, and S2 tidal currents in a 300 m depth interval near the volcano's summit, amplitudes are enlarged with respect to background, motion is anticyclonic, and current ellipses tend to be rectilinear. In contrast, the weather-band amplitudes are negiligle at the summit depths but increase ten-fold down the flanks of the volcano. A linear, baroclinic, analytic model of flow shows that: 1) the observational distributions are compatible with simple oscillatory forcing and an azimuthal mode-one wave trapped to the volcano topography; and 2) the topographic amplification factor peaks at a period of $\sim$2 days and rapidly declines at longer periods, suggesting that the spectral peak in currents at weather-band frequencies must result from a similar peak in forcing rather than from a topographic resonance condition. The presence of weather-band spectral peaks make Axial unlike other seamounts where long-term current measurements have been made. A numerical model of flow at Axial adds information: 1) on mean currents, which, as the observations confirm, circle the volcano in an anti-cyclonic sense, and 2) about flow into and out of the volcano's caldera. In the second case, it appears that flow up and over the caldera walls should occur at tidal periods.

OS31F-85 0830h POSTER

Compressible Flow, Entrainment, and Megaplume

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It is generally believed that low Mach number, i.e., low-velocity, flow may be assumed to be incompressible flow. Under steady-state conditions, an exact equation of continuity may then be used to show that such flow is non-divergent. However, a rigorous, compressible fluid-dynamical derivation proves that the acceleration of fluid in radial laminar motion between parallel disks is proportional to the divergence of the velocity, and, to the contrary, velocity would be constant in non-divergent flow. Briefly, for an ideal gas in steady-state, laminar, and frictionless flow, four equations may be derived to solve the system exactly for the four unknowns – density, pressure, temperature, and velocity – without assuming incompressibility or non-divergence. This work shows that this finding is true for water as well. It also exploits the new theory to show that turbulent boundary layers, including jets and plumes, must consist of low-density fluid that expresses some of the corresponding low pressure through the equation of state. In the final analysis, the divergence of the fluid is established to be one of the basic mechanisms that causes turbulent flows to mix with the ambient fluid. The relationship between acceleration and divergence helps explain the role of jets in mixing. Similarly, it helps to explain jet and plume entrainment, including the entrainment of ambient fluid into oceanic megaplumes of volcanic origin.

OS31F-86 0830h POSTER

Numerical simulations of mid-ocean ridge hydrothermal circulation including the phase separation of seawater

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We numerically investigate the hydrothermal circulation, including the phase separation of seawater, which is suggested to be an important factor which controls the structure of hydrothermal circulation. It is particularly important around the ridge axis area underlain by magma chambers. The phase separation of seawater generates fluids with Cl- concentrations both higher and lower than that of seawater. One of the evidence of the phase separation is the diversity of Cl-concentrations of hydrothermal vent water

We numerically investigate the hydrothermal circulation, including the phase separation of seawater. We aim to find how the phase separation affect the circulation structure, and to find a relationship between the circulation structure and the salinity of venting fluid. In our numerical calculations, the seafloor is assumed to be at 250 bar, and the bottom of the calculated region is set at 400 bar and 600°C. Supercritical phase separation is inevitable for these pressure and temperature ranges. We focus on the steady-state structure, which may exist beneath fast-spreading ridges.

We find that the phase separation leads to two-layered structure. The seawater circulates vigourously in the upper layer, whereas dense brine sinks to form a stagnant lower layer. The lower layer inhibits effective heat transport, decreasing the heat flow compared with the circulation without the phase transition. The thickness of the lower layer, and hence the heat transfer, depends on the pressure and temperature ranges and the Rayleigh number. Between the upper and lower layers, the two-phase co-existing region forms where the relative transport between the two phases takes place because of the density difference. The fluid flowing through the two phase region changes its concentration. The salinities of venting fluids are both higher and lower than that of seawater, because conservation of the salinity is required for the steady state. The range of the salinity depends critially on the effectiveness of the phase separation, which is parameterized as a coefficient for the relative velocity between the two phases.

OS31F-87 0830h POSTER

Plume-Induced Currents and Topographically Enhanced Circulation at Endeavour Ridge

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We use velocity records collected from moored current meters over the past two decades to examine the impacts of seafloor topography and hydrothermal venting on near-bottom (2000 m depth) current variability over the Endeavour Segment of Juan de Fuca Ridge. Focus is on the 50-m vertical resolution time series collected from July-October 2000 near the main Endeavour vent field and on time series collected from July-October 2001 at three along-ridge sites within the 100 m deep axial valley. Partitioning of the velocity variance into specific frequency bands reveals that semidiurnal tidal currents are marginally more energetic than diurnal tidal motions, and that the flow above the ridge crest is often dominated by wind-generated inertial events and low-frequency O(10 day) current oscillations. Observations, supported by numerical modeling, suggest that subinertial motions (periods >16 hours at 48N) are strongly enhanced by the ridge topography. Both diurnal currents and the "blue-shifted" inertial currents are amplified as the crest depth of the ridge is approached but attenuate rapidly within the confines of the narrow (1 km) axial valley. Semidiurnal currents are much less affected by the ridge and remain approximately uniform with depth within the first 250 m of the seafloor. Within a few tens of meters of the valley floor, the flow is dominated by 5 cm/s along-axis semidiurnal oscillations and a surprisingly strong (2 to 4 cm/s), persistently northward up-valley flow which appears to be independent of, and generally counter to, the prevailing flow in the overlying water column. Findings suggest that the enhanced near-bottom flow is maintained by an along-valley pressure gradient created by turbulent entrainment of the cold (2 °C) ambient water by the superheated (350 °C) plumes and lower temperature diffuse flow rising from venting regions along the valley floor. The mean-flow dynamics may resemble that of the summer sea-breeze in coastal fjords whereby summertime heating of the land and proximity of a pool of relatively cold ocean water (in this case, the deep ambient water at the southern and/or northern ends of the axial valley) gives rise to strong up-channel "winds". In analogy with coastal inlets, the steep sides of the axial valley confine the thermally driven flow, allowing cold, high salinity bottom water to enter the central sectors of the axial valley from the south. Again, in analogy with the sea-breeze model, near-bottom currents in the valley would remain steady except for temporal variations induced by changes in the overlying "synoptic-scale" pressure gradients associated with low-frequency motions and eddy-like flow. Results likely have implications for the variability in biotic and abiotic fluxes from the axial valley of Endeavour Ridge.

OS31F-88 0830h POSTER

Long-term trace element monitoring at Axial Volcano using Osmotic samplers in hydrothermal Plumes.

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Osmotically pumped samplers were developed for long term trace element sampling and were deployed on moorings located within hydrothermal plumes above Axial Volcano on the Juan de Fuca Ridge for ~ 1 year intervals from 1999-present. Osmotic samplers continuously collect samples by using osmotic pressure to pull samples into long coils of acid washed Teflon tubing. Samples are preserved by osmotically pumping ultrapure hydrochloric acid into the sample stream. Individual samples from the osmotic samplers are obtained by cutting the Teflon tubing into 1 meter lengths (1.005 ± 0.003m) with a ceramic razor blade and expelling the fluid into individual sample vials resulting in a sample size of 490 ± 10 mg. The tests that we conducted demonstrate that sample collection and processing produce negligible contamination for Mn and a measured concentration in the blank for Fe of 2.2 ± 2.5 nM Fe.

As part of the NEMO observatory, osmotic samplers were added to our moored arrays of sensors at Axial Volcano in June of 1999. These moored instruments extend from the seafloor up into the neutrally buoyant plumes overlying Axial Volcano. A pair of samplers were collected in both 2000 and 2001. Two additional samplers are currently moored at Axial and will be recovered in 2002. Results obtained from a single sampler (1999-2000) show a long term trend in which Mn concentrations decrease over the first 300 days, and then return to the initial values over the remaining 90 days of the record. This long-term trend is overlain by shorter variations of 10 to 20 days.

Results will be presented from two osmotic samplers deployed from 1999-2000 and two from 2000-2001. Short term variations will compared to variations in light backscatter and current direction and intensity. Longer term variations will be compared with water column hydrocast measurements made at this site at the times of deployment and recovery. Data will also be presented to demonstrate the efficacy of the sampler.

OS31F-89 0830h POSTER

Bacteriogenic Iron Oxide Deposits From Axial Volcano, Juan de Fuca Ridge, North-East Pacific Ocean

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The cell walls of bacteria are intrinsically reactive towards metal ions owing to the presence of acidic functional groups within the macromolecular constituents of the wall. A study of this interaction was performed on modern seafloor hydrothermal iron oxide deposits from the caldera of Axial Volcano (45°N, 128°W) at a depth of 1550m. The deposits were characterized by x-ray diffraction (XRD), light microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), energy dispersive x-ray spectroscopy (EDS), select area electron diffraction (SAED), inductively coupled plasma-atomic emission spectroscopy (ICP-AES) and loss on ignition (LOI).

The iron oxides XRD traces showed no long range order and all but one sample displayed two broad peaks at d-spacings of approximately 2.6Å and 1.5Å, indicating 2-line ferrihydrite. The exception to this pattern was a sample that not only displayed peaks at 2.6Å and 1.5Å, but also at 4Å, 2.04Å and 1.71Å and is termed here enriched 2-line ferrihydrite. It is termed here as enriched because later investigation indicated that it contained high concentrations of the trace elements Cr, Cu, Ni and Zn. Light microscopy of peroxide digested samples revealed mineralized twisted stalks of *Gallionella* spp. and the linear *Leptothrix* spp. with a large proportion of diatoms also being present. SEM observations on critically point dried specimens enabled observation of the mineralized bacteria and EDS analysis. EDS confirmed that the mineralization associated with the microorganisms was composed principally of Fe. SEM also revealed the large abundance of bacteria in these samples as a cluster of iron oxide on one of the SEM mounts proved to be almost entirely mineralized bacteria.

Thin section TEM observation revealed a close association of mineralization around the cell wall of the bacteria. TEM-EDS analyses are in agreement with SEM-EDS analyses. SAED on the mineralized bacteria revealed both 2-line ferrihydrite and enriched 2-line ferrihydrite in agreement with the whole-sample XRD analysis. The enriched 2-line ferrihydrite also revealed bacteria with a style of mineralization different from the other samples.

ICP-AES analysis of the 2-line ferrihydrite samples revealed Fe-oxide concentrations of ∼26% to 48%. Other major oxides (Al2O3, CaO, K2O, MgO, MnO2, Na2O, SrO, SiO2) and trace elements (As, Be, Cd, Cr, Cu, Ni, Pb, Sb, Ti, V, Zn) were also present. Silica was present at levels of ∼ 18%, but after a light microscopy investigation of some dried silica, siliceous diatoms were found to be the major source. LOI of the 2-line ferrihydrite samples revealed concentrations of organic matter at ∼10-15%. The enriched 2-line ferrihydrite has Fe-oxide concentrations of ∼58%, relatively high concentrations of the trace elements Cr, Cu, Ni, and Zn and an organic content of 5%.

Partition coefficients were calculated for both the normal and enriched 2-line ferrihydrite. The strong sorption ability of Fe-oxides was demonstrated by logKd values of the elements Al, As, Cu, Fe, Mn, Ni, Sb ranging from 3-6. The elements Be, Cd, Cr, Pb, Ti and Zn were not detectable in the water samples from which the Fe-oxides were being precipitated, making a calculation of logKd for these elements impossible. The lack of detectable elements in the water samples did serve to further illustrate the strong sorption ability of these microbial precipitates.

OS31F-90 0830h POSTER

NeMO Observatory Data Management, Manipulation, and Access on Desktop Computers and the World Wide Web

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Four years of annual visits to the NeMO seafloor observatory at Axial Volcano have provided the interdisciplinary science team with a large amount of data to manage. Each year a cruise report is compiled, including dive logs and maps, sample and experiment information, discipline summaries and more. Paper copies of the reports are distributed to cruise participants and digital copies are available on the NeMO website: http://www.pmel.noaa.gov/vents/nemo/. In addition, all the cruise-related data are input into a vector-based GIS (Geographic Information System), ArcInfo. During all four field seasons of the NeMO project (summer 1998 - 2001), this GIS database has been available at sea for use by the scientific party using a graphical user interface to the GIS, ArcView. Within the last year, the added capability of real-time ROV tracking over the GIS database has been available using ArcView Tracking Analyst. When all the data for the year have been processed (navigation, sample tables, etc.) they are brought into several programs for geographical reference and analysis. Maps can be created using a variety of programs, including the GIS, which provides a way to geographically display several types of data at the same time in a legible format. The GIS user can query the database in a variety of ways (for example, samples at a site for all years, or all instruments deployed and recovered at a site). One can also query for all of one type of sample (for example, bacterial traps deployed/recovered over a specific time interval). ArcInfo-compatible programs, such as Erdas Imagine, are also used for data analysis. Erdas is a valuable tool for raster-based data, such as sidescan and bathymetry images, which can be overlaid with vector-based data to locate lava flow boundaries, visualize lava morphologies, and guide the user in dive planning while at sea. This year we are working toward serving the NeMO database over the web using ArcIMS (Internet Map Server). ArcIMS will provide another way to disseminate the NeMO GIS database to users in the NeMO community and other interested parties. Users will be able to display and query the data, add new layers, and download data for local analysis. The database available via ArcIMS will begin with maps and selected data sets and will expand based on user input, available funding, and as more data become available.

URL: http://www.pmel.noaa.gov/vents/nemo/

OS31F-91 0830h POSTER

The Role of Biological Nitrogen Fixation in Hydrothermal Vent Ecosystems

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The possibility that chemolithotrophic microorganisms at hydrothermal vents are fixing nitrogen gas (N_2) has yet to be investigated thoroughly. At typical unsedimented mid-ocean-ridge hydrothermal vents, the concentrations of ammonium and nitrate (inorganic nitrogen sources that all microorganisms can utilize) are depleted in venting fluids above 10° C. Dissolved N_2, however, is present in high levels in both seawater and hydrothermal fluid. Nitrogen fixationthe reduction of

N_2 to ammonium by Archaea and Bacteriamay be important in nitrogen-limited habitats such as the subseafloor and diffuse vents. Nitrogen isotope ratios of vent animals, although highly variable, are consistently depleted in 15N relative to non-vent deep-sea fauna. One possible explanation is that some hydrothermal vent primary producers may be fixing molecular nitrogen (which has a $^{15}N/^{14}N$ of 0) and thereby providing vent animals with an organic nitrogen source that has negative $^{15}N/^{14}N$ values. The ability to fix nitrogen is distributed randomly throughout members of the Archaea and Bacteria, making it difficult to predict which hydrothermal vent microorganisms are potential nitrogen-fixers. The nitrogenase enzyme complex is responsible for nitrogen fixation, and is encoded by the *nifHDK* genes. The *nifH* gene in particular has been highly conserved throughout evolution, making it possible to design PCR primers that amplify the gene from an environmental sample. In order to identify potential nitrogen fixers in the subseafloor and free-living hydrothermal vent microbial communities, these primers were applied to vent fluid samples from diffuse vents at Axial Volcano and Endeavour Segment on the Juan de Fuca Ridge. The *nifH* gene was amplified from four different samples, including background deep-seawater, and cloned into *E. coli* vectors and sequenced. Phylogenetic analysis of the resulting amino acid sequences of the nitrogenase enzyme revealed that each sample contains a unique and highly diverse *nifH* population, distinct from the background deep-seawater *nifH*, and includes methanogens and anaerobic proteobacteria.

OS31F-92 0830h POSTER

Moderately halophilic bacterial populations from deep-sea hydrothermal vents: The effect of pressure and community time-series analysis

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Brines produced by super-critical phase separation beneath deep-sea mid-ocean ridges have been invoked to explain the occurrence of moderately halophilic microorganisms in deep-sea hydrothermal-vent environments (Baross and Deming 1995; Kaye and Baross 2000). While there is conclusive evidence that these brines exist at extremely hot (>400°C) temperatures (Kelley 1997), it is difficult to construct geochemical and geophysical models to describe extensive subseafloor brine environments at mesophilic to hyperthermophilic temperature ranges. An alternative explanation for the high abundance and diversity of moderately halophilic bacteria in low-temperature hydrothermal emissions and in the water column is that halotolerance is actually induced by an environmental stress other than salt. Pressure and heavy metals are likely candidates.

Diffuse flow environments at Axial Seamount and the Endeavour Segment of the Juan de Fuca Ridge are both elevated in heavy metals and under high pressure (150-220 atm). From these fluids we isolated numerous strains of halotolerant bacteria belonging to the genera *Halomonas* and *Marinobacter* and found that moderately halophilic bacteria comprised 0.01-10% of the total microbial community based on quantitative enrichments and epifluorescent counts. At ambient pressure, the isolates grow between -1 and 40°C and with up to 25% NaCl. Some strains grow with millimolar cadmium concentrations.

Pressure experiments are in progress to determine the optimal growth conditions of selected *Halomonas* strains in a pressure-temperature-salinity space constrained between 2-40°C, 2-20% NaCl and 1-660 atm. These growth rate data will reveal how pressure and salt interact to affect microbial physiology over a range in temperature, and they also hold implications for microbial adaptation to subseafloor environments of varying salinity. Also in progress are time-series molecular-phylogenetic analyses of moderately halophilic bacterial populations from diffuse flow sites on Axial Seamount collected annually since 1998. We expect that many of the organisms discovered by this molecular-phylogenetic approach will have been cultured. With the knowledge of their physiologies and how their diversity changes through time and in relation to fluid chemistry, these data may shed light on the dynamic subseafloor hydrothermal system that supports them.

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Kelley, D. S. 1997. Fluid evolution in slow-spreading environments. *In* Proceedings of the Ocean Drilling Program, Scientific Results, Vol. 153 (J. A. Karson, M. Cannat, D. J. Miller and D. Elthon, Eds.), pp. 399-415. Ocean Drilling Program, College Station, Tex.

OS31F-93 0830h POSTER

Modeling Metal Speciation in Subsurface Environments

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Oceanic subsurface environments are capturing attention as hospitable sites for microbial life. Most of these subseafloor environments are currently difficult to sample; we can only examine the surface expressions of such potentially energy-rich subseafloor habitats as deep-sea hydrothermal systems, serpentinizing subduction seeps, and carbonate-precipitating peridotite springs. The fluid flow paths and different solid substrates that give these environments their unique chemical characteristics are amenable to geochemical modeling, providing one means to examine the habitability of these locales. As a first step in characterizing subseafloor microbial environments, we calculated inorganic speciation of trace metals with biological roles. Many different enzymes require a central metal ion for function, some metals can be used for energy sources, and some metals are toxic, even in low concentrations. Metals, both those required for life and those that are toxic, may be biologically unavailable if complexed. The speciation of metals (Mn, Fe, Co, Ni, Zn, Pb, Cd) was examined in the presence of ligands (Cl^-, $SO_4{}^{-2}$, $HCO_3{}^-$, $CO_3{}^{-2}$) in solutions with major element compositions representing different subseafloor environments. We combined the latest thermodynamic data for inorganic ions and complexes in seawater and hydrothermal solutions with new estimates for metal bicarbonate and carbonate complexes to calculate equilibrium speciation of metals. As an example, subseafloor environments with temperatures and composition that reflects the mixing of seawater with endmember hydrothermal fluid (composition similar to that found at 21°N on the East Pacific Rise) have free metal ion concentrations that, in the absence of organic ligands, vary within biologically relevant temperature ranges. Preliminary inorganic speciation results indicate that for Ni, Fe, and Co, the temperature below which over 50% of the metal is the free ion is, respectively, 350°C, 220°C, and 150°C, leaving the bulk of these metals as free ions at habitable temperatures. However, for Mn and Zn this temperature is 40°C, raising questions of biological availability of these metals in warmer (100°C) environments. The highly toxic elements Cd and Pb never present more than 5% of their complement as the free ion in this modeled mixing system, making these hydrothermal habitats more hospitable than they otherwise appear.

OS31F-94 0830h POSTER

Tidal Perturbations of a Submarine Hydrothermal System

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In September of 1995, several temperature excursions were observed in the fluid evolving out of the Puffer vent located in the Main vent field of the Endeavour Ridge. These negative temperature deviations, ranging up to approximately 10 C in magnitude, coincided with high tide, and were accompanied by chloride enrichments. One, theory that explains this suite of data, postulates that these temperature and fluid chemistry variations have their origins in the pressure changes brought on by tidal cycles. In this hydrothermal system, the temperature of the evolving fluid and the pressure on the fluid just below the sea floor put the fluid on the two-phase curve right near the critical point. Under such circumstances, the fluid in the system would be highly compressible such that small pressure changes would result in large volume fluctuations. The changes in the height of the water column over the course of a tidal cycle produce the type of pressure oscillation that would be required to produce a significant change in fluid volume. The compression of the fluid that would result at high tide would establish a pressure gradient across the conduit wall of the vent, and the wall would crack. Such a cracking event would permit the inflow of colder saltier water, which would then mixes with the hot and relatively fresh vent effluent. The result would be colder saltier fluid rising from the vent, and this is consistent with experimental observations.

In order to study this phenomenon in more depth, a resistivity probe was developed and equipped with a thermocouple to allow continuous monitoring of the salt content and temperature of the effluent. The probe is capable of taking samples over very short time intervals for extended periods of time. Although we have not yet seen other temperature excursions on the time scale as those observed at Puffer, several sets of data collected by multiple probes clearly demonstrate the existence of a 24-hour tidal component in the both the resistivity and temperature oscillations of the fluid. The current focus of the research is on characterization and improvement of the probe, and analysis of the current data set.

OS31F-95 0830h POSTER

Observations and Sampling of an Ongoing Subsurface Eruption of Kavachi Volcano, Solomon Islands, May 2000.

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Kavachi Volcano lies on the New Georgia Group forearc only some 30 km east of the convergent boundary where the Indo-Australian plate subducts beneath the Pacific plate. One of the most active of SW Pacific arc volcanoes, eight recorded eruptions have built Kavachi above sea level since 1939, but no permanent island has yet survived. Despite the many observations of volcanic activity, there are no published reports of samples collected during an eruptive event. On the morning of 14 May 2000, the CSIRO research vessel RV Franklin visited the site in the course of a multidisciplinary investigation of submarine volcanic-hydrothermal systems in the island arc regions of Papua New Guinea and the Solomon Islands. We were surprised to find Kavachi in active eruption and spent 20 hr observing the eruption characteristics and sampling the adjacent waters. We fixed the location of the eruption column at $8°59.65'S$, $157°58.23'E$ and estimated the depth of the volcano peak at 2-5 m based on the appearance of breaking swells between eruptions. Eruptions typically occurred every 5 min, hurling incandescent blocks of lava (clearly visible at night) and black ash up to 70 m high, and mushrooming sulfurous steam plumes to 500 m. Local reports indicate Kavachi remains active, but still submarine, as of September 2001. A video record of the eruption activity will accompany this poster.

We comprehensively mapped the near-field hydrography and particle distribution by conducting two CTD/optical/rosette "tow-yos" to completely circle the eruption peak at a distance of about 1.5 km, approximately along the 500 m isobath. This ring transect revealed three distinct particle plumes: (1) an intense but thin surface layer to the west (240-300°T) of the peak, roughly overlying a submerged volcanic ash ridge; (2) a thick layer of multiple particle maxima extending from the seafloor up to the bottom of the pycnocline (at 200 m) to the southeast (120-210°T); and (3) a widespread bottom nepheloid layer. Three vertical casts at a distance of 4-5 km from the peak found multiple particle maxima on the volcano flanks to depths of 1500 m. Of 22 samples collected for ^3He, pH, and dissolved/particulate trace metals during the ring transect only two had a confirmed hydrothermal/magmatic character as indicated by elevated ^3He and total dissolvable Fe: one in the surface plume and one in a deep particle maxima. Dissolved Mn was everywhere <5 nM except for a value of 23 nM in the high ^3He surface plume sample. SEM photos show an overwhelming abundance of glass shards (including one with encrusted halite crystals), but no concentration of obvious hydrothermal precipitates. We conclude that the great majority of suspended particles were lava shards moving down the volcano flanks in multiple, quasi-continuous turbidity layers. Discharge of hydrothermal/magmatic fluids during the eruption was minor in comparison.

OS31F-96 0830h POSTER

Fluctuation in Flow Velocity and Temperature of Hydrothermal Fluids at Suiyo Seamount, Izu-Ogasawara Arc, Western Pacific

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We deployed a deep-sea fluid monitoring system, Medusa/Gemini, at Suiyo Seamount, Izu-Bonin Arc, Japan, in August 2001. The Medusa/Gemini is an instrument designed by a team lead by A. Schultz and monitors the flow rates and temperature of effluent flowing out of a cased seafloor borehole. We deployed three Geminis G3, G4 and G5 and recovered G3 and G5 by ROV "Hakuyo 2000". We recovered G4 using submersible "Shinkai2000" 23 days after the deployment. G3 was set up on two borehole sites with high temperatures of about 300°C for an hour. G5 was set up on the borehole with temperature of several tens of degrees for 9 hours. G4 was recorded flow rate, fluid temperature and seawater temperature for 23 days on the borehole site. Power spectrum analysis on this data shows clear periodicity. Flow rate and fluid temperature of Geminis shows wide variation with several peaks. Fluctuations in the fluid velocities show strong correlation with that of temperature for all Geminis. It suggests that the fluid is driven by buoyancy.

This research is funded by Ministry of Education, Science and Technology through Special Coordination Fund "Archaean Park" project.

OS31F-97 0830h POSTER

A month-long observation of thermal fluctuation at a hydrothermal site in the summit caldera of the Suiyo Seamount, Izu-Ogasawara Arc.

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Following the BMS drilling operations by R/V Hakurei-maru No. 2 at a hydrothermal site in the summit caldera of the Suiyo Seamount (Urabe et al., this meeting), we conducted seafloor observatory works by two successive cruises, i.e., an ROV "Hakuyo 2000" cruise supported by M/V Shinsei-maru from July 28 to August 11, 2001 and a manned-submersible "Shinkai 2000" cruise supported by R/V Natsushima from August 23 to September 18, 2001. We deployed and/or recovered 1 CTD with redox, pH, OBS and DO sensors, 2 precision pressure recorders, 5 ZABUTON thermal blankets, 3 SAHF heat flow probes, 5 seepmeters, 2 MAVS3 currentmeters and 3 sets of high temperature/redox recorders. Some of the instruments is still staying on the seafloor for a year-long monitoring. Except for the high temperature/redox recorders, the temperature probe devices were deployed at least several meters apart from visible vents.

The degradation of heat flow value to the west of the hydrothermal site was larger than that of the east, which indicated asymmetric thermal structure beneath the seafloor. Tidally-modulated temperature variations were commonly observed either in the temperature records of the water near the seafloor or in those of the sediment beneath the seafloor. Inverse correlation of temperature changes between several sites would imply simultaneous but different responses of fluid discharge and recharge against tidal loading.

Neither the temperature records from Aug. 5 to 24 in hot-water natural vent (292 to 298 deg C) nor those in warm-water vent (7 to 23 deg C) did not show apparent tidal component. The temperature of the hot water gradually rose up to 297 deg C towards middle of Aug. 14 and then stayed around 296 deg C during the rest of the days. on the other hands, the temperature of the warm water vent rose up from 7 to 15 deg-C fluctuation to 23 to 12 deg-C fluctuation on Aug. 14.

This research was funded by the "Archaean Park" Project (International research project on interaction between sub-vent biosphere and geo-environment funded by Special Coordination Fund of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan. The R/V Natsushima cruise with the sub "Shinkai 2000" was a part of the Deep Sea Research project of the Japan Marine Science and Technology Center (JAMSTEC).

OS31F-98 0830h POSTER

Stable isotopic compositions of CO in hydrothermal fluids: signature of sub-seafloor biosphere?

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Concentrations and stable carbon isotopic compositions (δ^{13}C) of CO_2, CH_4, and CO dissolved in hydrothermal fluids of the Suiyo seamount (ca. 1,380 meter depth), located in the southern part of the Izu-Bonin (Ogasawara) arc, have been determined precisely for each vent in the site, for the aim of searching geochemical signatures of subseafloor biosphere in hydrothermal fluids. If there would be some microbial chemosynthesic activities within the fluid conduit, concentrations and stable carbon isotopic compositions of such components must be altered through the activities, which could be result in heterogeneous compositions of such components within vents.

More than 30 samples have been sampled from more than 15 vents (both high and low temperature) in the site by using gas-tight water sampler (WHATS) attached to the Japanese manned submersible *SHINKAI 2000*, JAMSTEC. While δ^{13}C of CO_2 and CH_4 show homogeneous value with ± 0.5 $^{o}/_{oo}$ variation in the site, those of CO show average δ^{13}C of -31 $^{o}/_{oo}$PDB with 1 σ variation of more than 2.0 $^{o}/_{oo}$. The reason for the variation will be discussed in relation to the activities of sub-seafloor biosphere.

OS31F-99 0830h POSTER

Behavior of Bio-Essential Elements during Subvent Hydrothermal Alteration of Volcanic Rocks at the Suiyo Submarine Volcano, Japan

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Microorganisms require so-called bio-essential elements for their enzymatic activities and to construct their bodies. Mo, Mn, Cu, Zn and B are representative bio-essential elements and P is also essential major elements. In order to understand the ecological conditions of subvert microorganisms, it is necessary to understand the behavior of bio-essential elements in the hydrothermal fluids. The hydrothermal field of the Suiyo submarine volcano was drilled in order to examine the hydrothermal process and possibility of subvert microorganisms. Altered and less altered igneous rocks were recovered from these drilling procedures. Chemical compositions were determined on the bulk samples of drill cores to examine the elemental behavior during hydrothermal alteration. Also electron microprobe analyses were performed on the representative samples to examine the elemental distribution within the thin section scale (1cm x 1cm). Petrography and X-ray diffraction study indicate the various degree of alteration among the examined samples. Altered rocks contain abundant clays, sulfates and sulfides, and less altered rocks still exhibit the original igneous textures. Degree of alteration is related to the total REE concentrations or LREE behavior: LREE is depleted in heavily altered samples. It is found in this study that bio-essential elements are, in general, extremely mobile during hydrothermal alteration. For example, concentrations of B are depleted in heavily altered rocks, suggesting B was simply leached away from original rocks. On the contrary, concentrations of other metallic elements, such as Mo, are increased in the heavily altered rocks, associated with precipitation of sulfide minerals. Notable feature is behavior of P during alteration. Electron microprobe analyses indicate (1) the strong depletion of phosphate minerals in altered rocks and (2) co-precipitation of phosphates with hydrothermal sulfides. These data suggest that the bio-essential elements will be available for subvert microorganisms right after these elements are leached from rocks before sulfide precipitation.

URL: http://www.ganko.tohoku.ac.jp

OS31G HC: Hall III Wednesday 0830h

Recent Advances in Understanding Submarine Biosystems and the Future in Submergence Research I

Presiding: **P Fryer,** University of Hawaii**; S Pomponi,** HBOI

OS31G-108 0830h POSTER

The National Deep Submergence Facility

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The Deep Submergence Vehicle ALVIN has a long history of service to the ocean biology community from shallow mid-water to depths of 4500 meters and has developed many tools and techniques to meet unique sampling objectives. The flexibility of ALVIN's electrical, mechanical, data, payload, and hydraulic systems allows rapid integration of new sampling equipment, techniques and instrumentation. The support vessel, RV ATLANTIS, provides the necessary technical and scientific support to carry out field programs.

The remotely operated vehicle (ROV) JASON II, the ARGO II towed survey system, and the DSL-120A sonar can all be accessed as part of the National Deep Submergence Facility (NDSF) in a manner similar to DSV ALVIN. JASON can operate in water depths to 6000 meters and carries a standard sensor suite consisting of various video and film based imaging devices, side scan sonar, sector scanning sonar and manipulator. Additional sensors such as an electronic still camera, temperature probes, multibeam sonars and magnetometer have been used on the ROV, and connections are available to incorporate other specialized instrumentation. JASON II is a new vehicle and will be placed in service in mid-2002. ARGO II is a deep-towed vehicle designed to support both high altitude down-looking video and acoustic sonar sensors. Normal tow altitudes for video and 35mm film coverage are 10m. ARGO II can support a wide variety of cruise specific instrumentation as the vehicle has similar interface capabilities to JASON. The DSL-120A is also a deep-towed sidescan sonar with phase-difference bathymetric capability. It is normally towed 100-150m above the seafloor and provides a nominal 1-km swath of backscatter imagery and high-resolution bathymetry. The community will inform about the capabilities of these systems.

WHOI has two autonomous underwater vehicle systems (AUV) for use in submergence science operations, the Autonomous Benthic Explorer (ABE) and Remote Environmental Monitoring UnitS (REMUS). Although these are not formally a part of the NDSF, they are operated by WHOI personnel and are compatible with the NDSF assets. ABE was designed principally to address the need for long-term monitoring of the seafloor. It is powered by rechargeable gelled lead-acid batteries to facilitate testing and maintain low cost and has reliable and precise navigation and control. As presently configured, ABE's principal data is CTD, magnetometer, bathymetry, and monochrome stereo image pairs. REMUS is a low cost AUV designed for coastal monitoring and multiple vehicle survey operations. REMUS has been primarily funded by NOAA's National Undersea Research Program (NURP) and ONR's 6.1 and 6.2

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