6NH—9^{o} 51’ N-EPR

A Ridge2000 Time Critical Studies Response Cruise to an Eruptive Event

R/V New Horizon
4-23 May 2006
9^{o} 51’ North East Pacific Rise

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May 2006 Rapid Response to Evidence of Recent Eruption at $9^o50'$ N EPR

Purpose

1. To follow-up on recent indications that the $9^o50'$ N EPR site has had a seafloor eruption.
2. To document the possible eruption by:
    a. Surveying the water column to assess quantitatively and qualitatively the heat and (chemical, biological) mass flux associated with the possible eruption.
    b. Imaging the seafloor using towed, near-bottom digital camera (TowCam) (including wax-ball coring and 5-liter niskin bottle sampling during towing)
    c. Verifying exact locations of recently-deployed and 'old' but still-communicating OBSs, and deriving precise drift distances and directions.
    d. Sampling of 'new lava' via targeted rock dredging based on results from TowCam surveys
    e. Deploy expendable sonobuoys to 'listen' to seismicity in real time
    f. Deploy 2 particle/larval trap moorings
    g. Deploy Langrangian float to observe current behavior in deep water over the ridge.

Acknowledgements:

This cruise came together very quickly with the incredible cooperation of SIO Marine Facility, the officers and crew of the New Horizon, NSF, and the personnel and administrations of U. of Hawaii, WHOI, OSU, U.W and LDEO. The participating scientists are very grateful.

The cruise was blessed with calm conditions for the entire cruise, with absolutely no operations lost to weather. The officers and crew were outstanding: competent, extremely accommodating, and friendly; all departments went out of their way to help make this cruise a scientific success. Despite the lack of Dynamic Positioning, the officers held to track lines very well (generally dead on), especially under difficult conditions of a confounding surface current. The bridge met our changing needs with complete calm, professionalism, and good cheer, which the sleep-deprived scientists sincerely appreciated. The deck department performed flawlessly, despite the fact that it was the first experience with winch/a-frame deployments for 2 out of the 3 AB's. The SEG, Rob Palomares, was fantastic. He was everywhere that he was needed; his diverse knowledge, competence, energy, and abundant good cheer were made available to us 24 hours a day. We never had to look for him when it came time for one of our deployments or recoveries; he was there already. The engineering department was also extremely helpful to way beyond the call, by fabricating a number of tools and brackets for our over-the-side equipment and loaning us various supplies without hesitation. The galley department kept us very well fed; the food was great. Eddie Lograsso and Mark Smith were also very friendly and helpful, whether it was setting aside complete meals for scientists fully engaged in operations during a meal hour, or accommodating a scientist with special dietary needs, or making a birthday cake for two of our first time-at-sea scientists. A special thanks to Captain John Manion for his competence and very pleasant style of keeping us safe while efficiently getting us to where we needed to be.

Thanks to the officers and crew we had a very successful cruise and we had fun. Thank you.

Cast summary:

Cast 1: CTD #1, along axis (9.783 N to 9.875 N)

Cast 2: TowCam #1, along axis (9.818 N to 9.881 N)

Cast 3: CTD #2, cross axis at ~9.833 N (104.326 W to 104.250W)

Cast 4: TowCam #2, along axis (9.767 N to 9.63 N)

Cast 5: CTD #3, cross axis from (9.843 N, 104.311 W to 9.874 N, 104.253 W)

Cast 6: TowCam #3, along axis from (9.870N, 104.296W) to (9.917N, 104.302W)

Cast 7: CTD #4 initially towed along the axial summit from 9^o 52.00’ N to 9^o 54.22’ N; from 9^o 54.22’ N, turned right to proceed off axis on a 60^o heading.

Cast 8: TowCam #4 conducting several cross-axis transects with tightening right angle turns between 9^o 53.4’ N - 9^o 53.1’ N and 104^o 18’ W and 104^o 17’ W

Cast 9: CTD #5 vertical cast centered on the axial summit (9^o 49.843 N, 104^o 17.446 W)

Cast 10: Dredge-1 parallel to the ridge axis along a track from 9^o 54.50 to 9^o 54.70 N, along longitude 104^o 18.70’ W

Cast 11: CTD #6 vertical cast (9^o 50.828 N, 104^o 17.57 W) north of previous vertical cast 9

Cast 12: TowCam-5 traversed along-axis over the area of historical venting from the area of ~9^o 49.4’ N (just south of Tube Worm Pillar) to ~9^o 50.9’ N (the Bio Vent area)

Mooring Deployments (Sediment/Larval Trap-current meter) near Bio-9 and Tica vent sites. (~9^o 50.9’ N)

Cast 13: CTD #7 tow-yo parallel to the axial summit, but offset to the east by ~150 m (9^o 46.685’N, 104^o 17.161’W to 9^o48.50’N, 104^o17.10’W and then to 9^o51.60’N, 104^o17.65’W)

Cast 14: TowCam-6 This camera tow traversed along-axis tow covered the area of historical venting from the area of ~9^o 49.4’ N (just south of Tube Worm Pillar) to ~9^o 50.9’ N (the Bio Vent area), with several parallel tracks were made by letting the ship drift south to cover both east and west of the axis.

Ranging of Sediment/Larval Moorings. Ship ranged on both moorings; however, only Mooring #1's acoustic release would respond to deck unit.

Mooring 1 (with Aanderaa RCM11 current meter)

Drop Point: 9 50.33 N, 104 17.50 W Near Bio 9 Vent

Ranged position: 9 50.316 N, 104 17.565 W

(based on five ranges)

Mooring 2

Drop Point: 9 50.396 N, 104 17.523 W

No Ranged Position - release would not talk.

Based on drift of Mooring 1, Mooring 2 should be at: 9 50.382 N, 104 17.588 W

Cast 15: Vertical TowCam (#7) with in situ pump and electrochemical analyzer added. Deployed at 9°49.8'N 104 17.42'W. Collected pump sample at "stationary" position, then "random walked" at 3 mab to image seafloor in vicinity of former vent site.

Deployed Lagrangian float at ~9°49.8'N 104 17.42'W

Time Log:

May 4, 0945 hr (local): Depart SIO Marine Facility pier. Calm, ~60^{o}C, slight breeze.

May 6, 1215 hr: Stop for wet-test for CTD-rosette and 3 acoustic releases, as well as winch practice for new ABs. CTD tested with LISST mounted and powered by CTD. ISEA (electrochemical analyzer) was not mounted for this cast. Cast taken to 400 m, sensors appeared to work fine. All bottles tripped fine (no bottles in rosette position 16, 17, 18 for entire cruise).

Two new ABs practiced winch/J-frame operations using the hydrowire with only a weigh attached.

Also, three acoustic releases were then shackled to the hydrowire, lowered to 400 m. A hand-lowered transducer was used to communicate with the releases. One release, answered appropriately and opened on command, a second release did not answer back but did open on command, and the third neither communicated or opened.

~1530 hr: continued transit while seawater sampling crew practiced sampling operations.

May 7, ~0900 hr: Engineering department noted elevated pressure in stbd main engine gear box. They then noted visual quality of engine oil was 'off', suggesting possibility of water contamination, although oil viscosity was within specs. Ship stopped stbd main engine to change its oil. Ship continued transit at ~6 knots (instead of 10.7 knots) with just the port main engine until oil change completed. Once complete we proceeded at ~9.5 knots, while information was transmitted back to the SIO port engineer.

May 10, ~2230 hr: Arrive on station for first science operation—

May 10 (2300 hr) to May 16 (2355 hr): Science Operations at and near 9^{o} 51’ N, 104^{o} 17.3’W.

CTD Operations

Summary of CTD Observations to Date

The possibility of a recent eruption along the EPR at 9^o 51' N was first suspected by observant geophysicists aboard the R/V Knorr during the April 2006 cruise while attempting to recover one group of OBSs and deploy a replacement group. When a large percentage of the 2005 OBS would not communicate with the surface, or release from their bottom weights, and a few of the new 2006 OBSs stopped communicating, the shipboard scientists suspected that an eruption might have recently taken place or may even be underway. The use of MAPRs by the Knorr scientists provided limited, but very useful information suggesting that the hydrothermal output of the region had been stimulated since previous observations. MAPRs are self –contained sensors that measure turbidity (light backscatter) and temperature. There is no conductivity sensor so it is not possible to measure density, potential temperature, or potential temperature anomalies. Nevertheless, the MAPR data revealed a substantial particle anomaly over the ridge between about 9^o 46' and 9^o 51.5' N; the strongest particle plume was over 9^o 51' N.

One of the primary goals of the May response cruise was to greatly extend the observations of the hydrothermal plumes, both in terms of intensity, coverage (axial and cross-axis) and parameters measured. In the time available, we performed 5 long tow-yo (7.5 to 11+ hours) and 2 vertical casts with the CTD package. Our CTD package consisted of the SeaBird SBE 911 CTD+SeaTech 347 light backscatter sensor (turbidiy) + WetLabs CST-493DR transmissometer (light transmittance) + a LISST-Deep laser in situ scattering and transmission sensor (particle size distributions) + an ISEA electrochemical (voltametric) analyzer + a rosette of 21 10-liter SIO-built, Niskin-style sampling bottles. The Niskin bottles were subsampled for a suite of inorganic, organic and biological constituents (Table 1).

Table 1. List of Parameters Measured In Situ and Seawater Constituents Sub-sampled for.

In Situ Parameters Measured

1. Conductivity-temperature-pressure
2. Turbidity (light scattering, SeaTech turbidity sensor)
3. Light transmission (WetLabs Transmissometer)
4. Redox chemistry (ISEA Electrochemical Analyzer)
5. Particle size distribution (LISST)

Seawater Constituents (subsamples)

1. He (total and ^{3}He
2. Methane (concentration and stable isotopes)
3. H_2
4. Shipboard electrochemical analyses, iron sulfides, bimane, H_2S, Fe (II) and total Fe
5. Dissolved Inorganic Carbon
6. Alkalinity
7. pH
8. Total Dissolvable Metals

9. Microbial biomass (DAPI)
10. FISH
11. Molecular (Microbial) Community Diversity
12. Total organic carbon
13. Nutrients
14. Salinity
15. Particle qualitative characterization (SEM and TEM)
16. Particulate Carbon and Particulate Nitrogent (PC/PN concentration/stable isotopes)

The CTD package was towed while being alternately lowered and raised through the lower water column, resulting in a saw-toothed pattern (tow-yo). We extended the coverage along the ridge axial summit from nearly 9° 46.3'N to ~9° 54.2'N. Three cross-axis tow-yos were intended to evaluate both the off-axis component of the plumes and the effect of cross-axis currents with respect to the implications for possibly misjudging the frequency and location of vent sites on the basis of limited along-axis CTD or TowCam tows. In addition to the tow-yos, the two vertical CTD casts revisited sites noted to have high particle and temperature anomalies in order to obtain large volume in situ filtration samples for extensive molecular community diversity studies of hydrothermal plumes and to obtain higher resolution profiles.

Along-axis tow-yos revealed strong particle plumes from 9° 46.6'N to ~9° 52.2'N (Figure 1 and 2). The particle plume north of 52.2'N was comparatively quite week along axis to 54.0'N, the northern most point of this cruise's axial tow-yos. The most intense particle plumes were centered around 46.6'N, and 51.5'N. It was less intense, but still strong over 50'N, the site of the most intense particle plume observed during the April 2006 Knorr cruise using MAPRs.

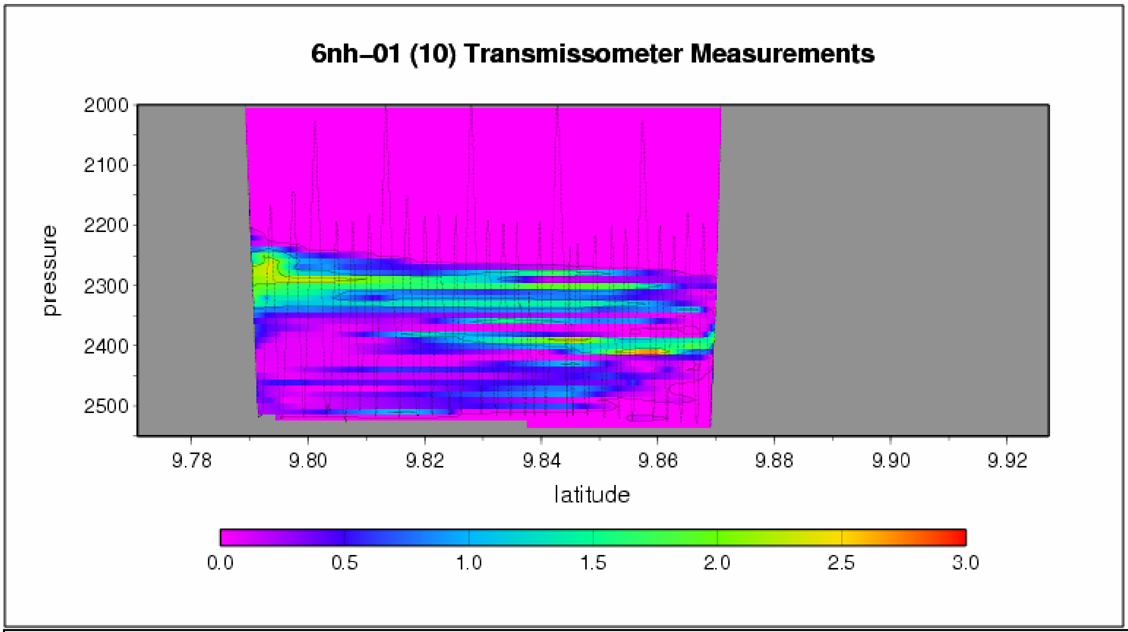


Figure 1. Particle anomalies for tow-yo along axial summit. Scale bar represents the anomaly, as the difference between values measured at sample depth and background depths just above plume depths. Faint saw-tooth line represents the actual profile trace of the CTD package. Numbers refer to percent (%) light transmission.

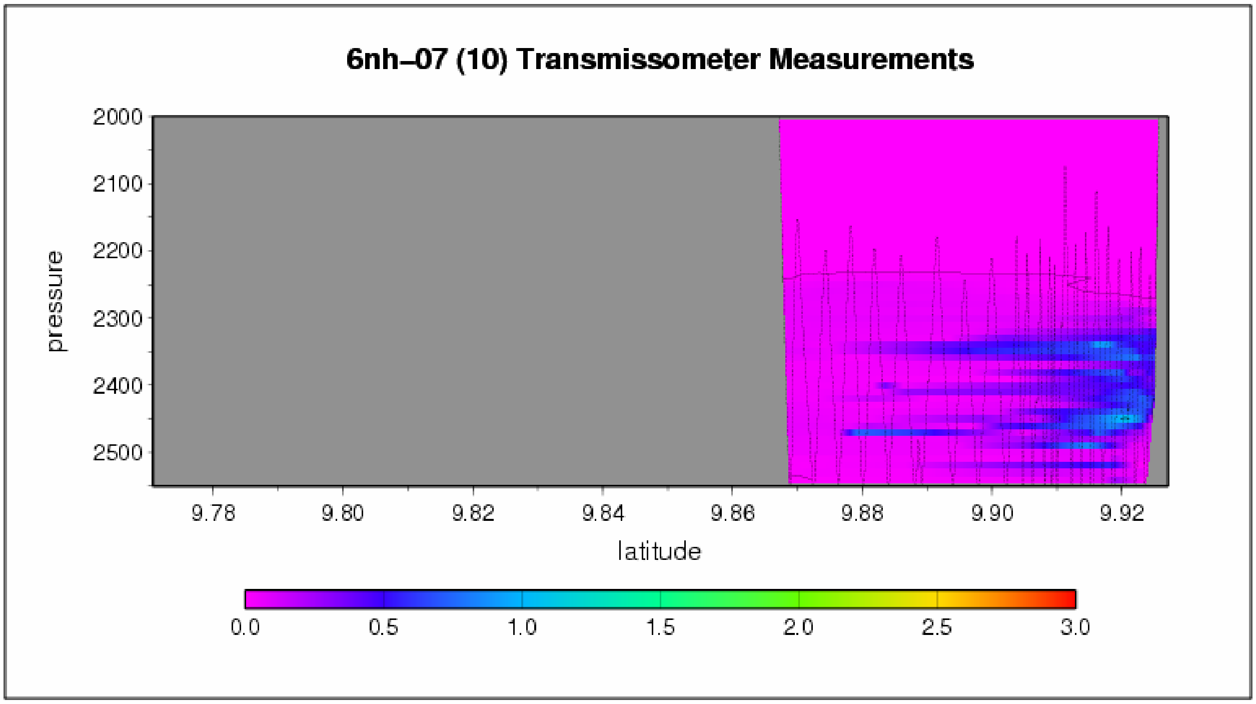


Figure 2. Particle anomalies for tow-yo along axial summit as far north as ~9° 54'N, where the tow-yo turned east on a 60° heading (cross-axis). This can be seen in the change in frequency of the saw-tooth pattern. Scale bar represents the anomaly, as the difference between values measured at sample depth and background depths just above plume depths. Numbers refer to percent (%) light transmission.

A later tow (Figure 3) made along-axis but off-set to the east of the summit by about 150 m (Cast 6nh-13) showed strong plumes throughout most of the region towed during Cast 1. The major difference was that the plumes observed in the off-set tow were generally stronger throughout the depth region from ~2220 m to 2500 m, whereas the plumes directly over the axial summit showed more vertical variability, consistent with their close proximity to venting sources subject to a cross-axis current.

The cross-axis two-yos clearly demonstrate the presence of a strong cross-axis component to deep currents present during the time frame of this cruise. Whereas strong particle plumes are evident to the east of the axis in both Casts 3 (crossing the axis near ~9° 50'N) and Cast 5 (crossing axis near ~9° 51'N), the plume is very weak or absent west of the axis (Figure 4). This effect is clearly demonstrated in the compiled up-down profiles for the entire Cast 3 (Figure 5), where the tight knot of near-background, plume-depth profiles representing the portion of the tow-yo cast west of the axial summit contrast with the higher plume signals of the axial and east portions of the cast. In fact the most intense particle plumes observed during the cruise were found about 1km east of the axis and, similar to the off-set axial tow-yo (Cast 13), tended to be deeper in the water column than axial plumes.

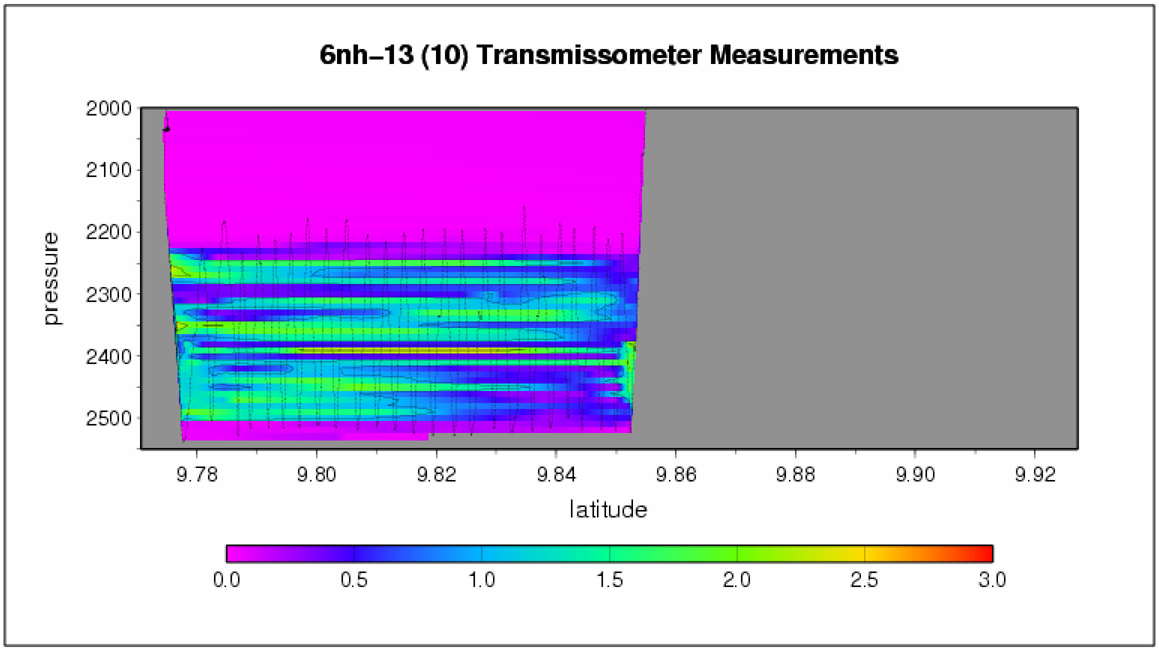


Figure 3. Particle plume observed along-axis, but offset from axial summit by ~150 m. (see Fig. 1 caption for explanation).

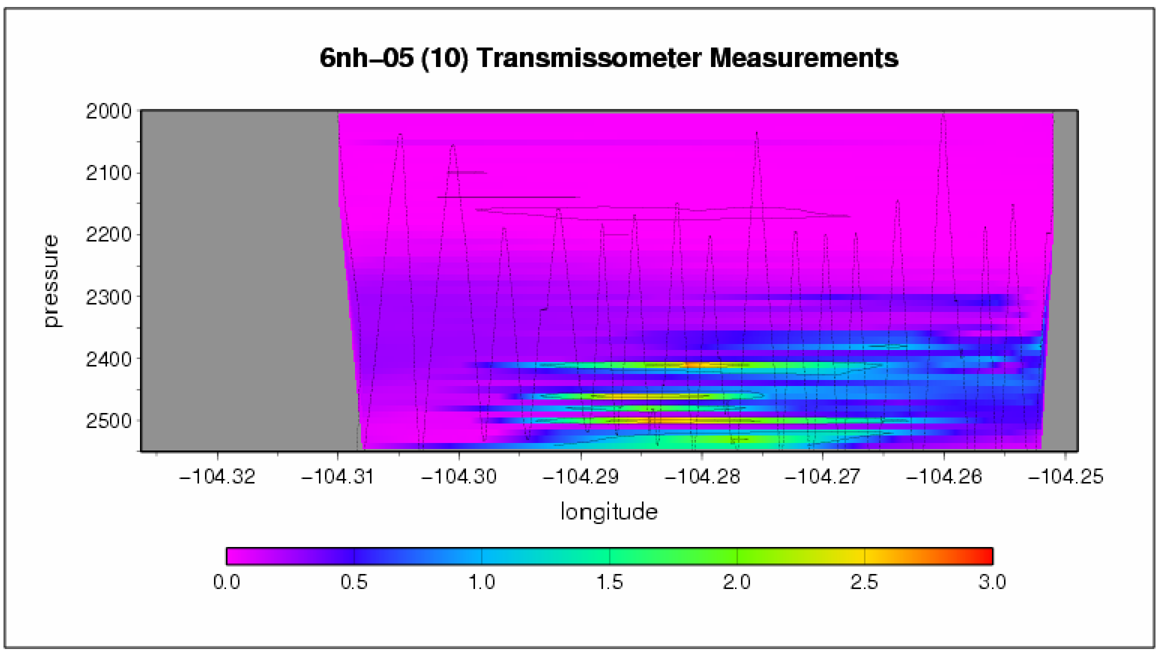


Figure 4. Cross-axis particle plume. Tow-yo crossed axial summit at about 104_o 17.4' W. (see Fig. 1 for further explanation of graph).

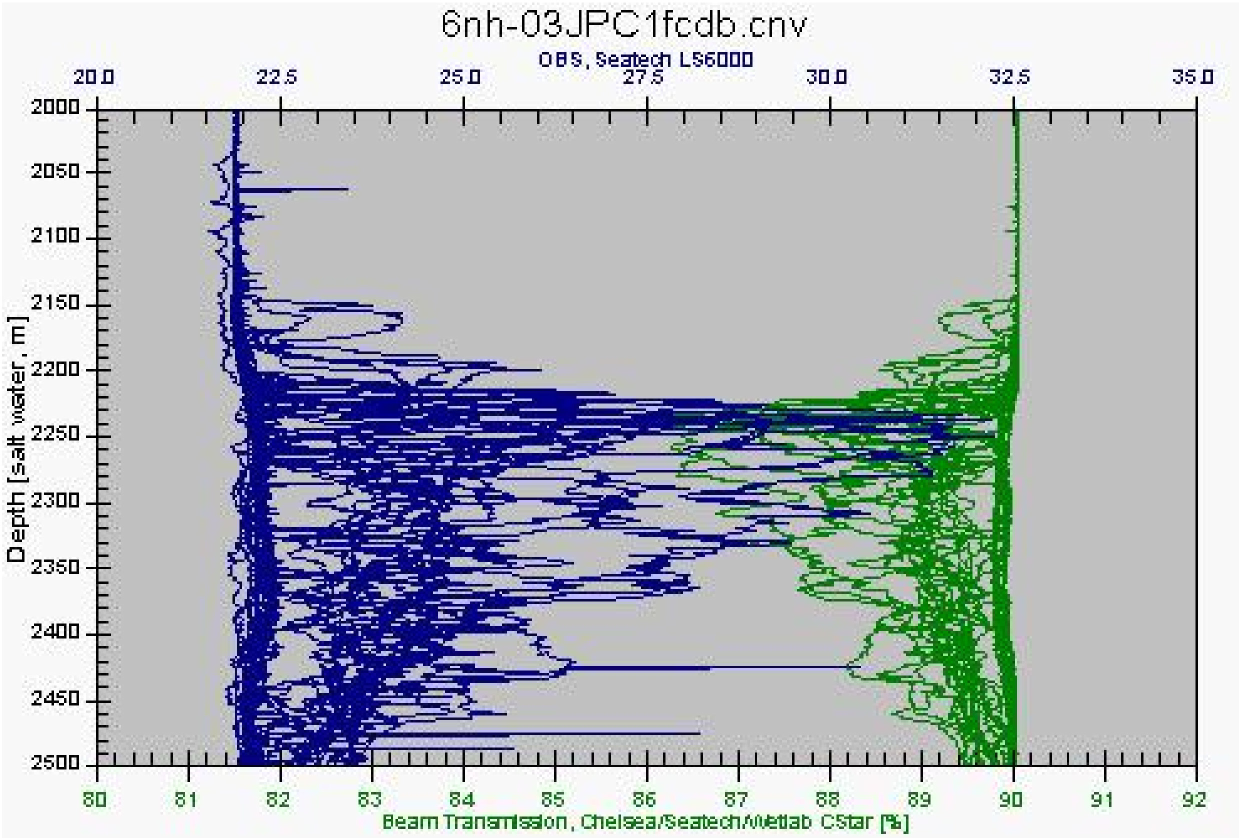


Figure 5. Composite profiles of light transmission (green) and light scattering (blue) values for entire Cast 3 tow-yo. Note tight knot of profiles that represent the west of axis portion of the cross-axis tow-yo.

Analyses of the temperature anomalies present in the hydrothermal plumes observed during this cruise are under way. From preliminary analysis, it appears that the temperature anomalies ($\Delta\theta$) are present though modest (generally <0.1 ^{o}C), with the strongest water column $\Delta\theta$'s found in the near bottom plumes. It is currently anticipated that the ratio of particle anomaly to temperature anomaly ($\Delta c/\Delta\theta$) will be found to decrease from axial to off-axis plume, consistent with continued particle formation during early maturation of the plume. Baker et al. (1994) found similarly low temperature anomalies in the post-991-eruption plumes, attributing this to the hydrographic masking of the $\Delta\theta$ due to the low salinity of the discharge fluids.

Most of the chemical and biological analyses of collected water samples must await their return to shore-based laboratories. However, ship-board methane analyses indicate very high levels of methane in the neutrally-buoyant plumes (to 350 nM), with even higher levels in the near bottom-collected (TowCam) samples (the latter possibly buoyant plumes over diffuse vents). The plume methane values are 50 to 100 times higher than normally found for (stable) chronic-style hydrothermal plumes from hydrothermally active unsedimented ridges and are significantly greater than the methane values (to 80 nM) measured over this portion of the EPR 6 months after the 1991 eruption (Mottl et al. 1995). Although these latter high concentrations of CH_4 were clearly associated with the earlier 1991 eruption, the specific origin of the CH_4 was unclear

(Mottl et al. 1995); the replicate gas samples collected for stable carbon analysis during the present (May, 2006) cruise should help to identify the origin of this year's very high methane. He, H_2, and total dissolved inorganic carbon measurements await shore-based laboratory analysis. Sulfides were detected in several of the water samples and are discussed in the next (electrochemical) section. Preliminary ship-board analysis of Fe(II) and total Fe indicate low levels, although total dissolvable metals, including iron will be analyzed on shore using more sensitive methods. A table of samples collected for all CTD and TowCam casts is included with the R2K DMS files submitted to the R2K Data Management Office.

On-deck and in situ electrochemical analyses

Our primary goal was to use an in situ voltammetric technique to map and investigate redox dynamics within a hydrothermal **event-style plume**, if present. A secondary goal was to map and investigate redox dynamics within **developing chronic-style plumes** over (known and new) actively venting seafloor.

Voltammetry:

In voltammetry, current is measured while scanning a voltage range, allowing simultaneous detection of multiple chemical species (analogous to varying wavelength and measuring absorbance with spectroscopy). The measured current for peaks detected during voltage scans is proportional to analyte concentration. Many important redox species can be characterized using voltammetry (Table I), including O_2, Mn^{2+}, Fe^{2+}, HS^-, S_x^{2-}, $S^0_{(aq)}$, $S_2O_3^{2-}$, $S_4O_6^{2-}$, $FeS_{(aq)}$, and Fe(III)-species. Because the voltammetric electrode scans a range of potentials, rather than constantly resting at a single potential, consumption of the chemical species measured is undetectable.

Details regarding construction and analytical methodology for the solid-state working electrodes are available elsewhere. Briefly, a standard three-electrode cell is used, incorporating an Au/Hg working electrode (0.1 mm diameter), a silver/silver chloride (Ag/AgCl) reference electrode (1 mm diameter), and a platinum (Pt) counter electrode (0.5 mm diameter). All electrodes are custom-made, sealed in commercially-available polyetheretherketone (PEEK) tubing using epoxy. Linear sweep, cyclic, or square wave voltammetry is used, scanning from -0.1 V to -1.85 V at a scan rate of 250-4000 mVs^{-1}. Electrochemical conditioning of the electrode surface between scans removes any chemical species from the surface of the electrode, restoring it for the next measurement. All electrodes are calibrated using a standard Analytical Instrument Systems, Inc. (AIS) benchtop DLK-60 electrochemical analyzer following established standardization procedures.

In situ electrochemical analyzer:

At the heart of the in situ voltammetric measurements is the AIS Model ISEA™-III electrochemical analyzer. A titanium pressure case (1 m long by 20 cm diameter, rated to >10,000 psi) houses the analyzer consisting of a potentiostat, a 4-electrode multiplexer, and an internal computer with removable flash memory. For CTD rosette and TowCam deployments, we modified the ISEA-III to utilize an internal 12VDC 12Ah sealed lead acid battery. Waterproof bulkhead connectors (Subconn, Inc.) allow cabled connection to external power source (if available) and RS-232 communication, temperature sensors, 4 voltammetric working electrodes and one counter and reference electrode. The analyzer is controlled by an internal IBM-compatible computer, capable of RS-232 communication to an outside computer that can be controlled in real-time during HOV and ROV deployments. The current ISEA-III represents a new design that is also capable of booting into a stand-alone data-logging configuration, which we utilized for CTD rosette and TowCam deployments.

Upon installation of a fully charged battery and blank flash memory card, the ISEA-III was mounted to either the CTD rosette or TowCam frame using a combination of hose clamps, custom brackets, and nylon webbing straps. Voltammetric electrodes were mounted into a custom cylindrical flowcell (1.25cm inner diameter) to limit turbulent flow across the electrodes. Electrodes were mounted within 0.5m of CTD sensors. In one instance, electrodes were mounted within a Niskin bottle in an attempt to quantify temporal bottle effects for redox species. Prior to deployment of the CTD rosette or TowCam package, the ISEA-III was preprogrammed with a start time (typically 10-20 minutes after entering the water) and a sequence of voltammetric parameters to cycle through the four deployed replicate working electrodes.

Although data can be downloaded via the bulkhead serial communication connector on the ISEA-III, removal of the flash memory card for direct download is orders of magnitude more fast, and opening the pressure case enables exchange of the battery in between deployments. Binary ISEA-III files were converted into raw data and text files using conversion applications from the manufacturer. Individual scans can be visualized immediately using a multi-file viewer application provided by the manufacturer. Individual scan analysis is currently underway using a combination of the manufacturer's software, a custom auto-analysis package, and Matlab.

On-deck electrochemical analyzer:

Niskins were sampled from the CTD rosette and TowCam using syringes and 3-way stopcocks to purge any air bubbles. Syringe samples were injected into a custom PEEK flowcell (Luther et al. 2002) containing electrodes to minimize chances for atmosphere oxygen contamination. Measurements were made using a standard DLK60 electrochemical analyzer (Analytical Instrument Systems, Inc.).

Preliminary results:

The ISEA-III was deployed on CTD rosette casts 1, 3, 5, 7, 9, 13, and TowCam cast 15. A total of 20,662 in situ voltammograms were collected, and a total of 47 discrete samples were measured from Niskin bottles. **Preliminary observation** of in situ scans reveal presence of reduced sulfide in several portions of casts 1, 3, 5, 7, 9, 13, & 15. More detailed, stringent data analyses for quantification and presence of other reduced and partially oxidized species are underway. Alignment of in situ voltammetric data to CTD and NMEA data is also underway. On-deck voltammetric analyses detected reduced sulfide in (Cast#-Bottle#): 1-2, 4-7, 5-5, 5-7, 5-10, 5-11, 8-8, 9-8, 13-7, 15-7, 15-9. Quantification calculations are underway.

Table 2. Electrode reactions at the Au/Hg electrode vs. the Ag/AgCl reference electrode. All data were obtained with a 100 μm diameter electrode. O_2 and H_2O_2 data were collected using Linear Sweep Voltammetry; all others using Cyclic Voltammetry or Square Wave Voltammetry. (MDL – Minimum Detection Limit)

	E_p ($E_{1/2}$) (V)	MDL (μM)
$O_2 + 2H^+ + 2e^- \rightarrow H_2O_2$	-0.30	2
$HS^- + Hg \rightarrow HgS + H^+ + 2e^-$	Adsorption onto Hg<-0.62	
$HgS + H^+ + 2e^- \leftrightarrow HS^- + Hg$	~ -0.62	< 0.1
$S^0 + Hg \rightarrow HgS$	adsorption onto Hg < -0.60	
$HgS + H^+ + 2e^- \leftrightarrow HS^- + Hg$	~ -0.62	< 0.1
$Hg + S_x^{2-} \leftrightarrow HgS_x + 2e^-$	adsorption onto Hg < -0.60	

$HgS_x + 2e^- \leftrightarrow Hg + S_x^{2-}$	~ -0.62	< 0.1
$S_x^{2-} + xH^+ + (2x-2)e^- \leftrightarrow xHS^-$	~ -0.62	< 0.1
$2\ RSH \leftrightarrow Hg(SR)_2 + 2H^+ + 2e^-$	typically more positive than H_2S/HS^-	
$2\ S_2O_3^{2-} + Hg \leftrightarrow Hg(S_2O_3)_2^{2-} + 2e^-$	-0.15	10
$S_4O_6^{2-} + 2e^- \rightarrow 2\ S_2O_3^{2-}$	-0.45	15
$FeS + 2e^- + H^+ \rightarrow Fe(Hg) + HS^-$	-1.1	molecular species
$Fe^{2+} + Hg + 2e^- \leftrightarrow Fe(Hg)$	-1.43	10
$Fe^{3+} + e^- \leftrightarrow Fe^{2+}$	-0.2 to -0.9	molecular species
$Mn^{2+} + Hg + 2e^- \leftrightarrow Mn(Hg)$	-1.55	5
$Zn^{2+} + Hg + 2e^- \leftrightarrow Zn(Hg)$	-1.02	< 0.1

Analyses of microbial diversity in the water column
Alexander Treusch, Stephen Giovannoni

For analyzing changes in the microbial community in the water column in response to the eruption, biomass samples were collected by two different methods. First, an *in situ* pump (McLane model WTS 6-1-142 LV) was deployed four times to collect biomass on 0.2 µm membranes from a big plume (sampled twice), a smaller plume and a background seawater sample. These samples will be processed in the laboratory to extract DNA and RNA in parallel. The DNAs will be used to get fingerprints of the microbial communities utilizing polymerase chain reaction (PCR) and terminal restriction lenght polymorphism (T-RFLP). Further, the construction and analysis of 16S rDNA libraries is planned to identify the groups of species that have been detected by T-RFLP. For confirming the results RNA dot-blot analyses will be performed.

The second method used to collect microbial biomass was the filtration of 10 and 100 ml seawater each for over 90 samples using 0.2 µm membranes. Seawater was collected during several cast with the CTD and the Tow-Camera and taken from the attached Niskin bottles. The resulting membranes will be used for cell counts after DAPI staining and to confirm results from the community fingerprinting by using fluorescence *in situ* hybridization (FISH).

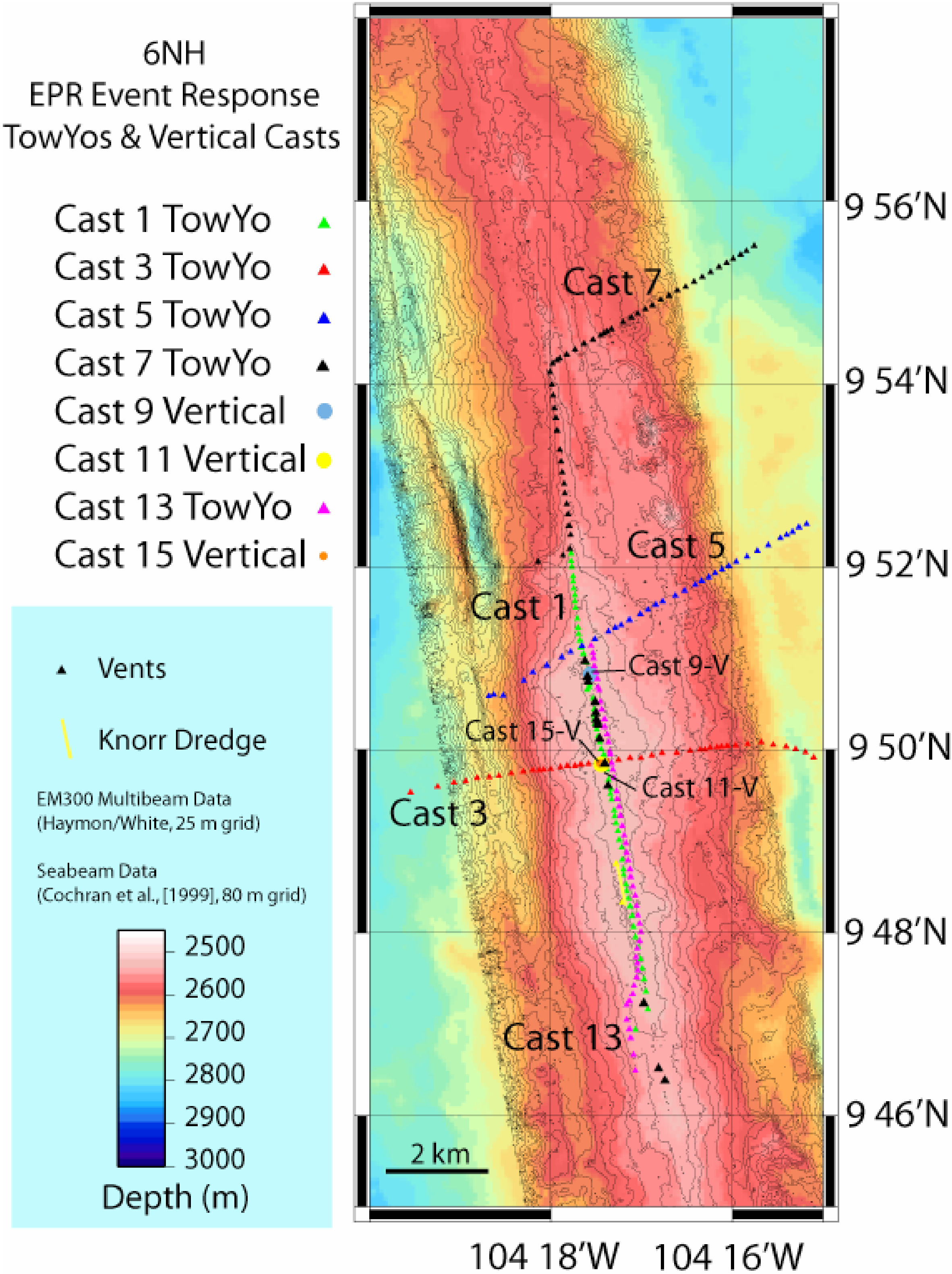


Figure 6. Map showing tow paths of CTD tow-yos as well as position of two vertical casts (Casts 9 and 11). Cast 15 was actually a TowCam deployment with the electrochemical analyzer and in situ pump attached.

CTD Cast Summaries

May 10, ~2300 hr:
Cast: 6NH-01—CTD #1; tow-yo.

CTD-rosette tow-yo along the axial summit trough of the ridge, including the axial region between 9°49'-51'N where 8 Ocean Bottom Seismometers (OBSs) had stopped communicating and another 3 would not release. The CTD package was towed from 9^{o} 47.000'N, 104^{o} 16.920'W directly over the axial summit to near 9^{o} 52.500'N, 104^{o} 17.820'W. The CTD tow-yo (9^{o} 47.000'N, 104^{o} 16.920'W to 9^{o} 52.500'N, 104^{o} 17.820'W) verified the presence of extensive and intense hydrothermal particle plumes. Hydrothermal plumes were observed over the entire tow, but were clearly most intense in the northern portion of the tow over the OBS study area near 9°50'N. Plume intensity and vertical structure was quite variable throughout the tow. Analyses of the corresponding temperature anomalies are underway, but the most substantial T^{o} anomalies appear to be near bottom (to ~30 mab) from ~9^{o} 49.7 to 9^{o} 50.5' N. Seawater samples have been collected for analysis of a wide variety of gas, other chemical and microbial constituents. Ship-board methane analyses reveal plume methane concentrations twice those previously measured in samples collected from the same area in the post-1991 time period. Although ship-board analyses indicate no detectable hydrogen sulfide in water samples collected so far, an in situ electrochemical analyzer frequently did detect sulfide in portions of the plume.

May 11; ~ 2246 hr:
Cast: 6NH-03—CTD #2, tow-yo

A cross-axis CTD-rosette tow-yo followed the TowCam. This cast found only very low-level hydrothermal plumes to the west of the axial summit; however, right at and, especially off-axis to the east, the plumes were strong. The off-axis (east only) particle plume extended in places from 2250 m to greater than 2500 m. Methane concentrations were high (33 to 123 nM) although not so high as found in axial samples. Methane carbon stable isotope values (on shore) will help to determine the degree to which these lower concentrations reflect microbial methane oxidation versus different (source) concentrations. In situ electrochemical analyzer detected H_2S in some samples, whereas ship-board analysis of Niskin bottle samples did not.

May 12; ~1951 hr:
Cast: 6NH-05—CTD #3, tow-yo.

This was another cross-axis tow (9.843 N, 104.311 W to 9.874 N, 104.253 W). We encountered the most intense particle plumes yet during this tow-yo, again the strongest signals were about one km east of the axial summit. We had encountered a similar pattern during the first cross-axis tow (Cast 3), although the highest level particle signals were less than during this cast. The source of the very intense plume is currently unclear, since the strong off-axis plumes are not consistent with the axial plumes encountered so far. The off-axis plumes also extend to greater than 2525 m, deeper than the bottom depth at the ridge summit to the west. Given the patterns of the plumes to date, it is clear that there is a very strong easterly bottom current, however the pattern also suggests a southerly component as well (SE to SSE). Consequently, one scenario is that there might be another source for the off-axis plumes from further north on the axis than we have yet towed. Therefore the next CamTow was directed to tow along the section of axial summit trough north of 9.870 N.

May 13; ~1510 hrs:
Cast: 6NH-07—CTD #4, tow-yo.

This cast started out retracing the track line of the previous cast's TowCam operation. The CTD was initially towed along the axial summit from 9^o 52.00' N to 9^o 54.22' N; however, only occasional small plumes (limited depth range and only modest intensity) were detected within the water column at a depth of ~2460 m. At 9^o 54.22' N, the ship bore to the right of the axial track-line to a heading of 060^o. On this heading we encountered only small plumes for the first 1.5 kms off-axis before finding more intense plumes that persisted for another 1.5 kms further east of the axial summit. A distinct vertically structured particle plume was observed from 1.5 to 3.0 km off-axis at depths extending from deeper than 2600 m to ~2260 m. This depth can be compared to the depth of the axial summit (~2550 m) due west of this off-axis plume. Consequently, the source(s) of the intense, vertically-extended off-axis plumes observed during Casts 3, 5, and 7 are still uncertain. Possible scenarios include: 1) advection from ridge with easterly currents and time-dependent continued particle formation (chemical precipitation; biomass production); 2) rigorous axial venting further to the north or south of the portion of the ridge summit surveyed so far during this cruise (i.e., north of 9^o 54' N or south of 9^o 46' N), along with a strong southerly or northerly component in the current. Previous work in this area (Nov. 1991, Mottl et al. 1995) indicate strong latitudinal differences in chemical signals (e.g., CH_4/Mn ratios), with the plumes over the 1991 eruption standing out relative to ridge sections to the immediate south or north. Shipboard methane data and shore-based analyses of collected samples for Mn, Fe and other constituents may help to identify differences or similarities between the off-axis plumes and nearby and more distant axial plumes. Site-time depending, we will also try to sample ridge areas further to the north and south.

May 14; 1418 hr:
Cast: 6NH-09 – Vertical CTD cast

A vertical CTD cast was centered on the axial summit (9^o 49.843' N, 104^o 17.446' W) at the location where the first cross-axis CTD-tow-yo deployment crossed the axis (see Cast #3). Strong plume signals (temperature and particle anomalies) had been found at this site during both of the previous casts. A major objective of this cast was to perform large volume in situ pumping to collect large amounts of (bio)particles for extensive molecular diversity studies; thus a large stable plume was necessary to insure that we could continuously sample (pump) it for 1.5 hours. During this vertical cast we encountered a very intense particle plume that was large enough in area and depth so as to easily keep the instrument package within the particle peak for the entire 1.5 hour pumping period. Four niskin bottles were tripped also at this depth. Following the pumping operation, the package was lowered to ~15 m above the seafloor where the deepest water sample was collected. The rest of the bottles were collected at various depths during the ascent. Water chemistry samples collected showed very high methane concentrations in the near bottom samples (~350 nm), with lower but still substantial methane values in the upper plumes (~130-230 nM); methane values in the shallowest but most intense particle plume (pump depth) was ~140 nM. Much other forthcoming chemistry data should shed considerable light on the nature of the hydrothermal fluids, but we emphasize that these plume values for methane and those from the TowCam near bottom samples are very high for an unsedimented ridge hydrothermal system, and are higher than found within a year of the 1991 eruption in this area.

May 15; 0232 hrs
Cast: 6NH-11 - Vertical CTD cast

Based on previous CTD tow-yo (Cast 1) data, this second vertical CTD cast was performed at an axial location further north (9^o 50.828 N, 104^o 17.57 W) than the previous vertical cast (Cast 9), in the area of the previously known M-Vent and Q-Vent. Relatively high temperature anomalies were observed in the water column, especially at around 65 m above bottom, but the particle plumes were more modest than found elsewhere (ex. Cast 9). Another in situ high-volume pump sample was collected at ~2400 m depth within the particle plume maximum for this station. As before the pump system was attached to the CTD rosette and the resulting sample will be used for later analyses of molecular community diversity. Methane concentrations were also lower than in some samples from previous casts, although they were still substantial (to >70 nM).

May 15; 2050 hr:
Cast #13—CTD tow-yo

This final CTD tow-yo was conducted along axis but for most of the tract was offset ~150 m to the east of the axial summit trough. It was intended to cover the possibility that our earlier axial summit tow-yo (Cast #1) may have missed evidence of some venting due to the strong easterly currents that have clearly been carrying the hydrothermal plumes to the east. The tow track for Cast 13 was 9^o 46.685’N, 104^o 17.161’W to 9^o48.50’N, 104^o17.10’W and then to 9^o51.60’N,104^o17.65’W. The tow started slightly south of previous tows and, revealed significant plumes south of those encountered on previously cruises. Overall, comparison of the light scattering data from this cast and the earlier Cast #1 which was towed along the axial summit, indicate higher particle concentrations150 m to the east of the axial summit. Temperature anomaly data are forthcoming. Methane concentrations from Cast 13 samples (36 to 163 nM) were similar or perhaps slightly less than those from Cast 1 (57 to 255 nM).

TowCam Operations

Geological Summary of TowCam Shipboard Photo-analysis
By Daniel Fornari, WHOI

Along strike extent of new lava flow: Four of the seven TowCam surveys (TC#1, 2, 3, & 6) were conducted along the EPR axis between 9° 46’N and 9° 57.5’N (Figure X). Tracks for these tows were planned using both DSL-120A sidescan data [Schouten et al., 2002; Fornari et al., 2004, in prep.] and EM300 multibeam data collected in November 2005 [R. Haymon and S. White, unpublished data]. The TowCam tracks attempted to traverse as many of the known high-temperature vent areas in this area to identify new lava flows, and assess their spatial extent, morphological characteristics, relationship to the axial summit trough (AST), and impact on the hydrothermal systems.

The new lava flow appears as a dark, glassy primarily lobate to sheet flow, devoid of any sediment and often covered with white to brownish microbial mat. The contacts between the new lava flow and older lobate to sheet flow terrain are sharp and easily discernable in the photographic data. The areas of white microbial carpeting on the new flow are coincident with the most actively venting areas, while the “olive-brown” microbial coatings are suspected to be remnant. The appearance of the lava and microbial mat/byproducts is extremely similar to that observed in 1992, following the 1991 EPR eruption at this site [Haymon et al., 1993; Rubin et al. 1994]. Based on preliminary shipboard analysis of the photographs, the along axis extent of the flow was determined to be from ~ 9° 47.5’N to 9° 55.7’N, covering ~15 km. In places, the new flow is rather continuous, for example between 9° 48’N and 50.5’N, while further to the north there are 50-200 m long sections of the axis that are not covered by new flow. Based on this estimate of along-strike extent for the new flow, it is possible that A and L vents in the 9° 46’N area may not have been engulfed by the new flow. In addition, because Q, M and Biovent in the 9° 50.7-51’N area are built on the rim of the AST or just outside of it (BioVent) they too may have survived. As noted below, Q vent was directly imaged and found not to have been engulfed by the new flow.

Across strike extent of new lava flow: The across strike extent of the new lava flow was determined in only a few places during TC#2, 3 & 4 [Figure 7]. During TowCam#3 the flow was observed to have ponded against the first inward facing fault on the east flank at a distance of ~900 m from the axis. During TC#4 a traverse over the Tica vent area near 9° 50.4’N was conducted and the new flow was imaged at ~600-700 m from the AST on the west side of the axis and ~400-500 m on the east side. On TC#2, the new flow was observed to end ~250 m on the east side of the axis. Much more survey work needs to be done to conclusively determine how far the new flow extends away from the axis along its length, however, it is clear that the flow was erupted from fissures in the AST and that it overflowed the trough in many places spilling out onto the EPR crestal plateau. The distal ends of the new flow in most cases consist of small pillows and lobate tubes snaking across the older lava surface.

Locus of eruption and morphological variability: There are areas of the new flow that appear to be within a narrow trough or along deep fissures that display extensive drainback features. These include wide areas of broadly curved plates of sheet lava, collapsed in place, that extend into the fissure. Based on previous mapping

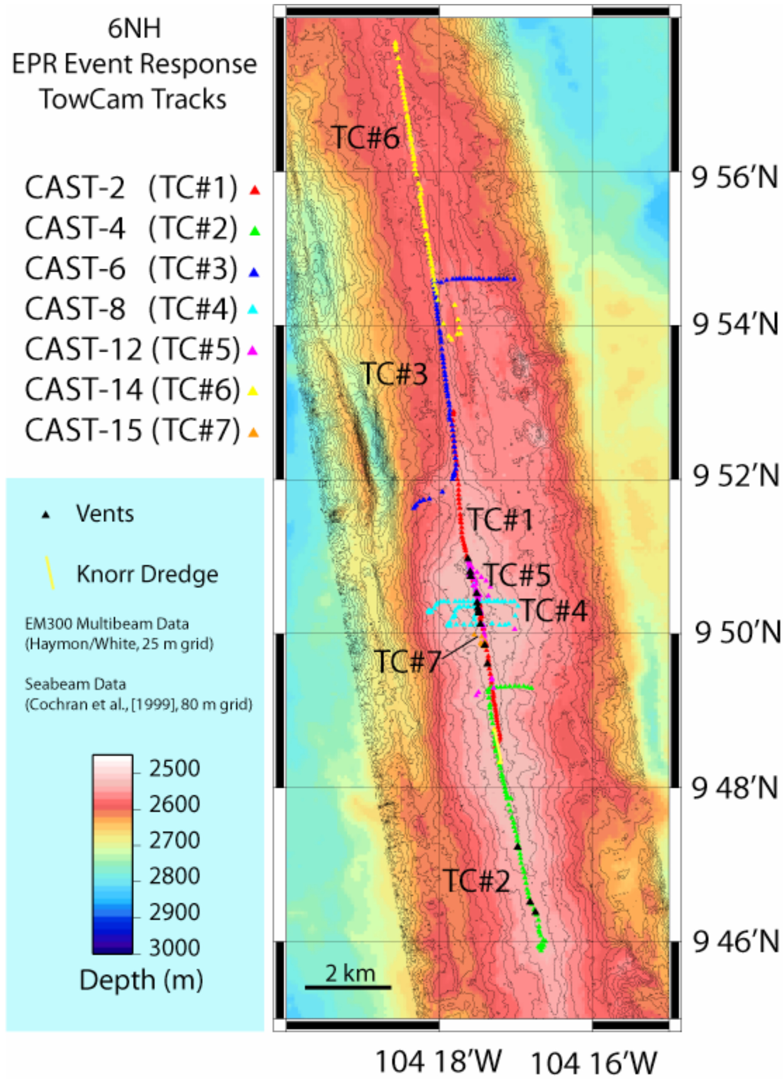


Figure 7. Locations of TowCam surveys on 6NH cruise, May, 2006.

and observations in the AST and the locus of the primary fissure system that fed the 1991 eruption [Haymon et al., 1993, Fornari et al., 1998, 2004, in prep.] it appears that the new lava flow was also sourced from fissures within the AST. The morphology of the new flow within the AST is often chaotic consisting of sheet and hackly lava as well as flattened lobate forms that sometimes surround older lava pillars and remnants that were part of the old AST floor. In a few cases the new lava appears to engulf older sulfides, however none of the older vents that existed within the AST floor in the 9° 49'-50.3'N area were directly observed, although these areas were also coincident with active venting and microbial production. In one case, M vent near 9 50.7'N on the east rim of the AST was directly imaged and a hiT logger (#6) was observed sitting on the new flow on the south side of the chimney. The chimney appeared to be active based on the white microbial mat on top of it and the small potential temperature anomaly observed on the TowCam CTD as we towed past it. Outside the AST and on the upper flanks of the ridge, the new lava flow has a lobate morphology with occasional small pillow forms at flow fronts or margins of the flow. In all cases where the new flow has lobate morphology and can be seen in context with the older flow surface, it is thin, likely <1 m thick. In many areas the pillows and lobate tubes at the distal ends of the new flow were decorated with glassy 'fingers', suspected to be late-stage surges of lava that pushed through the crusts as the last attempt to inflate or advance the flow. These features should be sampled with Alvin along with their corresponding host lava crusts as there may be interesting mineralogical textures and subtle geochemical variations reflected in the glass compositions.

Channelized flows: There are areas in the new flow that show prominent transitions between lobate and sheet flow and areas where the new flow clearly must have had a high effusion rate based on the linear and shear textures in the sheet flow surface [e.g., Soule et al., 2005; Garry et al., 2006]. Because of the orientation of the survey tracks and limited coverage we cannot determine specific areas where channelized flows exist or the extent or direction of the flows, but it is likely that lava flow channels in the new flow are present and were involved in transporting the lava off axis. Based on shipboard analysis of the photographs it appears that the most concentrated area of sheet lava with channel structures is in the ~9° 49’-51’N area. This may provide a hint that the locus of the eruption was concentrated along fissures in this section of the axis.

Axial summit trough - dimensions and morphology: The AST was crossed completely on one line during TowCam #4 near 9° 50.4’N. That profile, shown below in Figures Y and YY, suggests that the AST reformed quickly after the eruption following drain back and collapse over the primary fissure system feeding the eruption. Comparison of the detailed plot with previous mapping [Ferrini et al., in press] suggests the AST may be 10-15 m narrower at this location and perhaps a few meter shallower. The AST dimensions and plan view morphology will require more detailed surveying and hopefully a comprehensive near bottom multibeam and sidescan sonar mapping effort so that it can be compared with the baseline data collected in 2000-2004 [Fornari et al., 2004, in prep.; Ferrini, et al., in press].

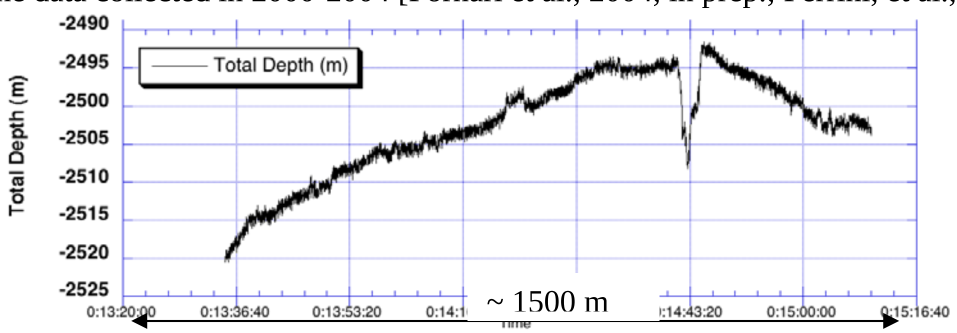


Figure 8. TowCam#4 near-bottom profile across the EPR axis near 9° 50.4’N, near the Tica vent area. Figure 9 below shows detail of the AST crossing.

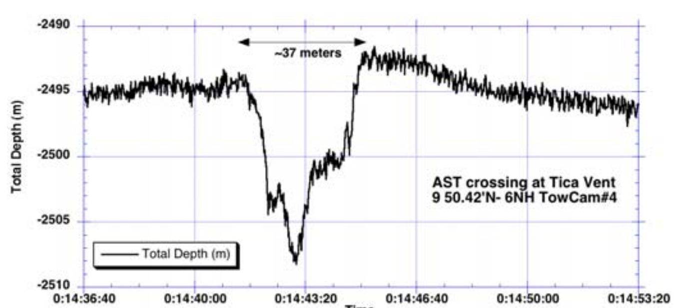


Figure 9. Detail of AST crossing on TC#4.

Biological Observation Summary: (Preliminary hydrothermal and biological results of seafloor imaging surveys with TowCam**)**

Tim Shank

Background: The WHOI TowCam camera covers a relatively narrow swath (~6 x 4.5 meters at 5 m altitude). The camera was towed (with basically "continuous" coverage) from 9°46'N to 9°57.6'N resulting in a single swath within and just outside the Axial Summit Trough along this region of the seafloor. In order to improve this coverage, several camera "dangles" in specific areas, like the Bio9 area, north of the Biomarker 141 area, and the East Wall areas we conducted as well as survey lines that crossed the axis in several places just north of 9°50'N (the Tica area). Hydrothermally active areas are defined as those in which venting was visually observed on the seafloor or that a ~0.5-2.0 increase in potential temperature was observed on the TowCam SBE25 CTD coincident with images of flocculent material in the water column (strongly suggesting that venting activity was just outside the camera's field of view). All tows were un-navigated, relying on ship's GPS and layback calculations for final seafloor positions, rather than well-ranged transponder net. The likely error in seafloor positions given the estimated layback of the camera system is ~50 meters.

Distribution of Hydrothermal Venting: Imaging surveys were conducted such that the survey coverage would be almost continuous (with overlapping latitudinal coverage linking separate tows) between 9°46.0'N and 9°57.5'N. The southernmost point of detected hydrothermal activity was at 9°46.5'N (e.g., TowCam plate 2) and the northernmost at 9°54.9'N. At the moment, it appears that the most spatially concentrated area of venting is between 9°49.7'N and 9°51.5'N with other relatively "high-activity" areas of venting near 9°47.5'N and 9°53.0'N. Near 9°49.7'N and 9°51.5'N where we had almost continuous coverage of the AST floor, these venting areas were most often separated by less than 10s of meters, particularly in the southern and northern end of this region. To date, only diffuse venting has been observed (see description below), but water column tow-yos indicate the presence of high-temperature venting

Microbial mats and/or byproducts: Extensive (apparent) microbial material existed in all areas of venting activity. From deep (i.e., several meters) within fissures to small cracks in the tops of lava remnants. Snow-blower type venting were observed in at least three locations. The large majority of venting was in the style of milky diffuse flow and not the snow-blower type. Extensive areas adjacent to and surrounding hydrothermally- active areas containing white apparent microbial mats and/or byproducts were laden with "olive-brown colored" mats (resembling webbing on the basalt surface in some areas)(TowCam plate 5). These appear to be the "remnants" or a later stage of the white microbial mats observed in venting activity. These apparent "olive" mats may indicate locations where venting was once vigorous and is now inactive. The distribution of the "olive" mats may indicate that diffuse flow has focused down in aerial extent to the present level.

Sessile Fauna: No sessile faunal colonization was observed in "newly-venting" areas.

Tubeworm tubes (all apparently belonging to *Riftia pachyptila*) were observed in a few areas near 9°49.2'N and 9°50.5'N. Lone individual (empty) tubes were observed over 100 meters from the center of the axial trough (both east and west of the Tica area)(TowCam plate 4), suggesting some sort of off-axis transport via lava flow or the water column. Aggregations of tubes lying horizontally on the floor were observed near the base of the east wall between the East Wall and Tica area, and a stand of empty tubes surrounded by lava were imaged near 9°49.2'N. None appeared mangled or scorched. Unlike following the 1991 eruption, no apparent shell debris was observed in any part of the surveyed area.

No live *Tevnia, Riftia*, or bivalves were observed. In fact, no live pre-existing communities were imaged. Subsequent Alvin dives are needed to locate communities that either survived the eruption in the eruptive area, identified as between 9°46'N and 9° 55.7'N, or outside the eruptive area to provide important information on the nearest source populations.

Mobile Fauna: With the exception of brachyuran crabs and zoarcid fish, all areas of extensive areas of diffuse flow were without megafaunal colonization. Brachyuran crabs increased in abundance proximal to venting activity. Galatheids were present in much fewer numbers than brachyurans, and their distribution seems unrelated to the distribution of venting.

Three non-cirrate octopods were imaged (one above the seafloor) on sheet flows close to venting areas.

Synaphobranchid eels were the most abundant demersal fish observed in all areas surveyed (gross estimate ~1 per 40meters of imaged seafloor). Zoarcid fish were present in similar abundance as in April and May 1991, both directly in diffuse flow issuing from cracks coated in apparent microbial mats/byproduct as well as "lying" out on sheet and lobate lava flows 10s of meters from the axial trough. Along the base of M Vent (TowCam plate 1; based on the discovery of a HOBO high-temperature probe still in the orifice deployed in March 2004), two thick aggregations of bythidid fish were observed (as in the past) nose down in seafloor openings through which clear vent fluids emanated (TowCam plate 1). Only a few other bythidids (in seemingly random locations) were observed throughout the survey area.

Comparison to 1991 and estimates of time-zero: From the more than 12,000 imaged reviewed, the venting and faunal composition and distribution is most similar to the period immediately following the 1991 eruption. The notable lack of apparent colonization (and/or growth) by *Tevnia jerichonana* (considered to be an early sessile colonizer of nascent venting; Shank et al., 1998) or other vent megafauna suggests that the initiation of activity was within the past ~3 to 9 months (aggregates of *Tevnia* 11 months following the 1991 eruption were up to 30cm in length). The initial colonization of *Tevnia* may be taking place as somewhat linear white objects (both sparse and in aggregations) in diffuse flow do exist in the TowCam images, but are too small (estimated to be only a few cm's in length) to be identified given the camera resolution, white background coloring, and venting activity (subsequent submersible imagery and sampling will be needed to identify these objects).

While faunal composition and distribution may be similar to that of April 1991, the style and type of apparent microbial mat/byproduct coating the seafloor is more reminiscent of 11 months following the 1991 eruption. The images of milky diffuse and snow-blower type venting in several locations within the 9°49'N-9° 51'N region that appear similar to March 1992. In April

1991, many of the microbial mats/byproducts were 10cm thick and gelatinous in appearance and to the touch. We may have imaged one small area (less than a few meters by a few meters) in the 9°49.3 area that had this morphological appearance. The spatial extent of discrete vent areas with microbial mats/byproducts covering the seafloor was “in between” that observed in 1991 and 1992.

While two sulfide structures were documented in TowCam images near 9°47.2’N and 9°50.5’N (in the vicinity of V and M Vents, respectively), confirmed black smoker venting was not observed. The notable lack of black smoker venting and chimneys may be due to the fact that black smoker chimneys may be there and were not imaged, or that black to gray smoke issuing from around broken pieces of basalt could be diffuse (as in 1991) and thus difficult to observe in TowCam images. Chimney growth was not apparent immediately following the 1991 eruption given the lack of time for chimney formation, and active black smokers 11 months after the April 1991 eruption were several meters tall (e.g., P Vent and Bio9 Vent). Without the presence of chimney structures in April 1991, it was difficult to observe black smoker venting with Alvin until the sub was less than a few meters in front of the fluids issuing through cracks in the basalt. CTD tow-yos throughout the TowCam survey area documented rise heights of extensive hydrothermal plumes indicating the presence of high-temperature venting. An estimate of the time of eruption and the initiation of venting based on black smoker chimney growth can not currently be made based on the ToWCam imaging surveys.

The lack of megafaunal colonization mentioned above and the observation that diffuse flow areas have experienced a focusing down of activity suggest that the eruption and the initiation of hydrothermal activity between 9°46’N to 9°57.6’N occurred within the last 6 months (since December 2005).

TowCam Cast Summaries

6NH-Cast 2
TowCam #1 May 11, 2006
Summary

The first TowCam survey was between 9° 49’N to 9 52.88’N along the trace of the axial summit trough (AST), imaging ~80% of the track with overlapping images from altitudes of ~4-5 m. Seafloor depths along the track were quite consistent at 2496-7 m. This depth is ~ 5-10 m shallower than previous measured depths along the AST floor in this area based on high-resolution, near bottom bathymetric data. Images at the start of the survey document black, glassy, fresh lava flows (lobates, pillows, and sheets) and murky or turbid bottom water (absent much of flocculent debris). Brachyuran crabs were observed but not in great numbers. The new lava flow was imaged in most of the photographs acquired on this traverse. The temperature anomalies we detected (up to ~3°C, 5 meters above the bottom) with TowCam’s CTD corresponded well with previous sites of venting, including the Tube Worm Pillar, Ty Vent, Bio9 Vent, Tica Vent, and M Vent. However, no markers or experiments (e.g., Biomarkers, Temperature probes, or OBSs) were observed. No black smokers were directly observed. Two “snow-blower” like vents were observed, but these areas of high hydrothermal flux, flow and microbial floc do not appear to be as intense or abundant as those documented from Alvin diving in the eruptive area in April 1991. The areas mentioned above appear much like the vents did in 1992, with remnant hydrothermal/sulfide staining in cracks and crevices where microbial biomass was likely high following the cooling of the lava. Empty tubeworm tubes were observed (both as clumps and as stray tubes) in the Tica and M Vent region. The new lava flow is present to the end of the tow, near 9° 52.88’N. Two rock core samples were recovered along with two, 5-liter niskin bottles, in areas of high temperature anomalies. Based on comparisons of the 1990 images collected on TowCam#1, to still and video imagery taken from Alvin in March 1992, we can confirm that a recent eruption has occurred. We tentatively suggest, based on the fresh, glassy character of the lava surfaces compared with the underlying lava that the eruption may have occurred between 1 and 6 months ago.

6NH-Cast 2 TowCam #1 - Seafloor Geology & Biology Preliminary Observations
11 May 2006

Time (GMT)	Brief Shipboard Description
20:33:22	approach to seafloor, water is cloudy with particulates
20:35:22	first bottom photo, new lava flow, lobate morphology
20:36:02	new lava flow, cloudy water
20:42:55	**RC-1 drop - on new lava flow**
20:51:02	collapse in new lava surface, some evidence for new flow on older lava
20:53:22	cloudy water over collapsed area
20:58:22	end cloudy water, previous section was extensively collapsed new flow
21:15:32	more collapse of new flow, sheet flow, with cloudy water
21:20:22	collapse in new lava with pillars
21:20:55	**RC-2 drop - on new flow**

21:23:42	RC-2 reel in
21:23:52	new lava, lobate morphology, appears to have 10-20 cm of void space under crust
21:43:42	new lava with remnant microbial mat along collapse margin, water still cloudy
21:54:12	collapse talus of sheet flow in new lava surface

Time (GMT)	**Brief Shipboard Description**
21:56:02	microbial mat along collapse margin in new flow
21:57:42	extensive particulates in water above new flow with widespread bacterial mats
21:57:55	**Niskin #7 fired in poten. Temp anomaly**
22:03:12	end of bacterial mat area on new lava
22:06:22	new lava- lobate morphology, water less cloudy
22:09:32	new lava with bacterial coating
22:09:55	**RC-3 drop on new lava in collapse area**
22:27:12	new lava, lobate with bacterial mat in cracks in the surface, cloudy water
22-28:02	new lava, collapse area in lobates with extensive bacterial mats
22:28:22	new lava, collapse area, showing multistage collapse and bacterial mats
22:40:12	new lava, collapse, extensive bacterial mats
22:47:42	new lava, collapse, extensive bacterial mat, smoky water issuing from collapse
22:48:22	new lava, bright white bacterial mat, active area
22:49:02	out of active area, still in new lava flow, sheet to hackly morphology
23:10:02	new lava, margin of collapse, active bacterial area, dead? Tubeworm tubes at base
23:12:12	cloudy water ends from active area just traversed, still on new lobate flow
23:14:32	cloudy water venting from fissure in new flow surface
23:15:02	cloudy water from fissure ends
23:17:00	lost altimeter, off bottom, cloudy water
23:28:22	back on bottom, new lava and active area of bacterial mats, collapse area
23:30:22	end of active, white bacterial mat area on new flow
23:33:52	new lava flow, lobate morphology
23:41:42	**vent chimney (M vent?)** sticking out of new lava flow at margin of collapse 2 fish holes with bithydid fish at base, white bacterial mat at top, worm tubes on side of chimney- **HI-T HOBO LOGGER IN PHOTO, LYING ON BASALT ON SOUTH SIDE OF CHIMNEY**
23:58:02	new lava collapsed lobates
00:08:33	new lava, transition to sheet flow
00:11:53	new lava, transition back to lobate, some small windows into older flow surface
00:13:12	cloudy water over new lava, lobate morphology
00:15;23	end of cloudy water, still on new lobate lava
00:16:12	new and old lava, lobate morphology, some particulates in water
00:17:33	end of new and old lava terrain, new lava continues from here as lobates
00:29:22	new lava, lobate morphology
00:29:43	new and old lava contact, lobate forms
00:30:12	start of old lobate flow terrain
00:40:22	new lava reappears, lobate forms
00:43:53	new lava, sheet flow with curtain folds
00:51:13	new lava transitions to lobate morphology
00:56:52	new lava, lobate flows, with some windows into older lobate surface

01:00:03	end of new lava, older lobate flow continues
01:03:43	transition back to new lava, lobate flow
01:10:03	new lava, sheet flow
01:11:33	new lava, transition to lobate flow
01:14:22	new lava with small exposures of older lobate surface
01:17:53	new lava with Fe staining
01:20:53	new lava with Fe staining ends
01:28:03	new lava contact with older lobate flow, cloudy water
01:29:43	old lobate lava, water cloudy
01:41:53	new lava contact with older lobate flow
01:46:53	end of new lava, contact with older lobate flow
01:57:03	new lava reappears, lobate form, over older lobate flow
01:59:43	new lava, lobate, skinny tubes snaking around older pillows and lobate

6NH-Cast 2 TowCam #1 Sample Summary
Rock Cores (1-6) and 5 liter Niskin Bottle (7-10) Samples
Red background means no sample recovered

Sampler	Date	Time	Depth	Altitude	Total Depth (m)
1	11-May-2006	20:42:55	2490.7	4.120	-2494.8
2	11-May-2006	21:20:55	2494.3	2.510	-2496.8
7	11-May-2006	21:57:55	2493.1	3.920	-2497.0
3	11-May-2006	22:09:55	2491.9	4.820	-2496.7
8	11-May-2006	22:43:55	2494.3	3.840	-2498.1
4	11-May-2006	22:48:55	2494.3	5.980	-2500.3
9	11-May-2006	23:05:55	2493.1	7.360	-2500.4
5	11-May-2006	23:10:55	2495.5	7.030	-2502.5
10	11-May-2006	23:21:55	2483.5	5.800	-2489.3
6	11-May-2006	23:37:55	2491.9	5.550	-2497.4

6NH-Cast 4
TowCam #2 May 12, 2006
Summary

TowCam#2 traversed the terrain along the axial summit trough between ~9° 46’N to 9° 49.3’N. Preliminary analysis of the photos indicates that new lava flow is present at 9° 47’N, but not further south. The camera track passed over A, L, and Marker 21 vent locations with no evidence of high-temperature venting, either imaged by TowCam or detected via its CTD. We did not observe chimneys in these areas. Several areas of high hydrothermal flux with temperature anomalies of ~>2°C measured by TowCam’s CTD were observed. At these sites, flow and microbial floc were present. The most intense activity occurs near ~9° 47.5’N, 9° 48’N and 9° 48.3’N. In many places, on this and TowCam#1, the new flow is observed to be <1 m thick based on exposures of older lobate and sheet flow surfaces, not covered by the glassy, black lobate to sheet lava flow. At the end of Tow#2, we traversed east of the AST near 9 49.3’W and observed that the new lava flow terminated ~250 m from the AST long the camera track. Two, 5-liter Niskin samples and six rock cores were collected along the traverse.

6NH-Cast 4 TowCam #2 - Seafloor Geology & Biology Preliminary Observations
12 May 2006

Time (GMT)	Brief Shipboard Description
18:23:41	older lobate lava, first bottom photo, cloudy water, near L vent?
18:24:48	**RC-1 drop - older lava**
18:40:51	transition to sheet flow in older lava
18:44:11	transition back to older lobate flow
18:51:41	collapse in older lobate flow
19:18:15	**RC-2 drop - older lava**
19:29:01	collapsed older lobate terrain, cloudy water near latitude of A vent
19:46:31	cloudy water, older collapsed lobate terrain
19:55:51	going along collapse margin of AST, still older flow
20:07:41	first appearance of new lava, lobate flow over hackly older flow in AST floornear 9 46.9’N
20:07:51	new lobate flow over older hackly sheet flow
20:09:51	new lava surrounding lava pillars and collapse talus in AST floor
20:10:55	**RC-3 drop - older lava**
20:12:11	older lobate lava on rim of AST
20:13:01	RC-3 reel in
20:17:31	older lobate lava surrounding old sulfide
20:26:41	older lobate to sheet transition
20:41:43	**Niskin #7 taken**
20:42:41	microbial staining on lava, new lava?
20:43:41	new lava? With extensive microbial mat and flux, small Tanomaly ~ 9° 47.4’N
20:44:11	end of microbial mat area, new lava, collapsed lobate area
20:47:11	entering extensive microbial mat, snowblower area in new lava
20:47:43	**Niskin #8 taken**
20:48:21	extensive microbial mat, intense white mats in cracks in new flow surface
20:49:11	end microbial mat area, new lava, collapsed area, in AST?
20:52:41	more microbial mat on margin of collapse in new flow
20:56:20	**Niskin #9 taken**
20:56:21	end of microbial mat area and cloudy water
21:00:01	new lobate flow surrounding lava pillars that are older
21:03:37	**RC-4 drop- may have hit older pillar but surrounding terrain is new lava**
21:05:41	new lava surrounding older lava pillars
21:07:01	last photo of new lava in collapse terrin of older flow
21:14:11	new lava appears again as lobate flow over older lobate flow
21:18:41	all new lobate lava
21:14:11	cloudy water, microbial mat, new flow
21:27:11	new lava with microbial mat, active flow from deep hole
21:28:23	**Niskin #10 taken**
21:33:41	collapse terrain in new flow
21:36:01	new lava - lobate with occasional windows into older flow surface
21:46:51	new lava transition to sheet flow

21:49:11	back into collapse terrain in new lava
21:51:31	entering active microbial mat area in new flow- collapse terrain
21:55:44	**RC-6 - drop in new lava**
21:57:31	RC-6 reel in
21:57:41	new flow with remnant and active microbial mats
22:11:11	new flow lobate with occasional windows into older lobate surface
22:18:11	new lava, extensive collapse area, some sheet flow in floor of collapse pits
22:33:11	new lava, lobate morphology
22:41:51	new lava, collapse area
22:48:01	crashed into lava pillar
22:55:57	**RC-5 drop new lava**
22:57:11	RC-5 reel in
23:06:11	new lava, lobate with some collapse
23:19:11	entering microbial mat area, both active and remnant
23:22:01	end microbial mat area in new flow
23:35:41	new flow lobate tongues, snaking over older lobate surface
23:37:01	last frame of new lava over older terrain
23:54:11	last frame of tow, all older lobate flows between this time and previous time

6NH-Cast 4 TowCam #2 Sample Summary
Rock Cores (1-6) and 5 liter Niskin Bottle (7-10) Samples
Red background means no sample recovered

Sampler	Date	Time	Depth	Altitude	Total Depth (m)
1.0	12-May-2006	18:24:48	2507.5	4.77	-2512.3
2.0	12-May-2006	19:18:15	2508.7	4.90	-2513.6
3.0	12-May-2006	20:10:55	2505.1	6.83	-2511.9
7.0	12-May-2006	20:41:43	2497.9	4.02	-2501.9
8.0	12-May-2006	20:47:43	2497.9	4.77	-2502.7
9.0	12-May-2006	20:56:20	2496.7	4.10	-2500.8
4.0	12-May-2006	21:03:37	2496.7	3.77	-2500.5
10	12-May-2006	21:28:23	2495.5	5.28	-2500.8
6.0	12-May-2006	21:55:44	2500.3	4.40	-2504.7
5.0	12-May-2006	22:55:57	2491.9	3.42	-2495.3

6NH-Cast 6
TowCam #3 May 13, 2006
Summary

TowCam#3 traversed the terrain along the axial summit trough from ~9° 51.5’N to 9° 54.3’N with the goal to assess the northern extent of the new lava flow, and search for hydrothermal activity that could be a source for observed off-axis plumes in CTD TowYo data (6NH-05) collected the previous evening. The most intense activity, up to ~2°C anomaly, occurred in a ~50 to100 m long segment of the axis centered at ~9° 53.0’N. Images from this area reveal active diffuse venting through cracks in broken sheet flows and pillow basalts. All active vent openings were coated with microbial mats and/or their byproducts, with no apparent faunal colonization (exceptions include demersal fish and brachyuran crabs). As in TowCam#1 and #2 surveys, no black smokers were documented. Three rock cores acquired along the survey track recovered basalt pieces, and four 5-liter Niskin bottles collected near bottom water associated with observed temperature anomalies. No activity was observed between 9°53.3'N and 9° 53.4'N. At 9°54.3'N, our survey track turned east to assess the off axis extent of the new flos, including whether lavas had reached the first inward facing scarp located 1 km from the axis based on DSL-120A sidescan data. TowCam images document tongues of the new flow along the easterly traverse. The new lava flow was observed to pond against the base of the scarp. The survey continued several hundred meters east of the scarp, documenting much older, sedimented lobate, pillow, and collapse lava terrain.

6NH-Cast 15 TowCam #3
13 May 2006

Time (GMT)	Brief Shipboard Description
14:03:21	first photo new lobate lava
14:05:00	new pillows
14:05:21	contact new lobates and old lobates*
14:05:31	old pillows- with animal colonization (holothurian)
14:05:31	**RC-1 on old lobate/pillow area**
14:29:31	Transition to old lobates
14:41:01	Transition to old pillows
14:43:11	Contact between old pillows and new pillow and lobates*
14:44:00	new lobates (mixed with new pillows)
14:48:11	Contact between old pillows and new pillow and lobates, until:
14:48:51	Contact between old lobates and new lobates*
15:02:31	new lobates until 15:02:31 where there is a contact again
15:07:31	end of old lobates
15:07:51	contact new and old lobates- until 15:08:01- brachyuran crabs*
15:13:41	microbial staining on new lava lobates*
15:14:41	microbial staining on new lava lobates*
15:14:51	microbial staining on new lava lobates*
15:15:41	remnant microbial mat on new lobates*
15:16:21	housing?*
15:19:31	iron-oxide staining between lobates
15:21:51	over central AST fissure (until 15:24:01) new lava all around
15:24:41	over central AST fissure
15:33:21	active area; microbial staining
15:34:21	extent of microbial staining and diffuse flow
15:35:31	new lobate lavas
15:38:01	over central fissure with new lava on either side*
15:38:41	active area, brachyurans, no colonization*; until 15:40:21
15:41:51	iron-oxide staining in this area
15:42:31	activity- white out

15:43:01	remnant microbial mat, floc, brachyurans
15:51:31	new lobates along the fissure margin
15:56:11	new and old contact
15:56:41	iron-oxide staining
15:58:51	diffuse flow activity extensive (outside of images) until 16:00:02*
16:00:02	contact new and old lobates through 16:03- area of contacts and fissure- old flow on fissure margin- very interesting
16:08:02	new lava filled up AST part way up older wall*
16:08:21	activity diffuse flow until 16:08:52
16:10:02	new lava lobates
16:16:42	area of extensive contacts until 16:22:31
16:20:51	octopus
16:21:01	old lobates until 16:25:21
16:25:31	old pillows and new pillow contact until 16:32:02
16:32:31	fissure cutting through older lobates
16:57:02	older lobates continuing for the past 25 minutes
16:57:22	fissure cutting through old lobates and pillows; 16:57:31*
17:09:02	pillow field with lots of little fingers on them
17:09:44	**RC-4 drop on old lobates**
17:20:22	contact of old pillows with new lobate lavas (17:21:02*)
17:26:52	new lobates continue to here
17:27:02	new sheet flow to lobate flow
17:32:32	iron-oxide staining area*
17:34:22	iron-oxide staining area*
17:41:12	contact old and new lobates and then back to old again
17:50:52	**RC-5 on old lobates**
15:55:52	old pillow field
18:19:32	back into new lobates; contact
18:27:52	microbial staining, diffuse flow*
18:28:02	remnant microbial mat until 18:29:12
18:30:42	back into the AST; new lava; talus floor
18:32:32	crossing fissure (not many brachyuran crabs) (18:34:32*)
18:35:02	new lobates
18:49:32	image of new lobate flow ponding up against inward facing scarp*
18:50:52	old basalt with collapse areas on east side of scarp
19:30:02	old lobate and collapses continue until the last image at this time

6NH-Cast 6 TowCam #3 Sample Summary
Rock Cores (1-6) and 5 liter Niskin Bottle (7-10) Samples
Red background means no sample recovered

Sampler	Date	Time	Depth	Altitude	Total Depth (m)
1.0	13-May-2006	14:13:41	2514.7	3.070	-2517.8
2.0	13-May-2006	15:15:58	2524.3	3.390	-2527.7
7.0	13-May-2006	15:39:15	2526.7	3.090	-2529.8
8.0	13-May-2006	15:43:18	2525.5	2.990	-2528.5

9.0	13-May-2006	15:58:58	2529.1	2.840	-2532.0
3.0	13-May-2006	16:09:35	2530.3	3.540	-2533.9
4.0	13-May-2006	17:09:44	2543.5	2.440	-2546.0
5.0	13-May-2006	17:49:50	2547.1	2.810	-2550.0
6.0	13-May-2006	18:24:49	2543.5	3.490	-2547.0
10	13-May-2006	19:39:19	2481.1	85.27	-2566.3

6NH-Cast 8
TowCam #4 May 14, 2006
Summary

The objective of TowCam#4 was to definitively cross the AST near 9 50.4'N (latitude of Tica vent) to get a profile of the terrain to see whether the trough was still present and if so what it's morphology and dimensions are. The west to east track would also provide a rough idea of whether the new flow had spilled out over both the west and east flanks of the EPR crestal plateau. The tow began ~ 800 m west of the AST and continued to ~800 m east of the trough. At ~ 700 m west of the AST, the distal end of the new lava flow was observed to overlie older lobate terrain in narrow ~ < 1-0.5 m diameter lobes that snaked across the seafloor. The new lava covers the seafloor up to the AST rim and displays morphologies ranging from lobate to sheet to hackly flows. Cloudy water and a temperature anomaly were observed within the AST. TowCam near-bottom profile across the Tica vent area, and comparison with previous mapping at this site indicates that the rim depth is perhaps 1-2 m shallower and the width is ~ 10-15 m narrower than it was before. The depth to the floor of the AST appears to be a few meters shallower as well. RC-2 sampled the new lava flow in or near the AST on this crossing. The new flow is also present on the east side of the AST out to 700-800 m where lobes of the glassy flow overlie older sediment covered lobate and sheet lava with some collapse features. The east to west traverse back to the AST was at the latitude of Ty vent (~9° 50.1'N also showed the seafloor to be partly covered by the new lava flow, clearly there must be several lobes that extend out from the AST. There are in places areas where the new flow surface morphology transitions from lobate to sheet or hackly sheet lava. It is likely that these may represent areas of channelized flow but more coverage is needed to confirm this. Once the collapse margin of the AST was reached diffuse flow in the new lava surface was observed issuing from cracks and there was cloudy water. An extensive area of white bacterial mats with active fluid venting and a potential temp. anomaly were observed in the floor of the AST and Niskin samples were taken (bottles 8 and 9) from this site. At 17:39:24 the TowCam was along the margin of the AST and hit the collapse wall allowing a crust of the new lava flow to slide into the interior of the camera frame. It was recovered on deck and sampled. It is being sent to Ken Rubin for Po dating with fragments of the glass being sent to Mike Perfit for geochemical analysis. A Niskin bottle was fired ~ 500 m from the seafloor within the plume.

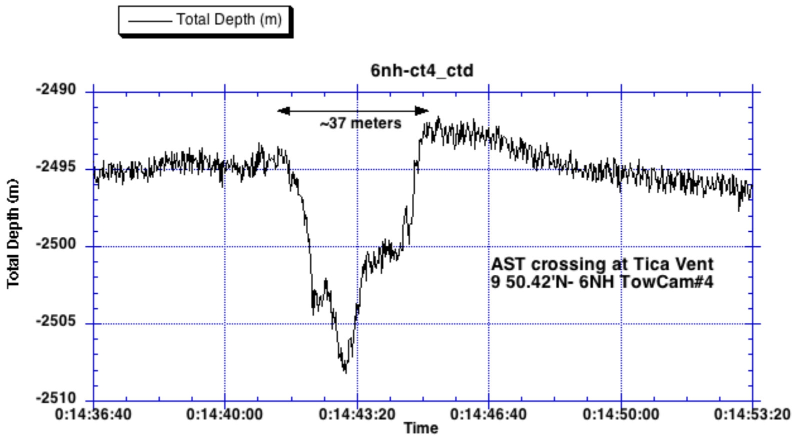


Figure 10.

6NH-Cast 8 TowCam #4 - Seafloor Geology & Biology Preliminary Observations
14 May 2006

Time (GMT)	Brief Shipboard Description
13:34:53	first photo older lava
13:39:53	**RC-1 drop older lava**
13:41:03	RC-1 reel in
13:50:43	new lava starts mostly lobates - some older lava too
14:14:18	new lava continues now sheetflow
14:29:23	new lava sheet flow now hackly
14:33:33	new lava now sheet flow again
14:34:43	**RC-2 drop new lava**
14:35:03	RC-2 reel in
14:40:03	new lava - sheet to ponded
14:41:43	new lava - water cloudy
14:44:22	**Niskin bottle 7 fired**
14:42:53	in fissure? Water cloudy
14:43:13	against wall/collapse margin
14:47:03	new lava, lobates, some areas of older lava
14:48:43	**RC-3 drop - new lava**
14:59:53	distal end of new lava flow, lobate lobe
15:10:00	making turn to south to next line
15:15:00	old lava - lobates and hackly sheets, some collapse
15:23:03	**RC-4 drop older lava**
15:23:14	RC-4 reel in
15:30:24	start of new lava- lobates- on older lava (lobates), next cross axis line
15:37:23	end of new lobate lava flow
15:37:33	start all older lobate lava
15:42:03	end all older lobate lava
15:42:13	start of new lobate lava flow
15:57:34	new lava continues cloudy water starts

15:58:44 new lava cloudy water stops
15:59:40 **RC-5 drop - not seen in photos**
16:21:34 new lava sheet flow
16:22:04 new lava now hackly
16:27:04 new lava now sheet flow
16:30:04 new lava now transitions to lobate
16:34:34 **RC-6 drop new lava**
16:35:24 RC-6 reel in
16:36:14 new lava lobates
16:36:44 new lava curtain folded sheet flow
16:40:44 new lava lobate flow starts
16:54:24 margin of new lava lobates, transition to sheet flow
16:57:34 new lava lobate morphology now
17:06:34 distal end of new lava flow lobe
17:06:44 older lobate flows
17:09:04 small lobe of new lava over older lobate flow- next 2 frames too
17:17:14 distal lobe of new lava, pillow to lobate, over older lobates
17:33:54 new flow, lobate with collapse
17:39:24 **along collapse margin in new flow, camera hits bottom- rock sample collected**
17:51:14 transition from lobate to sheet flow in new lava flow
17:55:34 diffuse venting and bacterial mat from cracks in new lava flow, floor of trough?
17:57:24 extensive bacterial mats on new lava flow
17:58:41 **Niskin bottle 8 fired**
17:59:14 along collapse wall, AST margin? With extensive bacterial mat on collapse talus
18:00:44 collapse margin in new flow with collapse talus at the base
18:02:54 start of cloudy water in trough
18:06:14 end of cloudy water in trough- still going along collapse margin
18:08:04 moved outside collapse trough to new lava flow, lobates
18:13:24 back into cloudy water over new lava flow- lobates
18:13:54 end cloudy water over new flow along collapse margin
18:15:29 **Niskin bottle 9 fired**
18:42:34 transition in new lava flow from lobates to sheet flow- possible channel?
18:43:34 new lava flow now lobate again
18:50:04 transition of new flow back to sheet flow from lobates
19:00:14 new lava flow with occasional windows into older lobate flow under it - last photo
19:13:59 **Niskin bottle 10 fired**

6NH-Cast 8 TowCam #4 Sample Summary
Rock Cores (1-6) and 5 liter Niskin Bottle (7-10) Samples
Red background means no sample recovered

Sampler	Date	Time	Depth	Altitude	Total Depth (m)
1	14-May-2006	13:39:25	2511.1	3.99 -	2515.1
2	14-May-2006	14:33:30	2490.7	4.67-	2495.3
7	14-May-2006	14:44:22	2495.5	5.02 -	2500.5
3	14-May-2006	14:48:28	2490.7	3.97 -	2494.6

4	14-May-2006	15:22:01	2506.3	3.29	-	2509.6
5	14-May-2006	15:59:38	2491.9	4.20	-	2496.1
6	14-May-2006	16:34:05	2505.1	3.14	-	2508.2
8	14-May-2006	17:58:41	2495.5	4.45	-	2499.9
9	14-May-2006	18:15:29	2485.9	6.23	-	2492.1
10	14-May-2006	19:13:59	1999.0			1999.0

6NH-Cast 12
TowCam #5 May 15, 2006
Summary

This camera tow traversed along-axis tow covered the area of historical venting from the area of ~9^{o} 49.4' N (just south of Tube Worm Pillar) to ~9^{o} 50.9' N (the Bio Vent area), with several parallel tracks were made by letting the ship drift south to cover both east and west of the axis. Images show fresh lava flows, typically as thin veneers over older flows. The new lava has extensive areas of sheet flow within the area imaged on this camera tow, consistent with high eruption rates in the area and perhaps it being a locus of the eruption. Diffuse flow was evident through the sheet flows, although no animal colonization of the new lava was evident. The highest temperature increases were recorded around the locations of the Q and M Vents. Water and rock core samples were also collected for analyses.

6NH-Cast 8 TowCam #5
May 15, 2006

Time (GMT)	Brief Shipboard Description
17:14:12	first photo new and old lava on collapse margin
17:15	new lobate lava
17:15	new lobate lava
17:20	new lobate lava
17:25	new lobate lava
17:28:51	**RC-1 drop new lava**
17:30	new lobate lava with shallow collapse (RC 1 coming up)
17:34	new lobate lava with collapse
17:34:02	margin of AST
17:34	sheet floor on AST floor –folded until east wall
17:36:02	new lobates on AST margin
17:37	contact of new and old lobates
17:40	new lobate lava and sheet flow
17:40:54	**RC 2 on bottom -new lava**
17:45:02	**Bottle #7**
17:47	new lobate to new sheet flow
17:49	new lobate and sheet flow
17:50	sheet flow
17:51:51	mooring weight? Left side of image

17:55	new sheet flow
17:56	new lobate to new sheet flow
18:00	in AST, floor with sheet flows and collapse talus
18:05	in AST, floor with sheet flows and collapse talus
18:07	Floc in water column begins
18:09	Floc in water column ends
18:10	in AST, floor with sheet flows and collapse talus
18:10	contact between new and old lobate
18:22:22	water jelly
18:25	new sheet flows, lobate flows and collapse talus
18:32:52	**RC #4 on sheet flow- new lava**
18:34	new sheet flow
18:35	new lobate and hackley sheet flow
18:40	new sheet flow
18:47	end of new sheet flow, start of lobate flow
18:48:42	new and old lobate contact
18:49	new sheet flow
18:52	new sheet flow ends, begin new lobates with mix of old and new, contacts
18:52	new lobates and contact with old
18:55	new lobate lava
19:10	new lobate lava
19:13	start of ropey sheet flow
19:15	new lobate lava
18:22	mix of lobate and sheet
19:23:52	**RC-5 on bottom- lobate crust- new lava**
19:31	end of sheet- begin sheet flow (good shots)
19:32:42	great sheet flow contact with sheet flow
19:36	end of sheet, into new lobates
19:38:32	new lobate contact with old
19:39:03	lava fingers burped out of pillow basalt
19:40	small temp anomaly; lots of contact between old and new lobates until 20:03
19:51:12	What is that? Baleen of a whale?
20:02:33	**RC #6 on new lobates**
20:04	contact with new hackeley sheet flow and then back to lobates
20:05	turning southeast to go off axis and then in toward East Wall to do a dangle
20:08	new lobates with mix of old and new, contacts
20:10	hackely sheet flow
20:11:13	zoarcid fish on hackely flow.
20:13	camera now turning left and being towed a little sideways
2015	new lobates
20:20	new lobates
20:25:43	red material with zoarcid fish on lobates
20:30	new lobates with beautiful fingers and contacts (lots here)(20:37:43; 20:38:13; 20:38:53; 20:39:43; 20:40:53)
20:40	camera coming back on axis and seeing a turbidity change
20:41	piece of wire on the seafloor

20:50	Now dangling near East Wall and a little north
20:51	lobates turn to sheet flow4
21:00	Traversing south along the west side of the AST
21:01	new lava sheet flow
21:10	Small temperature increase
21:13	South heading for Q and M Vent
21:24:13	floc in the water; remnant microbial mats and collapse
21:34:28	**Bottle #8 fired**
21:27	new and old lobate contacts close to the axis; camera hovering
21:35	new sheet flow (very expansive here new East Wall) all the way until:
21:40:53	new lava contact with old and new lobates
21:52	new lava contact with old and new lobates continued…
21:07	new lava lobates and few contacts
21:15	new lava lobates and few contacts
21:55	Small temperature crinkles
22:11	contact between lobates and new sheet flow
22:18:33	riftia tube on sheet flow?
22:21	increased floc in the water column until 22:22:33
22:21:27	**Bottle #9 fired** in small temp anomaly
22:29:23	fissure margin with microbial mat ion floor- looks active; at the latitude between M and Q Vent; activity up here
22:30	running along the east wall edge
22:23:23	microbial staining indicating venting through collapse talus; small temp increase
22:34:39	**Bottle #10 fired**
22:36:03	iron-oxide staining prevalent on lobates in this area; recently active
22:37	new lava lobates
22:40:43	last image

6NH-Cast 8 TowCam #5 Sample Summary
Rock Cores (1-6) and 5 liter Niskin Bottle (7-10) Samples
Red background means no sample recovered

1.0	15-May-2006	17:28:51	2485	5.85	-2490.5
2.0	15-May-2006	17:40:54	2488	3.17	-2491.4
7.0	15-May-2006	17:45:02	2487	4.22	-2491.3
3.0	15-May-2006	18:17:46	2492	3.47	-2495.3
4.0	15-May-2006	18:31:58	2492	3.82	-2495.7
5.0	15-May-2006	19:22:58	2493	2.79	-2495.9
6.0	15-May-2006	20:02:32	2494	2.64	-2496.9
8.0	15-May-2006	21:34:28	2488	4.70	-2493.0
9.0	15-May-2006	22:22:18	2491	5.55	-2496.2
10	15-May-2006	22:34:39	2491	3.62	-2494.3

6NH-Cast 14
TowCam #6 May 16, 2006

Summary

The objective of this TowCam survey was to explore the EPR axis north of 9° 54'N for additional venting areas and to determine the northern limit of the new lava flow. The traverse along the axis began with the camera a few hundred meters east of the axis near 9° 53.9'N. At 17:12 a relative increase in temperature was observed. As the tow continued north, another temperature rise was seen at 17:24 near 9° 54.0'N, when the camera was closer to the topographic axis based on the EM300 bathymetry. Niskin #7 collected water from this site. The tow proceeded north along the axis and we observed mostly new lava in both lobate and sheet morphology with occasional exposures of older lobate lava. It is unclear from just this tow where the eruptive fissure is or if there are multiple fissures along axis where the flow issued from. Some of the lobes of the new flow were observed to have delicate 'fingers' of glass extruded from the lobate surface probably as a late-stage pulse of magma broke the crust and extruded the fingers. The last image of the new lava flow was at 19:50:53 near 9° 55.7'N. From that point north to the end of the survey at 9° 57.8'N, the seafloor along the EPR axis was comprised of lobate to sheet lava with a dusting of sediment and variable areas of collapse. No diffuse flow or other hydrothermal indicators were observed. Niskin #8 was fired before leaving the bottom to get a background water sample away from a vent area.

6NH-Cast 14 TowCam #6 - Seafloor Geology & Biology Preliminary Observations
16 May 2006

Time (GMT)	Brief Shipboard Description
17:09:33	First bottom photo, new lava, flattened lobates, almost sheet like
17:11:03	deep fissure in new flow with drainback talus on margin, some bacteria/crabs
17:11:233	fissure in new lava flow with cloudy water and bacterial mat and brachyurid crabs
17:13:33	new lobate flow overlying older lobate lava, start of mostly older lobate terrain
17:14:13	mostly older lobate flows, occasional new lobate lobe observed in some photos
17:26:23	first appearance of new lava again during traverse to the north
17:31:33	new lava - sheet morphology
17:34:33	new flow - lobate morphology
17:53:03	new lava - distal lobate flow lobes with glassy fingers over older lobates
17:55:43	older lobate lava, no new lava in image area
18:07:23	new lobate/pillow lobes with well developed glassy fingers over older lobates
18:09:33	mostly new lava for last 2 minutes now going into older lobate flows
18:57:53	old lobated up to now, new lava lobe with glassy fingers in this image
19:00:43	new lobate flow overlying older sed. dusted lobate lava, new lava for last 3 min.
19:00:53	back into older lobate flows
19:17:43	still older lobate flows
19:17:53	small lobe of new lobate flow, continues for next ~ 3 min, then older lava again
19:20:43	older lobate flow
19:43:33	new lava over older lobate flow in part of frame, continues for next 3 min
19:46:33	all old lobate lava
19:50:03	small lobe of new lava overlying older lobate flow
19:50:53	last frame of new lava in this section of the flow for the last minute
19:50:53	**THIS MAY BE THE NORTHERN EXTENT OF THE NEW FLOW**

20:37:03	start of fissure in older lobate flows
20:38:53	sponges on lava pillar in collapsed area, old flow
21:17:03	transition from older lobate flow to old sheet flow
21:29:13	transition back to older lobate flows from old sheet flow
21:57:13	extensive collapse in older lobate flows
22:00:23	end collapse, back into older lobate flows
22:08:53	transition from older lobate flow to old sheet flow/ channel?
20:32:40	**RC-5 drop - older lava**
21:03:28	**RC-6 drop- older lava**
22:21:43	transition to older jumbled, hackly flow
22:23:23	transition to older lobates, perhaps margin of old channel area?
22:30:43	transition back to older sheet flow with curtain folds
22:31:43	last photo - curtain folded older sheet flow in older lava

6NH-Cast 14 TowCam #6 Sample Summary
Rock Cores (1-6) and 5 liter Niskin Bottle (7-10) Samples
Red background means no sample recovered

Sampler	Date	Time	Depth	Altitude	Total Depth (m)
7	16-May-2006	17:24:52	2531.5	4.6	2536.1
1	16-May-2006	17:30:42	2536.3	2.5	2538.8
2	16-May-2006	18:48:27	2542.3	3.3	2545.6
5	16-May-2006	20:32:40	2548.3	3.7	2552.0
6	16-May-2006	21:03:28	2549.5	3.2	2552.7
8	16-May-2006	22:28:07	2551.9	4.0	2556.0

6NH-Casts 15
TowCam #7 May 17, 2006
Summary

Our final lowering of the cruise was a combination vertical CTD cast and seafloor imaging survey using TowCam. We returned to an area just north of the old Biomarker 141 area (9°49.8'N 104 17.42'W) where a large hydrothermal plume signal was detected in a previous towyo survey. We positioned TowCam within the plume and sampled microbial communities via an autonomous pump and in-situ sulfide speciation via the ISEA (both instruments were mounted on TowCam), and then lowered the camera to image the seafloor to examine the hydrothermal source and associated biological colonization. Following an hour of pumping and electrochemical measurements of the plume, the camera was lowered to within 3 meters of the bottom, where large (~10 x 10 meter) areas were covered with microbial mat/byproducts and significant diffuse flow, including snow-blower type venting from a crack at the base of a collapsed wall. Temperature anomalies were detected from the CTD in these locations. Two 5-liter Niskin bottle collected near-bottom fluids associated with these active venting areas, and one Niskin bottle collected water from a turbidity plume at 2367 m (TowCam depth) during TowCam's ascent to the surface.

6NH-Cast 15 TowCam #7 - Seafloor Geology & Biology Preliminary Observations
17 May 2006

Time (GMT)	**Brief Shipboard Description**
04:26:53	first photo new lava with dozen brachyuran crabs and slightly murky water in the AST
04:27	collapse with ponded flow – 2 dozen brachyurans
04:30	crossed collapse from one side to the other- seeing new lobate flow on AST flows
04:31	few galatheids crabs on remnant margin
04:32	rat tail fish
04:35	margin of fissure with glassy basalt, cracks lined with microbes and milky diffuse flow. This could be the site of a black smoker. Subsequent images over the fissure with microbial and brachyuran crabs.
04:36	eastern side of the fissure with milky smoke, brachyurans. Venting along the visible length of the fissure bounded by broken sheet flow to the east and north, moving north a little; over 70 brachyuran crabs in 04:36:44
04:39	cracks in sheet flow lined with microbes, few brachyurans, at base of collapse wall
04:40:04	older microbial staining on sloped fissure margin- can see microbial mats in diffuse flow down in the fissure
04:40:34	diffuse flow coming from microbial covered fissure below lip of collapse
04:40:42	**Bottle 7 fired**
04:42	fissure margin with remnant microbial mats
04:45	contact of sheet ponded sheet floor and collapse on floor, then over remnant and back over collapse floor that continues for ~20 meters then another more narrow parallel collapse before stepping up just a meter or two to get over the wall of the AST
04:53	over fresh lobates outside the AST; very few brachyuran crabs and no deep-sea fauna attached
04:59	turning through the west to come back to the east;
05:02	contact between sheet flow and lobates (sheet flow about 10m wide); Towcam getting pulled backwards to the east
05:04:44	AST west wall- sheet flow goes up to the margin
05:06	galatheids and synaphobranhus eel on collapse margin
05:06:14	floor of the AST- ropey sheet flow with microbial staining in folds (with some remnant mat)
05:10:35	back over depression/fissure with milky diffuse flow, brachyuran crabs, and staining. This is as close as it comes to seeing a snow blower vent.
05:12:00	**Bottle 9 containing in-situ electrodes fired**
05:12:04	contact of sheet flow at fissure margin; Towcam then follows sheet flow for over a minute
05:15	sheet flow ends within the trough near a depression and a collapse wall
05:20	over collapse near the margin of the AST
05:25	outside the AST in collapse
05:28	Last picture on the bottom- ascending to surface

6NH-Cast 15 TowCam #7 Sample Summary
Rock Cores (1-6) and 5 liter Niskin Bottle (7-10) Samples
Red background means no sample recovered

Sampler	Date	Time	Depth	Altitude	Total Depth (m)
7	17-May-2006	4:40:22	2488.3	3.42	-2491.7
9	17-May-2006	5:12:22	2488.3	5.70	-2494.0
10	17-May-2006	5:35:05	2360.8		-2360.8

Dredge Operation Summary

Cast 6NH-10

Dredge-1 **900m east of the AST where new lava flow ponds against inward facing scarp as imaged in TowCam #3 at 18:49:32**

Dredge landed south of TowCam #3 line and crossed it for ~ 0.25 nm sampling new flow and possible older flows surrounding it

GMT Day	GMT Time	Wire Out (m)	Ship Lat. 9°N Min	Ship Long. 104°W Min	Comments
5/15/06	3:57				Dredge in water
5/15/06	5:25	2509	54.48	17.648	
5/15/06	5:28	2556	54.522	17.681	On bottom moving south to north
5/15/06	5:30	2576	54.54	17.658	
5/15/06	5:32	2604	54.566	17.65	45m of wire on the bottom
5/15/06	5:34	2635	54.597	17.681	75m of wire on the bottom
5/15/06	5:35	2650	54.598	17.687	90m of wire on the bottom
5/15/06	5:36	2655	54.598	17.674	105m of wire on the bottom
5/15/06	5:40	2660	54.65	17.659	Hydraulics not working, winch stopped, cannot reel in
5/15/06	5:45	2661	54.688	17.675	Aft control taking control
5/15/06	5:55	2665	54.745	17.66	Switched to 100hp hydraulic motor, winch now working hauling in
5/15/06	6:04	2574	54.786	17.65	Off bottom

Sediment/Larval Trap Mooring Summary

(D.K. Poehls, C.R. German, L.S. Mullineaux, K.J. Edwards & O. Rouxel)

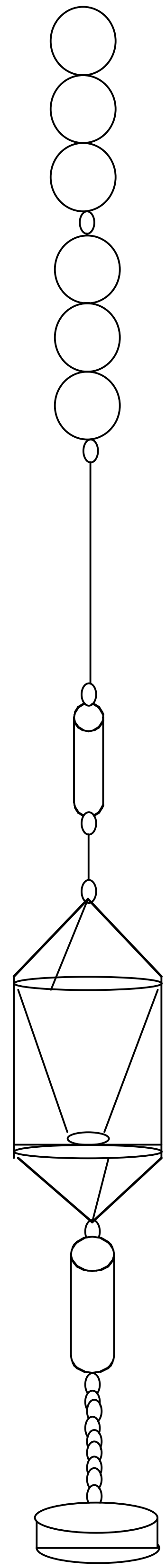
We initiated a time-series, multi-disciplinary project, to investigate the evolution of vent plume biogeochemistry and to quantify the larval flux to newly-forming biological communities. While gross hydrothermal fluxes exiting the seafloor are known to be significant, much remains unknown about the fate of this material as it disperses through the oceans, its impact upon ocean biogeochemistry, the extent to which microbial activity catalyses resultant biogeochemical reactions, or the role that larval supply plays in the succession sequence of biological communities. To address these issues, we deployed two moorings each equipped with a McLane PARFLUX Mark 78H-21 Sediment Trap, situated five meters above bottom. Both traps were set to collect particulate and larval flux in two day intervals over 40 days. The first mooring was deployed near the Tica vent area and has an estimated location at 9° 50.382 N, 104° 17.588 W. (Acoustic release: receive frequency 10.5, transmit frequency 12.0, enable code C, release code B.) The second mooring, additionally equipped with an Aanderaa RCM11 current meter, was deployed near the Bio 9 vent area. (Acoustic release: receive frequency 14.0, transmit frequency 12.0, enable code D, release code B) An acoustic ranging survey located the second mooring on bottom at 9° 50.316 N, 104° 17.565 W. We will use trace element, radionuclide and isotope analyses, mineralogy, and microbial culturing and phylogenetic techniques, to investigate biotic and abiotic reactions within, and fluxes from, buoyant and non-buoyant plumes. We will quantify species-specific larval fluxes using morphological and molecular identification of larvae and relate these fluxes to macrofaunal and megafaunal colonization observed in June. Additionally, Dr. Timothy Shank will use the larvae in ongoing investigations of temporal population genetics of vent organisms.

Figure 11. Mooring #1 Deployed (9^o 50.33’ N; 104^o 17.50)

Figure 12. Mooring #2 Deployed (9^o 50.50’ N; 104^o 17.52)

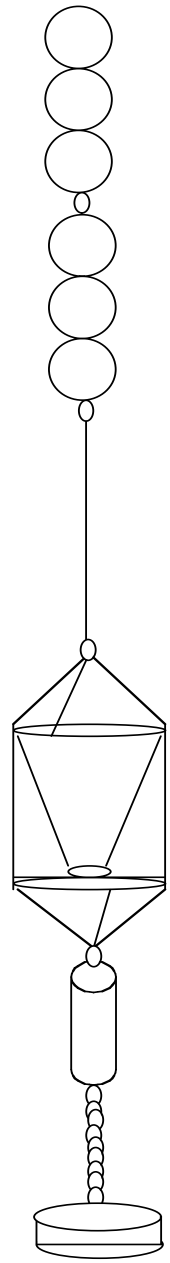
EPR Rapid Response May 2006 Š Mooring 1

Objects	Weight (water lbs)
6 17Ófloats @ 51lbs each	+306
Hardware	-40
RCM11	-41
Sediment Trap	-77
Release	-55
Weight (yellow)	-195
Going down	-105 lbs
Going up	93 lbs



EPR Rap id Resp onse Ma y 2006 Š
Mooring 2

Objects	Weight (lbs)
6 17Ó floats @ 51 lbs each	+306
Hardware	-38
Sediment Trap	-77
Release	-55
Weight (solid)	-240
Going Down	-104 lbs
Going Up	136 lbs



X 17Ó floats on chain (~5 m)

5/8Ós Š P - 5/8Ós

X 17Ó floats on chain (~5 m)

5/8Ós-P- ½Ós

37 m

½Ós ŠP Š
3*(½Ós -wire- ½Ós Š ½Ós)

Sediment Trap
(~3.5 m w/ bridles)

3*(½Ós - ½Ós Š chain- ½Ós)
P-5/8Ós

Acoustic Release

Link Š ½Ós
Pull-pin release ?
1m chain

Weight - solid

Poehls, May 4, 2006

Deployment of METOCEAN PROVOR Lagrangian Float

By Andreas Thurnhurr and R. Chadwick Holmes, LDEO

A METOCEAN PROVOR profiling float with pressure, temperature and conductivity sensors was deployed near the crest of the East Pacific Rise at 9-50 N, 104-18 W during the May, 2006 R/V New Horizon rapid response cruise. The main purpose of this deployment is to collect information on the Lagrangian dispersal of hydrothermal products released into the water column near the depth of neutrally buoyant event plumes. Complementary Eulerian velocity data near the ridge crest will be simultaneously collected by a current meter on a sediment-trap mooring deployed during the same mission. Prior to its release, the float was programmed to drift at a depth comparable to the float's maximum rated pressure of 2000dbar (~1980m) over cycles lasting 30 days. Pressure, temperature, and salinity measurements will be recorded every 12 hours throughout each drift cycle. At the cycle's end, the float will collect temperature and salinity profiles at a 11s sampling interval as it ascends to the surface for data transmission. The float is set to transfer data via the ARGOS satellite system over an 18 period before descending back to drift depth and commencing a new cycle. Over the coming months, the float displacement data will be published at
http://www.ldeo.columbia.edu/~ant/EPR_2006_Event_Float.

OBS: Shipboard Navigation Operations

by R. Chadwick Holmes, LDEO

The primary aim of the ocean bottom seismometer (OBS) component of the 9N rapid response cruise (6nh) was to determine the current status of the seismometer array deployed along the robust and active segment of the East Pacific Rise between 9 49' N and 9 51' N. This 12-instrument array has been maintained since October 2003 to continuously monitor "microseismic" activity along the ridge that is too small in magnitude to be measured from land. The LCHEAPO 2000 OBS instruments used by the experiment store ground motion data on an on-board hard drive, requiring a periodic retrieval of the full array for data collection followed by a redeployment of OBSs in the same array geometry. In April, 2006, the R/V Knorr sailed to 9N to perform the annual maintenance of the array, but was unsuccessful in retrieving 8 instruments. Of the remaining OBSs, 5 would not respond when queried with instrument-specific acoustic codes and 3 responded but would not return to the surface. Even more interestingly, the retrieved instruments all lay along the edges of the array. Given that microseismic activity along the ridge segment has profoundly increased since 2003 – an indication of subsurface magma migration – the OBS retrieval pattern looked suspiciously like the fingerprint of an axial surface eruption.

Of the 11 instruments launched on the Knorr cruise, only 2 were ranged to determine their final locations on the sea floor. Chad Holmes, a graduate student at Lamont-Doherty Earth Observatory and representative for the OBS project P.I., Maya Tolstoy, served as acoustic technician on the R/V New Horizon during the May 4-23, 2006 cruise with the goals of accurately locating the 9 remaining 2006 instruments and attempting to communicate with the 8 unrecoverable instruments deployed in 2005. When on-site, multiple measurements of the time it takes for an instrument to respond to an acoustic code can be used to effectively triangulate the location of an OBS. Chad found 2 of the 2006 instruments to be unresponsive to acoustic commands, but recorded an average of 237 usable travel times for each of the remaining 9. In addition, while the 5 mute 2005 instruments remained silent, data collected during both the R/V Knorr and R/V New Horizon cruises amounted to ~250 travel times for the 3 "stuck" 2005 OBSs. The location of the seismometers was an unqualified success, resulting in an average uncertainty estimate on the order of ~20 m. With locations this accurate, we have high hopes for capturing images of one or more instruments in situ during a future ALVIN mission – possibly even confirming the entrainment of the stuck OBSs in a branch of the confirmed axial lava flow!

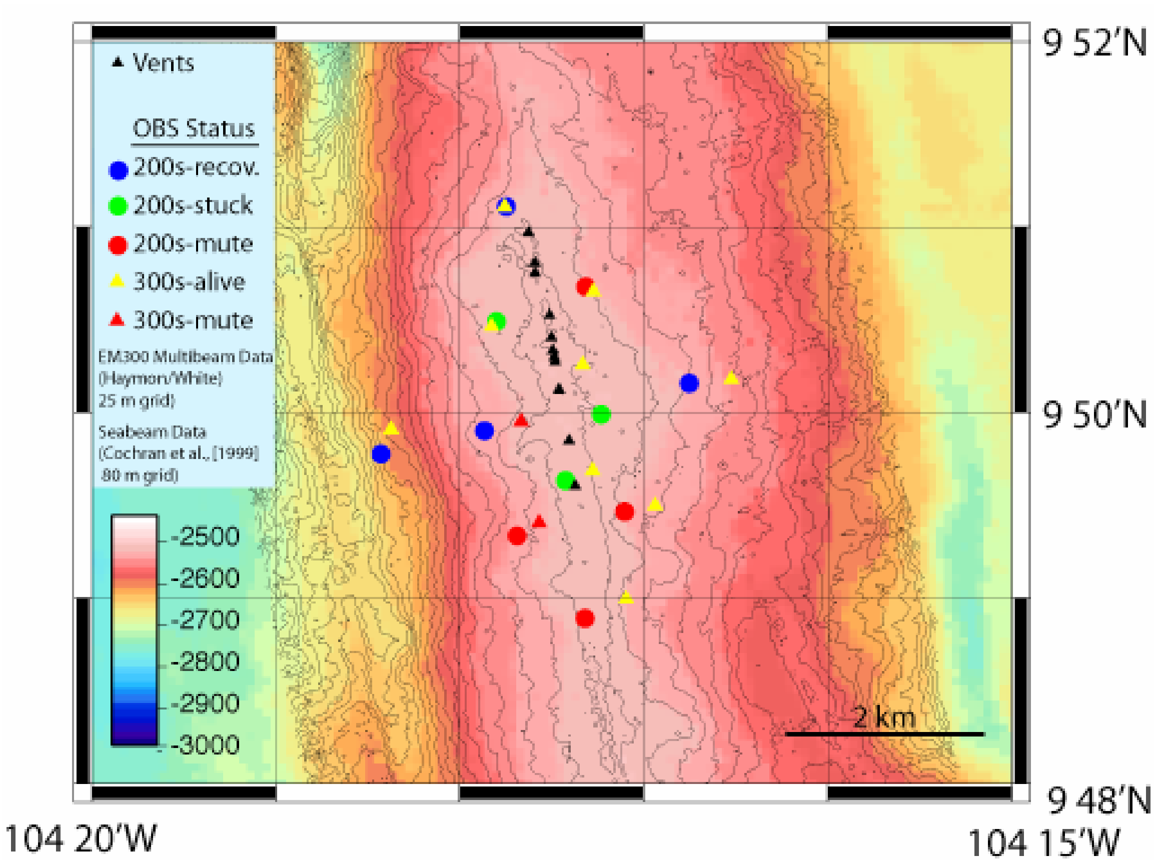


Figure 13. Map showing locations of remaining 2005 and newly deployed 2006 OBSs
Based on relocation efforts of Chad Holmes.

Tolstoy_EPR9N_2006_OBS_Data:
these are the archive folders
Checksheet_Scans
Data
Documents
Programs

Relocation_Logs

Tolstoy_EPR9N_2006_OBS_Data/Checksheet_Scans:
these are scans of the 200 and 300 series OBS
deployment checksheets
201.JPG; 202.JPG, 203.JPG, 204.JPG, 205.JPG, 206.JPG, 207.JPG, 208.JPG, 209.JPG, 210.JPG, 211.JPG, 212.JPG, 213.JPG, 301.JPG, 302.JPG, 303a.JPG, 303b.JPG, 304.JPG, 305.JPG, 307.JPG, 308.JPG, 309.JPG, 310.JPG, 311.JPG, 312.JPG

Tolstoy_EPR9N_2006_OBS_Data/Data:
these are folders containing the raw travel time data
2005_Crispin
2006_Chad
2006_Crispin

Tolstoy_EPR9N_2006_OBS_Data/Data/2005_Crispin:
Ranging data from 2005
202.all; 208.all; 209.all; 211.all; 212.all; site201,sn36; site202,sn12; site202,sn12,1; site203,sn70; site204,sn44; site205,sn46; site206,sn31; site207,sn20; site208,sn26; site208,sn26,1; site209,sn19; site209,sn19,1; site210,sn45; site211,sn35; site211,sn35,1; site211,sn35,2; site212,sn38; site212,sn38,1

Tolstoy_EPR9N_2006_OBS_Data/Data/2006_Chad:
these are folders containing ranging data from
the 2006 R/V New Horizon Rapid Response Cruise
206; 210; 212; 301; 302; 304; 307; 308; 309; 310; 311; 312

Tolstoy_EPR9N_2006_OBS_Data/Data/2006_Chad/206:
site 206 data
6nh_epr9n_s206_dl31_au31_135_02.15.txt
6nh_epr9n_s206_dl31_au31_135_17.28.txt
6nh_epr9n_s206_dl31_au31_137_01.04.txt
6nh_epr9n_s206_dl31_au31_137_05.17.txt
6nh_epr9n_s206_dl31_au31_combined_clean.txt
6nh_epr9n_s206_dl31_au31_combined.txt
site206_sn31-1146079858

Tolstoy_EPR9N_2006_OBS_Data/Data/2006_Chad/210:
site 210 data
6nh_epr9n_s210_dl45_au45_135_14.13.txt
6nh_epr9n_s210_dl45_au45_137_04.34.txt
6nh_epr9n_s210_dl45_au45_combined_clean.txt
6nh_epr9n_s210_dl45_au45_combined.txt
site210_sn45-1146076371

Tolstoy_EPR9N_2006_OBS_Data/Data/2006_Chad/212:

site 212 data
6nh_epr9n_s212_dl38_au38_131_12.34.txt
6nh_epr9n_s212_dl38_au38_132_02.56.txt
6nh_epr9n_s212_dl38_au38_133_02.10.txt
6nh_epr9n_s212_dl38_au38_135_09.05.txt
6nh_epr9n_s212_dl38_au38_135_19.16.txt
6nh_epr9n_s212_dl38_au38_137_01.35.txt
6nh_epr9n_s212_dl38_au38_137_06.12.txt
6nh_epr9n_s212_dl38_au38_combined_clean.txt
6nh_epr9n_s212_dl38_au38_combined.txt

Tolstoy_EPR9N_2006_OBS_Data/Data/2006_Chad/301:
site 301 data
6nh_epr9n_s301_dl49_au49_131_18.32.txt
6nh_epr9n_s301_dl49_au49_131_20.29.txt
6nh_epr9n_s301_dl49_au49_133_00.31.txt
6nh_epr9n_s301_dl49_au49_135_15.37.txt
6nh_epr9n_s301_dl49_au49_combined_clean.txt
6nh_epr9n_s301_dl49_au49_combined.txt

Tolstoy_EPR9N_2006_OBS_Data/Data/2006_Chad/302:
site 302 data
6nh_epr9n_s302_dl47_au47_131_18.25.txt
6nh_epr9n_s302_dl47_au47_131_21.25.txt
6nh_epr9n_s302_dl47_au47_132_11.21.txt
6nh_epr9n_s302_dl47_au47_134_10.48.txt
6nh_epr9n_s302_dl47_au47_135_17.23.txt
6nh_epr9n_s302_dl47_au47_137_04.41.txt
6nh_epr9n_s302_dl47_au47_combined_clean.txt
6nh_epr9n_s302_dl47_au47_combined.txt

Tolstoy_EPR9N_2006_OBS_Data/Data/2006_Chad/304:
site 304 data
6nh_epr9n_s304_dl22_au15_137_05.58.txt
6nh_epr9n_s304_dl22_au15_combined_clean.txt
6nh_epr9n_s304_dl22_au15_combined.txt
site304_sn22_ranging-1145876659

Tolstoy_EPR9N_2006_OBS_Data/Data/2006_Chad/307:
site 307 data
6nh_epr9n_s307_dl64_au64_131_11.43.txt
6nh_epr9n_s307_dl64_au64_131_18.13.txt
6nh_epr9n_s307_dl64_au64_135_20.32.txt
6nh_epr9n_s307_dl64_au64_137_00.40.txt
6nh_epr9n_s307_dl64_au64_combined_clean.txt
6nh_epr9n_s307_dl64_au64_combined.txt

Tolstoy_EPR9N_2006_OBS_Data/Data/2006_Chad/308:
site 308 data
6nh_epr9n_s308_dl66_au66_131_22.39.txt
6nh_epr9n_s308_dl66_au66_133_05.17.txt
6nh_epr9n_s308_dl66_au66_134_08.15.txt
6nh_epr9n_s308_dl66_au66_137_00.25.txt
6nh_epr9n_s308_dl66_au66_combined_clean.txt
6nh_epr9n_s308_dl66_au66_combined.txt

Tolstoy_EPR9N_2006_OBS_Data/Data/2006_Chad/309:
site 309 data
6nh_epr9n_s309_dl79_au79_131_13.36.txt
6nh_epr9n_s309_dl79_au79_131_17.29.txt
6nh_epr9n_s309_dl79_au79_133_04.58.txt
6nh_epr9n_s309_dl79_au79_135_02.33.txt
6nh_epr9n_s309_dl79_au79_135_08.36.txt
6nh_epr9n_s309_dl79_au79_135_19.19.txt
6nh_epr9n_s309_dl79_au79_135_21.12.txt
6nh_epr9n_s309_dl79_au79_137_23.43.txt
6nh_epr9n_s309_dl79_au79_combined_clean.txt
6nh_epr9n_s309_dl79_au79_combined.txt

Tolstoy_EPR9N_2006_OBS_Data/Data/2006_Chad/310:
site 310 data
6nh_epr9n_s310_dl73_au73_131_10.56.txt
6nh_epr9n_s310_dl73_au73_132_10.08.txt
6nh_epr9n_s310_dl73_au73_133_00.09.txt
6nh_epr9n_s310_dl73_au73_133_01.22.txt
6nh_epr9n_s310_dl73_au73_134_11.56.txt
6nh_epr9n_s310_dl73_au73_134_15.31.txt
6nh_epr9n_s310_dl73_au73_137_03.24.txt
6nh_epr9n_s310_dl73_au73_137_04.51.txt
6nh_epr9n_s310_dl73_au73_combined_clean.txt
6nh_epr9n_s310_dl73_au73_combined.txt

Tolstoy_EPR9N_2006_OBS_Data/Data/2006_Chad/311:
site 311 data
6nh_epr9n_s311_dl27_au27_134_09.41.txt
6nh_epr9n_s311_dl27_au27_137_01.46.txt
6nh_epr9n_s311_dl27_au27_137_05.37.txt
6nh_epr9n_s311_dl27_au27_combined_clean.txt
6nh_epr9n_s311_dl27_au27_combined.txt
site311_sn27-1146081910

Tolstoy_EPR9N_2006_OBS_Data/Data/2006_Chad/312:

site 312 data
6nh_epr9n_s312_dl57_au57_131_15.15.txt
6nh_epr9n_s312_dl57_au57_131_23.54.txt
6nh_epr9n_s312_dl57_au57_133_01.33.txt
6nh_epr9n_s312_dl57_au57_135_08.44.txt
6nh_epr9n_s312_dl57_au57_135_21.33.txt
6nh_epr9n_s312_dl57_au57_137_01.19.txt
6nh_epr9n_s312_dl57_au57_137_07.00.txt
6nh_epr9n_s312_dl57_au57_combined_clean.txt
6nh_epr9n_s312_dl57_au57_combined.txt

Tolstoy_EPR9N_2006_OBS_Data/Data/2006_Crispin:
these are the ranging data files from the
2006 R/V Knorr Cruise
site206_sn31-1146079858
site210_sn45-1146076371
site304_sn22_ranging-1145876659
site311_sn27-1146081910

Tolstoy_EPR9N_2006_OBS_Data/Documents:
these are various documents and figures related
to the OBS locations
NOTE: the final comprehensive spreadsheet is named
EPR_OBS_2006_New_Horizon_FINAL
EPR_OBS_2006_April.xls
EPR_OBS_2006_Knorr.txt
EPR_OBS_2006_Knorr.xls
EPR_OBS_2006_New_Horizon_FINAL.ods
EPR_OBS_2006_New_Horizon_FINAL.xls
EPR_OBS_2006_status2.ai
EPR_OBS_2006_status.eps
EPR_OBS_checkout_values.xls
OBS_Movement.ai

Tolstoy_EPR9N_2006_OBS_Data/Programs:
these are the programs/scripts used to locate
the OBSs given the raw travel time data
clean_ttfile.csh
obslocate

Tolstoy_EPR9N_2006_OBS_Data/Relocation_Logs:
these are the log files (direct output) of
obslocate from processing the relocations on
the R/V New Horizon Rapid Response Cruise
201_relocation_2005_6nh.txt
202_relocation_2005_6nh.txt

203_relocation_2005_6nh.txt
204_relocation_2005_6nh.txt
205_relocation_2005_6nh.txt
206_relocation_2005_6nh.txt
206_relocation_2006_6nh.txt
207_relocation_2005_6nh.txt
208_relocation_2005_6nh.txt
209_relocation_2005_6nh.txt
210_relocation_2005_6nh.txt
210_relocation_2006_6nh.txt
211_relocation_2005_6nh.txt
212_relocation_2005_6nh.txt
212_relocation_2006_6nh.txt
301_relocation_2006_6nh.txt
302_relocation_2006_6nh.txt
304_relocation_2006_6nh.txt
307_relocation_2006_6nh.txt
308_relocation_2006_6nh.txt
309_relocation_2006_6nh.txt
310_relocation_2006_6nh.txt
311_relocation_2006_6nh.txt
312_relocation_2006_6nh.txt

Appendices

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6. Alexander Treusch (OSU, scientist; Alexander.Treusch@science.oregonstate.edu)
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9. Tim Shank (WHOI, scientist; tshank@whoi.edu)
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11. Brooke Love (UW, Student; blove@ocean.washington.edu)
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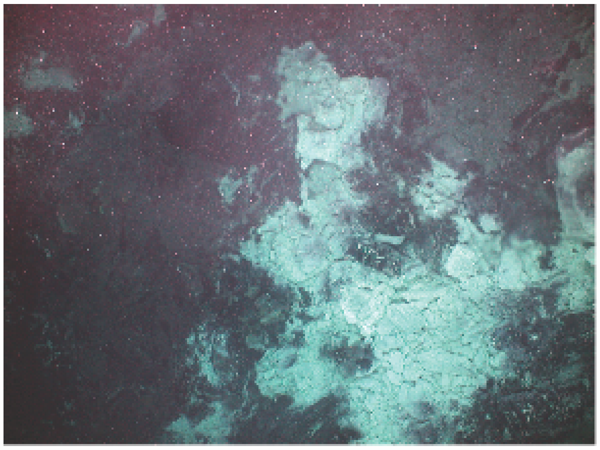
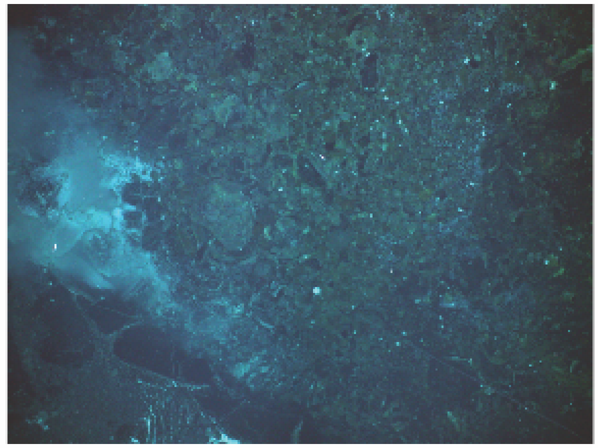
A2. Image Plates from TowCam Casts

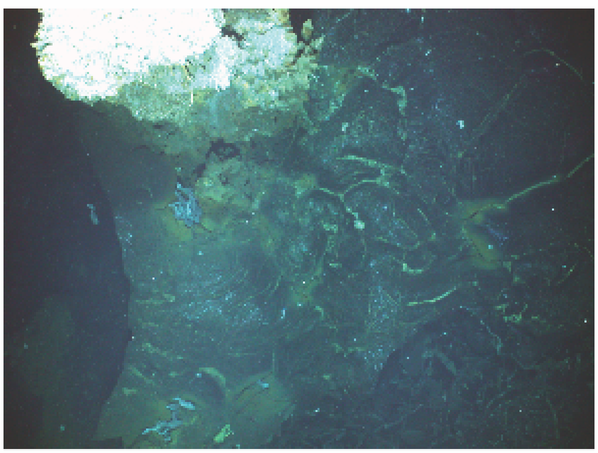
TowCam #1 6NH-Cast-02
May 11, 2006



2006_05_11_22_48_22.jpg
New lava surrounding white microbial mat and diffuse venting.

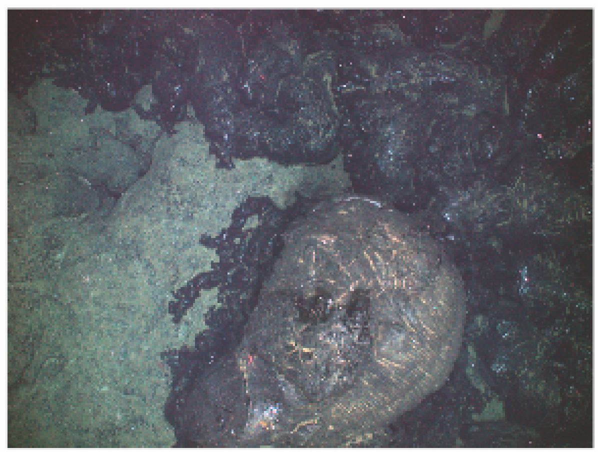


2006_05_11_23_14_32.jpg
Cloudy water venting from a fissure in new flow surface.

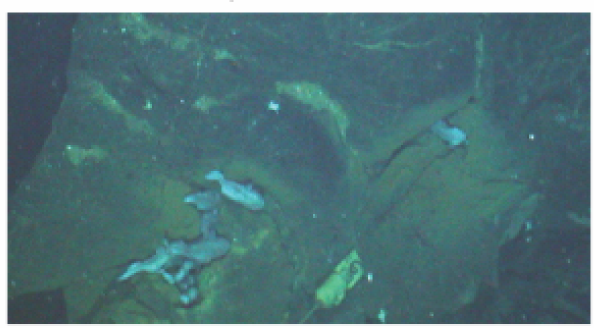


2006_05_11_23_41_42.jpg
M Vent chimnney sticking out of new lava flow at margin of collapse; 2 fish holes with bythidid fish at base, white mirobial mat at top, worm tubes on side of chimney

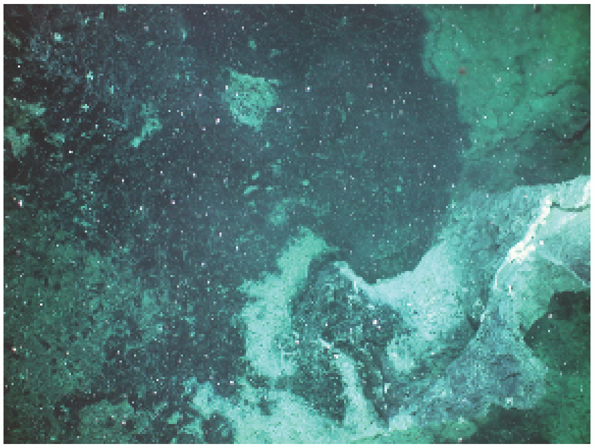
The casing of a high-temperature HOBO logger #6 on the southern side of the M Vent chimney (see also at right).



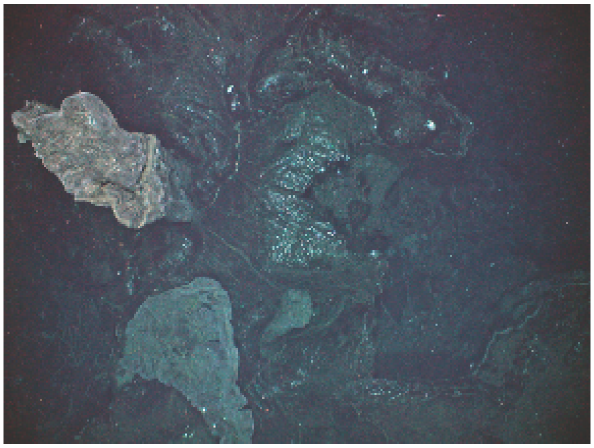
2006_05_12_00_29_43.jpg
New and old lava contact, lobate forms with non-vent nematocarcinid shrimp.



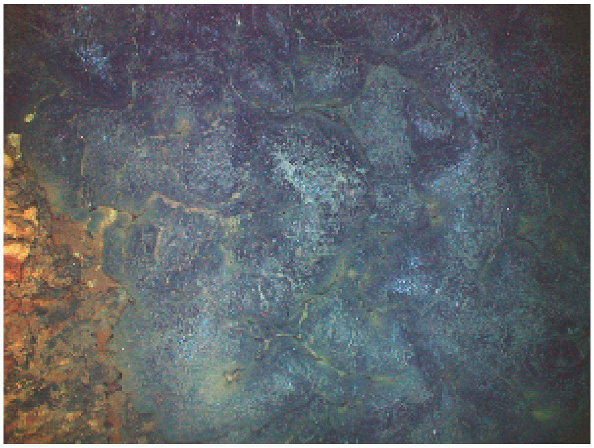
TowCam #2 6NH-Cast-04
May 12, 2006



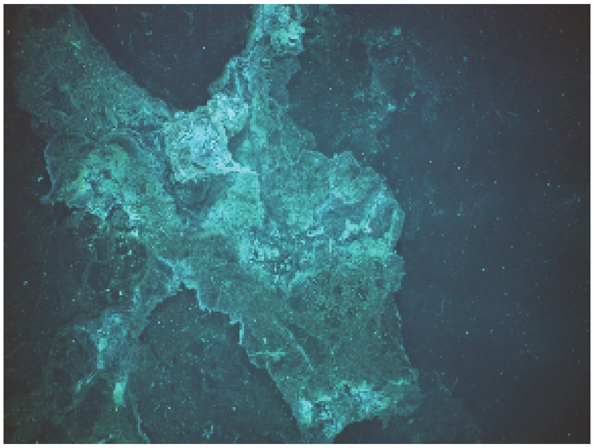
2006_05_12_20_47_41.jpg
Extensive microbial mat, intense white mats in cracks in new flow surface.



2006_05_12_21_00_01.jpg
New lobate flow surrounding older lava pillars.

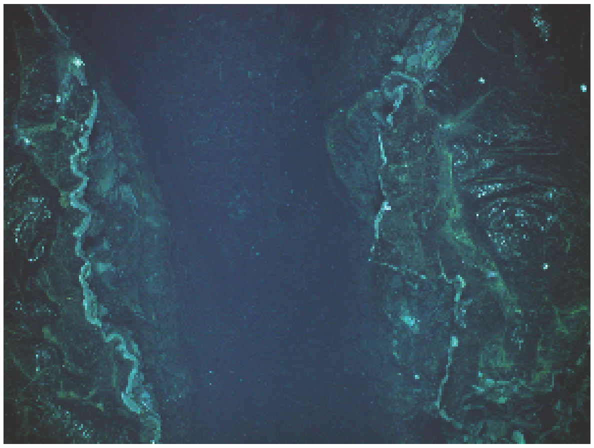


2006_05_12_20_17_31.jpg
Older lobate lava surrounding old sulfide.



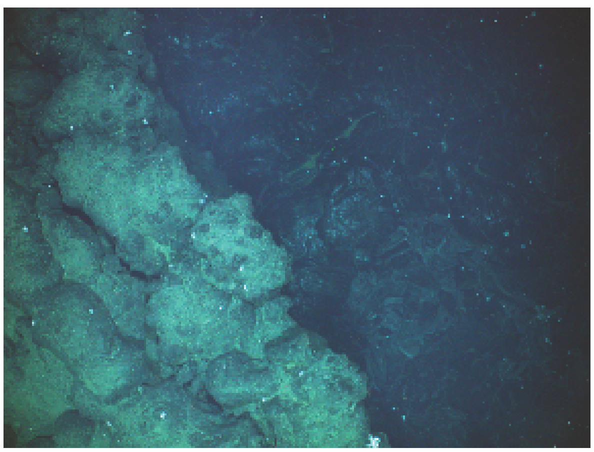
2006_05_12_20_52_41.jpg
Microbial mat on margin of collapse in new flow.

TowCam #3 6NH-Cast-06
May 13, 2006

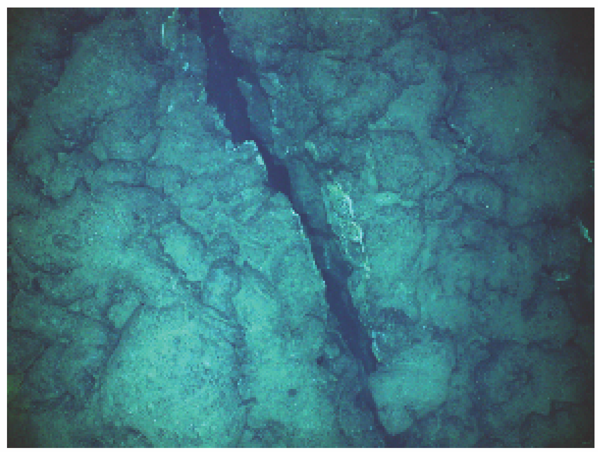


2006_05_13_15_38_02.jpg
Primary eruptive fissure with new lava on margins.

2006_05_13_15_38_41.jpg
Diffuse flow area on new lava flows.

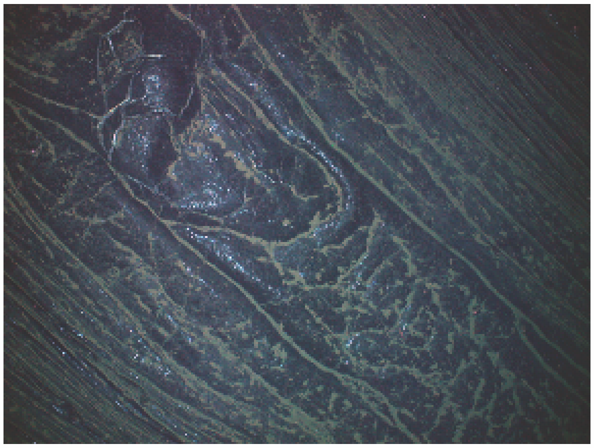


2006_05_13_16_08_02.jpg
Younger lava partly filling AST (up older wall)

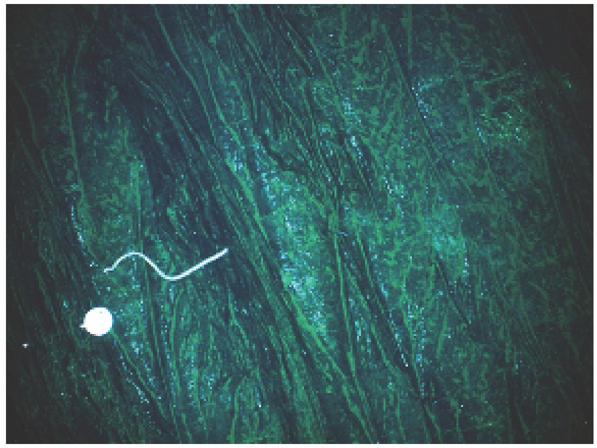


2006_05_12_20_52_41.jpg
Fissure cutting through old lobates and pillows.

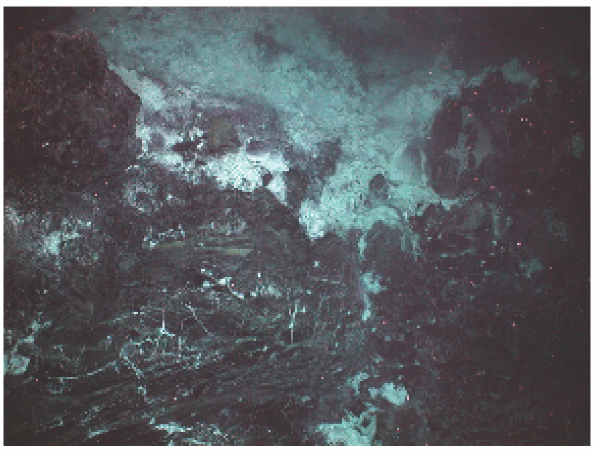
TowCam #4 6NH-Cast-08
May 14, 2006



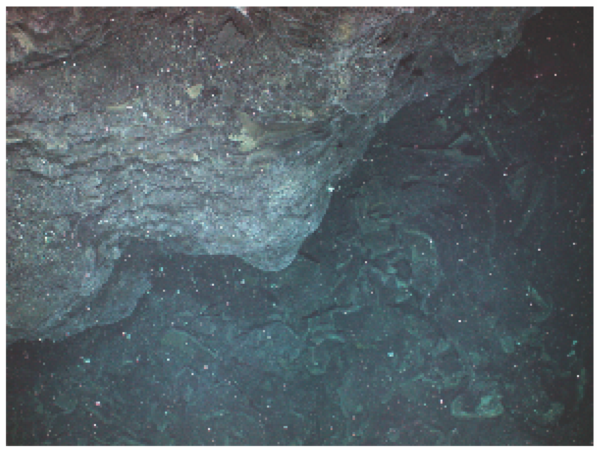
2006_05_14_14_26_03.jpg
Young sheet flow lava.



2006_05_14_14_35_03.jpg
Rock core being collected near Riftia tube on sheet flow.



2006_05_14_17_57_24.jpg
Difuse flow area surrounded by fresh lava flow.

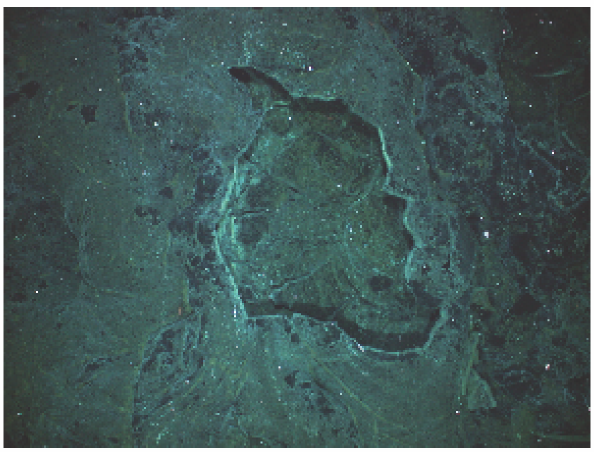


2006_05_14_18_00_44.jpg
Collapse margin in new flow with collapse talus at the base.

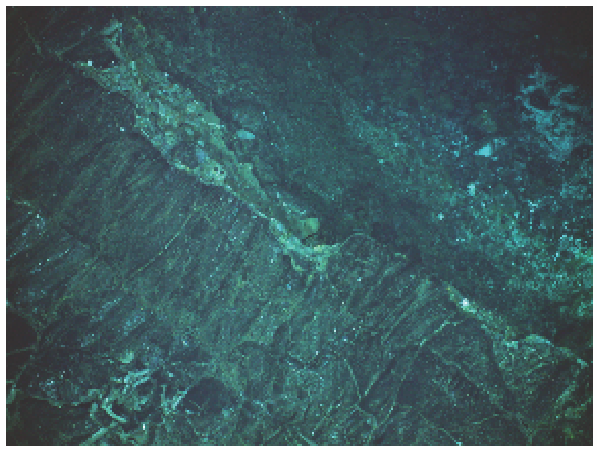
TowCam #5 6NH-Cast-12
May 15, 2006

2006_05_15_19_32_32.jpg
New sheet flow outside the AST.

2006_05_15_19_51_12.jpg
Striations in new lobate lava.

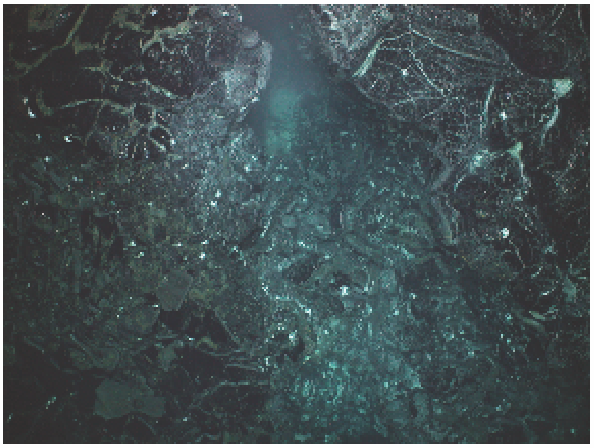


2006_05_15_21_24_13.jpg
Remnant microbial mats and shallow collapse.

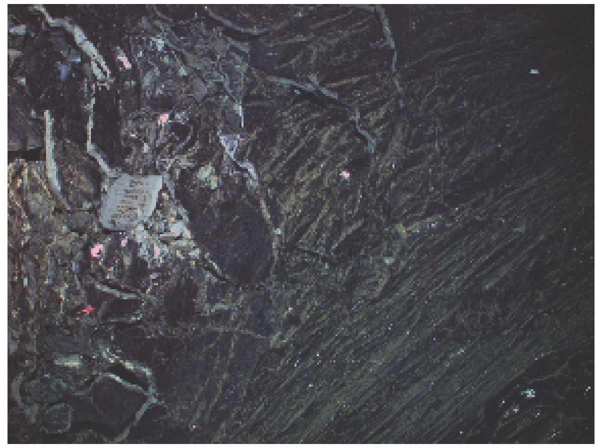


2006_05_15_22_29_23.jpg
Fissure margin with active venting area between M and Q Vent locations.

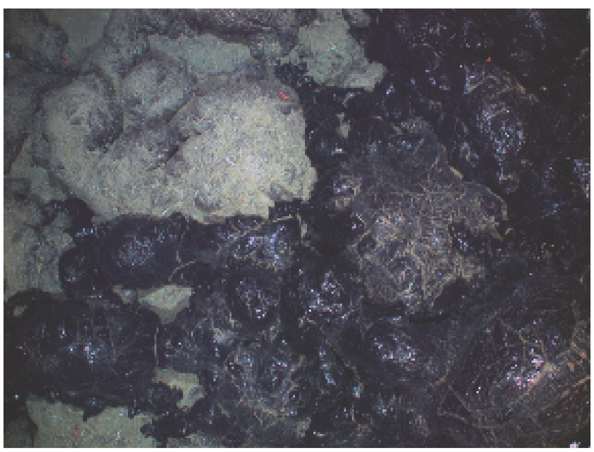
TowCam #6 6NH-Cast-14
May 16, 2006



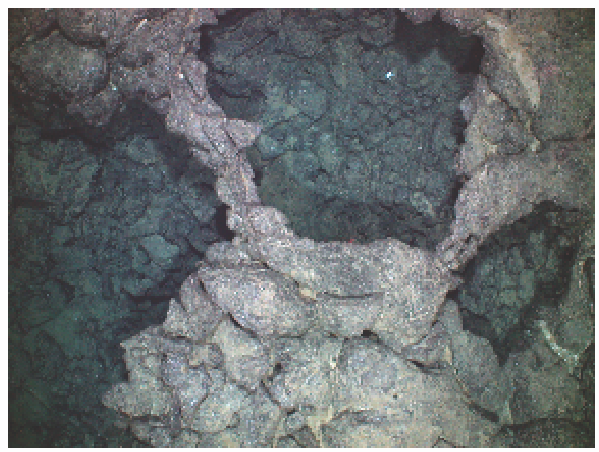
2006_05_16_17_11_23.jpg
Fissure in new lava flow with cloudy water and microbial mat and brachyuran crabs.



2006_05_16_17_31_33.jpg
New lava with heet morphology.

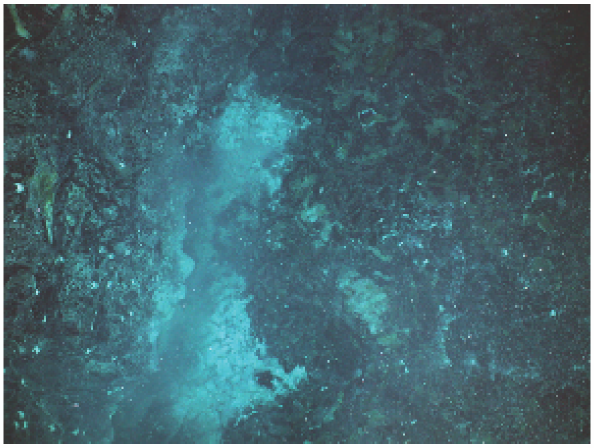


2006_05_16_19_00_43.jpg
New lobate flow overlying older sediment-dusted lobate lava.

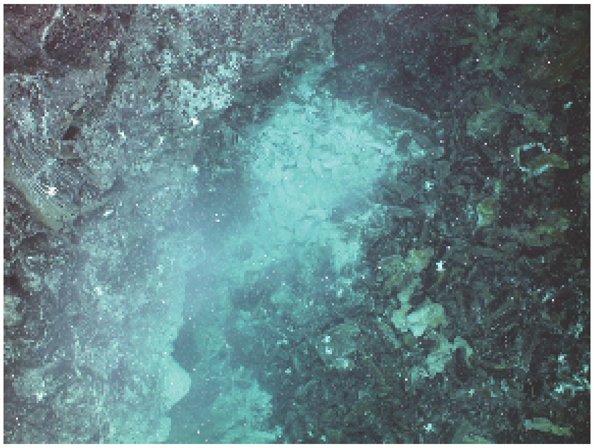


2006_05_16_21_57_13.jpg
Extensive collapse in older lobate flows.

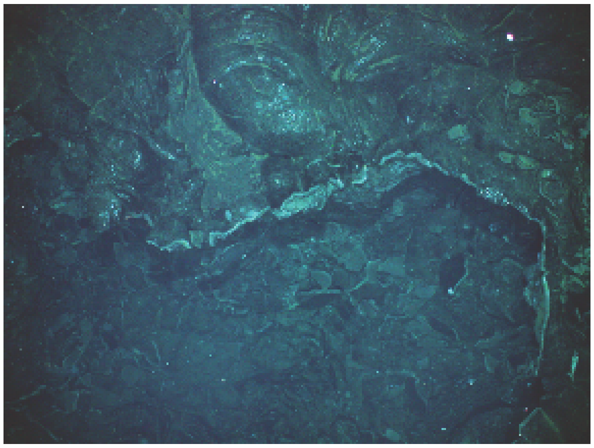
TowCam #7 6NH-Cast-15
May 16, 2006



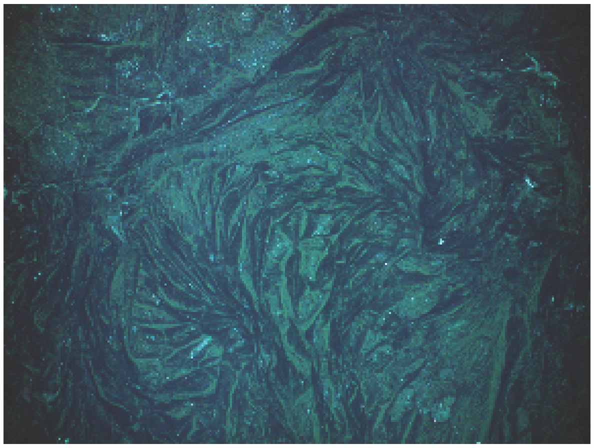
2006_05_17_04_41_04.jpg
Fissure lined with microbes and milky diffuse flow and brachyuran crabs.



2006_05_17_04_41_14.jpg
Diffuse flow emenating from microbial covered fissure below lip of collapse.



2006_05_17_04_50_44.jpg
Narrow collapse bewteen main AST and the 2-3 tall AST wall.



2006_05_17_05_19_54.jpg
Sheet flow morphology extending over collapse near the base of the AST wall.

A3. Data Management System (DMS) Forms

The following DMS forms have been deposited with the R2K Data Management Group.

- A01_expedition_overview_Cowen_6NH.doc
- A02_science_party_Cowen_6NH.doc
- A03_data_inventory_Cowen_6NH-1.doc
- B02_Dredge_Cowen_6NH.xls
- B03RockCore_Cowen_6NH.xls
- B06BottomInstruments_Markers_Cowen_6NH.xls
- Towed instrument_Cowen_6NH.xls

Associated data summary forms include:

- Master water sample inventory_6NH.xls
- 6nh_towcam_rockcore_inventory.xls
- Data Structure for 6NH TowCam Data.doc
- 6nh-dredge1.xls