Photograph of staromedusae from Jason Lowering J2-265, April 9. 2007

We are grateful to Captain Gary Chiljean and the crew of the R/V Atlantis and to the Jason II and DSL 120 groups for their tireless efforts to make this program a success.

Contents

1. Executive Summary

AT15-17 (the MEDUSA cruise) investigated seafloor spreading processes at two locations within the Ridge2000 Integrated Study Site on the East Pacific Rise (EPR). The main program on this cruise was the investigation of the overlapping spreading center at 9°03'N. This area was surveyed with *DSL-120A* for two lowerings over six days, followed by 16 days of mapping and sampling with ROV *Jason II* and WHOI *TowCam* lowerings during operational turnarounds of *Jason II*. We discovered one high-temperature hydrothermal vent (named the Medusa Vent to highlight the presence of unusual pink *Stauromedusae*) and an associated diffuse-flow hydrothermal field. We found no evidence of widespread recent eruptions, although loci of recent volcanism were identified on each limb of the overlapping spreading center. Most lavas observed and recovered were pillow basalts with fresh glass. In addition, 12 samples had a bluish or waxy glass aspect suggesting that they may be andesites (subject to confirmation by on-shore analysis). Samples recovered included ~300 rock samples, four double majors vent water samples, and biologic samples including riftia, tevnia, alvinella.

The second part of the program consisted of two add-on projects to investigate the recent (2005-06) seafloor eruption centered near 9°50'N. Two days of *DSL-120A* surveying covered the areas of known and suspected lava flows from the eruption. This survey revealed extensive landscape changes since the previous side-scan survey in 2001. Three days of *Jason II* time were used to conduct several types of activities to provide baseline data and infrastructural support to a broad cross-section of multidisciplinary investigations at the EPR Integrated Study Site. During this program, high resolution, near-bottom multibeam and magnetic data over the benchmark areas and axial summit trough were collected; sampling and observations were conducted along lava channels; two ocean-bottom seismometers that were trapped by lava from the 2005-2006 eruptions were recovered; and a lost compliance meter from the Webb/Cormier experiment was released and recovered.

2. Introduction

An over-riding goal in the study of mid-ocean ridges is to understand the linkages in the magmatic system from bottom to top (see, e.g., Ridge2000 Science Plan). In broad terms, this includes the melting and melt focusing processes occurring in the deep mantle melting regime (~100 km depth); the accumulation and crystallization of melt in the sub-crustal mush zone (~6 km) and over-riding melt sill (~2 km); the vertical and lateral transport of magma from the melt sill through dikes; the eruption of magma on the surface; and the hydrothermal activity and biota associated with magmatism. While we currently have information on pieces of the system in disparate areas, the goal of linking these processes has remained elusive. The overall goal of this program is to use the overlapping spreading center (OSC) at 9 03'N on the East Pacific Rise (EPR; Fig. 3.a-1) as a natural laboratory to explore the linkages between geochemical, geological, and hydrothermal variations on the seafloor and the magma supply system at depth. The unprecedented seismic and tomographic results that already exist for this area present a detailed window into a highly variable melt supply and storage system that allows these connections to be made.

To address this over-riding goal, we undertook a 35-day cruise on the R/V Atlantis from March 24 to April 27, 2007 (Manzanillo, Mexico to San Diego, CA). The bulk of the ship time (22 science days) was devoted to studying the 9°03'N OSC. An additional five science days, funded under separate grants, was devoted to work at the site of the 2005-06 eruption at 9°50'N on the EPR as part of the Integrated Study Site effort of RIDGE2000. All work was funded by the RIDGE2000 program of the National Science Foundation (Ocean Science, Marine Geology and Geophysics).

The primary research tools used during the cruise were the DSL-120A side-scan sonar system and the ROV Jason II, both operated by the National Deep Submergence Facility (NDSF) at Woods Hole Oceanographic Institution (HMRG will take over operation of the DSL-120a system following the cruise). Although our proposal did not call for the use of the WHOI TowCam system [Fornari, 2003], the vehicle proved to be enormously valuable during Jason II downtime and for surveying long distances quickly. We also collected a small number of wax cores in areas we did not intend to visit with Jason II. The following summarizes our work:

Activities and data products from the 9°03N OSC on AT15-17

- DSL-120A
    - Collected close to full side-scan backscatter coverage of the overlapping spreading center region, representing 235 km^2.
    - Collected 50% bathymetry coverage from phase bathymetry and SM2000 from 500 m wide N-S oriented swaths spaced 1000 m apart.
    - Collected three-component magnetic data using two deep-towed flux-gate magnetometers mounted on the 120a side-scan towfish.
    - CTD mounted on the vehicle and 4 MAPRs mounted on the wire, throughout survey
- Jason II
    - Conducted four Jason II lowerings (J2-264, J2-265, J-266, J2-267) for a total of 234 hrs deployed (one lowering lasted a record-breaking 100 hours).
    - Approximately 7000 digital photographs and 213 hrs continuous video for each of the three video streams.
    - 282 individual rock samples recovered, described and archived.
    - 4 double majors hydrothermal vent waters sampled.
    - Vent biota - consisting of tubeworms, mussels, clams, limpets and a crab were processed and frozen at -70°C (and stored in ethanol for the limpets)
- TowCam
    - Seven TowCam lowerings, covering 29.3 km
    - Produced approximately 10,000 digital photographs.
    - Both vehicle-mounted CTD and four MAPRs for water column hydrothermal surveying.

    - Collected three-component magnetic and total field magnetic data using a vehicle-mounted deep-towed flux-gate magnetometer on 4 tows.
- Wax core
    - Collected nine wax cores (eight recovered glass).

Activities and data products from 9°50'N (ISS site)

- **DSL-120a**
    - Collected four tracklines over 85 km, obtaining full side-scan backscatter coverage over the interpreted boundaries of the 2005-06 eruption, and 90% bathymetric coverage with phase bathymetry from the side-scan along with multibeam from SM2000.
    - Collected three-component magnetic and total field magnetic data using a vehicle-mounted deep-towed mounted flux-gate
    - CTD mounted on the vehicle and 4 MAPRs mounted on the wire, throughout survey
- **Jason II**
    - Successfully freed and recovered two OBSs and one compliance meter that had been stuck since the 2005 eruption.
    - Collected 23 lava samples, described and archived.
    - Surveyed ~ 15 line-km using SM2000 near-bottom multibeam.

Section 3: 9°03'N Overlapping Spreading Center Site

Section 3.a.
Transponder Array at OSC

On this cruise we deployed a long-baseline acoustic transponder net comprising 6 transponders in order to permit both DSL-120a sidescan and Jason II operations to collect various kinds of data in the same navigational framework. Initially we deployed 4 transponders on 200 m tethers. These 4 were deployed along the east limb of the OSC, in order to provide optimal coverage along the ridge crest of the East Limb and through the OSC basin. The transponders proved useful for navigation on the West Limb as well during *JasonII* lowering 267, and several Tow-Cam lowerings. Transponder locations were surveyed with full-circle tracks around individual transponders with RMS errors of ~<1 m. As the details of *JasonII* lowerings were planned, another 2 transponders were dropped along the east limb to expand the baseline coverage of acoustic navigation. Overall, long-baseline navigation was excellent with *JasonII* all along the east limb, and was marginal across the overlap basin ~8 km away from the nearest baseline. While we had long-baseline navigation for the *DSL-120A* survey, jumps across the baselines and large numbers of bad fixes made using the transponder navigation impractical. The transponders were all released and recovered without incident.

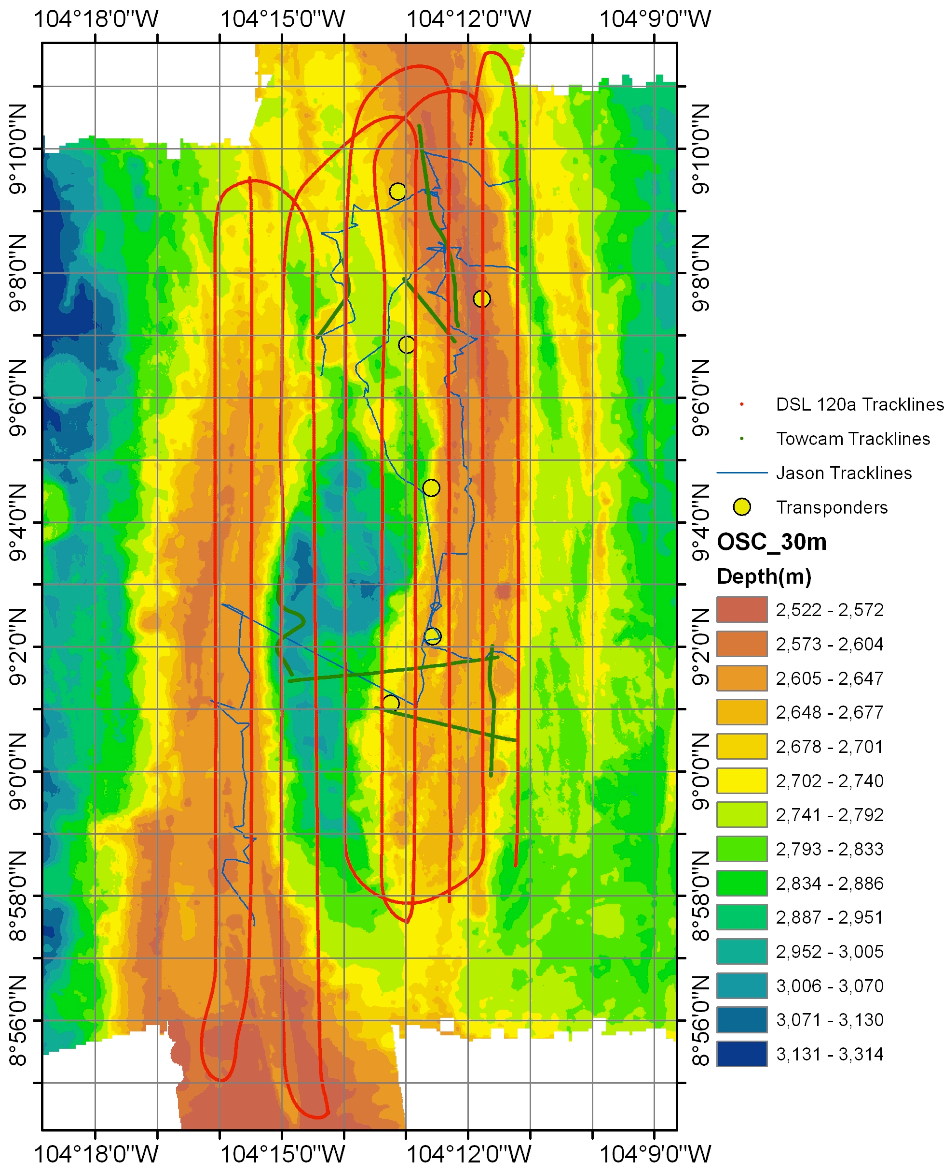


Figure 3.a-1. Locations of transponders at the OSC with the tracklines of all near-bottom vehicles deployed during the cruise.

Section 3.b.
DSL-120A Survey at OSC

The broadest scale data set collected was a *DSL-120A* side-scan sonar survey that covered an area of 20 x 10 km. The data were collected on 10 north-south oriented lines each ~20 km long that had slightly overlapping side-scan backscatter coverage and 400-500m gaps in bathymetric coverage between swaths. Hardware issues in the port transducer on the *120A* resulted in an asymmetric swath, narrower to port than starboard.

The DSL-120a system for this site was configured with the SM2000 multibeam system, 300 kHz doppler sonar, two fluxgate magnetometers, a CTD, and a series of MAPRs, in addition to the usual sensors providing side-scan and phase bathymetry. No problems emerged with any of these sensors, except that noise from the Doppler electronics introduced horizontal stripes to the side-scan image. The DSL fluxgate magnetometer was mounted on the starboard wing and run through the j-box into the telemetry system. A self-logging fluxgate, borrowed from WHOI Tow-Cam, was mounted on the port wing. MAPRs were put on the tow wire at 50, 125, and 200 m above the clump and hung 25 m below the clump.

We adjusted towing altitude to 115-120 m during the survey to maximize swath width. We found that towing higher than 120-125 m did not yield a wider usable swath. The SM2000 multibeam sonar was mounted on the towfish to improve the bathymetry quality, and complete the bathymetry through the nadir gap. Initial navigation for the survey was run under layback mode. The layback calculator uses ship speed, course, and wire out to calculate the position of the towfish in real time. The side-scan and bathymetry were mosaicked in real-time using the uncorrected layback positions by the HMRG and put on a display unit in the ship's main lab. Appendix **X** contains the sonar interpretations logged from the real-time mosaic. Long-baseline navigation was recorded, but was not found to be useful for the mosaicking process. Future cruises would benefit from being able to utilize the LBL data to place the side-scan data in a global reference frame. Resolving how to integrate LBL with layback navigation into the mosaic would improve the end product. Attempts to use of the 300 kHz Doppler during the DSL-120A operations resulted in electrical noise propagating through the side-scan return, and it was quickly decided to leave the Doppler turned off during the rest of the survey.

Operations commenced in the area with lowering 120a-51 on March 29, 2007 at 10:03Z. A magnetometer calibration spin was done from 10:50Z-12:15Z. This lowering obtained one line (~20 km) of data from 8°59'N to 9°10'N along 104°11.2'W (Figure 3.b-1), with an unusually large amount of pitching on the towfish before a fuse blew in the sub-box. Upon recovery, it was found that the MAPR hung below the clump weight had tangled with the tether. Fixing the sub-box problem involved diagnosing several other problems. Repairs to the towfish electronics took up most of March 30, 2007. Lowering 120a-52 began on March 30, 2007 at 23:00Z.

Lowering 120a-52 comprises the bulk of the sonar survey at the OSC site. We completed 9 lines over the course of this 4 day long lowering (Figure 3.b-1). Lines were spaced at 900m to optimize side-scan coverage. We covered 197 km of trackline, excluding turns. The ensonified area extends from 9°11'N to 8°56'S to match the ARAD 3d seismic latitude bounds, and over 104°05.5-11'W to cover the ridge axes on either limb plus the central overlap basin. The sonar lines are numbered in chronological order, with a pattern determined by the ship's ability to only make left turns while under tow from the port hydroboom. No persistent problems were seen with the vehicle attitude during this lowering. The average tow speed was 1.5 knots (2.78 kph) at 110-120 m altitude. This slightly increased the useful swath width for side-scan, although we found that the *useful* swath did not increase at altitudes higher than ~120 m.

Final side-scan mosaics with 2 m pixels were produced using edited layback navigation in time for *JasonII* lowerings. Initial bathymetry grids were produced shipboard. Processing to remove spurious soundings and intelligently merge the *120A* phase bathymetry and SM2000 multibeam will be completed on shore. We anticipate that a high-precision bathymetric map can be derived from the data.

The preliminary backscatter map permitted us to target *Jason II* study areas optimally, and develop detailed objectives for mapping and sampling prior to the lowering. The backscatter data were gridded at 2 m interval and plotted at 1:10,000 scale. Five main backscatter patterns were mapped visually and interpreted on the basis of past experience as follows: 1) Sinuous areas of low backscatter intensity = sheet flow lava channels, 2) Smooth to mottled areas of medium backscatter intensity = flat lava flows of lobate or pillow, 3) Hummocky areas with high backscatter intensity = pillow lava, 4) Smooth to mottled areas of very low backscatter intensity = sediment ponds, and 5) Linear patterns of alternating high backscatter intensity and shadows = fissures/scarps. Subsequent visual observations confirmed and refined these interpretations. Navigational offsets between the *DSL-120A* mosaic and *JasonII* locations were <30 m where distinctive landmarks could be identified by both systems.

Overall the side-scan survey revealed an OSC basin filled with large, constructional mounds that is bounded to either side by rifted and tectonically dissected ridge axes. Hummocky volcanic terrain was mapped nearly continuously through the OSC nodal basin. The backscatter pattern suggests two large sediment ponds in the basin. The slope up to the ridge axes bounding either side of the basin were also revealed as volcanic constructional slopes, devoid of scarps or fissures. The West and East limbs are broadly similar, consisting of tectonically dissected terrain. Undissected hummocky (pillow) ridges characterize the ridge axis farther away from the ridge tips on either axis. No distinct areas of particularly high backscatter intensity that might suggest younger flows were seen in the side-scan mosaic. Differences between the east and west ridge include the degree of tectonism (higher on the west), and presence of extensive volcanic collapse troughs (only on the east). It may be possible to define a "ridge tip" province from a more typical spreading ridge on the basis of morphology along the east limb. We tentatively map this transition near 9°03'N where the axial summit graben disappears or becomes a zone of large fissures without a readily definable ridge axis. A similar transition is not apparent on the west limb, where fissure density remains fairly high throughout. More sophisticated interpretation of the side-scan, and incorporation of the bathymetry data from the *120A*, will take place on shore.

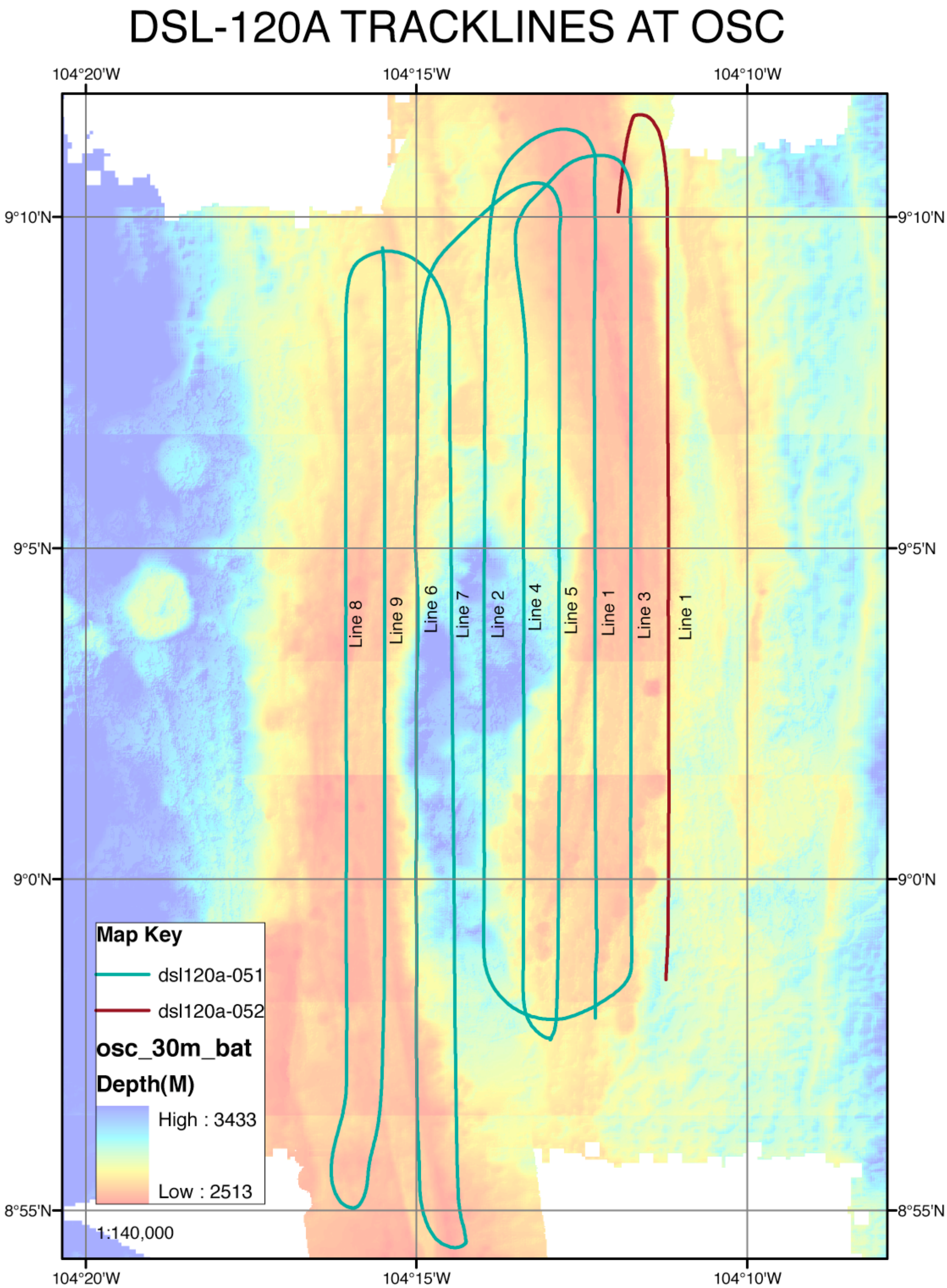


Fig. 3.b-1. DSL-120a track lines.

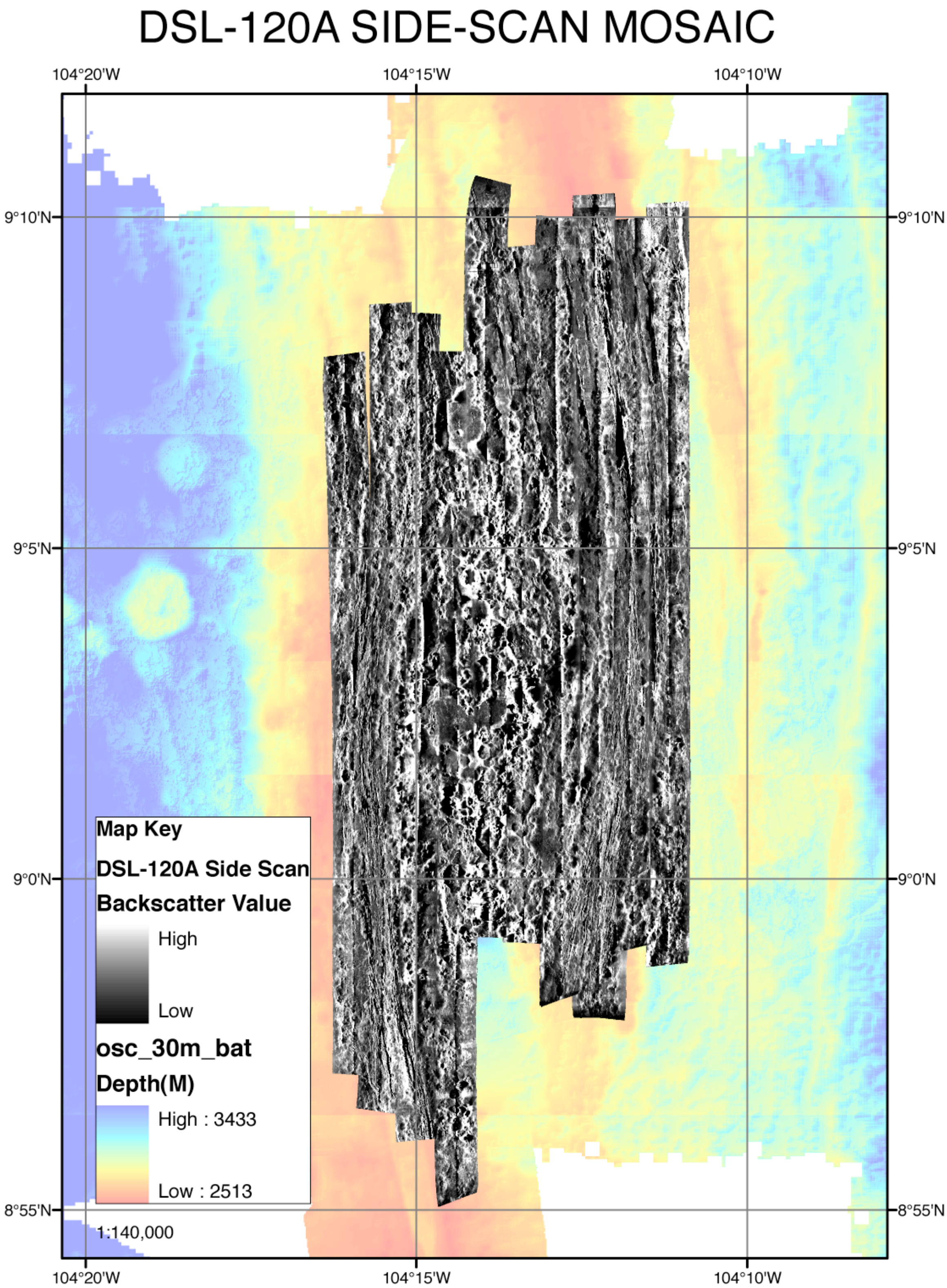


Fig. 3.b-2. DSL-120a side scan mosaic**.**

Section 3.c.
ROV Jason II Operations at OSC

Four Jason II lowerings were conducted in the area of the OSC (J2-264, J2-265, J-266, J2-267) for a total of 234 hrs deployed (one lowering lasted a record-breaking 100 hours). Approximately 7000 images of the ocean floor were collected using a 3.3 megapixel digital still camera and 300 watt/sec strobes pointed forward, triggered either automatically at pre-set intervals or manually when desired. Three video streams (so called, pilot's camera; lightbar; and 3-chip) were continuously recorded for a total of 213 hrs. In addition, a high resolution digital video recorder ("DVCam") could be turned on to record intervals of the 3-chip video stream. 282 individual rock samples were recovered (see Appendix); 4 double majors samplers were used to sample vent waters (see Section 3h); and various biota were collected (see Section 3i).

During Jason lowerings, four watch standers were typically on duty. The "watch leader "directed overall operations, kept track of where samples were collected and stowed, and wrote a brief watch summary of operations on each watch (See Appendix). A second watch stander was assigned to the role of "event logger, " who manned the Virtual Van. In addition to recording specific activities, such as course changes, samples collected, etc., the event logger recorded at regular intervals (approximately every 5 minutes) descriptive characteristics of the ocean floor according to a pre-set category menu that will be used to inform the Geographic Information System (GIS) analysis of the data (See Appendix for categories). In addition, during our cruise, we beta tested some of the categories proposed for RIDGE2000 data archiving. A third watch stander served as "mapper", plotting our position on a mylar map overlay. The fourth watch stander served as "data logger," changing and labeling DVDs where video data were recorded.

The following is a summary of operations during each of the four Jason II lowerings in the OSC area.

Lowering Id	Start/Launch	Start Data	End Data	End/On Deck
J2-264	2007/04/05 20:31:53	2007/04/05 22:11:40	2007/04/06 13:33:00	2007/04/06 18:29:00
J2-265	2007/04/07 01:40:00	2007/04/07 04:07:00	2007/04/11 04:19:00	2007/04/11 06:12:00
J2-266	2007/04/11 18:37:00	2007/04/11 22:52:00	2011/04/14 22:10:00	2011/04/15 00:34:00
J2-267	2007/04/15 03:19:00	2007/04/15 04:47:00	2007/04/17 10:51:00	2007/04/17 12:42:00

Lowering	Event Log # in Virtual Van; start (approx)	Event Log # in Virtual Van; end (approx)
J2-264	1440	4153
J2-265	4253	18746
J2-266	18787	25852
J2-267	25960	33419

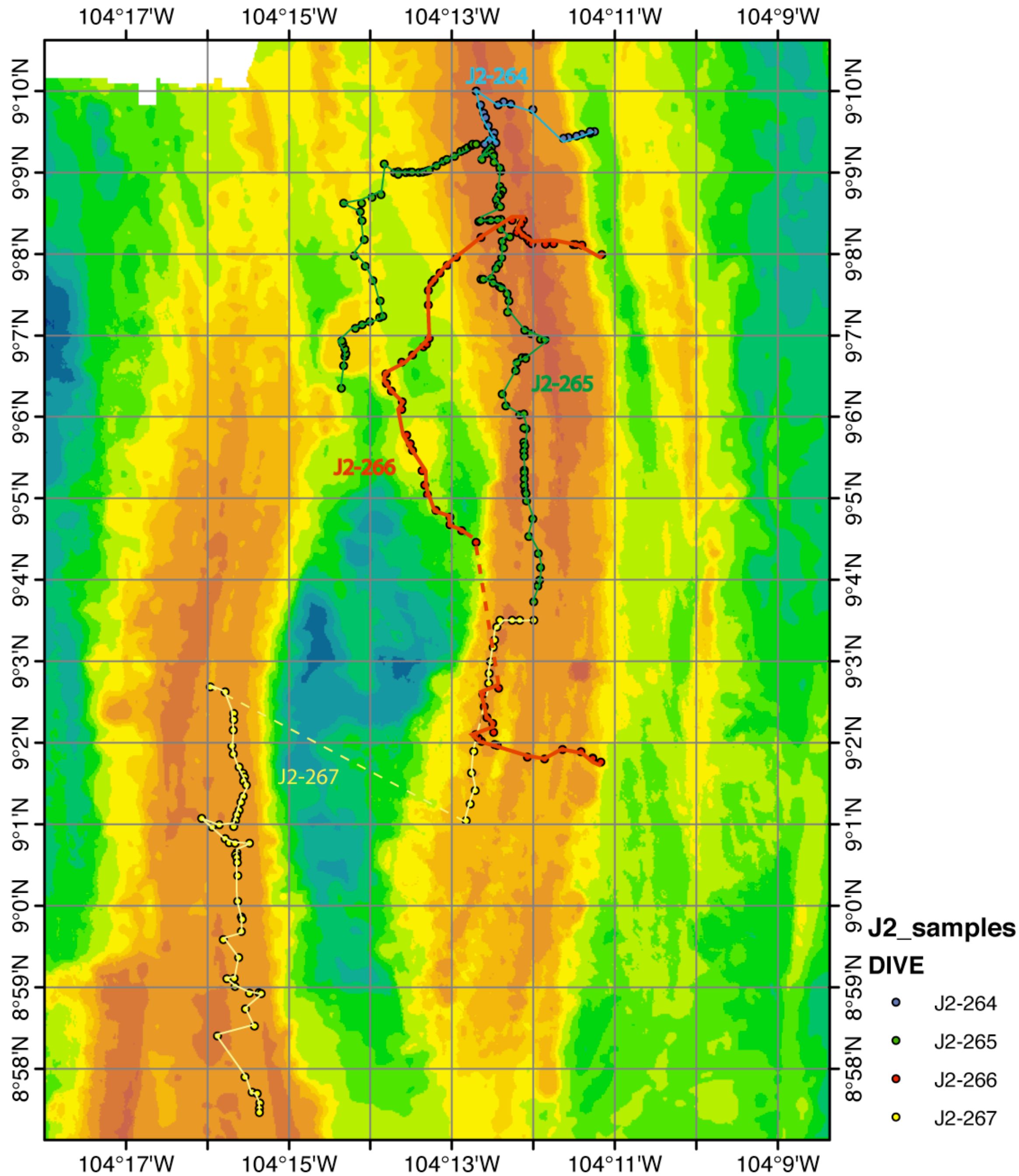


Fig. 3.c-1. Jason II tracks and sampling sites (four lowerings).

Dive Synopses

Dive J2-264

The goals of this dive were to characterize the geochemical variability of lavas erupted across axis above the robust part of the melt lens, to identify the location of the neovolcanic zone, most recent lavas, and to obtain samples both spatially across the ridge and from distinct morphologic features identified in the side-scan imagery. Many features sampled during this traverse continue south along the rift and can be compared to lavas collected and features observed along the second across-axis traverse 2-2.5 km to the south (J2-266). One sample collected from a dome west of the axial graben may be andesitic. If so, it is the northern most andesite sampled.

This traverse began east of the East Limb and moved westward, sampling a heavily sedimented cluster of cones off-axis. The traverse then crossed over a series of large faults composed of pillows and hackly flows draped in sediment. No young lavas were observed in this region. At the edge of the axial graben large domes composed of pillows were sampled and can be compared to similar features south along the ridge. Inside the axial graben, the pillow lavas and sheet flows contained more glass and were covered by little to no sediment.

Dive J2-265

The goal of dive 265 was to provide a detailed investigation of volcanism over the robust portion of the melt lens, both on-axis and off-axis to the west of the East Limb. It began on the western margin of the melt lens and followed a ridge of domes to the north. Samples collected along this traverse were generally sediment-covered pillows but several areas appeared to have relatively young lavas. The dive then turned east to explore volcanism across the melt lens. The seafloor in this area was highly tectonized and samples were collected from sedimented pillow lavas. No or few young lavas were observed until reaching theelevated East Limb. Traversing south along the crest of the East Limb revealed young glassy lobates, sheet flows, collapse features, pillow lavas and hydrothermal venting. Samples collected on axis ranged from basalts to andesites with varying phenocryst populations. This traverse provides a data set that will help answer questions regarding the volcanism over the anomalously large melt lens, off axis volcanism, and chemical variability both across and along axis.

Dive J2-266

This dive included an across-axis transect to the west of the southern portion of the East Limb, a northwest traverse of an elevated ridge through the nodal basin that marks the outer edge of the melt zone, and then an easterly traverse to complete a second across-axis transect across the East Limb. The southern transect was made to help answer several questions about the amount of volcanic activity in the meltstarved portion of the East Limb. It will help determine the nature of volcanism to the south of the robust melt lens and to determine how the geochemistry of the lavas may change along-axis. Although some of the lavas sampled during this traverse appeared to be relatively young, none appear as young as the lavas sampled within the axial graben to the north along the

East limb. Sedimented pillows were the dominant morphology in the region. During the northward traverse along the bathymetric high, several domes were sampled to determine the geochemical relationship between lavas erupted near the outer melt lens. Observations revealed sedimented pillows and faults throughout the outer melt zone region. A second transect across the East Limb was carried out to help characterize the geochemical variability of lavas erupted across axis beneath the robust part of the melt lens. Those samples will provide a basis for comparison (both geochemically and morphologically) to the northern and southern across-axis traverses and will permit a more detailed understanding of changes occurring across axis.

Dive J2-267

This dive began with a short cross-axial traverse of the East Limb, then a a southerly traverse along the neovolcanic zone on the East Limb, and a transit west across the OSC basin. The latter portion of the dive was a southward along-axis traverse of the west limb. The southern part of the east Limb was dominated by pillow lavas draped in sediment. No recent volcanism was observed. The west axis traverse provides data for comparison between the propagating east limb and the dying west limb. Samples collected from the west limb can be compared to those collected from the east limb to provide insight into questions about magma source, fractionation, and the relative age of volcanism. The western axis was dominated by lobate flows and pillow lavas. Sediment cover varied along axis, but was generally less south of 9°00’N. Meter- wide fissures were observed within portions along the western limb.

Figures 3.c.2-5 below: Tracklines and framegrab photographs for Jason II lowerings J2-264 through J2-267. Positions shown are from unedited navigation

J2-264

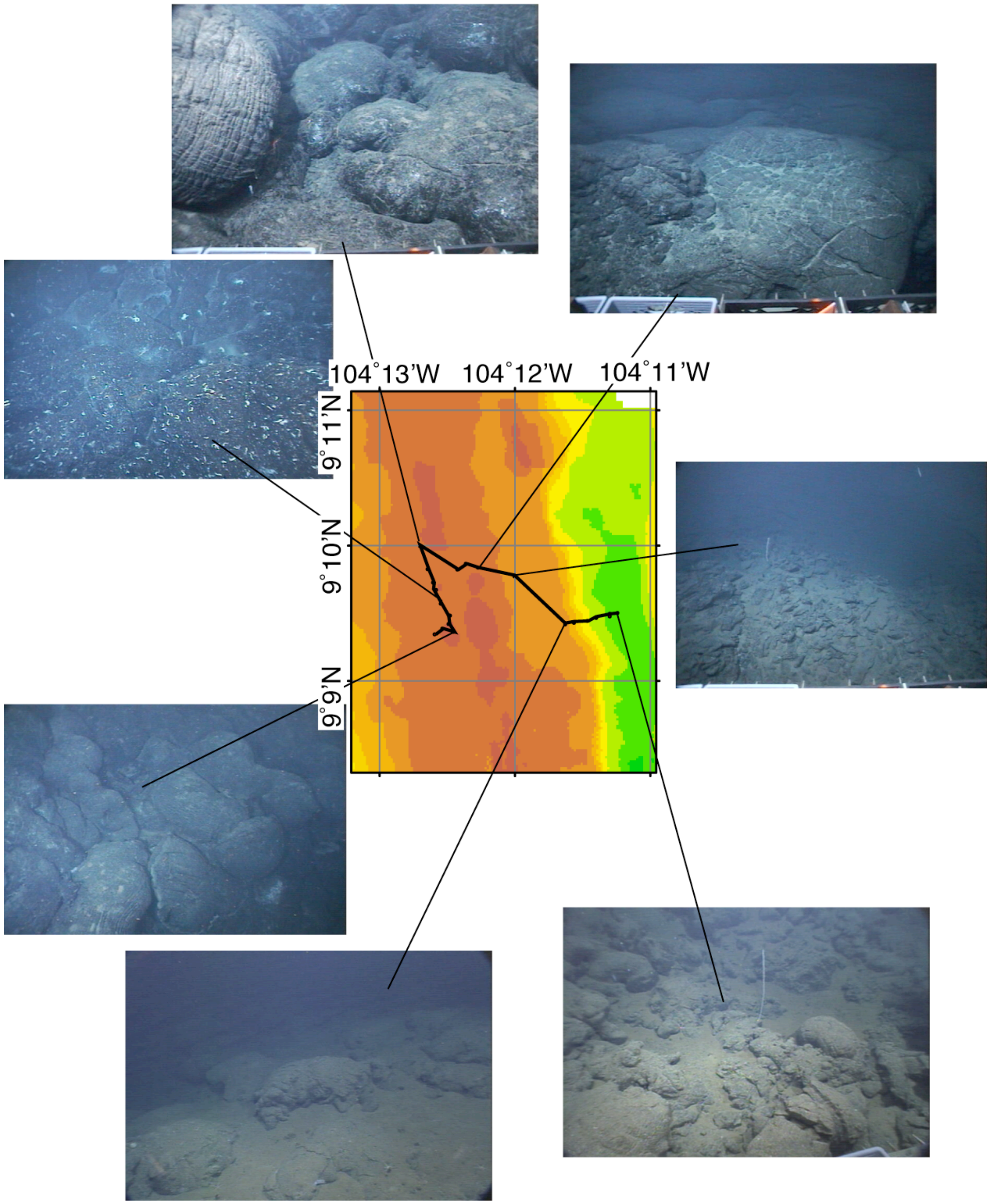


Figure 3.c-2.

J2-265

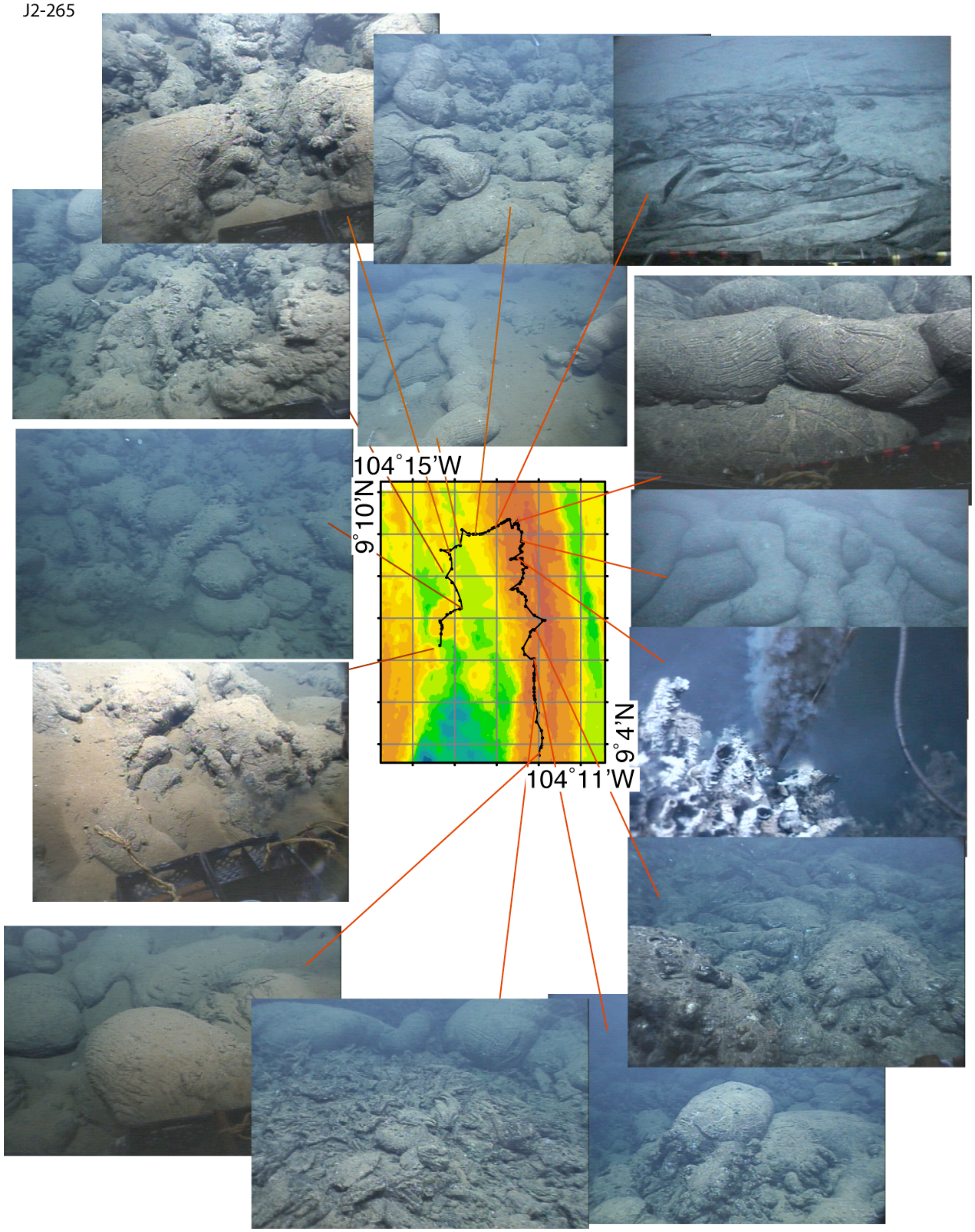


Figure 3.c-3.

J2-266

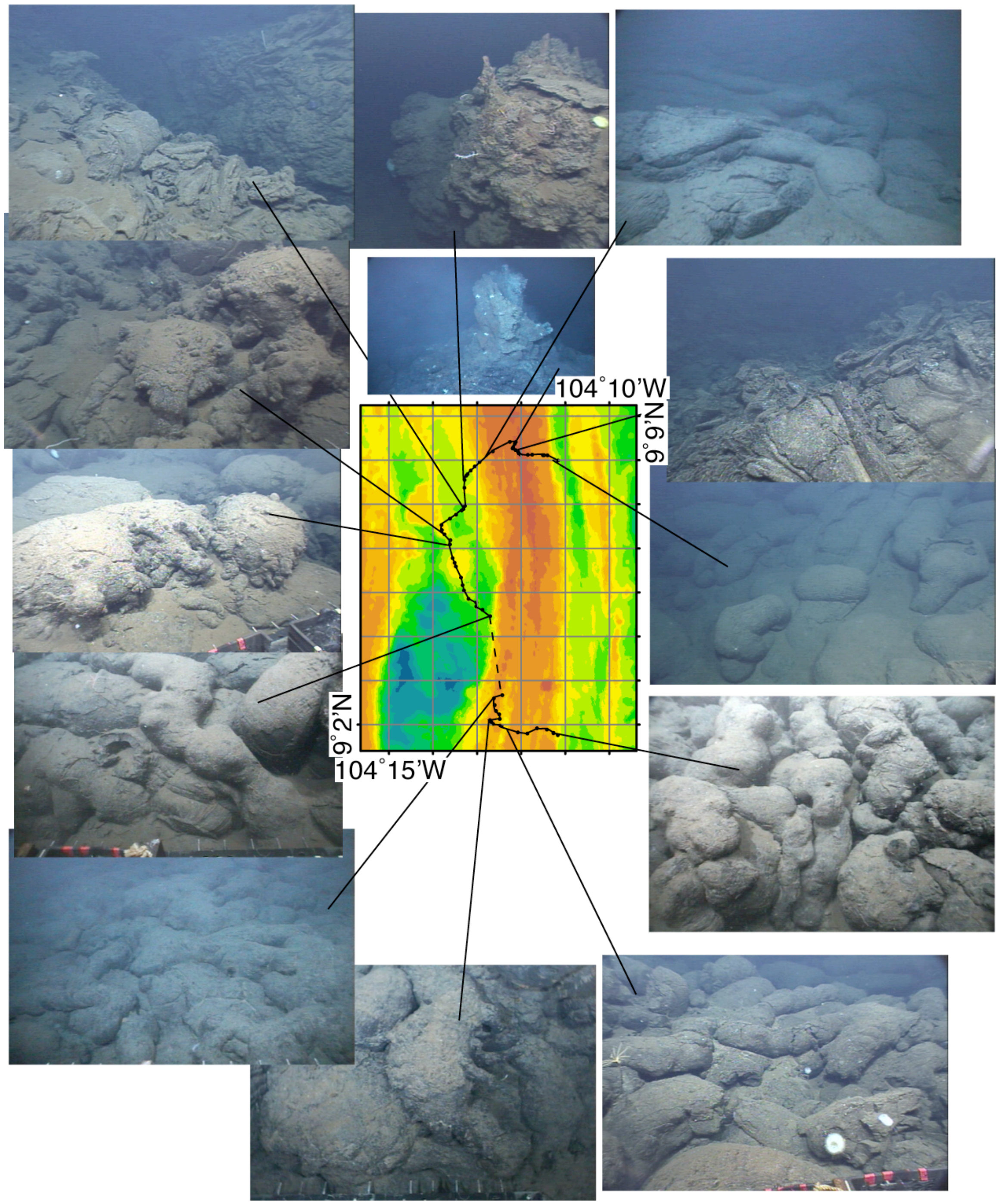


Figure 3.c-4.

J2-267

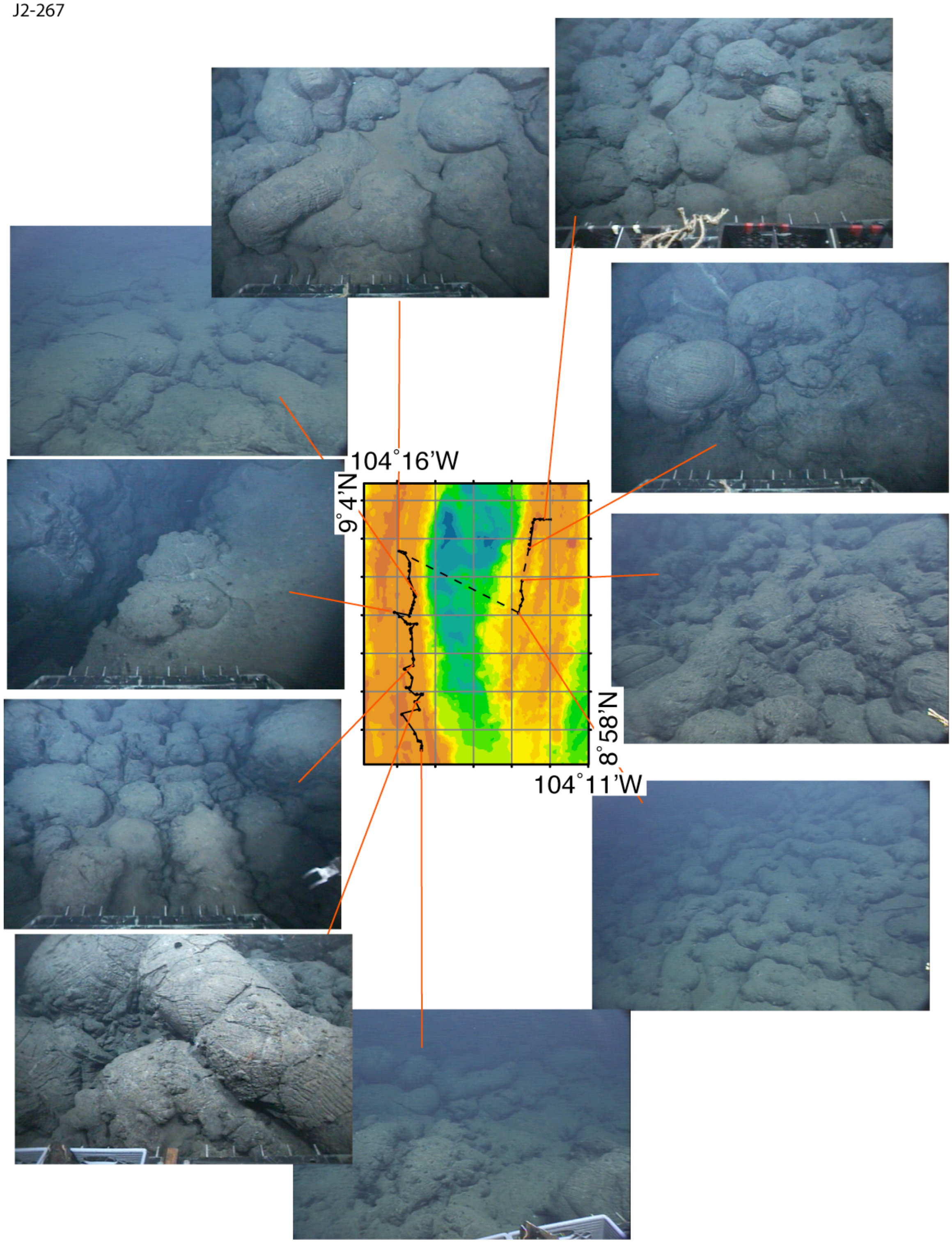


Figure 3.c-5.

Section 3.d.
TowCam Operations and Camera Tow Synopses

Operational Summary

The WHOI – MISO (Multidisciplinary Instrumentation in Support of Oceanography) Facility TowCam [Fornari, 2003] was used for 7 lowerings during the AT15-17 cruise. The system was configured to collect digital photographic and CTD data only, as a problem with the electronics in the winch junction box prevented implementing the wax-ball samplers. Camera s/n6006 was used for all lowerings with a delay time of 90-100 minutes and photo interval that varied between 10-15 sec. Towing speed was usually _ kt for most lowerings. A relay transponder (14.0 kHz receive / 9.0 transmit) was placed 100-200 m above the camera system to collect long baseline (LBL) navigation data during the tow. In addition, four MAPRs were placed at 4 set distances above the TowCam to record water properties data during each tow to help locate hydrothermal plumes (see MAPR section). For tows where the magnetometer was on the TowCam, we did a partial turn at the end of the lowering when the system was at ~1200 m depth by turning the ship ~ 90-180° so that the system turned through part of a full circle to provide calibration data used to process the magnetics. One important operational issue related to the CTD winch system is that the tensiometer was not operational for any of the tows. The sensor was broken and there were not spares on board. All attempts to repair it were unsuccessful. In the future, a spare tensiometer sensor for the hydrographic winches should be onboard at all times.

The TowCam system was used to ground truth the DSL-120A sidescan sonar imagery in areas with distinct acoustic textures to augment observational coverage provided by the *JasonII* ROV system as well as help plan ROV dives to optimize logistics and areas to be observed and sampled by *JasonII*. Approximately 10,000 3.3 megapixel digital color photographs of the seafloor were collected. In addition to the processed, date/time stamped images, files were made of CTD data and processed navigation data that was based on both long baseline (LBL) as well as layback information calculated using the camera depth and wire out. Near-bottom magnetic data were collected using the WHOI self-recording 3-axis fluxgate magnetometer on 4 of the tows that went across the EPR axis. HTML webgalleries and QT movies were also produced from the imagery and made available via the shipboard network within a few hours of the end of each lowering for use by the science party for dive planning.

Camera Tow Synopses

TowCam #1 30 March, 2007 (14:57Z – 21:14Z) 15 sec rep rate
[Relay xponder at 50 m, no Maggie, 4 MAPRs at 75m, 150m, 225m, 300 m]

The first tow investigated a large constructional dome and elongate ~ N-S ridges in the western portion of the northern OSC basin that overlie the western margin of the melt lens. The tow traversed the SW portion of the dome and continued up the southern end of one of the ridges during the ~4 hr on-bottom tow. Abundant evidence of relatively recent constructional volcanism was observed on the dome and the constructional ridge, including folded sheet flows on the flat-topped dome summit and constructional pillow lava escarpments on the ridge.

TowCam #2 4 April, 2007 (04:14Z – 13:42Z) 15 sec rep rate
[Relay xponder at 50 m, Maggie on, 4 MAPRs at 75m, 150m, 225m, 300 m]

Tow#2 was a E-W line that crossed the eastern EPR OSC limb at ~ 9° 1.5'N to investigate the across-axis distribution of volcanism along this portion of the ridge axis. The tow provides a detailed across axis profile of the axial terrain from the east flank of the limb into the eastern portion of the OSC basin.

TowCam #3 5 April, 2007 (04:23Z – 14:00Z) 15 sec rep rate
[Relay xponder at 100 m, Maggie on, 4 MAPRs at 75m, 150m, 225m, 300 m]
Tow#3 provided an along axis tow within the axial graben of the eastern EPR OSC limb between ~9° 7-10'N to help define the nature of the axial pillow mounds and walls of the graben. Part of the tow was planned to investigate a narrow linear fissure on top of one of the mounds near 9° 8'N for possible hydrothermal activity. Several images of small tubeworms were seen at that location within fissures. Overall the imagery from this survey suggests that volcanic terrain along this tow is very young.

TowCam #4 6-7 April, 2007 (18:34Z – 01:00Z) 10 sec rep rate
[Relay xponder at 100 m, Maggie on, 4 MAPRs at 75m, 150m, 225m, 300 m]
Tow#4 covered a SE to NW oriented track covering terrain along the west flank of the eastern OSC limb to characterize features in the DSL-120a sidescan data.

TowCam #5 11 April, 2007 (07:05Z – 14:30Z) 10 sec rep rate
[Relay xponder at 100 m, no Maggie, no MAPRs]
Tow#5 was a S to N traverse located ~1 km east of the EPR axis on the eastern OSC limb between ~ 9° 0-2'N to investigate features at the terminus of the eastern limb and relative ages of volcanic terrain compared to further north on the eastern limb and within the axial graben.

TowCam #6 14April, 2007 (01:14Z – 09:30Z) 10 sec rep rate
[Relay xponder at 50 m, Maggie on, 4 MAPRs at 75m, 150m, 225m, 300 m]
Tow#6 was a E to W crossing of the southern tip of the eastern OSC limb along ~9° 0.5'N between 104° 11-13'W to determine the E-W extent of younger volcanism and relationship to the underlying melt lens. This area overlies a zone where the melt lens tapers out. The youngest volcanics, largely pillow mounds and escarpments and some possible eruptive fissures are found in the western portion of the flow, suggesting that the inside ridge tip is the site of younger volcanism.

TowCam #7 14April , 2007 (14:28Z – 22:30Z) 15 sec rep rate
[Relay xponder at 50 m, no Maggie, 4 MAPRs at 75m, 150m, 225m, 300 m]
Tow#7 was dedicated to investigating sonar targets and areas where there MAPRs plume signals were observed during DSL-120a sidescan tows on the west flank of the deep overlap basin. Unfortunately, no hydrothermal signals were seen in the CTD data during the survey and no hydrothermal vents or indicators were observed in the images. The terrain consisted of heavily sedimented pillow and occasional lobate flows.

Approximate distances covered by TowCam are as follows:

TowCam1: 2.66 km
TowCam2: 6.20 km
TowCam3: 6.13 km
TowCam4: 2.36 km
TowCam5: 3.87 km
TowCam6: 4.25km
TowCam7: 3.84 km

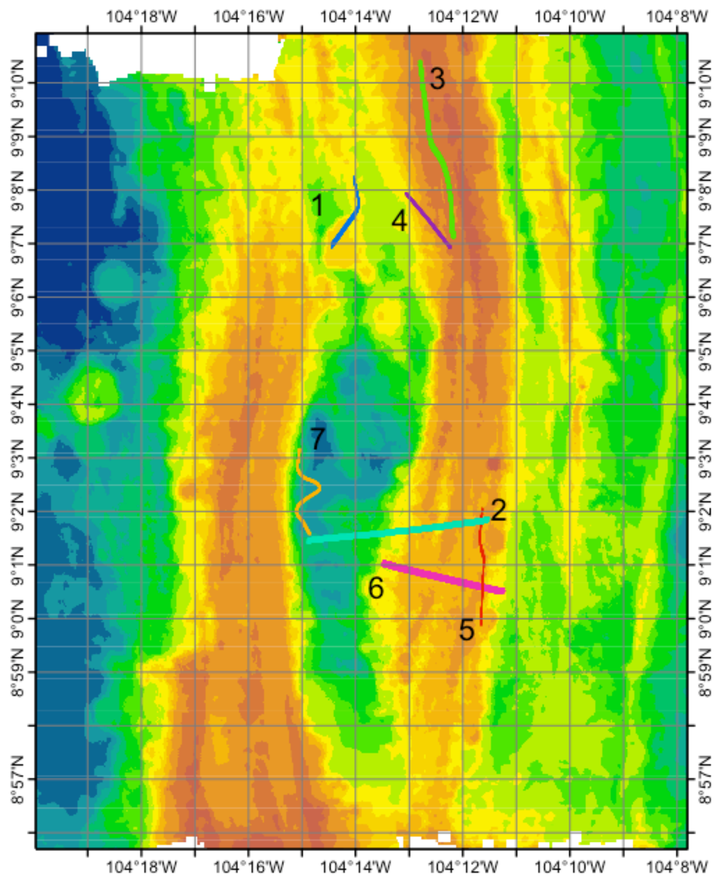


Figure 3.d-1 (above). AT15-17 TowCam tracks labeled with lowering numbers.

Figures 3.d-2 through 3.d-8 (below). Selected photographs from TowCam lowerings 1-7.

TowCam 1

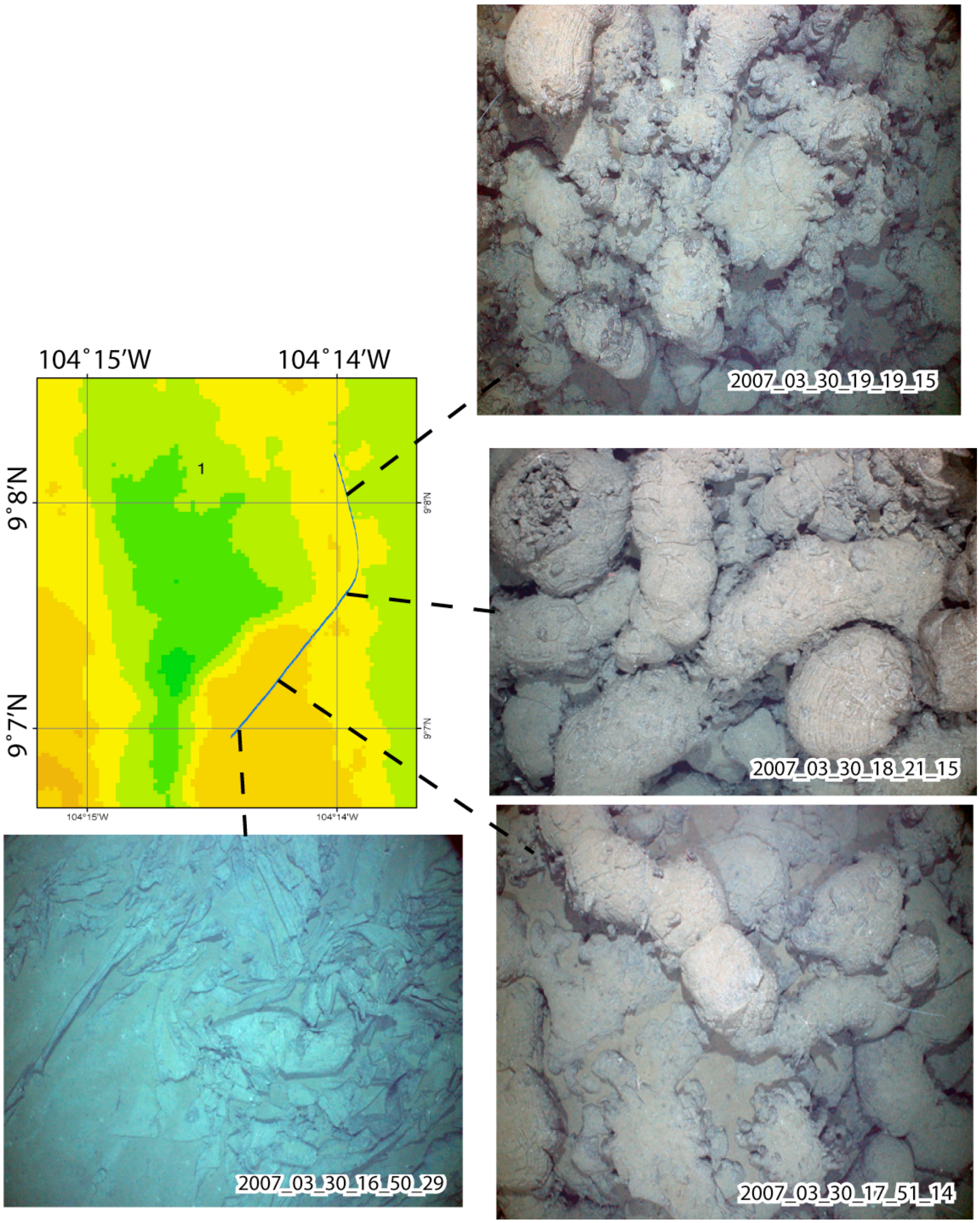


Fig. 3.d-2.

TowCam2

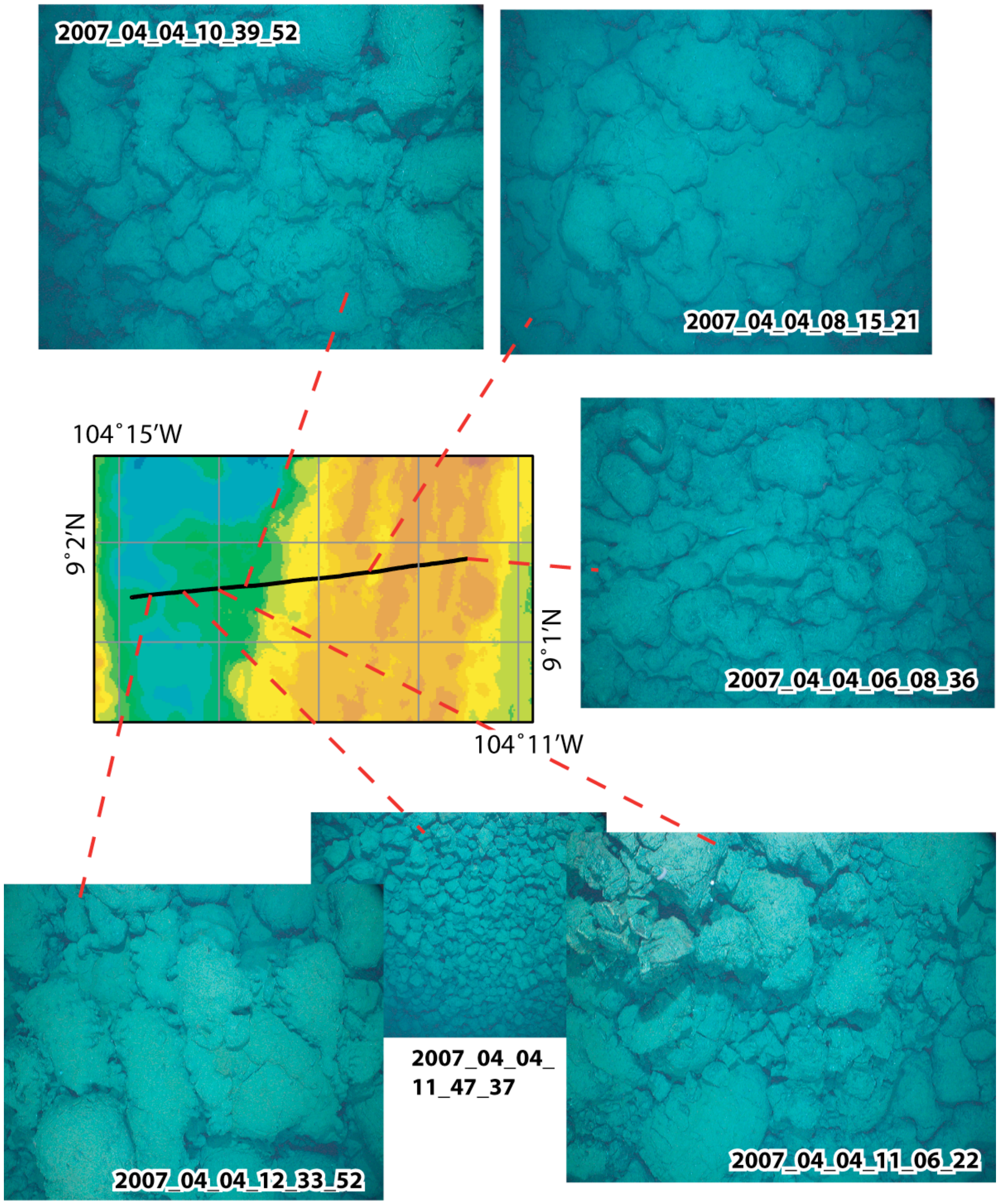


Fig. 3.d-3.

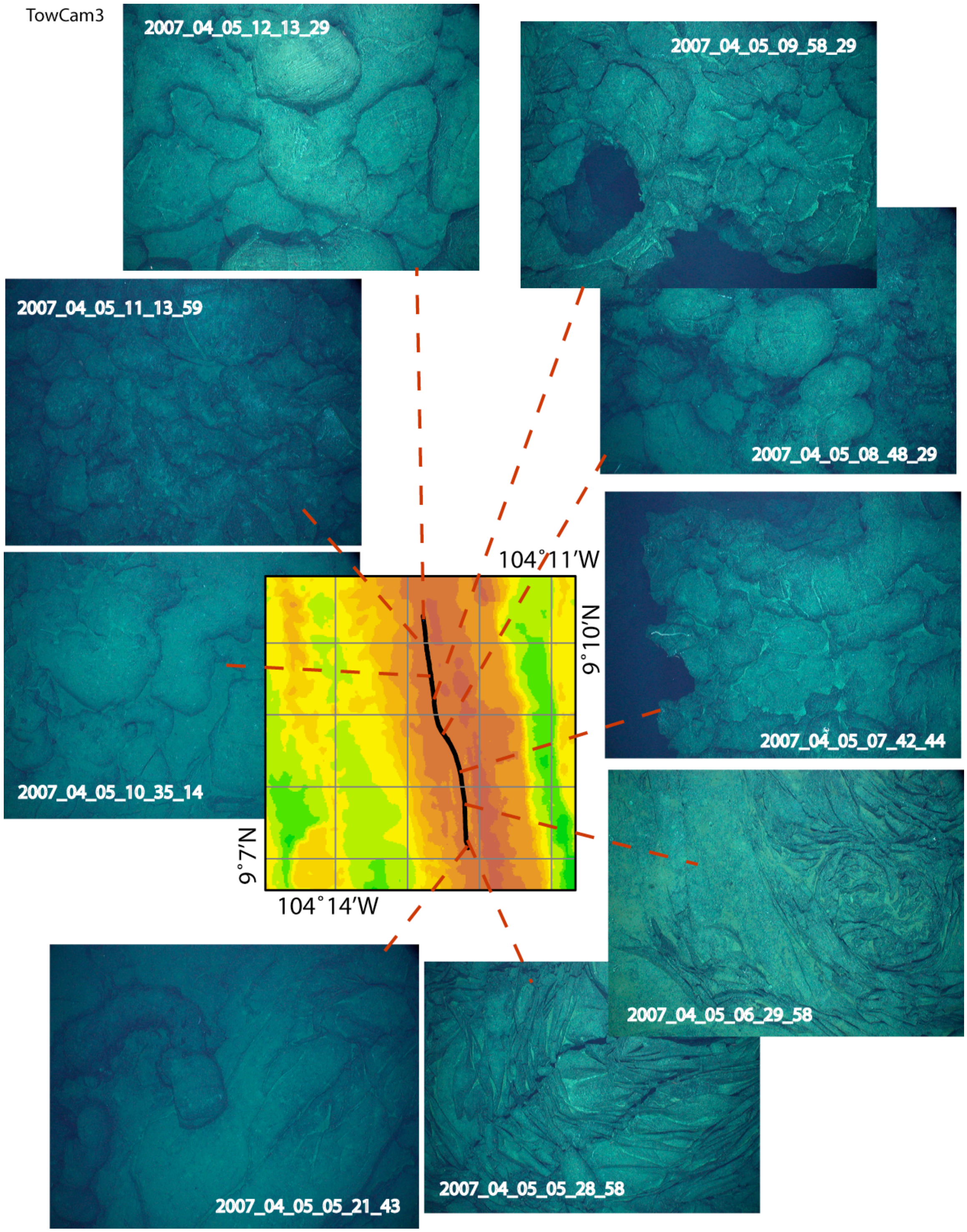

TowCam3
2007_04_05_12_13_29
2007_04_05_09_58_29
2007_04_05_11_13_59
2007_04_05_08_48_29
104°11'W
9°10'N
2007_04_05_07_42_44
2007_04_05_10_35_14
9°7'N
104°14'W
2007_04_05_06_29_58
2007_04_05_05_21_43
2007_04_05_05_28_58

Fig. 3.d-4.

TowCam 4

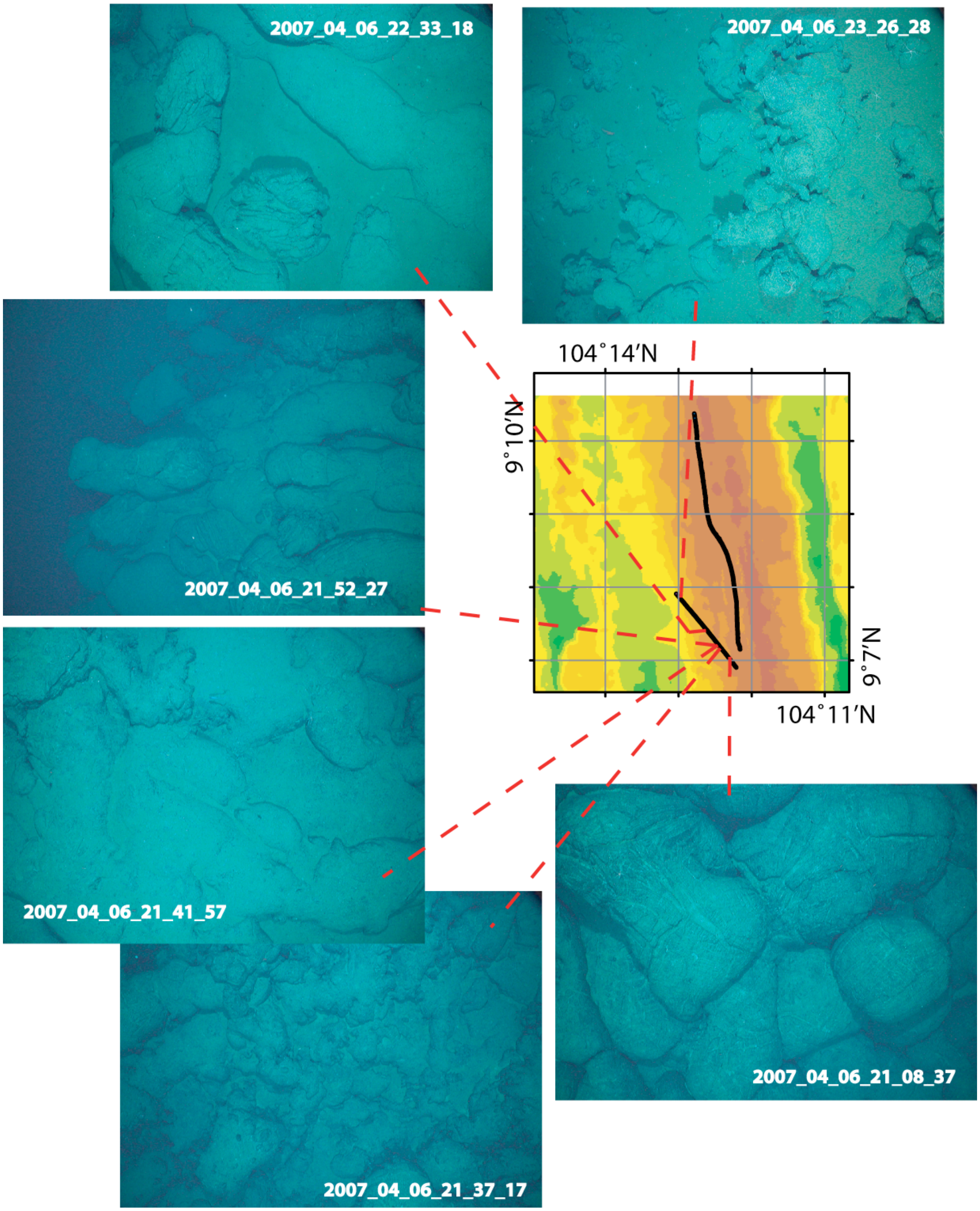


Fig. 3.d-5.

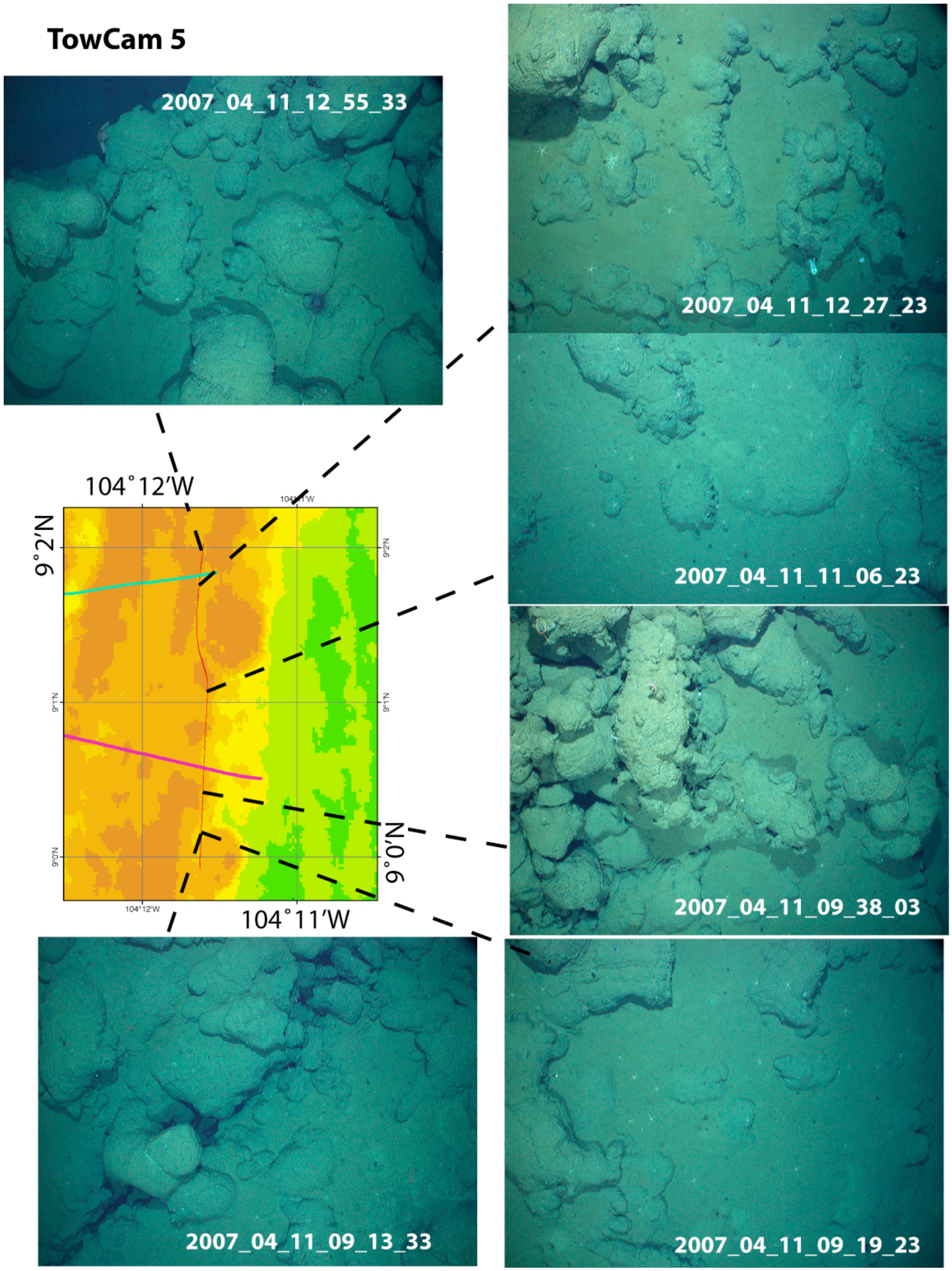

TowCam 5
2007_04_11_12_55_33
2007_04_11_12_27_23
2007_04_11_11_06_23
2007_04_11_09_38_03
2007_04_11_09_13_33
2007_04_11_09_19_23
104°12′W
104°11′W
9°2′N
9°0′N

Fig. 3.d-6.

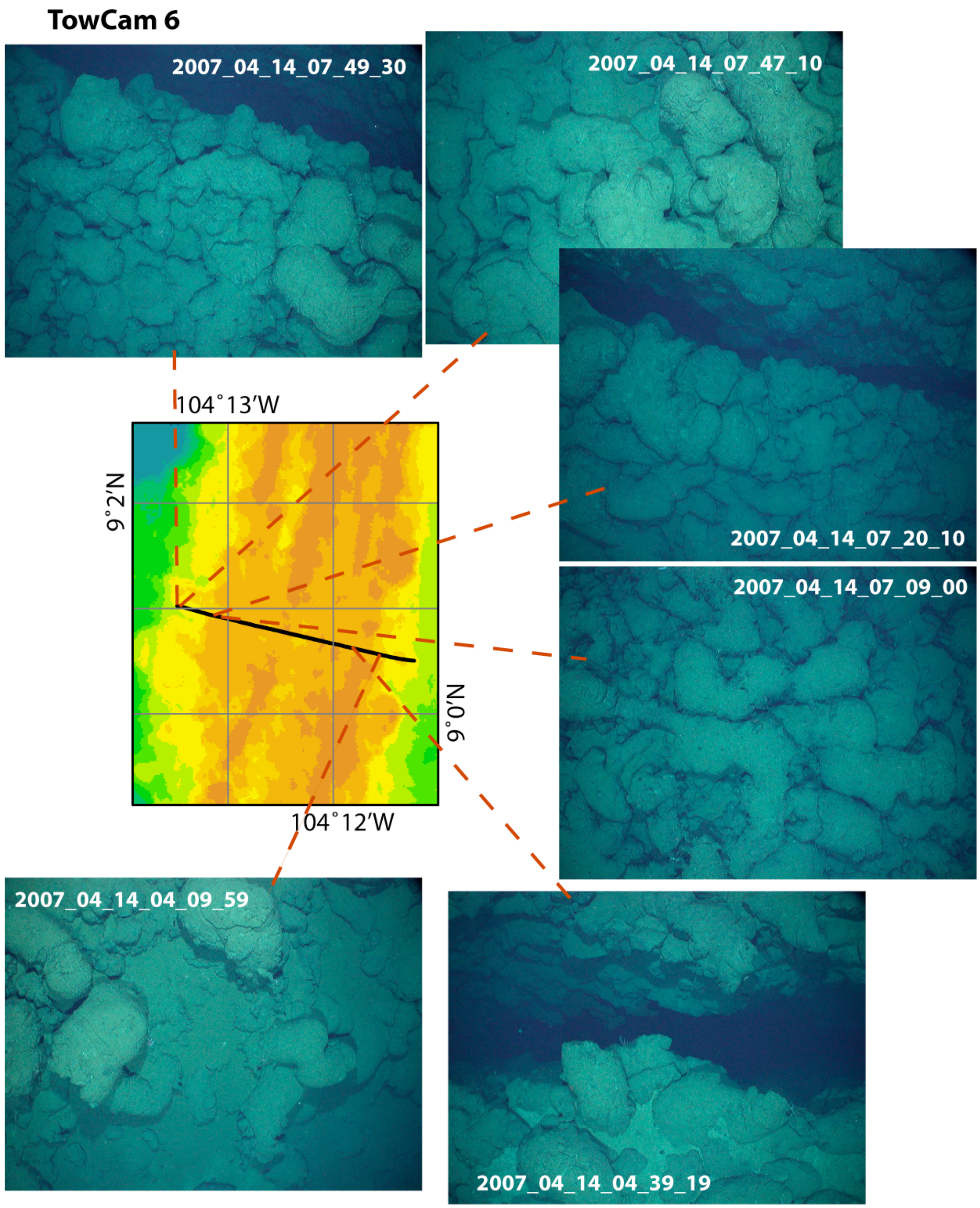

TowCam 6
2007_04_14_07_49_30
2007_04_14_07_47_10
2007_04_14_07_20_10
2007_04_14_07_09_00
104˚13'W
9˚2'N
9˚0'N
104˚12'W
2007_04_14_04_09_59
2007_04_14_04_39_19

Fig. 3.d-7.

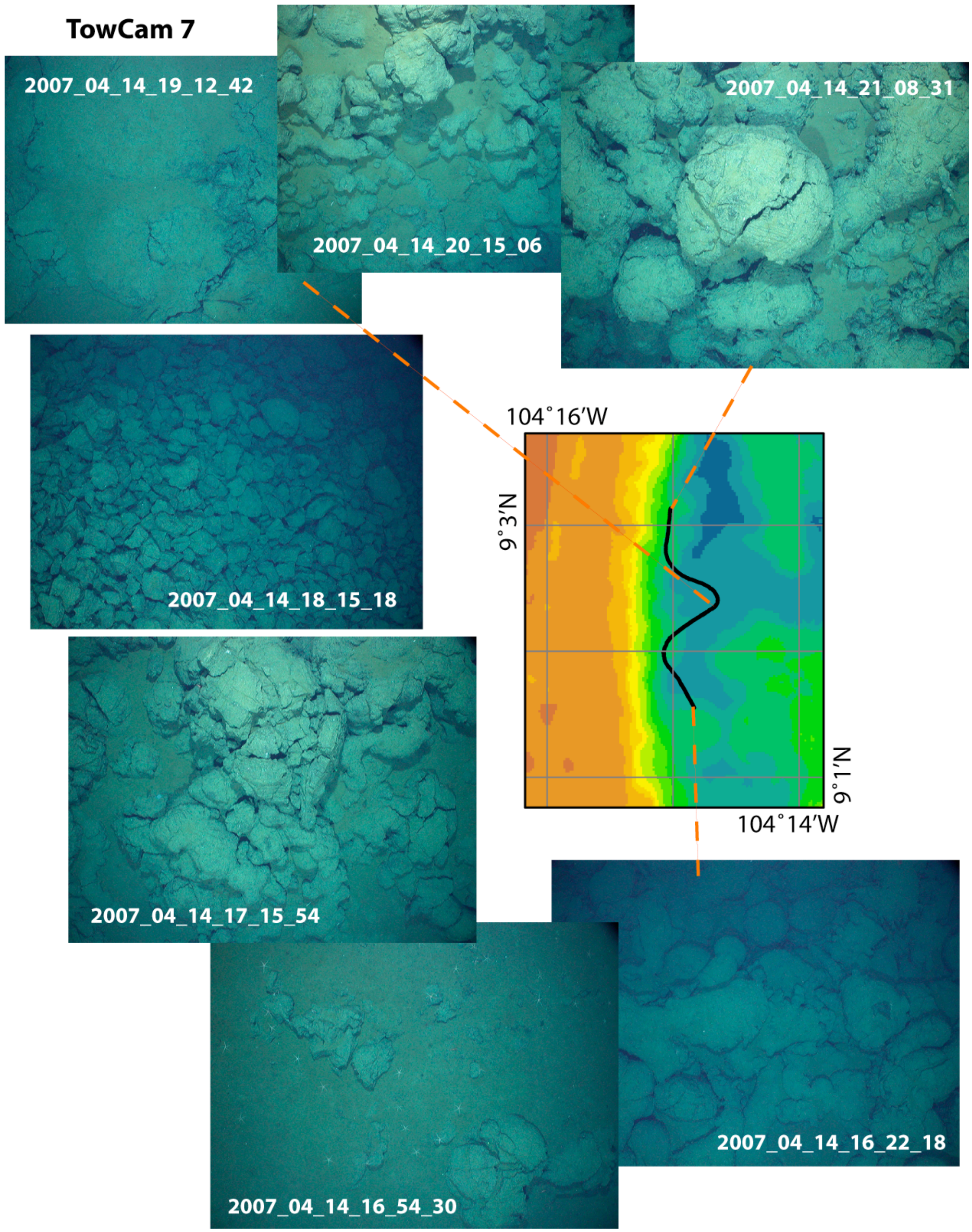

TowCam 7
2007_04_14_19_12_42
2007_04_14_20_15_06
2007_04_14_21_08_31
2007_04_14_18_15_18
104°16'W
9°3'N
9°1'N
104°14'W
2007_04_14_17_15_54
2007_04_14_16_22_18
2007_04_14_16_54_30

Fig. 3.d-8.

Section 3.e.
Hydrothermal Surveying

Summary of MAPR and CTD data

The water column at the OSC was mapped during the DSL-120A sidescan survey using both a CTD (conductivity - temperature - depth) recorder and MAPRs (Miniature Autonomous Plume Recorders) from the VENTS Program of the NOAA Pacific Marine Environmental Laboratory. MAPRs record data internally from temperature (°C), pressure, and nephelometer (LBSS) sensors. These data may be accessed after recovery through the MAPR terminal program and an Excel macro which converts the binary data file into a spreadsheet. This macro also converts the pressure measurements into depth and the LBSS voltage measurements into nephelometric turbidity units (NTUs). The CTD data was recorded but was of limited use as the lateral motion of the DSL-120A towfish did not allow the CTD detector to flush properly.

MAPRs were set at 75 m intervals along the wire in order to record data at approximately 75, 150, 225, and 300 m above the ocean floor. Background values for each MAPR were calculated by averaging the values for temperature and NTUs at depths of 1800-1850 m (the area above the plume but below the thermocline). These background values were then subtracted from the total temperature and NTUs for each MAPR.

Data from each MAPR were organized according to the corresponding DSL sidescan lines, and contoured using SigmaPlot's Transform 3D data function, using a Running Average contouring method and a sampling proportion of 0.1. Data were also contoured according to 100 m depth intervals for depths >2400 m, using the same contouring method described above. Temperature data did not show any significant anomalies, but light attenuation data showed definite areas of increased turbidity in the water column. Figures 3.e-1 to -6 show the 100 m depth intervals and their associated light attenuation anomalies, which correspond to hydrothermal plumes in the water column. Most of the intense plumes (>20,000 counts in excess of the background) are associated with DSL-120A lines 5 and 6, located adjacent to the east and west limbs of the OSC, respectively. It is likely that the newly discovered hydrothermal vent- Medusa -is the source of the nearest plume at 9°8.0'N and 104°11.5'W in Figures 3.e-2 and -3 (2400-2500 m depth and 2500-2600 m depth, respectively), but as only one vent was found, it is possible that the plume may have originated elsewhere. A TowCam photographic and CTD survey of the basin-facing slope of the western limb between 9°1.5'N-9°3.5'N and 104°14.9'W, where significant light attenuation anomalies were recorded (Fig. 3.e-6), did not show any evidence of hydrothermal activity.

The following figures show plume locations according to depth. The colors correspond to nephels counts above the background, where dark areas show locations with no light attenuation anomalies and bright areas show locations with very high nephels counts, indicating the presence of hydrothermal plumes. Figure 3.e-1 (2300-2400 m depth) shows a plume at approximately 8°57.0'N and 104°15.0'W. Figure 3.e-2 (2400-2500 m depth) shows several intense plumes, at approximately 8°57.8’N and 104°15.0’W, 9°5.6’N and 104°15.0’W, 9°2.0’N and 104°13.0’W, and 9°8.0’N and 104°13.0’W. Figure 3.e-3 (2500-2600 m depth) also shows intense plumes, at 8°59.5’N and 104°15.0’W, 8°59.0’N and 104°13.5’W, 9°4.5’N and 104°15.0’W, 9°8.5’N and 104°15.0’W, 9°6.5’N and 104°14.5’W, and 9°3.5’N and 104°14.5’W. Figure 3.e-4 (2600-2700 m depth) shows a large plume from 9°3.0’to 9°6.0’N at 104°14.5’W, a smaller plume at 9°0.5’N and 104°15.0’W, and other minor plumes. Figures 3.e-5 and -6 (2700-2800 m depth and 2800-2900 m depth, respectively) both show a plume from 9°1.5’to 9°4.0’N at 104°15.0’W.

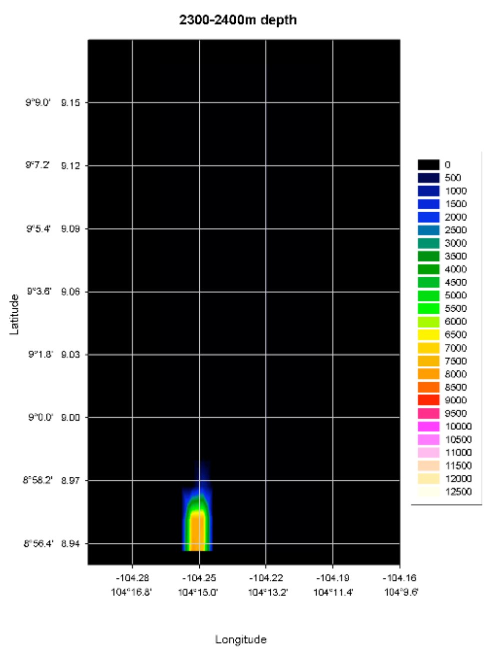


Figure 3.e-1. 2300-2400 m depth

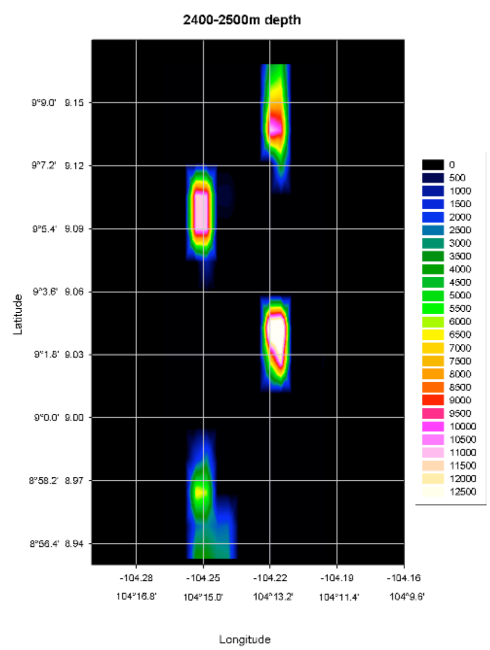


Figure 3.e-2. 2400-2500 m depth

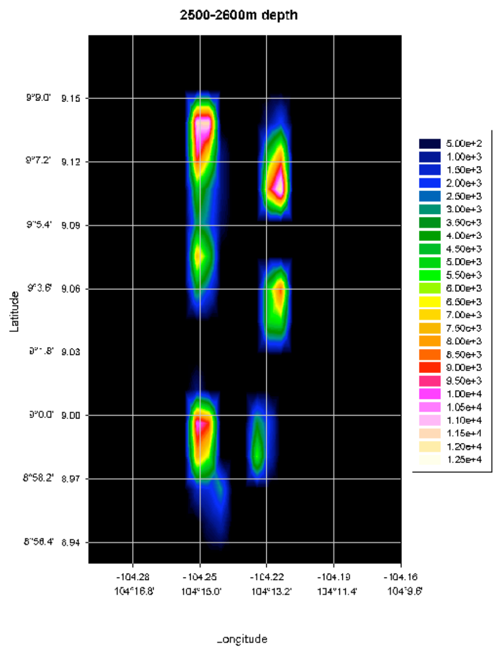


Figure 3.e-3. 2500-2600 m depth

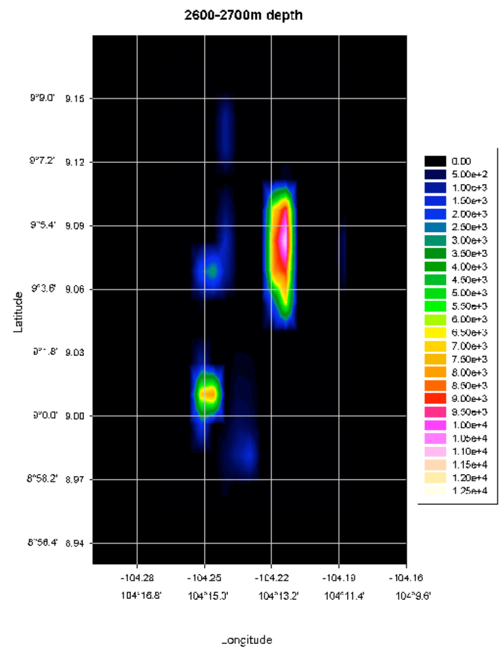


Figure 3.e-4. 2600-2700 m depth

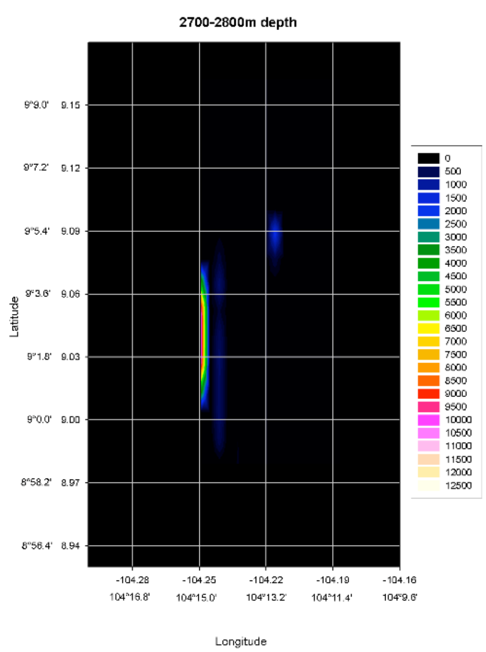


Figure 3.e-5. 2700-2800 m depth

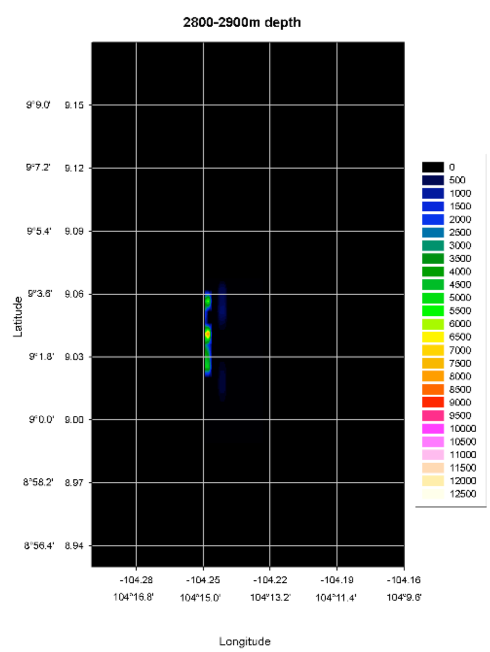


Figure 3.e-6. 2800-2900 m depth

Section 3.f.
Magnetics

Data were collected by two three-component fluxgate magnetometers that were mounted to the wings of the DSL-120A towfish. One was recorded within the sonar data stream and the other was the WHOI self-recording magnetometer. The sensors are identical. MatLab codes were used to make corrections to the magnetic data that were collected. First, heading corrections were made to account for the variability in total field that arises based on the azimuth heading of the ship. Next, the International Geographic Reference Field (IGRF) corrections were applied to the data. Once this calculation is performed, the values are then subtracted out and what is left is the local magnetic anomaly field caused by magnetization of the rocks. 3-D inversions of the magnetic field in the presence of topography will be done on-shore to produce magnetization maps of the OSC. Rock samples for magnetic analysis were also collected which provide for a broad coverage of the OSC's eastern and western limbs. Small scale variations in the magnetic anomalies found in the layer 2a basalts of the OSC can give clues and aid in making interpretations as to the nature and variability of the magma network beneath the limbs and overlap basin of the region.

The following are plots (Figs 3.f-1 through 3.f-10) created for each of the 10 track lines conducted with the DSL-120a over the OSC. The plot displayed in blue shows the pitch of the vehicle as the data was collected. Red displays roll of the vehicle and green displays the altitude above the seafloor as each of the track lines was conducted. Finally, the plot displayed in black shows the total field anomaly in nT left over after making heading and IGRF corrections. A strong correlation between pitch of the vehicle and the noise (spikes) indicates the need for additional filtering. Aside from the 10,000 nT spikes associated with vehicle pitching, the data appears well behaved.

Figs 3.f-1 through 3.f-10 (below). Magnetic results for each DSL-120a track line as described in text.

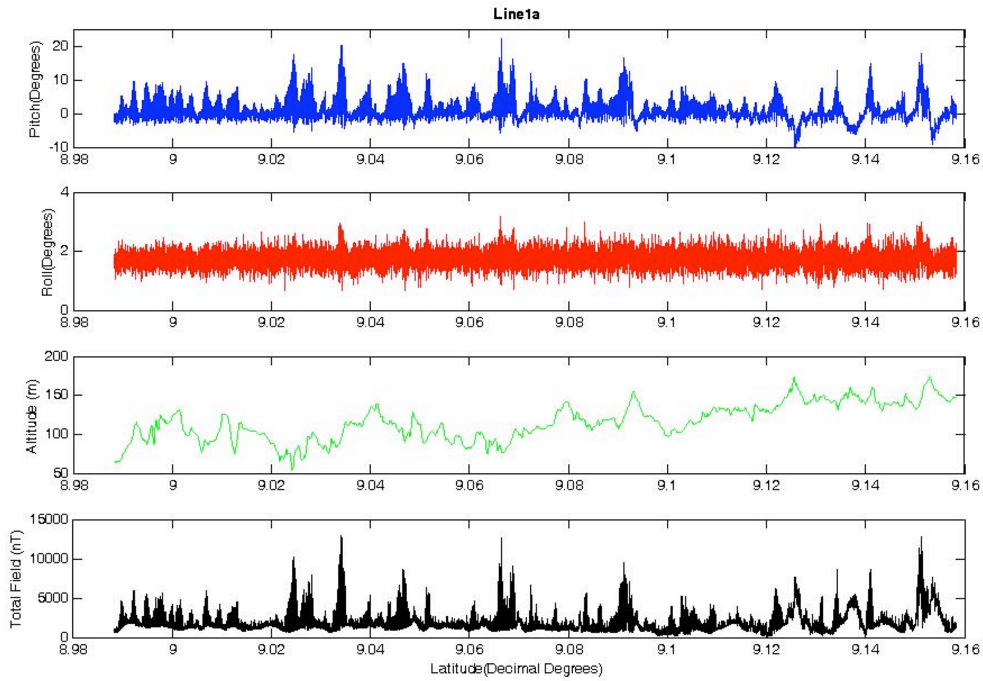


Figure 3.f-1.

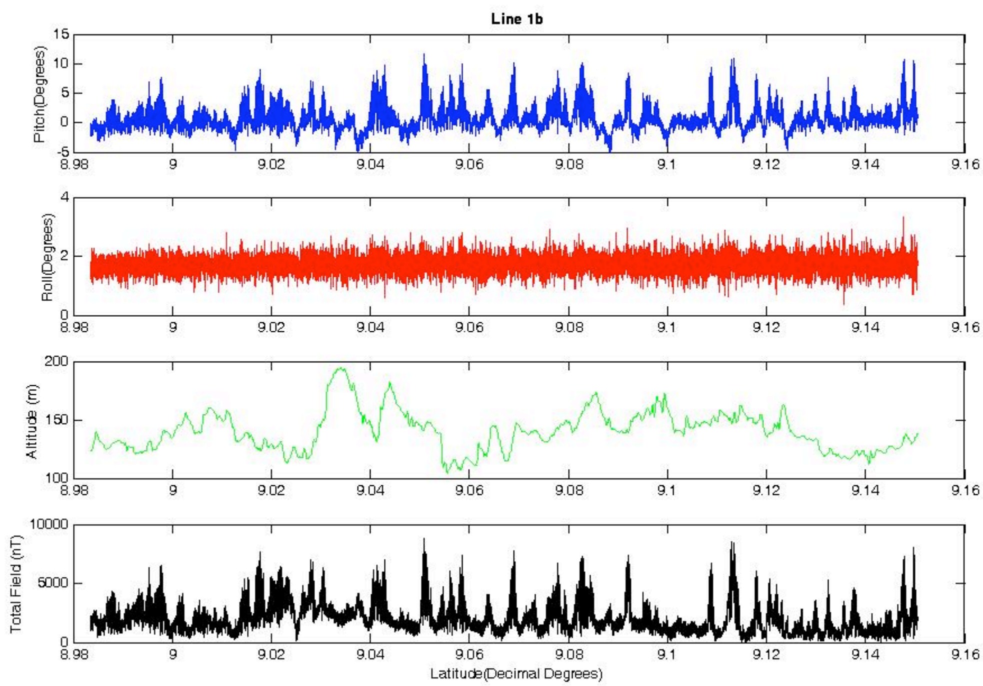


Figure 3.f-2.

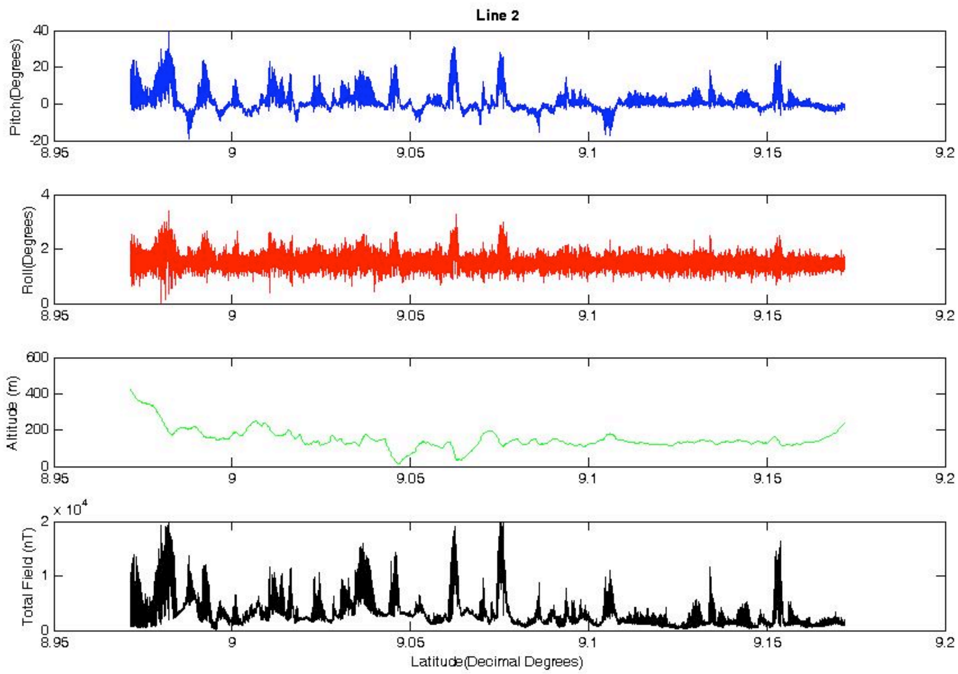


Figure 3.f-3.

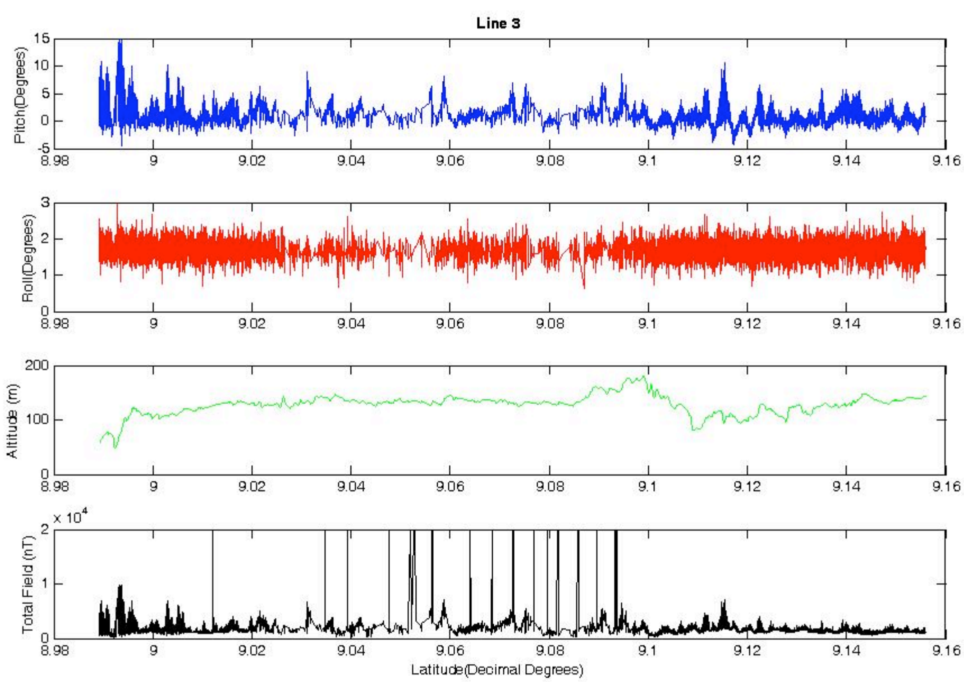


Figure 3.f-4.

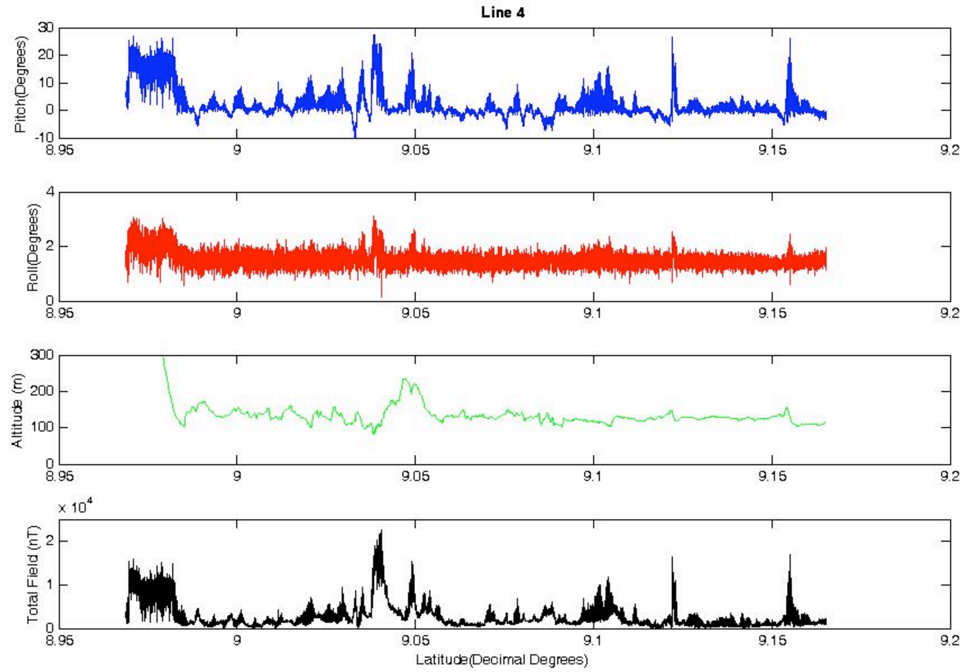


Figure 3.f-5.

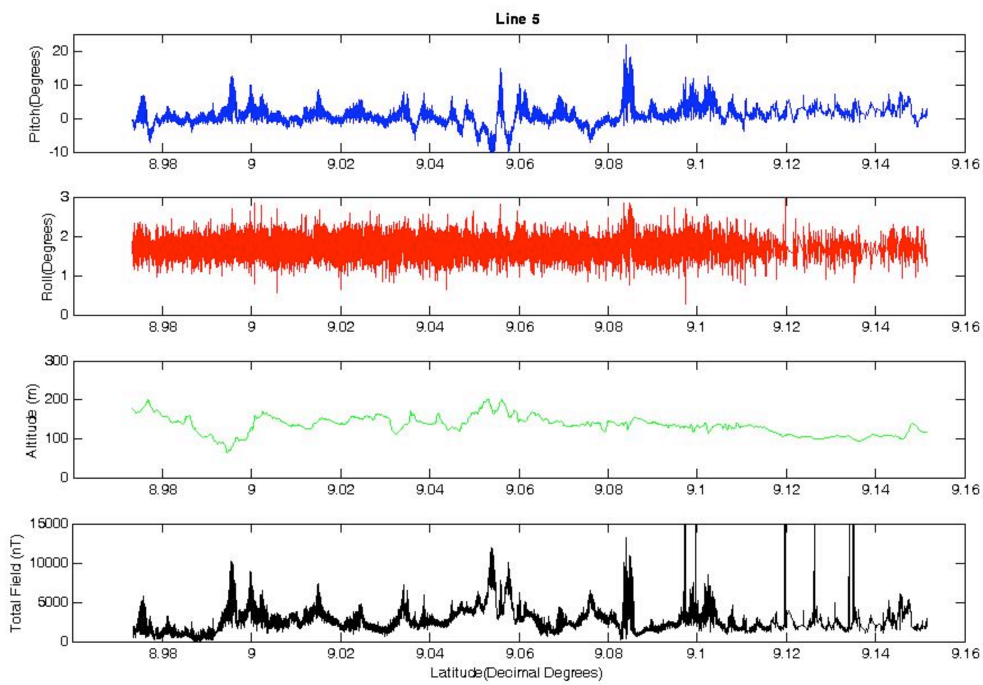


Figure 3.f-6.

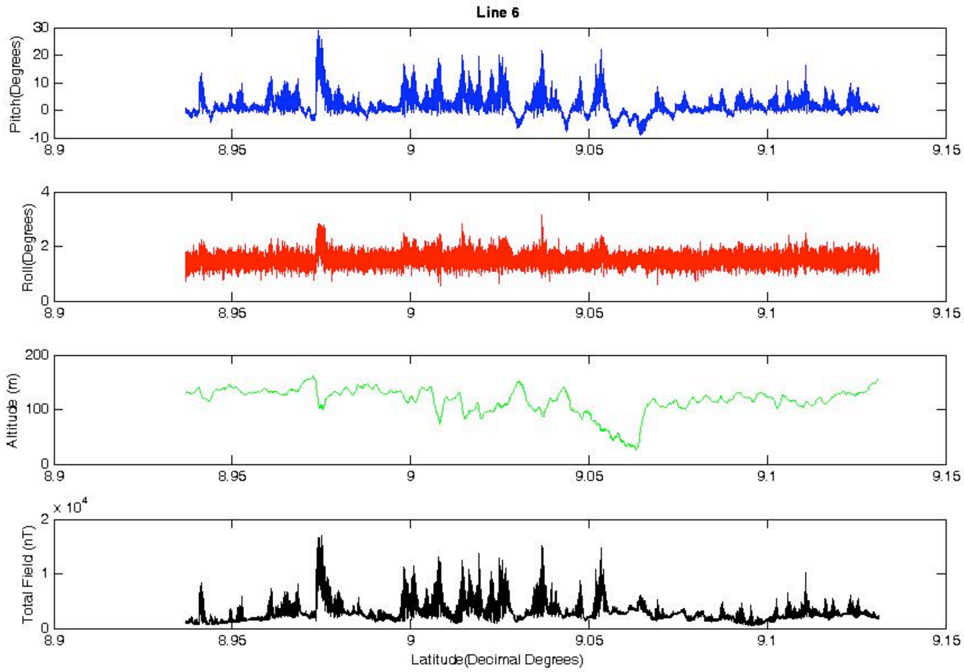


Figure 3.f-7.

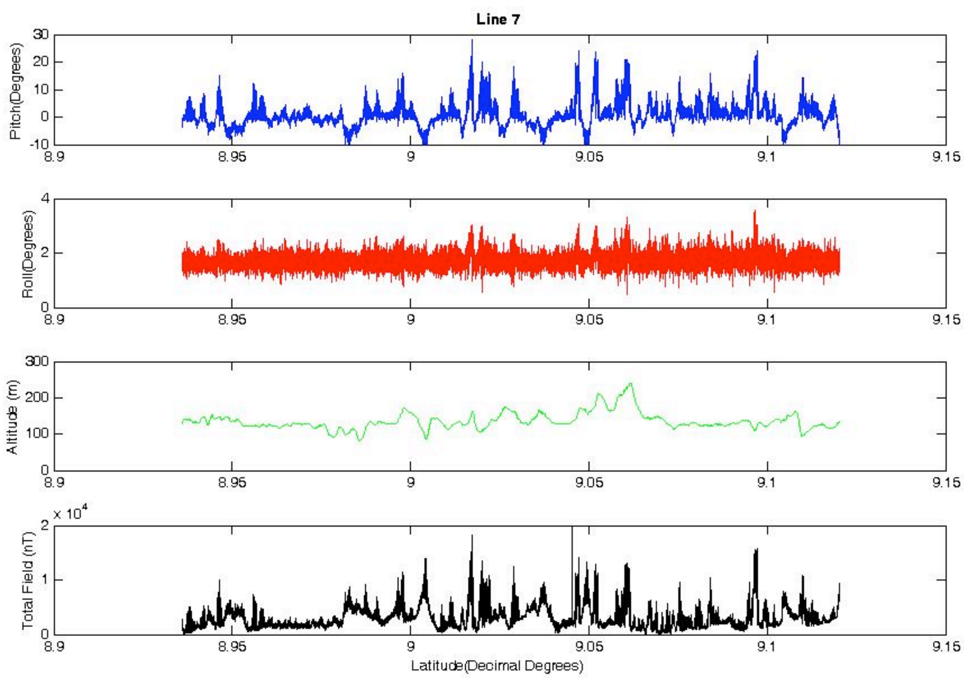


Figure 3.f-8.

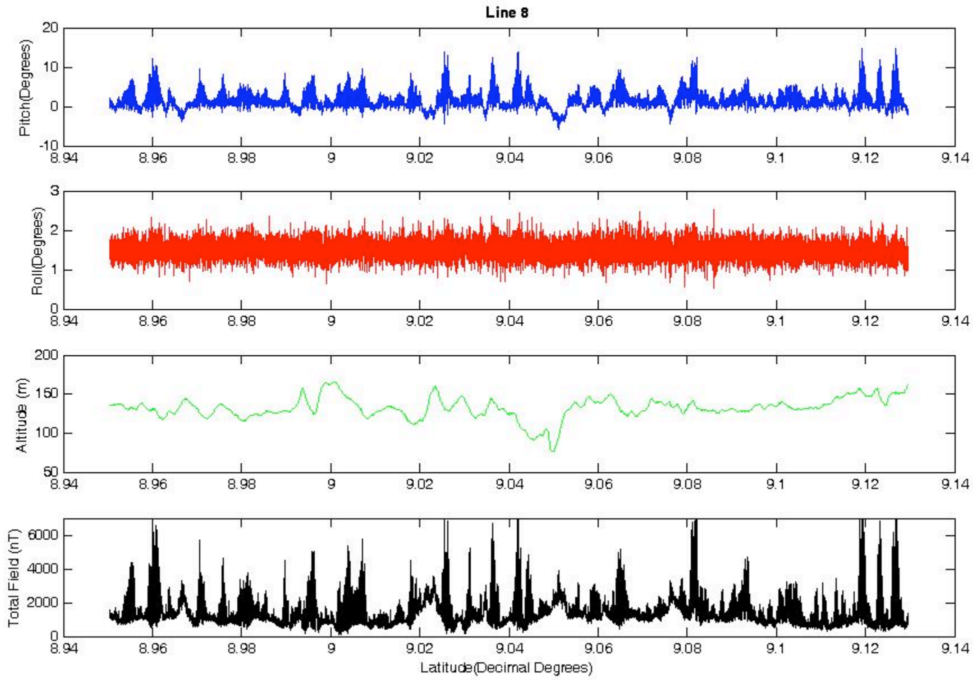


Figure 3.f-9.

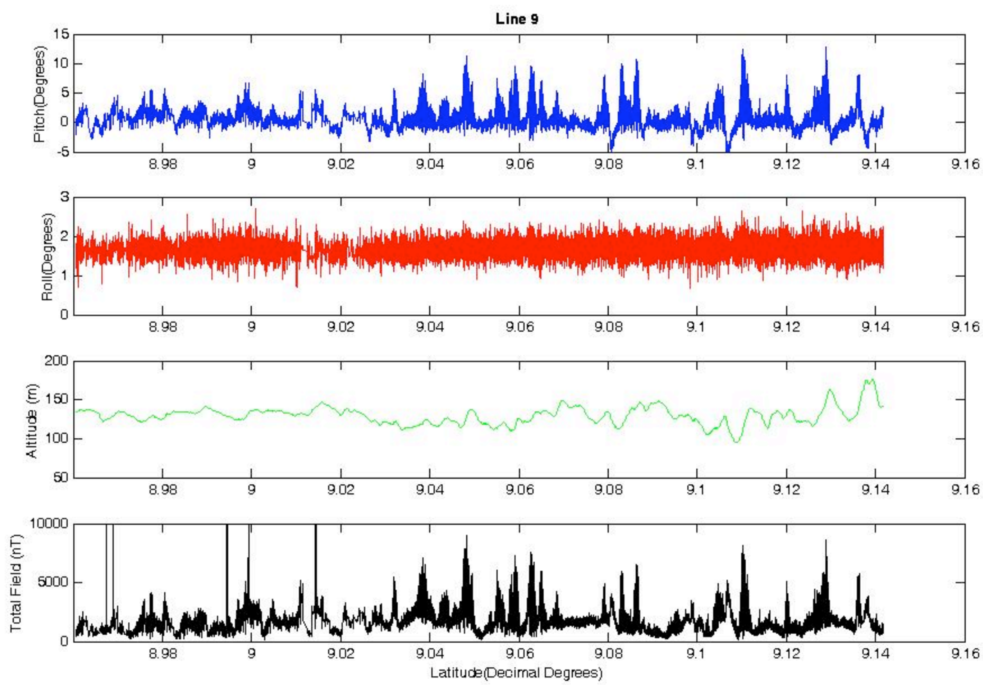


Figure 3.f-10.

Section 3.g.
Rock Sample Collection, Description and Archiving

During our OSC study, 284 individual rocks samples were recovered with Jason II, and eight wax cores that recovered at least some glass were performed (see Fig. 3g-1). Our sampling effort focused most heavily on- and off-axis on the East Limb (~80% of samples) with fewer samples collected along the axis of the West Limb. All samples were described, using the attributes listed on the Rock Description Table (see Appendix). The majority of samples were basaltic pillow fragments, >90%with at least some fresh glass. In addition to the obvious basaltic lavas, a subset of lavas had either a bluish tint or a waxy glass aspect, suggesting that they may be andesites (to be confirmed by shore-based analysis). These samples are:

Andesite	Andesite (likely)
041007-0213	040907-2130
040907-2358	041007-0425
041007-2247	041007-0147
041307-1751	040907-2314
041307-1225	
041007-1618	Andesite (probable)
040807-0848	041307-2033
	Basalt or basaltic andesite
	040907-1804

All samples were archived; glass, when present, was spalled off; thin section billets and whole rock slabs were cut; and the resulting sample subsets and splits were distributed to Klein, Perfit, Sims and Ridley, as indicated in the Rock Description Table (see Appendix).

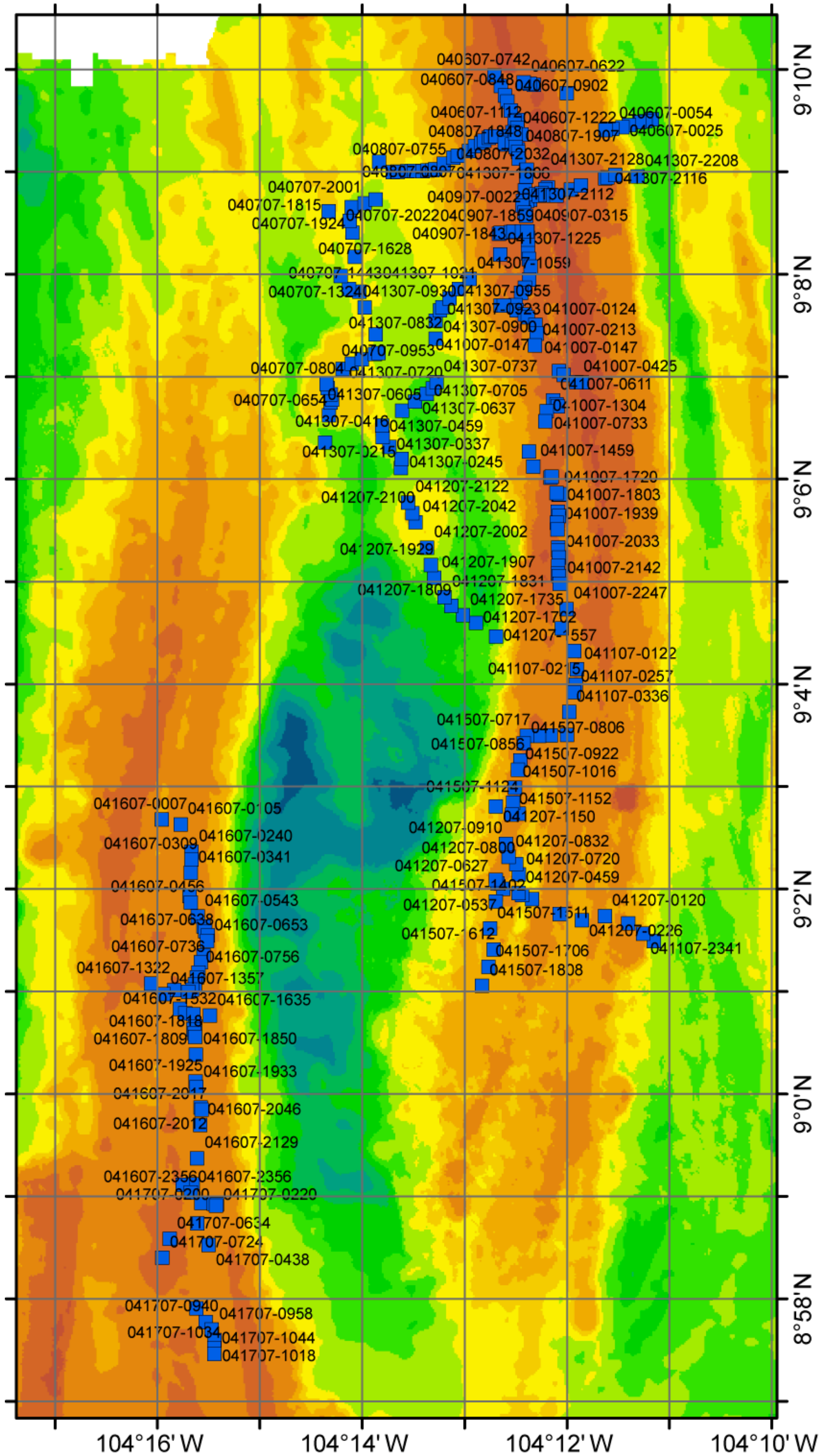


Fig. 3.g-1. Rock samples collected during Jason II dives.

Section 3.h.
Hydrothermal vent waters: Sampling and Analysis

The 'Medusa' vent fluids have a measured maximum exit temperature of 335°C. As the total chlorinity of the fluids from this vent are ~60% of that in seawater (based on their refractive index), this demonstrates the fluids have phase separated. Typical 'black smoker' fluids have measured 25°C 1 atm pH values in the 3-3.5 range, and the Medusa fluids are within this range. The hydrogen sulfide concentration are relatively (but not unusually) high at 10-20 mmoles/kg. A total of 8 fluid samples were collected from 1 orifice, and while all contain variable admixtures of seawater, overall sample quality is very good.

Section 3.i.
Biological Sampling and Preservation

Biological samples were collected opportunistically at the OSC site. Some organisms were attached to sample rocks and removed during rock processing. Others were collected intentionally from the Medusa vent site and processed immediately upon arrival at the surface. Collected phyla included Mollusca (2 *Calyptogena* clams, 6 *Bathymodiolus* mussels, 100+ limpets), Cnidaria (1 hydoid colony, 2 anemones), Porifera (3 sponges), Echinodermata (2 brittle stars), Arthropoda (1 brachyuran crab), and Annelida (3 *Riftia*, 14 *Tevnia*, 1 *Alvinella*, 1 *Branchipolynoe*, 2 unknown polychaetes). With a few exceptions, organisms were placed directly into plastic bags and frozen at -70ºC. Preceding this freezing process, the bivalve shells were separated, and pieces of the foot and gill of the *Calyptogena* were cut off and preserved independently. One of the *Riftia* worms was first pressed between two frozen weights before being bagged and frozen. Limpets were stored in a vial of 99% ethanol and kept at room temperature. All samples were sent to Dr. Tim Shank at WHOI. *Riftia* samples will be distributed to Dr. Pete Girguis at Harvard University, and mussel samples will be sent to Josh Osterberg at Duke University.

A catalog of biological samples collected is presented in the Appendix.

Section 4: EPR Eruption Response and Ridge2000 ISS site

4.a. DSL-120A lowering 50 Summary (S.M. White & S.A. Soule).
We conducted two days of DSL-120a system operations during AT15-17 in support of the project which seeks to do a before/after comparison of side-scan and bathymetry from the most recent eruption of the EPR at 9°50'N (~1 yr ago). One DSL-120a lowering was made and 2 transponders were recovered. This add-on project was successfully completed despite some early delays related to equipment malfunctions.

We arrived on station at 1330Z on March 26. We stopped at 3 waypoints to activate the existing transponder network. The DSL Benthos 455 box was unable to hear replies from any of the transponders, but the portable DS-7000 did awaken all of the transponders. The survey track was navigated entirely in layback mode. The Alvin DSOG Benthos box was used to obtain LBL navigation files during the later tracklines. These files will have to be merged in post-processing. The Doppler sonar produced interference and inconsistent navigation, so we turned it off as well.

We arrived at the DSL-120a launch point at 1630Z on March 26. Problems with the sonar electronics delayed the deployment until 2200Z. Four MAPRs we put on the tow wire and below the clump weight. Relative to the clump (z=0), MAPR-6 was at 200 m, MAPR-8 was at 125 m, MAPR-31 was at 50 m, and MAPR was at -25 m. A fluxgate magnetometer was deployed on each wing of the 120a tow body, one from the DSL group and one self-logging instrument ordinarily used for the WHOI Tow-Cam. The SM 2000 multibeam sonar was also mounted on the towfish frame to fill the bathymetric nadir gap. The sonar was towed at 120 m altitude during most of the survey. We towed at 1.6 knots and set the acquisition to 0.8 sec rep rate to match this speed.

The survey collected approx 80 km of trackline centered around 9°50'N and extending 9°58'N to 9°45'N (Figure 4.a-1). The survey width varies from ~1 km (one swath width) up to 3.5 km. Trackline separation was designed to give full bathymetric coverage.

The side-scan immediately revealed a number of new features. Most prominent are a large number of lava channels that did not exist in the 2001 vintage side-scan. These features show up as low backscatter areas in the new data (Figure 4.a-2). The shape of the axial trough has changed markedly in some areas as well, although the extent of these changes is still under investigation. Comparison of new and old flow fronts and bathymetric differencing will be carried out after the cruise. Preliminary interpretation thus corroborates the idea that this recent eruption created a large amount of new terrain around the EPR, making it a major eruption.

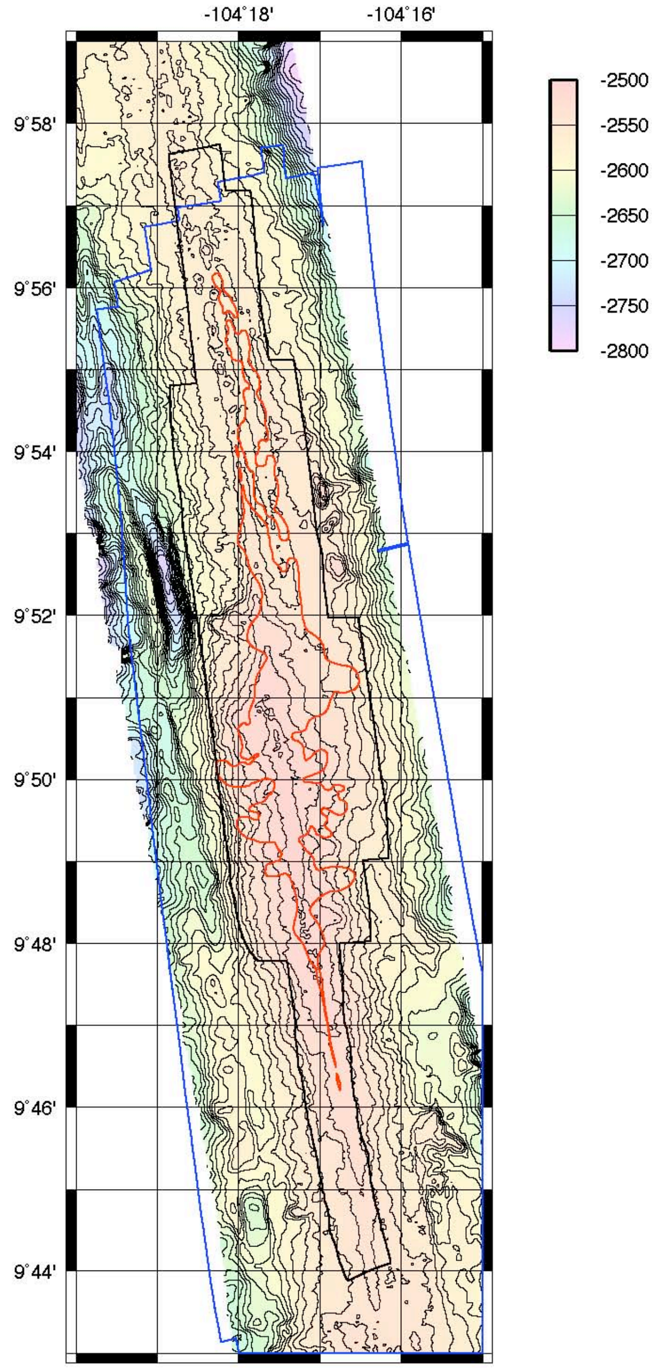


Figure 4a-1. Extent of DSL-120A lowering 50 (black line) over the eruption (red line) inferred from earlier mapping by S.A. Soule and D. J. Fornari. Blue line shows the extent of a DSL-120A side-scan survey from 2001 (AT7-4) by Schouten and others. Underlying bathymetry is the EM300 swath collected in 2005 (White et al., 2006).

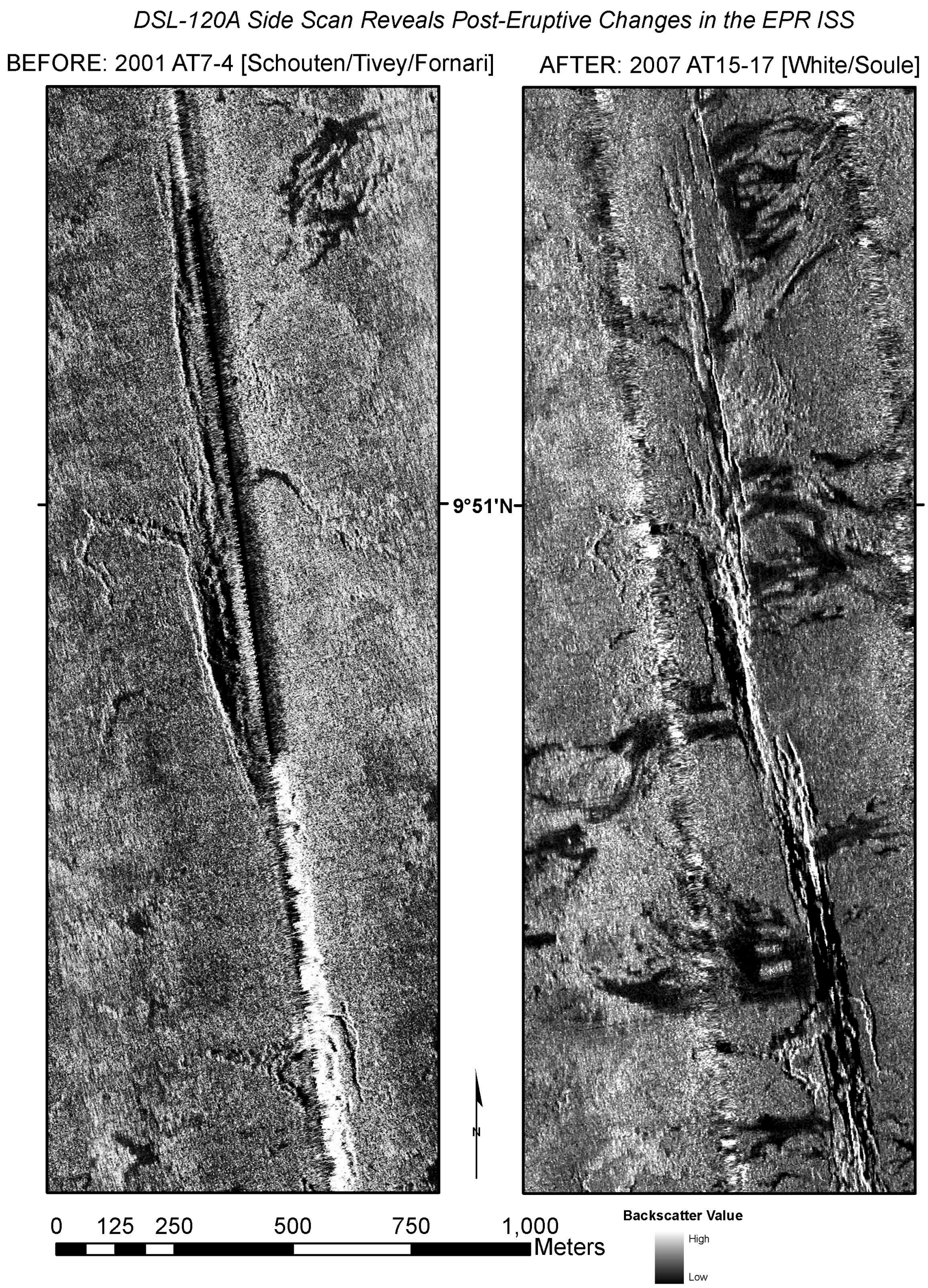


Figure 4a-2. Comparison of changes in the seafloor as revealed by side-scan survey from before (left panel) and after (right panel) the eruption of the EPR. Extensive changes in the local seafloor as a result of the eruption are highlighted by the numerous new low-backscatter lava channels (black areas) seen on the new image.

4.b. Jason Dive 268 Summary – EPR ISS Infrastructure Dive (D.J. Fornari & S.A. Soule)

The objectives of Dive 268 were to conduct several types of surveys to provide baseline data that would be useful to a broad cross-section of multidisciplinary investigations at the EPR ISS. The primary tasks were to: 1) install navigational benchmarks at key areas where experiments and high- and low-temperature vents are located (Fig. 4.b-1); 2) survey-in the benchmarks using long-baseline (LBL) acoustic data and reference them to the experiment sites and high-temperature vent sites; 3) conduct low altitude (3-4 m) surveys across the axial summit trough (AST) over the benchmark areas; 4) collect high resolution, near-bottom multibeam and magnetic data over the benchmark areas and attempt to survey between benchmark areas to provide a broader context of AST morphology and bathymetry for current and future EPR ISS experiments; 5) attempt recovery of three ocean-bottom seismometers (OBSs) that were trapped by lava from the 2005-2006 eruptions; 6) collect additional samples and observations of the 2005-2006 lava flow, especially in areas where the flow advanced within lava channels and extended furthest from the source vents in the AST, and 7) recover a lost compliance meter from the Webb/Cormier et al. experiment that failed to acoustically release during AT15-16 (Fig. 4.b-2).

Figure 4b-1. Photos of *JasonII* and elevator prior to Dive 268. Upper left photo shows benchmark design, upper-right photo shows arrangement of Benchmarks 1&2 on basket along with sample basket prior to launch. Lower left shows syntactic float packs rigged on swing arms. The float packs were attached to the OBSs to provide additional buoyancy. Lower right photo shows elevator rigged with additional benchmarks (foreground) and sample basket in wooden box (background).

Given the along axis area to be covered during the dive, between ~ 9° 49'-51'N (Fig. 4b-2), the logistics for Dive 268 required deploying an elevator to the seafloor to carry additional benchmarks that were to be installed after Benchmarks 1&2, as well as additional sample bins to collect lava samples. The elevator was deployed prior to the dive and surveyed in using LBL from the ship; it landed ~ 200 m west of the Tica vent site. The start of operations were advanced by ~12 hours by the generous donation of ship time by the PIs of the 9° 03'N OSC program - Klein, White, Perfit, Von Damm - who had completed their survey work 12 hrs early.

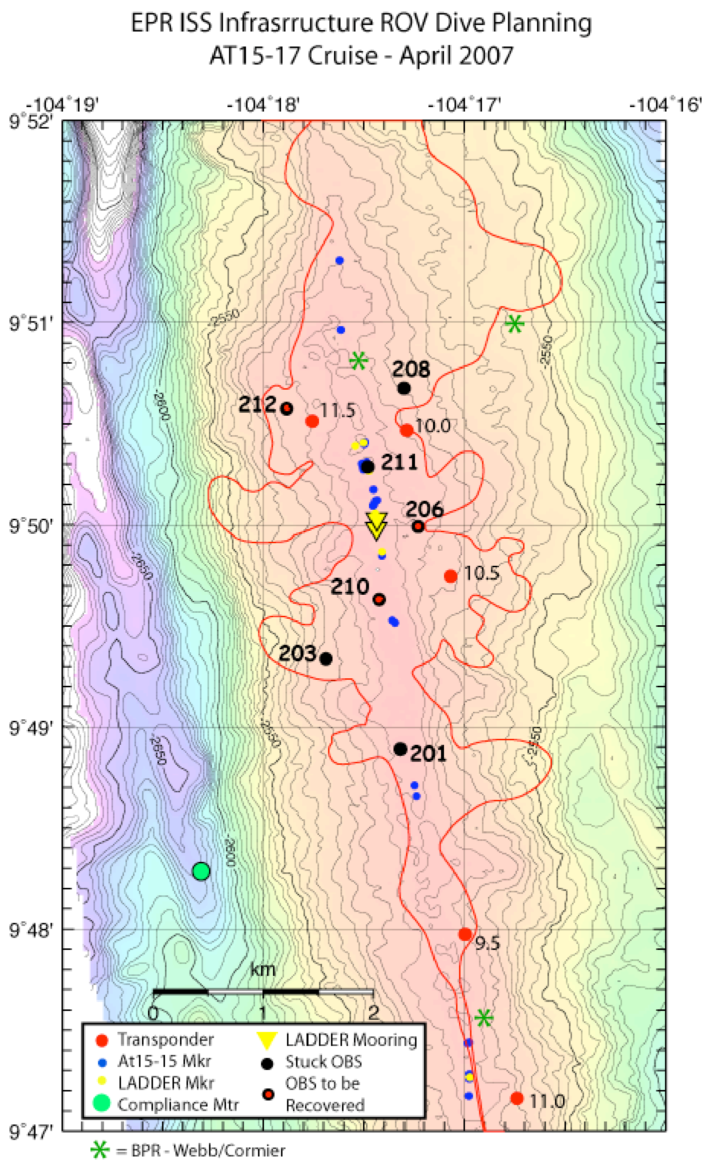


Figure 4.b-2. Summary of locations of key experiments and instruments, as well as 5 of the 6 permanent acoustic transponders currently deployed at the EPR ISS (another transponder, 11.5 kHz - is ~2 km south of the 11.0 kHz near 9 46'N). The red line on the map is the most recent limit of the 2005-2006 EPR lava flows from an analysis of ~150,000 TowCam images collected since May 2006 to Jan. 2007 [Soule et al., submitted].

An operational summary for Dive 268 is shown in Table 4b-1. We started in the northern portion of the field area and worked south, given the locations of OBS212 and the compliance meter to be recovered. The main tasks for the dive are discussed in five separate sections and include: Benchmark surveys, SM2000 near-bottom multibeam surveys and low-altitude transects, OBS and compliance meter recoveries, hiT vent observations, lava channel mapping and sampling.

18 April, 2007 Z

0600	Launched *JasonII* for Dive 268
0745	On bottom searching for OBS 212
0820-0834	SM2000 Calibration lines
1220	Located OBS212
1415	OBS212 on deck
1517-1628	Traverse & sampling up lava channel west of AST from OBS212 site
1748	Benchmark 1 deployed
1756-1821	Benchmark 1 LBL survey
1823-2005	Benchmark 1 across AST SM2000 surveying
2009	Transit from Benchmark 1 to OBS206 site
2200	Located OBS206
2250	OBS 206 released

19 April, 2007 Z

0015	OBS 206 on deck
0020	Heading to Benchmark 2 site
0204	Benchmark 2 deployed
0209-0224	Benchmark 2 LBL survey
0302	At elevator to switch baskets and get other benchmarks
0702	Benchmark 3 deployed
0714-0730	Benchmark 3 LBL survey
0743-1259	Benchmark 2&3 across AST SM2000 surveying
1302	Transit to Benchmark 4 site
1423	Benchmark 4 deployed
1440-1455	Benchmark 4 LBL survey
1531-1745	Benchmark 4 across AST SM2000 surveying
1747	Start transit to OBS 210 site
1850	At OBS210, attempting excavation of instrument
2015	Leaving OBS210 site, not recoverable
2025	Start of long N-S AST SM2000 surveying between 9° 50’-51’N– 6 lines

20 April, 2007 Z

0831	End of long N-S AST SM2000 surveying
0902-1850	Mapping and sampling of long lava channel east of AST at 9° 51’N
1900-2200	Transit from end of lava channel to elevator, switch baskets and release
2220	Elevator released
2305-2320	Resurvey of Benchmark 2 using LBL

21 April, 2007 Z

0030	Elevator on deck
0030-0230	Visual observations at Bio9, P and Ty/Io high-T vent areas
0325-0358	Resurvey of Benchmark 4 using LBL, 2 collections using 2 transponder pairs
0419	Setting up for SM2000 survey of AST between 9 49.5'-49.8'N, south of LADDER moorings
0437-0749	SM2000 survey of AST south of LADDER mooring
0757	Start of transit to compliance meter
1025	At compliance meter
1053	Compliance meter released
1302	Compliance meter on deck, *JasonII* coming up.
1353-1411	Magnetometer spins at 1200 m – 3 turns each in both CW and CCW directions
1518	Jason 2 on deck, commence transit to San Diego

Table 4b-1. Operational summary of *JasonII* Dive 268**.**

Benchmarks

Four benchmarks were installed and surveyed-in during Dive 268. The locations were determined based on proximity to high-T vent sites and ongoing biological experiments at diffuse flow vents in the area (Figs. 4.b-3 and 4.b-4). The procedure for installing the benchmarks involved locating the associated vent sites and then determining which side of the AST rim to best place the benchmark based on the terrain. Areas of extensive collapse proximal to the AST wall were avoided. Benchmarks were deployed by *JasonII*; the milk crates that form the base of the benchmark were weighted with additional rocks from the surrounding flow. The ROV was positioned with the benchmark at the front of the basket and the vehicle heading 000°. Once Jason LBL navigation was consistent we commenced 15 minutes of LBL data collection with the vehicle sitting on the bottom and not moving (Table 4b-2).

Benchmark #1 LBL Survey – April 18, 2007

1756 Start recording LBL data while sitting at Benchmark #1 for 15 min with Jason heading 000° and benchmark at middle of basket

1821 End recording LBL at Benchmark #1, reset Doppler to Jason LBL
Preliminnary position from renav is: 9° 50.981'N 104° 17.666'W,

X=4274 Y=79225, Depth 2504m

Benchmark #2 LBL Survey – April 19, 2007

0209 Start collecting 15 minutes of LBL fixes at Benchmark #2.
0224 End LBL data collection for 15 minutes at Benchmark #2
Preliminnary position from renav is: 9° 50.401'N 104° 17.473'W,

X=4627 Y=78157, Depth 2501m

Benchmark #2 LBL Survey – April 20, 2007

2305 Jason1 LBL nav back on and collecting data while in position at Benchmark #2
2320 End LBL nav collection at Benchmark #2
Preliminnary position from renav is: 9° 50.409'N 104° 17.478'W,
X=4619 Y=78171, Depth 2501m

Benchmark #3 LBL Survey – April 19, 2007

0714 Start collecting LBL data while sitting at Benchmark #3 site with J2 at 000 heading and benchmark at front of basket

0730 End LBL data collection at Benchmark #3 site.

Preliminnary position from renav is: 9° 50.308'N 104° 17.464'W,
X=4643 Y=77986, Depth 2501m

Benchmark #4 LBL Survey – April 19, 2007

1440 Start 15 min LBL recording at Benchmark #4 with *JasonII* oriented 000 and benchmark at front of basket.

1455 End recording of LBL at Benchmark #4

Preliminnary position from renav is: 9° 50.126'N 104° 17.428'W,
X=4710 Y=77650, Depth 2503m

Benchmark #4 LBL Survey – April 21, 2007

0325 Started collecting LBL data at Benchmark #4 using B/C pair (10.0/10.5)
0342 End LBL data collection at Benchmark #4 with B/C pair
0343 Started collecting LBL data at Benchmark #4 using A/B pair (11.5/10.0)
0358 End LBL data collection at Benchmark #4 with A/B pair

Table 4b-2. EPR ISS benchmark survey times and preliminary locations. *These data should **NOT** be used for final positions of the benchmarks*. Post-cruise processing/analysis of the data are required to establish final surveyed positions for each benchmark that is integrated with SM2000 bathymetry.

Navigation data, including raw travel times from the three primary transponders used for all the Dive 268 operations, are included in the original data disks for the AT15-17 cruise. The information includes raw travel time data for the transponder surveys that were done in 2006 on the AT15-6 and AT15-13 cruises in June and November, respectively. Post processing of LBL data for the Benchmark surveys and analysis of the data will be required to properly calculate the best positions for each benchmark. **The positions listed in Table 4b-2 should be considered preliminary.**

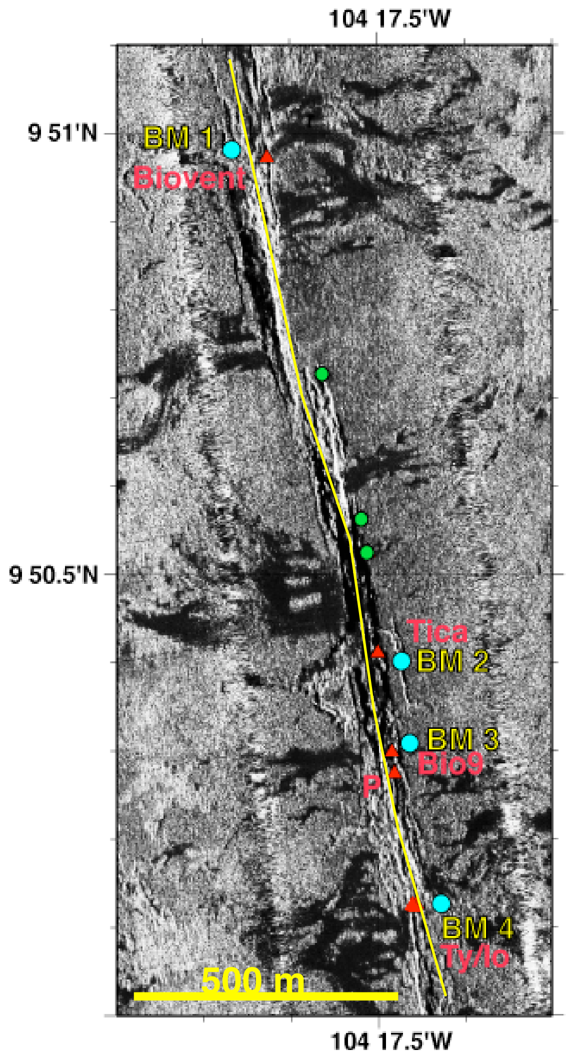


Figure 4.b-3. Map showing locations of EPR ISS benchmarks and high-T vents (red triangles) and low-T diffuse flow areas (green dots) overlaid on new DSL-120a sidescan sonar collected during AT15-17, March, 2007 (S. White and S.A. Soule). Dark, dendritic patterns on sidescan image are low reflectivity lava channels emanating from the AST (thin yellow line shows trace) that formed during the 2005-2006 eruptions.

SM2000 surveying

Surveying using the 200 kHz near-bottom multibeam system on *JasonII* (SM2000) was conducted to produce detailed topographic maps that could be used for establishing digital elevation models of the AST, and specific experiment areas where studies at the ISS are being carried out (Figure 4.b-4). Once processed, these data can provide a topographic baseline along the AST to be used to measure changes caused by subsequent eruptions or tectonic events. These data will augment the physical benchmarks deployed and surveyed during the dive.

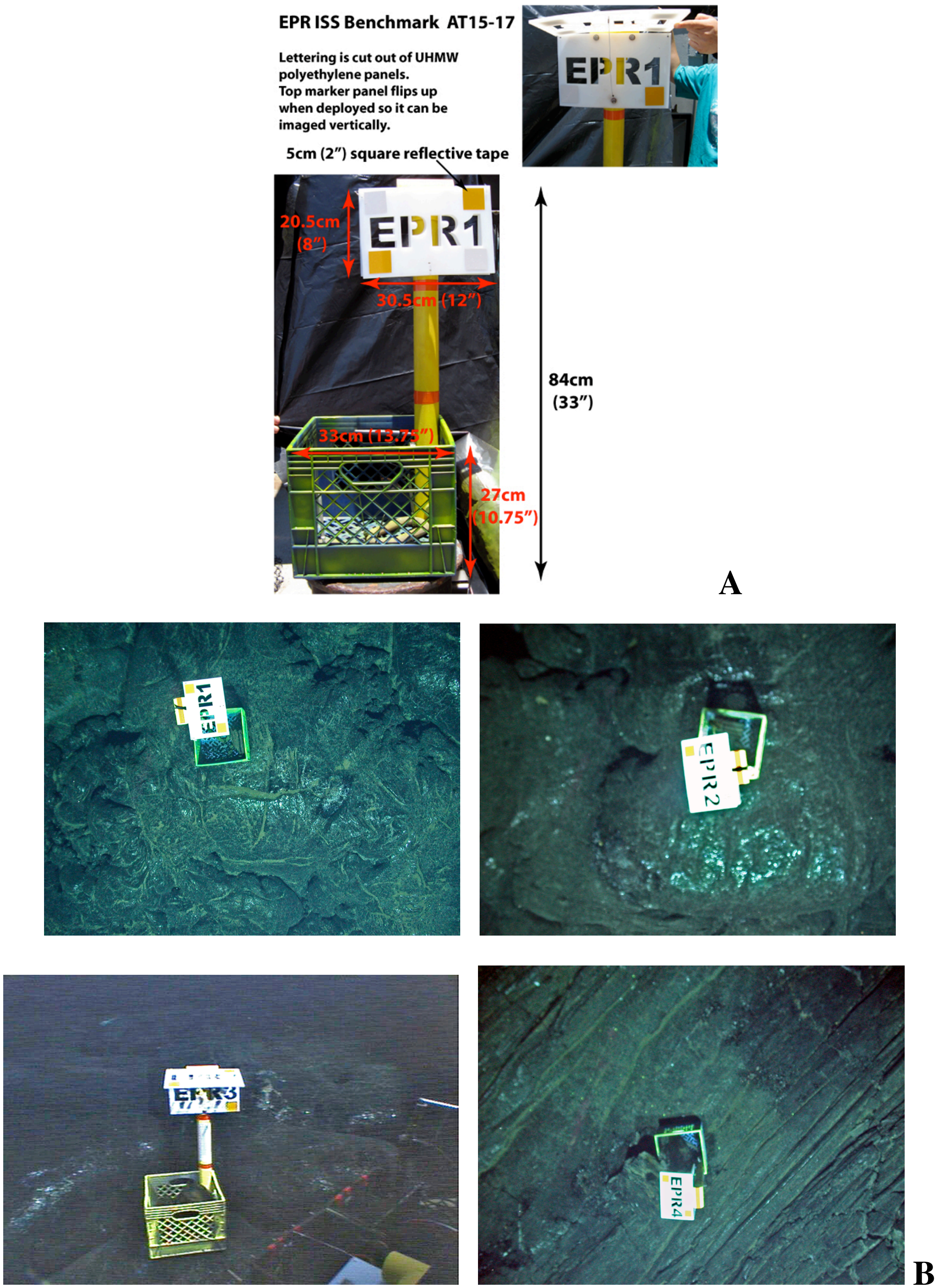


Figure 4.b-4. A) Dimensions of EPR ISS Benchmarks. B) Digital photographs taken from *JasonII* of the four EPR ISS Benchmarks installed during Dive 268.

The SM2000 sensor was calibrated soon after arriving on bottom by running 3 lines over the same terrain on reciprocal headings at 5, 10 and 15 m altitudes. For all of the across-AST and along-AST surveys, the ROV was run in 'constant depth' closed-loop control –meaning the vehicle depth was kept at 2490 m and the seafloor allowed to rise and fall beneath it while traversing the seafloor. This depth was determined after several crossings of the AST and establishing that we would not loose bottom-lock with the 1200 kHz DVL Doppler on *JasonII* that has a maximum range of 30 m, but a practical range of ~ 20-25 m. Throughout the surveys, bottom lock was maintained except for very sporadic intervals when there were only 3 beams or momentary loss of bottom lock. This occurred when we recovered OBSs and the elevator during the dive, the ROV had to rise off the bottom by ~100 m to permit the ship to maneuver safely during recovery operations and when samples were collected and we were too close to the seafloor. During those times bottom lock was lost but it was re-established prior to commencing subsequent surveys.

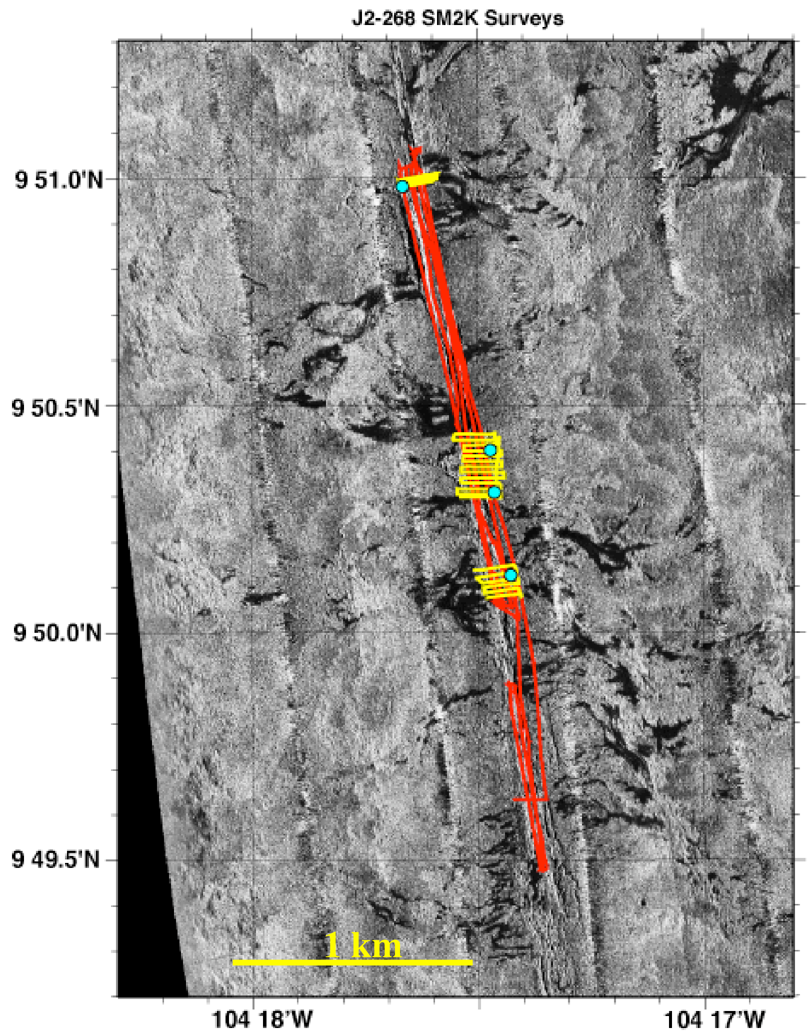


Figure 4b-5. Map showing locations of EPR ISS benchmarks (blue dots) and SM2000 near-bottom bathymetry surveys (yellow and red tracks) overlaid on new DSL-120a sidescan sonar collected during AT15-17, March, 2007 (S. White and S.A. Soule). Dark, dendritic patterns on sidescan image are low reflectivity lava channels emanating from the AST that formed during the 2005-2006 eruptions.

Figure 4b-5 shows the locations of primary SM2000 surveys. Within each benchmark site across-AST areas each ~150 m wide by ~100-200 m long (N-S) were surveyed. The across-AST survey between Benchmark 2 and 3 was done continuously as these two areas are prime sampling and observational sites. In order to tie together the 4 benchmark areas, long N-S oriented SM2000 survey lines were run to completely map the AST over ~ 2 km. Data density and control should be excellent within the benchmark areas given the multiple crossings.

OBS and compliance meter recoveries

An important objective of the dive was to attempt recovery of the 3 OBSs that were still communicating acoustically but found to be trapped in the 2005-2006 lava flows [Tolstoy et al., 2006; Cowen et al., 2007] based on direct observations from the fiber optic TowCam during the June 2006 AT15-6 event response cruise and Alvin during AT15-15. Figure 4.b-6 shows a map of the OBS locations over the new sidescan imagery. Figure 4.b-7 shows *JasonII* video camera frame grabs of the recovery operations for OBSs 212 and 206, and the attempted recovery of OBS 210. Figure 4b-8 shows photographs of the recovered OBSs on deck, and Figure 4.b-9 shows images of the compliance meter.

The two recovered OBSs were both trapped by hackly lava flows that clearly compromised the anchors and release assemblies, and partially buried the floatation sphere hard-hats. Because the hackly flow was quite broken up in both cases, the OBSs were easily pulled from the flow after each syntactic float pack was attached to the lift bail. For OBS 212 the frame was partially buried and a large rock was wedged between the pressure housings. Once that was cleared and the frame shaken so that the lava rubble fell off, it was clearly observed to be buoyant and was released. The same was true for OBS 206, which also was easily pulled from the hackly flow, shaken to be sure no large pieces of lava were trapped inside the base, and then released. The additional ~12# of syntactic floatation helped the OBSs rise quickly at ~ 35 m/min. In all cases the ship was used to recover the instruments. Given the calm weather and rapid ascent speed, minimal time was lost in having *JasonII* off the bottom during recoveries. In some cases sampling or other operations were done during portions of the OBS ascent. The OBSs were washed with fresh water after recovery and placed under a tarp for offloading in San Diego at SIO-MARFAC. The acoustics were disabled when they were on the surface using the ORE deck box left by the WHOI buoy group.

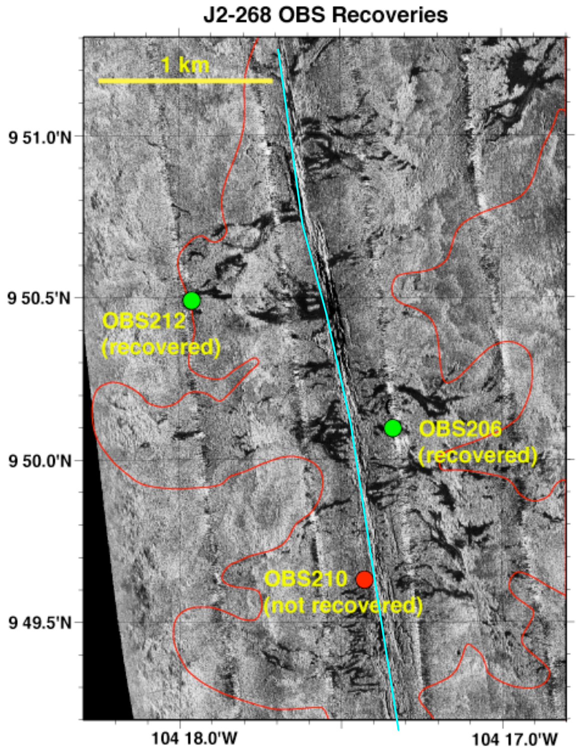
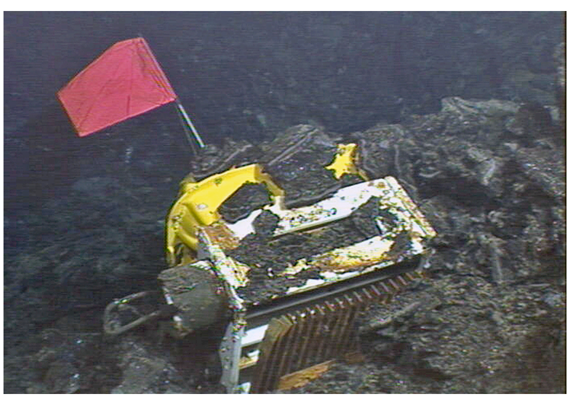
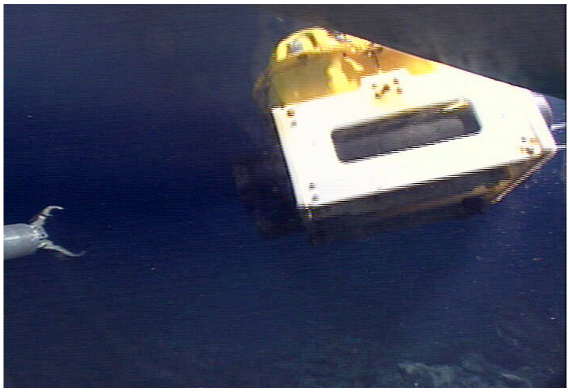


Figure 4.b-6. Map showing locations of OBS recoveries on AT15-17, *JasonII* Dive 268 plotted over the new DSL-120a sidescan sonar data collected during AT15-17, March, 2007 (S. White and S.A. Soule). Thin red line is the limit of the 2005-2006 lava flows mapped using TowCam data [Soule et al., submitted]. Thin blue line shows trace of AST. Dark, dendritic patterns on sidescan image are low reflectivity lava channels emanating from the AST that formed during the 2005-2006 eruptions.

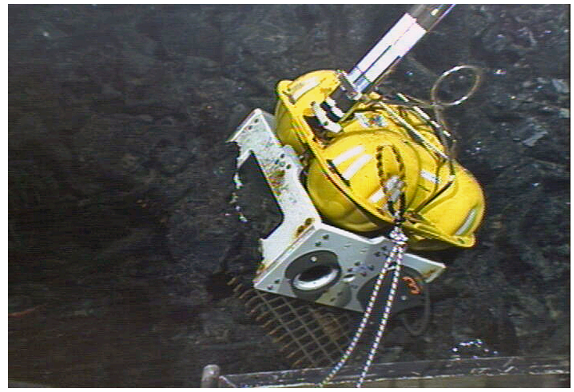


OBS212 site

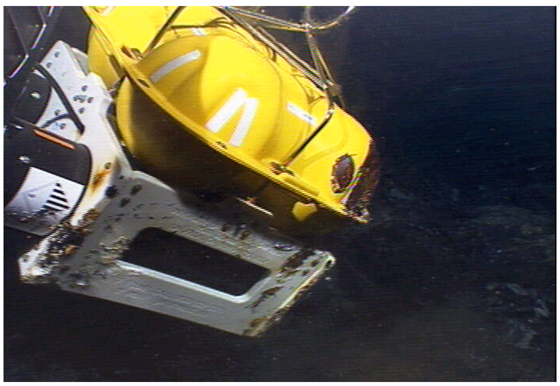
OBS212 rock on pressure housings



OBS212 released

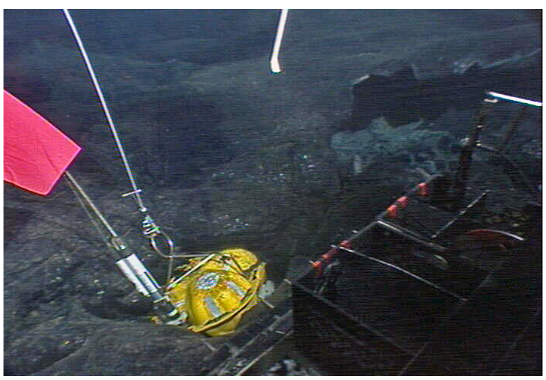


OBS206 site



OBS206 scorched plastic frame

OBS206 anchor buried in lava - after release



OBS210 site

OBS210 after trying to
clear lava flow

Figure 4.b-7. *JasonII* photographs of OBS recovery operations undertaken during dive 268.

OBS210 was considerably more buried by the new lava and the flow around it was a lobate flow rather than the hackly lava found at OBS 212 and 206 sites. While the area to either side of OBS210 was partially collapsed lobate crust , the OBS itself was situated over what appeared to be a small lava pillar. The base of the OBS was completely buried and proved impossible to dislodge, despite considerable effort to break through the surrounding lava using *JasonII* and clear the debris using the manipulators. It may be possible with a dedicated 24-36 hr dive and the proper manipulator tools to clear enough rubble away from the OBS to dislodge it, but it was clearly not possible within the time we had available, and the manipulator capabilities. In addition, the seismometer pressure housing appeared to be filled with lava, although it was difficult to determine whether it was fragmental debris or in-place lava, suggesting that of the three OBSs, 210 is the most likely to have been compromised by the eruption.

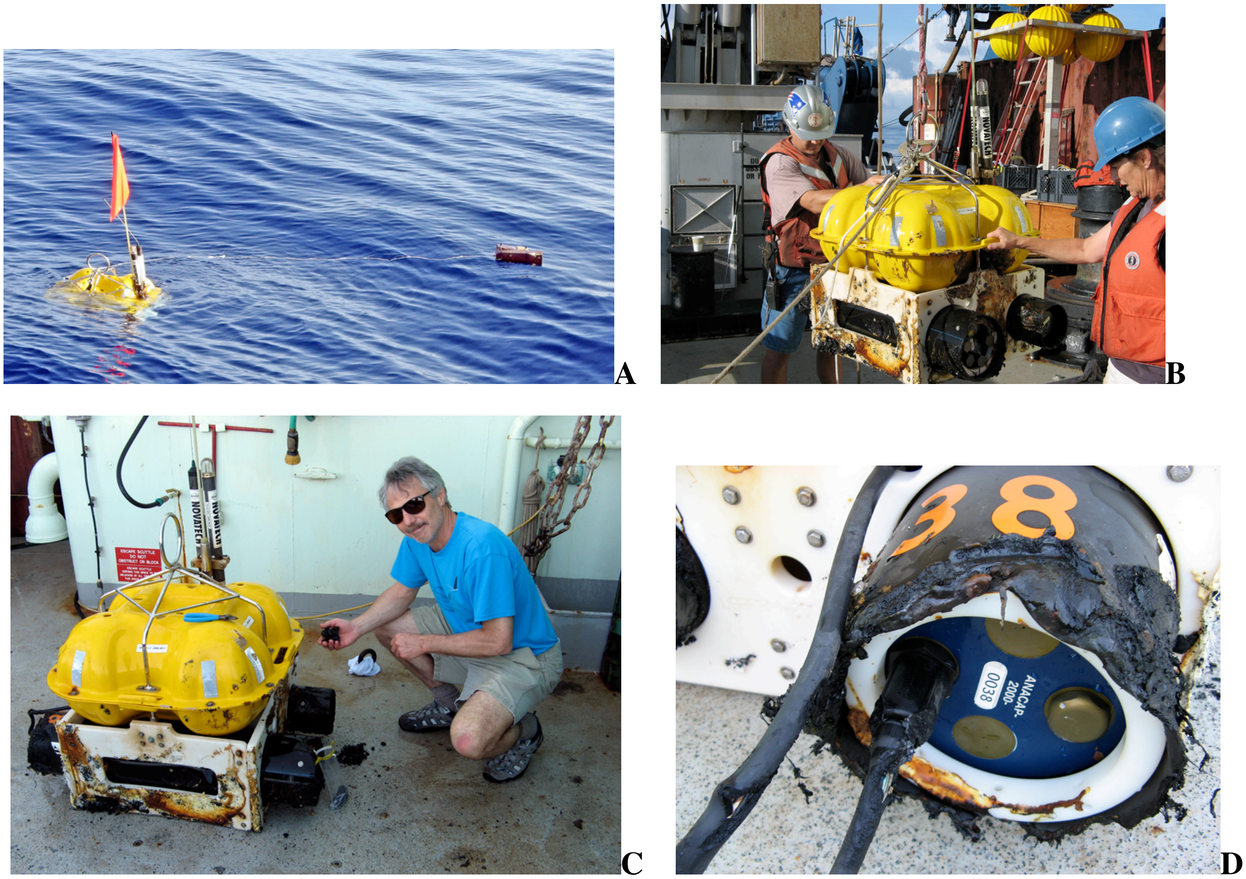


Figure 4.b-8. Photographs of recovered OBS 212 on deck. A) OBS 212 on the surface. Syntactic float block is at right. B) OBS 212 being landed on deck. C) Recovering glass from inside OBS 212. D) Electronics housing of OBS 212 showing partially melted plastic cowling and frayed cable.

The compliance meter lost on AT15-16 (Webb/Cormier et al.) had been well surveyed when it failed to return to the surface so was easily located at the end of Dive 268. It was found on sediment covered lobate lava flows in a normal attitude. On inspection, neither weight had released so both burn wires were cut using a knife tool and the ROV manipulator. One weight was observed to fall out and the other weight was not observed when we turned the instrument partly on its side. The instrument appeared to be buoyant so it was released. In hindsight, we should have cleared the other weight cover to ensure that the weight had in fact dropped as the instrument surfaced very slowly and took over 2 hrs to reach the surface. It was recovered normally and washed down. With instructions from Webb, the instrument was dismantled, the sensor disconnected from the electronics and packed for shipment. The Li batteries were removed from the electronics case and the acoustics were turned off. All cables were washed and the unit was readied for shipment on arrival in San Diego. Figure 4.b-9 shows the instrument on the seafloor and recovered on deck.

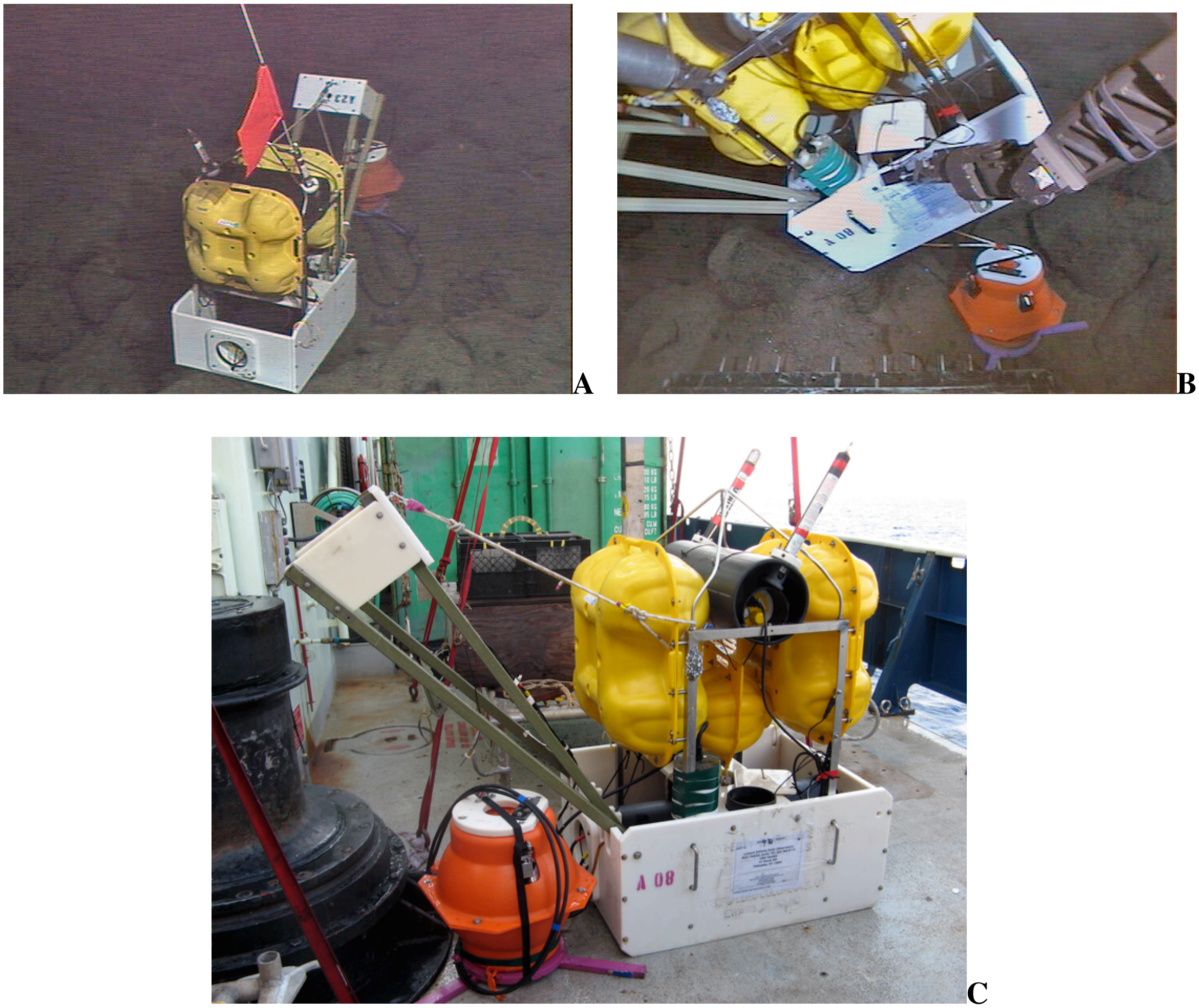


Figure 4.b-9. A) Compliance meter on the seafloor as observed by Jason on Dive 268. B) Manipulating instrument frame to release weights. C) Compliance meter on deck on R/V Atlantis.

Hi-Temperature hydrothermal vent observations

Time was spent during the dive making observations at four high-T vent sites within the ISS bull's eye – Bio9, P, Ty and Io vents. This was done in order to locate the benchmarks as well as to collect images for use in characterizing the vent areas. Some of the time was also spent making observations immediately surrounding the vents in the AST to characterize the terrain and establish relative distances between vents like Ty and Io, which are only ~8 m apart, and the surrounding structure in the AST floor and adjacent walls. In addition, we conducted low-altitude imaging over the vents where possible although the downlooking digital still camera on *JasonII* did not focus properly at times and the strobe used was only 300 watt/sec output so some of the images are dark. Hopefully, further downlooking imaging can be done on subsequent Alvin dives in late 2007-2008 to collect additional data that can be merged with the high-resolution SM2000 bathymetry.

Lava channel mapping and sampling

We conducted two transects along lava channels occupied by the 2005-06 flowwith the objectives of gathering photographic data corresponding to the acoustic textures in the DSL-120a sidescan sonar imagery and collecting samples that reflect a temporal sequence of the down-flow progression of the lava (Figure 4.b-10). Transect locations were selected to cover the most interesting features observed in the new sonar data and were coordinated with the surveying objectives of the infrastructure dives. We used lava channels imaged in the AT15-17 DSL-120a sidescan data to constrain flow pathways and to ensure that sampling was conducted along unique flow paths. Samples were collected at ~250 m spacing along each transect.

Transect A, west of the AST, began at 9˚50.5'N and followed a bearing of ~050˚ for ~0.9 km, from near OBS212 to the AST (Figure 4.b-10). We started the transect at the location of OBS212, which was trapped in a hackly flow. The channel, which defines the path of the lava flow, is discontinuous, and often times interrupted by areas of hackly, broken lava crusts within which remnants of the smooth sheet flows can be seen. The lava channel itself comprised flat sheet flows that contained lineations striking NE. The channel margins comprised hackly flow that graded into lobate flows along either margin. A total of five samples were collected along the transect from a variety of flow morphologies. The total elevation change along the transect was 15 m.

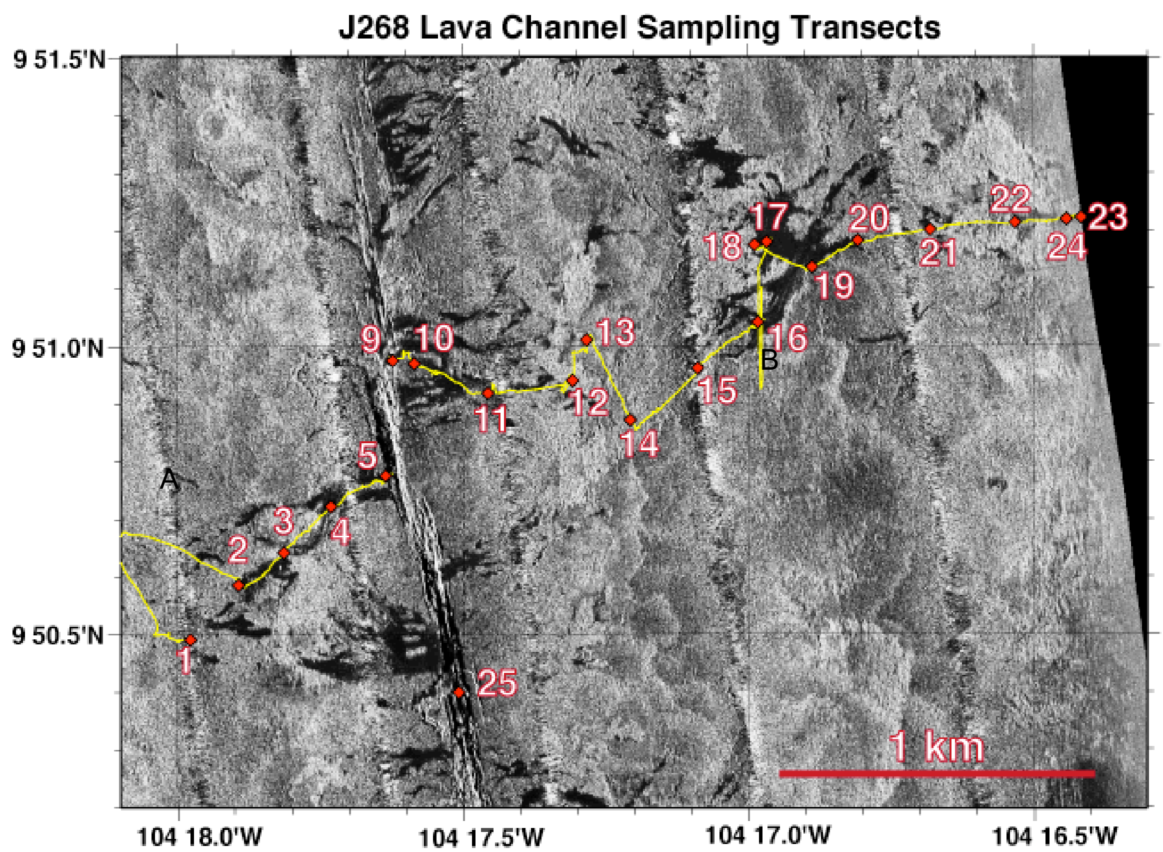


Figure 4.b-10. Map showing locations of lava samples collected during Jason Dive 268 from two lava channels between 9° 50.5'-51.3'N, west (Transect A) and east (Transect B) of the AST. Sample 1 was collected ~1 m from OBS212 and Samples 6 and 8 (not shown) were collected next to OBS 206 and 210 respectively. Samples 7 was not recovered. In addition, glass was collected from inside OBS212. Samples from OBS 212 and OBS206 have been processed and will be sent to K. Rubin (U. Hawaii) and M. Perfit (U. Florida) for geochemical analyses and Po dating.

Transect B, on the east ridge flank, began at the AST at 9˚51'N and followed a bearing of ~080˚ for ~2 km. We initiated the transect by traveling due south through a lava channel to orient ourselves relative to the sidescan imagery. Between the multiple channel strands that originate at the AST, hackly crusts of broken lobate are present and correspond with highly specular acoustic textures in the DSL-120a data. We followed the channel down-flow to an area where several channel strands are abruptly terminated. The channels appear to have been covered, at this location, by a ridge of hackly material ~2-3 m in height. The ridge is reminiscent of levees that are sometimes present at the edges of channels and parallel to the flow direction, but the observed feature is oriented orthogonal to the flow direction. Two SM2000 survey lines were run at 10 m altitude in order to image the hackly ridge. We traversed to the north for ~300 m in order to investigate an acoustic contact between highly specular terrain that we had identified as hackly flow and smoother terrain that we interpreted as lobate flows. We found the contact ~40 m north of its location in the sidescan imagery, indicating a southward navigation shift is required in the sidescan data. Across the contact, we found very low relief lobate flows. The lobate flows were unequivocally produced during the new eruption and had numerous *kipukas* of older lava poking through. A sample was collected within the lobate terrane. There is no channel visible in the sidescan imagery for the next 500 m down-flow, and we found hackly sheet flows covering this area. Upon reentering the lava channel we conducted two N-S oriented photo surveys to further constrain navigational error in the side-scan data. These surveys crossed three channel strands, each separated by hackly flows. At the southern extent of the photo survey we observed 2005-06 lobate flows, which allowed us to determine that the acoustic contrast between new and old lava in lobate lava flows is quite difficult to determine in the sidescan imagery without correlative bottom observations. We followed the lava channel to the easternmost extent of the sidescan survey, which was coincident with our mapped extent of the eruption. Here, it was difficult to determine where the new flow ended. It appears that the distal ends of the flows are more sedimented than the proximal portions. We identified two possible locations where the flow ended, each marked by a hackly ridge (flow toe?) ~3 m high, overlying a more heavily sedimented sheet flow. Samples were collected at each ridge. A total of 16 samples were collected on transect B over a distance of ~2 km and an elevation change of 53 m.

Acknowledgments

We thank the *JasonII* operations group of the WHOI National Deep Submergence Facility (NDSF) and the officers and crew of R/V Atlantis for their excellent support during the survey and recovery operations on AT15-17 in general, and specifically for Dive 268. Program managers at the National Science Foundation and shore-based support personnel at WHOI Marine Operations and NDSF were instrumental in funding and organizing the logistics for the 3 day EPR ISS survey, and we are grateful for this opportunity to collect data that will benefit both the Ridge2000 program and the EPR ISS community of researchers.

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Soule, S.A., D.J. Fornari, M.R. Perfit and K.H. Rubin, How large is a Mid-Ocean Ridge lava flow?: 2005-2006 Eruptions at the East Pacific Rise 9° 46'-56'N, *Geology*, (submitted).

Tolstoy, M., Cowen, J.P., Baker, E.T., Fornari, D.J., Rubin, K.H., Shank, T.M., Waldhauser, F., Bohnenstiehl, D., Forsyth, D.W., Holmes, R.C., Love, B., Perfit, M.R., Weekly, R.T., Soule, S.A., and Glazer, B., 2006, A sea-floor spreading event captured by seismometers: *Science*, v. 314, p. 1920-1922.

Section 5. Outreach Activities

5.a. Web Site: Dispatches from Sea

http://www.nicholas.duke.edu/OSCexpedition/

On our cruise, a daily web log with pictures was posted on the Duke University server, as an outreach to the community. The log was a portion of a web page explaining the background, intention, and cruise participants of the expedition. Included in the web log were daily updates of collection of data and samples, technology used to procure these data, initial scientific interpretation of evidence as it became available, and life experiences upon the ship for the thirty-seven day journey. In addition to reporting on the research conducted, the log addressed a K-12 grade educational pilot forum for four of the five weeks, during which students were in communication with the scientists. Dispatches from sea were written and posted by Laura Preston, a high school science teacher from New Hampshire.

5.b. FLEXE Project

As part of the NSF Criterion II activities associated with this grant, the PIs hosted the Ridge2000 FLEXE education team (Goehring and Preston) during the April '07 research cruise. The FLEXE team used the opportunity to pilot the student-to-scientist FLEXE Forum and develop ideas for future learning activities (curriculum) for the FLEXE project.

FLEXE Project Summary

FLEXE ("From Local to Extreme Environments") is a 4-year NSF collaborative project between the Ridge 2000 research community, Pennsylvania State University College of Education, and the GLOBE (www.GLOBE.gov) program. The FLEXE project involves middle and high school students in systematic, facilitated investigations of data they collect from their local environment and comparable data from an "extreme environment" – in particular deep-sea environments that include tectonic spreading centers and hydrocarbon seeps. Students' understanding of scientific inquiry and of earth systems are developed through: **data-oriented fieldwork and analysis** (including analytical comparisons with data from the deep-sea and partner schools); **structured, web-based interactions** with professional scientists and with students in partner schools; and **culminating activities**, including reporting and peer review. FLEXE involves ridge scientists in a variety of roles, including a core group of US researchers (representing a range of disciplines) advising on the scientific content of FLEXE materials. Evaluation is focused on formative and summative measures to gauge and improve achievement of project goals. FLEXE is an outreach project of the Ridge 2000 research community.

Cruise Activities:

The FLEXE project is in its first year of funding, and from March to mid-May 2007, FLEXE investigators are piloting key components of the full program. Seven schools (14 middle school science classes) already familiar with GLOBE agreed to participate in the pilot. One critical component tested during the spring pilot is the FLEXE Forum, a web-based facilitated interaction between students and scientists, focused on analysis of data. To enable access to scientists as well as to feature the deep-sea environment, the Forum was designed to run during the April '07 EPR research cruise. Goehring sailed with the science party to facilitate student-scientist interaction via the Forum, and post material to the FLEXE website, sending text and images from the ship to programming staff at PSU. Each week of the cruise, participating students accessed the FLEXE system to examine a new dataset and engage in a structured Q&A with scientists. Pilot content centered on the concept of energy transfer between components of the earth system. Featured on-board scientists included Scott White of USC and Karen Von Damm of UNH, as well as Peter Rona of Rutgers University, not on the cruise. In addition to running the Forum, FLEXE team educators (Goehring and Preston) worked with the science party to understand current research questions and develop ideas for FLEXE learning activities.

Next Phase:
In mid-May, at the end of the pilot, FLEXE evaluators will collect feedback from teachers, including interviews and questionnaires, for formative evaluation of all pilot activities. During the summer, the full suite of learning activities for the Temperature Unit will be developed. During the 2007-08 academic school year, the full FLEXE system will be tested with 30-40 GLOBE schools, including schools from one other English-speaking country.

5.c. Ridge2000 Metadata

In addition to cataloguing the data from the cruise in various spreadsheets for our own use, we also compiled the data into seven different official Ridge2000 metadata forms. Times and locations of the Jason II dives were collected in real time and recorded into the vehicle dive form (B13). During the cruise the DSL120A and the Towcam were towed behind the ship. Locations and times of these tows were collected and logged into the towed instruments form (B14). After surveying the transponders for navigation purposes, data from the navigator's log was used to complete the transponder form (B04). Both the rock wax core and the dive sample forms (B03 and B10) were completed by taking data from the watch leader's log, the virtual van, and from rock description forms. The four bio-markers that were set down were also logged into the bottom instruments form (B06) by using data from the virtual van.

6. AT15-17 Operational Issues

Overall the ship and vehicle facilities used during AT15-17 performed very well and both the DSOG personnel and Atlantis officers and crew were exceptional in their dedication and execution of the ship and vehicle operations. The galley crew and meals were superb as usual. That said, there were some important issues that came up that should be mentioned so that the operator can take corrective action. Based on the experience on this leg, are some suggestions for improvements to some of the capabilities of the DSL-120a sidescan and Jason II system that should be considered by the operator and the UNOLS Deep Submergence Science Committee.

R/V Atlantis
Atlantis sailed from Manzanillo without it's full compliment of generators. Apparently this is a situation that has been going on for some time and is due to be corrected during the yard period after this leg. It would have been appropriate for this status to have been communicated to the Chief Scientist as it happened during the cruise that we experienced situations where were there could have been insufficient power to operate all the required systems (i.e., traction winch, Jason II, Effer crane, ship's propulsion, and hotel load).

During initial operations of the hydro winches the tensiometer failed and no spare was available. There was considerable uncertainty as to why it failed and how it had been wired. The TowCam and rock coring operations were done for most of the leg without the tensiometer. The operations were successful but this situation is not recommended and the ship should carry sufficient spares for this key sensor on the hydro winches.

The port drain in the main lab continues to be a problem in that it does not drain. The engineering department was very accommodating in working to clear it every few days, but it appears that there has been no routine clearing of the drains at each port stop. We understand that the drainage system on the ship, as delivered was inadequate, however some measure of protective maintenance (ie – routine reaming of the pipe or onboard industrial drain snake) is recommended. This is also true for some of the science cabins that experienced waste line drain problems.

The SSSG technicians provided excellent support in all over the side operations and in maintaining the shipboard computing system. Because of the nature of the ROV operations and the volume of data acquired in general on deep submergence cruises, we believe it would very advisable for the operator to increase it's onboard mass storage capacity. 1 terabyte drives are routinely available for very modest cost (~$500 each). Purchasing a few of these so that there are not issues related to storage and transfer of data is recommended.

The Effer – knuckle crane – used to launch and recover both the sidescan and ROV systems failed early in the cruise. The hydraulics in the winch that reels in the recovery line failed. While the shorebased DSOG responded very quickly and positively to this problem and a repair was effected within ~8 hrs, this single point failure should be backed up by a ready spare motor or adequate hydraulics seals rebuilding kits. In addition, the ship had a similar type crane that was partially dismantled on the starboard quarter. It is our understanding that this crane is incapable of serving the needs of the DSOG ROV/sidescan systems. The operator should remedy this and ensure that standard shipboard facilities can handle the ROV systems without having to ship duplicate infrastructure.

ROV Jason II and DSL-120a sidescan
The sidescan and ROV system are a powerful suite of survey vehicles that permitted us to map and sample a large area of seafloor efficiently and to excellent advantage in terms of being able on the same cruise to both map and acquire key samples from specific seafloor features. The NDSF should be sure that with the transfer of the DSL-120a sonar to the U.

Hawaii HMRG group, that the collaboration between the two groups is well-structured so that the US research community continues to have access to these systems both in tandem as well as individually. The comments below are specific to each system.

DSL-120a sidescan

The sidescan system performed well after the first lowering, which had problems with unequal power/output from the two arrays causing problems with signal to noise and poor phase bathymetry. It appears that little was done to solve existing problems with the sidescan system since it was last used on the Haymon Galapagos cruise over 18 months ago. DSOG and now HMRG should better maintain and prep the systems to try to minimize startup problems like we encountered. After the repairs were done after the first sidescan lowering the system performed much better with more and equivalent power to each ducer array. The sidescan data are excellent and were processed very well by the HMRG group. The navigation data stream continues to be problematic for the sidescan system. An LBL navigation network was established and provided good LBL data that was acquired during the sidescan surveys. However, no routine software had been developed to accept the LBL input and merge it systematically with the layback data. Further to the issue of navigation data for the sidescan system, the 300 kHz bottom-lock Doppler introduced too much noise into the sidescan data and was not used except for a few intervals to demonstrate that when on –it was negatively impacting the data acquisition. The SM2000 trigger appeared to work and data were acquired normally, however, not processed in real time. The near-bottom multibeam (SM2000) is a standard sensor provided by DSOG and data from it should be routinely processed and made available.

ROV Jason II

The navigation system for Jason LBL tracking was excellent but was the old system that had been in use for a long time. A new, prototype navigation system was installed prior to the cruise but it appeared that it was not fully operational. In order to survey in transponders and collect LBL data during the sidescan surveys, we used the Alvin top-lab Benthos 455 acoustic command box and the computing resources of top lab to collect LBL data and survey the transponders. We hope that continued effort will be put into the new LBL hardware and that DSOG communicates between the ROV and Alvin group about how the LBL and DVLNav systems are set up as it appeared that some functionality on the Alvin system was not similar to that present in the ROV system.

Data were handled extremely well by the group and C. Sellers the data engineer. Data collection and recording during Jason cruises is challenging and one could make the case for additional support for data tasks. Also, DSOG should consider implementing routine, real-time display/plotting of the SM2000 data when being collected by the ROV or sidescan as this would help in real-time planning of surveys as well as providing a measure of quality control. HMRG personnel seemed confident that software they are developing could do this. In addition, having real-time plotting of the Jason2 track on a ~

12hr basis, or as part of the virtual van data stream (NB – the plotting function in the virtual van is not operational) would also be helpful.

The digital still camera (Scorpio- Insite) worked well, but the strobe output is only 300 watts and the image quality as well as range could be improved by carrying a 600 watt/sec. strobe. The weight difference between these two housings is only ~ 10# so is well worth the extra payload. When used in downlooking mode on D268, the camera did not always focus well so many of the images are out of focus. Perhaps this was also a lighting issue but it should be better set up so that when in fixed focus the downlooking digital camera acquires in-focus images.

There was considerable discussion at the end of the cruise between Fornari and DSOG personnel regarding the Virtual Van and the fact that the data written to the DVDs is not functional in a stand-alone mode- like it is for Alvin framegrabber data. These two real-time integrated data display systems have proven to be critically useful for both real-time data analysis, cruise planning, and post-cruise data processing. DSOG must make these systems functional equivalents, within the context of each vehicle type, and provide the data on a dive-by-dive basis such that it can be played on any computer, and not restricted to being accessed only over the WWW. Further, the real-time virtual van system should not be physically tied to the control van. This will ensure that the data can be used until the science party arrives in port so they can complete metadata requirements and writing of the cruise report.

7. APPENDICES

(see attached)