elements such as Ti, Nb, Ta, Zr and Hf etc.). Deep portions of recycled oceanic lithosphere (refertilized previously depleted peridotites) are the most likely candidates for OIB sources [*Niu et al.*, Geochemistry of near-EPR seamounts: importance of source vs. process and the origin of enriched mantle component, *Earth Planet. Sci. Lett.*, *199*, 327-345, 2002] in terms of petrology, geochemistry and mineral physics.

V72A MCC: Hall C Sunday 1330h

Linking Chemistry and Microbiology in Seafloor Hydrothermal Systems I
Posters *(joint with B, OS)*

Presiding: **T Urabe,** University of Tokyo**; R Embley,** NOAA Pacific Marine Environmental Laboratory

V72A-1279 1330h POSTER

Broad-Host Range Vector-Particle: Gene Transfer Particles From Thermal Vents

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Viruses or virus-like particles (VLPs) are common in aquatic ecosystems, however, VLP-host interactions and its commitments to gene transfer in the environment is yet unclear. We have proposed that at least some of the widely distributed VLPs could be general gene transfer agents among a wide range of microbial host cells, and might function as a universal vector (1-4).

To elucidate such a broad host range gene transfer mediated by "VLP", the sampling site was extended to the hyper hydrothermal vent, and boring cores. VLP (v) and cell (b) abundances per ml water samples from drilling holes of Suiyo seamount were: APSK04 ($28^\circ 34.303' N, 140^\circ 38.618'$E, 1385 m deep, $21^\circ C, b = 8.26 \times 10^6$, v = 6.03×10^6); APSK07 ($28^\circ 34.299' N, 140^\circ 38.690'$E, 1386 m deep, $250.5^\circ C, b = 5.33 \times 10^4$, v = 2.52×10^4); a natural vent near APSK05 ($28^\circ 34.322' N, 140^\circ 38.594'$E, 1382 m deep, $304.7^\circ C, b = 3.23 \times 10^4$, v = 1.85×10^4).

A boring core sample was obtained from APSK06 ($28^\circ 34.313' N, 140^\circ 38.617'$, 1386 m deep), from which a hyper thermophilic Archaean, *Thermococcus kodakaraensis* was successfully cultivated in sulphur supplemented medium between 70 and $90^\circ C$.

VLP production was observed from *T. kodakaraensis*, whose VLP (v) and cell (b) abundances per ml at 480 h culture at $70^\circ C were : b = 3.61 \times 10^9$, v = 3.46×10^9.

Transduction experiment at multiplicity of infection of *ca* 0.2 using particles from APSK07 and *T. kodakaraensis* showed a plate efficiency on recipient *Escherichia coli* AB1157 by *ca* 72 % and *ca* 89 % regardless of UV treatment of the particle. Gene transfer frequency of APSK07 particle was ($\times 10^{-5}$ cfu/particle) between 2.4 and 0.92, and that of *T. kodakaraensis* particle was between $\times 10^{-4}$ and $\times 10^{-5}$ cfu/particle.

These findings suggest the non-specific gene transfer by such particles may be a ubiquitous event in the natural environment. Such gene transfer particles may have mediated gene flux among phylogenetically diverse microbial communities since the early age of the Earth. This research was partly supported by "Archaean Park Project", through MEXT, Japan.

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V72A-1280 1330h POSTER

Archaeal Community in the Hydrothermal System at Suiyo Seamount on the Izu-Ogasawara Arc

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Archaeal communities in extreme environment have been analyzed by phylogenetic analysis using 16S rDNA gene and fluorescent whole cell in situ hybridization method. These culture-independent methods revealed archaeal communities with much higher diversities than those found by conventional culture methods. In this work we have extended the culture-independent method to the analysis of microbial diversity in a deep-sea hydrothermal system at Suiyo Seamount.

In the Archaean Park Project supported by Special Coordination Fund, several holes were bored and cased in the crater of the Suiyo seamount on the Izu-Ogasawara arc (about 1,400 depth) in 2001 and 2002. Hydrothermal fluids form these cased holes and black smoker chimneys were sampled at various sites on Suiyo seamount. The fluids were filtered to collect the microbial cells. Filters and black smoker chimney samples were crushed and DNA was extracted and purified. The DNA was used to amplify archaeal 16S rDNA fragments by PCR using an archaea specific primer set. The PCR fragments were cloned and sequenced. Archaeal PCR clones of different samples will be compared.

V72A-1281 1330h POSTER

Characterization of a Novel Thermococcus sp. from a Hydrothermal Vent of the Suiyo Seamount

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The Suiyo seamount is located at 210 km north-northwest of Chichijima Island of the Izu-Bonin Arc. The hydrothermal vents of the Suiyo seamount discharges hot water as high as 308 degrees. We obtained a novel Thermococcus sp. from the hydrothermal vent and partially characterized it. The Thermococcus sp. was observed as usual coccus in initial stages of culture, but changed to transparent cells, within which one or a few spots exist. In the present study, the process of the alteration of the appearance was studied. Materials and Methods: Hot water (maximum temperature of 100 degrees) from a hydrothermal vent of Suiyo seamount was filtrated with a Nuclepore filter (pore size 0.2 micro m) on a research vessel. The filter was brought back to the laboratory, being kept at ?20 degrees, and inoculated into the Thermococcus medium (JCM280, pH 7.0) under anaerobic conditions (nitrogen:hydrogen:carbon dioxide=80:10:10). This was cultured at 80 degrees. For observation by fluorescent microscopy, fluorescent dyes Live/Dead (Molecular Probes) were used. Results and Discussion: The Thermococcus sp. was purified by a series of dilutions to extinction. Analysis of 16S rDNA indicated that this organism belongs to Thermococcus, showing the highest homology of 99.5 percent with T. sulfurophilus. This organism showed a peculiar characteristic; in growth curve, the cell density once declined in an early stage of growth, and then, increased again. We took the culture at the point of the first peak and saw it by phase contrast microscopy. Some cells are singular, but the others are in pairs. Surprisingly, the paired cells fused in 1 h under microscopic observation, which could explain the decline in the growth curve. The steady state of the coccus was very short, and it soon changed to transparent cells, which looked transparent under phase contrast microscopy, and within which one or a few spots exist. These spot green-fluoresced under fluorescent microscopy with Live/Dead. This finding suggests that the transparent cells are live and the spots contain DNA. The possibility that the spots represent spores is discussed; there have been no reports of spores of Thermococcus.

V72A-1282 1330h POSTER

Euryhaline Halophilic Microorganisms From the Suiyo Seamount Hydrothermal Vents.

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The euryhaline halophilic microorganisms grow in a wide salinity range from <3% NaCl (seawater equivalent) to >15% NaCl or to even saturation (about 30% NaCl). A number of euryhaline halophiles have been found in a wide range of habitats from oceanic and terrestrial regimes, from deep-sea vents and seeps, and from Antarctic sea ice and terrains. We have isolated the euryhaline strains independently from a Mid-Atlantic Ridge vent fluids and Antarctic terrains are closely related species of the genus Halomonas.

Some euryhaline halophiles maintain intracellular osmotic balance by controlling the concentration of compatible solute such as ectoine. This compatible solute not only stabilizes the proteins from denaturation caused by high salt concentration but also serves as a protectant against stresses such as heating, freezing and drying.

The sub-seafloor structure of a hydrothermal vent is highly complicated with mosaic heterogeneity of physicochemical parameters such as temperature and salinity. This premise led us to the hypothesis that some euryhaline halophiles including Halomonas species well adapt to a wide salinity-ranged habitat in the sub-vent.

To test this hypothesis, isolation and characterization of euryhaline halophiles from the Suiyo Seamount hydrothermal vents were conducted the drill-cored rock samples from the sites APSK-02, 03, and 07 and the filter-trapped fluid particle samples from the sites APSK-01 and 05 were used. For initial cultivation, a heterotrophic bacterial medium of 15% NaCl was used. The samples was added to the medium and incubated under both aerobic and anaerobic conditions at room temperature.

A total of 5 euryhaline halophilic strains were obtained and phylogenetically characterized: two strains (both related to Marinobacter) from APSK-02 core section 2; one strain (related to H. meridiana) from APSK-07 core section 3; and two strains (related to H. meridiana and H. variabilis) from APSK-01 trapped particles. In addition, some thermophilic halophiles that grow at 20% NaCl and 90 degree C were isolated from APSK-02, although phylogenetic and physioloigcal studies are under way. This research was supported by Archean Park project.

V

V72A-1283 1330h POSTER

Salinity, pressure and heavy-metal stress response of moderately halophilic bacteria isolated from hydrothermal-vent environments

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Moderately halophilic bacteria comprised 0.01-10% of the total microbial community in low-temperature hydrothermal emissions and in the overlying water column. The presence of these microorganisms was initially thought to be linked to brines that are produced by super-critical phase separation beneath deep-sea mid-ocean ridges. While there is conclusive evidence that these brines exist at extremely hot (>400°C) temperatures, it is difficult to construct geochemical and fluid-flow models which would delineate extensive subseafloor brine environments in mesophilic to hyperthermophilic temperature ranges. An alternative hypothesis 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 and along the Southern East Pacific Rise are both elevated in concentrations of heavy metals and under moderate pressure (150-270 atm; higher beneath the seafloor). From these fluids we isolated numerous strains of moderately halophilic bacteria belonging to the genera *Halomonas* and *Marinobacter*. At ambient pressure, isolates grew between -1 and 40°C, with up to 25% NaCl, and with 2.0-3.0 mM cadmium. The isolates displayed widely varying pressure maxima and cell yields as a function of temperature and salinity. High pressure and salt (and heavy metals?) may independently induce a stress response that enables these bacteria to cope with all of these stresses. Also in progress are molecular-phylogenetic analyses of moderately halophilic bacterial populations from diffuse flow sites along the Juan de Fuca Ridge. We expect that many of the organisms detected using our novel primers will have been cultured. With the knowledge of their physiologies and how their diversity changes in relation to fluid chemistry, these data may shed light on the dynamic subseafloor hydrothermal system that supports them.

V72A-1284 1330h POSTER

Analysis of microbial community structures within the core recovered at hydrothermal site of Suiyo seamount, Izu-Bonin Arc, Western Pacific

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Microbial communities in a core obtained from hydrothermal site of Suiyo seamount, Izu-Bonin Arc, Western Pacific (140 38'E, 28 34'N; -1391 m), were characterized using PCR-denaturing gradient gel electrophoresis (DGGE) analysis based on the 16S rRNA gene. The core (APSK05) was collected with the tethered marine rock-drill so called 'BMS' to approach the Subvent Biosphere directly below the seafloor. The depth of the bore hole was 6.6 m, and the length of recovered core was 3.6 m. The hydrothermal fluid with temperature 304?C came out of the hole at the 4.4 m depth of the hole. This phenomenon suggests that the hydrothermal fluid came out in the result of the perforation of cap rock sealed by clay. The subcore APSK05-2-1 (pumicite) from the surface of the bore hole, APSK05-2-2 (clay with fine sulfide crystals) from the ca. 1 m depth of the bore hole, APSK05-3-2 (clay stone) from the ca. 3 m depth of the bore hole, and APSK05-5-2 (dacite with very fine pyrite) from the ca. 5 m depth of the bore hole were fractured with the vise, respectively. The eubacterial 16S rRNA gene fragments were obtained in the core from 0 to 3.4 m of core length by PCR amplification using the specific primer set. The PCR-DGGE analysis showed the bacterial bands affiliated with alpha, beta, gamma-Proteobacteria, and Firmicutes. A part of the bacterial bands was related to the microbe clones retrieved from the terrestrial hot springs. This result suggests that the core above the cap rock kept the temperature suited for moderate thermophilic microbes.

V72A-1285 1330h POSTER

Impact of the Colonization by Paralvinella sulfincola on the Microbial Diversity Associated with a Deep-Sea Hydrothermal Vent Sulfide Chimney (Axial Seamount, Juan de Fuca Ridge)

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In the early stages of high temperature deep-sea hydrothermal vent chimneys growth, the walls remain porous and allow the escape of hydrothermal fluids as well as an inflow of seawater. This gradual mixing creates sharp thermal and geochemical gradients and provides potential habitats for physiologically diverse microorganisms. The annelid polychaete Paralvinella sulfincola colonizes the external surfaces of these structures, covering them with layered mucous tubes that locally alter the mixing of discharged hydrothermal fluids and surrounding seawater. Modifications of the physical and chemical conditions combined with an accumulation of elemental sulfur (S0) in P. sulfincola mucous tube are thought to be responsible for the deposition of a thin marcassite (FeS2) crust on outer surfaces of anhydrite chimneys (Juniper et al. 1992). This marcassite deposition could partly be induced by a shift in the composition of microbial communities that would to be locally associated with the presence of P. sulfincola. To test this hypothesis, we evaluated the impact of the colonization by P. sulfincola on the microbial communities present at the surface of an active sulfide chimney. Bacterial and archaeal 16S rRNA genes were amplified from DNA extracted from a P. sulfincola tube and from a chimney mineral sample. Using the statistical analysis demonstrated by Singleton et al. (2001), both clone libraries from the chimney sample have been shown to be significantly different from those of the P. sulfincola tube sample, even though the major phylogenetic groups of these libraries were similar. As it has been observed at other deep-sea hydrothermal vent sites, the Epsilon-Proteobacteria and the Deep-sea Hydrothermal Vent Euryarchaeotic Group 1 were the dominant components of both bacterial and archaeal clone libraries. These results seem to indicate that P. sulfincola affect the microbial community composition on high temperature chimneys.

V72A-1286 1330h POSTER

Microbial Diversity Associated with High Temperature Sulfide Deposits Along the East Pacific Rise Deep-Sea Hydrothermal Vents

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In January 2002, hydrothermal chimneys were collected using DSV Alvin from active vents from 9°17N to 9°50N and 20°49N to 20°50N. Hydrothermal fluids were collected for end member chemistry prior to collecting the sulfide deposits. Chimney samples were sub-sectioned, separating surface and associated biofilm samples from inner chimney samples. Microbial diversity of sub-samples was assessed using culture-dependent and culturing-independent small subunit (16S) ribosomal RNA-based techniques. Initial bacterial diversity assessments using denaturing gradient gel electrophoresis (DGGE) support the global prevalence of epsilon *Proteobacteria* associated with deep-sea sulfide structures. These are closely related to the sulfur-reducing isolate *Nautilia lithotrophica*. The biofilm communities varied in complexity with one sample containing several 16S rRNA sequences (phylotypes, OTUs) of alpha, epsilon, and gamma *Proteobacteria* while others contained a single phylotype of epsilon *Proteobacteria*. One proteobacterial phylotype was present in all but one of the surface samples, and this sample contained unique alpha and epsilon proteobacterial sequences. The inner chimney samples lacked the most common epsilon proteobacterial 16S rRNA sequences. Enrichment culturing was restricted to selecting for thermophilic chemolithoautotrophic hydrogen-oxidizing *Bacteria*. The widespread distribution of *Persephonella* spp. was confirmed, and novel enrichments of a sheathed and as yet unidentified chemolithotroph were obtained.

V72A-1287 1330h POSTER

Three-dimensional Visualization and Porosity Analysis of Seafloor Hydrothermal Chimney Microhabitats

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Within seafloor hydrothermal vent chimneys, fluid and mineral disequilibria provide dynamic microenvironments for microbial colonies whose identities are largely unknown. However, few techniques exist for studying the physical and chemical microstructure of these habitats rapidly and non-destructively. Because chimney void space and mineral geometry define the physical environment, visualization and porosity analysis of chimney structure in three dimensions at the microscale is the first step in relating vent microorganisms to their environment. Synchrotron X-ray computed microtomography is a non-destructive technique for microscale imaging of porous and compositionally heterogeneous natural samples in three dimensions. Sample size was 500 x 500 x 265 voxels (1 voxel = 4.74 μm). Spatial resolution was about 12 μm for this study and is dependent on sample size. The final grayscale image depends on X-ray transmission through the sample, which is a function of material composition and density. Therefore, differences between void space, sulfide minerals, and sulfate minerals are pronounced. Synchrotron X-ray computed microtomography data were collected on chimney samples collected during the Atlantis/Alvin Extreme 2001 cruise (Oct.-Nov., 2001) to 9°50 N on the East Pacific Rise. Existing samples from active vents and 3-day old chimneys from deployment of a retrievable mineral microcosm (see companion abstract by Dunn et al.) were compared. Porosity and pore connectivity (defined as the percentage of pores that are connected to the sample exterior) were calculated from microtomography data using custom algorithms.

Analysis by X-ray diffraction of a 3-day old sample (sample A) show that it is composed of pyrite with lesser amounts of anhydrite. A sample of a preexisting chimney (sample B) is composed mostly of pyrite with lesser amounts sphalerite. Three-dimensional images of mineral volumes from microtomography show bladed sulfide grains in sample A and colloform sulfide grains in sample B. The sulfate grains in sample A are euhedral and contain many pits and cracks, indicating mineral dissolution. The overall morphology of sample A is a loose matrix of individual crystals while the structure of sample B is more compact with irregular shaped channels. Calculated porosity was 55.48% for sample A and 44.16% for sample B. Over 99% of total porosity for both samples is due to connected pores. Each sample has a different composition, morphology,

and porosity at the microscale, which leads to large differences in possible microhabitats within each sample. Sample A has both sulfide and sulfate minerals that are loosely aggregated and provide a larger mineral surface area than the compacted structure of sulfides in sample B. Total porosity of sample A is greater than sample B, however fluid flow is not channelized as it is in sample B. Our observations suggest that as sulfide mineral growth replaces anhydrite, dissolution of remnant sulfate within young chimneys creates a porous disequilibrium microhabitat that should be attractive for the colonization of sulfate-reducing microorganisms as temperature decreases.

V72A-1288 1330h POSTER

A Retrievable Mineral Microcosm for Examining Microbial Colonization and Mineral Precipitation at Seafloor Hydrothermal Vents

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Although seafloor hydrothermal vent environments are known to support thriving ecosystems, the microscale physical and chemical environment suitable for microbial colonization and the identity of pioneering organisms is unknown. Because of the fragility of young chimneys and their ephemeral nature, novel methods for sample retrieval and analysis are required. The mineral microcosm consists of four titanium mesh chambers containing crushed minerals mounted on a titanium base that allows for fluid flow through the chambers. The chambers can be filled with different minerals or mineral mixtures (or no minerals) to supply different substrates for microbial colonization and different local microenvironments as minerals react with the surrounding fluids. The device sets on top of an active hydrothermal vent for a period of days to weeks to allow colonization and mineral reaction. The mineral microcosm was deployed during the Atlantis/Alvin Extreme 2001 Cruise (Oct.- Nov.,2001) to 9° 50'N on the East Pacific Rise a total of three times, for ~ 24, ~ 96, and ~ 48 hours each. It was deployed in two different environments, twice in lower temperature (<300°C), diffuse-flow environments and once (for ~96 hours) in a higher temperature black smoker environment (>350°C).Seed minerals included sulfides, sulfates, magnetite, apatite, and quartz, both individually and in mixtures. In the first 24-hour deployment, dissolution of anhydrite but not sulfide minerals within the chambers indicated high temperatures in chamber interiors and rapid reaction rates. Temperatures measured on chamber exteriors before retrieval ranged from 4° -98°C. The 96-hour deployment on a hot vent (fluid ~370°C before deployment) resulted in extensive mineral precipitation and chimney growth inside the mineral chambers, on the outer surfaces of the chambers, and on the platform as a whole, creating microchimneys several centimeters tall. The young chimneys were mainly composed of pyrite with lesser amounts of chalcopyrite and sphalerite and with thin veneers of anhydrite on exterior surfaces in contact with seawater. Bulk trace element analyses of the newly formed chimneys show concentrations of Ag, Cd, Co, Cr, Mo, Ni, and Pb (up to ~200 ppm) but a lack of As, Sn, U, and W. On the last deployment in a polychaete-rich, diffuse-flow area (vent temperature ~300°C), the microcosm was covered with biofilm and polychaete tubes had formed on the surface during the ~48 hours on the vent. Temperatures at chamber exteriors had decreased to 16- 20°C, suggesting that the vent was not vigorous enough to maintain a large flow through the chambers. Although no evidence for microbial colonization was obtained in these initial deployments, the device can simulate the mineralogy and temperature gradients of a natural hydrothermal chimney. Young chimney samples of known age (~96 hours) obtained from the second deployment were analyzed by synchrotron X-ray computed tomography for porosity and mineralogy and compared with existing chimneys at these sites (see companion abstract by Ashbridge, et al.).

V72A-1289 1330h POSTER

The Role of Serpentinization in Metasomatism, Carbonate Precipitation and Microbial Activity: Stable Isotope Constraints from the Lost City Vent Field (MAR 30°N)

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Integrated studies of the Atlantis Massif that hosts the Lost City Vent Field (LCVF) at 30°N west of the Mid-Atlantic Ridge provide constraints on the role of serpentinization in metasomatism, carbonate precipitation and microbial activity in off-axis hydrothermal systems. This fault-bounded, dome-like massif is comprised of variably altered and deformed peridotites and gabbroic rocks, with less abundant basalts and pelagic carbonates. Cataclastic deformation is prevalent at the top of the scarp and is marked by carbonate-filled fractures and breccias that contain varying serpentinite, gabbroic and basaltic components set in a well-lithified micritic carbonate matrix, similar to ophicalcites in many ophiolite terrains. The rocks record multiple phases of serpentinization, talc-metasomatism, rodingitization, and carbonate precipitation that are related to progressive deformation, seawater infiltration, and veining during the tectonic and hydrothermal evolution of the massif. Our petrological and geochemical studies indicate that continuous serpentinization reactions are critical in promoting hydrothermal circulation and in controlling fluid compositions, and that fluid flow was characteristically channeled through faulting and fracturing. In addition to the production of heat through exothermic reactions, serpentinization results in reduced, high pH fluids, which enhance carbonate precipitation and the transport of elements such as Si, Al, and Cr. Elevated volatile concentrations provide nutrients for mesophilic to hyperthermophilic organisms that may include methane- and hydrogen-oxidizers.

The main phases of serpentinization and metasomatism resulted in depletion in ^{18}O relative to unaltered mantle peridotites. Bulk rock O-isotope compositions of serpentinites and gabbros vary between 2 and 5.5$^{o}/_{oo}$ (VSMOW); samples with metasomatic talc assemblages, as well as serpentine- and talc-bearing veins lie within a narrow range of 2.9 to 3.9$^{o}/_{oo}$. Our data indicates that serpentinization and metasomatism occurred at similar temperatures (>~200°C) and varying fluid-rock ratios. C- and O-isotope analyses highlight distinctions in carbonate lithologies. The C- and O-isotope compositions of pelagic sediments and the LCVF chimneys are similar to compositions of aragonite associated with other oceanic serpentinites and indicate a marine source of carbon and ambient temperatures of precipitation. In contrast, the matrix of the breccias and carbonate veins in the peridotites and gabbros show a large range of isotopic compositions and reflect local interaction of seawater with methane-rich fluids during serpentinization and carbonate precipitation. C- isotope compositions of -6 to -2$^{o}/_{oo}$ (VPDB) in some veins indicate a ^{13}C-depleted component in the hydrothermal fluid, presumably methane; whereas compositions of +2 to +3.5$^{o}/_{oo}$ may reflect a loss of methane. Samples with negative $\delta^{13}C$ values commonly exhibit negative $\delta^{18}O$ values (-20 to -2$^{o}/_{oo}$ VPDB) that correspond to carbonate precipitation temperatures of 25-200°C. These data, together with results of microbial studies of the LCVF, substantiate the importance of serpentinization and the production of methane- (and hydrogen-) rich fluids in supporting thermophilic microorganisms. Thus, the LCVF may provide a model for understanding the link between hydrothermal alteration, fluid chemistry, and biological activity in peridotite-hosted hydrothermal systems.

V72A-1290 1330h POSTER

Biogeochemistry of Hydrothermal Chimney Environments: Continuous-Flow Experiments at *in situ* Temperature and Pressure

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Recent interest in the existence of a subsurface microbial biosphere at hydrothermal vents has resulted in a plethora of new questions that might best be answered using interdisciplinary techniques that combine geochemistry, microbial ecology, and molecular biology. Ideally, such studies will quantitatively address issues concerning what organisms exist in the subsurface, what metabolisms are sustained in the hydrothermal environment, and what effects these active organisms might have on the nearby fluid and rock. We present a new experimental approach to studying these questions that enables monitoring of an active hydrothermal community of microbes in the presence of chimney material at *in situ* temperature and pressure. This apparatus is designed as a continuous-flow reactor from which fluid samples can be extracted during the course of the experiment to measure chemistry and biomass, and at the termination of an experiment solids can be extracted for analysis of mineralogical changes and microbial identification.

Results of a series of experiments conducted using hydrothermal chimney material (solids and microbial community) collected from 21° N and 9° N East Pacific Rise are presented. At 70° C, a seawater-based fluid with additional NO_3^-, CO_2(aq), and H_2(aq) was reacted with chimney material from L vent, 9° N EPR. The fluid lost significant NO_3^-, PO_4^{3-}, and gained SO_4^{2-} even after accounting for the contribution from anhydrite dissolution. No significant sulfide or iron was observed in the fluid. Analysis of the DNA extracted from the solids at the termination of the experiment using partial 16S-rRNA sequence data revealed that the dominant bacteria were S-oxidizing tube worm endosymbionts, a S/NO_3^- reducing member of the *Deferribacter* genus, and a H_2-oxidizing/NO_3^- reducing strain of Aquifex. Mineral analysis from before and after the experiment indicates the loss of pyrrhotite (FeS) and anhydrite ($CaSO_4$), and the gain of an Fe-oxide phase tentatively identified using magnetic remnance and Mossbauer as goethite (FeOOH), responsible for the minimal Fe in solution. An abiotic control experiment was conducted under the same conditions, where the chimney material was first freeze-dried under vacuum, then autoclaved to sterilize without producing any artificial mineral changes. This experiment shows no loss of NO_3^-, PO_4^{3-}, no additional SO_4^{2-} gain after anhydrite dissolution, and a steadily increasing dissolved iron concentration, implying the net dissolution of pyrrhotite. Results from additional experiments testing different fluid chemistry, temperature, and source chimney similarly show linkages between the measured fluid chemistry, the identity of the dominant organisms in the experiment, and bulk changes in the mineralogy.

V72A-1291 1330h POSTER

Geochemistry of Phosphorus and Nitrogen in Volcanic Rocks Altered by Submarine Hydrothermal Activities at the Suiyo Seamount in Japan

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Phosphorus and nitrogen are essential major elements for all microorganisms. In order to understand the ecological conditions of subvent microorganisms and thermophilic microorganisms on ocean floor, it is necessary to understand the behavior of bio-essential elements not only in hydrothermal fluids but also in the subvent environment. Nine sites of hydrothermal discharging area were drilled in the Suiyo volcanic caldera, Izu-Ogasawara (Bonin) island-arc, western Pacific. Approximately 2 to 10 m deep drill core samples were recovered in the last two years. Chemical compositions and hydrothermal mineral assemblages in the drilled core samples were determined by XRF, ICP-MS, and XRD. Morphology of phosphorous-bearing minerals and their chemistry were examined by electron microprobe. Nitrogen isotopes were measured by the EA-IRMS system. Primary igneous-rock texture (such as euhedral

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plagioclase phenocryst) is found in the less altered rocks. They often associated with montmorillonite. Highly altered rocks are divided into two groups. First group is characterized by extensive (up to 90%) replacement of primary igneous mineral assemblage by chlorite, mica and sulfide. Second group is cemented with large amounts of sulfates with sulfide (mainly pyrite). It is found in a few drill core sections that hydrothermal hydrous silicate minerals change with depth from montmorillonite to chlorite and mica through mixed layer of chlorite/montmorillonite. This may suggest the more extensive and higher temperature alteration in deeper zones in a certain area. Electron microprobe analyses and bulk chemical composition indicate that the depletion of phosphorous in altered rocks (below 0.1 wt%) but enrichment of phosphorous in sulfide zones. This suggests that phosphorous was easily dissolved from igneous rocks by hydrothermal process, but readily precipitated with sulfides. The reason for co-precipitation of phosphates with sulfides is not certain, but such co-precipitation mechanism, thus solubility of phosphates, may control the phosphorous concentrations in hydrothermal fluids and the extent of subvent microorganisms. Ammonium is depleted in the hydrothermal fluids (up to 25 micro M (Ishibashi, 2002, personal communication)) from Suiyo Seamount. On the other hand, nitrogen was enrichment (up to 0.12 wt%) in hydrous silicate minerals, particularly in mica. FT-IR analyses indicate that ammonium ion was easily substituted potassium ion of interlayer of sheet silicate minerals. The total ranges of nitrogen isotopic compositions are -10.5 to -15.7 per mil for montmorillonite, -12.5 to -14.7 per mil for chlorite/montmorillonite, and -10.2 to -12.2 per mil for mixtures of mica and chlorite. These values are extremely light compared to the seawater value (approximately zero), and explained by generation of ammonium in subvent area by hydrothermal fluid/rock interaction in subvent area. On the contrary, nitrogen isotopic compositions (-4.8 vs. +0.9 per mil) of bacterial mat on mussels and organic matter in surface sediments were different compared to hydrothermal hydrous silicates. These suggest that thermophilic surface microorganism may use nitrogen both from seawater and hydrothermal fluids. Our study also suggests that nitrogen isotope compositions of organism can be used to distinguish subvent microorganisms from the surface microorganisms.

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

V72A-1292 1330h POSTER

Organic Complexing in Smectite Clay Minerals Under Hydrothermal Vent Conditions

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A hydrothermal vent at the Juan de Fuca ridge was found to contain smectite-rich clay minerals. At vent fluid temperatures (300-350° C) smectite quickly reacts to form more stable minerals, such as illite or chlorite, by incorporating metal cations. While similar investigations have assigned the catalytic properties of clays strictly to the surfaces, it is our hypothesis that organic molecules are polymerized in the smectite interlayers during reaction. Upon incorporation of metal cations and primary organic molecules in the expandable interlayer of these clays, gradual changes in the electrochemical environment may catalyze bio-oligomers that are essential components of life.

For comparison, we have examined both dioctahedral (montmorillonite; SWy-1) and trioctahedral (saponite) smectite clay minerals which react to illite and chlorite, respectively. An illite standard (IMt-1) has also been examined as a catalyst. Progressive steps in the reaction process have been monitored through hydrothermal experimentation simulating seafloor and subseafloor volcanic conditions in welded gold capsules. K-saturated smectite clays were reacted with aqueous 10 M methanol solutions up to six weeks. Reaction progress was monitored weekly.

Results suggest that organic complexity increases as a function of mineralogical reaction. While producing some similar complex organic compounds, reactions starting with illite yielded significantly lower product concentrations than those with the smectites, suggesting the expandable interlayers play an important role in catalysis. Organic analyses were performed by GC-MS; clay analyses by x-ray diffraction.

V72A-1293 1330h POSTER

Hydrothermal Tar Mounds in Escanaba Trough, Southern Gorda Ridge

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Mounds of asphaltic petroleum were located and sampled by the submersible ROV Tiburon at two sites on the 3300-m-deep, sediment-covered floor of Escanaba Trough, southern Gorda Ridge. The northern site (41.01°N) consists of several individual mounds up to 1 m across and 25 cm high that occur within 100 m of active hydrothermal vents and polymetallic sulfide deposits. These mounds are not covered by sediment and serve as solid substrates for anemones and sponges. Fragments of a partly-buried tar mound at the southern site (40.69°N) were recovered near a field of inactive sulfide deposits. The mounds have a lobate morphology in which younger lobes with lustrous surfaces drape over older lobes encrusted by mud and faunal debris. In cross section, individual lobes have dense rinds, softer inner walls, and hollow cores.

Coupled gas chromatography-mass spectrometry analyses of tar samples show the presence of a mixture of aliphatic and aromatic hydrocarbons. The aliphatic fractions have homologous n-alkane distributions from n-C_{12} to n-C_{36} with C_{max} = n-C_{28}, and a distinctive even-over-odd C-number predominance. Epimer ratios for hopanes and steranes indicate hydrocarbons that are relatively immature. The polycyclic aromatic hydrocarbons (PAH) are dominated by high-molecular-weight parent molecules such as pyrene and phenanthrene; alkylated derivatives are minor constituents. The aromatic fractions also contain a large unresolved complex mixture (UCM). The presence of high-molecular-weight PAH (e.g., benzo-pyrene, indeno-pyrene) reflects formation at high temperatures compared to conventional petroleum. Microwave digestion followed by inductively coupled plasma-mass spectrometry analyses of the soluble organic fraction from three tar samples reveal the following concentrations: 0.1 to 0.2 wt% S, 1 to 10 ppm Mg, Al, P, Cr, Fe, Ni, Cu, Zn, As, Se, and Ba, 1 to 100 ppb Pd and Pt, and 1 to 10 ppb Au. The insoluble residues separated from these samples, analyzed by scanning-electron microscopy and energy-dispersive X-ray spectrometry, contain particles of talc, barite, Fe sulfide, and Fe oxide.

Physical characteristics of the Escanaba Trough tar mounds indicate that viscous petroleum flowed onto the sea floor and condensed into solid deposits that accreted by eruption of flow lobes through breakout points on mound surfaces. The occurrence and composition of the tar mounds further indicate a hydrothermal origin for the petroleum, contemporaneous formation with sulfide deposits, and generation by rapid pyrolysis of organic matter in the sediment.

V72A-1294 1330h POSTER

A Search for Biomarkers in Microbial Origin in Hydrothermal Fluids From Hydrothermal Vents at the Suiyo Seamount

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We tried to search biomarkers in microbial origin in hot fluids from hydrothermal vents. Hot water samples were collected from three natural hydrothermal vents (Tmax. = 310, 221, and 48° C) and a drilled core (APSK05, Tmax. = 21° C) located in a seafloor hydrothermal system developed on atop of the Suiyo Seamount, Izu-Ogasawara island-arc, western Pasific, using a ROV *Hakuyo 2000*, during the *Shinsei-Maru* cruise in July-August 2001 and the *Shinryu-Maru* cruise in August 2002. Hot water passed through a ODS disk (Empore Extraction Disk 90mmϕ) with a pre-filter (pore size 1μm), and dissolved organic matter was adsorbed on the ODS disk. The adsorbed organic matter was eluted with toluene using Soxhlet extractor for 12h. After the eluents were concentrated, they were analyzed by GCMS. Some hydrocarbons that show basepeak at M/Z = 69 were found in hot water from APSK05, and these compounds may indicate the existence of alkylcyclopentanes that are characteristic for some thermoacidophilic bacteria, and that have been reported from the seafloor deposits of the Suiyo Seamount.

V72A-1295 1330h POSTER

Time Variation of Fluid Chemistry at Iheya North Seafloor Hydrothermal System, mid-Okinawa Trough

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Seafloor hydrothermal system at Iheya North, mid-Okinawa Trough, was discovered by the deep tow camera system in 1995. It is located at 27°47.2"N, 126°63.9"E and water depth of 1000m. The first fluid samples were collected by "Shinkai 2000" in 1996. Since then, fluid samples have been collected almost every year till 2002.

Iheya North seafloor hydrothermal system extends about 200m in NS and 150m in EW directions. There are at least 9 hydrothermal vents in the area. Some of them are several tens meters high sulfide chimney emitting hydrothermal fluid from their top and side wall. The maximum temperature measured was 311°C at the center part of this field. The temperatures of venting fluids at the peripheral parts of the system are lower than that at the central part.

The chemical compositions of hydrothermal fluids have spatial and time variations. Before 1999, salinities of hydrothermal fluids tend to be lower at the peripheral part of the system. The relationships between K and Cl concentrations lie on a single line originating from the origin. It means that the phase separation of the hydrothermal fluids under the seafloor influences the spatial variation of the hydrothermal fluids in this system. The line indicates that the chemistry of the hydrothermal fluid is K-rich compared to those of the sediment-starved mid-ocean ridge hydrothermal fluids. It means that the fluids are reacted with hot acidic rock of the mid-Okinawa Trough. High concentrations of other components, such as NH_4 and Li, indicate that the fluid is also reacted with the sediment of the mid-Okinawa Trough.

After 2000, there were large decreases in salinities of the hydrothermal fluids in the southern part of this system. Hydrothermal fluid of one of the vent in southern part of the system becomes almost zero salinity. This sudden change in salinity indicates the big change in sub-seafloor hydrology in this hydrothermal system. When the hydrothermal system was aged and the path way of the hydrothermal fluid was clogged by chemical precipitates, the steam phase, more mobile than the liquid phase, may become preferentially emitted in the peripheral area. This may explain the change in salinities of vent fluid observed in this hydrothermal system.

V72A-1296 1330h POSTER

Carbon, nitrogen and sulfur isotopic characterization of biological samples from chemo-synthetic communities in southern Okinawa, Japan

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Direct measurement of carbon, nitrogen, and sulfur isotopic compositions of the seafloor hydrothermal bacteria involves many difficulties, mainly due to lack of suitable size of samples. In contrast, the isotopic measurements of the hydrothermal vent animals can easily be made. The animals depends mainly on bacterial primary production. Carbon, nitrogen, and sulfur budget from the bacterial source should be estimated using the stable isotopic compositions of the soft tissue constituents. The hydrothermal environment involves several types of chemoautotrophc and methanotrophic bacteria such as suspending, matting, and endosymbiosis. Each hydrothermal vent animal feeds on or harbors the bacteria according to their physiology and ecology. For example, the crustaceans, Shinkaiya and Alvinocaris, feed on bacteria and the deep-sea mussel, Bathymodiolus, harbors endosymbionts in their gill tissues. Our objectives are to make clear the sources of carbon, nitrogen, and sulfur of these bacteria and the relationship between the bacteria and the geochemistry of emitting hydrothermal fluids. We studied the vent animals from two hydrothermal systems where the tectonic settings are significantly different. One is located on the volcanic front of the Ryukyu Arc and the other is located on the west edge of the Okinawa Trough back-arc basin. The former hydrothermal vent site is active in the caldera where sediment starved hydrothermal system, while the latter site is active on the thick sediment-covered small trough. The geological settings of these two hydrothermal sites would provide different geochemical environments. We will discuss how the vent animals succeed to the geochemical characteristics from the viewpoint of stable isotope geochemistry.

V72A-1297 1330h POSTER

Measurement of in situ Methane Oxidation Rate in Hydrothermal Vent Area, Suiyo Seamount in the Izu-Bonin Arc

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Methane is one of the important carbon sources for the hydrothermal vent ecosystem. Extensive studies about dissolved methane concentration and methane carbon isotope composition at hydrothermal vent area have been investigated, much remains to be learned about methane production and oxidation by microorganisms at the ecosystem. The quantitative estimation of the organic carbon supply to the hydrothermal vent ecosystem with methane oxidation by the microorganisms is an important study in order to grasp carbon flow of the ecosystem. In the present study, we measured in situ oxidation rate of dissolved methane at hydrothermal vent area in the Suiyo Seamount, Izu-Bonin (Ogasawara) Arc. The oxidation measuring equipment which was combined Niskin water sampler with Time-series water sampler having 12 acrylic cylinders was attached to the Japanese manned submersible SHINKAI 2000. At the sea floor, Niskin sampler was hold up just above the low temperature vent and sea water in the sampler was replaced in the hydrothermal fluid. Then the Niskin sampler closed just before starting time-series sampling and incubation experiment started on site. Hydrothermal fluid in Niskin sampler was sampled in the 30 min or 1 hour interval by Time-series water sampler and methane oxidation was stopped immediately by mercuric chloride solution added in each cylinder previously. Time-series samples were immediately transferred to the 30-ml glass bottles on board. Bottles were slowly overflowed with sample water and sealed with no headspace. After sealing, the samples were stored in freezer until methane concentration analysis at the laboratory. The dissolved methane concentration was measured with an automatic system consisting of a purge and trap apparatus and a gas chromatograph with a flame ionization detector. The in situ methane oxidation rate at the hydrothermal vent area was 0.016/hr, and methane consumption rate, which is obtained from multiplying the methane oxidation rate by the methane concentration, was 13.6 nM CH_4/hr. It suggests that dissolved methane oxidation by microorganisms should be an important organic carbon source for the hydrothermal vent ecosystem at the Suiyo Seamount.

V72A-1298 1330h POSTER

CO enrichment in hydrothermal plumes: Suiyo seamount, Izu-Bonin arc

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We surveyed effluent hydrothermal plumes in and around the water column of Suiyou seamount (ca. 1,380m depth, 2km diameter), Izu-Bonin arc using R/V Kairei. Our study especially focused on the measurements of concentration and stable carbon isotopic compositions of carbon monoxide (CO) and methane (CH_4) in the plume. We also sampled venting fluids using manned submersible Shinkai 2000 to compare the chemical composition and isotopic compositions of CO and CH_4 with those in hydrothermal plume. We detect strong CH_4 anomalies not only on the water columns within the caldera, but also on those at outsides of the caldera wall at the depth of ca. 1,100-1,150m, the sill depth of the caldera wall. When we correct for the effect of ambient seawater mixing, the stable carbon isotopic compositions of CH_4 in plume coincide well with that at venting fluid, suggesting that aerobic methane oxidation is minimum within this plume. We also detect slight CO enrichment in hydrothermal plume. The stable carbon isotopic compositions of CO in the plume, however, exhibit highly ^{13}C depleted value (-110 to -60$^o/_{oo}$ PDB) compared with those in seafloor venting fluid (around -30$^o/_{oo}$ PDB). Besides, the plume water exhibit higher CO/CH_4 ratio along with the distance from the fluid venting site. We conclude that some microbial CO production is active within this plume. The CO enrichment in deep seawater could be also good indicator for seafloor hydrothermal activity, especially for aged plume. This research is funded by Ministry of Education, Science & Technology through Special Coordination Fund ARCHEAN PARK project.

V72A-1299 1330h POSTER

Geochemistry of hydrothermal plume in the Suiyo Seamount Caldera.

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Chemical compounds of the hot basalt origin are discharged into the deep ocean via hydrothermal plume by the deep-sea hydrothermal activity. The hydrothermal plume is widely diffused to the ocean by mixing with ambient seawater. Chemical reactions and interactions with microorganisms in the diffusion process of the hydrothermal plume are important to comprehend the oceanic geochemical cycles. Recently, it has been clarified that the variation of hydrothermal activity is greatly controlled in the tidal current. Not only geochemical observation but also physical observation, such as water current measurement, are necessary for the understanding of the deep-sea hydrothermal systems including the behavior of hydrothermal plume. In order to observe the diffusion process of hydrothermal plumes, sampling and chemical mapping of the hydrothermal plume and measurement of water current were carried out at the Suiyo Seamount Caldera during research cruises under the ?Archaean Park? project funded by MEXT.

The three-dimensional acoustic current meters were moored at the height of 13m and 125m above the bottom in the Suiyo Seamount Caldera. At the 13m height, average water current speed and current direction were 10.46 cm/second and 228.1 degrees, respectively, and maximum water current speed was over 40.46 cm/second. On the other hand, average water current speed and current direction at the 125m height were 3.87 cm/second and 57.8 degrees, respectively. The strong water current of the southwest direction in 24 hours periods existed near bottom of the caldera. In addition, downward current and water temperature depreciation were observed, when there was the strong current in 24 hours periods. These results suggest that the low-temperature ocean water around the Suiyo Seamount flows toward the bottom of caldera periodically.

The mini CTDT-RMS mounted twelve 1.2L Niskin bottles and the in-situ pH sensor were installed on the ROV or manned submersible. The hydrothermal plume samples were collected by taking the distance from the chimney gradually and pH change was monitored during the sampling and observing at the hydrothermal active areas. Alkalinity, pH, hydrogen sulfide, total dissolved inorganic carbon (DIC), chemical species of trace metals (particulate, dissolved and organic form) and nutrients in the hydrothermal plume samples were analyzed. Though DIC concentration in the hydrothermal plume sample gradually decreased with dilution and diffusion of the plume, DIC concentration in the caldera was higher than that in the seawater around the seamount. These results indicate that many chemical compounds discharged by hydrothermal activity have been remained in the caldera. According to the pH mapping of the hydrothermal area in the caldera, low pH areas in the patch state were located in each hydrothermal area. The low pH areas seem to have been formed by getting together with some hydrothermal plume. During long-term monitoring of pH at the hydrothermal active area in the caldera, the decreases of 0.3‘0.4pH in 24 hours periods correspond with the results of water current were detected.

V72A-1300 1330h POSTER

Manganese Oxidizing Bacteria in Guaymas Basin Hydrothermal Fluids, Sediments, and Plumes

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The active seafloor hydrothermal system at Guaymas Basin in the Gulf of California is unique in that spreading centers are covered with thick sediments, and hydrothermal fluids are injected into a semi-enclosed basin. This hydrothermal activity is the source of a large input of dissolved manganese [Mn(II)] into Guaymas Basin, and the presence of a large standing stock of particulate manganese in this basin has been taken as evidence for a short residence time of dissolved Mn(II) with respect to oxidation, suggestive of bacterial catalysis. During a recent Atlantis/Alvin expedition (R/V Atlantis Cruise #7, Leg 11, Jim Cowen Chief Scientist), large amounts of particulate manganese oxides were again observed in Guaymas Basin hydrothermal plumes. The goal of the work presented here was to identify bacteria involved in the oxidation of Mn(II) in Guaymas Basin, and to determine what molecular mechanisms drive this process. Culture-based methods were employed to isolate Mn(II)-oxidizing bacteria from Guaymas Basin hydrothermal fluids, sediments, and plumes, and numerous Mn(II)-oxidizing bacteria were identified based on the formation of orange, brown, or black manganese oxides on bacterial colonies on agar plates. The Mn(II)-oxidizing bacteria were able to grow at temperatures from 12 to 50°C, and a selection of the isolates were chosen for phylogenetic (16S rRNA genes) and microscopic characterization. Endospore-forming Bacillus species accounted for many of the Mn(II)-oxidizing isolates obtained from both hydrothermal sediments and plumes, while members of the alpha- and gamma-proteobacteria were also found. Mn(II)-oxidizing enzymes from previously characterized Bacillus spores are known to be active at temperatures greater than 50°C. The presence of Mn(II)-oxidizing spores some of which are capable of growing at elevated temperatures - in hydrothermal fluids and sediments at Guaymas Basin suggests that Mn(II) oxidation may be occurring immediately or very soon after hydrothermal fluids emerge from the seafloor.

V72A-1301 1330h POSTER

Behaviors of Mn and Fe in hydrothermal lpumes and diffused flows at the Suiyo Sea Mt., Izu-Bonin arc

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We studied for hydrothermal plumes and diffused flows at the Suiyo Sea Mount in the Izu-Bonin arc by using in situ Mn-Fe analyzers (GAMOS). GAMOS-II (Geochemical Anomalies MOnitoring system) is an in-situ chemical analyzer used to detect manganese and/or iron anomalies in neutrally buoyant plumes and to map distributions in bottom seawater over vent fields. During NT 01-09 (SHINKAI 2000 / NATSUSHIMA, JAMSTEC) and KR 01-15 (KAIREI, JAMSETC) cruises, GAMOS-II measurements were conducted for plume observation. Manganese, iron concentrations and temperature anomalies were observed in the caldera of the Suiyo seamount . Three maxima in temperature were detected at 1,080 m, 1,200 m and 1,280 m. But only one peak was observed for iron and manganese. Shallow plum at 1,080 m has a lower Metal /heat ration compared to deeper plume. GAMOS-IV was designed for stand-alone operation of up to one month. GAMOS-IV was deployed on seafloor for long term observation of manganese concentration and water temperature in hydrothermal diffused flow using ROV HAKUYO 2000 in August, 2001 and manned submersible SHINKAI 2000 in September, 2001 and 2002. Anomalies of manganese concentration (- 4,000 nM) and water temperature (- 6.0°C) were observed coincidentally. The Mn/T ratio observed at this diffused flow were almost same with high temperature fluid in the seamount and uniform throughout each two deployments. This indicates that the diffused flow in the Suiyo seamount had single source fluid same as the high temperature fluid.

V72A-1302 1330h POSTER

Periodic sampling of diffuse flow to monitor chemical fluctuation

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We developed a sampling device named 'N1' in order to collect diffuse flow periodically for one or two days. To confirm fluctuation of chemical compositions by chemical analysis, sampling volume of N1 is designed as 0.5 ml to a few ml. N1 is composed of two peristaltic pumps (suction rate is about 0.1 ml/min.), a 250-m length of 1-mm I.D. (inner diameter) Teflon tubing for sample storage, a flexible bag filled with red-colored silicon oil, a controller and batteries. These parts are aligned in a flame of 40 × 30 × 30 cm, and whole weight is 28 kg in air and 20 kg in water. At programmed time, the pump starts introducing fluid sample through the inlet into the Teflon tubing replacing distilled water. Then, the other pump injects red-colored silicon oil for separation of the sample. An approximate time required for sampling 1.0 ml fluid and waiting for telescopic motion of tubing is 30 minutes. Sampling interval and sampling duration can be programmed.

We deployed N1 at the Suiyo hydrothermal field (depth = 1370 m) during the ROV Hakuyo2000 dive program in 2002, which was conducted as a part of Archaean Park Project. We successfully collected hydrothermal fluids from two sites. At the second operation, inlet of N1 was set 20 cm above a 50 cm wide orifice, where several small but energetic emanations up to 300°C were observed. We obtained 30 fluid samples of 1.0 ml, every 30 minutes for 16 hours. Silica concentration ranges from 140 μM to 530 μM, higher than that of ambient seawater (130 μM). We noticed that emanation of high silica concentration flow (340-590 μM) continued for about 4 hours. Fluctuation of silica concentration showed good correlation with that of manganese and Si/Mn ratio is nearly equal to that of high temperature fluid. Depletion in magnesium concentration is correlated with high silica and manganese concentrations.

V72A-1303 1330h POSTER

Tidal bottom current modulation of chemical environment in the Suiyo hydrothermal site in the Izu-Ogasawara (Bonin) Arc.

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Intense seafloor observatory studies were done at the Suiyo hydrothermal site in the summer of 2001 and 2002. Deployed instruments on the seafloor were CTD (Idronaut, Ocean Seven 316), Digiquartz precision pressure sensor and its recorder, 3-D acoustic current meters (NOBSKA, MAVS3), high temperature and redox recorders at the vents, in-situ laser particle analyzer (Sequoia Scientific, LISST-Deep), methane sensor (CAPSUM METS) with its data logger, etc. The Suiyo Seamount hydrothermal site is located in the summit caldera of Izu-Ogasawara (Bonin) Arc (1380 m deep, 28.572 N, 140.643 E). The tide is mixed type dominant with semi-diurnal component.

There is no tidal components in temperature and redox records neither at high temperature vents (300 deg C) nor at low temperature vents (less than 200 deg C). Whereas the temperature, redox, methane concentration in the seawater, particle characters measured just above the seafloor had strong semi-diurnal components. The methane concentration varies from several micro mol/litter to several tens of micro mol/litter associated with 200 mV redox change in the central part of the hydrothermal site. Semi-diurnal strong bottom current over 40 cm/sec appeared several hours after high tides introduced entrainment of ambient waters in the marginal part of hydrothermal site and accelerated mixing of vent water with bottom water in the central part of the hydrothermal site.

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).

V72A-1304 1330h POSTER

Long-Term Monitoring at Hydrothermal Sites of Suiyo Seamount, Izu-Ogasawara Arc, Western Pacific

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Many attempts have been made to acquire time-series measurements at Suiyo Seamount, Izu-Bonin Arc, Japan, during Aug. 2001 - Aug. 2002. Among many instruments deployed on the seafloor at a hydrothermal site in the summit caldera of the Suiyo Seamount, we report the results by Medusa/Gemini (deep-sea fluid monitoring system) and SAHF (Stand Alone Heat Flow meter). We deployed Medusa/Geminis at hydrothermal systems in August 2001 and August 2002 for about two weeks. The Medusa/Gemini monitors the flow rates and temperatures of effluent flowing out of cased seafloor boreholes and areas of warm diffusive flow. Fluctuations in the fluid temperatures show strong correlation with seawater temperatures for all Geminis. The fluid velocities show strong positive correlation with those of temperatures in cases of Geminis on top of cased seafloor boreholes; however, they show negative correlation in cases of Geminis on diffusive flow areas. It suggests that the fluid is driven by buoyancy through the cased seafloor borehole. Spectral analyses provide no strong evidence for tidal modulations. We monitored temperatures for about four months using 60-cm geothermal probe (SAHF) in the hydrothermal site. Temperatures showed tidally correlated fluctuations and long-term, a month-long, fluctuations. These fluctuations can be explained by the movement of bottom water induced by tidal pressure variations. This research was funded by Ministry of Education, Science and Technology through Special Coordination Fund "Archaean Park" project.

V72A-1305 1330h POSTER

Dual-scale hydrothermal circulation inferred from detailed heat flow measurements in the Suiyo Seamount Hydrothermal System, Izu-Bonin Arc

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Hydrothermal activity within the caldera of Suiyo Seamount was investigated in detail using manned or remotely-operated submersibles, and by deep-tow imagery and seismic surveys. Hydrothermal regime in the Suiyo-seamount is characterized by a geochemically uniform fluid, shallow reservoir depth, very permeable seafloor, and venting without creating big chimneys.

Detailed heat flow surveys were carried out through four research cruises conducted in 2001-2002. Geothermal probes, called SAHF (Stand-Alone Heat Flow) meter, are 1m in length, and five thermistors are installed at 11-12 cm intervals.

Heat flow is highest (> 10 W/m^2) within the active area. These values were obtained close to black smokers, thus are affected by the venting or very shallow reservoirs. To the east, heat flow is uniform around 4 W/m^2. Since there were no indications of discharge, this area is dominated by thermal conduction, and its heat source would be a hydrothermal reservoir capped by some impermeable layer.

To the west, we detected very low heat flow values of less than 0.3 W/m^2, only several tens of meters away from the active area. A similar heat flow anomaly was detected in the TAG hyudrothermal mound of the Mid-Atlantic Ridge (Becker et al., 1996).

We penetrated at 1-2 m away from two isolated active sulfide mounds. At both sites subbottom temperatures were about 40 degC at 10-20 cm depth, then they decreased to about 20 degC at 30-40cm. The temperature reversals suggest a meter-scale hydrothermal circulation, where a hot fluid discharges as a branch flow from the main vent to the mound. An impermeable structure of the mound and a permeable sediment surrounding the mound would make this very local circulation possible.

We suggest a dual scale hydrothermal circulation system, one with several meters scale, and the other with few tens of meters scale. The former would be driven by a suction created by discrete venting of high temperature fluid, and the latter is a regional-scale circulation which can be described by DarcyOs law of flow in porous media.

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

V72A-1306 1330h POSTER

Geophysical structure of a hydrothermal system in the Suiyo Seamount, the Izu-Bonin Island Arc, Western Pacific

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Surface geophysical, airgun-OBS and deep towed surveys by R/V Kairei KR01-15 cruise and heat flow measurements by submersible Shinkai 6500 (NT01-08 cruise), were conducted to characterize geophysical features of a hydrothermal system in the Suiyo Seamount as a part of Archaean Park Project. The SeaBeam2112 and proton magnetometer data were collected over the seamount area to derive bathymetry, backscatter image, crustal magnetization. The results suggest 1) the seamount was formed during Brunhes Epoch (<0.78Ma), 2) low magnetization area exits on its summit, 3) its eruption accompanied with low backscatter materials, and 4) a collapse occurred in NNE side of the caldera after its formation. 2-D ray tracing results, using four OBS data with a GI gun across the seamount in NE-SW direction, indicate 1) P wave velocity of 2.2-4.2 km/s (2km thickness) locates all over the observation line, and 2) the relatively low velocity material exits under the caldera. Three deep towed equipments (WADATSUMI, a seismic reflection system and a magnetometer) were separately towed 100-200m above the sea floor to map the hydrothermal area in the caldera. The WADATSUMI supplied side scan sonar intensity images and sub-bottom profiles which reveal 10m thickness layer in the SW side of the caldera. The SW-NE seismic reflection image indicates two layers beneath the caldera; their thicknesses are 11m and 23m at the center of the hydrothermal site and both of them become thicker in the SW side. The low magnetization

area is limited only in eastern side, which probably results from higher rock alteration by the hydrothermal activity. Eleven heat flow data across the hydrothermal site indicate anomalously high (>10W∧ (m^2)), high (ca.4W∧(m^2) without hydrothermal activity, and low (ca.0.2W∧ (m^2)) at the center, the eastern side and the western side of the hydrothermal site, respectively. All the data show that the hydrothermal area has different features between the SW and NE sides, and we will present a model to explain these features.

V72B MCC: Hall C Sunday 1330h

Phase Equilibria, Partitioning, and Transport Posters

Presiding: **C A Geiger,** Universitt Kiel

V72B-1307 1330h POSTER

Phase relations of a carbonaceous chondrite at lower mantle conditions

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The refractory element ratios of Earth's mantle are close to carbonaceous chondrite values. One of the ideas on Earth's bulk composition is that the Earth is made of carbonaceous chondrite-like materials, but the redox state of Earth is closer to that of Enstatite chondrite than carbonaceous chondrite. We do not know exactly when and how the reduction event was occurred at proto Earth. Therefore, it is important to considering differentiation process of early earth that the phase relations of mantle composition are investigated under variable Fe/FeO conditions at high pressures. Allende meteorite (CV chondrite) is applicable to one of the oxidized model of the proto earth, whereas the most reduced model is Peridotite and Metal. We report the phase relations of Allende meteorite in the pressure range from 22 to 30 GPa, at 1600-2300 °C. We use natural Allende meteorite as starting material. The Kawai type multianvil apparatus was used for the present experiments. The truncated edge length of the anvil was 2 mm. We use two kinds of heating element, $LaCrO_3$ and Re. $LaCrO_3$ heater was used for subsolidus experiments, and Re heater was used for melting experiments. Pressure calibrations were made at high temperatures using il-pv phase transition, Al_2O_3 content of Pv determined by in situ X-ray diffraction measurements with the Jamieson's Gold scale [1]. The micro-area X-ray diffractometer and EPMA were used for phase identification and compositional analysis of run products. The liquidus phase changed from garnet to Mg-perovskite at about 24.5 GPa, and magnesiowustite remained second liquidus phase. The solubility of mafic components in Ca-perovskite in Allende composition is higher than that reported on Peridotite bulk composition. The Ca/(Ca+Mg+Fe) ratio of Ca-perovskite is 0.6 in Allende experiments, whereas that is 0.9 in Peridotite experiments [2]. Our result suggests that chemical differentiation process could change with FeO contents of magma ocean.
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V72B-1308 1330h POSTER

The High Pressure Stability of K-Cymrite and Phases in the System Or-H_2O

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The sinks for and processing of LIL elements, such as potassium, and water in Earths mantle are important to the planets evolution, crustal recycling, and the production of mantle melts. Sanidine hydrate or K-cymrite ($KAlSi_3O_8 \cdot nH_2O$) is an example of a crystalline phase for which a hydrous phase is more stable at high pressure than the anhydrous counterpart (e.g., sanidine). A multianvil synthesis study has been carried out to delimit the upper pressure stability of K-cymrite (Kcym) using two starting compositions - 1) gel-$Or_{97}Qtz_3$ and 2) natural sanidine (adularia) $Or_{97}Ab_3$ - each with equimolar H_2O (charges sealed in welded Pt capsules) over the range 4.5 to 12 GPa and 1000 to 1300 °C.

Consistent with Massone (1995) and Thompson et al. (1998), Kcym is stable at 4.5 GPa in the assemblages Kcym+silica+melt (1) or Kcym+Jd+melt (2) across the temperature range. Kcym reacts to K-wadeite ($K_2Si_4O_9$) + kyanite + silica + H_2O or melt at 1000 °C and ∼6 GPa; the reaction boundary has positive slope of ∼2.5 MPa/°C and is similarly placed to the anhydrous reaction sanidine ⇔ K-wadeite + kyanite + silica (Yagi et al., 1994). The next reaction occurs at ∼9 GPa where $KAlSi_3O_8$-hollandite (Kholl) forms at the expense of K-wadeite + kyanite + silica. However, a phase with $KAlSi_3O_8$ stoichiometry but low oxide total, therefore undoubtedly hydrous, also typically occurs with Kholl up to ∼11 GPa and 1200 °C; it is presently under investigation to determine what structure type it has (stuffed-Kholl, Kcym, or ?).

A melt component appears over a large range of conditions from 4.5 to ∼7.5 GPa and 1000 °C to 10 GPa and 1200 °C which may be attributable to both thermal gradients in the multianvil charges and discontinuous states of hydration in the charge. The melt volume increases with an increase in temperature and a decrease in pressure on the phase diagram. Melts are enriched in both SiO_2 and H_2O (by low oxide totals in microprobe analyses) and Na_2O and BaO in system-2 experiments. Melt is dominant at the hot portions of the charge but a clear melt-solid boundary is absent.

These experiments demonstrate that K-cymrite and perhaps another hydrous $KAlSi_3O_8$ polymorph can exist over a broad range of conditions at high pressure and should be important to crustal recycling or potassic interactions in the mantle lithosphere and deeper in the mantle if bulk compositions permit.

V72B-1309 1330h POSTER

Aluminum Substitution in MgSiO3 Perovskite: Confirmation of Multiple Mechanisms by NMR Spectroscopy

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The substitution of Al into MgSiO3 perovskite has significant effects on this minerals properties, but the structure of the solid solution remains incompletely constrained. To test mechanisms in which Al substitutes on "B" (Si) sites, creating corresponding oxygen vacancies, we have synthesized perovskites of nominal composition Mg(Si0.9Al0.1)O2.95 at 1600 C and 27 GPa. High-field (14.1 and 18.8 T) Al-27 NMR spectra show three main features: a broad peak ("A") whose width and shift with field are consistent with a disordered, distorted site with a chemical shift (cs) of about 7 ppm and quadrupolar coupling constant (CQ) of 7.5 MHz; a narrow peak ("B") with cs of about +6 ppm and CQ of about 1 MHz, and a third, smaller, peak ("C") with cs of about +15 ppm and CQ about 2 MHz. Peak A is probably due to Al in possibly partially collapsed A sites with coordination number of six or higher; peak B is probably due to Al in octahedrally symmetric B sites not associated with O vacancies. Peak B has more than twice the area of peak A, indicating a preference for B sites in this composition and thus necessitating O vacancies for at least global, if not local, charge balance. Peak C is likely to represent Al in B sites adjacent to such vacancies. Although its cs is rather low for AlO5, it is not far from the value of 18 ppm for the trigonal bipyramidal site with unusually long Al-O bonds in SrAl12O19. The relatively low intensity of peak C suggests that most O vacancies are not ordered next to Al in B sites, but are disordered among most or all O sites in the structure. The entropy generated by both cation and vacancy disorder thus must be included in any accurate model of the thermodynamics of this phase. In Al-bearing perovskites with excess Mg/Si, as is probably most relevant to the lower mantle, an oxygen vacancy mechanism is thus likely to important, allowing the possibility of enhanced diffusivities and water content. At the same time, charge coupled-substitution with Al in A sites also plays a role. The NMR data rule out the "brownmillerite" structure as a likely MgAlO2.5 end-member, as no AlO4 is observed.

V72B-1310 1330h POSTER

A genesis of carbonatitic melt within eclogite

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Recently, the number of studies for investigation of fluid or melt inclusion in diamond and ather mantle minerals has been rapidly, mainly due to progress of analytical instrument. Anderson et al (2001) and Coltorti et al. (2001) showed that CO2-rich fluid and carbonatitic melt are the major component among the inclusions and their transport would have profound effects in magmatism, metasomatism and others. The several lines of evidences indicate the existence of some recycled carbon. Some metasomatic agent is considered to have originated from recycle carbonates in the arc system (Papua New Gunea; McInnes and Cameron 1994) and in hot spot (Hauri et al. 1993). Hoernle et al. (2002) discussed that the carbonatite magma in the Cape Verde Islands originated from the subducted carbonate sediments.

Yaxley (1999) carried out experiments in the 60 wt.% eclogite + 40 wt.% CaCO3 system at 3.0-3.5 GPa. He showed that in the partial melting of carbonated eclogite, the first melt coexisting with calcite is carbonatitic.

In order to understand the role of carbonate-bearing eclogite in the upper mantle, we determined phase relations in the system 90 wt.% MORB-10 wt.% CaCO3 experimentally at 2.7-8.0 GPa and 800-1300°C. The solidus temperature decreases from ca. 1200°C at 3 GPa to ca. 950° at c.a. 4 GPa dramatically due to the appearance of dolomite below solidus. At 3.5-4.0 GPa, calcite is stable in solidus and carbonatitic melt is produced. With increasing pressure to 8 GPa, dolomite saturated solidus temperature increase up to c.a. 1200°C. Melt reacts with garnet and changes its composition from dolomite to calcitie with increasing temperature.

In the subduction zone with relatively cold oceanic lithosphere with carbonate sediments, carbonate is stable at least up to 8 GPa. On the other hand, subducted hot oceanic plate may produce carbonatitic melt, which will cause metasomatism in the lithosphere overlying wedge mantle and high-pressure metamorphic rocks. Because solidus temperature of dolomite eclogite is 300-400°C lower than carbonated lherzolite (1330°C), partial melting of dolomite eclogite is not rare in the upper mantle and possibly account for the origin of carbonatitic magma and their common role as metasomatic agents.

V72B-1311 1330h POSTER

Opx-Cpx Trace Element Partitioning in Mid-Ocean-Ridge Melting Residues

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We have obtained major (EPMA) and trace (SIMS) element mineral compositions on a suite of plagioclase- and vein-free abyssal peridotites (AP) exposed at the ocean floor along mid-ocean ridges. In terms of their melting history, they cover the entire AP compositional spectrum from very fertile compositions (Cr# spinel ∼0.12, Yb_N ∼10, $(Ce/Yb)_N$ ∼0.2) to highly depleted (Cr# spinel ∼0.58, Yb_N ∼1) ($_N$ denotes CI-chondrite normalized). At this stage we have measured trace elements in cpx and opx (mostly 3-6 analyses per grain) for 10 representative samples in order to address the following questions: (1) do large opx porphyroclasts reveal trace element zonation that can support a disequilibrium melting hypothesis as predicted by REE diffusion experiments [1]? (2) Are opx and cpx in equilibrium? (3) How well do the measured data agree with literature partition coefficients?

(1) With the exception of 1 sample, all opx do not show trace element zonation within analytical error. This suggests that LREE diffusion rates in opx at solidus conditions are faster than predicted from laboratory diffusion experiments on diopsides. Significant core-rim variations in cpx (which have generally smaller grain size) have not been observed either in any of our plag- and vein-free peridotites (n ∼80). (2) The general trace element pattern of cpx is mimicked by

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