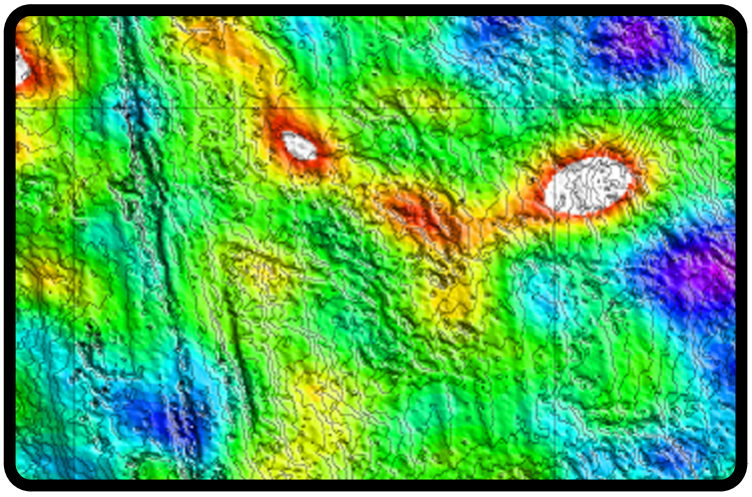
Near-Bottom Investigations of the Central Anomaly Magnetic High (CAMH) at the East Pacific Rise 9° 25'-57'N



Cruise Report

R/V Atlantis

Voyage 7 Leg 4









January 10, 2002

Funded by NSF-OCE9819261

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Near-Bottom Investigations of the Central Anomaly Magnetic High (CAMH) at the East Pacific Rise 9° 25'-57'N

Manzanillo, MX to Manzanillo, MX
November 5, 2001 to December 4, 2001

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R/V Atlantis Voyage7 Leg 4
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1. Introduction

This field and laboratory research addresses fundamental properties of young ocean crust: volcanic accretion of ocean crust, the rapid thickening of layer 2A, and the nature of the layer 2A/B boundary. The geophysical surveys and sampling program were designed to investigate the relationship between the shape of the near-bottom magnetic field and the volcanic history of the mid-ocean ridge (MOR). Recent data suggest that young MOR crust evolves rapidly, and acquires its geophysical characteristics within a narrow zone along the axis. However, the identification of the processes by which upper crustal accretion takes place - i.e. by relatively focused on-axis lava deposition, or more broadly distributed lava deposition both on and off-axis, remain important questions to be resolved. Understanding how magma is supplied to the crust at a MOR and the mode of its emplacement are questions of primary importance if we are to understand the history of crustal accretion and volcanic stratigraphy in the vertical dimension. We suggested in our proposal for this work that high-resolution magnetic data offer important constraints on both the lateral and vertical dimension of crustal accretion. The map-based field data we have collected to date support this contention.

The primary hypothesis to be tested by our field and laboratory studies is that the Central Anomaly Magnetic High (CAMH), as recorded in near-bottom magnetic data, reflects both the width of the neovolcanic zone and the spatial distribution of lava emplacement on the fast spreading East Pacific Rise (EPR) between 9° and 10°N. The Central Anomaly Magnetization High is a zone of high crustal magnetization centered on the spreading axis of the EPR and is a common feature of many other MOR systems [Klitgord et al., 1975]. Near-bottom magnetic measurements of the CAMH indicate that the width of this zone is roughly between 4 and 6 km and is not dependent on spreading rate (e.g. Tivey, 1988), which argues against an exclusively geomagnetic source for this anomaly. The CAMH is thought to reflect the presence of recently emplaced and highly magnetic lavas, which record both the recent doubling of the geomagnetic field intensity [Guyodo and Valet, 1996] and low-temperature alteration [Klitgord et al., 1975; Klitgord, 1976]. Together these lead to a 5-6 fold reduction in lava magnetization over the past 20 kyr [Gee and Kent, 1994]. The width of the CAMH is thus a first-order estimate of the width of the axial neovolcanic zone, and the structure of the CAMH provides important insight into the processes of upper crustal accretion at a fast-spreading MOR and its neovolcanic architecture.

Information on the vertical structure of ocean crust comes from seismic data collected over the study area. These data show that seismic layer 2A doubles in thickness within 1 to 2 km of the rise axis, which strongly suggests the possibility of lava deposition off-axis [Christeson et al., 1992; 1994; 1996; Hooft et al.,1996; Carbotte et al., 1997]. Because young lava is highly magnetic, off-axis lava deposition has important consequences for the magnetic character of the CAMH. Forward models show that the complicated structure of the near-bottom CAMH can be successfully reproduced by the combination of a lava deposition distribution convolved with a lava magnetization function that describes the variation in lava magnetization with age. This lava magnetization function is a combination of geomagnetic paleo-field intensity, which has varied by a factor of 2 over the last 50 kyr, and low temperature alteration, which decreases the remanence of lava with exposure to seawater. The success of the forward modeling suggests that the inverse process is also possible i.e. a deconvolution of the magnetic data for the lava distribution, which can then be integrated for layer thickness.

This approach was initially tested using two near-bottom magnetic profiles across the EPR axis collected in 1994 using Alvin's magnetometer. Using those data, we were able to estimate the relative thickness of the magnetic lava layer which is remarkably consistent with existing multichannel seismic estimates of layer 2A thickness [Schouten et al., 1999]. Our primary objective for this research program was to verify the presence of off-axis lava depocenters, and to establish the correlation between the shape of the CAMH and the distribution of lava emplacement.

Three primary survey tools were used to carry out this research. The first is the Autonomous Benthic Explorer (ABE) [Yoerger et al., 1996] which collected near-bottom magnetic data [e.g. Tivey et al., 1997; 1998] and micro-bathymetry using an Imagenex 675

kHz pencil beam altimeter. The second is the DSL-120A side-scan sonar; a 120 kHz frequency sonar system capable of producing 1-2 m pixel resolution images of seafloor backscatter amplitude [e.g. Scheirer et al., 2000]. The third vehicle system is Alvin which would have allowed us to collect additional near-bottom magnetics and micro-bathymetry data in addition to the primary function of making detailed *in situ* observations of seafloor contacts and collecting precisely located samples of seafloor lava across and along important contacts established by the near-bottom magnetic field, bathymetry and sonar maps.

To investigate the relationship between lava deposition and the structure of the near-bottom CAMH, we carried out detailed, multi-sensor, near-bottom surveys during R/V Atlantis Voyage7 Leg 4 in November, 2001 at two areas located on the axis of the well-studied EPR between 9°N and 10°N [e.g. Detrick et al. 1987; Macdonald et al., 1992; Haymon et al., 1991, 1993; Harding et al., 1993; Carbotte and Macdonald, 1993; Toomey et al., 1994; Kent et al., 1994; Perfit et al. 1994; Wright et al., 1995; Lee et al., 1996; Fornari et al. 1998; Cochran et al., 1999; Kurras et al., 2000] (Figures 1 and 2). One area is near 9°28'-29'N and the other area is centered at 9°50'N. These two areas represent fast-spreading segments with contrasting styles of volcanic construction and seismic layer 2A thickening and different near-bottom magnetic character [Schouten et al., 1999].

2. Cruise Logistics and Operational Summary

R/V Atlantis left Manzanillo, Mexico at 1900L on Nov. 5, 2001 to commence the cruise. The detailed operations summary for the cruise is presented in Table 1. In general, the ship facilities worked very well and the crew and technical teams performed superbly. The major points to note regarding ship facilities are as follows.

- Problems arose with the main engines/propulsion during the transit back to port which delayed arrival. These problems continued into the transit of the following leg, despite significant effort by the ship's engineering department.
- The starboard hydro-winch was used for rock coring and in general performed well. Speeds of 80-100 m/min were sustained for the coring operations. However, there were nagging problems with boom controls (boom out/in was too fast) and the brake sticking. Based on recent information from the ship we understand the needed overhaul of the boom and controls was carried out by the ship's engineering team on the subsequent leg.
- Drainage in the main lab and elsewhere in the ship continues to be a serious problem which the operator should be encouraged to address – it should be a higher priority with the operator than it currently appears to be.
- Noise in the forward 1st platform science bunks continues to be a problem, especially when the bow-thruster is used. There seemed to be excessive vibration during the cruise, more so than what many of us remember on past cruises.

Regarding Alvin, no dives were possible because one of the view-ports was not able to be certified and no replacements were available on board. The science party was notified of this just the day prior to the cruise. One important point that should be considered for future operations is that if the post-cruise inspections of the Alvin view-ports had been done during the transit back to port on the preceding leg, then there would have been considerably more time to address the problem and get a spare down to the ship before we sailed. We decided to sail on time because no confirmed spare view-port was available, and we had planned to spend the first week of the cruise doing DSL-120A surveying. We felt this would give WHOI an opportunity to resolve the view-port issue and get a replacement out to the ship while on station at the EPR. After about 2 weeks,

WHOI was able to get one certified view-port ready and went to great effort in arranging an air-drop of the view-port while we were at sea. Unfortunately, the view-port sent to us sustained damaged, probably during exit from the airplane and could not be repaired at sea. No Alvin dives were made during the cruise.

2.1 Navigation

Navigation of short segments of the DSL-120A survey lines (~4-5 km-long area near the ABE dive areas) and all of ABE surveying was by bottom-moored transponders. Surveyed positions for transponders are listed in Table 2. Transponders were deployed in the two detailed survey areas at 9° 50'N and 9° 28'-29'N. In the 9° 50'N area, we also used 2 permanently installed (expendable) transponders, which have been part of the long-term monitoring of this area (e.g. Shank et al., 1998). Average RMS error for the 11 transponder positions is 0.55 m. Minor adjustment of the positions noted in Table 2 were made based on analysis of the travel times recorded by ABE. The only differences were for transponders J and H (Table2 B.). For J transponder the x-y positions are 5-10m different than those listed in Table 2. For H transponder, the x-y positions are 7-20 m different than those listed in Table 2. Long portions of the DSL-120A survey lines were navigated using a layback scheme employing acoustic travel time, wire out and ship's position. The Hawai'i Mapping Research Group (HMRG) team and shipboard scientists expended considerable effort in re-navigating all the survey lines using a combination of layback and transponder navigated portions of the survey lines to fix the positions of key features in each detailed survey area at 9° 50'N and 9° 28'-29'N.

2.2 DSL-120A Side-Scan Sonar Surveying

Data regarding the logistics of the DSL-120A sonar surveying are presented in Table 3. Acoustic backscatter data were collected on all lowering and the overall quality is excellent, as good or better (visually) than the previous DSL-120 system produced in the past few years (e.g. Scheirer et al., 2000) (Figures 3-12). During the initial lowerings it was necessary to experiment with the correct power levels to produce the most reliable data and minimize the system's tendency to lock-up. Once optimal power-levels were established the sonar was relatively trouble-free and produced excellent backscatter on both sides. Some of the backscatter data collected on the first few lowerings suffered from low signal on one side of the sonar swath. This led us to re-running some of the lines to better image the seafloor features. Data were processed at sea, and charts produced as postscript files and printed on the large-format plotters on the ship. Backscatter data were gridded at both 4m and 2m resolution. Backscatter imagery was also plotted with the 1989 position of the axial summit collapse trough (ASCT) [Fornari et al., 1998]. In most cases, the new ASCT position agrees very well with the old one and provides a temporal sense of the stability of the axial trough over the past 12 years since it was first surveyed using the Argo 100 kHz sonar in 1989 [Haymon et al., 1991; Fornari et al., 1998]. In some places, we believe there is a navigation offset of ~50-70m to the west for the 1989 pick of the ASCT walls. Shifting the old ASCT position this distance is, in most areas, sufficient to have the position coincide with the ASCT location displayed by the new DSL-120A data collected during the cruise. The details of the ASCT walls and individual narrow fissures, especially north of 9° 40'N where they are well-delineated, show excellent correspondence between the 1989 Argo I side-scan sonar and the DSL-120A

backscatter imagery. Areas where ASCT position or details of the sonar imagery appear to not correspond will be a focus of post-cruise data analysis.

Phase-bathymetric data were collected but not processed at sea. There continue to be issues regarding signal-to-noise for the system that need to be resolved in order to optimize the phase-bathymetric data produced from this sonar. It is thought that much of this work will revolve around the modification of the power system for the sonar. However, post-cruise analysis of the phase-data indicates that for the latter lowering, reasonable phase coherence is present and the data can be processed to yield bathymetry. This will be part of the post-cruise data analysis effort by HMRG and WHOI scientists.

One important attitude sensor for the DSL-120A sonar that was not operational is the bottom-lock doppler. This sensor would be used for both altitude information and dead-reckoning information to assist with navigation processing. Efforts are continuing to integrate the doppler into the DSL-120A sonar system. Additional information regarding DSL-120A sonar acquisition and processing are included in Appendix 3.

2.3 Autonomous Benthic Explorer (ABE) Surveying

Operational data for ABE surveys is presented in Table 4 and presented in more detail in Appendix 1. A total of 11 ABE dives were carried out during the cruise. ABE Dives #52-57 were conducted at the 9° 50'N survey area and ABE Dives #58-62 were conducted at the 9° 28'- 29'N site. Detailed maps of ABE data for the detailed survey areas at 9° 50'N and 9° 28'-29'N are shown in Figures 13-18. ABE completed a total of 327 km of bottom tracks over 147 hours. For all track lines, we collected cross-track bathymetry using a scanning sonar (Imagenex - 675 kHz), magnetometer data, and temperature and salinity records using a CTD. On selected track lines, we collected snapshot video images. Two areas were surveyed with a total area of approximately 14.3 km^2, including virtually complete, overlapping bathymetric coverage with lines spaced from 40 to 60 m apart. ABE traversed the seafloor at an altitude of 20-30 m for all the survey lines.

In addition to gathering the desired seafloor geophysical and geological data, we also demonstrated an important new capability for ABE. During many of the dives, we left ABE unattended, transited out of range, and performed other work. These included DSL120A sonar operations, rock coring, and camera tows. We scheduled the other tasks based on projections of the completion of the ABE dive (which entails uncertainty due to variability in power usage that depends on terrain). In each case we arrived back on station either as ABE was completing its track lines or while it was ascending.

2.4 Towed Camera Surveys

Fourteen towed camera surveys were conducted with a leased digital deep sea camera that was modified at sea to operate with high-intensity deep-sea strobes (Benthos 383 system). Locations of the tows are shown in Figures 19-20 and pertinent data for each tow is listed in Table 5. Examples of the digital images are shown in Appendix 2. Various deep sea photographic equipment had been brought on the cruise on a contingency basis. This proved very valuable once it was determined that no Alvin diving could take place. A 35mm camera was readied by the Alvin group to operate as a stand-alone system using a strobe and DeepSea Power&Light (DSPL) SeaBatteries (24VDC/48 amp/hr). Once the digital camera was up and running we decided not to use the 35mm system.

On a parallel path, the Aquapix digital camera (leased from Dr. Ian Macdonald of Texas A&M University) was worked on by Al Duester of the ABE group. Prior to the cruise we had the engineer responsible for developing the Aquapix camera (a Nikon 990 Coolpix consumer grade camera in a DSPL housing), Mr. Mark Roberts of Harbortronics LLC, Gig Harbor, WA, install an intervalometer in the camera so that it could be triggered every 15 seconds in remote mode. The camera was equipped with a 500MB CompactFlash memory card.

A. Duester was able to successfully modify the Aquapix camera to trigger the deep sea strobe system. Andy Billings and Rod Catanach of the ABE Group modified a fiberglass time-lapse camera frame that D. Fornari had placed on the ship as the frame for the towed system. The digital camera system employed a 12 kHz pinger to provide distance above bottom. The camera was flown successfully at ~5-7 m altitude during each lowering. Image quality was excellent and approximately 500 digital photographs were collected on each lowering. Bottom time for each survey line was ~2hr 11 min. The short survey time was dictated by the capacity of the CompactFlash card and the fact that the start of the imaging took place when the system was powered–up on deck prior to deployment. No delay function was possible. The digital photographs provided an important capability to preliminarily ground-truth specific contacts displayed in the DSL-120A sonar data and the ABE near-bottom magnetics and micro-bathymetry maps.

2.5 Rock Coring

A total of 42 rock cores were collected in the detailed survey areas near 9° 50'N and 9° 28'-29'N. Station location data are shown in Table 6. Rock cores were located on specific features displayed in the DSL-120A backscatter imagery and/or ABE magnetics and micro-bathymetry maps. Geochemical analyses of the samples will be done by M. Perfit (U. Florida) [major and trace-element chemistry], K. Sims (WHOI) [U-series disequilibria], and M. Kurz (WHOI) [He isotopes].

On several deployments of the towed camera we experimented with rock core head designs to see how effective glass chip collection would be during camera tows that were equipped with deployable rock cores. This is part of a separate NSF funded equipment development project that Fornari is the PI on. A. Billings designed several different types of heads and glass we recovered on each deployment. Because we know that the head hit several times during the tow no unique position is available for these samples so they were cataloged separately from the normal rock cores (see Appendix 2 for photographs of the core head design).

3. Preliminary Data and Interpretations

3.1 DSL-120A Magnetic Data

A 3-axis magnetometer was installed on the DSL-120A sonar fish for all lowerings. Data from the sensor were successfully recorded along with relevant attitude data that will permit analysis for near-bottom magnetic anomalies. The data are part of a WHOI graduate student's Generals Project (C. Williams), so other than verifying the integrity of the data and the requisite attitude and navigational information, no other shipboard processing was carried out. The data will be processed and analyzed on shore in the coming year. These data provide an intermediate scale of magnetic anomaly variation and will allow us to link the two detailed study areas at 9°50'N and 9°29'N together.

3.2 ABE Near-Bottom Magnetic Data

Magnetic anomaly field data were collected by ABE in two areas: at 9° 50'N covering the axis and the east flank, and at 9° 29'N covering both east and west sides of the axis (Figures 13-18). The northern survey area covers ~2 km along the axis and extends to ~2.5 km east of the axis. The southern area covers ~1.5 km along the axis and extends from ~2.5 km west of the axis to ~2 km east. Magnetic field and micro-bathymetry data were collected at 30 m altitude above seafloor except for ABE dives 55, and 56 in the southeastern section of the northern area, where the altitude was 20 m.

The observed total field data were calibrated for the effects of the ABE vehicle and then interpolated onto a 15 m spaced grid. The regional magnetic field based on the 2000 IGRF was removed from the data to obtain the magnetic anomaly field. The anomaly field data were upward continued from the uneven observation plane to a level plane above the topography and then reduced to the pole (RTP) to remove the skewness effects of latitude. The reduction to the pole requires bordering of the data and while the complete central anomaly was imaged in the southern 9°29N study area, the northern study site only encompasses the eastern half of the anomaly and thus bordering is a little more suspect in this case. It is anticipated that inversion for crustal magnetization will show similar correlation as seen in the RTP anomaly maps.

The magnetic field in the 9° 50'N area is extremely linear parallel to the axis and very much reflects the 1994 Alvin 2771 profile collected at 9˚50'N [Schouten et al., 1999]. The field contains a consistent narrow magnetic low with flanking highs over the ~2 km of axis imaged in the survey. The eastern edge of the CAMH lies consistently at 1.7 km from the axis and is extremely sharp and unexpectedly linear. It does not follow the morphology. The sharpness of this edge, known from Alvin dive 2771, could not be modeled with steady state lava deposition (i.e. a gradational boundary). A more punctuated form of lava deposition was suggested [Schouten et al., 1999]. Near the location of the CAMH edge, camera tows #5,# 6, and #9 show clear contact between relatively unsedimented lavas to the west and heavily sedimented flows to the east. We suspect the punctuation is the result of an active normal fault mostly buried beneath the recent lava flows in the area (immediately south of the area this normal fault is continuous over several kilometers in the side-scan records).

The magnetic field in the 9°28'-29'N area is extremely asymmetric (we have no such comparison in the northern area, which covers only the eastern flank). The western part of the CAMH is very high with the highest magnetization toward the western edge. By contrast, the eastern side of the CAMH is significantly lower than the western side. The western edge of the CAMH is not straight as in the northern area but appears to follow the scalloped western edge of the flat summit of the EPR at ~1.2 km west of the axis (a lesser, older CAMH edge follows scalloped morphology at ~2.0 km west of the axis). The eastern edge of the CAMH follows along the (faulted) eastern edge of the EPR summit at less than a kilometer from the axis. In contrast to the volcanic constructional character of the western edge, the eastern edge of the flat EPR summit at less ~<1 km from the axis appears to be controlled by outward facing scarps that bound a trough floored by heavily sedimented flows. Where substantial volcanics flowed over the eastern edge and locally filled an adjacent trough, the CAMH follows the zone of younger volcanic infill (Figure 17c).

The axial summit collapse trough (ASCT) at 9°28'-29'N is also marked by a magnetization low but it is not as well developed as in the northern study area. A more

significant linear low is found associated with the off-axis trough located 800-900 m west of the ASCT. This graben is, 50-100 m wide and 4-6 m deep, and is floored with unsedimented curtain folded sheet flows The relative amplitudes of the CAMH in the 9°28'-29'N area correlate with what we can glean from side-scan and micro-bathymetry. Side-scan data show a profusion of dendritic patterns indicating voluminous lava transport westward from the axis, but not eastward. This agrees with the western rim of the axial trough being several meters deeper than the eastern rim. Near the western edge of the flat EPR summit, scalloped patterns in the side-scan and micro-bathymetry indicating lava flow fronts and suggesting massive lava deposition dominate. This agrees with the highest magnetization at this location. The next highest magnetization is over the dendritric patterns immediately west of the axis indicating lava transport (but not so much deposition). The lowest magnetization is found over the flat summit east of the axis where side-scan data show a predominance of fissuring and faulting indicative of relatively lower lava depositional activity compared to that of the western flank. Camera tows, in general confirm, the direct correlation between CAMH and the younger volcanics, which define the neovolcanic zone. Together, these observations all clearly demonstrate that the detailed magnetic character of the CAMH is primarily controlled by the distribution of volcanic accretion.

3.3 DSL-120A Side-scan Sonar Data

The key preliminary observations from the sonar data are:

1) The synoptic view afforded by the DSL-120A backscatter data is that the ridge axis is dominated by the scalloped acoustic reflectors, which we infer to be lava flow surfaces and flow fronts. This is primarily evident in the near axis terrain from 9° 55'N down to 9° 27'N, and extending outward from the axial trough to variable distances - usually 1-1.5 km on either side of the trough. The EPR crest over the mapped region shows extensive re-paving by successive volcanic flows as evidenced by scalloped flow-front margins consistent with eruptions originating from the axis and flowing onto the upper rise flank out to ~2 km. There are very few faults within ~2 km of the ASCT, but we note they are more evident south of the 9° 37'N OSC [Smith et al., 2001]. Most of the faults are low relief (<~10-20m) based on sonar shadow geometry and ABE micro-bathymetry data, and all but one trend nearly parallel to the N10°W trend of the EPR axis in this area.

2) The trace of the ASCT over the 55 km area mapped shows excellent correlation to detailed features mapped in 1989 using Argo II [Haymon et al., 1991; Fornari et al., 1998], and in 2000 using the old DSL-120 sonar [AHA-Nemo2 cruise, Fornari et al., 2000]. In some cases the trough position from 1989 is offset but the overall shape is consistent with the sonar reflectors in the 2001 data suggesting that a small (50-100 m) DC shift would correct the problem. This offset will be further investigated during the shore-based analyses.

3) There are numerous indications of dendritic flow channels emanating from the ASCT in various sections of the ridge axis principally in the 9° 50'N, 43'-45'N, 37'N, and 26'-29'N areas. In some cases, we confirmed, with the towed camera imagery, that the channels are floored by smooth-surfaced sheet flows, which originate from the ASCT over areas as great as ~ 5 km (along strike in the 9° 26'-29'N area), and coalesce away from the trough at distances of ~500 m to <1000 m. Spacing between these areas of inferred sheet flows can be from a few hundred meters to several kilometers. These features are key areas where

ground truth observations and sampling are required and where we hoped to focus our Alvin dives.

4) Fields of ~10-30 m high lava mounds or ridges, several hundred meters wide and up to ~1 km long, occur at distances of >1.5 km from the ASCT and in some areas are concentrated at ~2-2.5 km in the region between ~9° 53'-57'N, 9° 43'-47'N and 9° 31'-34'N on the east side of the axis, and at 9° 43'N, 9° 35'-36'N west of the axis. At times the pillow mounds appear cut by faults and fissures, while in some areas their construction appears to be younger than the tectonic features they overprint.

5) The region of the ASCT between 9°26'-29'N appears very different between the DSL-120 sonar data collected last year on the Melville cruise (AHA-Nemo2) and this year's sonar imagery. Specifically, over this ~5 km region, the ASCT looks much more subdued in this year's data. Relief on the splayed ASCT walls appears to be much less and the trace of the ASCT is absent from ~9°26'N to 9°27'N. The spatial coincidence of this anomaly in the ASCT trace and the extensive area of apparent sheet-flows and lava channels cascading to the west, across the ridge crest is striking. Based on a preliminary analysis of the old 1989 Argo sidescan sonar data, it does not appear that the extensive sheet flows or lava channels are present. However, the narrow (300m) swath width of those data, and the fact that the 1989 survey lines were run very close to the axis makes a definitive assessment difficult. We intend to continue to investigate differences between 1989 Argo sonar and2000- 2001 DSL-120 a side-scan sonar data throughout the EPR crest between 9° 57'-27'N. Given the nature of the sonary imagery, our working hypothesis is that there has been a recent eruption in this area; possibly even as recently as the past 18 months. This is one area that will be a focus of several Alvin dives to investigate the nature of these flows, how they terminate to the west, and the character of the walls and floor of the ASCT in this region.

6) The 9° 26'-29'N area is also striking in the asymmetry between the western and eastern sides. The west side is dominated by a wide (~2 km) constructional volcanic terrain of scalloped flow fronts, sheet flow channels near the ASCT, and highly reflective lava surfaces, while the east side has a much narrower constructional zone (~1 km). The seafloor area east of the near-axis flow fronts is dominated by sedimented seafloor with occasional lava outcrops (mottled acoustic reflectivity), finely fissured terrains and fault scarps, and pillow mounds which show variable degrees of tectonism.

3.4 ABE Micro-Bathymetry Data

Imagenex 675 kHz pencil-beam altimeter data were combined with ABE pressure depth data to produce micro-bathymetry for the detailed survey areas at 9° 50'N and 9° 28'-29'N (Figures 13 and 16). Data were gridded at 5 m and contoured at 1 m. Post-cruise data processing will be done to determine if the grid interval can be reduced while still maintaining the integrity of the data resolution.

The micro-bathymetry maps correlate extremely well with the DSL-120A sonar imagery. Areas of scalloped, high-amplitude backscatter on the sonar imagery conform with areas of tight contours in the micro-bathymetry and in general, flow surfaces identified based on continuity of backscatter reflectivity are consistent with lava flow lobes mapped in the micro-bathymetry. Regions of collapsed lava flow surfaces and the ASCT are also very well

depicted in the micro-bathymetry (Figure 13b), and correlate strongly with mottled reflectivity in the DSL-120A sonar data.

Post-cruise analysis will be dedicated to correlating micro-bathymetry with specific reflectivity units in the DSL-120A data to get a first-order assessment of lava flow units and dimensions. Detailed analysis will seek to establish limits of lava flow margins, slopes and collapse dimensions/characteristics at various scales over the detailed survey areas. Collecting lava samples from specific outcrops along flow margins is critical to establishing these relationships.

4.0 Establishing Field Relationships – Planned *In Situ* Observations and Sampling

Our funded research consists of a three-part survey strategy: 1) detailed sonar imagery using the DSL-120, 2) ABE for near-bottom magnetics and 3) Alvin for visual observations and sampling. One critical element of our plan is visual observations and sampling across seafloor volcanic and tectonic contacts, so that positive geological relationships can be established between the sonar data and ABE near-bottom magnetics and micro-bathymetry. We have listed below our priorities for how we would utilize Alvin dive time to complete our field studies.

As demonstrated by the maps and figures in this report, the DSL-120A side-scan imagery, and ABE micro-bathymetry and magnetic data collected during the AT7-4 cruise are superb. These data define the spatial distribution and occurrence of volcanic accretion on the flanks of the EPR. However, the definitive ground truth of these observations remains to be done. The loss of the Alvin dives due to the view-port problem meant that on the AT7-4 cruise we lost the ability to carry out an essential component of the proposed work. As stated in our proposal, this was "…to confirm geologic features and volcanic contacts *inferred* from the side-scan and magnetic observations", and "…to sample the lavas for paleomagnetic and U-series analyses to calibrate the lava magnetization vs age function we use to invert the near-bottom magnetic field for lava deposition." (Schouten et al., NSF CAMH proposal, p. C12).

In-situ observations are required to provide the documentation and geological context for sampling terrains that represent the three general components of the proposed lava deposition model. They are:

1) the spatial relationship between the volcanic accretion zone, as displayed in the side-scan sonar data and micro-bathymetry, and the magnetic data as displayed by the CAMH anomaly character and location,
2) the lava emplacement mechanisms over variable distances from the axis (100s to 1000s of meters) and their subsequent deposition patterns and relationships,
3) the existence and relative importance of off-axis eruptions as deduced from the DSL-120A side-scan sonar imagery and micro-bathymetry.

The 10 Alvin dives we hope to carry out are basically split between the two study areas at 9° 50'N and 9° 28'-29'N. All the dives will be tasked with systematically sampling specific features in the volcanic terrain displayed by the sonar and micro-bathymetric maps, to recover rock samples for geochemical, paleomagnetic and U-series analysis. We will build a database of *in situ* observations that will allow us to quantitatively relate seafloor features at meter-scale to the mapped acoustic facies (e.g. to assess the various types of backscatter response in the DSl-120A imagery which include sediment cover, sheet flows and channels, lobate flows,

pillow flows, etc). Finally, Alvin underway magnetic field data will be collected to augment the ABE and DSL-120A magnetic field data. This information will provide the link in continuity between the various scales of measurement. What follows is a brief description of the objectives for the diving in each of the two study areas. The objectives are related to the map-based data in Figures 23 and 24.

4.1. EPR 9° 50'N Area Dive Objectives

Objective 1: (Fig 21, B area on map) *Locate lava flow(s) boundary(ies) and flow fronts as suggested by Camera Tows#5 and #6, to characterize the volcanic and tectonic relationships of this region and its relationship with the magnetic CAMH edge-anomaly. Determine the extent to which this boundary is fault related.*

Several traverses of the flow fronts and region over which the CAMH anomaly is present are needed for sampling and detailed magnetics measurements from Alvin. What is the nature of this boundary: is it a flow front? Is there evidence of a fault damming the lava flow? Is there tube fed flow? Was lava transported from the axis, or is there evidence of off axis eruption? What is the apparent delta-like distribution of lava caused by: fast sheet flow spreading out after the slope change? Make detailed magnetic crossings of the boundary to confirm the correlation between flow edge and magnetic field. Magnetic crossing of outcrops : determine intensity/direction (inclination) of magnetization (is there any tilting?).

Investigate the normal fault scarp in DSL-120A side-scan sonar (arrow in Fig 21C), ABE micro-bathymetry (1-3m throw) and Camera tows #5 and 6, that appears to run along the extremely straight eastern magnetic edge anomaly mapped with ABE. The small fault scarp is continuous over ~2km on the side-scan records immediately south of the area.

Objective 2: (Fig 21, A area on map) *Investigate the scalloped morphologies clearly imaged in the side-scan and micro-bathymetry maps that coat the flanks of the EPR axis. Determine their origin and volcanogenic setting and relationship to magnetic and age contrasts.*

We infer that the scalloped morphologies are lava flow fronts that result from single or multiple eruptions from fissures along the axis or directly in the ASCT. The limited camera tow coverage suggest that these flow fronts consist of pillow lavas followed by lobates fed from sheet flows. The most frontal facies are pillow cylinders or tubes that occasionally extrude from the front on top of older lobates and sheet flows. Why do these scalloped areas have the ubiquitous semi-circular geometry? Are they in fact one eruption event? What is the nature of the lava distribution system that builds these scalloped features? We plan to document and visually image these features and sample across them. Dive traverses will be planned to follow flow units “upstream” to see where the flows are sourced. A key volcanic process question is whether the flows spread in a sheet-like flow behind an advancing front or by channels or tube fed flow?

Objective 3: (Fig 21, A area on map) *Investigate the nature and origin of prominent lava channel networks found on the EPR crest.*

What is the genetic origin of these channels? Are they channels with levees or collapsed tube systems? How far can they be followed from the axis? Do they begin at the ASCT? Is there any evidence to suggest that these channels have been used more than once? What is the relationship between these channels and the scalloped lava flow fronts? Determine the extent to which lava channels form the major distribution system for the accretion of lava

on the flanks of the EPR axis. The relationship between lava channels and the scalloped flow morphology is of critical importance in understanding the accretionary history of this spreading center, and by analogy, many MOR crests.

Objective 4: (Fig 21, C area on map) *Dive on the western flank of the EPR crest to document and contrast why the side-scan data show markedly fewer lava channels there than on the eastern side.*

We plan to investigate this by diving in the ASCT at 9° 50.3'N and following the major channel that breaches the west wall of the ASCT at this location and trends to the west into the scalloped lobate lava terrain. What is the origin of this channel: is it a flow channel or a collapsed tube? How does the channel terminate: with a continuing tube system or a flow front? Why is there an absence of channels west of the ASCT? Are they simply covered over by more recent volcanism or filled with talus from collapsed flows? Can we see evidence for skylights in the lobate lava flows which would suggest buried lava tubes?

4.2. EPR 9° 28'-29'N Area Dive Objectives

Objective 5: (Fig.22, B area on map) *Determine the origin, nature and relative age of the axis parallel Western Trough, ~800 m west of the ASCT.*

A single video traverse with ABE at 9˚28.3'N show very fresh curtain folded lava flows cut by a ~0.5m wide open fissure that trends parallel to the trough (~352°). ABE temperature data show no anomalies along surveyed length of trough. The trough correlates with a near-bottom magnetization low implying a nonmagnetic root zone consistent with the presence of a dike keel. We would investigate the geological and age relationships of the trough with the surrounding terrain. The N-S variations in the extent to which lava channels are cut by the Western Trough, or may overflow it must be investigated to determine the volcanic and relative age relationships of this prominent feature with the recent eruptions on the EPR crest in this area. Do lava flows from the present ASCT flow over the walls and floor of this trough or are they cut by it? Is there evidence of flow along the trough floor? Do flows to west of trough source from this trough or can they be traced to the ASCT flows? Is the trough undergoing active extension? Is the trough simply an axis-parallel graben acting as a gutter for channeling lava coming from the axis toward a point of overflow at northern end of survey. Is the trough a currently active secondary spreading center or is it a formerly active primary spreading center (a.k.a. abandoned spreading center). We would also investigate the channeled terrain between the present-day ASCT and western trough: are the channels: lava flow channels or collapsed tubes? Is there evidence of multiple flows having used the channel system. Do channels bury other channels?

Objective 6: (Fig.22, A area on map) *Investigate and sample the scalloped nature of the side-scan and microtopography on the western flank.*

Similar to objective #2 in the 9° 50'N area. Here, we would investigate the origin, nature and age relationships of these prominent scalloped features. The western flank in this area shows a remarkably clear correlation with magnetic anomaly highs (Figure 22). We wish to confirm this correlation with *in situ* observations.

Objective 7: (Fig.22, C area on map) *Eastern flank.*

Drive over the eastern wall of the ASCT to determine the collapse versus structural nature of this boundary. Investigate the asymmetric nature of the ASCT walls in this area that appear to have played an important role in distributing recently erupted lava mostly to the west of the ASCT. We would follow flows down to eastern "cement pond" trough (Figure 22). Confirm the direction and flow of lava. What is the "cement pond" floored by: sediments or lava? Camera Tow #14 suggests that it is a combination of both. Investigate the contacts at the margins of the "pond", especially at the northern end where a major flow crosses and fills the "pond". We would compare these flows with the material that floors the "pond". This feature in particular shows another remarkable correlation with the ABE magnetic data and strongly suggests that the magnetic field data do, indeed, reflect the volcanic accretion patterns. Sample and make magnetic traverses using Alvin across several of the "pond" boundaries. Determine the relationship between the magnetic boundary and observations *in situ*, and collect samples for geochemical and paleomagnetic analyses.

Objective 8: (Fig.22, C area on map) *Determine the onset of faulting on eastern flank.*

The eastern flank of the EPR here contrasts sharply with the western flank in that it appears to be dominated by tectonic activity in the form of small-throw normal faults parallel to the EPR axis. By conducting traverses across the far eastern flank, off-axis, we would investigate the origin and timing of the faulting: is it syn-volcanic or post volcanic? Do flows butt up against the faults or are they cut by them?

Objective 9: (Fig.22, A area on map) *Off axis lava mounds on western edge of survey area.*

Mound-like volcanic features are found off-axis in a number of locations along the EPR between 9° 57'-25'N. We believe these mounds formed off-axis via fissure eruptions located ~>500-2000 m from the current ASCT. We need to better characterize these volcanic mounds and determine their history and sample lava from them. Are these mounds formed off-axis? We plan to sample and investigate geological, geochemical and age relationships of these mounds with the surrounding terrain.

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Figures

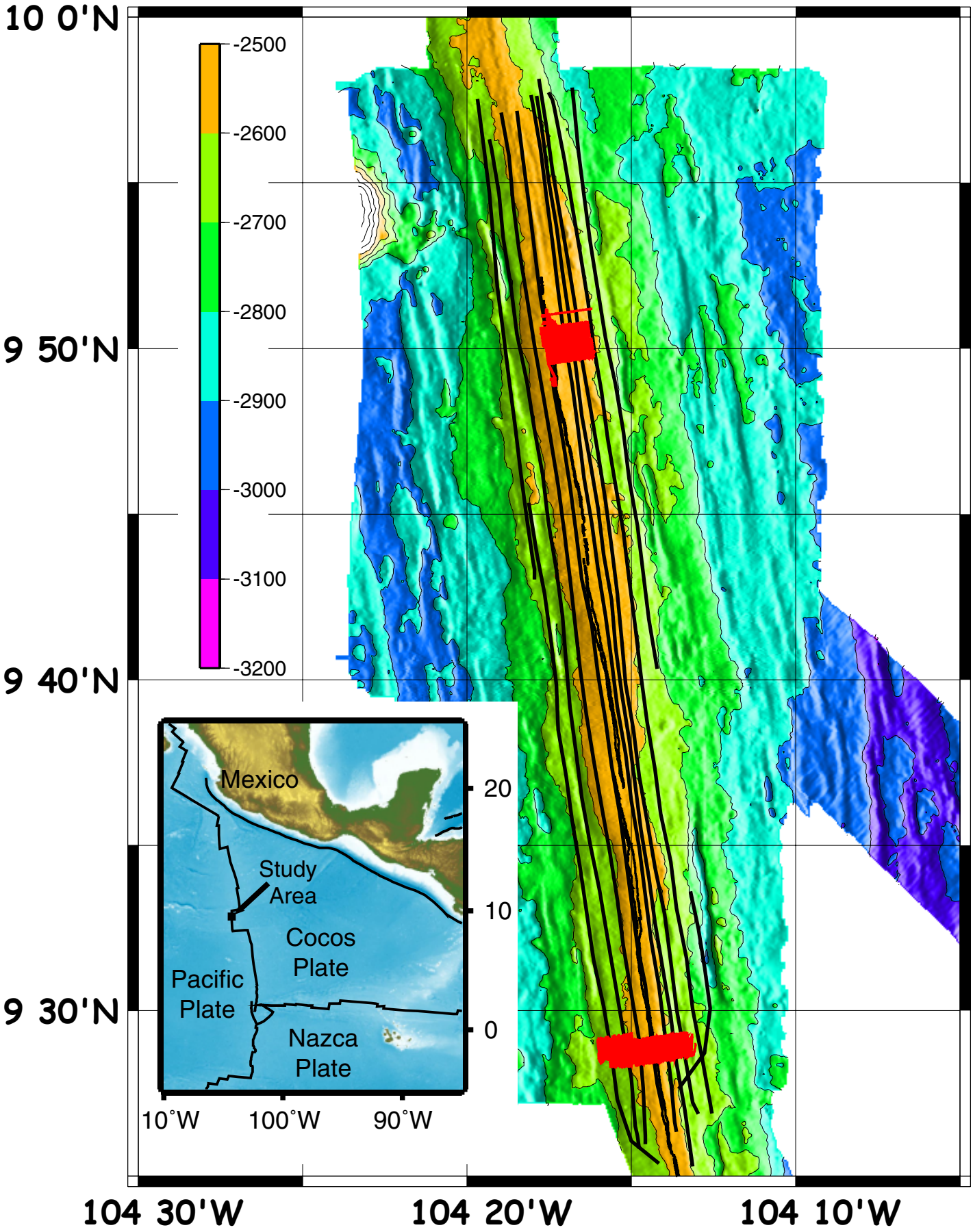


Fig 1. Location map showing relationship of study area on the EPR to plate boundary in the eastern Pacific (inset). Large map shows DSL-120A sonar tracklines (black) and ABE tracks over multibeam bathymetry from Cochran et al. (1999). Contours in meters.

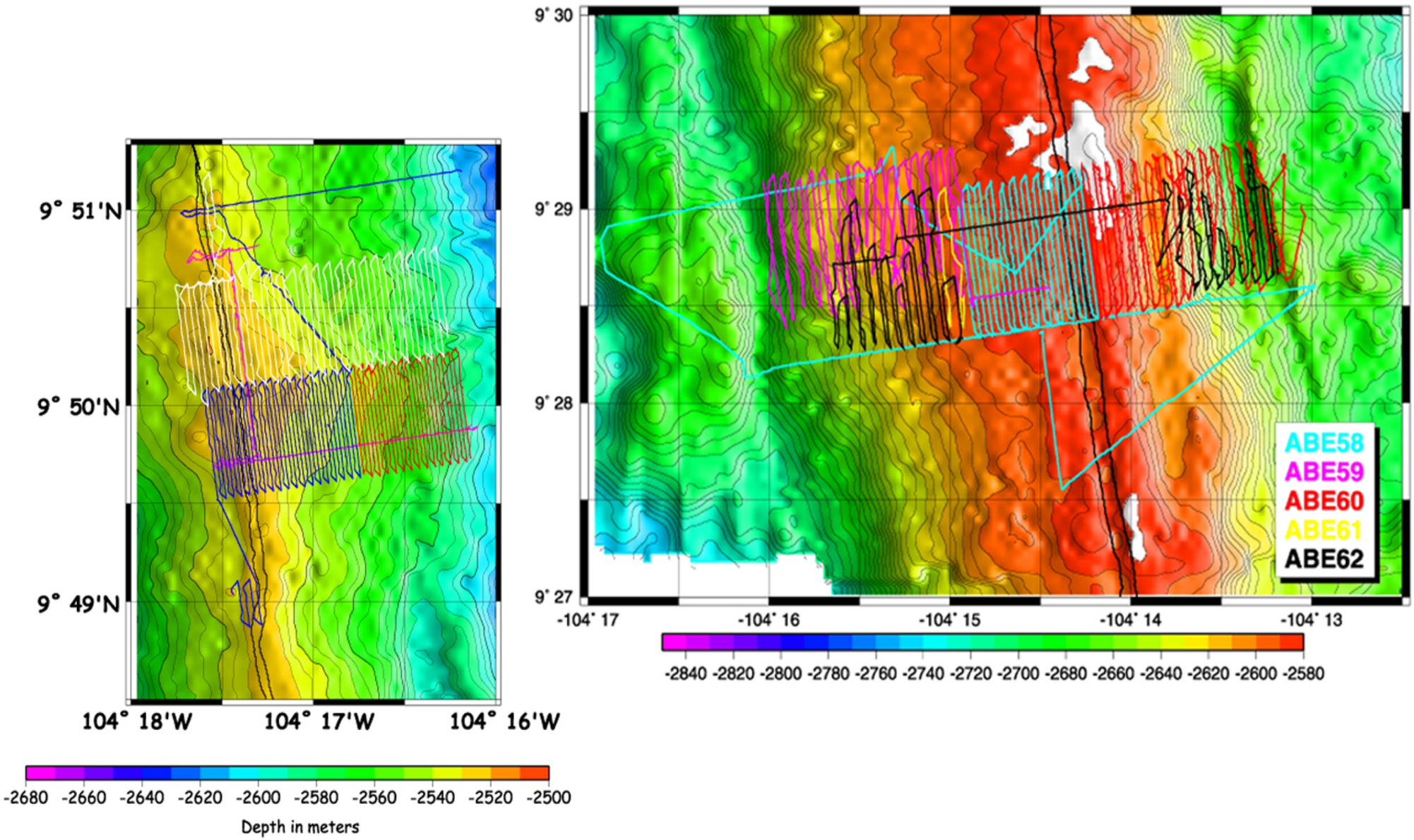


Figure 2. (left) ABE tracks for the EPR 9° 50'N detailed survey area (magenta=Dive#54, red=Dive#55, blue=Dive#56 and white=Dive#57. (right) ABE tracks for the EPR 9° 28'-29'N detailed survey area. Dive tracks per inset key. Bathymetric conours based on multibeam bathymetry from Cochran et al., 1999.

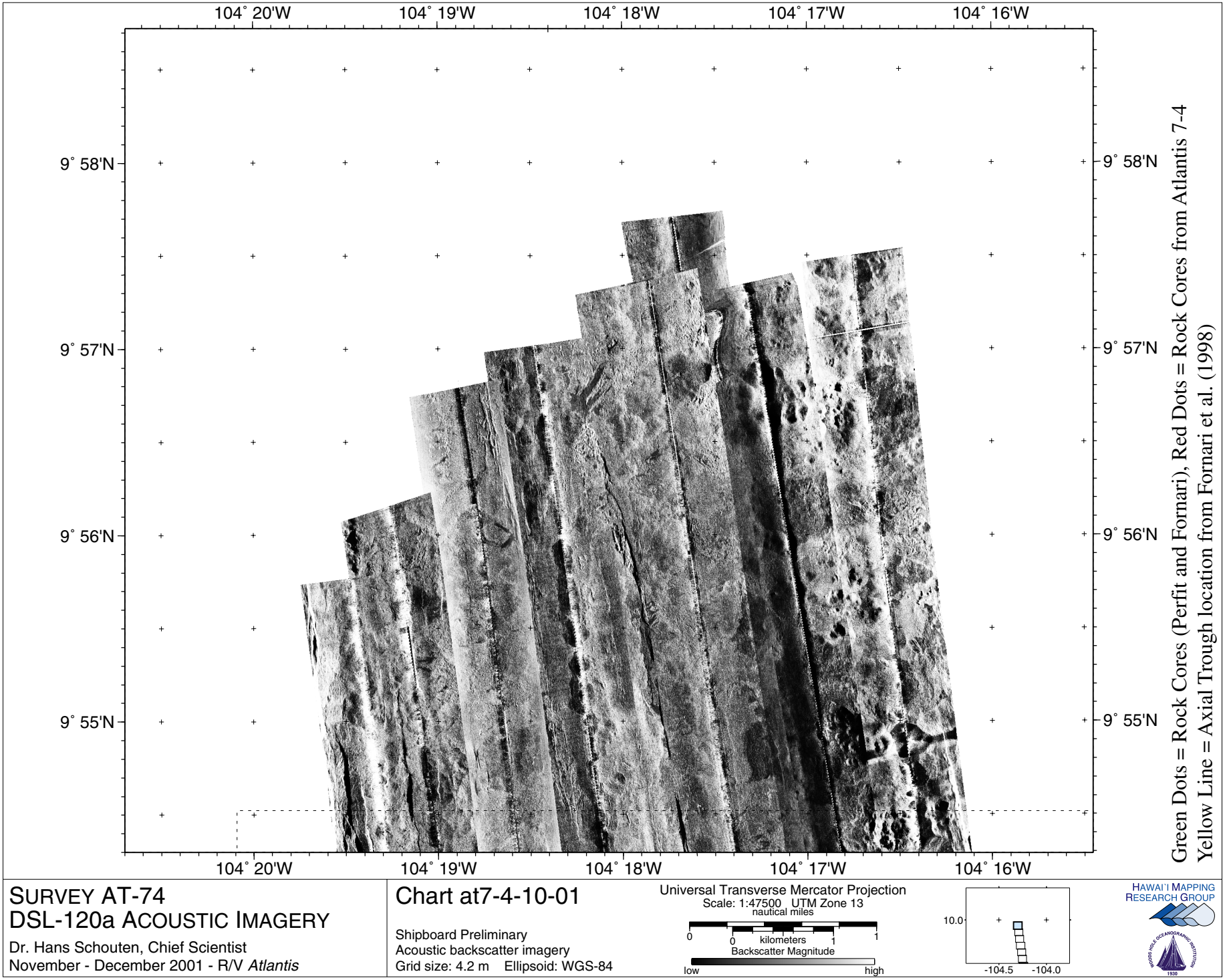


Figure 3. DSL-120A side-scan sonar image. White is strong acoustic reflector, gray or black is low reflectivity or acoustic shadow.

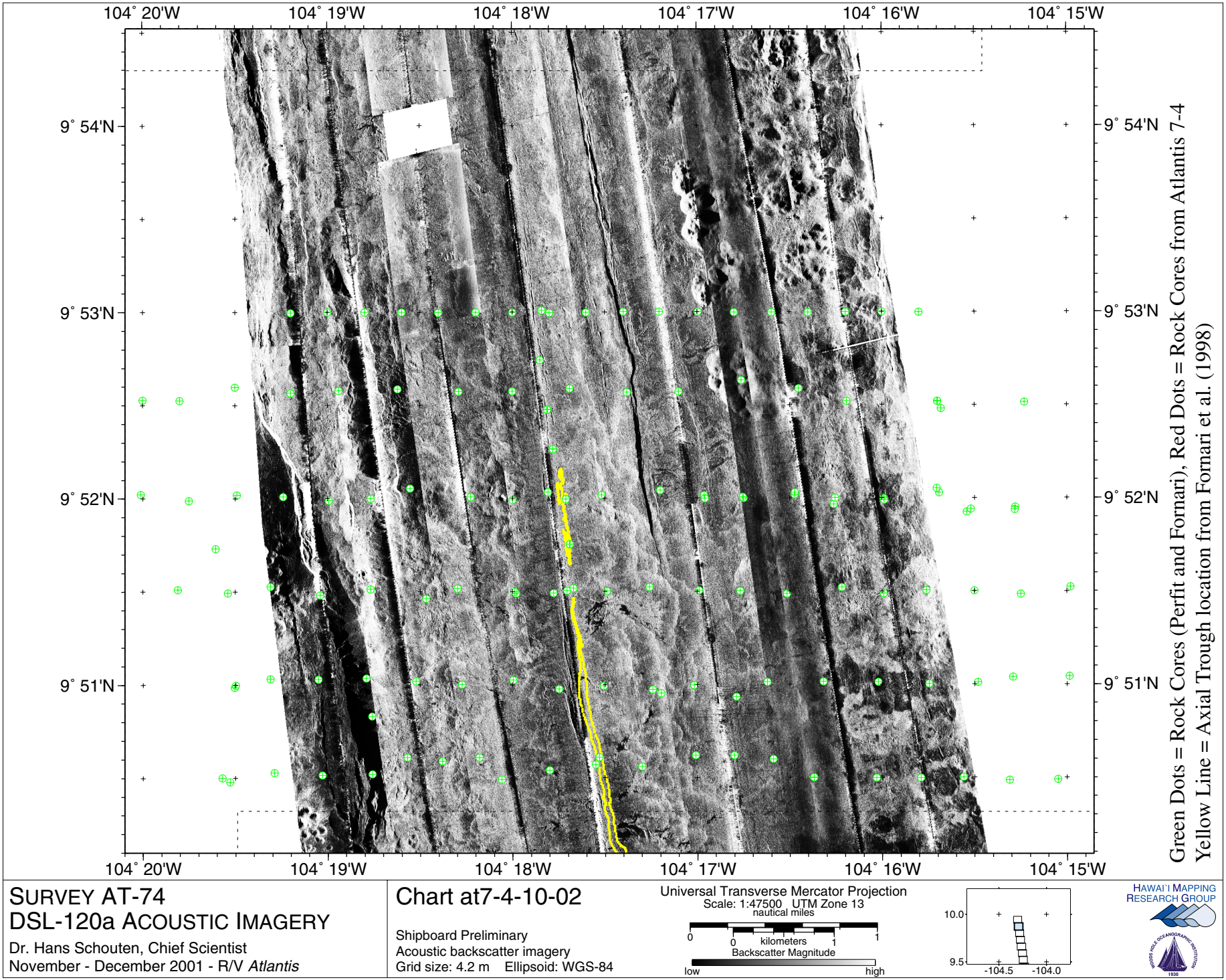
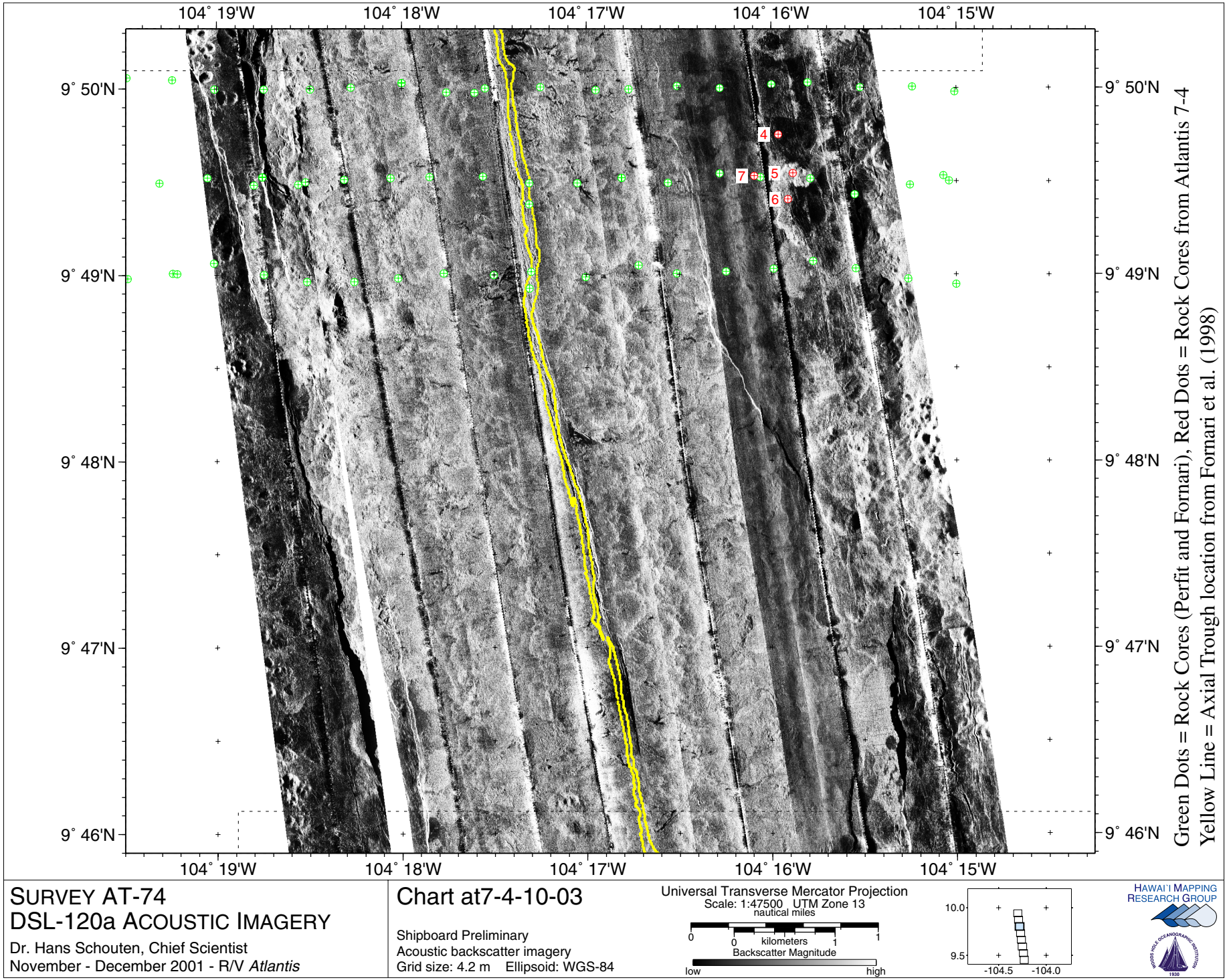


Figure 4. DSL-120A side-scan sonar image. White is strong acoustic reflector, gray or black is low reflectivity or acoustic shadow.



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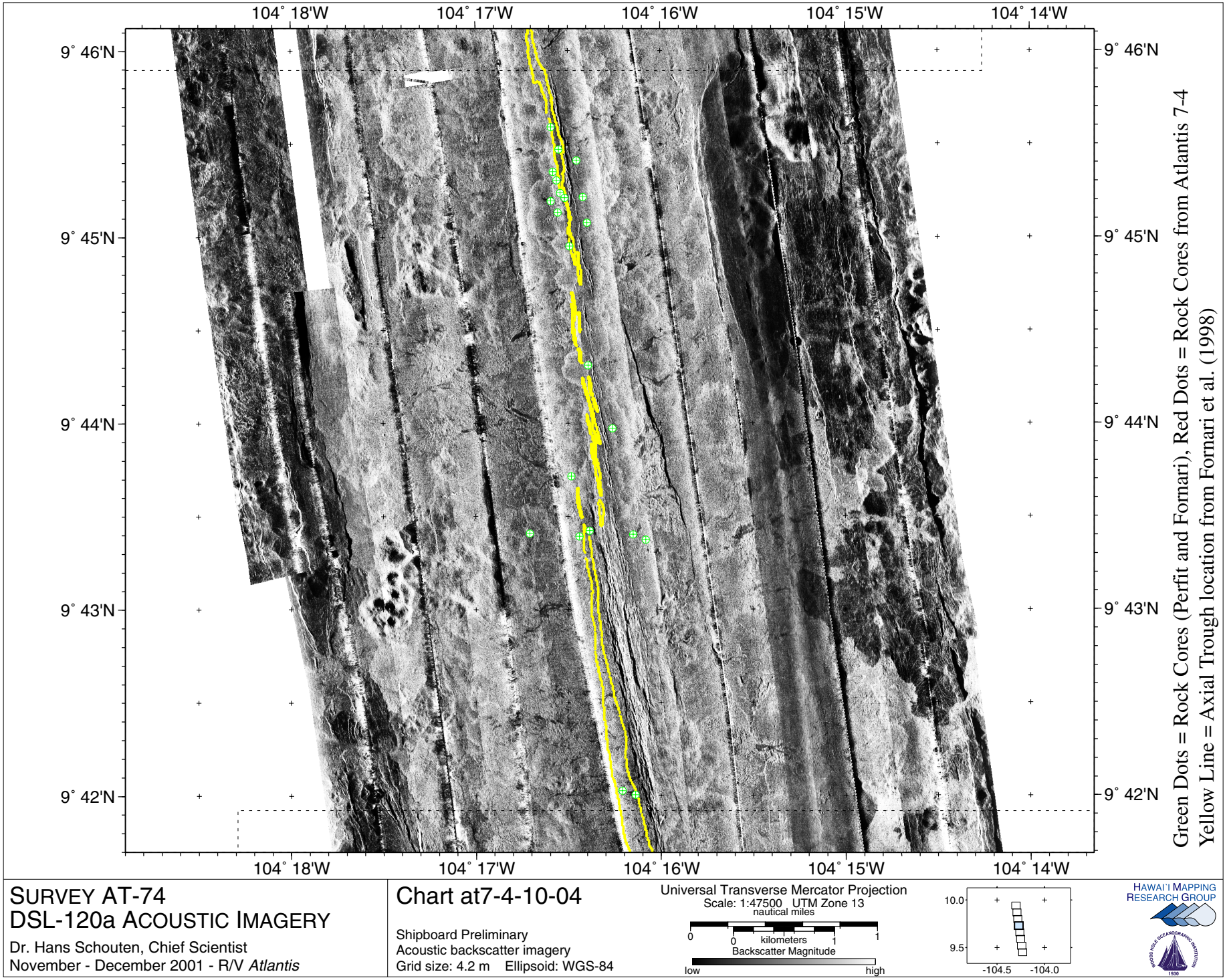


Figure 6. DSL-120A side-scan sonar image. White is strong acoustic reflector, gray or black is low reflectivity or acoustic shadow.

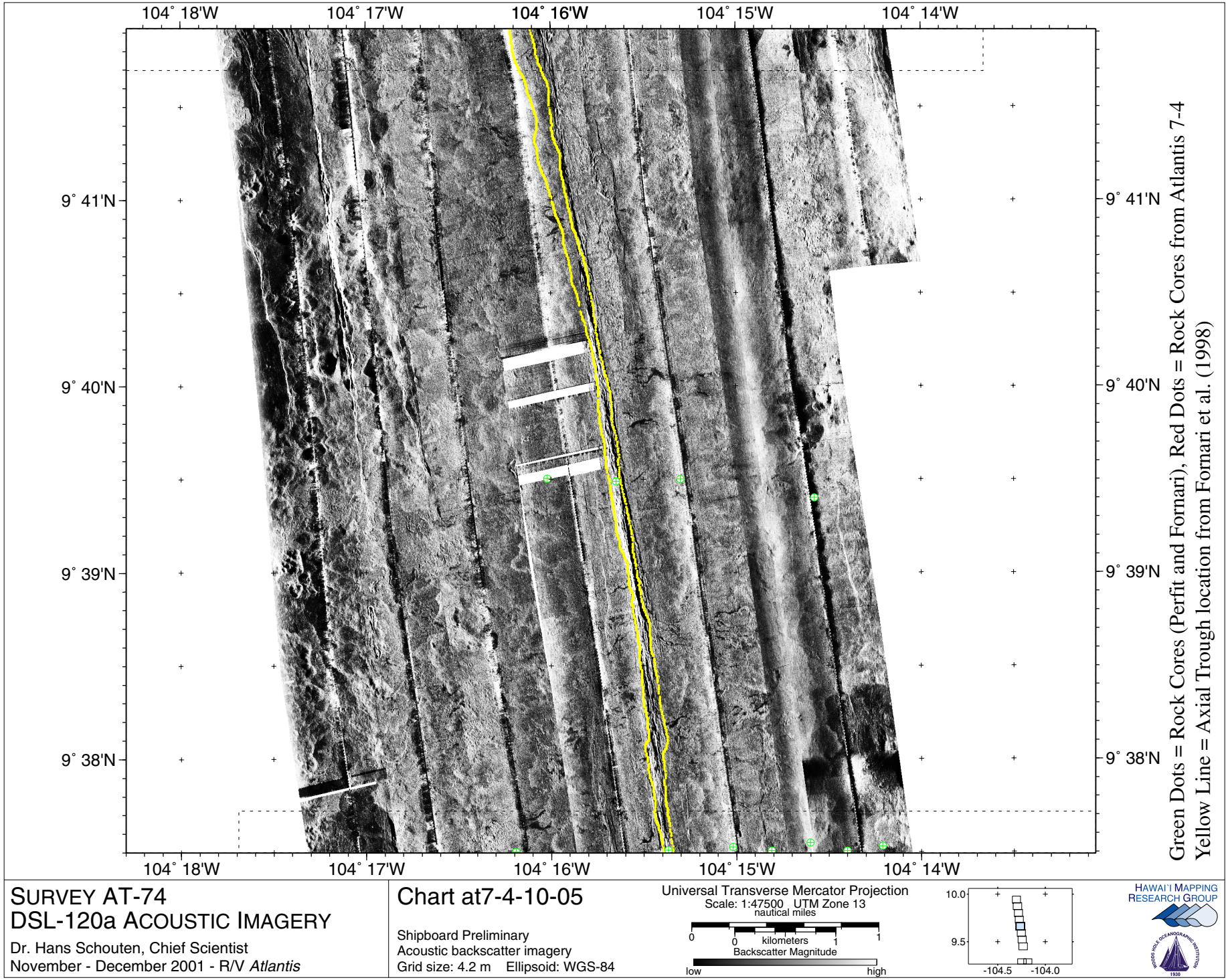


Figure 7. DSL-120A side-scan sonar image. White is strong acoustic reflector, gray or black is low reflectivity or acoustic shadow.

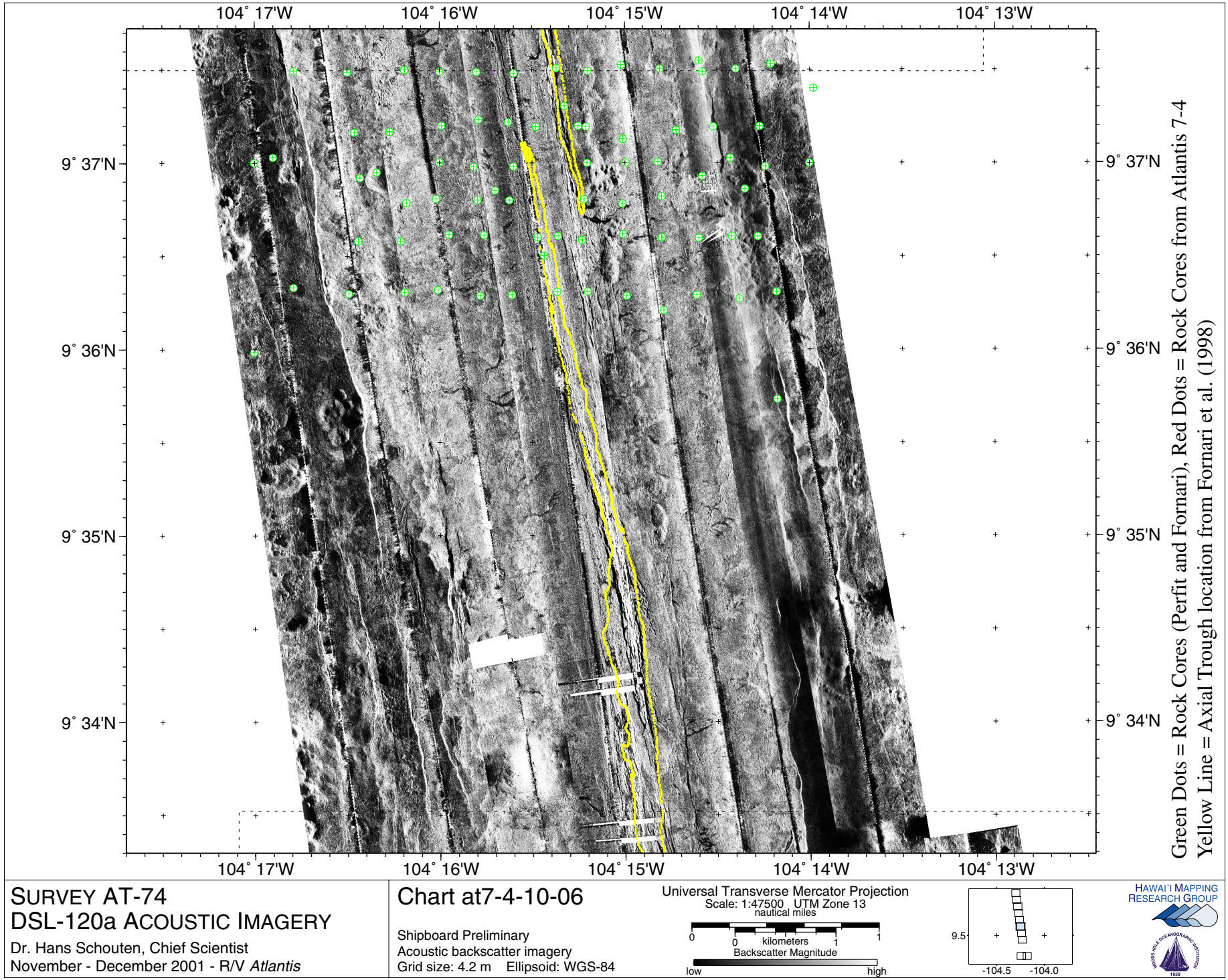


Figure 8. DSL-120A side-scan sonar image. White is strong acoustic reflector, gray or black is low reflectivity or acoustic shadow.

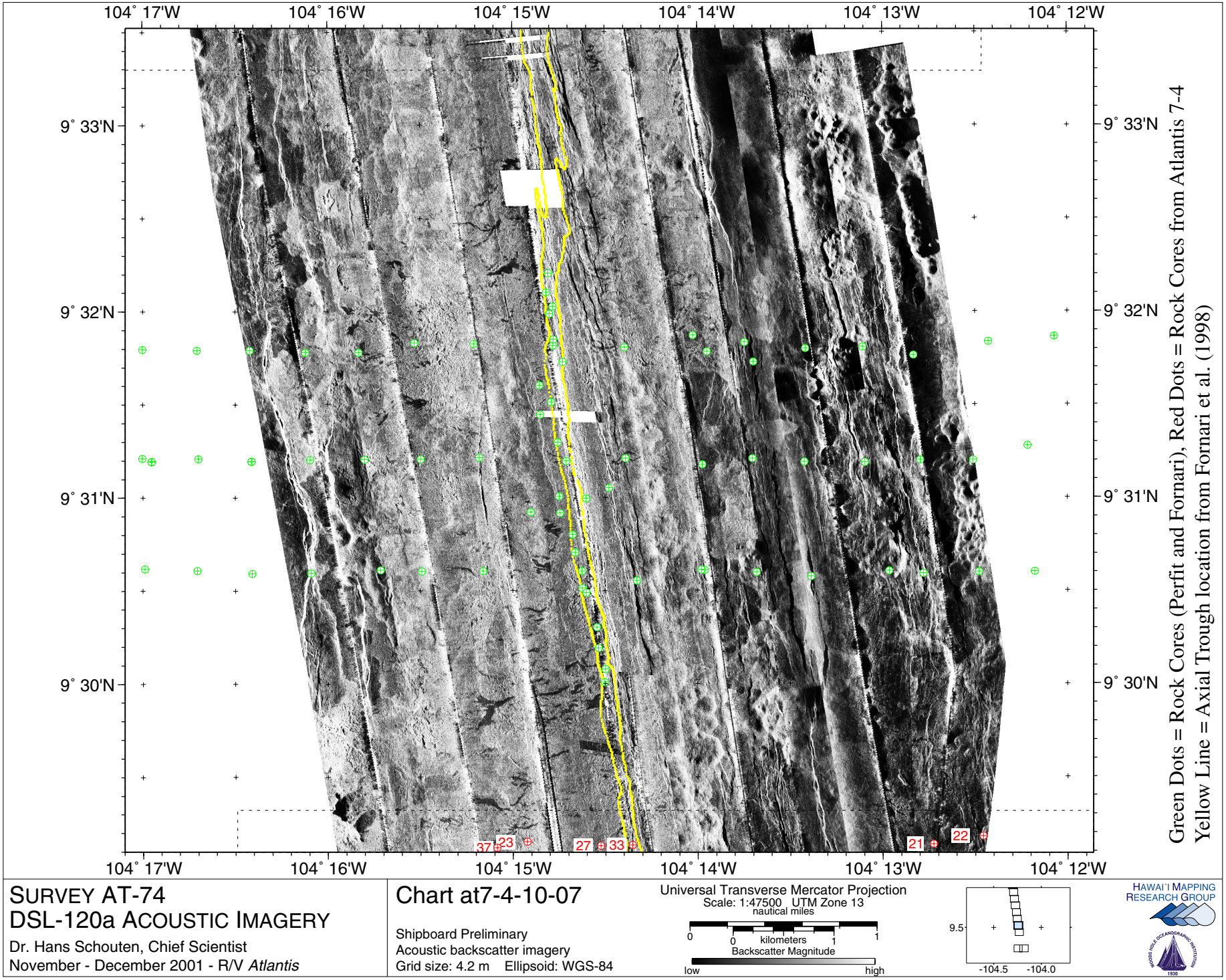


Figure 9. DSL-120A side-scan sonar image. White is strong acoustic reflector, gray or black is low reflectivity or acoustic shadow.

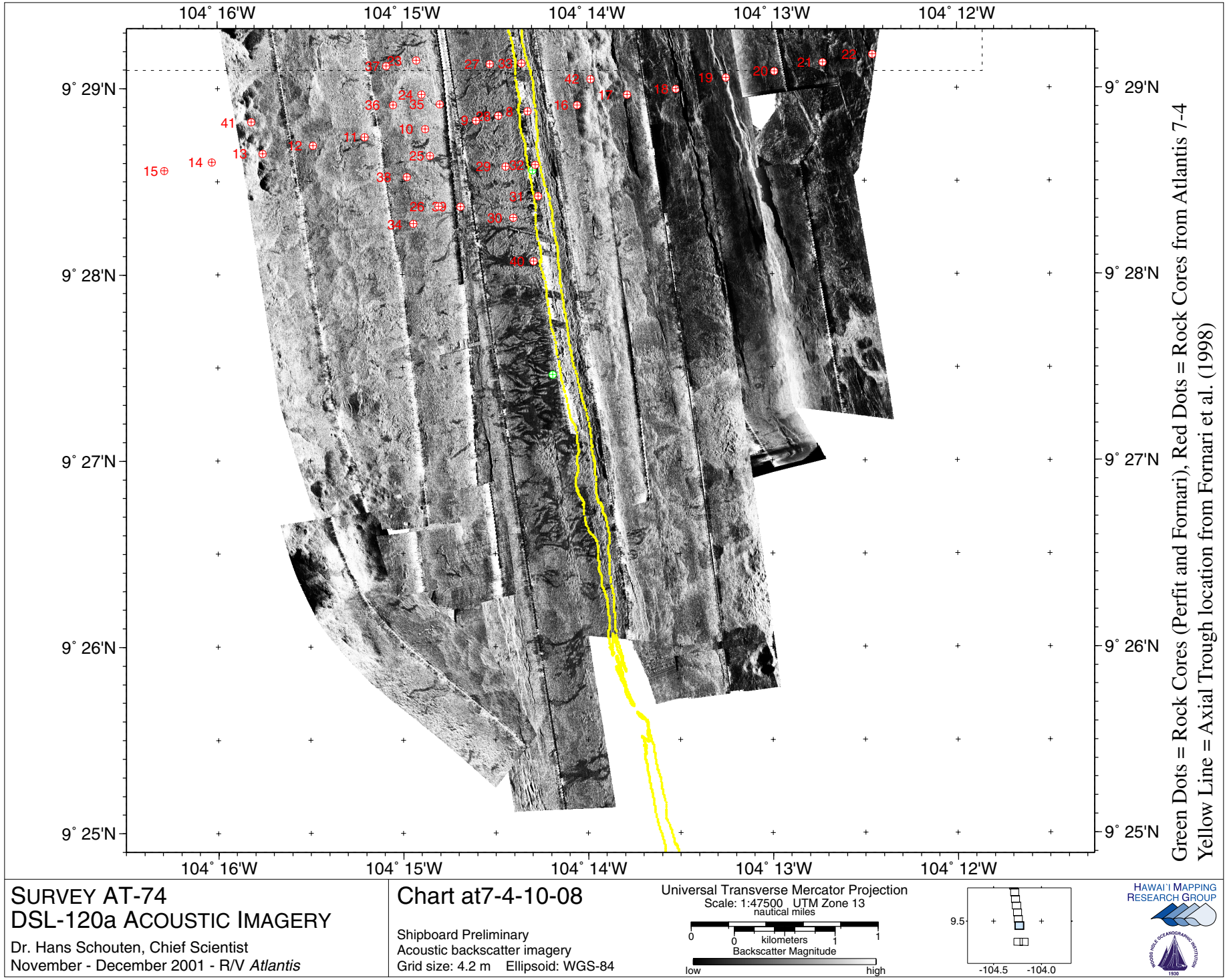


Figure 10. DSL-120A side-scan sonar image. White is strong acoustic reflector, gray or black is low reflectivity or acoustic shadow.

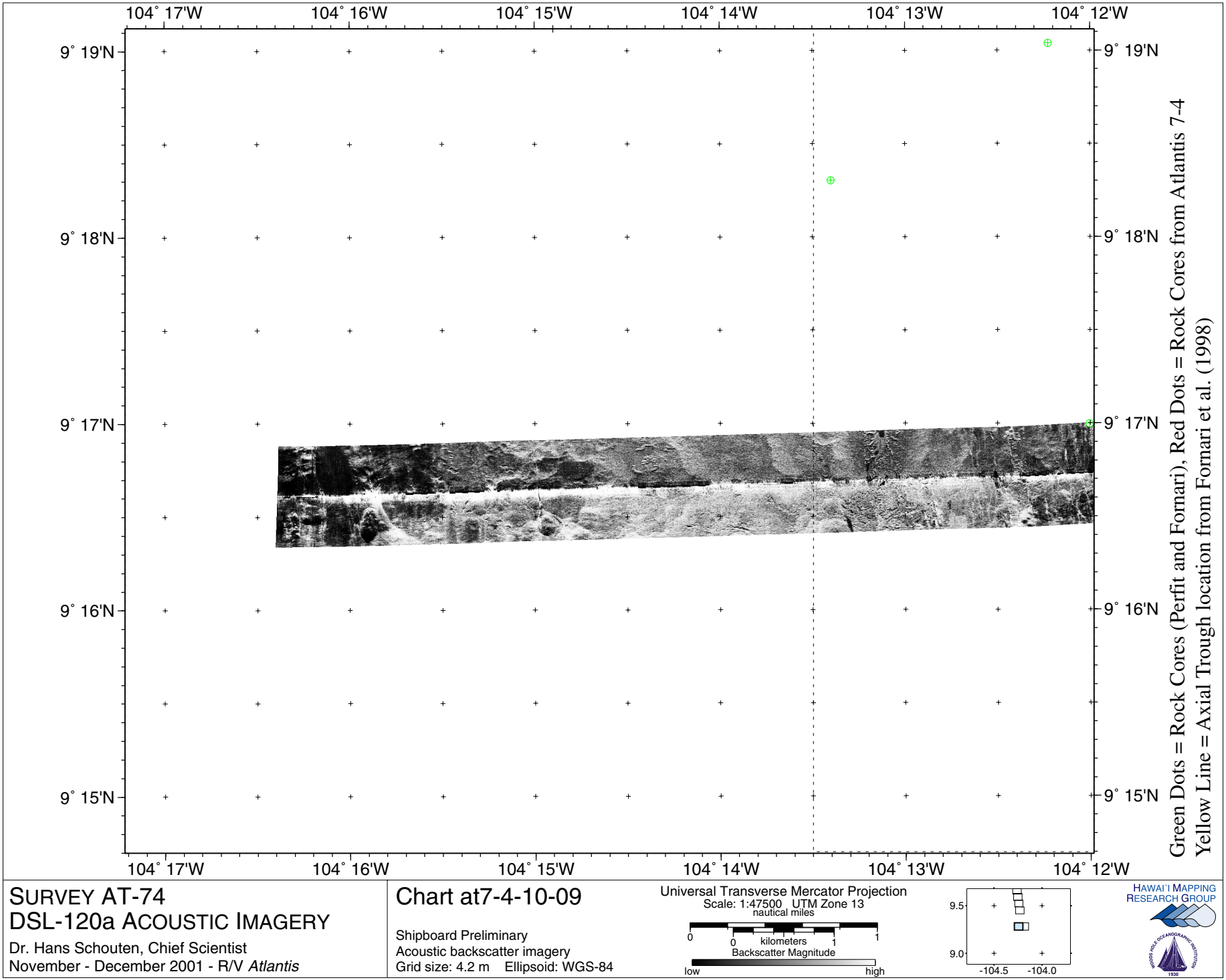


Figure 11. DSL-120A side-scan sonar image. White is strong acoustic reflector, gray or black is low reflectivity or acoustic shadow.

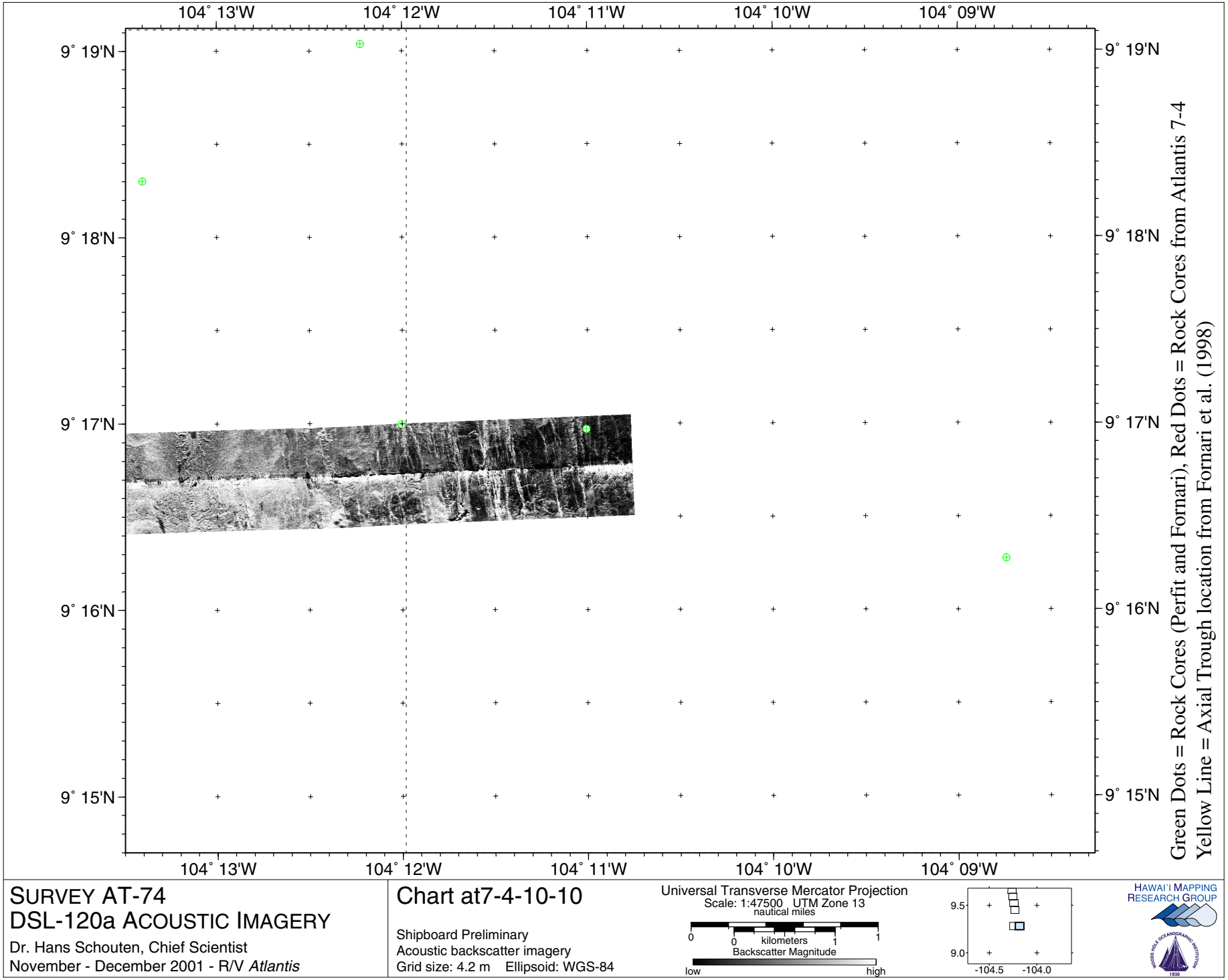


Figure 12. DSL-120A side-scan sonar image. White is strong acoustic reflector, gray or black is low reflectivity or acoustic shadow.

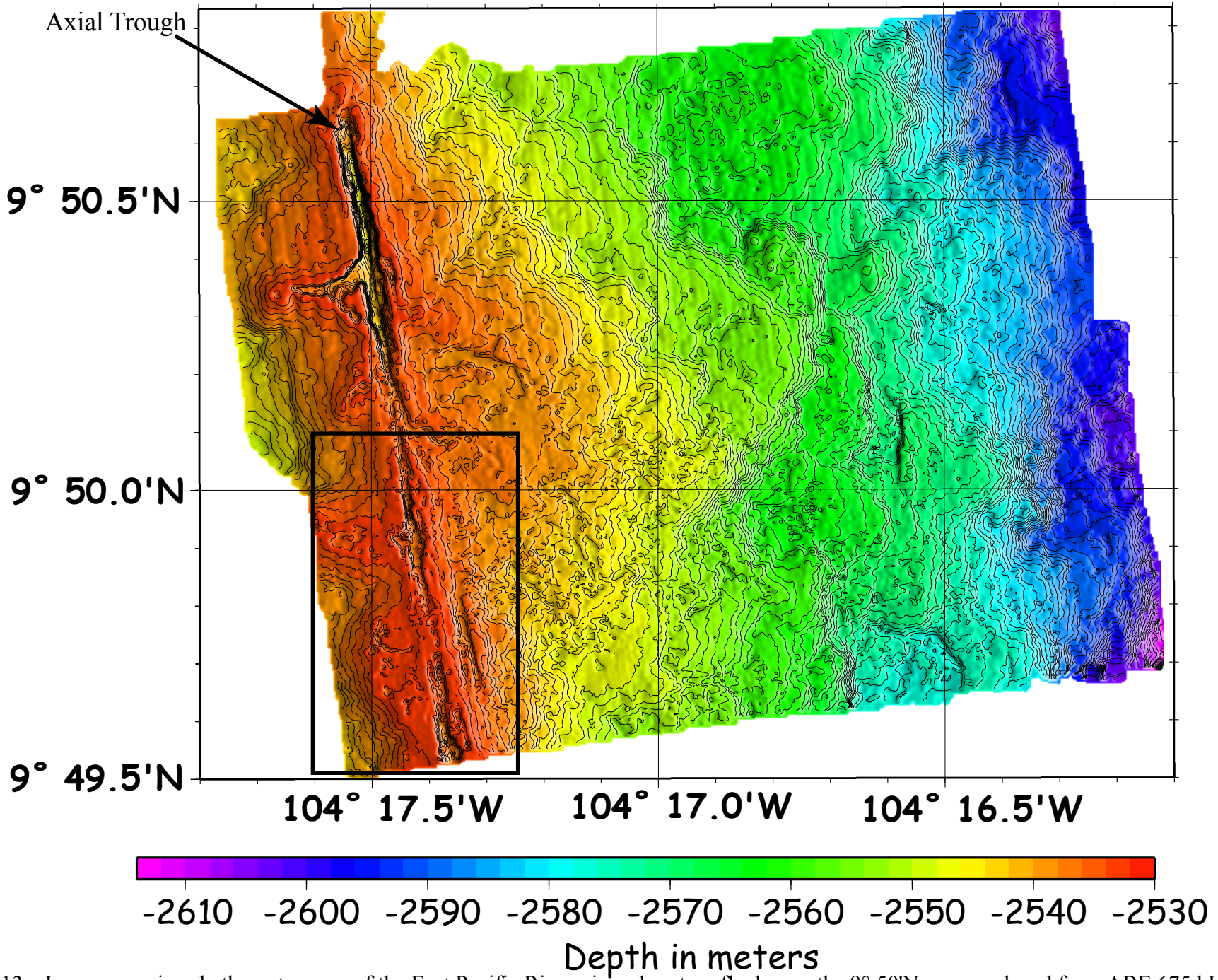


Fig 13a. Imagenex micro-bathymetry map of the East Pacific Rise axis and eastern flank near the 9° 50'N area produced from ABE 675 kHz pencil-beam altimeter and pressure depth data. Colorbar shows depth contours in meters. Contour interval is 1 meter, color changes every 2 meters, grid interval is 5 meters. Black box outlines area shown in Fig 13b.

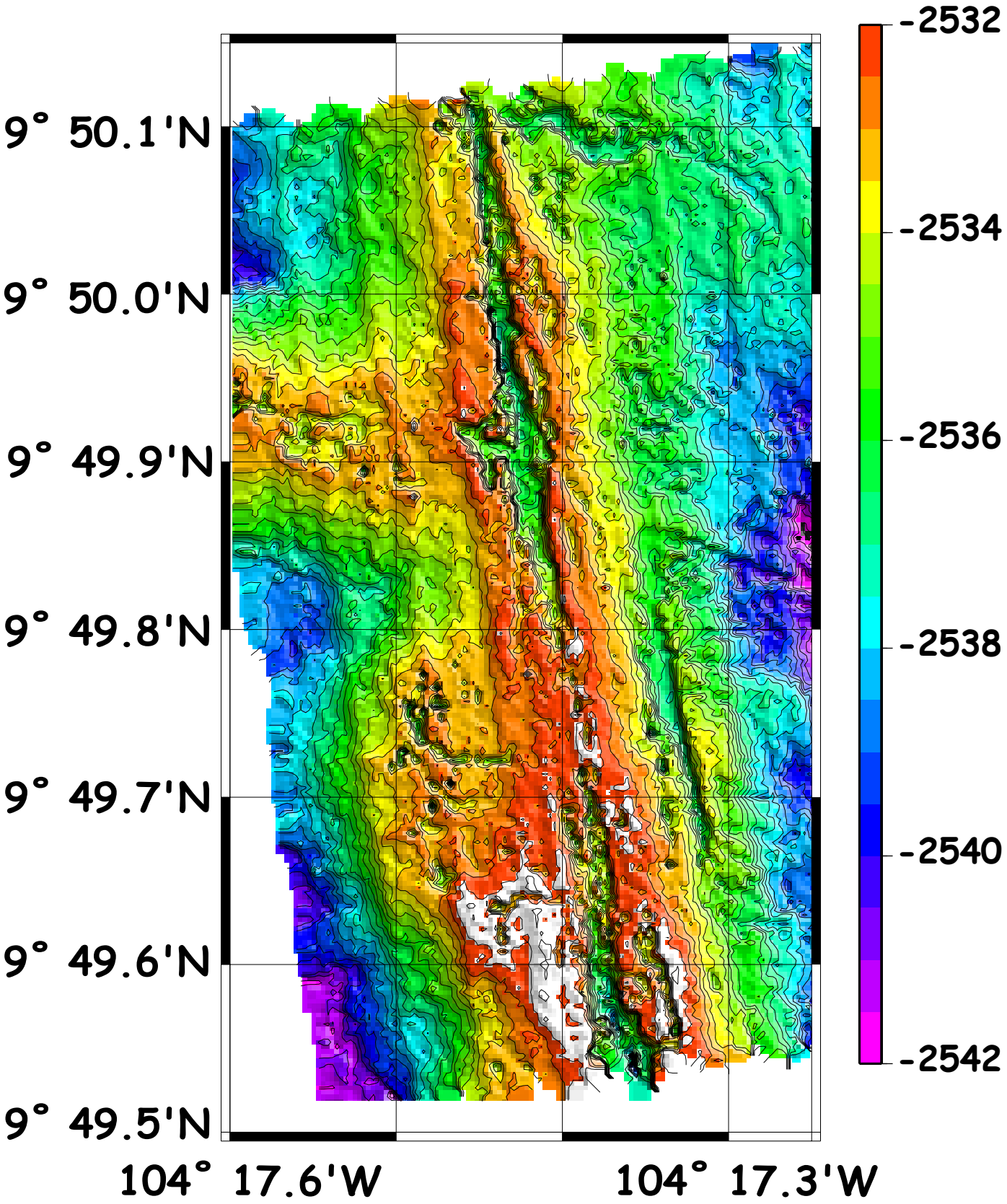


Fig 13b. Imagenex micro-bathymetry map of the axial summit collapse trough (ASCT) for the area between 9° 49.5'N and 9° 50.1'N on the East Pacific Rise crest - the location of the Biotransect (Shank, et al., 1998) and where several well-studied high temperature hydrothermal vents are located (e.g. Von Damm et al., 1995, 1997, 2000). Color changes and contour intervals 0.5 meters.

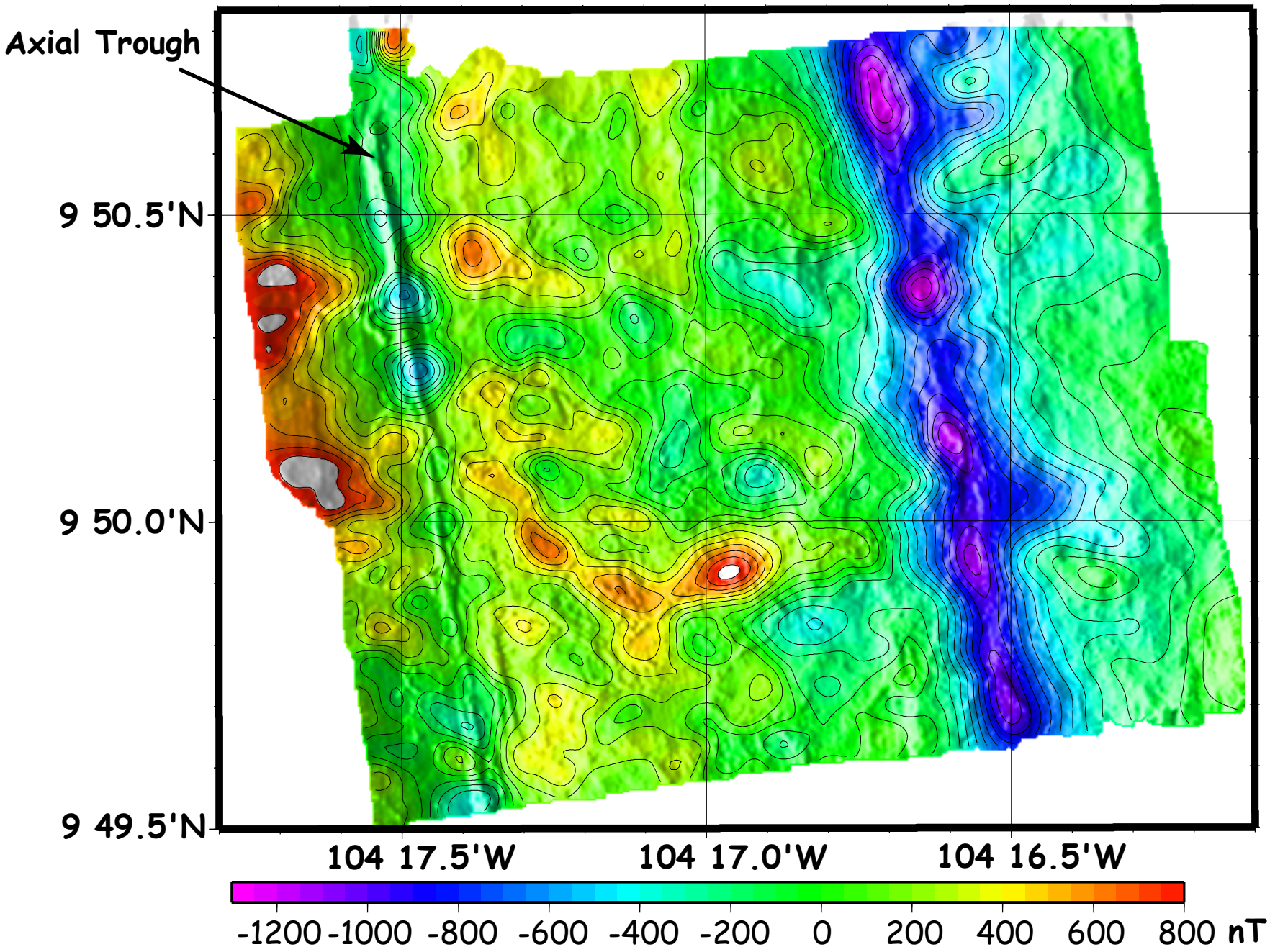


Fig 14. Preliminary shipboard observed magnetic anomaly map made from data collected during ABE surveys on the East Pacific Rise axis near 9° 50'N□Data are contoured at 100nT, color changes every 50 nT.



Fig 15. DSL-120A side-scan sonar image for the area covered by ABE surveys in the 9° 50'N area (outlined by red box).

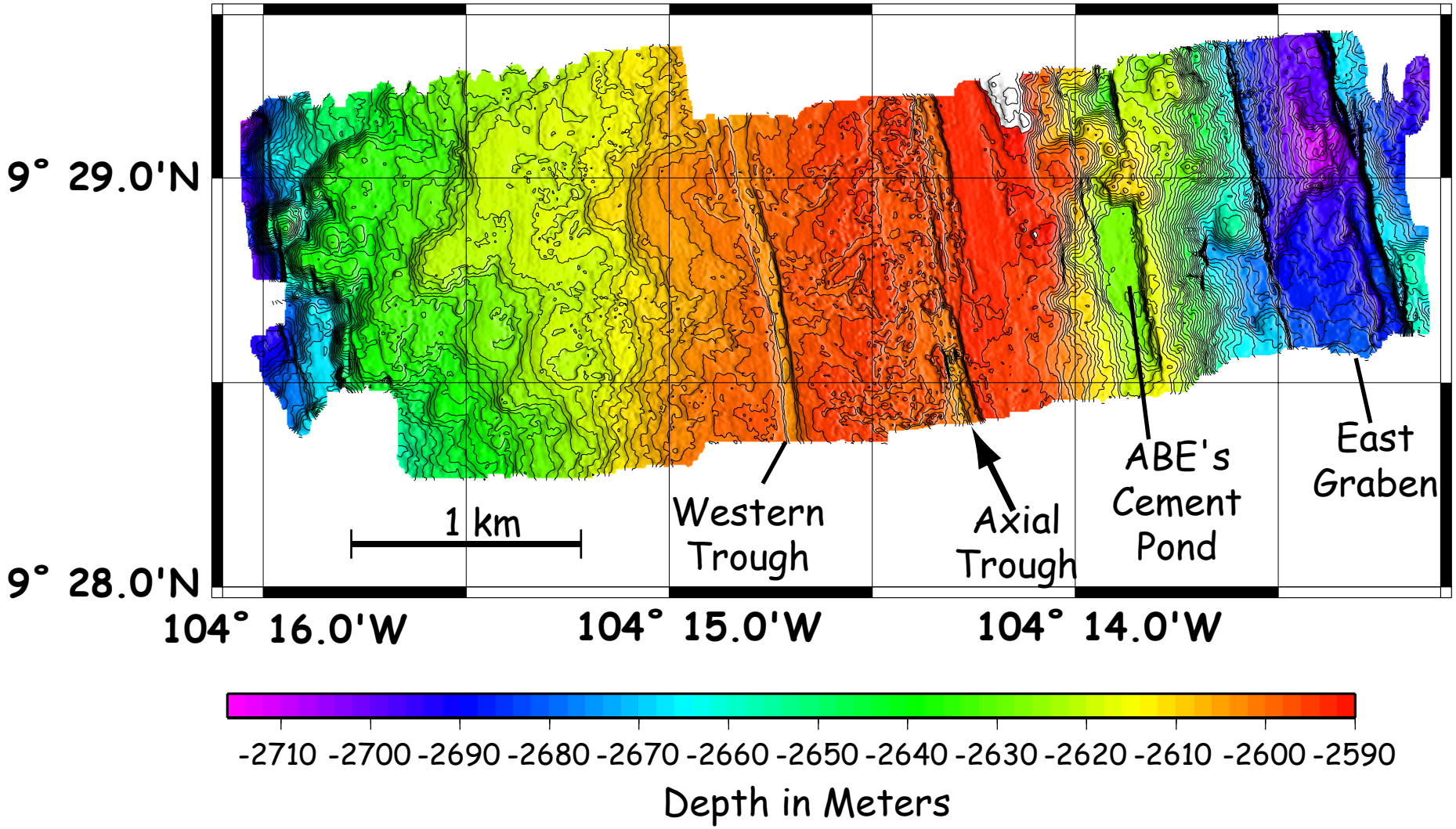


Fig 16. Imagenex micro-bathymetry map of the East Pacific Rise axis and upper flanks in the 9° 28'-29'N area produced from ABE 675 kHz pencil-beam altimeter and pressure depth data. Colorbar shows depth contours in meters. Contour interval is 1 meter, color changes every 2 meters, grid interval is 5 meters.

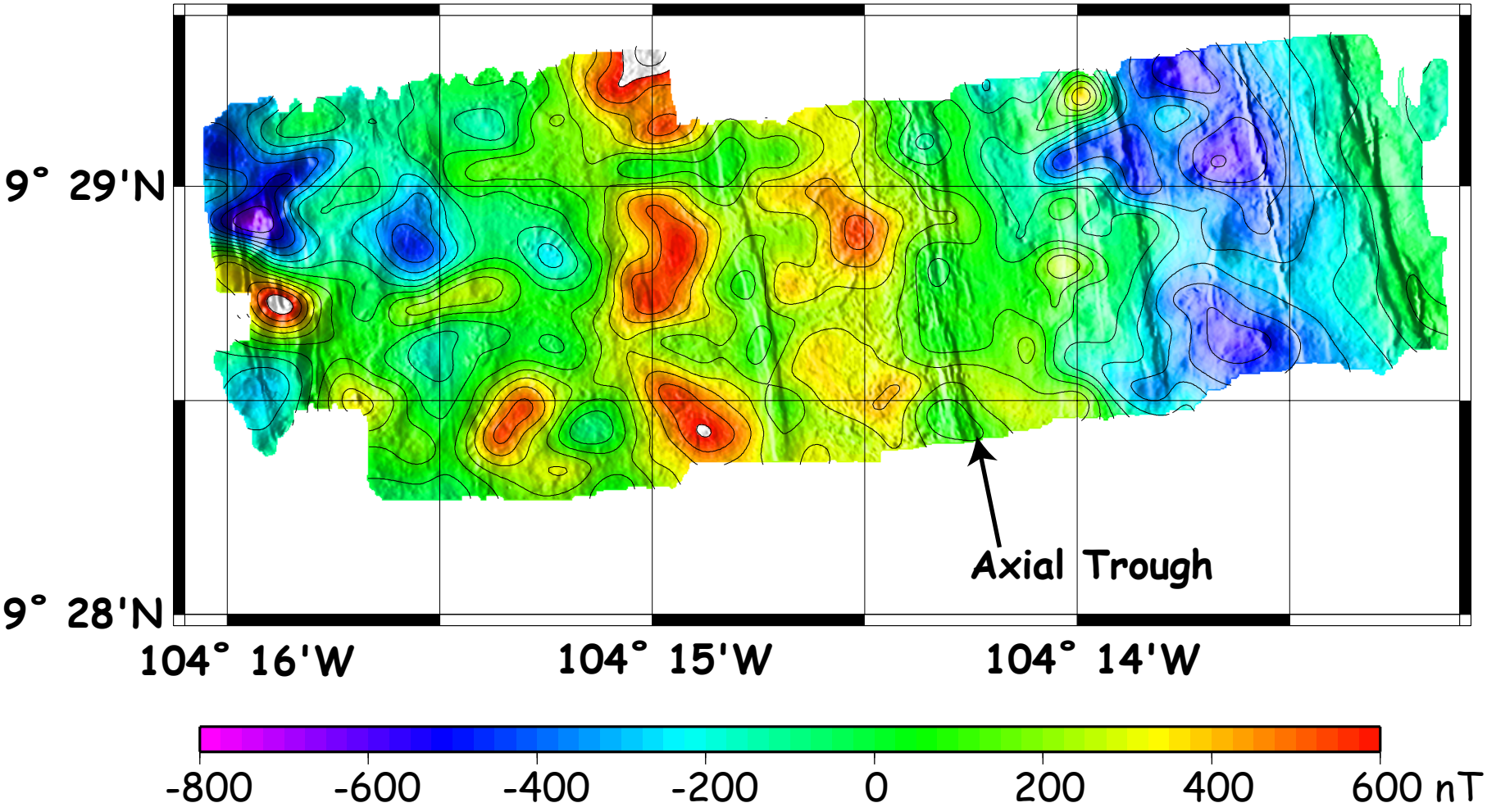


Fig 17a. Preliminary shipboard observed magnetic anomaly map made from data collected during ABE surveys on the East Pacific Rise axis between 9° 28'-29'N□Data are contoured at 100nT, color changes every 50 nT.

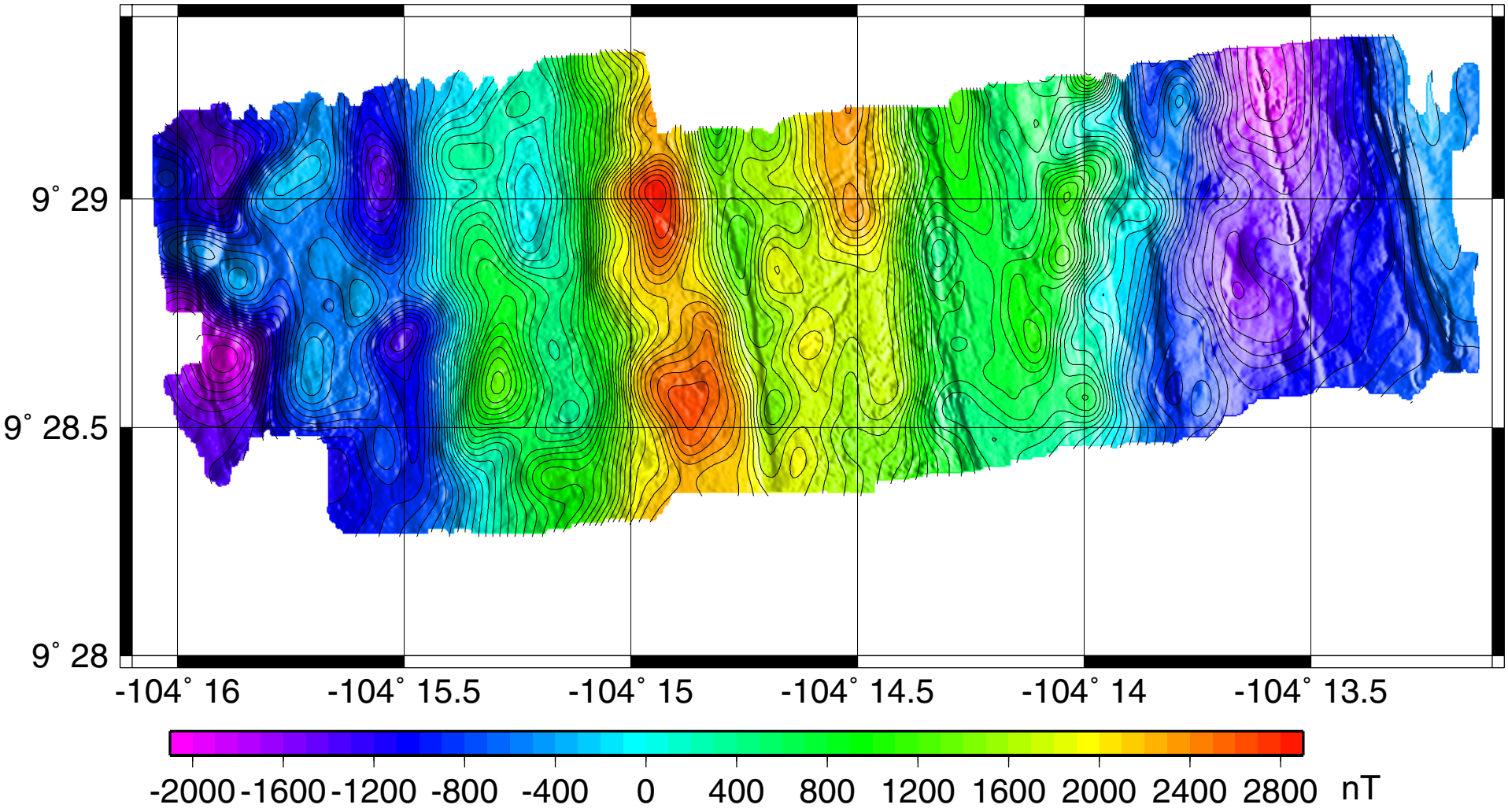


Fig 17b. Preliminary, reduction-to-the-pole magnetic anomalies based on ABE data. Contour interval is 100 nT.

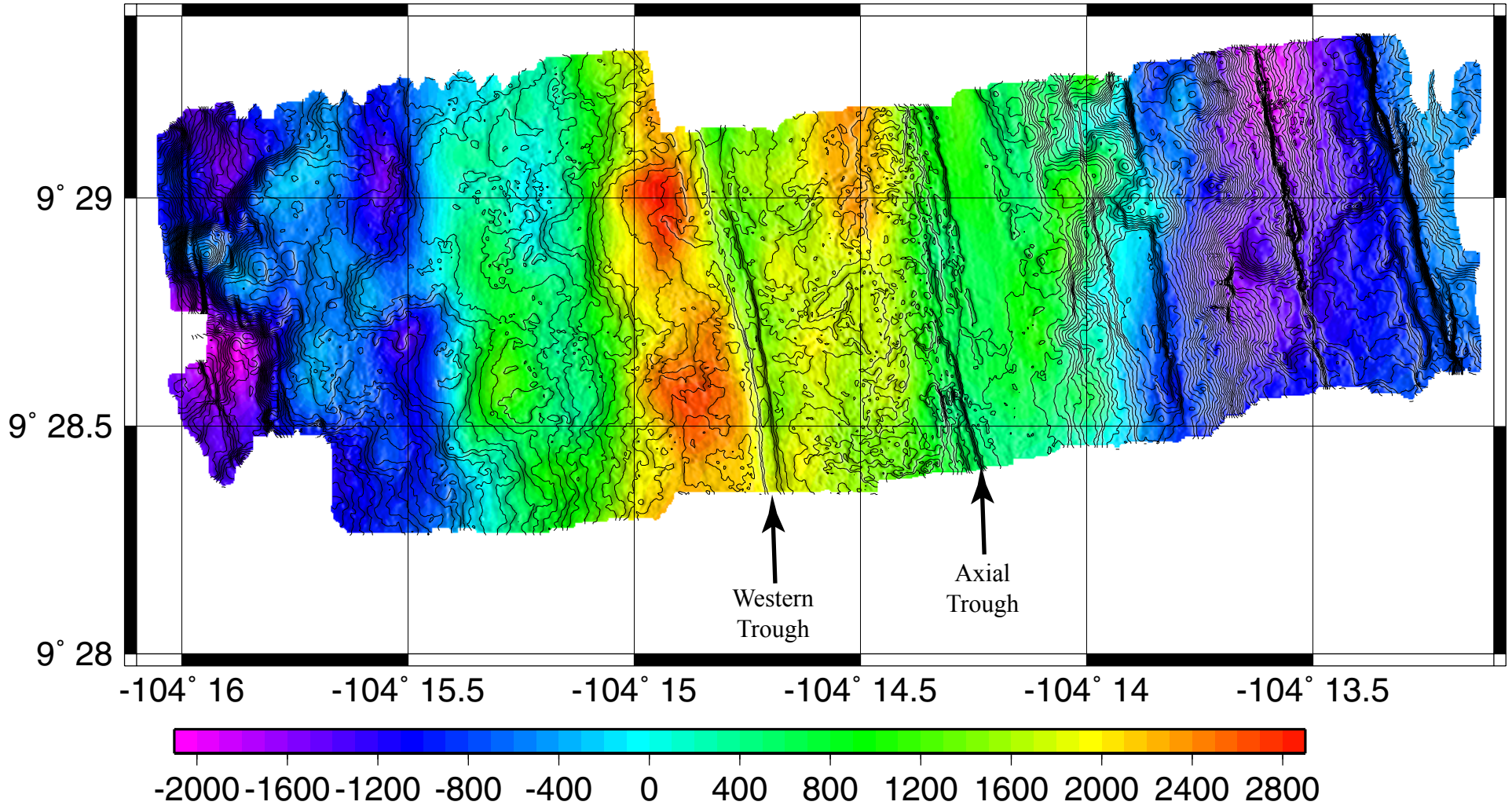


Fig 17c. Preliminary, reduction-to-the-pole magnetic anomalies based on ABE data with ABE micro-bathymetry contours overlaid (2 meter contour interval). Magnetics ontour interval is 100 nT. Note strong correlation between edges of magnetic highs and constructional volcanic topography as defined by micro-bathymetry. Also, magnetic lows are coincident with axial trough and western trough.

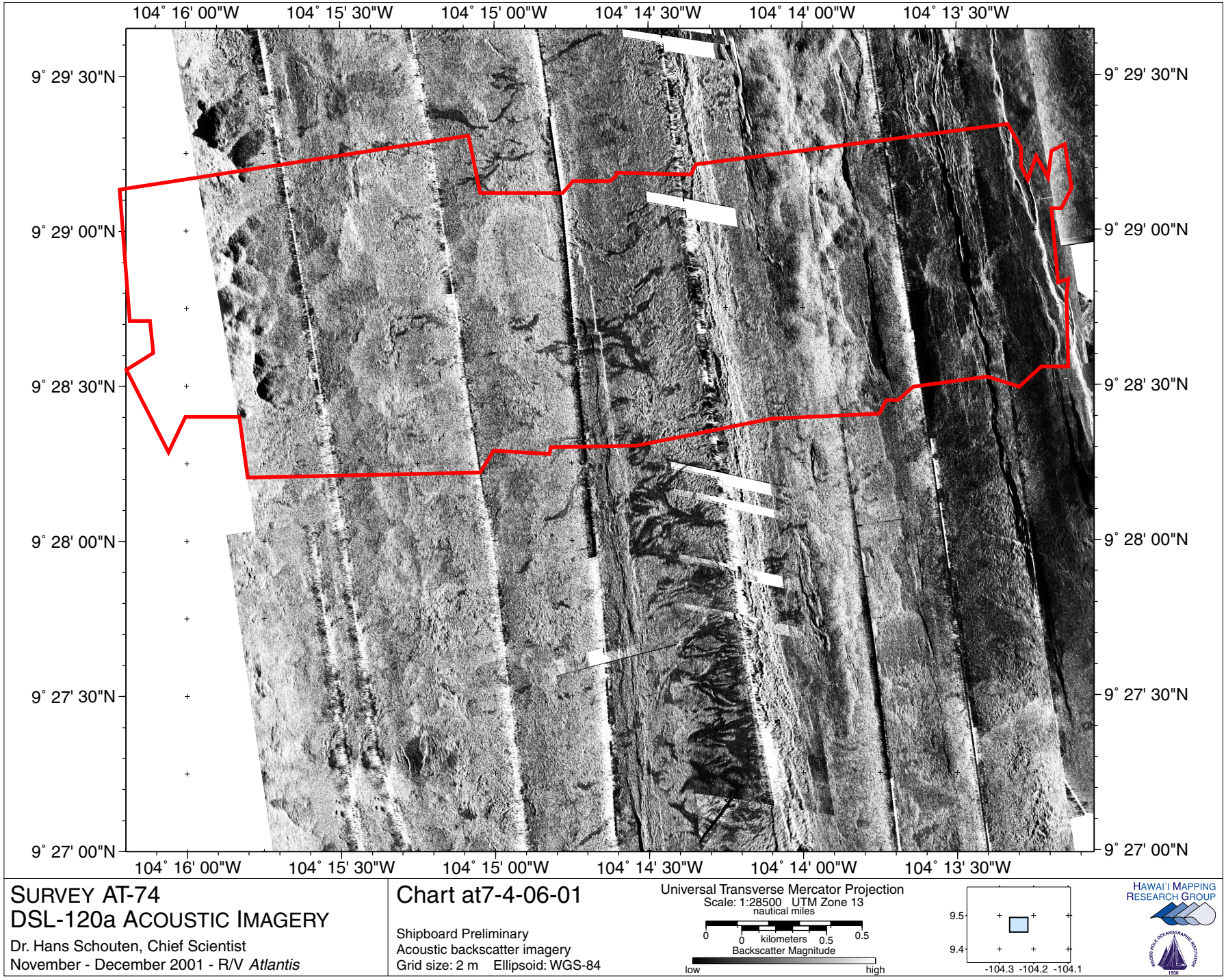


Fig 18. DSL-120A side-scan sonar image for the area covered by ABE surveys in the 9° 28'-29'N area (outlined by red box).

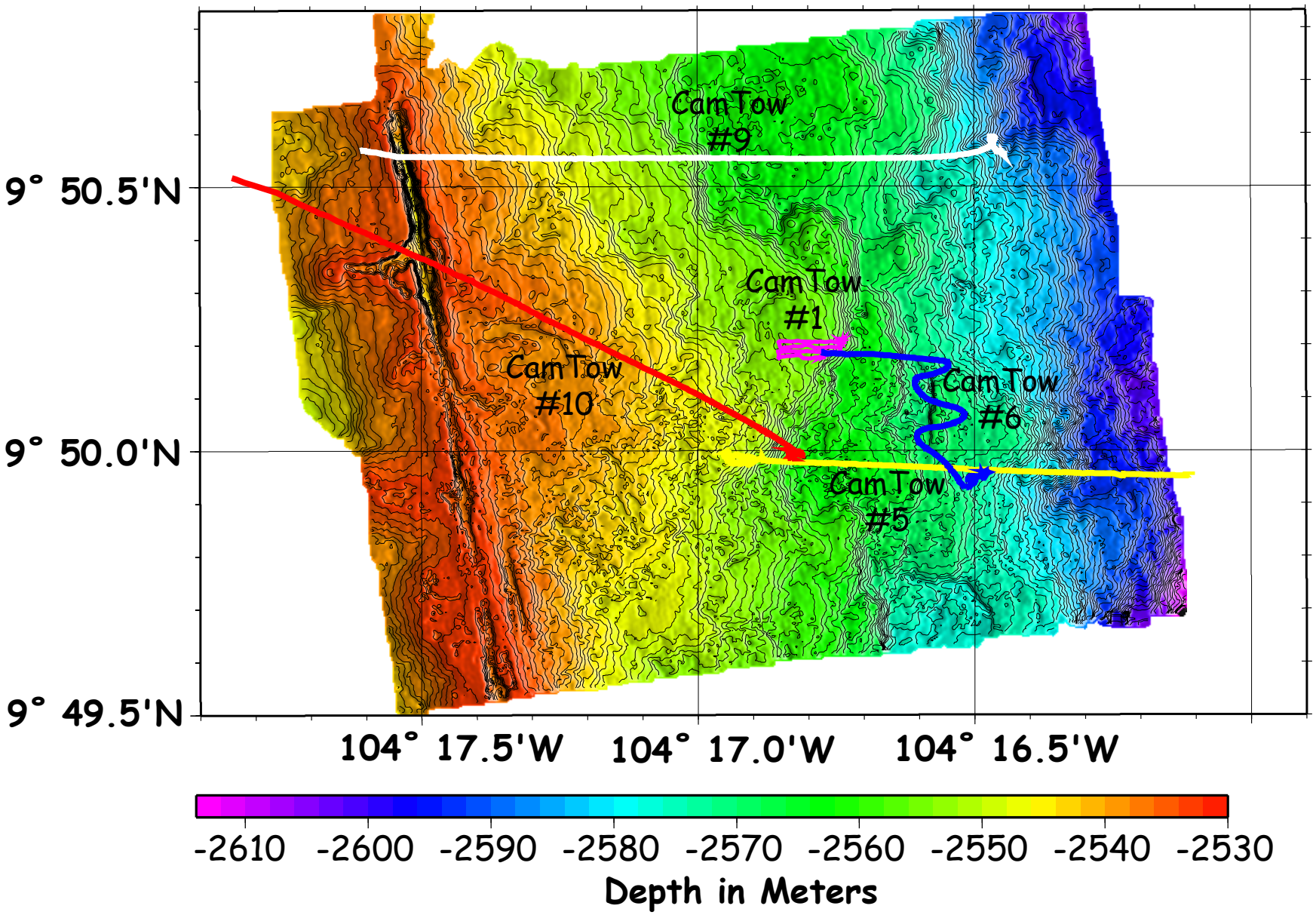


Fig 19.Towed camera survey tracks in the 9° 50'N survey area on the EPR crest. Bathymetry based on ABE Imagenex data, 1 m contours, 5 m grid size.

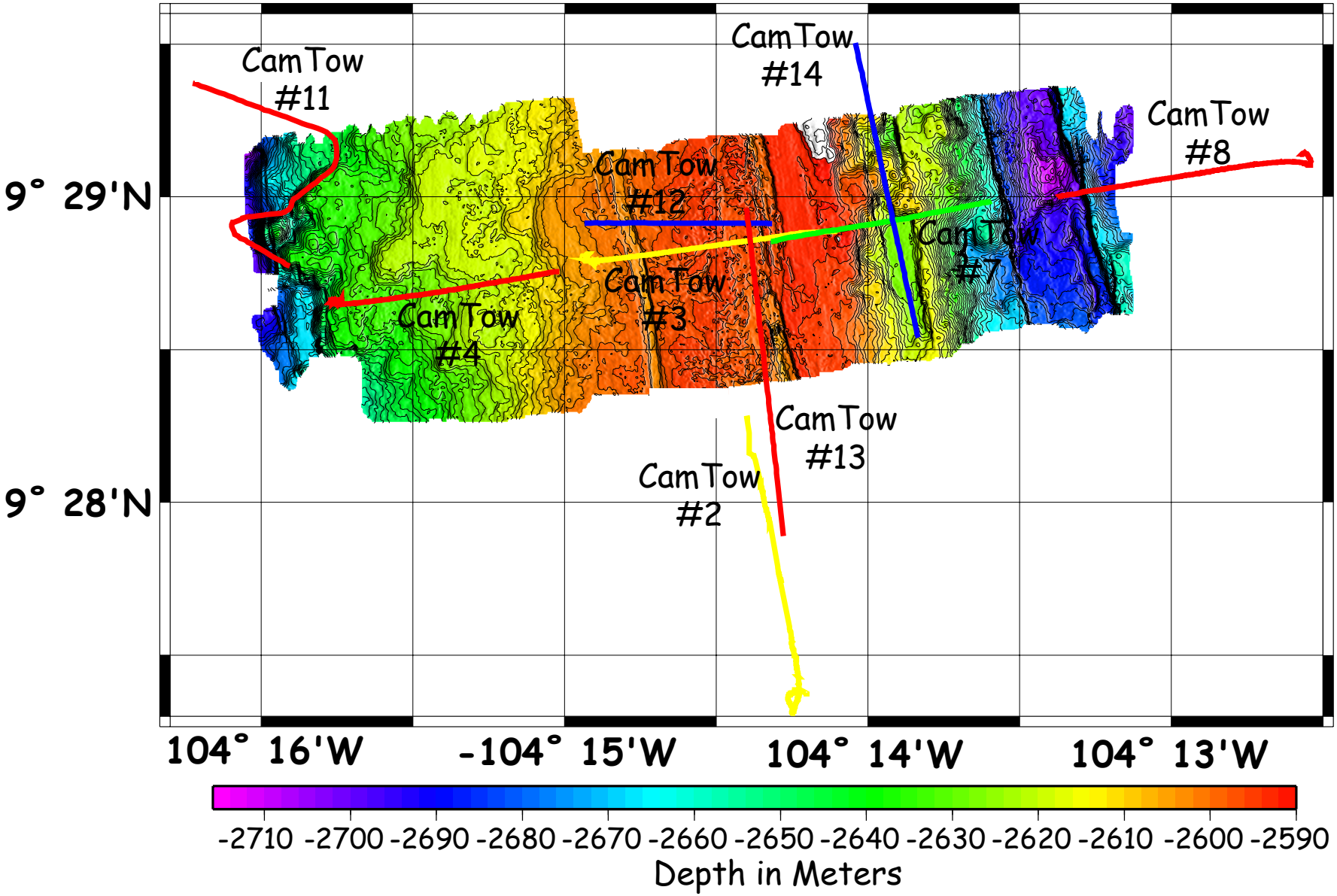
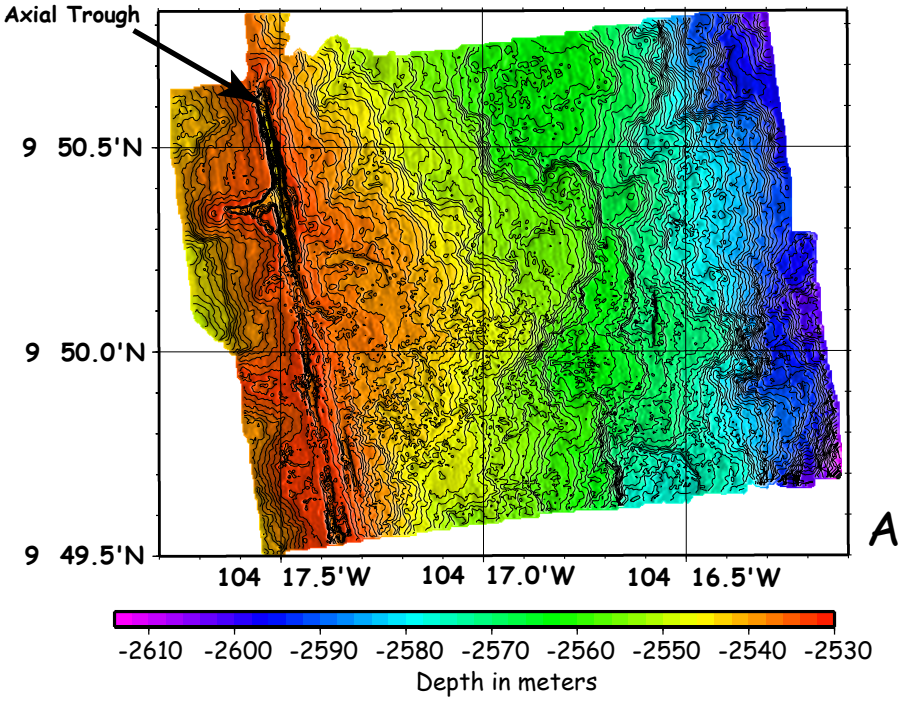
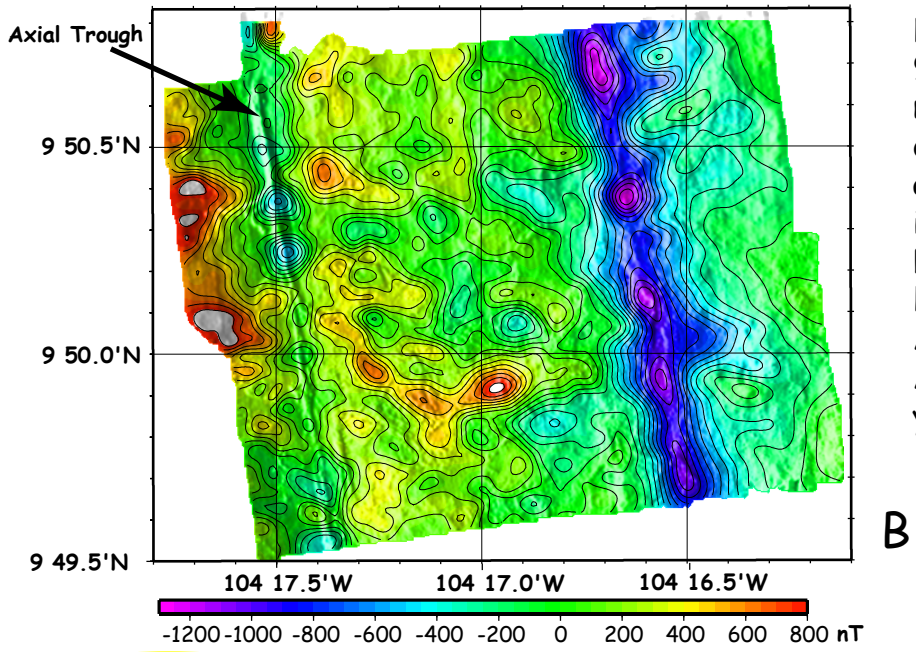


Fig 20. Towed camera survey tracks in the 9° 28'-29'N survey area on the EPR crest. Bathymetry based on ABE Imagenex data, 1 m contours, 5 m grid size.





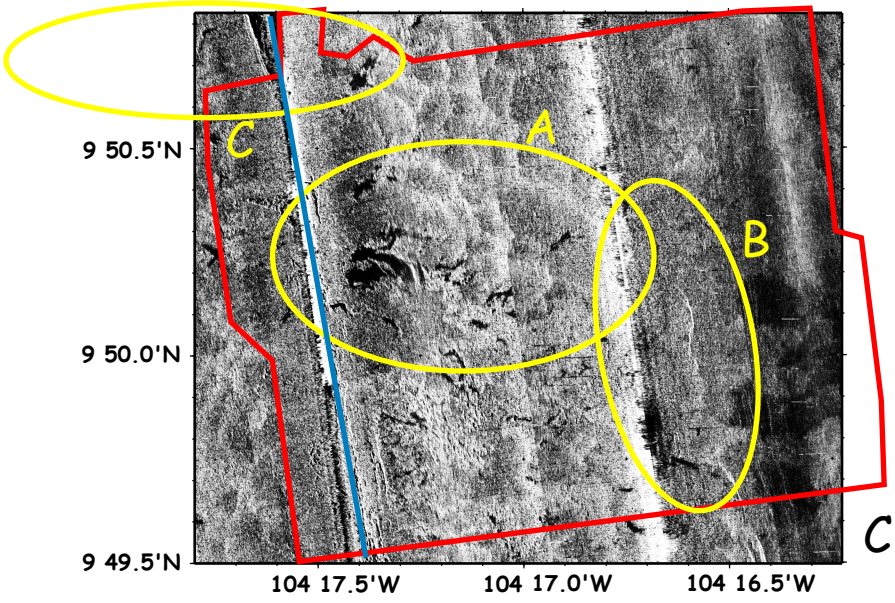
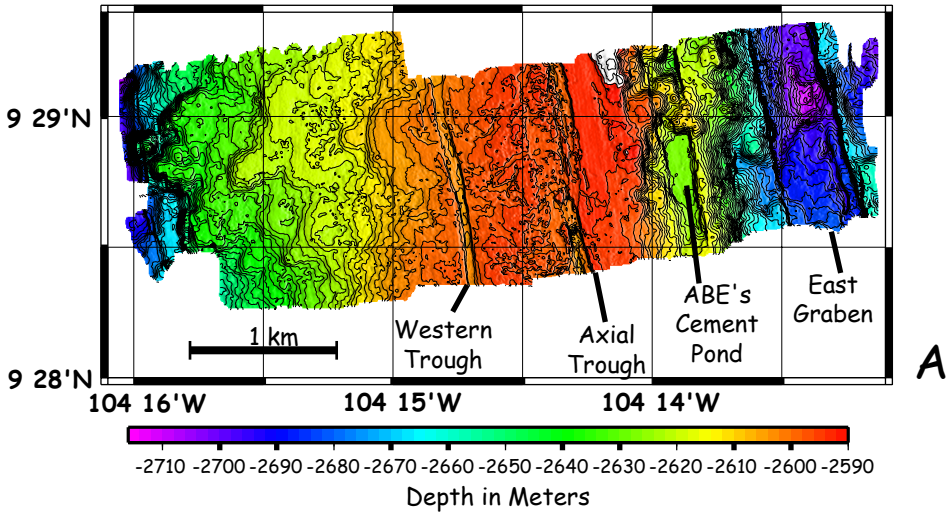
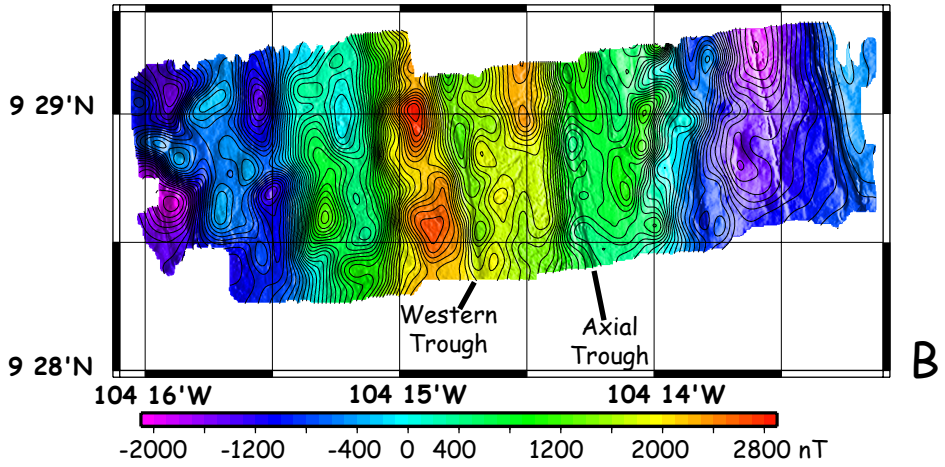


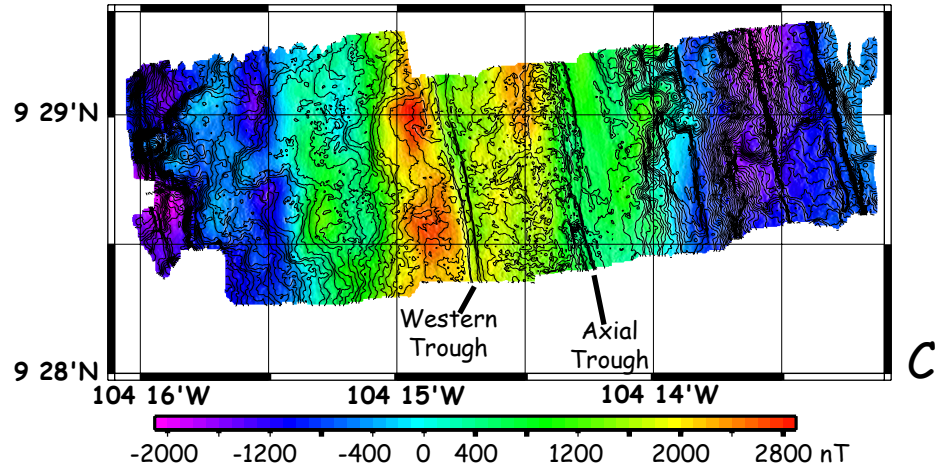
Fig 21. Summary maps for the 9 50'N EPR area showing ABE micro-bathymetry (A), ABE observed magnetic anomaly map (B), and DSL-120A sidescan sonar imagery (C) with the area covered by maps A-B outlined in red. Blue line shows location of ASCT. Areas to be investigated during Alvin dives are circled in yellow on map C.



A

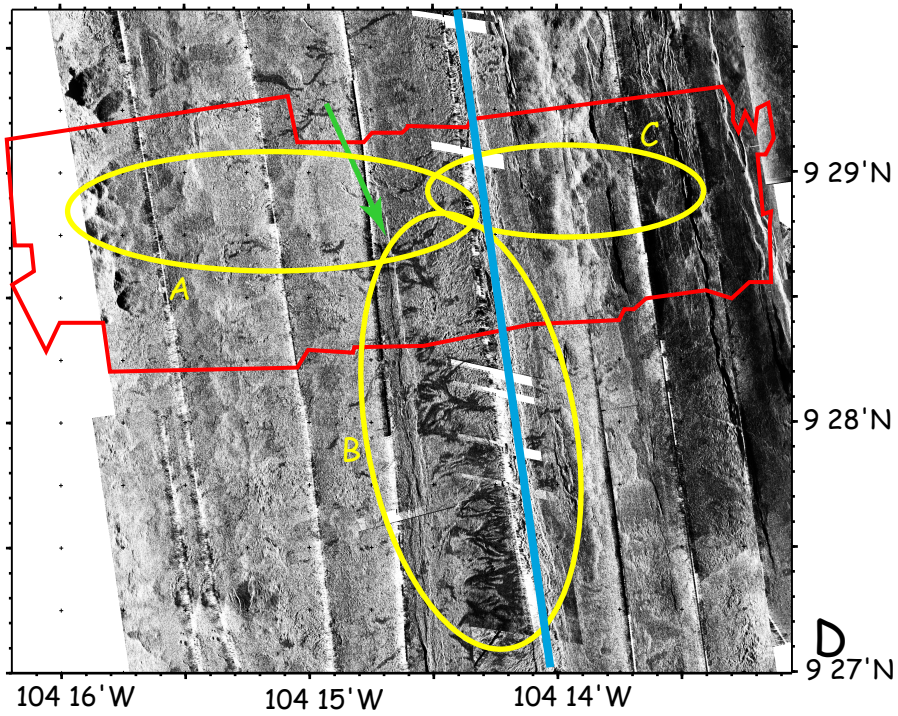


B



C

Fig 22. Summary maps for the 9 28'-29'N EPR area showing ABE micro-bathymetry (A), reduced-to-the-pole (RTP) magnetics (B), RTP magnetics with micro-bathymetry contours (C), and DSL-120A sidescan sonar imagery (D) with the area covered by maps A-C outlined in red. Areas to be investigated during Alvin dives are circled in yellow on map D. ASCT trace is shown as a blue line in map D. Green arrow points to Western Trough.



D

Atlantis 7-4
Cruise Report

Tables

Table 1.
R/V Atlantis Voyage 7 Leg 4 ,Nov. 5 to Dec. 3, 2001

Daily Operations Summary

Nov 5 (JD309)	Depart Manzanillo at 1900hrs L (0100Z, Nov 6), headed south at 13 kts for EPR crest.
Nov 6 (JD310)	Continue transit, good weather during day, rougher at night when crossing the Gulf of Tehuantepec.
Nov 7 (JD311)	Continue transit, weather cloudy, making ~12-12.5kts. Arrive at EPR crest near 9° 26'N to deploy E and F transponders for DSL-120A sonar survey and survey-in transponders. Continue deploying transponders (C and D) up near 9° 50'N, and surveying them in.
Nov 8 (JD312)	Launched DSL-120A sonar at 1515Z, waited for ~2 hrs for seas and wind to die down. Some problems with DP and traction winch which were solved and launch proceeded. Stopped at 1000m to do calibration turn for maggie. At 1800Z proceeded o/c170° towards start of Survey Line #1.
Nov 9(JD313)	Continuing Line #1 of Survey #1, headed SSE, records look good, especially on starboard side. Port sidescan record looks weaker. At 1000Z sonar fish is at ~9° 40'N, speed is 1.4 kts. EOL#1 at 9° 27'N at 1852Z.. Pulling up wire to start turn for Line#2. Seas/wind coming from ENE, going to head the ship SW and back down the line to maintain good towing configuration. SOL#2 at 2139Z.
Nov 10 (JD314)	Continuing north on Line#2. Weather blustery, winds to 25kts making ABE launch doubtful. Also, Al/Dana have things to fix on ABE so have decided to delay ABE test lowering and continue sonar survey. SOL#3 at 2042Z..
Nov 11 (JD315)	Continuing Line#3 southwards. Winds down to ~15kts, weather good. EOL#3 at1830Z. Recovering sonar to fix problem with port side low signal strength and to do ABE test lowering at 9° 50'N this evening. Sonar on deck at ~2030Z. Heading north to re-survey transponders A & B to better calibrate 9° 50'N net.
Nov 12 (JD316)	Completed re-survey of A/B transponder net at 0030Z. Preparing for ABE test dive. 0148Z ABE in the water and going down on Dive #52. 0155Z ABE problem, program not cleared so it dropped its descent weight – recovering ABE. 0243Z ABE back on deck, testing systems. ABE re-deployed for Dive #53 at 0445Z. At 0614Z ABE aborted at ~1100 m depth. Recovered ABE at 0810Z, ship standing by until early morning and will then re-deploy the DSL-120A sonar. 1532Z deploying DSL-120A sonar. 1615Z fish at 478 m, problems with electronics, going to recover the sonar. 1752Z sonar on deck – troubleshooting.

Table 1.
R/V Atlantis Voyage 7 Leg 4 ,Nov. 5 to Dec. 3, 2001

Nov 13 (JD317)	At 0030Z, commenced rock coring ~1 km long pillow ridge just west of EPR axis near 10N. Had some problems with hydrowinch brake but it was fixed in ~30 min. Did RC#1 to #3, all successful. 0524Z, RC#3 on deck, going to dip test sonar fish. 0610Z, sonar working, going to proceed with launch for Survey #2, Line#4. Continuing problems with GFI ground fault showing on maggie circuit. Also, stbd side of sonar seems to quite intermittently, but backscatter records very good and phase on both sides appears coherent. SOL#4 1113Z.
Nov 14 (JD318)	Proceeding south on Line #4, west of EPR axis, ~0844Z EOL#4. Turn to head north on SOL#5 at 1101Z.
Nov 15 (JD319)	Continuing north on DSL-120A Survey#2, EOL#5 at 0101Z. Turned to head south on Line#6, SOL#6 at 1115Z.
Nov 16 (JD320)	EOL#6 at 0908Z. Hauling in sonar. DSL-120A sonar on deck at 1129Z. Underway north to 9° 50'N area and ABE test lowering site. 1437Z ABE launched for Dive #54. Test dive to cross transponder baselines and collect sample data types. 2110Z ABE aborted mission due to false-alarm about a low-battery voltage reading in the fail-safe program .
Nov 17 (JD321)	ABE on deck 0010Z. Problem with port thruster on Atlantis, standing by until 0230Z before proceeding with operations. Decided to launch DSL-120A for Survey #3 to acquire another line west of Line#6. Launched sonar at 0315Z. near 9° 58.5'N and 104° 20'W to run Line#7 heading south. EOL#7 at 1516Z.. DSL-120A on deck at 1715Z.. Prepared ABE for launch #55, while in transit at 1733Z for airdrop of Alvin viewport at 1900Z. Airdrop successful, but viewport damaged and unusable. Steamed to ABE launch site for dive #55. 2030Z ABE was launched. 2345Z ABE was on the bottom.
Nov 18 (JD322)	0020Z ABE started planned survey. 1330Z ABE signaled it was coming up having finished approximately 28 lines of a 40 lines program. 1539Z ABE on the surface. 1735Z ABE on deck. 1859Z DSL-120A was launched at 9º47'N for survey #4, Line 8. Intermittent noise problems with sonar, voltage lowered to 241V and noise decreased 2140Z.
Nov 19 (JD323)	Continued noise problems with sonar, noise fixed at 0302Z. 1038Z SOL #9 and EOL #9 at 1152Z. SOL #10 at 1316Z. and EOL #10 at 1703Z. SOL #11 at 1858Z and EOL #11 at 2230Z at 9º25'N.
Nov 20 (JD 324)	DSL-120A on deck at 0038Z and ship in transit to ABE site #56. 0354Z ABE launched at 9º51'N and began track plan at 0600Z. At 1000Z moved ship to DSL-120A sonar line #12. 1146Z DSL-120A launched. SOL #12 at 1357Z at 9º57'N.

Table 1.
R/V Atlantis Voyage 7 Leg 4 ,Nov. 5 to Dec. 3, 2001

Nov 21 (JD 325)	EOL #12 at 0201Z. Steamed to ABE recovery site. ABE had completed all of the first box and 4 lines of the little box before running out of battery power and surfacing. One of the sonar processing computers' hard drive down. Camera Tow #1 started at 0931Z. Camera set to B&W and taking pictures every 15 minutes. Camera flown 5-6 m of the bottom. Approximately 2 hours and 10 minutes of bottom photos taken. 1500Z DSL-120A launched for line #13 and SOL #13 at 1718Z at 9º57'N, imaging smooth featureless eastern flank of EPR.
Nov 22 (JD 326)	Continuing line #13. 0752Z the Magnetometer/CTD/PAS disk ceased recording due to being full, and was started again at 0822Z after copying the data to a different machine and purging the disk. EOL #13 at 1545Z. After DSL-120A recovery, ship underway to pick up transponders E and F. Second transponder recovered at 2009Z and ship proceeding to deploy transponders G, H, I and J for the southern net. Finished deployment at 2249Z and ship underway for ABE #57 launch site near 9º50'N.
Nov 23 (JD 327)	ABE #57 launched at 0129Z. Camera 'Thing' in water at 1318Z for camera tow line #2. 2 hours and 11 minutes of bottom photos were taken (534 B&W photographs) of the flows on the western margin of the axial trough at 9º27' - 9º28'N. Camera recovered and back on deck at 1714Z, then corer in the water for rock core #4 at 2037Z at 9º50'N. 2214Z corer back on deck with 2-3 pieces of glass and 1g of manganese sediment. Rock core #5 in the water at 2231Z at 9º49.5'N.
Nov 24 (JD 328)	0005Z rock core #5 recovered at 9º49'N with 1-2 g of glass with Mn coatings from 4 of the 7 drill bits that hit. 0201Z rock core #6 in water and recovered at 0330Z at 9º49'. Obtained 0.5-1 g of glass with some Mn coatings. Rock core #7 in water at 0338Z and recovered at 0504Z at 9º49'. 0721Z ABE #57 recovered and at 0725Z proceeded to launch position for DSL-120A sonar survey #7 at 9º35.5'N, 104º13.45'W. 0913Z arrived at DSL-120A launch station and launched DSL-120A at 0924Z. Noise problems on the way down, but seemed to be fixed at 1212Z by a voltage adjustment to 237V. SOL #14B at 2126Z and EOL #14B at 2330Z at 9.4668ºN, 104.2426ºW.
Nov 25 (JD 329)	0225Z launched ABE dive #58 at 9º28.36'N, 104º14.50'W for calibration dive at 9º28'N. At 0300Z did a test lowering of camera with target altitude of 5m and frame size of 6.4m x 4.8m. Completed rock cores 8, 9, 10, 11, 12, and 13 near 9º28'N. By 1458Z ABE had appeared to settled down on its gridline survey after a night of carousing around the seafloor. Al was content to let us steam south to begin DSL-120A sonar line #15. Arrived at launch point (9º16.58'N, 104º18.0'W) at 1632Z and launched DSL-120A at 1642Z. 1847Z SOL #15 at 9º16.61'N, 104º16.27'W. 2259Z EOL #15 at 9º16.783'N, 104º10.592'W. This completed the DSL-120A sonar operations.

Table 1.
R/V Atlantis Voyage 7 Leg 4 ,Nov. 5 to Dec. 3, 2001

Nov 26 (JD 330)	DSL-120A on deck and underway to pick up ABE at 0130Z. ABE dive #58 completed and ABE was on deck at 0730Z. Completed rock cores #14 and #15 at 9º28'N. 0813Z camera tow #3 launched at 9º28.7804'N, 104º14.8904'W. , 2 hours and 12 minutes of bottom photos recovered and camera on surface at 1217Z. Completed rocks 16, 17, 18, 19 near 9º29'N. 2016Z camera tow #4 launched at 928.662'N, 104º15.737.
Nov 27 (JD 331)	Camera on deck at 0020Z with 2 hours and 14 minutes of bottom photos. 0040Z ABE dive #59 launched at 9º28.59'N, 104º14.46'W. Completed rock cores 20, 21, 22 near 9º29'N covering areas off axis. No hits on core bits for rock core 20 but some on rim. Camera tow #5 launched at 1010Z at 9º49.976'N, 104º16.913'W. Camera on deck at 1417Z with 2 hours and 11 minutes of bottom photos taken showing a probable transition from fresh lava to older, sedimented lava. Camera tow #6 launched at 1628Z at 9º49.953'N, 104º16.475'W. Ended camera tow at 1935Z with 2 hours and 13 minutes of bottom photos taken. 2200Z steamed south to 9º28'N to monitor ABE. 2245Z received ABE transmissions showing that it was still on bottom.
Nov 28 (JD 332)	0020Z ABE signaled that it was leaving the bottom. During ABE's ascent the ship was moved to do rock core #23 at 9º29'N. 0044Z rock core #23 launched with 4-7gms of fresh glass recovered from 9º29'N. 0300Z ABE was on deck. 0332Z rock core #24 in the water at 9º29'N. 0524Z rock core #25 in the water at 9º28.6'N. Camera-tow line #7 launched at 0734Z at 9º29.018'N, 104º13.437'W resulting in 2 hours 13 minutes of bottom photographs being taken at 9º29'N. 1135Z camera back on deck before launching rock core #26 at 1207Z at 9º28'N. Camera-tow line #8 launched at 1430Z at 9º29.109'N, 104º12.557'W producing up to 2 hours 20 minutes of bottom photographs. Camera back on deck at 1832Z. Rock core #27 and 28 launched at 9º29.1'N and 9º28.8'N respectively.
Nov 29 (JD333)	Rock core #29, 30 and 31 taken from 9º28.6'N to 9º28.3'N. 0805Z camera-tow line #9 launched at 9º50.584'N, 104º.16.467'W. The camera system includes a retractable rock-coring device on this line. 1114Z ended camera tow line #9 with approximately 2 hours and 18 minutes of bottom photos. Camera was recovered at 1205Z. Transponders C and D were recovered between camera launches. 1440Z camera tow line #10 was launched. At 1745Z ended camera tow line #10 with approximately 2 hours and 14 minutes of bottom photos. 1837Z camera on deck with onboard rock coring system which collected approximately 1g of fresh glass. Ship steaming south to 9º28.5'N to retrieve ABE. 2200Z ABE on deck. Rock core #32 started at 2237Z producing no glass but up to 1g of sulfides.

Table 1.
R/V Atlantis Voyage 7 Leg 4 ,Nov. 5 to Dec. 3, 2001

Nov 30 (JD 334)	Rock core #33 launched at 0025Z and was back on deck at 0200Z with fresh glass and little Mn-oxide. 0230Z recovered transponder G, and redeployed it as transponder K at 0320Z. Finished surveying transponder K at 0510Z. Camera-tow line #11 launched at 0605 at 9º28.713'N, 104º15.830'W. Only one transponder fix was made on the camera for the duration of the bottom photography so camera navigation was estimated by Tom Cook. Camera back on deck at 1008Z. 1046Z rock core #34 launched at 9º28'N. 1249Z ABE #61 launched at 9º28.533'N, 104º14.935'N. Rock core #35 launched at 1408Z onto the northern end of an off-axis trough to the west of the ASCT, 9º29'N. Camera-tow line #12 launched at 1548 at 9º28.914'N, 104º14.978'W also onto the northern end of the off-axis trough. 1655Z sampling performed using wax-covered 'balls' attached to the camera system. 1700Z it was realized that ABE was trying to use dead-reckoning to navigate but not succeeding, so an 'abort' signal was sent. Camera left the bottom at 1815Z to be back on deck in time to recover ABE. ABE recovered, problem fixed and back in the water at 2110Z. Stayed in the area to listen to ABE and make sure it is working properly, then moved to rock core #36 location, 9º28.9'N. Rock core #36 launched at 2219Z.
Dec 01 (335)	Rock core #36 recovered at 0002Z. Completed rock cores 37, 38, 39, and 40. Launched camera-tow #13 at 0805Z. At 1110Z camera was on deck with about 2 hours and 10 minutes of bottom photos taken. Completed rock core #41 at 1415Z and at 1420Z steaming toward camera-tow #14 launch point 9º28.440'N, 104º13.813'W. Started camera-tow line #14 1532Z and ended line at 1730Z with about hours and 2 minutes of bottom photos taken. At 1810Z camera was brought on deck. At 2021Z completed rock core #42 at 9º29'N. ABE recovered and commenced finishing transponder recovery. Departed for Manzanillo at ~2100L.
Dec 02 (336)	Transit to Manzanillo
Dec 03 (337)	Transit to Manzanillo
Dec 04 (338)	Arrived in Manzanillo at ~0100L.

Table 2.

AT7-4

Surveyed Transponder Positions

A. Surveyed Transponder Positions

ID #	X	Y	LATITUDE		LONGITUDE		Z	FREQUENCY	TYPE	
A	6297.9	76416.9	9	49.45750	-104	-16.56115	2388.5	10.0	XPENDABLE	
B	5979.1	77947.9	9	50.28809	-104	-16.73626	2387.6	11.0	XPENDABLE	
C	7634.9	78097.7	9	50.36936	-104	-15.83243	2412.7	8.5	Release "E"	
D	7769.3	76082.7	9	49.27619	-104	-15.75907	2407.9	9.5	Release "D"	
E	14258.7	40868.2	9	30.17171	-104	-12.21678	2514.8	8.5	Release "B"	Recovered 11/23
F	14623.0	37180.9	9	28.17129	-104	-12.01792	2530.9	9.5	Release "H"	Recovered 11/23
G	8165.4	36334.1	9	27.71188	-104	-15.54285	2471.6	11.0	Release "C"	Recovered 11/30
H	10581.0	37035.6	9	28.09246	-104	-14.22428	2394.5	10.0	Release "F"	
I	12834.8	36738.3	9	27.93117	-104	-12.99402	2491.1	9.5	Release "H"	
J	10238.5	40038.9	9	29.72180	-104	-14.41123	2391.8	8.5	Release "B"	
K	11392.9	36877.7	9	28.00679	-104	-13.78110	2379.0	11.0	Release "C"	

B. Adjusted Transponder Positions Based on ABE Travel-Time Data (NB- only J and H are different from above table).

ID #	X	Y	LATITUDE		LONGITUDE		Z	FREQUENCY	TYPE	
A	6297.9	76416.9	9	49.45750	-104	-16.56115	2388.5	10.0	XPENDABLE	
B	5979.1	77947.9	9	50.28809	-104	-16.73626	2387.6	11.0	XPENDABLE	
C	7634.9	78097.7	9	50.36936	-104	-15.83243	2412.7	8.5	Release "E"	
D	7769.3	76082.7	9	49.27619	-104	-15.75907	2407.9	9.5	Release "D"	
E	14258.7	40868.2	9	30.17171	-104	-12.21678	2514.8	8.5	Release "B"	Recovered 11/23
F	14623.0	37180.9	9	28.17129	-104	-12.01792	2530.9	9.5	Release "H"	Recovered 11/23
G	8165.4	36334.1	9	27.71188	-104	-15.54285	2471.6	11.0	Release "C"	Recovered 11/30
H	10603.4	37028.7	9	28.0887	-104	-14.22121	2394.5	10.0	Release "F"	
I	12834.8	36738.3	9	27.93117	-104	-12.99402	2491.1	9.5	Release "H"	
J	10243.2	40047.3	9	29.72630	-104	-14.4087	2391.8	8.5	Release "B"	
K	11392.9	36877.7	9	28.00679	-104	-13.78110	2379.0	11.0	Release "C"	

Table 3. DSL-120A Side-Scan Sonar Surveys Operational Data for AT7-4 cruise. All times GMT.

Lowering #	In water	Bottom	Lv Bottom	On Deck
1	1507 8Nov	1910 8Nov	1834 11Nov	2042 11Nov
2	1535 12Nov	Abort 630M Ground Fault		1752 12Nov
3	0638 13Nov	1111 13Nov	0908 16Nov	1129 16Nov
4	0316 17Nov	0518 17Nov	1502 17Nov	1722 17Nov
5	1859 18Nov	2118 18Nov	2230 20Nov	0038 20Nov
6	1146 20Nov	1348 20Nov	0201 21Nov	0412 21Nov
7	1508 21Nov	1642 21Nov	1544 22Nov	1805 22Nov
8	0924 24Nov	1145 24Nov	2330 24Nov	0130 25Nov
9	1633 25Nov	1843 25Nov	2300 25Nov	0122 26Nov

Table 4. ABE Operational Data for AT7-4 Cruise.

Dive	Date	Start	Launch	On bottom	Start 1st line	End survey	Surface	On Deck	Km Surveyed	Survey Time	Sonar Pings
52	12-Nov	0:39	0:45	0:45	0:45	0:45	0:50	1:33	0.0	0:00	
53	12-Nov	4:39	4:46	6:07	6:07	6:07	7:09	8:14	0.0	0:00	
54	16-Nov	8:23	8:30	11:53	12:07	14:58	17:10	18:05	6.7	2:51	35500
55	17-Nov	14:34	14:38	17:45	15:59	7:22	9:39	11:35	30.1	13:44	118175
56	19-Nov	21:44	21:49	0:36	0:51	22:21	0:34	21:30	48.4	22:20	196050
57	22-Nov	19:22	19:28	22:06	22:19	21:57	0:35	1:15	53.1	23:38	214200
58	22-Nov	20:18	20:22	23:02	23:12	22:11	0:47	1:30	50.6	22:59	208025
59	26-Nov	18:32	18:40	21:18	21:26	18:08	20:41	20:56	45.7	20:42	187425
60	28-Nov	12:59	13:06	15:36	15:44	12:43	15:20	15:50	48.8	20:59	190000
61	30-Nov	6:40	6:45	9:20	9:29	11:02	13:30	13:41	3.0	1:33	14875
62	30-Nov	15:04	15:10	17:42	17:51	12:31	15:11	15:51	40.5	18:40	169250
								Totals	326.9	147:23	1333500

Table 5. Towed Camera Survey Operational Data for AT7-4 Cruise.

					On bottom			Off bottom		
Tow#	**JD**	**Month**	**Day**	**Year**	**Time(Z)**	**Depth(m)**	**Wire Out(m)**	**Time(Z)**	**Depth(m)**	**Wire Out(m)**
1	325	Nov	21	2001	10:30	2551	2532	12:15	2551	2530
2	327	Nov	23	2001	14:11	2589	2575	16:29	2587	2599
3	330	Nov	26	2001	09:11	2469	2576	11:30	2610	2609
4	330	Nov	26	2001	21:16	2672	2619	23:30	2591	2630
5	331	Nov	27	2001	11:09	2546	2528	13:25	2623	2633
6	331	Nov	27	2001	17:21	2557	2555	19:35	2498	2545
7	332	Nov	28	2001	08:31	2693	2676	10:44	2620	2573
8	332	Nov	28	2001	15:21	2706	2685	17:40	2706	2714
9	333	Nov	29	2001	08:56	2663	2562	11:14	2526	25274
10	333	Nov	29	2001	15:31	2541	2544	17:45	2546	2688
11	334	Nov	30	2001	06:59	2626	2652	09:15	2626	2713
12	334	Nov	30	2001	16:46	2589	2583	18:15	2588	2576
13	335	Dec	1	2001	09:00	2582	2579	11:10	2586	2620
14	335	Dec	1	2001	15:32	2609	2597	17:30	2607	2661

Table 6. Atlantis 7-4 Rock Core Data

Rock Core #	Date (Julian Day)	Time hit (GMT)	Lat 9ºN (minutes)	Long 104ºW (minutes)	Dec. Lat.	Dec. Long.	Depth (m)	Wire-out (m)	Approx. Weight (g)	Comments
1	11/13/2001 (317)	1:48:20	59.684	19.53	9.3255	-104.3255	2591	2584	5	
2	11/13/2001 (317)	3:18:56	59.699	19.586	9.994983333	-104.3264333	2592	2585	7-8	
3	11/13/2001 (317)	4:47:34	59.753	19.604	9.995883333	-104.3267333	2592	2587	2-3	
4	11/23/2001 (327)	21:26:00	49.7519	15.9622	9.829198333	-104.2660367	2608	2609	0.5-1	
5	11/23/2001 (327)	23:17:00	49.543	15.885	9.825716667	-104.26475	2619	2614	1-2	
6	11/24/2001 (328)	2:45:00	49.405	15.9112	9.823416667	-104.2651867	2608	2606	0.5-1	
7	11/24/2001 (328)	4:21:00	49.5284	16.0931	9.825473333	-104.2682183	2602	2594	5	double hit, average position of two locations
8	11/25/2001 (329)	5:22:43	28.8753	14.3217	9.481255	-104.238695	2582	2576	8-10	
9	11/25/2001 (329)	7:06:00	28.8273	14.6017	9.480455	-104.2433617	2587	2581	10	
10	11/25/2001 (329)	8:50:00	28.781	14.877	9.479683333	-104.24795	2590	2590	5	
11	11/25/2001 (329)	10:32:00	28.7377	15.2049	9.478961667	-104.253415	2606	2615	5	
12	11/25/2001 (329)	12:20:00	28.694	15.4821	9.478233333	-104.258035	2615	2626	2-3	
13	11/25/2001 (329)	14:04:00	28.6503	15.7555	9.477505	-104.2625917	2623	2637	1-2	
14	11/26/2001 (330)	4:03:00	28.605	16.0301	9.47675	-104.2671683	2679	2678	5-10	
15	11/26/2001 (330)	5:47:00	28.5599	16.2886	9.475998333	-104.2714767	2663	2660	2-3	double hit, average position of two locations
16	11/26/2001 (330)	13:10:00	28.9075	14.0539	9.481791667	-104.2342317	2583	2545	5	
17	11/26/2001 (330)	14:56:00	28.9642	13.7836	9.482736667	-104.2297267	NA	2610	1	seabeam being fixed
18	11/26/2001 (330)	16:43:00	28.9938	13.5203	9.48323	-104.2253383	2671	2675	2-3	
19	11/26/2001 (330)	18:25:00	29.055	13.249	9.48425	-104.2208167	2662	2664	1-2	
20	11/27/2001 (331)	2:18:00	29.0895	12.988	9.484825	-104.2164667	2588	2695	0.5-1	double hit, average position of two locations
21	11/27/2001 (331)	4:04:00	29.1366	12.7246	9.48561	-104.2120767	2694*	2700	3-4	*Depth taken only at beginning of survey (0542z) because of ABE; double hit, average position of two locations
22	11/27/2001 (331)	6:24:36	29.17975	12.4573	9.486329167	-104.2076217	2712*	2712	5-7	*Depth taken at beginning of survey (0542z) because of ABE; double hit average position of two locations
23	11/28/2001 (332)	1:28:00	29.1511	14.9228	9.485851667	-104.2487133	2592	2598	4-7	
24	11/28/2001 (332)	4:20:00	28.96715	14.8954	9.482785833	-104.2482567	2592	2585	5-10	double hit, average position of two locations
25	11/28/2001 (332)	6:11:00	28.63765	14.8497	9.477294167	-104.247495	2591	2592	5-7	double hit, average position of two locations
26	11/28/2001 (332)	12:51:00	28.3657	14.805	9.472761667	-104.24675	2585	2590		
27	11/28/2001 (332)	21:10:00	29.1299	14.5264	9.485498333	-104.2421067	2586	2580	>10	
28	11/28/2001 (332)	23:10:00	28.8513	14.4812	9.480855	-104.2413533	2587	2587	>10	

Table 6. Atlantis 7-4 Rock Core Data (continued)

Rock Core #	Date (Julian Day)	Time hit (GMT)	Lat 9ºN (minutes)	Long 104ºW (minutes)	Dec. Lat.	Dec. Long.	Depth (m)	Wire-out (m)	Approx. Weight (g)	Comments
29	11/29/2001 (333)	0:57:00	28.5795	14.4404	9.476325	-104.2407	2588	2594	10	
30	11/29/2001 (333)	2:50:00	28.304	14.4000	9.471733333	-104.24	2585	2585	2-5	
32	11/29/2001 (333)	23:22:00	28.5877	14.2799	9.476461667	-104.2379983	2584	2585	<1	no glass, only sulphides
33	11/30/2001 (334)	1:10:00	29.1345	14.354	9.485575	-104.2392333	2585	2589	2-5	
34	11/30/2001 (334)	11:35:12	28.2718	14.9415	9.471196667	-104.249025	2587	2586	5-10	
35	11/30/2001 (334)	14:55:00	28.9136	14.7973	9.481893333	-104.2466217	2592	2586	5	
36	11/30/2001 (334)	23:06:00	28.9111	15.0496	9.481851667	-104.2508267	2595	2604	5	
37	12/01/2001 (335)	1:23:00	29.12	15.087	9.485333333	-104.25145	2602	2601	5	position taken @ 0124Z and depth taken @ 0101Z
38	12/01/2001 (335)	3:17:52	28.523	14.975	9.475383333	-104.2495833	2592	2588	3-5	
39	12/01/2001 (335)	5:10:00	28.364	14.685	9.472733333	-104.24475	2587	2594	3-5	double hit, average position of two locations
40	12/01/2001 (335)	7:07:02	28.0698	14.2903	9.46783	-104.2381717	2590	2590	5-10	
41	12/01/2001 (335)	13:16:00	28.8192	15.81695	9.48032	-104.2636158	2625	2625		double hit, average position of two locations
42	12/01/2001 (335)	19:22:45	29.04745	13.9805	9.484124167	-104.2330083	2595	2587	3-4	double hit, average position of two locations

Appendix 1

Summary of ABE Operations on AT7-4

Appendix 1
Summary of ABE Operations, AT7-4

Summary

On this voyage, we conducted 11 ABE dives. ABE completed a total of 327 km of bottom tracks over 147 hours (see Table 4 for a summary of operational statistics). For all tracklines, we collected cross-track bathymetry using a scanning sonar (Imagenex), magnetometer data, and records of temperature and salinity. On selected tracklines, we collected snapshot video images. Two areas were surveyed with a total area of approximately 14.3 km^2, including virtually complete, overlapping bathymetric coverage with lines spaced from 40 to 60 km.

In addition to gathering the desired seafloor data, we also demonstrated an important new capability for ABE. During many of the dives, we left ABE unattended, transited out of range, and performed other work. These included DSL120 operations, rock coring, camera tows, and transponder recoveries at another site. We scheduled the other tasks based on projections of the completion of the ABE dive (which entails uncertainty due to variability in power usage depending on terrain). In each case we arrived back on station either as ABE was completing its tracklines or while it was ascending.

Dives ABE52-57 were conducted at the 9 50’ site, dives ABE58-ABE62 were conducted at the 9 29’ site.

Dives ABE52 and ABE53

On these two dives, ABE did not reach the bottom due to engineering problems. ABE52 had a failure on launch, and the vehicle released both descent and ascent weights shortly after entering the water. ABE53 terminated when the connector to the compass flooded at a depth of 1100 meters. The control system correctly diagnosed the fault and aborted the dive, and the vehicle returned to the surface for recovery.

Dive ABE54

On this dive, ABE reached the bottom and made a short survey. ABE crossed several acoustic transponder baselines, and crossed the ASCT 4 times. The dive aborted early due to a false low-battery message. After this dive, we changed the low-battery abort logic to require many consistent messages to trigger an abort.
Time on bottom: 2:51
Survey distance: 6.7 km

Dive ABE55

ABE executed 28 1 km tracklines out of a planned set of 40. The tracks started at the eastern edge of the survey area and were oriented parallel to the ridge axis. Trackline and bottom following was excellent with a trackline spacing of 40 meters and a nominal survey height of 25 meters off-bottom. Significant plume activity spotted due to a temperature anomaly. After recovery, we found that the sonar was scanning asymmetrically. The data was usable although quality was diminished. This was corrected for the next dive. The dive again terminated due to persistent, incorrect low battery messages from one of the three packs, and that pack was replaced.
Time on bottom: 13:06
Survey distance: 30.1 km

Appendix 1
Summary of ABE Operations, AT7-4

Dive ABE56
On this dive, ABE landed to the north of the acoustic transponder net and made a pass from east to west in order to locate the magnetic anomaly at the northern extent of the survey area. ABE then crossed the ASCT twice, then executed a 1.5 km camera run, and rejoined the grid started on the previous dive. ABE completed that grid survey, adding another 40 1 km tracks spaced 40 meters apart which extended the grid several hundred meters to the west of the ASCT. ABE then started a smaller survey of an interesting lava flow approximately 1 km to the south with a trackline spacing of 60 meters at a height of 40 meters. The mission ended when ABE's batteries were depleted. While ABE was surveying, we left the site and conducted a DSL120a survey starting approx 10 miles to the north. We left ABE unattended for 16 hours, although we received some acoustic returns from ABE during the DSL120a tow. We arrived back on the site approximately 15 minutes before ABE surfaced. Sonar and magnetometer performed well, and temperature records show anomalies near known vents along the ASCT.

Time on bottom: 22:20
Survey distance: 48.4 km

Dive ABE57
On this dive, ABE completed 1km tracklines in a box above the grids filled on ABE55 and ABE56. We used 60 m line spacings and flew at a nomimal height off bottom of 40 meters. After completing the grid, the vehicle executed 2 tracklines over the ASCT to the north. Sonar and magnetometer performed satisfactorily, and known vents along the ASCT showed up on the temperature record. During the ABE dive, we conducted a camera tow with "the Thing" and obtained 4 rock cores.

ABE 58
This was our first dive at the 9 29' site. ABE made a complete tour of the area, crossing all acoustic baselines and starting a grid to the west of the ASCT. ABE's acoustic tracking had a failure at the western edge of the survey, which was later determined to be the result of "acoustic wrap-around", which produced a set of consistent pings longer than the programmed 10 second acoustic cycle time. Minimum time gates were added after this dive to prevent this in the future. ABE completed 23 1.4 km tracklines, spaced 60 meters at a nominal height of 40 meters. Sonar and magnetometer performed well. The temperature record showed anomalies along the ASCT including an apparent plume extending to the southwest, as well as an unexplained anomaly extending for several hundred meters located approximately 1.2 km to the east of the ASCT. During the dive, we also completed a camera tow, 6 rock cores, and ran a DSL120a survey line.

ABE 59
On this dive, ABE started with a camera run across the sharply defined graben wo the west of the ASCT. For the following sonar and magnetics survey, ABE experienced poor transponder coverage on the western slope of the ridge. We attempted to fill in by using ranges from another transponder, which performed poorly. Navigation fixes were spotty, and the vehicle deadreckoned much of the time. After post-processing the navigation

data, we were able to recover fixes from over 2/3 of the survey area. The sonar and magnetometer performed well, and we observed a small temperature change in the graben. During this dive, we also complete 3 rock cores in the 9 29' area, and made 2 camera tows up at the 9 50' area. We arrived back at the 9 29' site approximately 1 _ hours before ABE depleted its batteries and began its ascent. We took another rock core during the ascent.

ABE 60

On this dive, ABE surveyed to the eastern side of the ridge. Acoustic navigation coverage was slightly improved over the previous dive, although a substantial shadow zone was evident after ABE descended a steep section. During this dive we conducted 3 rock cores at the 9 29 site, then steamed back to the 9 50' site where we ran two camera tows over targets observed in the ABE59 bathymetric map, and recovered two transponders at the northern site.

ABE 61

This dive was planned to fill in the holes in the grids from ABE 59 and ABE60. We moved the western most transponder slightly to the east of the ridge crest to fill to hole in the coverage to the east, and changed limits on range gates to improve coverage to the west. We also increased the acoustic update interval from 10 to 15 seconds to reduce bounce arrivals. After ABE reached the bottom and started surveying, it was clear that it was not navigating properly. We aborted the dive using the acoustic command system (its first use), and replanned the tracks to fill all the gaps with the remaining time before we had to leave station. Atlantis recovered the vehicle 10 minutes after it surfaced, and we launched it again 90 minutes later after switching hydrophones and adjusting some software. We conducted a camera tow during the dive.

ABE 62

On this dive, our adjustments to the acoustic navigation system were largely effective, and ABE successfully filled all the major holes in the grid from the previous 4 surveys despite some intermittent returns. These intermittent returns were not a result of obvious shadowing and must be investigated. Sonar and magnetometer performed well, and we observed scattered temperature anomalies on the western flank and when crossing the ASCT. The survey ended following completion of the last trackline, which was planned to bring the vehicle to the surface to meet our departure deadline. We completed 5 rock cores and two camera tows during the dive.

Appendix 2

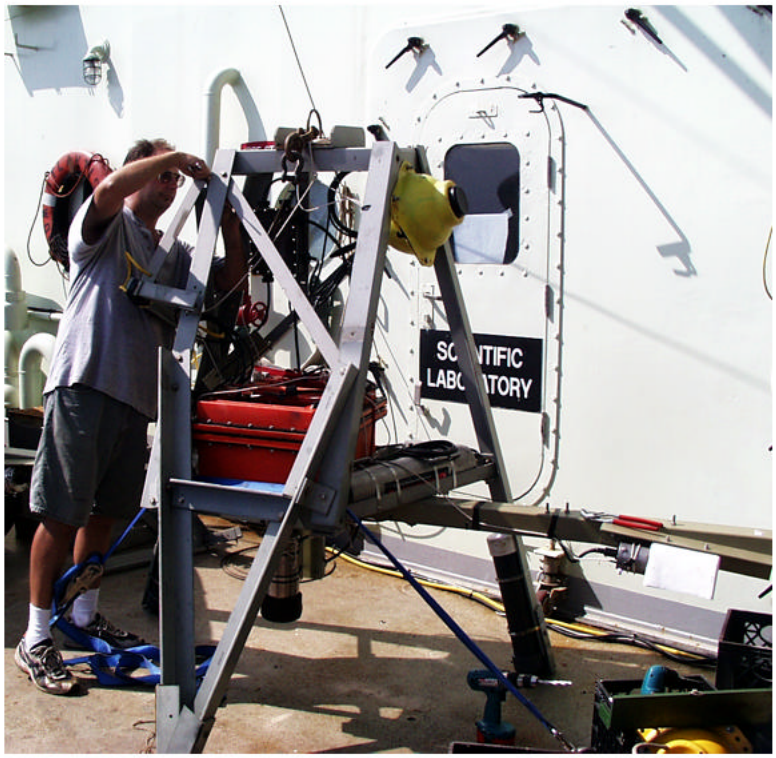
Atlantis 7-4 Cruise Report

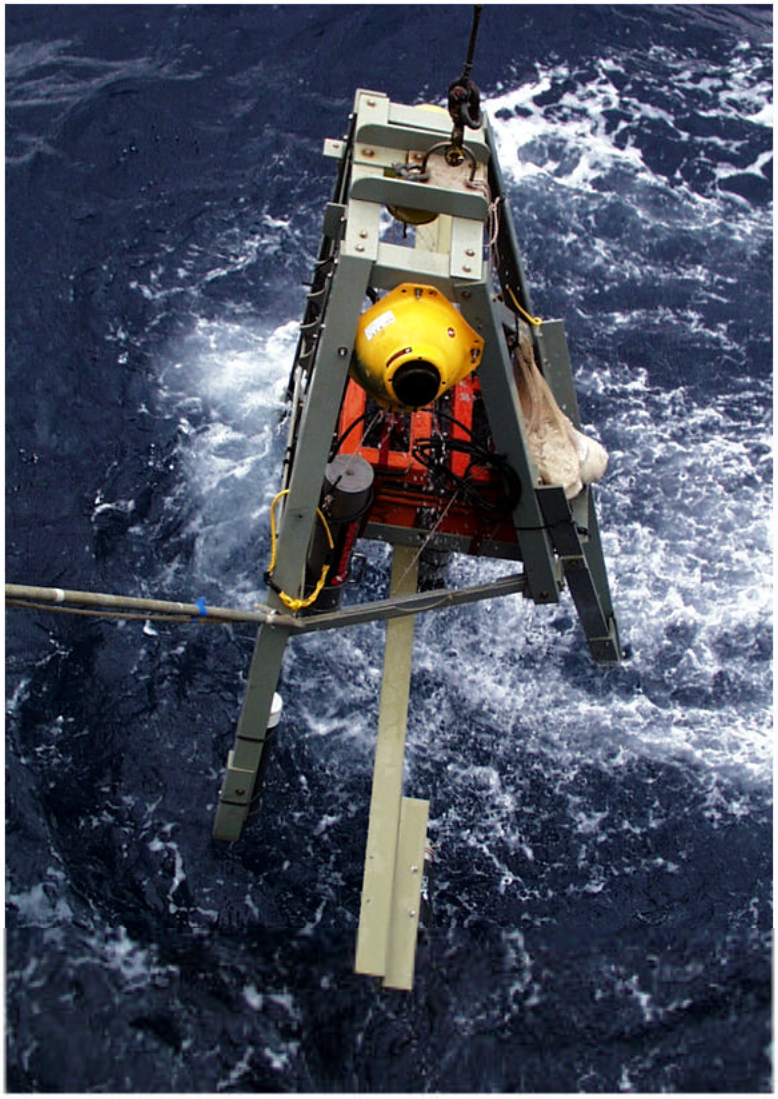
Deep Tow Camera Photos

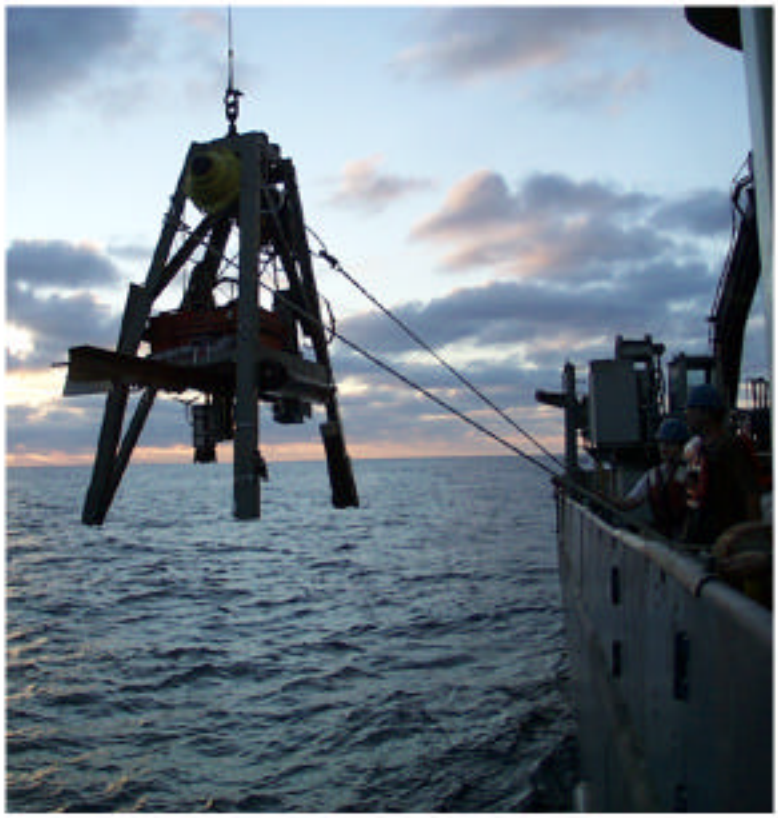
(captions for each photo indicate year_month_day_hour_min_sec)

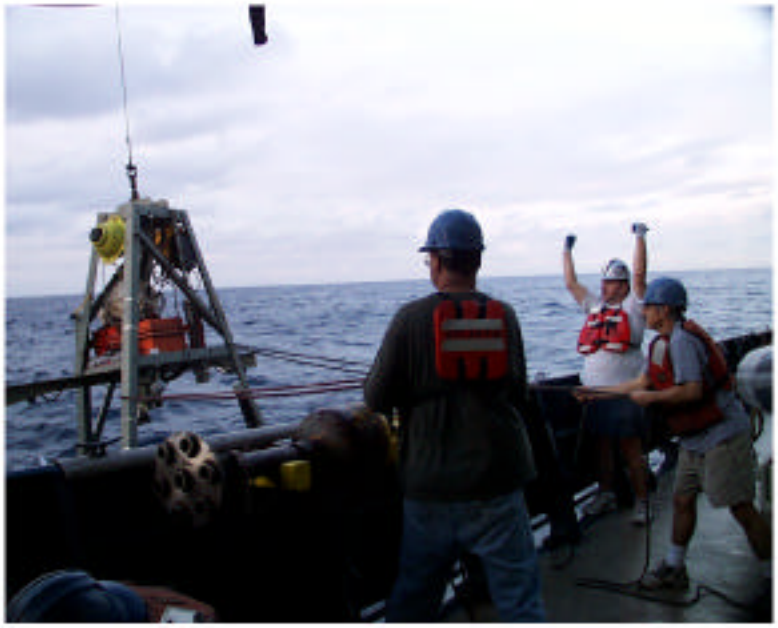
Nov. 2001

Atlantis 7-4
Camera Deck Photos

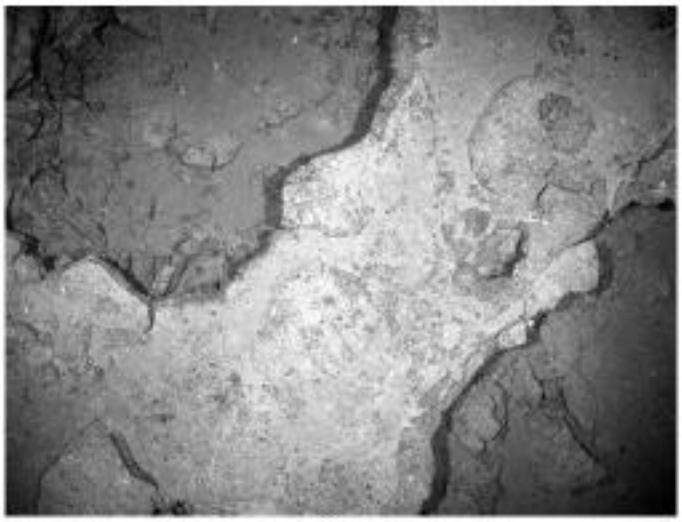








Atlantis 7-4
Camera Tow 6 Examples



2001_11_27_18_12_47



2001_11_27_18_59_33



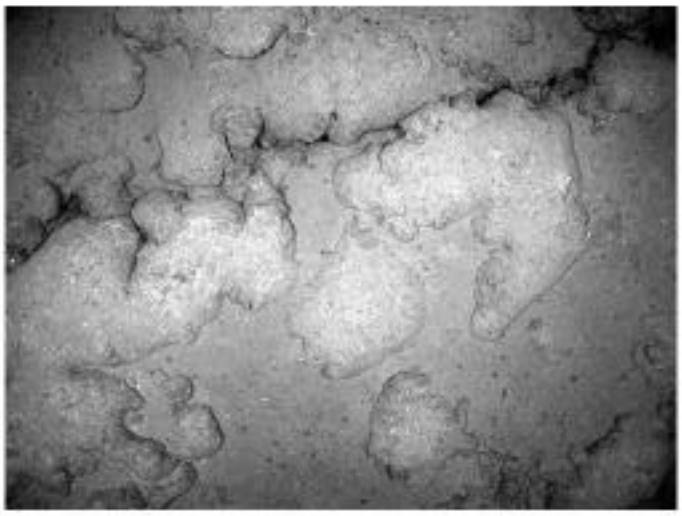
2001_11_27_18_07_32



2001_11_27_18_13_17



2001_11_27_17_36_17



2001_11_27_19_22_48

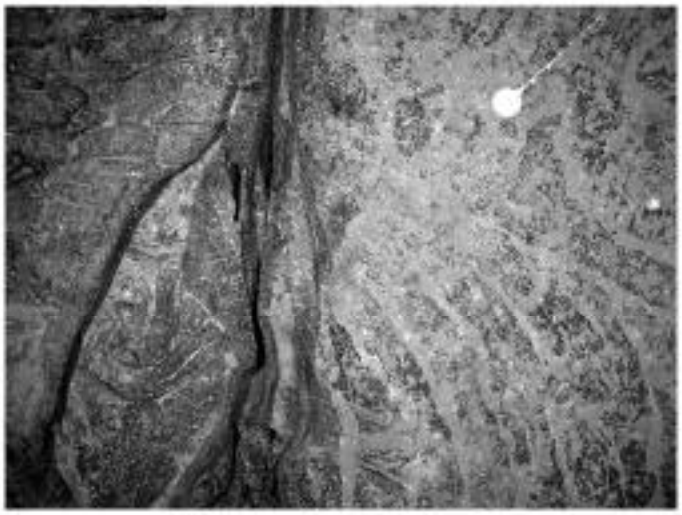
Atlantis 7-4
Camera Tow 10 Examples



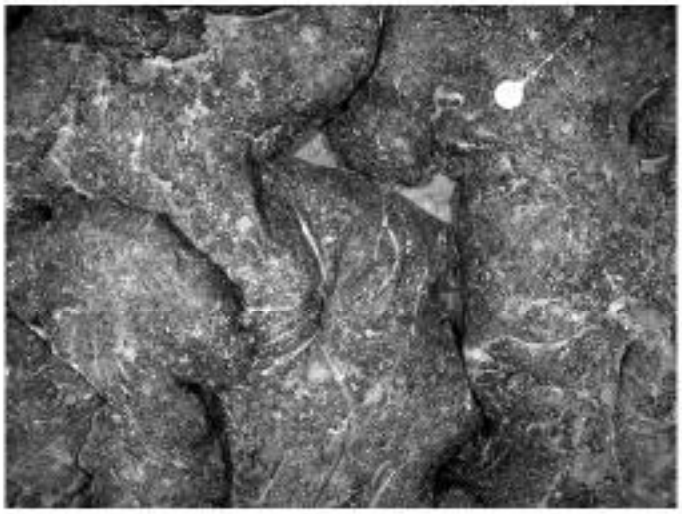
2001_11_29_16_24_25



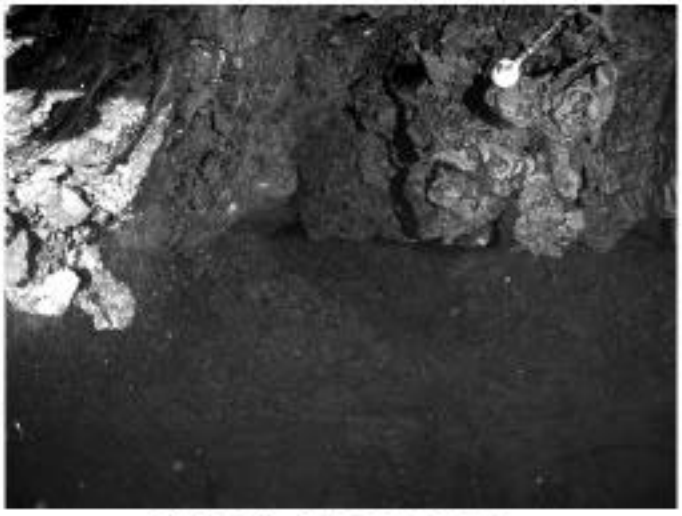
2001_11_29_16_30_55



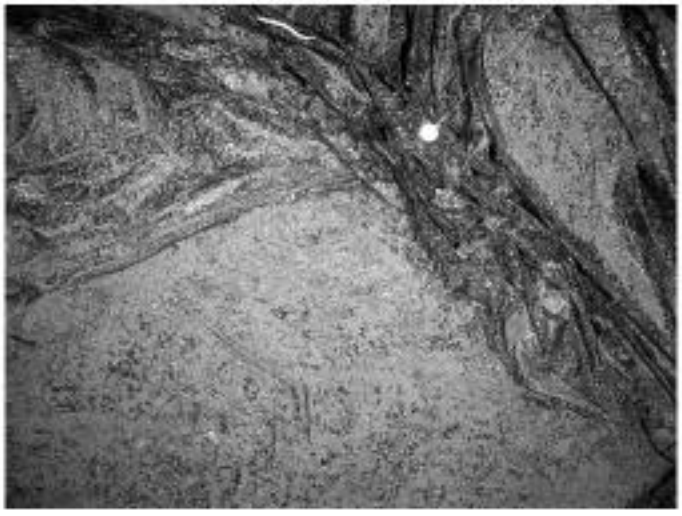
2001_11_29_16_39_40



2001_11_29_16_55_25



2001_11_29_17_32_25



2001_11_29_17_34_25

Atlantis 7-4
Camera Tow 13 Examples



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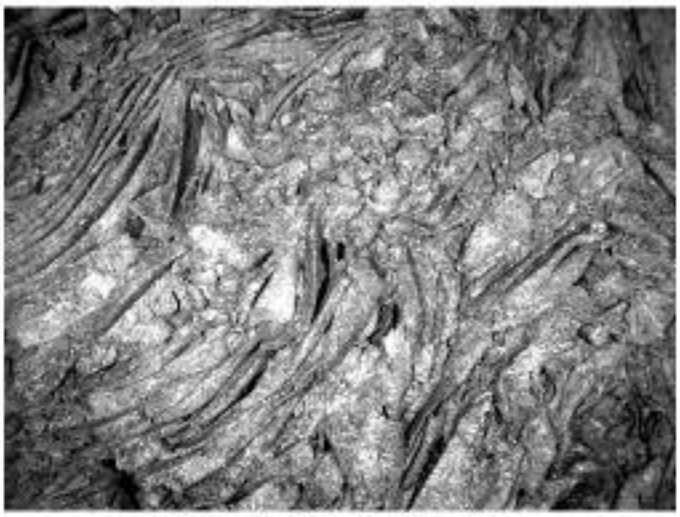
2001_12_01_10_20_07



2001_12_01_09_23_52



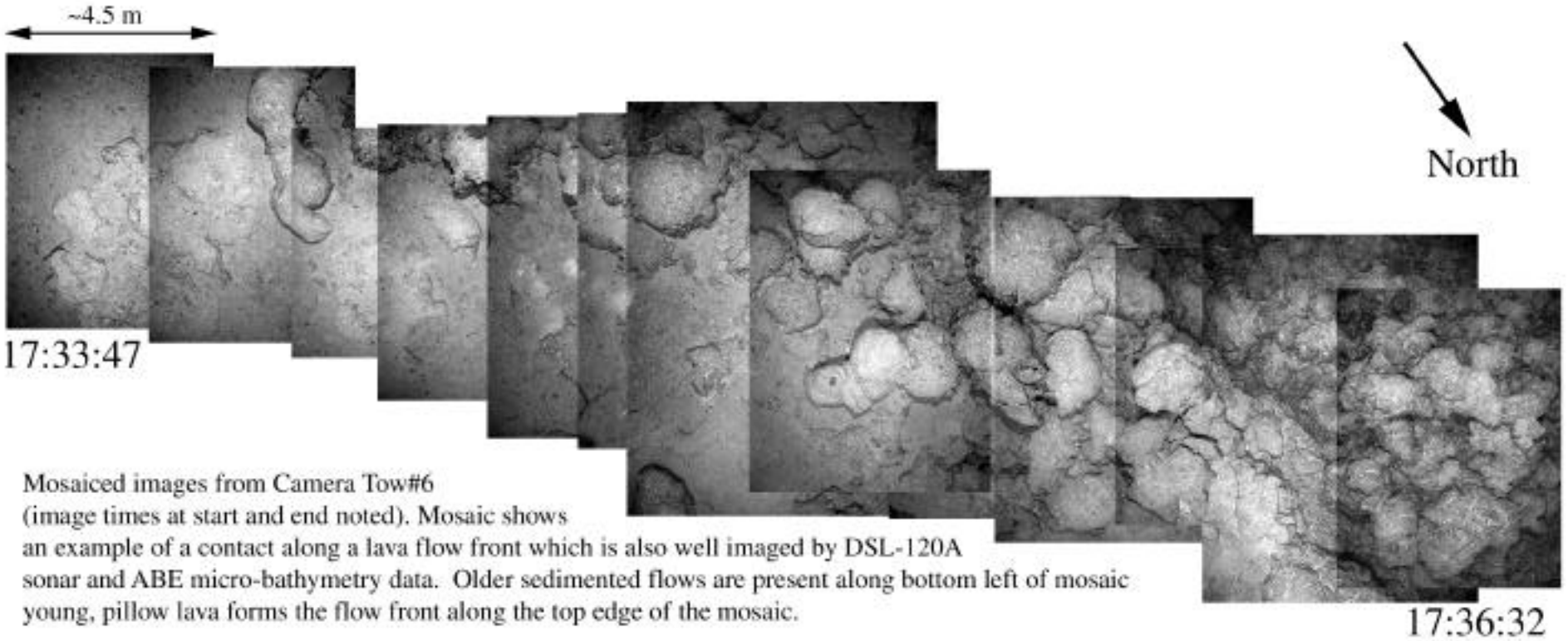
2001_12_01_09_27_37



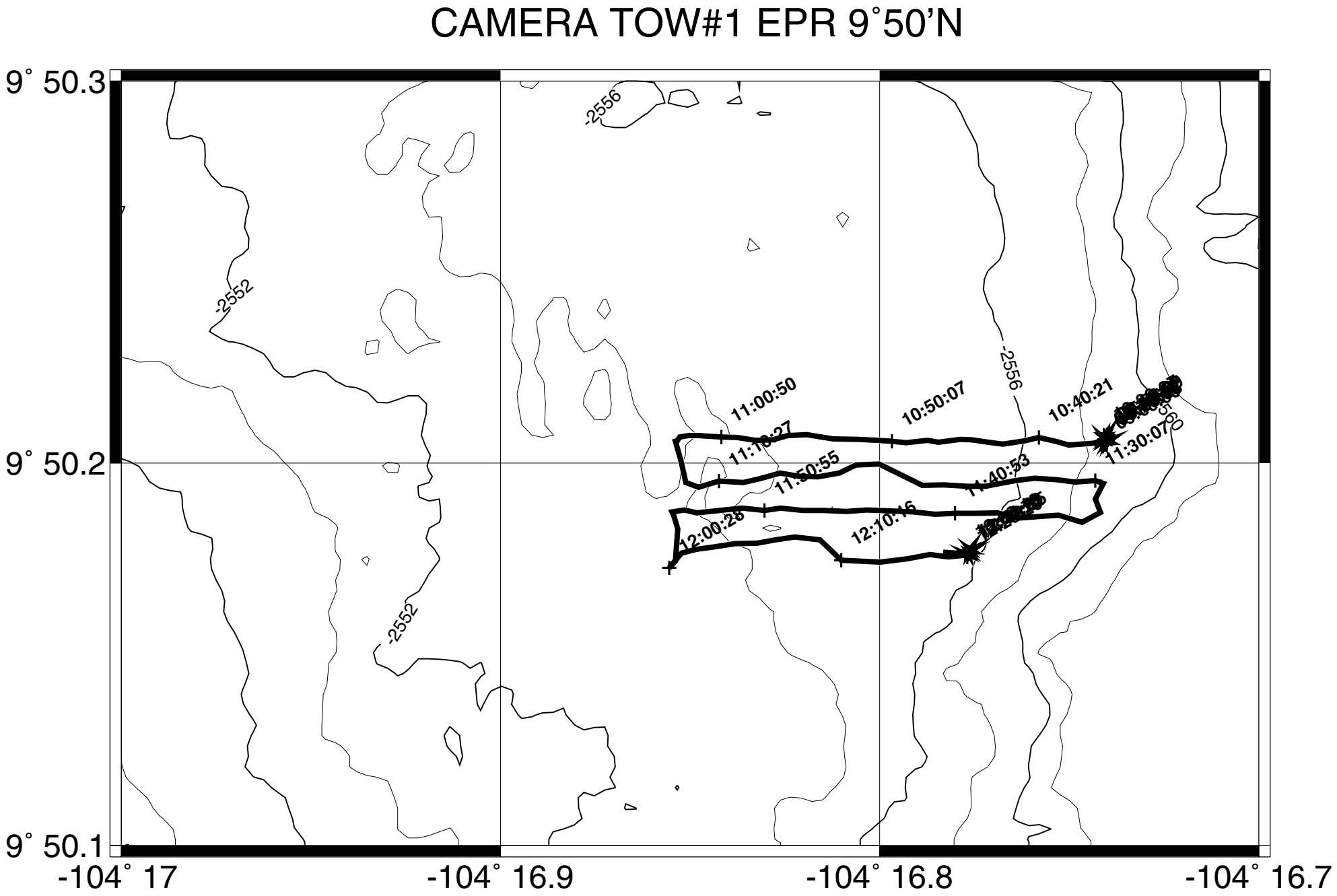
2001_12_01_09_02_22



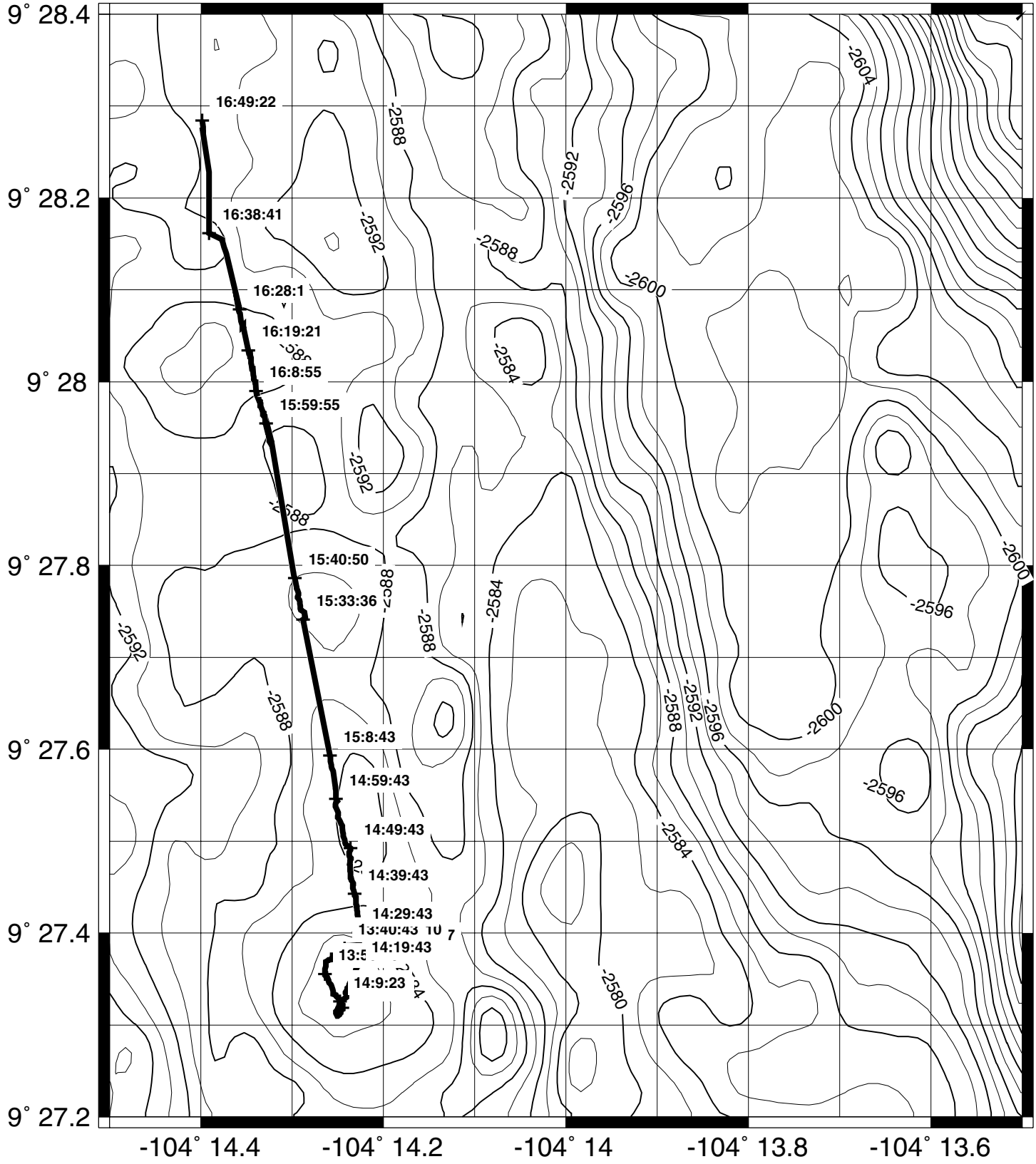
2001_12_01_10_13_07



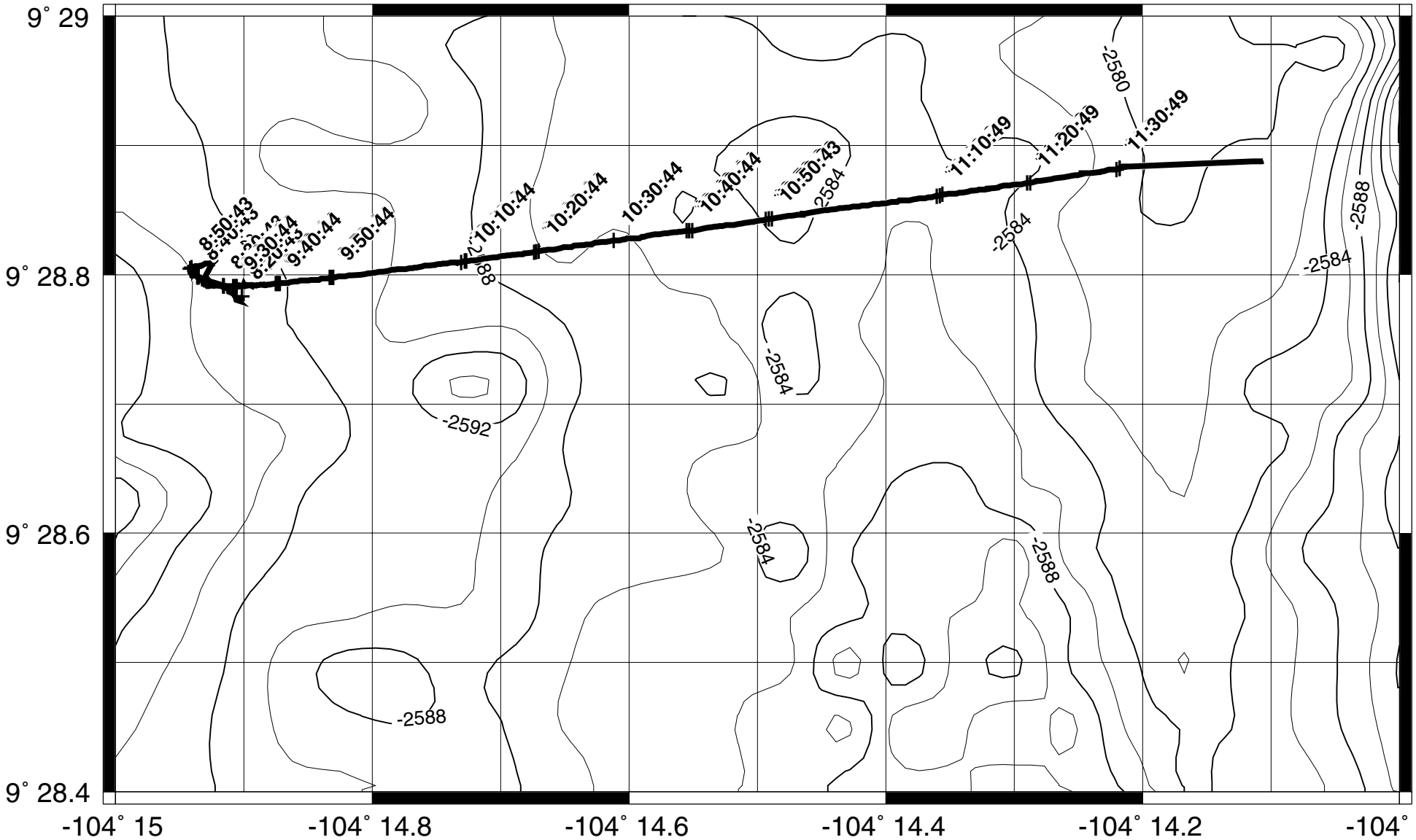
Mosaiced images from Camera Tow#6
(image times at start and end noted). Mosaic shows
an example of a contact along a lava flow front which is also well imaged by DSL-120A
sonar and ABE micro-bathymetry data. Older sedimented flows are present along bottom left of mosaic
young, pillow lava forms the flow front along the top edge of the mosaic.


CAMERA TOW#1 EPR 9˚50'N
9˚ 50.3
9˚ 50.2
9˚ 50.1
-104˚ 17
-104˚ 16.9
-104˚ 16.8
-104˚ 16.7
-2556
-2552
-2556
-2552
11:00:50
10:50:07
10:40:21
11:30:07
11:50:55
11:40:53
12:00:28
12:10:16

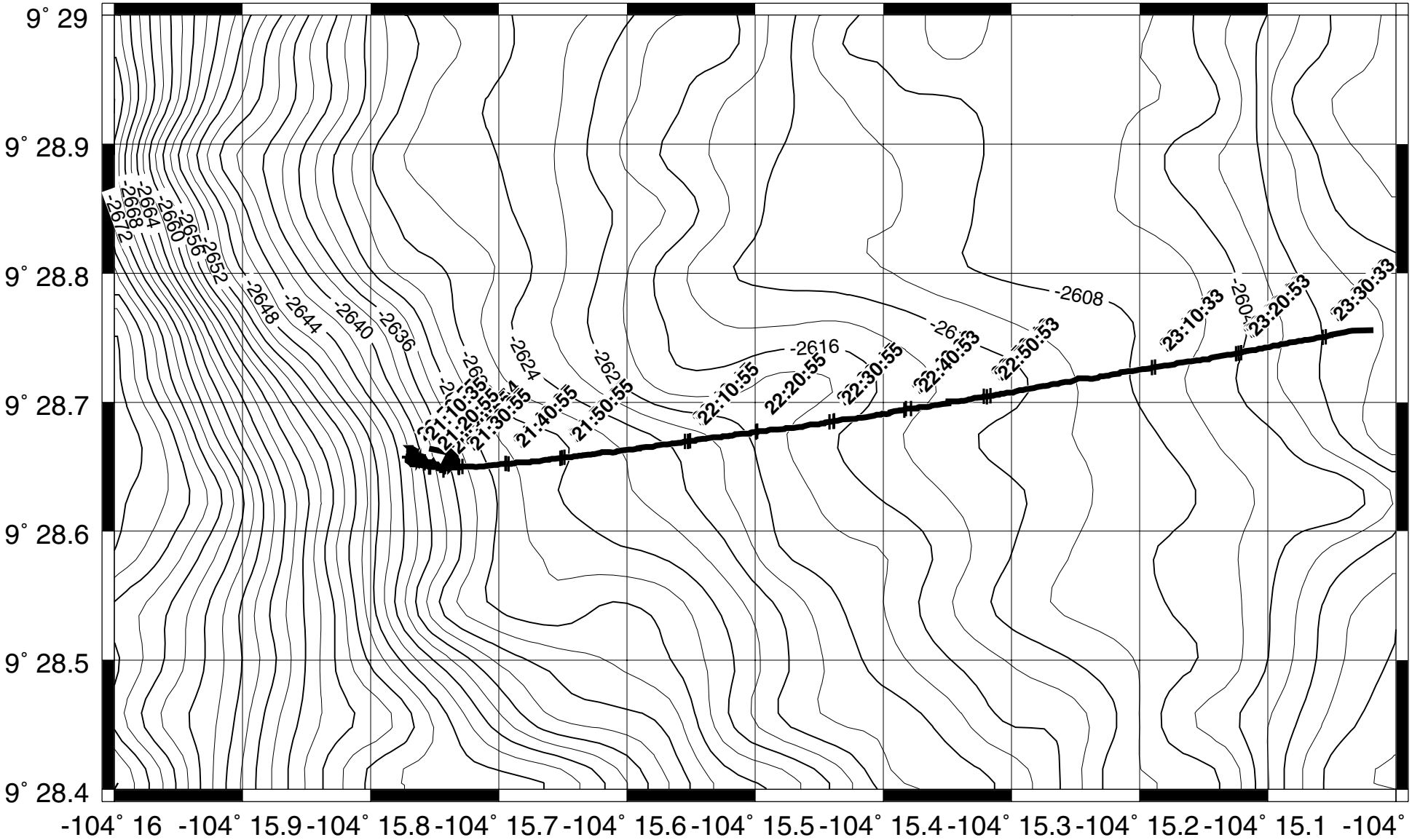
CAMERA TOW#2 EPR 9˚28'N



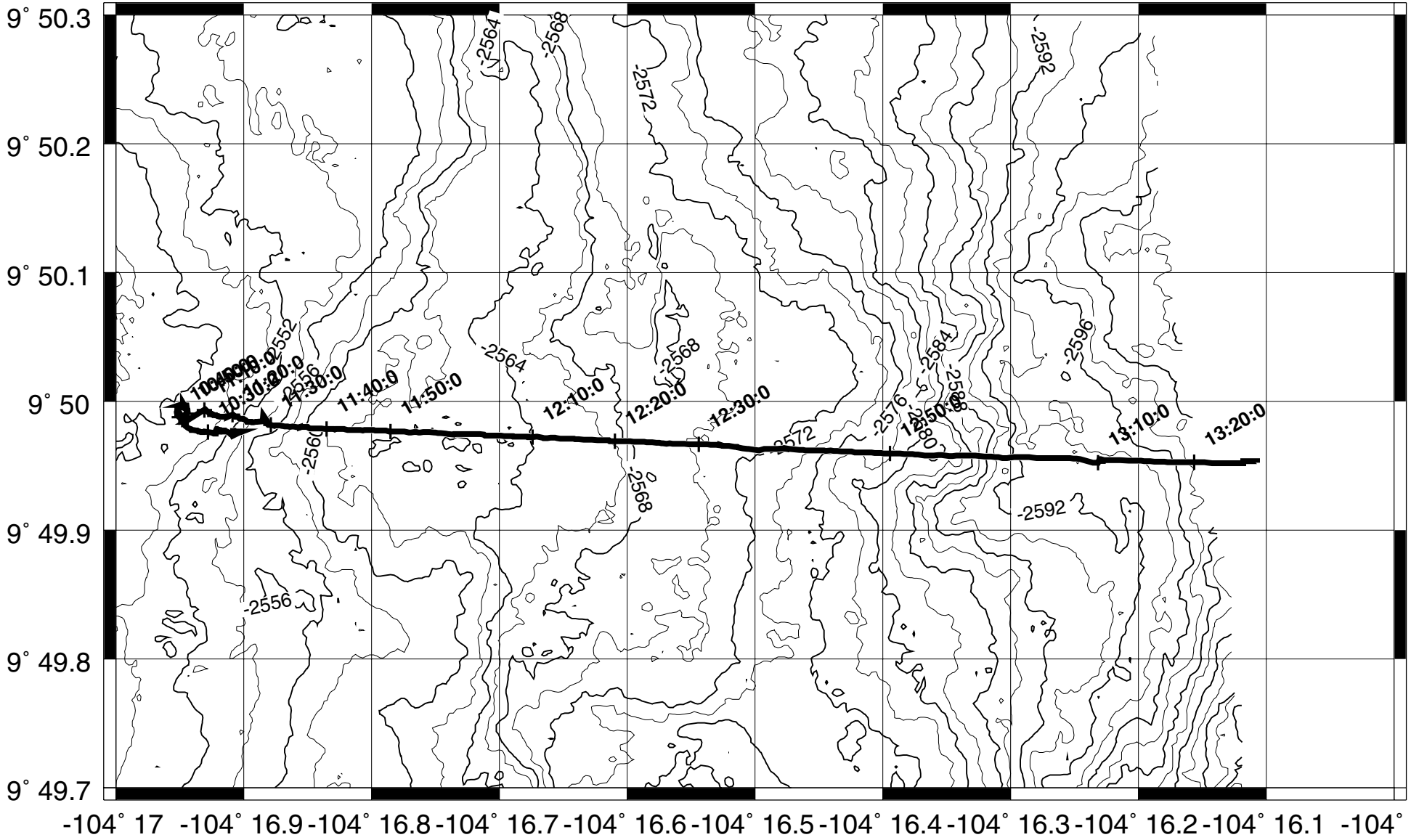
CAMERA TOW#3 EPR 9˚28’N



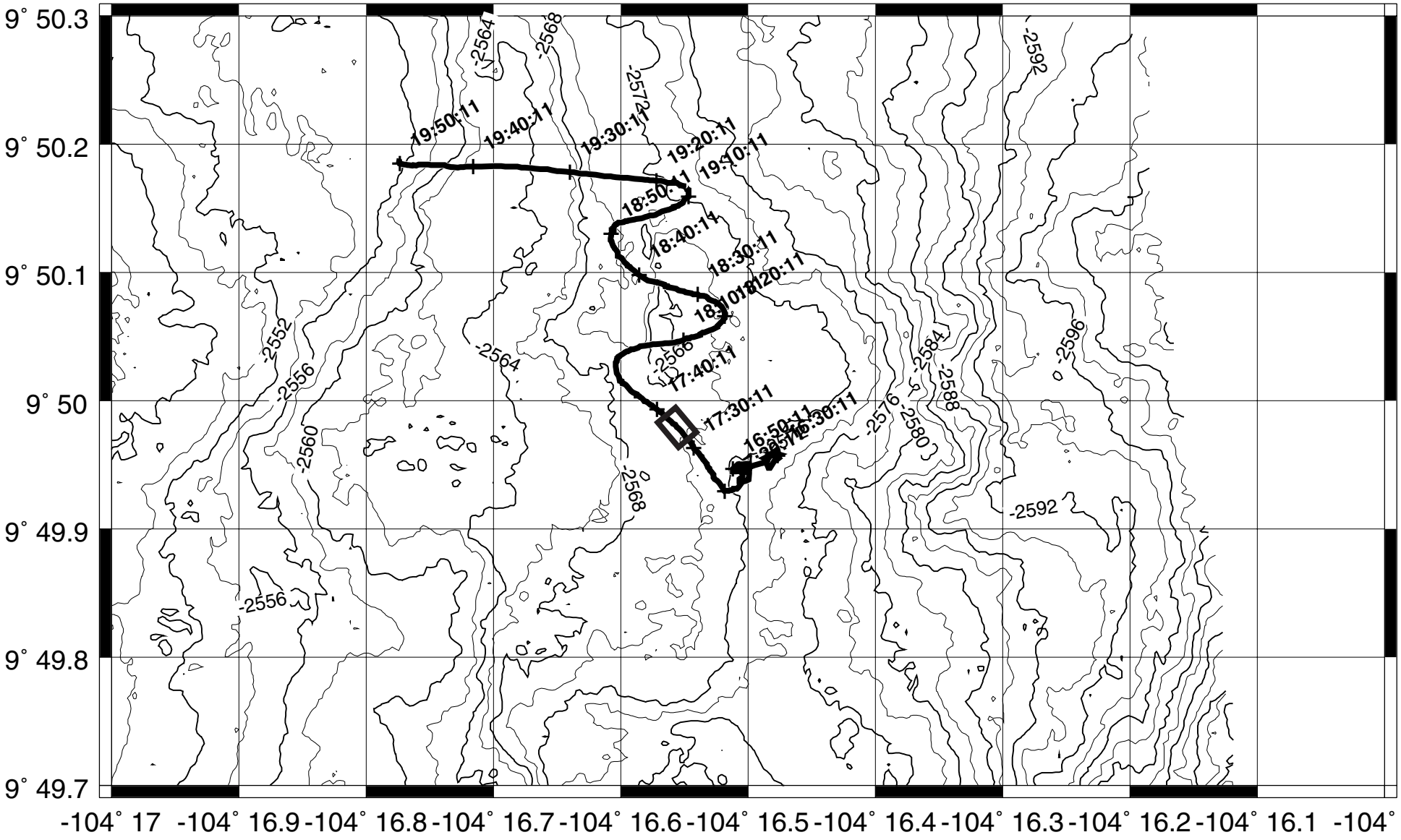
CAMERA TOW#4 EPR 9˚28'N



CAMERA TOW#5 EPR 9˚50'N

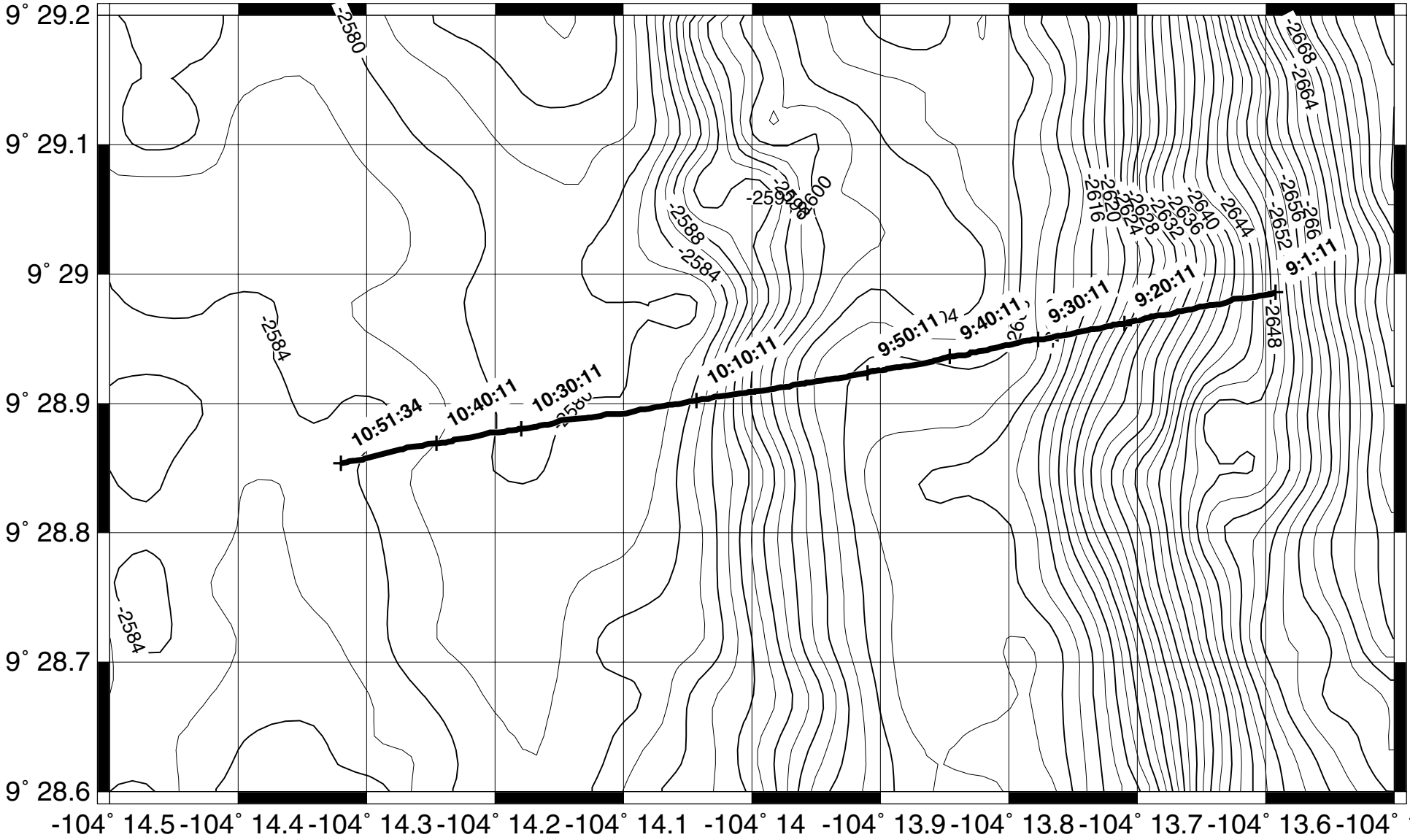


CAMERA TOW#6 EPR 9˚50'N

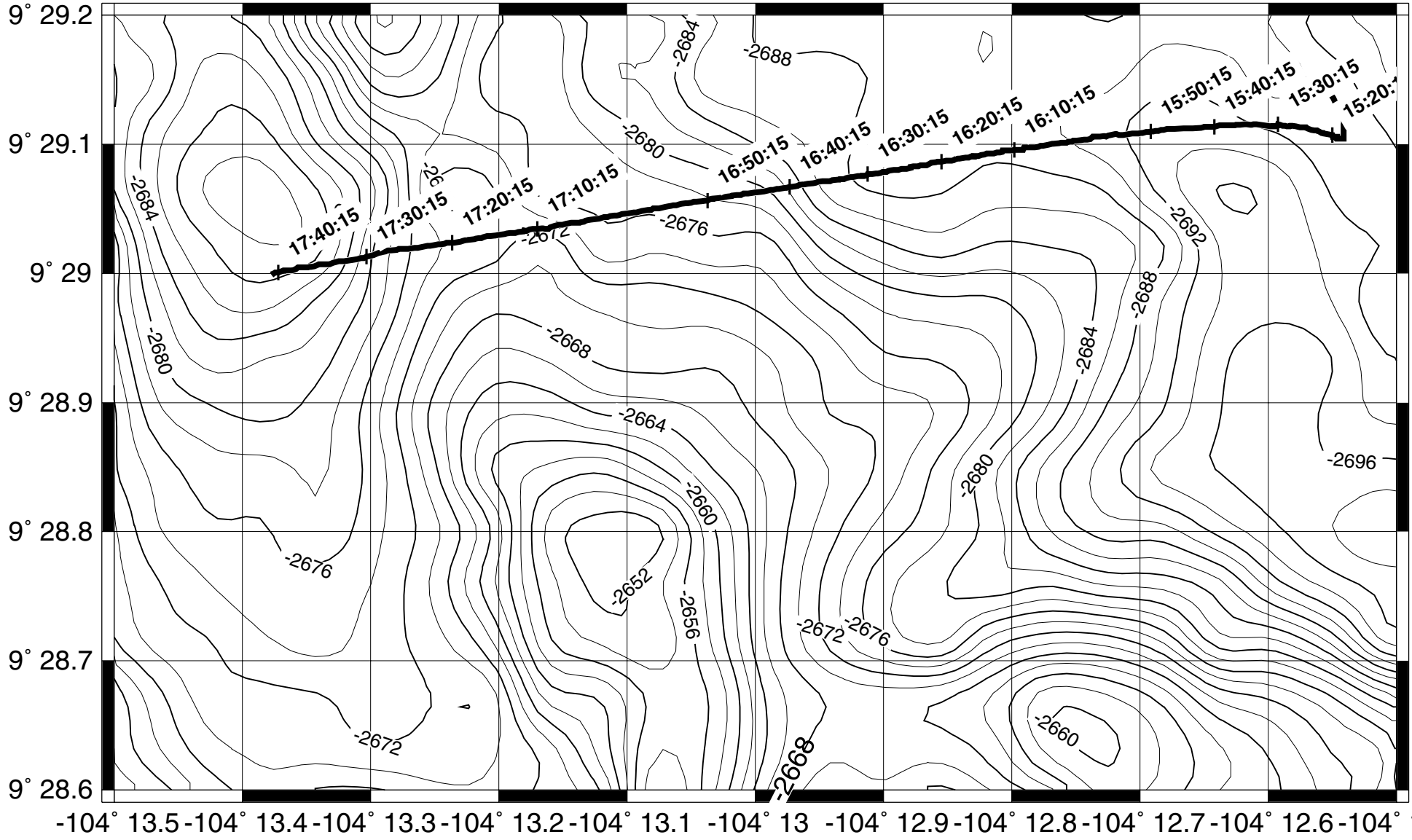


Box at 17:33:47 to 17:36:32 along track shows area where images of lava flow-front were photomosaiced.

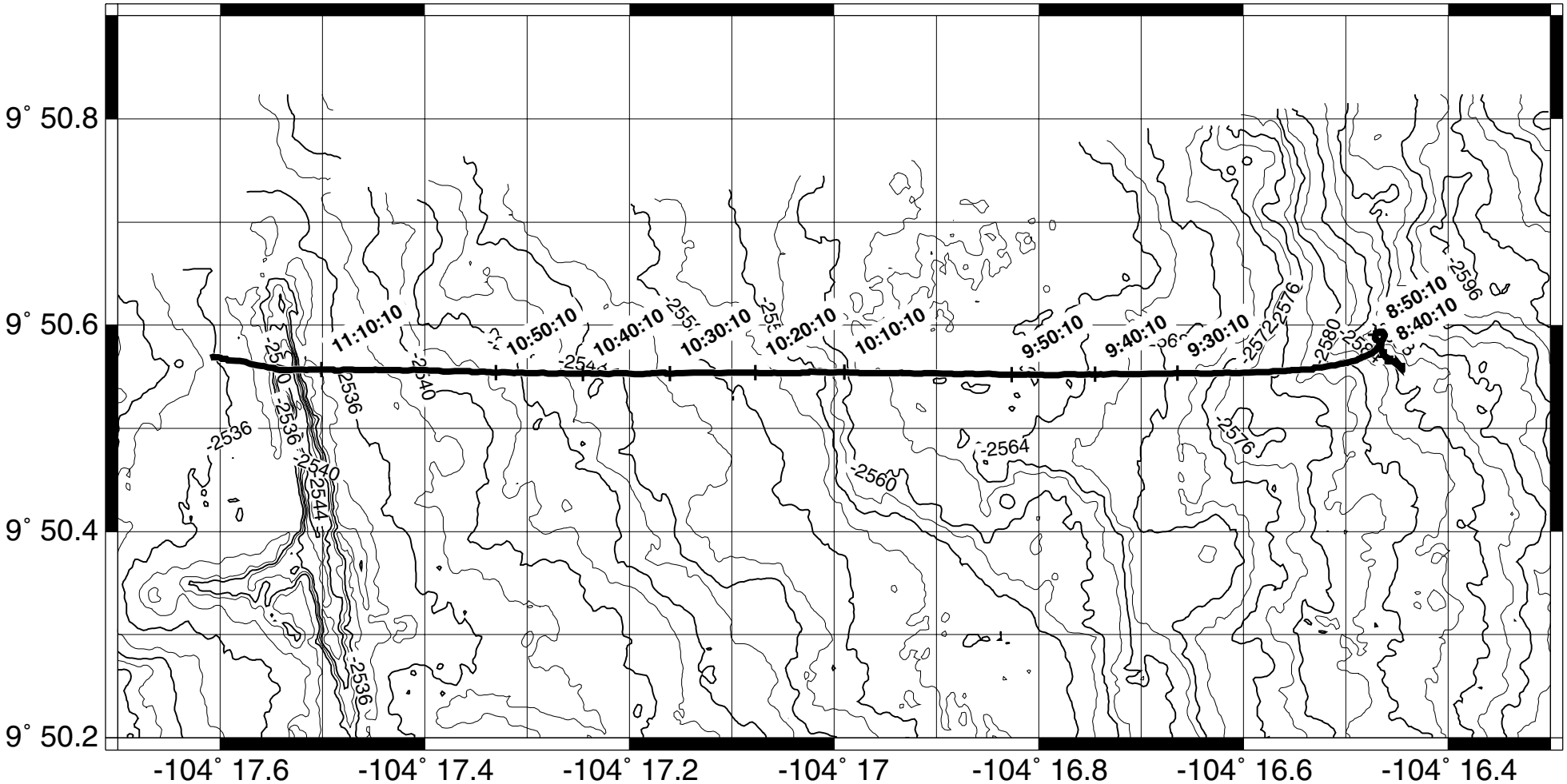
CAMERA TOW#7 EPR 9˚28 N



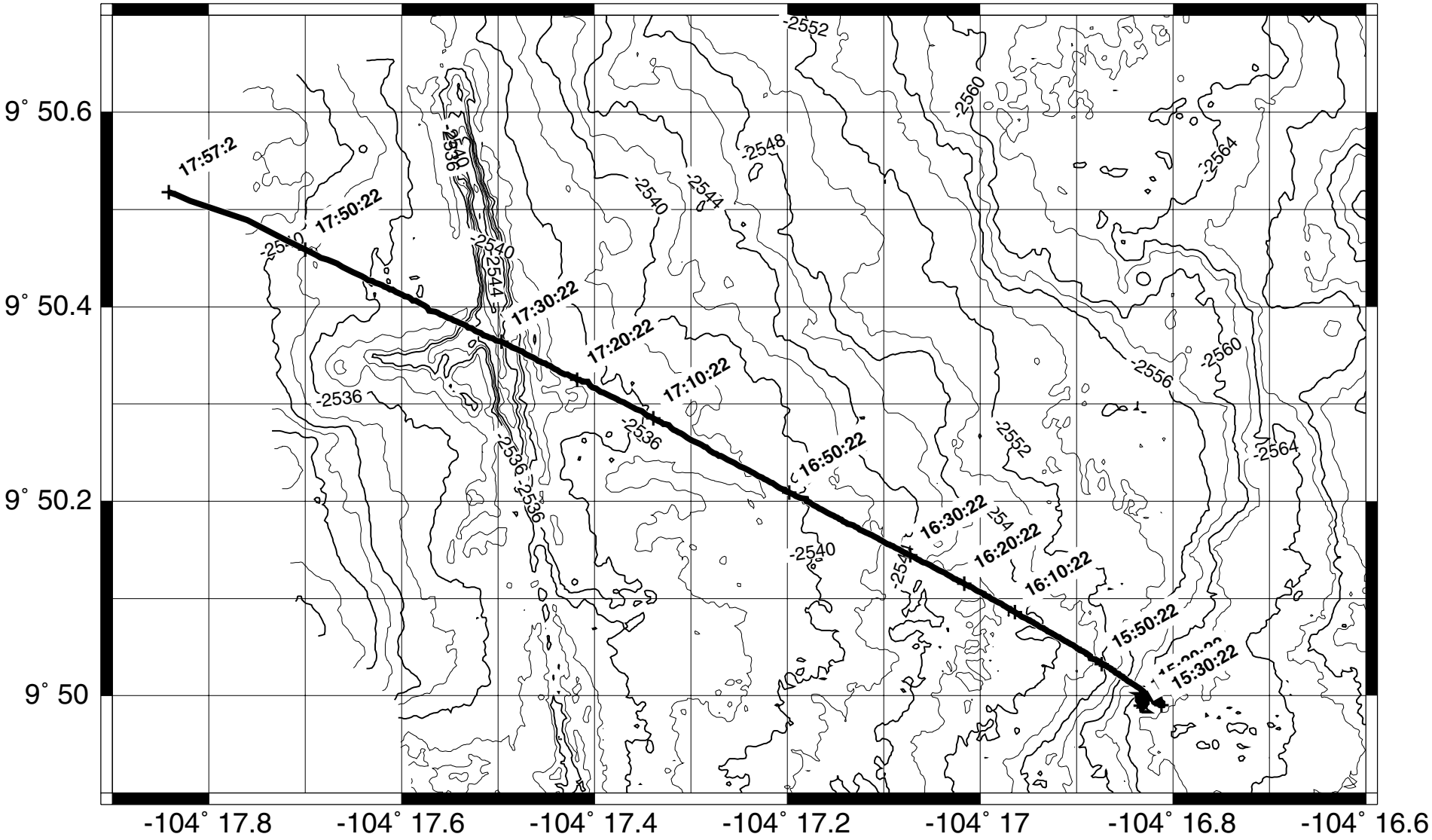
CAMERA TOW#8 EPR 9˚28 N



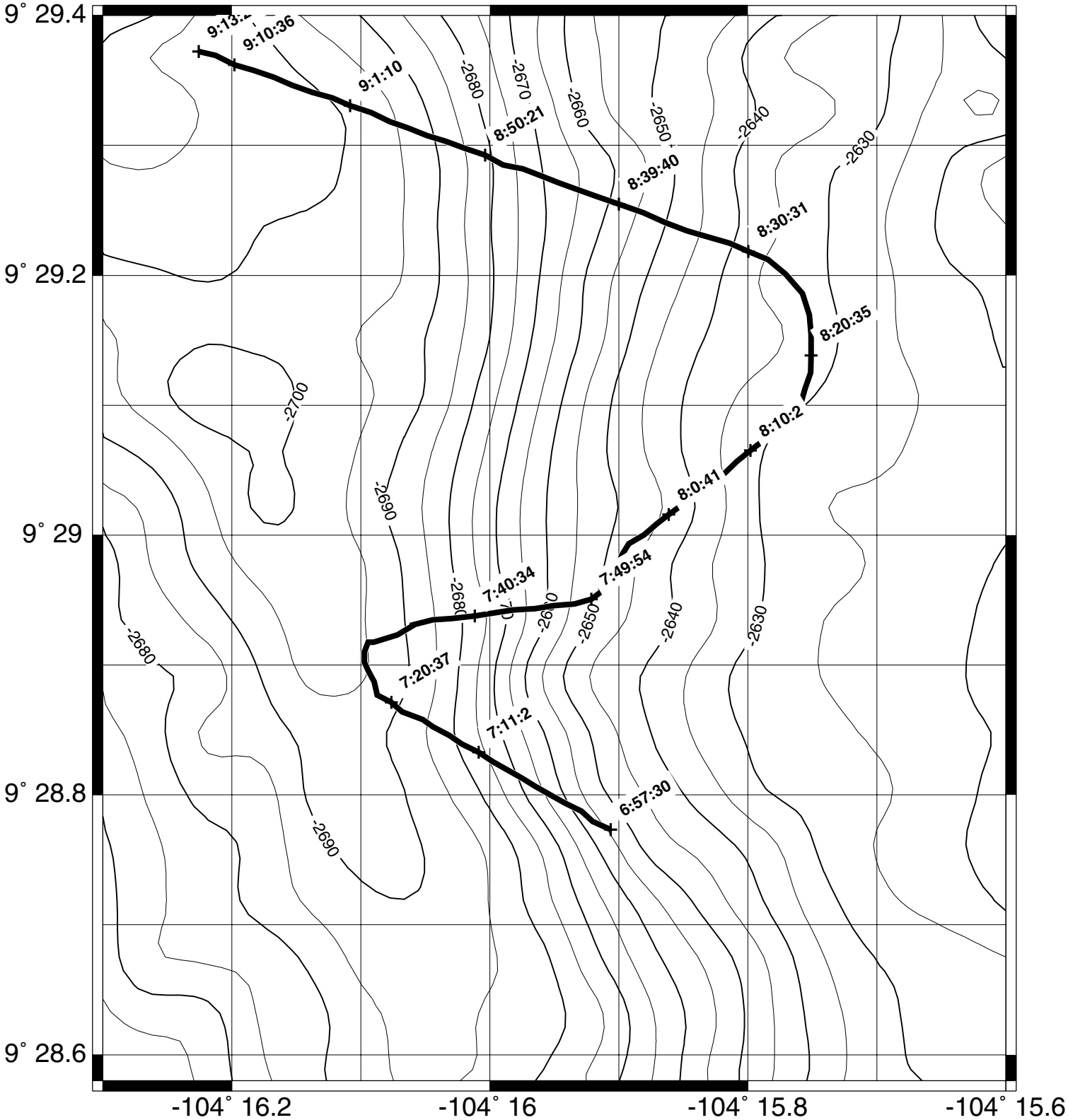
CAMERA TOW#9 EPR 9˚50 N



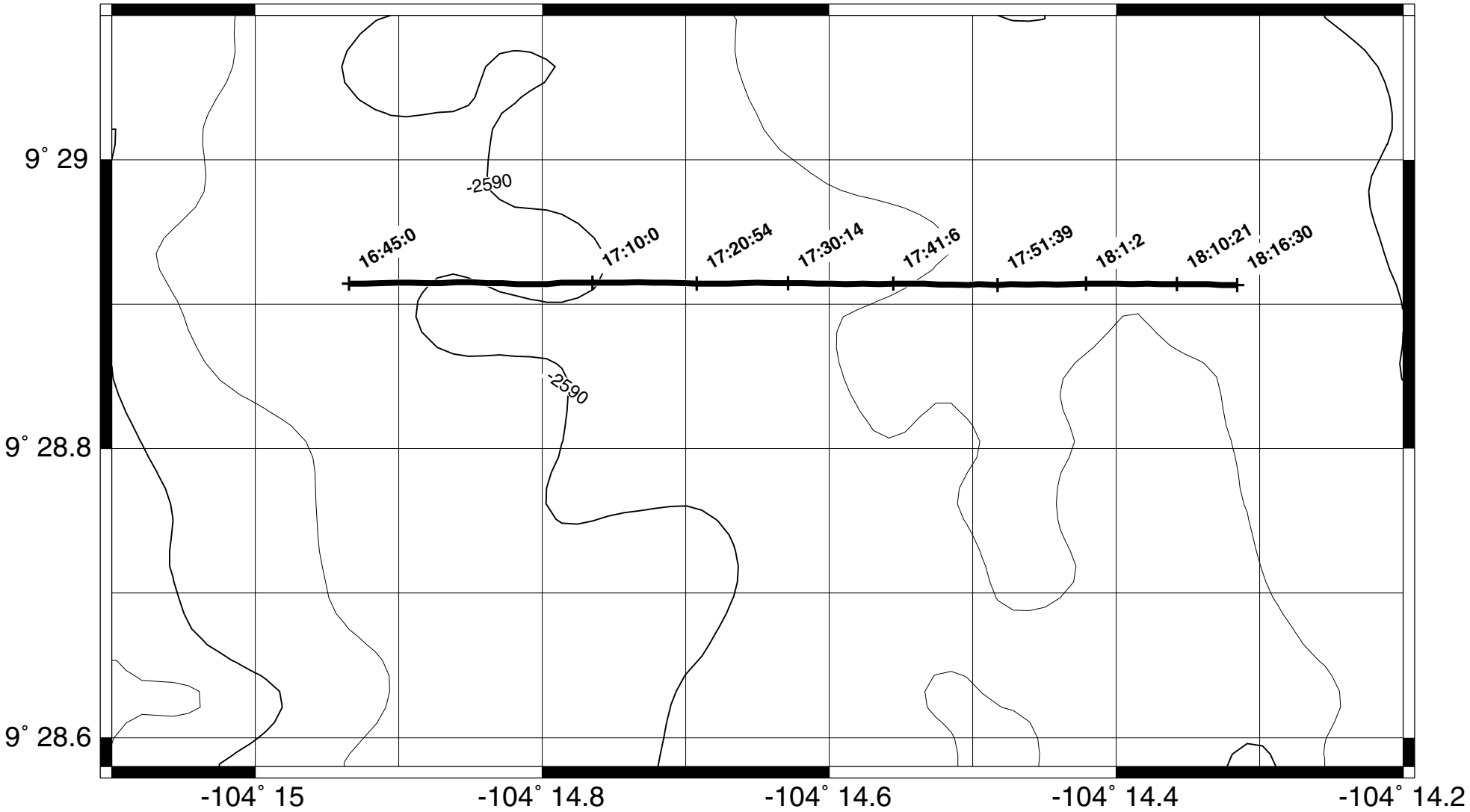
CAMERA TOW#10 EPR 9˚50 N



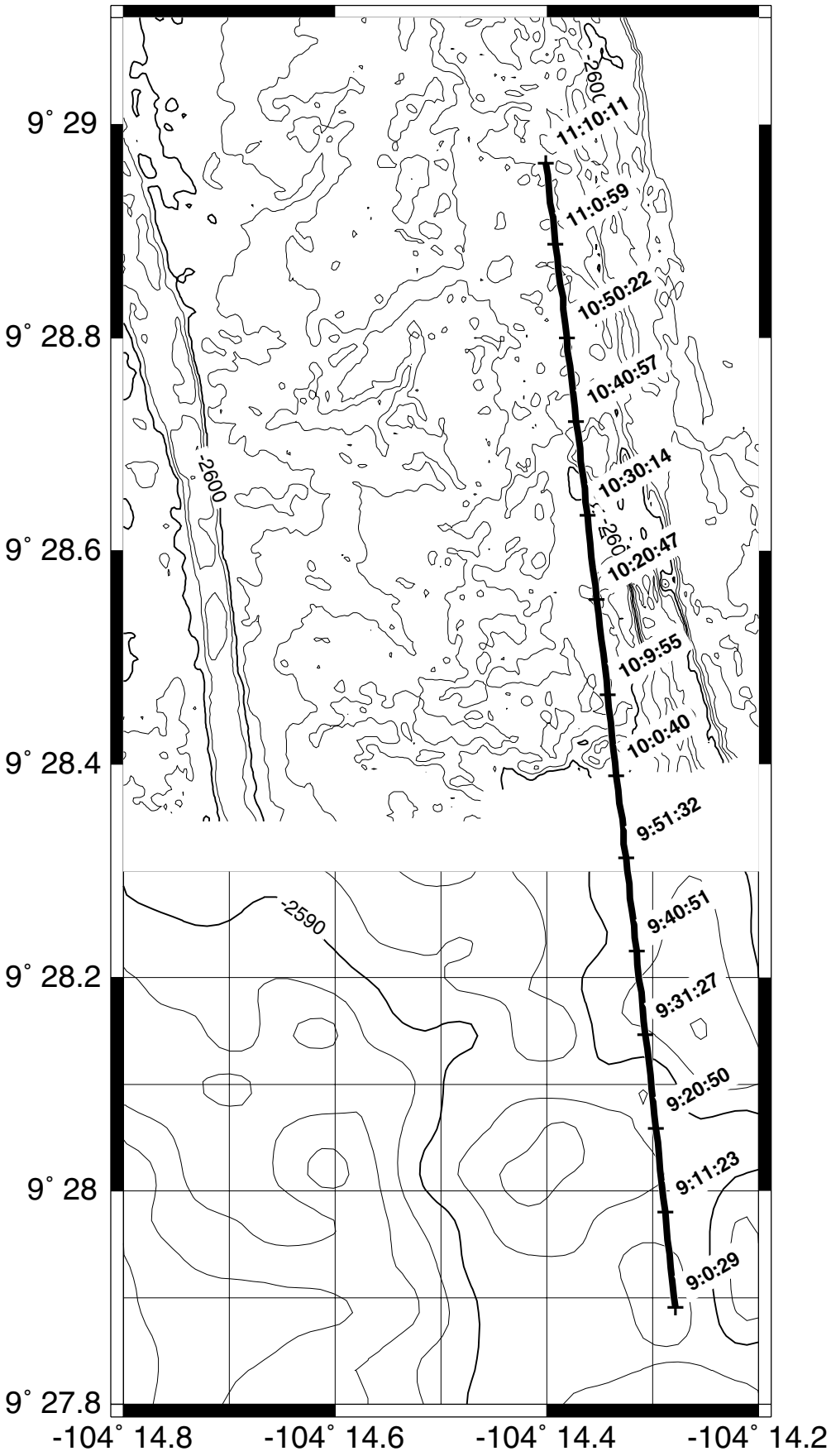
CAMERA TOW#11 EPR 9˚28 N



CAMERA TOW#12 EPR 9˚28 N



CAMERA TOW#13 EPR 9˚28 N



CAMERA TOW#14 EPR 9˚28 N

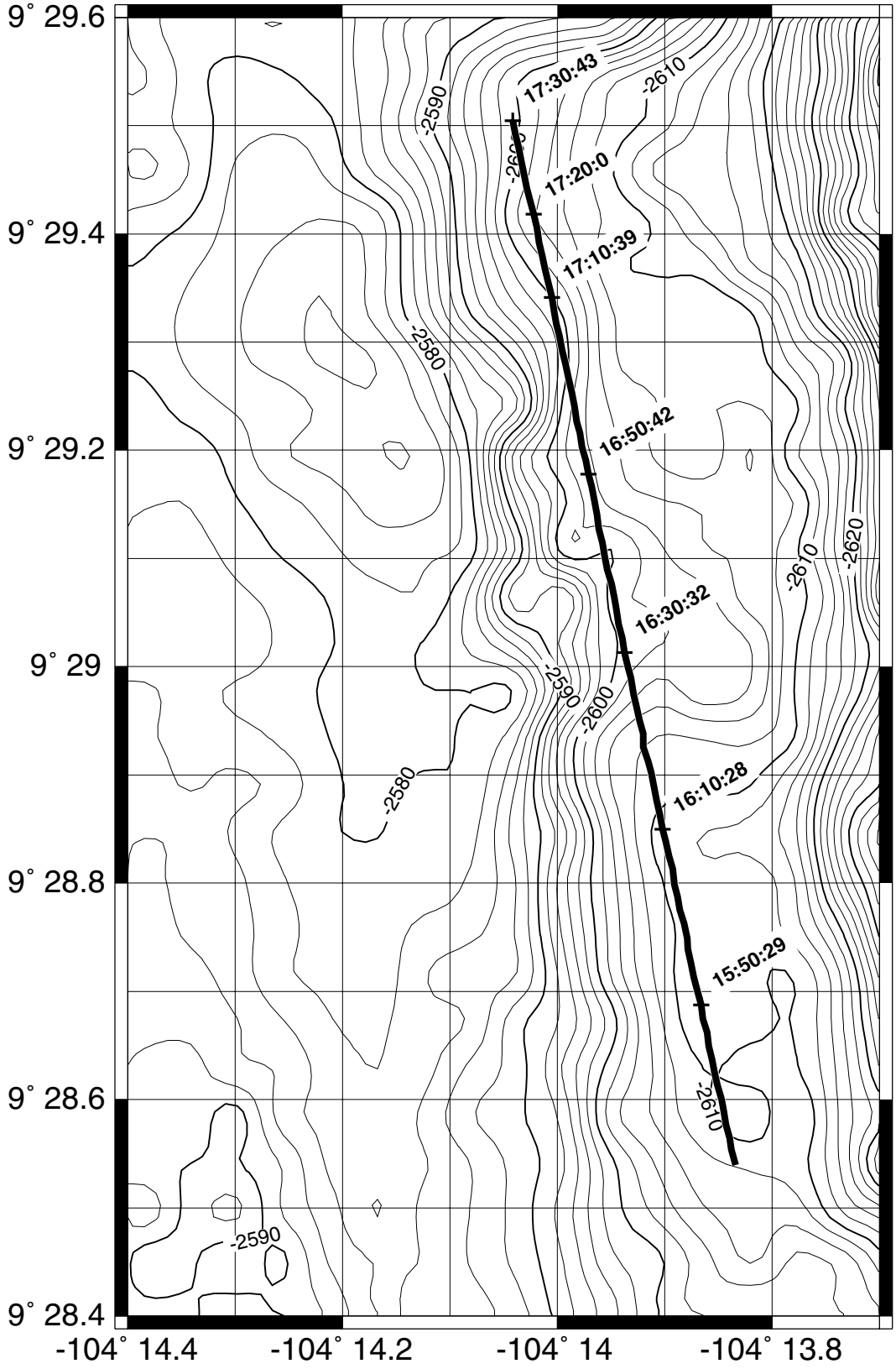


Photo Prefix - Date		**Atlantis 7-4 Camera Tow #1 Photo Descriptions**						
2001_11_21								
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**	
10:26		On Bottom						**Legend**
10:27	Lobates	Inflated lobates with bread crust cracks						For TRANSitions
10:28	Lobates	same photos of lobates as camera lowers to bottom						H = Hackly
10:29	Lobates	Inflated lobates with bread crust cracks, sediment cover			M			S = Smooth
10:30	Lobates	Inflated lobate with bread crust crack	10:30:16		M			C = Curtain
10:31	Lobates	Lobates						L = Lobate
10:32	Lobates	Lobates, one inflated lobe with cracks, others low relief lobes with sed cover			M			J = Jumbly
10:33	Lobates	Lobates, med sedimentation			M			N = Lineated
10:34	Lobates	med sed cover, glassy sheen visible, few knobs and ornaments						P= Pillows
10:35	Lobates							
10:36	Lobates	Lobates, med sed cover, few knobby areas			M			> = transitions to
10:37	Lobates	same area as 10:36			M			e.g. N>L
10:38	Lobates	same area as 10:36						lineated transitions to lobate
10:39	Lobates							
10:40	Pillows	Pillows, with striations, trans to lobates, moving up flow direction	10:40:16		M		L>P	For SEDiiment cover
10:41	Pillows	Broad lobe forks into 2 elongate pillows, round pillows, knobby lobe adjacent to it	10:41:01		M			L = low
10:42	Lobates	knobby, narrow, lobes w/ some +2 m pillows, partly rifted						M = medium
10:43	Lobates	knobby, narrow, lobes w/few, smooth, inflated lobes, med sed cover, bread crust cracks			M			H = high
10:44	Lobates	Knobby lobes						
10:45	Lobates	Knobby lobes			M			For COLlapse Feature
10:46	Lobates	Knobby pillows, partly striated, med sed cover, cracked, knobby lobes			M			* = collapse feature present
10:47	Lobates	Knobby, drizzled lobes			M			** = good view
10:48	Lobates	Lobes						*** = interesting one
10:49	Lobates	Lobes, med sed cover, narrow and knobby			M			
10:50	Lobates	lobes, with cracks, med sed cover, drizzled pattern		fish				
10:51	Lobates	Lobes						For BIOlogy
10:52	Lobates	Lobes, partly inflated, broad, med sed cover			M			ALF = alien life form
10:53	Lobates	Broad lobes, cracks,						BS = brittle stars
10:54	Lobates	broad lobes, with med sed cover						SC = sea crabby
10:55	Lobates	long narrow tubes lobes,						SF = star fish
10:56	Lobates	Lobes, med sed cover, narrow and drizzly						SA = sea anenome
10:57	Lobates	Lobe size increasing, braod, med sed cover, glassy crust visible			L			
10:58	Lobates	braod lobes, big cracks in crust tops						
10:59	Lobates	Lobes, heavier sed cover, flatter			M			
11:00	Lobates	Broad lobes						
11:01	Lobates	Lobes, narrow and knobby						
11:02	Lobates	Bread crust crack in bulbous lobe, med sed cover			M			
11:03	Lobates	Lobes, partly knobby						
11:04	Lobates	Lobes						
11:05	Lobates	Broad lobes with sed cover on top, more tube like, less interstitial toe lobes						
11:06	Lobates	Lobes						
11:07	Lobates	Lobes with cracked crust, lobe edges						
11:08	Lobates	Lobes, see edge of collapse			M	*		
11:09	Collapse	Collapse feature, rubbly bottom, lobes with sed cover at bottom, shallow collapse			M	*		

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #1 Photo Descriptions**					
2001_11_21							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
11:10	Collapse	Shallow collapse feature with rubble from roof crust at bottom				*	
11:11	Collapse	Lobes with collapse feature, still same featrue, low relief				*	
11:12	Collapse	End of Collapse features in lobate crust, med sed cover, still shallow collapse				*	
11:13	Lobates	Back to lobe with med sed cover,				*	
11:14	Lobates	Collapse feature, shallow, rubbly bottom, edge of collapse				*	
11:15	Collapse	skylight collapse, ~ 2 x 3 meters,				*	
11:16	Lobates	Lobates with med sed cover, broad, with knobby toes					
11:17	Lobates	Lobes					
11:18	Lobates	Lobes, knobby edges, glassy sheen, partly collapsed, but not a pit					
11:19	Lobates	Lobes					
11:20	Collapse	Deep collapse, U shaped, island of crust				*	
11:21	Collapse	same collapse, top of lobate crust pieces partly collapsed down			M	*	
11:22	Lobates	Broad lobes, partly folded and lineated sheet-like flow on top,			M,H		
11:23	Lobates	Lobates, knobby, partly rounded, several toes					
11:24	Lobates	Lobes					
11:25	Lobates	Lobes, broad, linear drain pipe lobe					
11:26	Lobates	Lobes, pinch and swell in lobe s, med sed cover			M		
11:27	Lobates	Lobes					
11:28	Lobates	Lobes, heavier sed cover			M,H		
11:29	Lobates	Lobes					
11:30	Lobates	Lobes					
11:31	Lobates	Broad flat topped lobe, heavy sed cover on top,			H		
11:32	Lobates	Guess what....lobes,					
11:33	Lobates	Guess what....lobes, but with partly curtain folded area	11:33:16				
11:34	Lobates	Lobes, med to low sed cvoer,	centipede				
11:35	Lobates	Drizzly lobes, toe like, central braod lobe					
11:36	Lobates	drizzly, mushwroom like toe lobes, med sed cover			M		
11:37	Lobates	Same lobes as 11:36					
11:38	Lobates	knobby, small toe lobes,					
11:39	Lobates	broad surface to some lobes, sed cover at top,					
11:40	Lobates	Lobes					
11:41	Lobates	Lobes, glassy sheen, braod, stair step flow edges					
11:42	Lobates	Broad lobes					
11:43	Lobates	Broad lobes					
11:44	Lobates	Broad lobe with narrow tube lobe feeding it					
11:45	Lobates	knobbys lobes					
11:46	Lobates	long tube lobe with knobby, drizzly lobes surrounding it					
11:47	Lobates	irregurlar flat lobe, with toes					
11:48	Lobates	Knobby, drizzly lobes					
11:49	Lobates	Knobby, drizzly lobes					
11:50	Lobates	Lobes					
11:51	Lobates	Broad lobes					
11:52	Lobates	Lobes, knobby, cracsk on crust top					
11:53	Lobates	Knobby , drizzly lobes, med sed cover					

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #1 Photo Descriptions**					
2001_11_21							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
11:54	Lobates	Lobes					
11:55	Lobates	Lobes					
11:56	Lobates	Broad flaot topbes, heavy sed cover at top, crackked lobes					
11:57	Lobates	long tube lobe with knobby, drizzly lobes surrounding it					
11:58	Lobates	pillow like lobes, partly striated, high reflectivity bright photo	11:58:01	BS			
11:59	Lobates	Lobes					
12:00	Lobates	Lobes					
12:01	Lobates	Lobes					
12:02	Lobates	Lobes, flat, heavier sed cover, edge of collapse feature is visitble				*	
12:03	Lobates	Lobes					
12:04	Lobates	Broad lobes, with some narrow toes and knobby lobes					
12:05	Lobates	Broad lboes with partly striated flat top with med sed cover			M		
12:06	Lobates	Broad flat lobe continued					
12:07	Lobates	heavy sed cover on broad flat top of a lobe					
12:08	Lobates	heavy sed cover on broad flat top of a lobe					
12:09	Lobates	heavy sed cover on broad flat top of a lobe					
12:10	Lobates	Lobes					
12:11	Lobates	Bright bulbous lobes	12:11:46				
12:12	Lobates	Broad and knobby lobes			L		
12:13	Lobates	Broad and knobby lobes					
12:14	Lobates	Lobes		Fish			
12:15	Lobates	Lobes with fish		Fish			
12:16		OFF BOTTOM					

Photo Prefix - Date		Atlantis 7-4 Camera Tow #2 Photo Descriptions					
2001_11_23							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL FT**	**TRANS**
14:08	Water	Begin to see bottom, Alien Life Form 1, hackly lava and curtain folds		ALF			
14:09	Hackly	Hackly lava with curtain folds					
14:10	Curtain folds	Curtain folded flow, part hackly					
14:11	Curtain folds	Curtain folded flow, high frequency of folds transition to folds spaced by smooth areas					H>S
14:12	Curtain folds	Smooth sheet flow with curtain folds, medium to heavy sediment cover		BS	M,H		
14:13	Sheet flow	Smooth sheet flow with curtain folds, heavy sediment cover		BS	M,H		
14:14	Sheet flow	Smooth sheet flow with curtain folds, heavy sediment cover		BS	H		
14:15	Curtain folds	Whirl structures in a moderate - heavy sedimented smooth-folded flow			M,H		
14:16	Curtain folds	Narrow channels of ribbon folds spaced by smooth sediment covered sheet flows			M		C>S>C
14:17	Curtain folds	Narrow channels of ribbon folds spaced by smooth sediment covered sheet flows			M		C>S>C
14:18	Hackly	Sediment covered curtain folds transition to Hackly flow			M		C>H
14:19	Hackly	Hackly lava with curtain folds, Low sed. cover, abrupt trans. from curtain flow			L		
14:20	Hackly - Curtain	Hackly lava with increase in area covered by curtain folds					
14:21	Curtain folds	Curtain folded flow with low sediment cover, high frequency of folds			L		
14:22	Curtain folds	Curtain folded flow with low sediment cover, high frequency of folds, partly jumbled					
14:23	Curtain - Jumble	Jumbled curtain flow transitions to smooth curtain sheet flow w/ heavy sed cover			H		JC>SC
14:24	Smooth - Curtain	Heavy sediment covered smooth-partly curtain folded flow		BS	H		
14:25	Smooth	Heavy sediment cover over smooth sheet flow					
14:26	Smooth - Lineated	Smooth sed covered sheet flow transitions to lineated sheet flow w/ low sed cover			L,H		S>N>S
14:27	Smooth - Lineated	Series of alternating, wide lineated sheet flows w/low sed cover and wide, sed covered smooth flows					N>S>N
14:28	Lineated	Lineated, partly curtain folded sheet flows with medium sediment cover			M		
14:29	Lineated - Curtain	Lineated, partly curtain folded sheet flows with medium sediment cover		ALF	L		
14:30	Hackly - Collapse	Curtain flow > Hackly patch > glassy Lobate crust, collpase feature w/ hackly bottom			L	*	C>H>L
14:31	Collapse	Collapse feature with lobate crust, low sed cover, <1 m relief in collapse, skylights				*	
14:32	Collapse	Skylights and narrow bridge of lobate crust, Hackly bottom, moderate sed cover			L, M	*	
14:33	Collapse	Collapse structure continues, lobate crust, low distance hackly bottom of crust pieces		SC	L,M	*	
14:34	Collapse	Collapse structure continues, lobate crust, bottom shows increase in sed cover				*	
14:35	Collapse	Partial view of wall under lobate crust to base of collapse				**	
14:36	Collapse	Lobate crust, collapse feature, low sed cover, irregular forked shaped to collapse				*	
14:37	Collapse	Edge of lobate crust and bottom of collapse feature, patches of sed at base				*	
14:38	Collapse	Edge of lobate crust and bottom of collapse feature				*	
14:39	Collapse	Base of collapse feature shows sed covered smooth lobate flow, pieces fit like puzzle				**	
14:40	Collapse	Edge of lobate crust and bottom of collapse feature, part hackly				*	
14:41	Collapse - Hackly	Hackly, jumbled bottom of collapse feature, pieces of roof crust at on floor				*	
14:42	Hackly	Hackly base of collapse feature?, shadows show relief similar to collapse edge	14:42:49	?		?	
14:43	Hackly - Lineated	Abrupt transition from hackly lava to lineated sheet flow			L,H		H>N
14:44	Lineated	Lineated sheet flow, med - heavy sed cover, low-relief collapse in flow surface,					
14:45	Collapse - Lineated	Collapse in lineated sheet flow, crustal pieces of roof fit together at base like puzzle			M	*	
14:46	Lineated - Collapse	Elliposoidal collapse in lineated sheet flow, fractures are radial to center of collapse	14:46:34		M, H	*	
14:47	Smooth	Smooth, heavy sed covered, sheet flow, small collapse feature in crust			H	*	
14:48	Smooth-Lineated	Abrupt contact of sed covered smooth flow and low sed cover, lineted-curtain flow	14:48:34		H		S>N
14:49	Hackly - Collapse	Hackly piedes of roof crust, high altitude of camera, can see shadow of collapse edge				*	
14:50	Smooth	Sed covered crust and rim of collapse feature, low-relief to base of collapse			H	*	
14:51	Sediment Cover	Heavy sediment cover over lava			H		
14:52	Sediment Cover	Heavy sediment cover over smooth sheet flow			H		
14:53	Sediment Cover	Heavy sediment cover over smooth sheet flow			H		

Legend

For TRANSitions
H = Hackly
S = Smooth
C = Curtain
L = Lobate
J = Jumbly
N = Lineated
> = transitions to
e.g. N>L
lineated transitions to lobate

For SEDiiment cover
L = low
M = medium
H = high

For COLlapse Feature
* = collapse feature present
** = good view
*** = interesting one

For BIOlogy
ALF = alien life form
BS = brittle stars
SC = sea crabby
SF = star fish
SA = sea anenome

2001_11_23							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL FT**	**TRANS**
14:54	Sediment Cover	Brittle stars on heavy sediment covered smooth sheet flow		BS	H		
14:55	Collapse	Low relief (< few cm) collapse in roof of heavy sediment covered smooth sheet flow			H	*	
14:56	Collapse - Smooth	Heavy sed cover, partly curtain folded crust, crustal edges of sheet flow				*	
14:57	Transition/Contact	Cracked edges of smooth sed covered flow step down over swrily curtain flow	14:57:19		H	*	S>C
14:58	Hackly	Hackly patch of lava in sediment covered curtain folded flow, Hackly lava could be collapsed crust					S>H
14:59	Smooth - Curtain	Heavy sed cover on smooth, partly curtain folded sheet flow					
15:00	Smooth	Sediment covered smooth sheet flow, patches of low sed covered lineated flows			H		
15:01	Smooth	Heavy sediment cover over smooth and partly lineated sheet flow		BS	H		
15:02	Lineated-Folded	Heavy sediment cover over smooth and partly lineated and folded flow		ALF	H		
15:03	Smooth - Lineated	Heavy sediment cover over smooth and partly lineated flows with med sed cover		BS	M,H		
15:04	Hackly - Lobate	Remnant roof of lobate crust, hackly lava covers lineated sed covered sheet flow			L, M	*	N>H
15:05	Collapse	Lobate crust roof, Hackly lava at edge of crust covers smooth flow, 2nd collapse in smooth flow			M	**	L>H>S
15:06	Smooth - Folded	Heavy sed covered smooth, partly folded sheet flow > lineated sheet flow, levee	15:06:49		H		S>N
15:07	Lineated	Lineated sheet flow, low sed cover, cracks cut cross to flow direction			L		
15:08	Lineated	Lineated sheet flow, med sed cover, partly curtain folded					
15:09	Jumbled	Transition from lineated sheet flow to jumbled sheet flow,	15:09:34				N>H
15:10	Jumbled	Jumbled sheet flow, minor curtain folds > Hackly to lineated sheet flow (jumbled patch in a lineted sheet flow?)					J>H>N
15:11	Lineated	Lineated sheet flow, low sed cover, small circular blebs in the flow > smooth flow			L, H		N>S
15:12	Lineated	Lineated sheet flow, heavy sed cover over parts of the flow					
15:13	Lineated	Lineted sheet flow, cracks show partial subsidence of crust>hackly levee> smooth flow			L, H		N>H>S
15:14	Lineated	Lineated sheet flow, heavy sed cover over smooth parts of the flow			L, H		L>S
15:15	Sediment Cover	Heavy sediment cover over sheet flow			H		
15:16	Sediment Cover	Heavy sediment cover over sheet flow			H		
15:17	Sediment Cover	Heavy sediment cover over sheet flow	15:17:34	ALF	H		
15:18	Sediment Cover	Heavy sediment cover over sheet flow		BS			
15:19	Sediment Cover	Heavy sediment cover over sheet flow		BS			
15:20	Curtain folds	Sediment covered flow with cutain folds poking through sed cover			H		
15:21	Lineated-Lobate	Transition from sed covered lineated flow to folded-lobate flow and broken edge at levee					N>L
15:22	Lobate	Lobate flow forms roof crust of collapse feature, bottom is smooth and sed covered	15:22:34			*	
15:23	Collapse or	Collapse feature, smooth bottom (fallen roof crust?), curtain folds and lobates form roof					
15:24	Contact?	Either a window showing a smooth sed coverd flow under a lobate-folded flow or a smooth sh	15:24:34				L>S>L
15:25	Curtain - Smooth	Transition from curtain folded flow to smooth, sediment covered sheet flow					C>S
15:26	Sediment Cover	Sediment covered, lineated, partly folded sheet flow			H		
15:27	Sediment Cover	Sediment covered, lineated, partly folded sheet flow			H		
15:28	Sediment Cover	Sediment covered, lineated, partly folded sheet flow			H		
15:29	Sediment Cover	Sediment covered, lineated, partly folded sheet flow			H		
15:30	Jumbled	Medium sediment cover, curtain folds, swirl structure, transition to jumbled flow	15:30:49	SC	H		S>J
15:31	Sediment Cover	Transition from curtain fold to smooth-lineated sheet flow, heavy sediment cover			H		J>SN
15:32	Sediment Cover	Heavy sediment, flat, lineated sheet flow, Brittle stars			H		
15:33	Sediment Cover	Heavy sediment, lineated folds peak through sediment cover			H		
15:34	Sediment Cover	Sediment and stars on smooth sheet flow			H		
15:35	Sediment Cover	Sediment and stars on smooth sheet flow			H		
15:36	Sediment Cover	Sediment and stars on smooth sheet flow			H		
15:37	Sediment Cover	Cracks in smooth sheet flow surface, sea slug (15:37:19)		Sea Slug	H		
15:38	Lineated	Heavy sediment cover over lineated sheet flow, crack perpendicular flow, whirls in flow surfac	15:38:19		M		L>C
15:39	Curtain folds	Curtain folded, with some smooth areas between folds, trans to partly lobate > lineated					C>L>N
15:40	Lineated	Transition contact, sed covered lineated sheet flow, hint of folds and lines			H		C>N

2001_11_23							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL FT**	**TRANS**
15:41	Jumbled	Jumbled-hackly patch amidst the lineated sheet flow	15:41:49				N>J
15:42	Lineated	Sediment covered lineated sheet flow, flow margin broken at transition to curtain fold patch			H		N>C
15:43	Hackly-Smooth	Hackly lava and curtain folds form patch in middle of lineated sheet flow					
15:44	Lobate	Collapsed margin from smooth sheet flow to lobate flow					
15:45	Lobate	Collapse features in lobate flow				*	S>L
15:46	Collapse	Collapse feature in lobate flow				*	
15:47	Smooth	Transition from lobate crust with collapse feature to lineated, sed covered sheet flow		Eel?	H		L>S
15:48	Lineated - Ropey	Ropey, curtain folded flow channel in middle of lineated sheet flow, low sed cover on ropey			N, H		N>R
15:49	Lineated	Lineated sheet flow, heavy sediment cover, partly broken crust surface			H		
15:50	Hackly-Jumbled	Hackly and jumbled, partly folded patch flow amid a lineated sheet flow with sed cover			M		H>N
15:51	Lineated	Lineated sheet flow, heavy sediment cover			H		
15:52	Lineated	Heavy sediment cover over lineated sheet flow, Fish	15:52:19	Fish	H		
15:53	Lineated	Subsidence/collapse fo lineated sheet flow crust, low to med sed cover			L, M		
15:54	Smooth - Lineated	Sediment cover on smooth flow, low sed cover on lineated sheet flow			M		S>N
15:55	Lineated	Lineated, partly folded sheet flow with cracks cross cutting the flow direction	15:55:50		L		
#####	Lineated	Core hitting the bottom, plume of sediment visible, lineated flow, partly folded			M		
15:56	Sediment Cover	Heavy sediment cover on smooth sheet flow, cracks (<10cm? wide) in surface indicate minor collapse of crust			H		
15:57	Sediment Cover	Heavy sediment cover on smooth sheet flow, cracks in surface indicate minor collapse of crust			H		
15:58	Sediment Cover	Heavy sediment cover on smooth sheet flow, cracks in surface indicate minor collapse of crust					
15:59	Lineated	3-4 m collapse of crust in lineated sheet flow with heavy sed cover	15:59:50		H	*	
16:00	Lineated - Collapse	Small collapse in lineated sheet flow shows flow edges from different flows, 2nd collapse in lir	16:00:04			**	
16:01	Lineated	Med sed covered lineated sheet flow, nice texutre present in flow, minor collapse/cracks			M	*	
16:02	Lineated - Folded	Smooth sed covered flow > lineated > low sed covered folded-curtain flow					
16:03	Hackly - Curtain	Hackly- curtain flow, 2nd hit by core?, transition to lineated flow w/ collapse in crust	16:03:20		L	*	N>HC>N
16:04	Lineated	Lineated sheet flow with med sediment cover			M		
16:05	Lobate	Lobate crust, flow margin w/ lineated flow is collapsed,					N>L
16:06	Collapse	Lobate flow with skylight collapse feature, 3 skylights with two sea anenome	16:06:50	SA		***	
16:07	Collapse	Smooth sheet flow w/ channel for ropey flow flowing out from under collpased lobates?					L>C
16:08	Hackly - Curtain	Ropey, hackly and curtain flow, high camera altitude makes it hard to see					
16:09	Jumbled - Hackly	Jumbled and Hackly flow, excellent texture displayed, part of a collapse feature?					
16:10	Collapse	Wall of collapse feature visible, 3 arm bridge of lobate crust separating 3 collapse featues	16:10:35, 50			***	
16:11	Collapse - Lobate	Lobate crust , lobes come towards central point, small and large collapse features	16:11:20			*	
16:12	Collapse - Lobate	Skylights in lobate crust, ~ 1m of relief to bottom of collapse	16:12:35			*	
16:13	Collapse - Lobate	Lobate roof crust with collapse features, roof rubble at bottom of collapse feature					
16:14	Smooth - Curtain	Smooth and curtain sheet flow appear to be at the bottom of a large collapse, several meters in width					
16:15	Collapse	Remnant lobate roof in middle of collapse feature surrounded by hackly lava and rubble	16:15:05, 20			*	
16:16	Collapse	Collapse features in lineated and smooth flows, part hackly lava	16:16:50	Starfish		*	
16:17	Collapse - Lineated	Narrow bridge of lineated roof crust surrounded by hackly lava, several levels of flows?	16:17:05	SF, SA		*	
16:18	Collapse - Hackly	Hackly and curtain folded crust with collpase featues, looks partly jumbled and rubbly				*	
16:19	Hackly - Curtain	Hackly and curtain folds, transition to smooth sediment covered sheet flow					H>S
16:20	Lineated	Areas of curtain folds in a sediment covered smooth, mostly lineated sheet flow					
16:21	Lineated	Lineated sheet flow with moderate cracking in the crust, medium sed cover, flow edges of smooth flow staircase dc			M		
16:22	Smooth	Edges of a smooth sheet flow, edges stair case down in two steps to sed covered bottom					
		Off Bottom					

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #3 Photo Descriptions**					
2001_11_26							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
9:10	Hackly	hackly, jubmled					
9:11	Rubble	rubble, jumble, pieces of lienated flow					
9:12	Rubble	rubble , lobate crust pieces, hackly					
9:13	Hackly	more hackly rubble, with smooth, lineated, large intact pieces on floor,					
9:14	Hackly	hackly lava					
9:15	Hackly	hackly lava, minor curtain flows					
9:16	Hackly	hackly and minor curtain folds					
9:17	Hackly	hackly lava, jumbled, rubble					
9:18	Hackly	hacly lava, rubble, jumble flow					
9:19	Hackly	jumble, curtain fold, hackly					
9:20	Curtain	edge of flow, folds,					
9:21	Hackly - Curtain	minor lobate and collapse in hackly curtain folded flow					
9:22	Hackly	highly folded flows, jumbled and hackly					
9:23	Hackly	hackly lava and jumbled					
9:24	Hackly	edge of lobate and small collapse in hackly flow					
9:25	Lobate	mix of lobate with hackly jumbled flow					
9:26	Curtain	curtain folds, high frequency with hackly lava and smooth broken pieces of sheet flows and or lobates					
9:27	Curtain	curtain folds, high frequency with hakly lava and smooth broken pieces of sheet flows and or lobates					
9:28	Smooth	TRANSISTION into lobates from folded jumbled flow, smooth sheet flow is up flow direction = older					J>L
9:29	Smooth	flow edges of smooth curtain flow and hakcly lava on flow edge					
9:30	Hackly	flow edges, hackly lava on border with smooth flow					
9:31	Hackly	hackly lava, jumbled, rubble					
9:32	Hackly	hackly, jumbled, rubble					
9:33	Hackly	hackly edge of smooth sheet flow, curtain folds close to edge, abrupt chnge at flow margin					H>S
9:34	Curtain	sedimented heavy curtain-smooth sheet flow, distinct flow margin with hackly lava					
9:35	Smooth	smooth sheet flow with heavy sediment cover		FISH	H		S>C
9:36	Smooth	smooth sheet flow with heavy sediment cover, flow margin with folded flow, jumbled, curtains			H		
9:37	Curtain	jumbled curtain folded flow, part hackly, high frequency of folds					
9:38	Curtain	curtain folds, piece of sheet or lobe,					
9:39	Curtain	Curtain folded flow	9:39:35				
9:40	Curtain	Whirl structure in the curtain folded flow, trans to lineated sed covered sheet flow	9:40:05		H		C>L
9:41	Smooth	sediment cover on smooth and lineated sheet flow with cutian folds, cracks and breaks in crust					
9:42	Smooth	cracks and rubble in smooth flow, hackly part of a flow in a smooth sheet flow, trans to hackly				H	S>H
9:43	Lobate	hackly trans to lobates, low sed cover on lobes					H>L
9:44	Lobate	lobates, low sed cover, some shine			L		
9:45	Lobate	lobates, med sed cover, few meters width, minor hint of pillow sturctures			M		
9:46	Lobate	Lobates, med sed cover, some pillows, edges of lobates irregular and not joining, its			M		
9:47	Collapse	small collapse in field of lobates, low relief lobes, low sed cover			L	*	
9:48	Collapse	small collapse in field of lobates still visible				*	
9:49	Lobate	flow margin of individual lobates are distinct, bottom floor of sed visible btween lobes.					
9:50	Lobate	Lobate flow, ALF, med sed		ALF	M		
9:51	Collapse	Big collapse in lobate field, pillows near edge, dominant lobate crust, flat lobes				*	
9:52	Collapse	edge of collapse in lobate field, flat med sed covered lobates,			M	*	
9:53	Lobate	Lobates					
9:54	Lobate	Brittle stars, lobates, med. Sed cover, flate ,		BS, fish	M		
9:55	Lobate	Fish, lobates, med sed. Cover, wide flat lobe		Fish	M		

Legend

For TRANSitions
H = Hackly
S = Smooth
C = Curtain
L = Lobate
J = Jumbly
N = Lineated
> = transitions to
e.g. N>L
lineated transitions to lobate

For SEDiiment cover
L = low
M = medium
H = high

For COLlapse Feature
* = collapse feature present
** = good view
*** = interesting one

For BIOlogy
ALF = alien life form
BS = brittle stars
SC = sea crabby
SF = star fish
SA = sea anenome

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #3 Photo Descriptions**					
2001_11_26							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
9:56	Lobate	Sedimented lobate edge, looks like collapse, curtain folds visible			M	*	
9:57	Lobate	glassy lobates, more inflated than others,					
9:58	Lobate	Lobate crust for large collapse feature, rubbly bottom				*	
9:59	Collapse	Collapse feature, rubbly bottom trns into lobates, possible collapse of a inflated lobate flow edge				*	H>L
10:00	Lobate	lobes trans to sheet flows, hackly and jumbled, shadow edges show minor collapse of jumbled crust					L>S
10:01	Hackly	hackly and jumbled curtain flow, low relief collapse feature edge cross cuts flow	jelly tornado			*	
10:02	Hackly	Hackly flow					
10:03	Hackly - Curtain	Hackly curtain folded flow	Eel				
10:04	Curtain	Curtain folded flow, Hackly, low sed cover			L		
10:05	Hackly	Hackly rubbly flow, minor curtain folds					
10:06	Hackly	Hackly rubbly flow, trans to smooth-curtain sheet flow, med sed cover, cracks in crust			M		H>SC
10:07	Curtain	Sed covered smooth-curtain flow trans to high frequency curtain flow,			H		
10:08	Hackly - Curtain	AWESOME PHOTO: flow edge of smooth curtain flow under a high pile of hackly lava	10:08:05				
10:08	Collapse	collapse feature, bottom is rubble of pieces of hackly folded roof crust, edge of collapse				*	
10:09	Hackly	Hackly lava flow,					
10:10	Hackly	Hackly lava flow, low sed cover					
10:11	Hackly	Transition from Hackly lava to curtain folded sheet flow, shows edge of flow margin					H>C
10:12	Curtain	Curtain folded flow, high frequency of curtains, elongate folds					
10:13	Hackly	Hackly, folded curtain flow, minor smooth pieces of crust in flow.					
10:14	Collapse	Collapse edge of lobate flow margin with sed covered smooth curtain sheet flow	10:14:05		M	*	L>SC
10:15	Lineated	Lineated sheet flow, med. To heavy sed cover, flow margin with lobate flow is collapsed			M		
10:16	Lobate	Transition from lineated sheet flow to lobate flow, broken up flow margin, hackly	10:16:05				N>L
10:17	Hackly	Hackly, jumbled curtain folded flow, some smooth areas in flow with sed cover			M		
10:18	Smooth	Hackly curtain folded flow, trans to area of smooth curtain flow with med sed cover, minor collapse in flow top				*	H>SC
10:19	Smooth	Hackly curtain folded flow, trans to area of smooth curtain flow with med sed cover, minor collapse in flow top				*	H>SC
10:20	Hackly - Smooth	Hackly jumbled curtain flow in contact with sed covered smooth sheet flow	10:20:35				HC>S
10:21	Smooth	Smooth sheet flow with heavy sed cover, cracks in flow,edge of lobate crust collapse minor c	10:21:50		H	*	S>L
10:22	Lobate	Lobate crust with collapsed flow margin, smooth-curtain flow at base, with rubble	10:22:20			*	
10:23	Lobate	Lobate crust with collapse feature, curtain folds with sed cover at base,			M	*	
10:24	Lobate - Curtain	rubble and sed covere curtain folded flow at base of collapse featrue, lobate crust				*	
10:25	Lobate	lobate crust, Collapse feature, rubble at bottom, < 1 m of relief in collapse				*	
10:26	Collapse	Collapse feature, lobate roof crust curtain folds with sed at bottom of collapse	10:26:50		M	*	
10:27	Collapse	Collapse feature, lobate roof crust , bridge collapse, skylights	10:27:35			*	
10:28	Lobate	Lobates, med sed cover, minor curain folds			M		
10:29	Lobate	Lobates with some curtain folds, edge of collapse feature: skylight				*	
10:30	Collapse	Collapse feature, lobate crust, skylight few meters across				*	
10:31	Collapse	Collapse feature, rubbly bottom, low sed cover, lobate crust as roof	Fish, SA			*	
10:32	Collapse	Collapse feature, bridge of lobate crust, bathtub rings visible on side of wall,				**	
10:33	Collapse	smooth sed covered flow at bottom fo collapse feature, lobate crust, island of lobate crust				*	
10:34	Collapse	collapse in lobates flows				*	
10:35	Collapse	pockets of collapses(0.5x1m) in lobate				*	
10:36	Collapse	more collapses in lobates				*	
10:37	Collapse	more collapses in lobates				*	
10:38	Rubble	rabbles					
10:39	Hackly	hackly with sheet flow margin on right					

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #3 Photo Descriptions**					
2001_11_26							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
10:40	Lineated	Lineated sheet flow, med. To heavy sed			M,H		
10:41	Lineated	contact from lineated sheet flow to flat sedimented area			H		
10:42	Smooth	flat sedimented area			H		
10:43	Curtain	contact from flat sedimented area to curtained sheet flow then lineated sheet flow	10:43:20		H		
10:44	Lineated - Hackly	lineated sheet flow to messy sheet flow then hackly					N>H
10:45	Hackly	hackly with some lineated sheet flow features to flat heavily sedimented area			H		H>S
10:46	Smooth	flat sedimented area with some crackes			H		S>H
10:47	Smooth	flat sedimented area to hackly			H		S>H
10:48	Smooth	flat sedimented area to hackly			H		S>H
10:49	Lobate	lobates with collapse				*	
10:50	Lobate	lobates with small hole-like collapse and contact to jambled				*	
10:51	Hackly	jambled to hackly					
10:52	Hackly	hackly		SA			
10:53	Hackly	hackly to sedimented flat with sligh lineation					
10:54	Curtain	curtained sheet flow with multi flow directions					
10:55	Curtain	curtained sheet flow with multi flow directions with rubbles between					
10:56	Curtain	curtained sheet flow with multi flow directions with rubbles between					
10:57	Curtain	curtained sheet flow with multi flow directions with rubbles between					
10:58	Curtain	curtained sheet flow with multi flow directions with rubbles between					
10:59	Curtain	curtained sheet flow with multi flow directions with rubbles between					
11:00	Curtain	more curtained sheet flows with sediment slightly increased					
11:01	Curtain	more curtained sheet flows with sediment slightly increased					
11:02	Smooth	flat sedimented area with some lineated and curtained sheet flows					
11:03	Smooth	flat sedimented area with some lineated and curtained sheet flows and whirles(0.5x0.5m)					
11:04	Smooth	flat sedimented area with lineated flows and piles of rabbles					
11:05	Lobate	lobate island roof crust and rabbles at the bottom of collapses	11:05:05	A, flowers		**	
11:06	Collapse	Lobate crust, three collapse features:skylights,				***	
11:07	Hackly	Hackly folded curtain flow, difficult to see					
11:08	Collapse	Wall of collapse feature visible, hackly and rubly bottom, low sed cover	11:08:36		L	**	
11:09	Collapse	Collapsed edge of lobate flow, rubbly bottom, begins to transition to lineated-curtain flow				*	L>NC
11:10	Curtain	Folded-curtain flow, med sed cover, small collapse in top of flow, transitions to hackly lava			L	*	
11:11	Collapse	Hackly lava and rubble, edge of collapsed flow margin of lobate roof crust				*	
11:12	Hackly	Hackly lava and rubble					
11:13	PILLARS	2 LAVA PILLARS!!!! , several meters high, rubbly bottom	11:13:35, 50	flower		***	
11:14	PILLARS	1 LAVA PILLAR, hackly bottom, remnant island of lobate crust	11:14:20, 35	flower		***	
11:15	Collapse	Large collapse feature, ege of lobate margin and floor, rubbly bottom, bathtub rings on walls				*	
11:16	Hackly	hackly rubble lava, minor hints of lobate crust from roof of flow,		jelly fish			
11:17	Hackly	Jumbled, rubbly bottom of a large collapse feature					
11:18	Collapse	Wall of collapse feature visible, hackly and rubly bottom, low sed cover, some lobes		SA		*	
11:19	Rubble	fuzzy blur spot, rublbly bottom of collapse, edge of collapse visitble					
11:20	PILLARS	Pillar structures collapsed lobate flow, bathtub rings, smooth curtain flow at bottom	11:20:06				
11:21	Collapse	edge of collapse feature, bathtub rings on wall, curtain flow at bottom	11:21:20	flower		*	

11:30 OFF BOTTOM

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #4 Photo Descriptions**					
2001_11_26							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
21:15		ON BOTTOM					
21:16	Lobate	elongated lobes with buds , sed pretty hight and hard to see the detailed features			HM		
21:17	Lobate	same location					
21:18	Lobate	same location					
21:19	Pillow	pillow flow among elongated lobes. In general more sediment on lava and more weathered lava than cam tow3					
21:20	Lobate	Maingly elongated lobate with one pillow flow					
21:21	Pillow	pillows and loabets with buds					
21:22	pillow	pillows and loabets with buds					
21:23	pillow	pillow becomes more dominat on the flat sedimented ground					
21:24	pillow	same as 21:23					
21:25	pillow	weathered pillow or lobates with buds, not elongated any more					
21:26	pillow	More pillows(0.5 to 2 m long), straiation become more obvious on the flat heavily sed ground.			H		
21:27	pillow	More pillows(0.5 to 2 m long), straiation become more obvious on the flat heavily sed ground.			H		
21:28	pillow	3.5m long pillow with small round-shaped lobate/pillow		fish			
21:29	pillow	3.5m long pillow with small round-shaped lobate/pillow					
21:30	pillow	one or two distinctive pillow with bread crust loabates					
21:31	lobate	round lobates still on the flat heavily sedimented ground					
21:32	lobate	lobates have more buds					
21:33	lobate	more sedimented lobates			H		
21:34	lobate	more sedimented lobates			H		
21:35	lobate	same as above			H		
21:36	pillow	round pillow with buds					
21:37	lobate	0.5m size lobates					
21:38	lobate	more weathering and more sediment on assumed to be lobates			H		
21:39	lobate	same as the above			H		
21:40	lobate	less flows on the flat bottom, one 4m long lobate with collapse					
21:41	lobate	flat lobates					
21:42	lobate	lobates with buds, more continuous than before		SF			
21:43	lobate	flat bottome wih afew lobates		SF			
21:44	lobate	flat bottom with ropy sheet flow					
21:45	sheet	whieled sheet flow with rabbles inside			M		
21:46	sheet	ropy sheet flows on the flat bottom			M		
21:47	sheet	ropy sheet flows with hackly			M		
21:48	sheet	0.5x0.3m collapse in folded sheet flows with hackly around		ALF	M	*	
21:49	jumble	jumbly			L		
21:50	jumble	jumbly			L		
21:51	jumble	jumbly					
21:52	jumble	jumbly					
21:53	jumble	jumbly with some folded features					
21:54	jumble	jumbly					
21:55	jumble	jumbly					
21:56	jumble	jumbly with some folded features					
21:57	jumble	jumbly					
21:58	jumble	jumbly					
21:59	jumble	jumbly					
22:00	jumble	jumbly with some ropy features					

Legend

For TRANSitions
H = Hackly
S = Smooth
C = Curtain
L = Lobate
J = Jumbly
N = Lineated
> = transitions to
e.g. N>L
lineated transitions to lobate

For SEDiiment cover
L = low
M = medium
H = high

For COLlapse Feature
* = collapse feature present
** = good view
*** = interesting one

For BIOlogy
ALF = alien life form
BS = brittle stars
SC = sea crabby
SF = star fish
SA = sea anenome

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #4 Photo Descriptions**					
2001_11_26							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
22:01	jumble	jumbly with some ropy features					
22:02	jumble	jumbly with some ropy features					
22:03	jumble	contact with jumbly to flat bottom with a few folded flows					
22:04	jumble	jumbly					
22:05	jumble	jumbly with some folded flows					
22:06	sheet	more ropy sheet flows than jumbles					
22:07	jumble	jumbles with folded flows					
22:08	jumble	Jumbly and hackly lava					
22:09	Hackly	knobby piece of hackly lava above rest of flow, 1.5 m diameter					
22:10	Hackly	1x2 meter collapse in hackly, jumbled lava, shallow collapse	22:10:21			*	
22:11	Hackly	med sed cover over hackly flow, small, low relief 1m diam collapse feature			M	*	
22:12	Hackly	Hackly lava flow, close up photos, small, knobby, hackly ball structures <.5 m diam	22:12:36				
22:13	Curtain	Flow margin of smooth sed covered curtain flow and hackly lava, med sed cover			M		SC>H
22:14	Curtain	Collapsed edge of curtain folded flow with hackly curtain flow below, med sed cover	22:14:21		M	*	
22:15	Lava Wall	Awesome Photos: lava wall under a smooth sheet flow, heavy sed, hackly at base,	22:15:06, 51	BS	M,H	*	
22:16	Fissure	Forked fissure in hackly lava flow, heavy sed cover at base, .5-1 m wide fissure,	22:16:21			***	
22:17	Fissure	.5 m Fissure/crack continues through sed covered smooth curtain flow, part hackly			H	*	
22:18	Hackly	Hackly curtain flow, med sed cover, roof crust of fissure, crack visible, trans to lobates			M	*	H>L
22:19	Lobates	Lobate, heavy sed cover, bulbous, drizzly, pumpkin patch like			H		
22:20	Lobates	Lobes are getting b roader, irregular toe lobes on edges, heavy sed cover			H		
22:21	Lobates	Lobates, heavy sed cover, ~.5 m wide, narrow and elongate			H		
22:22	Lobates	Four bulbous lobes with numerous buds, surrounded by narrow, sed covered, long lobes	22:22:21		H		
22:23	Pillows	Tube pillows, good striations, with buds among knobby lobates, med sed cover			M		L>P
22:24	Lobates	Long narrow tubes with buds, one pillow amidst the lobes, low to med sed cover			L,M		
22:25	Lobates	Lobes, narrow and irregular, med sed cover			M		
22:26	Lobates	Lobes, low sed covery, glassy shine		BS	L		
22:27	Lobates	Broad lobes, slightly inflated, small collapse fature				*	
22:28	Lobates	Lobes, similar to above					
22:29	Lobates	Broad, flat lobes, med sed cover, collapse feaure: skylight				*	
22:30	Lobates	Lobes, low sed cover, broader and edges of lobes contact each other			L		
22:31	Lobates	Lobes, more independent of each other, broader, med sed cover			M		
22:32	Lobates	Lobes, individual lobes less distinct, are broader flatter and join together		BS	L		
22:33	Lobates	Broad flat topped lobes, little void space between lobe edges			M		
22:34	Collapse Feature	Collapse feature in pinching out lobe, med sed cover	22:34:51		M	***	
22:35	Lobates	Broad lobes, curtain folds in voids between lobes, med sed cover			M		
22:36	Collapse Feature	Lobate roof crust and edge of collapse feature, rubbly bottom, ~6m long collapse			M	*	
22:37	Lobates	Broad, flat lobes, med sed cover, trans to rubbly zone of broken up folded-lineated sheet flow			L		L>C
22:38	sheet	Broken up folded sheet flow, flow margin with lobate crust broken up,			L,H		C>L
22:39	Hackly	Hackly lava patch among lobate flow, trans to folded-hackly flow					L>H
22:40	Hackly	Hackly lava flow, jumbled, rubbly					
22:41	Hackly	Hackly, folded flow, low sed cover, jumbled looking					
22:42	Curtain	Whirled structure in jumbled curtain folded flow, part hackly					
22:43	Hackly	Hackly jumbled flow, partly folded,					
22:44	Hackly	Hackly jumbled flow					
22:45	Hackly	Hackly jumbled flow					

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #4 Photo Descriptions**					
2001_11_26							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
22:46	Ropey	ropy sheet					
22:47	sheet	contact with ropy sheet and flat sedimented bottom					
22:48	Curtain	whirled ropy sheets on the flat bottom with some jumbled pieces					
22:49	Curtain	whirled ropy sheets on the flat bottom with some jumbled pieces, then flat bottom with a collapse				*	
22:50	Hackly	hackly jumbled with some breadcrust pieces		fish			
22:51	Hackly	hackly jumbled flow					
22:52	Ropey	ropy sheet flow with jumbled pieces					
22:53	jumble	jumbly					
22:54	jumble	jumbly					
22:55	jumble	jumbly					
22:56	Lineated	contact from jumbly to lineated sheet flow	22:56:36		H		J>N
22:57	Lineated	lineated sheet flow which is covered up with sediment with a few ropy features					
22:58	Lineated	lineated sheet flow which is covered up with sediment with a few ropy features					
22:59	Lineated	lineated sheet flow which is covered up with sediment with a few ropy features					
23:00	sheet	contact from sedimented flat sheet flow to ropy sheet flows	23:01:06				S>C
23:01	sheet	back to flat sedimented bottom with some ropy features and jumbled pieces					
23:02	sheet	more ropy sheet flows on the flat sedimented bottom		SA			
23:03	Lobates	contact from the flat bottom to lobates					S>L
23:04	Lobates	the other edge of lobate flows that show collapses and back to the flat bottom with ropy flo	23:04:51	fish			
23:05	sheet	flat sedimented bottom					
23:06	sheet	flat sedimented bottom that changes to hackly flows	23:06:36				
23:07	Hackly	hackly flows with some of ropy flows		fish	M		
23:08	Hackly	hackly jumbled flow					
23:09	Hackly	contact from hackly to lobates					H>L
23:10	Lobates	lobates fill the entire image					
23:11	Lobates	lobates with ropy feature					
23:12	Lobates	lobates with a 5x4m large collapse				*	
23:13	Lobates	lobates					
23:14	Lobates	lobates					
23:15	Lobates	lobates					
23:16	Lobates	lobates					
23:17	Lobates	lobates					
23:18	Lobates	lobates with some ropy features, a collapse (50% of the image)				*	
23:19	Lobates	lobates and					
23:20	Lobates	lobates to ropy flow to lobates					
23:21	Lobates	lobates					
23:22	Lobates	lobates with 1x3m collapse				*	

23:30 OFF BOTTOM

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #5 Photo Descriptions**					
2001_11_27							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
11:06		At bottom					
11:07	Lobates	lobes, little sediment, dusting on top and in cracks,					
11:08	Lobates	Lobes with little sediment, small ropey folds between lobes, lobe edges meet up			L		
11:09	Lobates	Broad lobes, low sed cover on top, lobe edges conjoin, little void space between lobes			L		
11:10	Lobates	Broad lobes, low sed cover on top, lobe edges conjoin, little void space between lobes			L		
11:11	Lobates	Lobes more narrow, similar low dusting of sed cover, glassy sheen on edges					
11:12	Lobates	Meter width lobes, partly bulbous, some narrow and tubular lobes					
11:13	Lobates	Meter width lobes, partly bulbous, some narrow and tubular lobes			L		
11:14	Lobates	Lobes are broader, sec cover at top,					
11:15	Lobates	Broad lobes, pinch and swell tubular lobes,					
11:16	Lobates	Broad lobes, pinch and swell tubular lobes,					
11:17	Lobates	Broad lobes, pinch and swell tubular lobes,					
11:18	Lobates	Lobes, narrow meter width irregular tubes					
11:19	Lobates	Irregular bulbous lobes some tube lobes					
11:20	Lobates	Irregular bulbous lobes					
11:21	Lobates	Bulbous lobes trans to broad flat lobes, low sed cover			L		
11:22	Lobates	Irregular, narrow lobes, low sed cover					
11:23	Lobates	Irregular, narrow, slightly knobby lobes					
11:24	Lobates	Irregular, narrow, slightly knobby lobes, toothpaste-like pillow feature	11:24:43				
11:25	Lobates	Irregular, pinch and swell, partly knobby lobes, low sed cover		Fish			
11:26	Lobates	Broad lobes, small knobby toes on edges					
11:27	Lobates	Meter size lobes, sed cover in cracks, lobes over lineated sheet flow					L>N
11:28	Lineated	Lineated sheet flow, med sed cover, trans to hackly area at flow margin and lobes					
11:29	Collapse Feature	Back to lobates, Collpase feature in lobes, roof crust still intact as one piece, ropey	11:29			***	
11:30	Lobates	Low sed cover on lobes, small collapse, knobby edges,			L		
11:31	Lobates	Brod lobes, with knobby toes					
11:32	Collapse Feature	Knobby Broad lobes, Collapse feature, rubbly bottom				*	
11:33	Lobates	Lobates					
11:34	Lobates	Lobate crust, med sed cover, collapse feature, ~5 m wide, bottom is ropey-curtain folded	11:34:28		M		L>C
11:35	Hackly	Curtain folds trans to hackly lava, curtain folds					C>H
11:36	Hackly	Curtain folds in a hackly lava flow					
11:37	Hackly	Hackly lava tans to lineated, partly curtain folded sheet flow					
11:38	Sheet	Lineated sheet flow and margin with curtain folded flow					
11:39	Sheet	Curtain folded flow, samll collapse in lobes in a curtain flow, low sed cover				*	
11:40	Sheet	Lineated sheet flow, curtain fold in small channels within flow					
11:41	Sheet	Lineated curtain folded flow, med to heavy sed cover smooth sheet flow	11:41:28		M,H		
11:42	Sheet	Heavy sed cover smooth sheet flow, glass rind peaks through, flow margin with lineated shee	11:42:58	BS	H		S>N
11:43	Sheet	Lineated-smooth sheet flow margin, heavy sed on smooth sf, fissure in folded flow					
11:44	Sheet	Flow margin continued, trans to curtain folded flow, med sed cover,					
11:45	Sheet	Curtain folded flow, part hackly, smooth-curtain flow visible on photo edge, crust roof is cracked					
11:46	Hackly	hackly lava with curtain folds					
11:47	Hackly	hackly lava with curtain folds,					
11:48	Hackly	hackly lava with curtain folds, partly jumbled					
11:49	Sheet	Flow margin of smooth sheet flow and hackly curtain sheet flow,					S>H&S
11:50	Sheet	Curtain folded flow, high frequency of folds, part hackly					
11:51	Sheet	Flow margin of smooth sheet flow and hackly curtain sheet flow,	11:51:43				

Legend

For TRANSitions
H = Hackly
S = Smooth
C = Curtain
L = Lobate
J = Jumbly
N = Lineated
> = transitions to
e.g. N>L
lineated transitions to lobate

For SEDiiment cover
L = low
M = medium
H = high

For COLlapse Feature
* = collapse feature present
** = good view
*** = interesting one

For BIOlogy
ALF = alien life form
BS = brittle stars
SC = sea crabby
SF = star fish
SA = sea anenome
SU = sea urchin

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #5 Photo Descriptions**					
2001_11_27							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
11:52	Sheet	Curtain folded flow, high frequency of folds, part hackly					
11:53	Hackly	Hackly curtain folded flow					
11:54	Sheet	Curtain folded flow, part hackly					
11:55	Sheet	Curtain folded flow, part hackly					
11:56	Sheet	Curtain folded flow, flow margin of smooth-sed covered sheet flow visible on photo edge					
11:57	Collapse Feature	Hackly lava, collapse of hackly crust visible, partly lobae crust, Collapse feature				*	
11:58	Collapse Feature	Collapse Feature, lobate crust w/ low sed, bottom is smooth-ropey sheet flow, with rubble				*	
11:59	Lobates	Lobates, low sed cover, narrow and partly borad,					
12:00	Lobates	Bulbous lobes, broad lobes, low sed cover,					
12:01	Lobates	narrow bulbous lobes, low sed cover,					
12:02	Lobates	Broad lobes with irregular edges, Collapse feature				*	
12:03	Collapse Feature	Collapse Feature, lobate crust w/ low sed, bottom is rubble				*	
12:04	Collapse Feature	Lobes, med sed cover on top, borad, collapse feature continues				*	
12:05	Collapse Feature	second collapse feature in lobes, Bridge Collapse, lobe bridge is 3m wide,				**	
12:06	Lobates	Lobes, continutation of right collapse feature, smooth sed flow at bottom,				*	
12:07	Lobates	Lboes, med sed cover on top, flat and round,			M		
12:08	Lobates	Lobes, narrow and irregular					
12:09	Lobates	Broad lobes, med sed cover			M		
12:10	Lobates	narrow bulbous lobes, med sed cover, part knobby			M		
12:11	Lobates	tube and broad lobes,					
12:12	Lobates	narrow irregular lobes, sed cover on top, knobby bulbous lobes <.5m diameters					
12:13	Lobates	Irregular lobes,					
12:14	Lobates	Small lobes, partly knobby					
12:15	Lobates	Few flat lobes among knobby, ball like lobes					
12:16	Lobates	Knobby, ball like lobes					
12:17	Lobates	narrow, skinny, tubes and knoby lobes					
12:18	Lobates	Knobby lobes, med sed cover			M		
12:19	Lobates	Bread crust cracks in inflated bulbous lobes w/ knobby lobes					
12:20	Lobates	Bread crust cracks in inflated bulbous lobes w/ knobby lobes					
12:21	Lobates	Bread crust cracks in inflated bulbous lobes w/ knobby lobes, heavy sed cover, broad flate lobes					
12:22	Lobates	Knobby lobes, and flat lobes with heavy sed cover		SF			
12:23	Lobates	Knobby lobes					
12:24	Lobates	Knobby lobes, partly bulbous		Fish			
12:25	Lobates	Knobby, partly bulbous lobes, med sed cover, high altitude of camera					
12:26	Lobates	Knobby, partly bulbous lobes, med sed cover, high altitude of camera					
12:27	Lobates	Knobby partly bulbous lobes,					
12:28	Lobates	Really knobby lobes, possible collapse of old flow by new flow (sw photo corner), TUBE	12:28:28				
12:28	Collapse Feature	BIG trans to sed cover, long (+5m long, 1m wide) pillow lava tube with buds, collapse feature	12:28:43			*	L>old S
12:29	Lobates	Heavy, Heavy sed cover over smooth, partly lobate, sheet flow			H		
12:30	Lobates	Heavy sed cover between spaced out bulbous lobes, with med sed cover		BS	M		
12:31	Lobates	Heavy sedimented lobe, tubular and narrow, pinch and swell, irregular edges to lobes			H		
12:32	Lobates	Heavy sedimented lobes, narrow and tubular, some bulbous ball-like lobes-pillows			H		
12:33	Pillows	Isolated pillows with buds in size of 1m on the heavily sedimented relatively flat bottom			H		
12:34	Pillows	Broken pieces of flows with heavy sediment with pillows			H		
12:35	Lobates	heavily sedimented lobates on the heavily sedimented irregular bottom		BS	H		

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #5 Photo Descriptions**					
2001_11_27							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
12:36	Lobates	heavily sedimented lobates on the heavily sedimented irregular bottom		BS	H		
12:37	Lobates	ball-like pillow flows with buds, elongated lobates on the heavily sedimented bottom		BS, fish	H		
12:38	Lobates	ball-like pillow flows with buds, elongated lobates on the heavily sedimented bottom		BS, Seaurc	H		
12:39	Lobates	heavily sedimented lobates on the heavily sedimented irregular bottom	12:40:43	t cucam	H		
12:40	Lobates	heavily sedimented lobates on the heavily sedimented irregular bottom			H		
12:41	Pillows	elongated pillows and lobates on the heavily sedimented bottom	12:41:28		H		
12:42	Pillows	elongated pillows and lobates on the heavily sedimented bottom			H		
12:43	Pillows	more pillows , some 5m long on the heavily sedimented bottom			H		
12:44	Pillows	more pillows and lobates on the heavily sedimented bottom			H		
12:45	Pillows	pile of pillows and elongated pillows with full of buds on the heavily sedimented bottom			H		
12:46	Pillows	short pillows with buds around on the heavily sedimented bottom			H		
12:47	Lobates	bread crust lobates, irregular lobates on the heavily sedimented bottom			H		
12:48	Sedimented	heavily sedimented irregular bottom			H		
12:49	Lobates	weathered lobates flows on the heavily sediemented bottom			H		
12:50	Lobates	lrregular lobes, small pillows, knobby flows on the heavily sedimented bottom	12:50:58	SA,SC	H		
12:51	Lobates	weathered lobates flows and more fresh pillows on the heavily sediemented bottom			H		
12:52	Pillows	small crack on the bottom, ball-like pillows on the H sed bottom			H		
12:53	Pillows	short pillows and lobates on H sed bottom with a small crack			H		
12:54	Pillows	short pillows and lobates on H sed bottom with a small crack			H		
12:55	Pillows	drain-pipe pillow and knobby flows on H sed bottom			H		
12:56	Pillows	pile of pillows and ball pillows on H sed bottom			H		
12:57	Pillows	1-2m long pillows on H sed bottom			H		
12:58	Pillows	1-2m long pillows with many buds on H sed bottom			H		
12:59	Pillows	irregular lobates and small pillows on H sed bottom		SA	H		
13:00	Pillows	1-2m long pillows with buds on H sed bottom			H		
13:01	Pillows	1-2m long pillows with buds on H sed bottom			H		
13:02	Sedimented	weathered lava flow pieces on h sed bottom			H		
13:03	Sedimented	weathered lava flow pieces on h sed bottom, bottom getting more flat			H		
13:04	Sedimented	very flat H sed bottm with traces of flow pieces			H		
13:05	Sedimented	flat H sed bottm with traces of flow pieces			H		
13:06	Sedimented	flat H sed bottm with traces of flow pieces		BS	H		
13:07	Sedimented	flat H sed bottm with traces of flow pieces			H		
13:08	Sedimented	flat H sed bottm with traces of flow pieces			H		
13:09	Sedimented	flat H sed bottm with small ball pillows			H		
13:10	Sedimented	flat H sed bottm with small ball pillows and pieces of old flows		BS, SU	H		
13:11	Sedimented	flat H sed bottm with small ball pillows and pieces of old flows			H		
13:12	Sedimented	flat H sed bottm with small ball pillows and pieces of old flows, worml holes on the bottom	13:12:43		H		
13:13	Sedimented	flat H sed bottm with small ball pillows and pieces of old flows, worml holes on the bottom	13:13:43	worm	H		
13:14	Sedimented	flat H sed bottm with small ball pillows and pieces of old flows, small fissure(0.5m wide)			H	*	
13:15	Sedimented	flat H sed bottm with small ball pillows and pieces of old flows, smal crack			H		
13:16	Sedimented	flat H sed bottm with small ball pillows and pieces of old flows, smal crack			H		
13:17	Sedimented	flat H sed bottm with small ball pillows and pieces of old flows, smal crack			H		
		end of the tow,					

13:25 OFF BOTTOM

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #6 Photo Descriptions**					
2001_11_27							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
17:20		On bottom					
17:21	Lobates	Heavy sedimented, spaced, lobates			H		
17:22	Lobates	Heavy sediment lobates, spaced apart, bulbous, bread crust cracks, knobby-budded edges	17:22:47		H		
17:23	Lobates	Heavy sediment lobates, spaced apart, bulbous, bread crust cracks, knobby-budded edges		BS	H		
17:24	Lobates	Heavy sedimented lobates, island of lobate crust?, flat topped, broad lobates			H		
17:25	Lobates	Heavy sedimented lobates with knobby edges		BS	H		
17:26	Lobates	Heavy sedimented lobates with knobby edges			H		
17:27	Pillows	Open ended pillow with budded-knobby lobate coming out opening in pillow	17:27:17				
17:28	Lobates	Medium-Heavy sedimented lobates, spaced apart, H sed floor, low relief lobes, flat, irregular			M,H		
17:29	Lobates	H-sed on bottom, lobes, few knobby-budded bulbous lobes-pillows, bread crust cracks			H		
17:30	Lobates	H -sed cover lobes, some pillows ~1m diameter		Fish	H		
17:31	Lobates	H -sed cover lobes, some pillows ~1m diameter			H		
17:32	Lobates	Smoother flatter sheet flow, partly lobate, H sed cover,			H		
17:33	Lobates	H-sed floor with smooth sheet like lobates			H		
17:34	Pillows	Tube pillows, striated, knobby tube pillows, H-sed floor, budded	17:34:02		H		
17:35	Pillows	Knobby pillows, H-sed bottom, rifted pillows			H		
17:36	Pillows	Transition to fresh pillows and lobes, L sed cover, High frequency of pillows and lobes, knobby	17:36:17		L		L>LP
17:37	Lobates	Drizzly and knobby pillows and lobes, bulbous, L sed cover			L		
17:38	Lobates	Collapse feature edge w/ knobby lobate and pillow M sed roof crust, rubbly bottom			M	*	
17:39	Lobates	Fresh, knobby,lobes w/ bread crust cracks and ball like lobes, very intermingled lobes					
17:40	Lobates	Fresh, knobby,lobes w/ bread crust cracks and ball like lobes, very intermingled lobes					
17:41	Lobates	Fresh, knobby,lobes w/ bread crust cracks and ball like lobes, very intermingled lobes					
17:42	Lobates	Fresh, knobby,lobes w/ bread crust cracks and ball like lobes, very intermingled lobes					
17:43	Lobates	Knobby lobes, few pillows, low sed cover, very intermingled, narrow lobes			L		
17:44	Lobates	Low sed covered knobby lobes, party drizzly			L		
17:45	Lobates	Bulbous lobes, low sed cover, part drizzly and ball like			L		
17:46	Pillows	Knobby pillows and drizzly lobes					
17:47	Lobates	Knobby pillows and drizzly lobes					
17:48	Lobates	Drizzly and knobby lobes with ball-like interstitial toes between lobes					
17:49	Lobates	Broad lobes, low sed cover, more tubular, knobby edges					
17:50	Lobates	Knobby edged flat topped lobes, L sed cover			L		
17:51	Lobates	Knobby lobes, low sed cover, elephant hide texture, part drizzly			L		
17:52	Lobates	Knobby lobes, low sed cover, elephant hide texture, part drizzly			L		
17:53	Lobates	Bulbous lobes, low sed cover, part drizzly and ball like			L		
17:54	Lobates	Bulbous lobes, low sed cover, part drizzly and ball like			L		
17:55	Lobates	Ball like and drizzly, partly bulbous lobes,					
17:56	Lobates	Ball like and drizzly, partly bulbous lobes, sed cover increasing, M sed cover			M		
17:57	Lobates	Ball like and drizzly, partly bulbous lobes, sed cover increasing, M sed cover			M		
17:58	Lobates	Knobby and ball like part drizzly lobates, some bulbous lobes with bread crust cracks and buds					
17:59	Lobates	Knobby and ball like part drizzly lobates, some bulbous lobes with bread crust cracks and buds					
18:00	Lobates	Knobby and ball like part drizzly lobates, some bulbous lobes with bread crust cracks and buds					
18:01	Pillows	Pillows, bulbous and tubular, pinch and swell, bread crust creack, knobby lobes surround					
18:02	Pillows	Pillows, bulbous and tubular, pinch and swell, bread crust creack, knobby lobes surround					
18:03	Lobates	Knobby bread crust cracked, narrow tubular lobes, sed cover increasing, smooth area					
18:04	Lobates	Knobby pillows and lobes, trans to H sed cover flat sheet lobes					
18:05	Lobates	H sed flat sheet lobes, FISSURE/CRACK then pillow/lobe higher crust casting shadow,Collapse	18:05:02		H	*	

Legend

For TRANSitions
H = Hackly
S = Smooth
C = Curtain
L = Lobate
J = Jumbly
N = Lineated
P = Pillow
> = transitions to
e.g. N>L
lineated transitions to lobate

For SEDiiment cover
L = low
M = medium
H = high

For COLlapse Feature
* = collapse feature present
** = good view
*** = interesting one

For BIOlogy
ALF = alien life form
BS = brittle stars
SC = sea cucumber
SF = star fish
SA = sea anenome
SS = sea spider
SU = sea urchin
C = coral plant

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #6 Photo Descriptions**					
2001_11_27							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
18:06	Lobates	Broad flat lobates, knobby edges, spaced apart, heavy sed in between lobes			H		
18:07	Lobates	Fissure/ Crack in drizzly lobates , bulbous lobes, H sed cover on bottom	18:07:32		H		
18:08	Pillows	Tubular pillows, budded at tip, knobby lobes	18:08:17				
18:09	Pillows	Pillows, bulbous and tubular, pinch and swell, bread crust crack, small collapses in floor			H	*	
18:10	Pillows	Tubular pillows, budded, pillows appear to come out of crack in bottom crust, CF,bridge	18:10:02	SC		*	
18:11	Collapse Feature	Collapse Feature edge, smooth heavy sed, broken up rubbly lobate crust			H	*	
18:12	Collapse Feature	CF, in smooth sheet-lobate flow, H sed on collapse bottom, Bridge Collapse,	18:12:47	Fish	H	*	
18:13	Collapse Feature	Collapse feature w/ edge of fresh cracked lobes over heavy sed bottom, (EXTRUSION?)	18:13:17		H	*	
18:14	Sedimented	H sed cover over flat sheet, partly knobby lobes, Brittle Stars and Coral Plant	18:14:47	Bs, C	H		
18:15	Sedimented	H sed cover over flat sheet, partly knobby lobes, Brittle Stars and Coral Plant			H		
18:16	Sedimented	H sed cover over flat sheet, cracked lobes, small collapse feature			H		
18:17	Sedimented	H sed cover over flat sheet lobes, partly tubular lobes stick out,		BS	H		
18:18	Sedimented	Long crack in crust of H sed cover sheet like lobes, few pillows, Coral plant	18:19:02	C	H		
18:19	Sedimented	H sed cover lobes			H		
18:20	Sedimented	H sed cover lobes			H		
18:21	Sedimented	H sed cover lobes, small collapse feature, broken edges in lobes			H	*	
18:22	Sedimented	H sed cover lobes, small collapse feature, broken edges in lobes			H	*	
18:23	Collapse Feature	Collapse feature, H sed lobes, less sed on lobes around collapse, H sed in bottom			h	*	
18:24	Sedimented	H sed cover, collapse, cracks in crust top			H		
18:25	Sedimented	H sed cover, collapse, cracks in crust top, Inflated edge around collapse	18:25:47		H	***	
18:26	Sedimented	H sed cover lobes			H		
18:27	Sedimented	H sed cover lobes			H		
18:28	Sedimented	H sed cover lobes, partly knobby edges			H		
18:29	Sedimented	H sed cover lobes			H		
18:30	Sedimented	H sed cover lobes, bulbous knobby tubular pillows			H		
18:31	Pillows	Bulbous, budded, pillows on H sed cover bottom			H		
18:32	Pillows	Tubular pllows, partly budded, , bulbous pillows		SS			
18:33	Pillows	Knobby pillows and lobes					
18:34	Pillows	Stubby tubular pillow (small hole in pillow near bio), budded pinch and swell tube pillows	18:34:02				
18:35	Pillows	Lobes, and pillows, M sed cover, Deep colpase feature, Pillows for crust, rubbly bottom		SU	M	*	
18:36	Collapse Feature	Collapse feature, ball like rubble at bottom, M sed cover, 5 m width, lobate pillow roof		SF	M	*	
18:37	Sedimented	H sed covered lobes and pillows, edge of Collapse feature			H		
18:38	Lobates	Fresh, irregular lobes, Less sed cover, Broad lobes, with L sed cover on top,			L		
18:39	Lobates	Fresh, irregular lobes, Less sed cover, Broad lobes, with L, budded and knobby pillows			L		
18:40	Lobates	budded and knobby lobes, intermingled,					
18:41	Lobates	Tube and broad flat lobes, L sed cover on top, part drizzly lobes			L		
18:42	Lobates	Knobby and ball like part drizzly lobates, some bulbous lobes with bread crust cracks and buds					
18:43	Lobates	Knobby and ball like part drizzly lobates, some bulbous lobes with bread crust cracks and buds					
18:44	Lobates	Knobby and ball like part drizzly lobates, some bulbous lobes with bread crust cracks and buds		Fish			
18:45	Lobates	Knobby and ball like part drizzly lobates, with bread crust cracks and buds, M sed cover			M		
18:46	Lobates	M sed, knobby and partly bulbous lobates			M		
18:47	Lobates	M sed, knobby and partly bulbous lobates			M		
18:48	Lobates	M sed, knobby and partly bulbous lobates			M		
18:49	Lobates	M sed, knobby and partly bulbous lobates			M		
18:50	Lobates	High altitude hard to see bulbous lobates			M		

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #6 Photo Descriptions**					
2001_11_27							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
18:51	Lobates	M sed, knobby and partly bulbous lobates			M		
18:52	Lobates	L sed, knobby, drizzly, bulbous lobates, intermingled			L		
18:53	Pillows	Pillows and knobby lobates, L sed cover			L		
18:54	Pillows	Pillows and knobby lobates, L sed cover			L		
18:55	Pillows	Pillows, bread crust cracks, moderately tubular, knobby, low relief lobes					
18:56	Pillows	Pillows on a H sed floor, buds and knobby sides, nice aerial views of pillow filed			H		
18:57	Lobates	Broad flat lobates , H sed cover on top, edges of lobates meet			H		
18:58	Lobates	H sed lobates, low relief, irregular edges		SF	H		
18:59	Lobates	Tubular bulbous lobes, M sed cover, H sed in cracks, TRAP DOOR PILLOW	18:59:33	SF	M		
19:00	Lobates	M sed broad flat topped lobates with knobby toe edges			M		
19:01	FAULT?	FAULT!? H sed lobes down dropped : Bread crust cracked pillow lobes up, HIGH RELIEF	19:01:33		H		
19:02	Pillows	Spaced apart lobes on H sed bottom, TUBE PILLOWS!! W/ few buds	19:02:48		H		
19:03	Pillows	Irregular pillows and lobes on H sed bottom, cracked and knobby			H		
19:04	Pillows	Isolated pillows, with buds on H sed bottom, small tubes connect pillows like tunnel ways	19:04:48		H		
19:05	Pillows	Isolated pillows and tubular pillows on H sed bottom, budded and knobby			H		
19:06	Lobates - Pillows	H sed covered lobes and pillows		BS	H		
19:07	Lobates - Pillows	H sed covered lobes and pillows		BS, SC	H		
19:08	Lobates - Pillows	H sed covered lobes and pillows			H		
19:09	Lobates - Pillows	H sed covered lobes and pillows			H		
19:10	Lobates - Pillows	H sed covered bottom with isolated pillows conjoined by umbililcal connecting tube	19:10:18	flowers	H		
19:11	Pillows	Tube pillows on a H sed bottom			H		
19:12	Lobates - Pillows	H sed covered lobes and pillows, budded and isolated			H		
19:13	Pillows	H sed covered pillows and lobes, pillows are isolated from each other			H		
19:14	Lobates - Pillows	Pillow and lobes, budded on edges, bigger than previous features, H sed bottom			H		
19:15	Pillows	Budded pillow, H sed bottom, tubular pinch and swell lobates, knobby edges		SF	H		
19:16	Pillows	Tubular pinch and swell lobates with knobby edges, few billows			H		
19:17	Pillows	Budded pillows, tubular, H sed bottom			H		
19:18	Pillows	Budded pillow, H sed bottom, cracked lobate crust sits high on new chilled surface			H		
19:19	Pillows	Knobby pillows and lobes, H sed bottom, irregular lobe and pillow edges, budded			H		
19:20	Pillows	Knobby pillows and lobes, H sed bottom, irregular lobe and pillow edges, budded			H		
19:21	Lobates - Pillows	Pillows and lobes, some tubular and knobby on H sed gloor			H		
19:22	Lobates - Pillows	Pillows and lobes on H sed bottom, budded and isolated, FLOW MARGIN FEATURE?	19:22:48		H		
19:23	Lobates - Pillows	Flow margin Contact of toes from a sheet like lobe, very linear curious feature, H sed	19:23:03		H		
19:24	Lobates - Pillows	H sed covered lobes and pillows, Large crack/fissure splits sheet like lobe flow	12:24:48		H		
19:25	Lobates	Crack separates sheet lobe from H sed pillows and lobes, Broad flat topped lobes	12:25:03		H		
19:26	Pillows	Pillows with buds, intermingled, fresh looking, L sed cover, bulbous pillows,	12:26:03, 18		L		L>P
19:27	Lobates	Intermingled drizzly and knobby lobes and pillows					
19:28	Lobates	Intermingled drizzly and knobby lobes and pillows, M sed cover			M		
19:29	Lobates	Intermingled drizzly and knobby lobes and pillows, M sed cover			M		
19:30	Lobates	Intermingled drizzly and knobby lobes and pillows, M sed cover			M		
19:31	Pillows	Moderatley tubular Pillows, bread crust cracks, knobby, low relief lobes			M		
19:32	Lobates - Pillows	Drizzly, ball structure lobes, bulbous pillows, M sed cover			M		
19:33	Lobates - Pillows	Drizzly, ball structure lobes, bulbous pillows, M sed cover			M		
19:34	Lobates - Pillows	Drizzly, ball structure lobes, bulbous pillows, M sed cover			M		
19:35		Off Bottom					

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #7 Photo Descriptions**					
2001_11_28							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
8:30	Hackly	On bottom, Heavy sed bottom, with pieces of hackly lava		BS	H		
8:31	Hackly	H sed bottom with pieces of hackly lava, small collapse in smooth crust			H	*	
8:32	Hackly	H sed bottom, pices of hackly lava, crack in crust		BS	H		
8:33	Curtain - Hackly	Hackly curtain folded lava with H sed cover		BS	H		
8:34	Curtain - Hackly	Hackly curtain folded lava with H sed cover		BS	H		
8:35	Curtain - Hackly	Hackly curtain folded lava with H sed cover		BS	H		
8:36	Hackly	H sed cover, smooth bottom, hackly lava piles		BS	H		
8:37	Hackly	Hackly curtain folded lava with H sed cover		BS	H		
8:38	Hackly	H sed cover, smooth bottom, hackly lava piles			H		
8:39	Hackly	H sed cover, smooth bottom, hackly lava piles			H		
8:40	Hackly	H sed cover, smooth bottom, hackly lava piles			H		
8:41	Hackly	H sed cover, smooth bottom, hackly lava piles			H		
8:42	Fissure	H sed cover, smooth bottom, curtain lava, Collapse Fissure, deep crack			H	*	
8:43	Fissure	Deep fissure/crack, 1m wide , H sed bottom, curtain-hackly lava	8:43:07		H	***	
8:44	Fissure	H sed bottom, 2nd crack, .2 m wide, cuts smooth bottom and curtain folded pile	8:44:52		H		
8:45	Curtain - Hackly	H sed cover, smooth sed bottom, hackly and curtain lava piles and pieces			H		
8:46	Fissure	H sed bottom, hackly piles, deep fissure <1m wide, cuts hackly lava	8:46:52		H	***	
8:47	Fissure	Fissure is <2 m deep?, hackly lava wall going down it, H sed cover on top	8:47:07		H	***	
8:48	Fissure	Smooth pieces w/ H sed cover, Fissure w/ hackly lava drizzled on sides of crack	8:48:07, 22		H	***	
8:49	Hackly	H sed cover , smooth bottom, Hackly curtain lava piles and pieces			H		
8:50	Hackly	H sed cover , smooth bottom, Hackly curtain lava piles and pieces			H		
8:51	Collapse Feature	Large Collapse feature, rubbly bottom, hackly curtain roof, high cam altitude,	8:51:07		H		
8:52	Collapse Feature	Over Large Collapse Feature bottom, very hard to see bottom			H		
8:53	Collapse Feature	Edge of collapse, hackly curtain wall few meters high, collapse continues	8:53:22		H		
8:54	Collapse Feature	Collapse feature bottom, high altitude can't see bottom			H		
8:55	Collapse Feature	Edge of coolapse, hackly part lobate roof crust, can't see bottom, pillow lava crust	8:55:22		L		
8:56	Pillows	H sed bottom, smooth, small pillow balls on sed cover,			H		
8:57	Pillows	H sed cover, over smooth sheet pieces and pillow balls			H		
8:58	Pillows	H sed cover, broken up pillow			H		
8:59	Lobates	H sed cover over knobby lobes			H		
9:00	Pillows	H sed cover, pillows, hackly pieces scattered		Fish, BS	H		
9:01	Hackly	Hackly lava piles, H sed bottom,			H		
9:02	Hackly	Hackly lava piles, H sed bottom,			H		
9:03	Pillows	Knobby pillows H sed bottom		SS	H		
9:04	Pillows	Knobby pillows H sed bottom			H		
9:05	Lobates	H sed bottom, knobby lobes, few pillows			H		
9:06	Lobates	Knobby lobes, H sed bottom			H		
9:07	Pillows	Budded pillows, H sed bottom,			H		
9:08	Pillows	Sedimented bottom, collapsed pillow	9:08:52		H	***	
9:09	Pillows	small collapse in pillow, H sed bottom			H		
9:10	Pillows	Radial splat structures on sed surface, pillows,			H		
9:11	Pillows	Pillows on H sed bottom,			H		
9:12	Lobates	Knobby lobes, H sed bottom, "mirror image" pillows		BS	H		
9:13	Sheet	H sed sheet flow, cracked rubble areas, few isolated pillows		SF	H		
9:14	Lobates	H sed cover with ropey curtain lava piles, small collapse, knobby lobates,			H	*	
9:15	Pillows	pillows and knobby lobes, tubular, isolated, H sed bottom			H		

Legend

For TRANSitions
H = Hackly
S = Smooth
C = Curtain
L = Lobate
J = Jumbly
N = Lineated
> = transitions to
e.g. N>L
lineated transitions to lobate

For SEDiiment cover
L = low
M = medium
H = high

For COLlapse Feature
* = collapse feature present
** = good view
*** = interesting one

For BIOlogy
ALF = alien life form
BS = brittle stars
SC = sea crabby
SF = star fish
SA = sea anenome
SS = sea spider

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #7 Photo Descriptions**					
2001_11_28							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
9:16	Pillows	knobby pillows H sed bottom, curtain lava pieces			H		
9:17	Pillows	Knobby pillows, H sed bottom, curtain folds, tubular pillows			H		
9:18	Pillows	knobby and striated pillows, H sed bottom			H		
9:19	Pillows	Sedimented bottom, collapsed pillow	9:19:37	Doily?	H		
9:20	Pillows	Lobes and pillows, H sed bottom, curtain folded pieces, small collapse			H	*	
9:21	Hackly	Hackly lava piles, H sed bottom, pillows			H		
9:22	Pillows	pillows isolated, H sed bottom, curtain folds and cracks in sheet flow			H		
9:23	Pillows	bulbous and tubular budded pillows, H sed bottom	9:23:27	SC	H		
9:24	Pillows	bulbous and tubular budded pillows, H sed bottom			H		
9:25	Pillows	bulbous and tubular budded pillows, H sed bottom			H		
9:26	Pillows	toothpaste pillow, bread crust cracks, H sed bottom, budded pillows			H		
9:27	Sheet	Broken up section of sheet flow, tubular knobby pillows		eel	H		
9:28	Pillows	Tubular budded pillows			H		
9:29	Lobates	H sed over knobby lobes and sheet flow			H		
9:30	Lobates	H sed over knobby lobes and sheet flow			H		
9:31	Pillows	small collapse, knobby pillows, highly budded, Trap Door Pillow!!,	9:31:52		H	*	
9:32	Pillows	Tubular budded pillows, H sed bottom, knobby lobate flow	9:32:52	SC	H		
9:33	Pillows	Radial rifted pillow, elephant hide texture,	9:33:52		H		
9:34	Lobates	Drizzly lobes, narrow tubular pillows, intermingled,	9:34:52		H		
9:35	Pillows	toohpaste pillows, trap door pillow, bulbous pillow,	9:35:22, 52	SS, Fish	H		
9:36	Pillows	tubular pillow field, budded, H sed bottom, elephant hide textures		SF, ALF	H		
9:37	Pillows	bulbous pinch and swell conjoined pillows, egg shell pillow (37:52)			H		
9:38	Pillows	Bulbous, knobby, tubular pillows, narrow (<.2 m wide) in the crust	9:38:52		H		
9:39	Fissure	.2m wide fissure in lobes and pillows, hollow area underneath pillows?	9:39:22		H	***	
9:40	Fissure	Fissure in crust, .5 m wide, lobe cross section, 2m wide slab fallen at edge, CF? Pillows at bot	9:40:22	fish	H	***	
9:41	Pillows	pillows and lobes, M sed bottom			M		
9:42	Pillows	pillows and lobes, going down slope? Flow front? Broad flat M sed lobes			M		
9:43	Lobates	Broad flat M sed, lobes, sheet like tops, edges mesh together			N		P>S
9:44	Lobates	Broad flat M sed, lobes, sheet like tops, edges mesh together					
9:45	Lobates	Broad flat M sed, lobes, sheet like tops, edges mesh together					
9:46	Lobates	Broad flat M sed, lobes, sheet like tops, edges mesh together					
9:47	Lobates	Broad flat, joined lobes, .3 m cracks in the smooth sheet like tops,					
9:48	Lobates	Broad flat lobes					
9:49	Lobates	Broad flat lobes, M sed cover			M		
9:50	Lobates	Broad flat lobes trans to narrow lobe toes w/ irregular edges					
9:51	Lobates	Flat lobes w/irregular edges, pillows come out of lobe tops, tubular pillows w/buds	9:51:52				
9:52	Pillows	Fissure? In pillows and sheet like lobe, H sed bottom, tubular pillows,	9:52:07		H	*	
9:53	Pillows	narrow drizzle lobes, bulbous knobby pillows,					
9:54	Pillows	tubular pillows, inch and swell					
9:55	Fissure	Fissure, sheet lobes, pillows, collpased pillow w/spilled sheet lobe	9:55:37			*	
9:56	Pillows	bulbous pillows, tubular pillows, H sed bottom			H		
9:57	Fissure	Fissure .5 m wide, in smooth sheet w/ few pillows,				*	
9:58	Pillows	Hackly collapse in sheet lobe flow, Pillows overlie surface	9:58:37				
9:59	Fissure	Wide and deep trough Fissure? 4 m slab of pillow island, split by 1m wide fissure	9:59:22			*	
10:00	Lobates	Lobes and pillows, H sed bottom					

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #7 Photo Descriptions**					
2001_11_28							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
10:01	Pillows	Pillows, budded, H sed bottom					
10:02	Pillows	H sed bottom wih knobby lobes and pillows, pillow with drain out at bottom	10:02:52		H		
10:03	Sheet	H sed sheet like lobes, minor pillow structure			H		
10:04	Lobates	very knobby lobes, part hackly, tubular pillows					
10:05	Pillows	Cracked and hackly lobes, tube pillows					
10:06	Pillows	budded pillow field					
10:07	Pillows	intermingled tubular and budded pillows		Star fish			
10:08	Pillows	intermingled tubular and budded bulbous pillows					
10:09	Pillows	2 m rifted pillow, elephant hide texture, tubular pillows	10:09:37				
10:10	Pillows	Bulbous budded pillows					
10:11	Pillows	drizzly ball like lobes, few pillows, L sed cover			L		
10:12	Pillows	tubular pillows, bulbous pillow, HOLLOW PILLOW	10:12:52				
10:13	Fissure	Fissure .2 m wide, sheet lobes and pillows, H sed bottom			H	***	
10:14	Lobates	Irregular lobes, broad flat, toes					
10:15	Pillows	Tubular, budded, pillows					
10:16	Pillows	Tubular, budded, pillows					
10:17	Pillows	Pillows and knobby lobes, budded, bulbous					
10:18	Pillows	lobes and pillows intermingled					
10:19	Pillows	egg shell pillow w/"yolk lava", fissure or small crack <.1 m wide,	10:19:07			*	
10:20	Lobates	H sed sheet lobes,			H		
10:21	Fissure	Fissure/crack ~.3 m wide, in m sed flat lobates	10:21:22			***	
10:22	Curtain	H sed bottom, small collapse in crust trans to curtain folded flow				***	
10:23	Fissure	Collpased crust in a curtain folded flow, Beautiful fissure in curtain flow, .5 m wide,	10:23:37			***	
10:24	Sheet	sheet like flow, cracked, small collapses, lobes					
10:25	Fissure	H sed lobes and pillows, high altitude, Fissure!!! Deep, lobate crust,				***	
10:26	Fissure	.5 m wide Fissure, Deep, lobate crust, 2nd fissure up tow, lobe crust,	10:26:07, 52			***	
10:27	Lobates	Lobates, intermingled, knobby edges, L sed cover			L		
10:28	Lobates	Lobates, intermingled, knobby edges, L sed cover			L		
10:29	Lobates	Lobateds, cracked and rifted crusts, toe-like edges, L sed cover			L		
10:30	Lobates	Broad flat lobes, bulbous knobby areas on lobes, part drizzly					
10:31	Lobates	Broad flat lobes, bulbous knobby areas on lobes, part drizzly, L sed cover			L		
10:32	Lobates	Brod flat lobes, L sed cover, tubular lobes, intermingled			L		
10:33	Lobates	L sed cover, narrow tubular lobes,	10:33:52	SC	L		
10:34	Lobates	Lobates, L sed cover			L		
10:35	Lobates	broad flat topped lobates w/ intermingled toes					
10:36	Lobates	broad flat topped lobates w/ intermingled toes		SC			

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #8 Photo Descriptions**					
2001_11_28							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
15:20		On Bottom		BS	H		
15:21		H sed bottom = flat, planar, featureless bottom, brittle stars, minor lava flow outcrops			H		
15:22		H sed bottom			H		
15:23		H sed bottom, curtain folded flow, M sed cover,			M		
15:24		H sed bottom			H		
15:25		H sed bottom, minor pillows			H		
15:26		H sed bottom			H		
15:27		H sed bottom, few pieces of sheet type flows		SC	H		
15:28		pillows, tubular, H sed bottom			H		
15:29		Pillows, tubular and bulbous on H sed bottom			H		
15:30		H sed bottom, isolated pillows			H		
15:31		H sed bottom, minor lobate and pillow pieces		SC	H		
15:32		H sed bottom, pillows			H		
15:33		Isolated pillows on H sed bottom			H		
15:34		H sed bottom, isoloated pillows, tubular and ball pillows			H		
15:35		H sed bottom, pillows			H		
15:36		H sed bottom			H		
15:37		H sed bottom			H		
15:38		H sed bottom			H		
15:39		H sed bottom			H		
15:40		H sed bottom trans to curtain and smooth sheet flow, broken flow front/margin?			H		
15:41		Flow margin of curtain-folded sheet flow	15:41:10		H		C>Sed
15:42		H sed bottom			H		
15:43		H sed bottom			H		
15:44		H sed bottom, few pillows			H		
15:45		H sed bottom			H		
15:46		H sed bottom, hackly patch			H		
15:47		H sed bottom, fractured, cracked part of smooth sheet flow (broken flow edge?)			H		
15:48		H sed bottom - sea stars, worms, brittle star, cucumbers		sea star	H		
15:49		H sed bottom			H		
15:50		H sed bottom			H		
15:51		Pillows, knobby, on H sed bottom			H		
15:52		Scarp? in a pillow field, drop in bathymetry, wall of pillows leads to basal pillow field,	15:52:55		H	***	
15:53		Collapse pit? Isolated block of flat lobes and pillows away from edge, pillows on bottom	15:53:40		H	***	
15:54		Collapse pit edge? Pillows on fringe of pit > H sed bottom			H	***	
15:55		H sed bottom,			H		
15:56		Pillow balls and tubular pillows on H sed bottom, knobby and budded		SC	H		
15:57		Knobby pillow balls on H sed botoom		SC	H		
15:58		H sed bottom, few pillows			H		
15:59		TOMOKO HITS THE BOTTOM!!!!!!!!!!!!, sed cloud from hitting bottom	15:59:10		H		
16:00		H sed bottom, pillows,		ALF plan	H		
16:01		tubualr pillows, bright white patchs in sed?,		fish	H		
16:02		tubular knobby pillows			H		
16:03		H sed bottom, pillows,		SF	H		
16:04		H sed bottom, no pillows			H		
16:05		H sed bottom, no pillows			H		

Legend

For TRANSitions
H = Hackly
S = Smooth
C = Curtain
L = Lobate
J = Jumbly
N = Lineated
> = transitions to
e.g. N>L
lineated transitions to lobate

For SEDiiment cover
L = low
M = medium
H = high

For COLlapse Feature
* = collapse feature present
** = good view
*** = interesting one

For BIOlogy
ALF = alien life form
BS = brittle stars
SC = sea crabby
SF = star fish
SA = sea anenome

Photo Prefix - Date		Atlantis 7-4 Camera Tow #8 Photo Descriptions					
2001_11_28							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
16:06		H sed bottom, small collapse			H		
16:07		H sed botom, smooth sheet pieces			H		
16:08		H sed bottom			H		
16:09		H sed bottom, minor outcrop of lobe			H		
16:10		H sed bottom, minor outcrop of lobe			H		
16:11		H sed bottom, worm hole colony,		worms	H		
16:12		H sed bottom, worm hole colony,			H		
16:13		H sed bottom			H		
16:14		H sed bottom			H		
16:15		H sed botom, minor hackly pieces			H		
16:16		Curtain folded flow, H sed cover			H		
16:17		Hackly lava on H sed bottom, minor curtain folded pieces			H		
16:18		Folded lava pieces on H sed bottom	16:18:40	sea star	H		
16:19		Ring structure in sediment? Jumbly lava pieces, partly curtian					
16:20		H sed bottom w/ hackly lava pieces					
16:21		H sed bottom					
16:22		curtain folded piles, cool plant in (22:55), H sed bottom		fern			
16:23		H sed bottom		SC			
16:24		H sed bottom, smooth sheet pieces, small collapse in crust		SU		*	
16:25		H sed bottom, curtain lava					
16:26		curtain lava pieces, few pillows , H sed bottom					
16:27		Hackly, knobby pillows, H sed bottom		fish			
16:28		Hackly lava on H sed bottom, minor curtain folded pieces					
16:29		Hackly lava on H sed bottom, minor curtain folded pieces					
16:30		pillows, bulbous, toothpaste					
16:31		Hackly, knobby pillows, H sed bottom					
16:32		Hackly, knobby pillows, H sed bottom					
16:33		Hackly, knobby pillows, H sed bottom					
16:34		Hackly, knobby pillows, H sed bottom					
16:35		Hackly, knobby pillows, H sed bottom					
16:36		Hackly, knobby pillows, H sed bottom					
16:37		Hackly, knobby pillows, H sed bottom		fish			
16:38		Hackly, knobby pillows, H sed bottom					
16:39		Triple Fissure/Crack .5 m wide, lobes and pillows at edge, few m deep,	16:39:40	worm		***	
16:40		Large third fissure, 2 m wide, flat striated rifted pillows at roof, M sed, rubble in pit	16:40:10	SF		***	Fis > Sed
16:41		H sed bottom					
16:42		isolated pillows, tubular and bulbous					
16:43		bulbous pillows					
16:44		Knobby lobes, toothpaste pillows	16:44:40				
16:45		knobby pillows pieces on H sed bottom					
16:46		pillow balls on H sed bottom, knobby flat lobes, flow front of lobes?					
16:47		knobby pillows on H sed bottom					
16:48		Pillows on H sed bottom					
16:49		H sed bottom, knobby pillows, bulbous pillows					
16:50		H sed bottom w/ pillows					

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #8 Photo Descriptions**					
2001_11_28							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
16:51		Pillows on H sed bottom, hackly knobby pieces					
16:52		H sed btoom, elongate pillows					
16:53		bulbous pillows					
16:54		bulbous pillows on H sed bottom		SC			
16:55		trap door in sheet flow, toe lobes come out of lifted "door" flow out onto flow top	16:55:40				
16:56		H sed bottom					
16:57		WOW! 3 m Star structure in sediment? Star fish, H sed bottom	16:57:40	SF			
16:58		knobby pillows in H sed bottom					
16:59		H sed bottom					
17:00		sheet pieces in H sed					
17:01		H sed bottom					
17:02		knobby pillows and lobes, partly bulbous, Fissure crack, <.3 m wide		fish		*	
17:03		Cool sea flower, SC, H sed bottom		plant			
17:04		H sed bottom					
17:05		small collapse in sed, fissure-like, pillow flow on edges				*	
17:06		H sed bottom no pieces					
17:07		H sed bottom, cracks, holes in sheet flow, hollow area?	17:07:55				
17:08		cracks and holes continue in crust top in sediment					
17:09		H sed bottom, knobby pillows, bulbous pillows					
17:10		H sed bottom, few pillows					
17:11		H sed bottom		SC			
17:12		H sed bottom					
17:13		Flat piece of sheet flow in sed bottom					
17:14		H sed bottom					
17:15		H sed bottom					
17:16		H sed bottom					
17:17		H sed bottom					
17:18		H sed bottom, few pillow and lobes, partly knobby					
17:19		H sed bottom, isolated pillows, Elongate partly knobby pillows, little ball buds	17:19:55				
17:20		H sed bottom w/ few knobby pillows		ALF			
17:21		pillows, elongate and bulbous, knobby					
17:22		pillow and lobe piles					
17:23		pillow pile,partly tubular					
17:24		pillow pile (small bulbous balls) on edge of Fissure (deep, < . 5 m wide), pillow increase at crac	17:24:25			*	
17:25		Elongate striated pillow, bulbous pillows, knobby and budded pillows,	17:25:40			*	
17:26		Bulbous pillows on edge of deep fissure/crack, 2 m deep, pillows/rubble at bottom,	17:26:40	SA		***	
17:27		6 m wide fissure, isolated pillow slab 2m wide in pit, Extra wide and deep pit!!!	17:27:25			***	
17:28		Off bottom					

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #9 Photo Descriptions**					
2001_11_29							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
8:56		At Bottom, hackly pieces and larger lobe pieces on flat H sed bottom, 50-60% coverage			H		
8:57	Lobates - Pillows	knobby lobes, ball lobes, elongated bulbous budded lobes, tube pillow on H sed bottom, 90% coverage			H		
8:58	Lobates - Pillows	knobby lobes, ball lobes, flat broad lobes, minor tube pillow on H sed bottom, 95-100% coverage			H		
8:59	Lobates - Pillows	knobby lobes, ball lobes, flat broad lobes, minor tube pillow on H sed bottom, 95-100% coverage			H		
9:00	Lobates - Pillows	knobby lobes, ball lobes, flat broad lobes, minor tube pillow on H sed bottom, 95-100% coverage			H		
9:01	Lobates - Pillows	knobby lobes, ball lobes, irregular thin lobes, minor tube pillow on H sed bottom, 95-100% coverage			H		
9:02	Lobates - Pillows	knobby lobes, ball lobes, irregular thin lobes, minor tube pillow on H sed bottom, 95-100% coverage			H		
9:03	Lobates - Pillows	knobby lobes, ball lobes, bulbous lobes on H sed bottom, 95-100% coverage			H		
9:04	Lobates - Pillows	knobby lobes, ball lobes, bulbous budded pillows on H sed bottom, 90-100% coverage			H		
9:05	Lobates - Pillows	knobby lobes, ball lobes, bulbous budded pillows on H sed bottom, 90-100% coverage			H		
9:06	Lobates - Pillows	knobby lobes, flat irregular lobes, bulbous budded pillows on H sed bottom, 90-100% coverage			H		
9:07	Lobates - Pillows	knobby lobes, bulbous budded pillows on H sed bottom, 90-100% coverage			H		
9:08	Lobates - Pillows	knobby lobes, ball lobes, short tube pillows on H sed bottom, 90-100% coverage			H		
9:09	Lobates - Pillows	knobby lobes, ball lobes, flat broad lobes on H sed bottom			H		
9:10	Lobates - Pillows	knobby lobes, flat irregular broad lobes					
9:11	Lobates - Pillows	knobby lobes, ball lobes, irregular flat lobes, elongated tube lobes					
9:12	Lobates - Pillows	knobby lobes, ball lobes, tube lobes					
9:13	Lobates - Pillows	knobby lobes, budded ball lobes, irregular flat lobes, bulbous pillows					
9:14	Lobates - Pillows	knobby lobes, budded ball lobes, budded irregular flat lobes, bulbous pillows, 50-70% coverage					
9:15	Lobates - Pillows	knobby lobes, budded ball lobes, budded irregular flat lobes, bulbous pillows, 60-80% coverage					
9:16	Lobates - Pillows	knobby lobes, budded irregular flat broad lobes					
9:17	Lobates - Pillows	knobby lobes, budded irregular flat broad lobes, drizzly lobes, 2x2m CF					
9:18	Lobates - Pillows	knobby lobes, irregular flat broad lobes, elongated tube lobes					
9:19	Lobates - Pillows	knobby lobes, irregular flat broad lobes					
9:20	Sheet	Trans to flat smooth sheet with occasional 1m long cracks with H sed			H		LP>S
9:21	Sheet	minor c.f.s. on smooth flat bottom then Trans to irregular elongated lobes with M sed			M		S>L
9:22	Lobates	knobby lobes, elongated flat lobes with M-H sed, 80% coverage			M,H		
9:23	Lobates	knobby lobes, flat broad lobes,elongated flat lobes, 1.5x2m CF on flat broad lobe				*	
9:24	Lobates	knobby lobes, bulbous lobes					
9:25	Lobates	knobby lobes, drizzly lobes, ball lobes,1.5x2m CF in flat bottom with 1x0.5m lobe piece in it.	9:25:11			*	
9:26	Lobates	knobby lobes, flat broad irregular obes, ball lobes,1.5x1.5m CF in flat lobe				*	
9:27	Lobates	knobby lobes, drizzly lobes, ball lobes, flat broad lobes					
9:28	Lobates	knobby lobes, flat broad lobes, bulbous tube lobes		SC			
9:29	Lobates	flat irregular lobes, knobby lobes with M sed			M		
9:30	Lobates	flat irregular lobes, knobby lobes with M sed			M		
9:31	Lobates	flat irregular lobes with rough surface with 0.5x2 CF.				*	
9:32	Lobates	flat irregular lobes, knobby lobes with M sed		fish	M		
9:33	Lobates	flat irregular lobes, knobby lobes with M sed			M		
9:34	Lobates	flat broad lobes, knobby lobes, 2x2m CF in flat broad lobe, irregular lobes, M-sed				*	
9:35	Lobates	flat broad lobes, knobby lobes, 5.5x5?m CF, M-sed, irregular lobes				*	
9:36	Lobates	flat broad lobes, knobby lobes, M-sed, irregular small lobes			M		
9:37	Lobates	small knobby irregular lobes					
9:38	Lobates	small knobby irregular lobes, drizzly lobes, M sed			M		
9:39	Lobates	small knobby irregular lobes, flat irregular lobes, M sed			M		
9:40	Lobates	knobby irregular lobes, inflated and cracked ball lobes			M		
9:41	Lobates	flat irregular lobes, cracked flat broad lobes, M sed			M		

Legend

For TRANSitions
H = Hackly
S = Smooth
C = Curtain
L = Lobate
J = Jumbly
N = Lineated
> = transitions to
e.g. N>L
lineated transitions to lobate

For SEDiiment cover
L = low
M = medium
H = high

For COLlapse Feature
* = collapse feature present
** = good view
*** = interesting one

For BIOlogy
ALF = alien life form
BS = brittle stars
SC = sea crabby
SF = star fish
SA = sea anenome

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #9 Photo Descriptions**					
2001_11_29							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
9:42	Lobates	knobby lobes, flat irregular lobes, flat broad lobes, flat broad lobe bridge bet. 2 CFs				*	
9:43	Lobates	knobby lobes, flat irregular surface lobes, 3x3m CF				*	
9:44	Lobates	flat broad lobes, irregular lobes, M sed			M		
9:45	Lobates	flat irregular lobes, elongated flat lobes, 1.5x2m CF				*	
9:46	Lobates	cracked flat broad lobes, large CF, CF bottom is rubbles and c.f.s. with H sed					
9:47	Collapse Feature	lobe bridge bet. 2 CFs, flat broad lobe	9:47:26			*	
9:48	Lobates	flat ball lobes, irregular flat lobes, 2 1x1m CFs.				*	
9:49	Lobates	flat ball lobes, irregular flat lobes, 3 0.5x1m CFs., cracked lobe				*	
9:50	Lobates	flat broad lobes, small irregular flat lobes, a few <1x2m CFs				*	
9:51	Lobates	small flat lobes, knobby lobes, edge of CF				*	
9:52	Collapse Feature	Edge of CF with rubbles, lobe bridge bet. 2 CFs.				*	
9:53	Collapse Feature	Edge of CF with rubbles, lobe bridge bet. 2 CFs., c.f.s. on flat H sed in CF bottom			H	*	
9:54	Collapse Feature	CF bottom: rubbles, bolbous elongated pillow, ball lobe, elongated budded lobe, lobe crust				*	
9:55	Lobates	Back to surface layer: flat irregular-shaped lobes with <1x1m CFs				*	
9:56	Lobates	Back to surface layer: flat irregular-shaped lobes with <1x1m CFs		fish		*	
9:57	Lobates	Back to surface layer: flat irregular-shaped lobes, edge of large CF,				*	
		CF bottom: rubbles and c.f.s. on H sed flat bottom		fish	H		
9:58	Curtain	CF bottom: c.f.s. on H sed flat bottom to partly hackly			H		
9:59	Curtain	c.f.s. on h sed flat bottom and hackly to lobe crust, lobate bridge bet. 2 CFs with rubbles				*	
10:00	Hackly	Hackly with c.f.s. pieces to c.f.s. on H sed flat bottom to H sed flat bottom			H		
10:01	Hackly	H sed flat bottom to hackly with c.f.s. pieces, 4m wide flat area, then c.f.s.			H		
10:02	Hackly	Hackly with c.f.s. pieces					
10:03	Hackly	Trans from hackly with c.f.s. pieces to budded ball lobes	10:03:41				H>L
10:04	Lobates	elongated bulbous lobes, ball lobes, drizzly lobes, flat irregular lobes, knobby lobes					
10:05	Lobates	flat broad lobes, knobby lobes, M sed					
10:06	Lobates	flat irregular knobby lobes					
10:07	Lobates	flat irregular knobby lobes, knobby lobes,					
10:08	Lobates	knobby lobes, small irregular knobby lobes					
10:09	Lobates	bread-crust lobes, knobby lobes, bolbous elongated pillows, L sed			L		
10:10	Lobates	Field of bread-crust lobes, knobby lobes, bolbous pillows, L sed			L		
10:11	Lobates	Field of bread-crust lobes, knobby lobes, bolbous pillows, L sed			L		
10:12	Lobates	Field of bread-crust lobes, knobby lobes, irregular small flat lobes					
10:13	Lobates	Field of bread-crust lobes, knobby lobes, irregular small flat lobes					
10:14	Lobates	ball lobes, knobby lobes, irregular small flat lobes					
10:15	Lobates	knobby lobes, irregular small flat lobes, irregular flat broad lobes, tube lobes					
10:16	Lobates	knobby lobes, irregular small flat lobes					
10:17	Lobates	knobby lobes, irregular flat broad lobes, L sed			L		
10:18	Lobates	knobby lobes, irregular flat broad lobes, L sed			L		
10:19	Lobates	elongated flat lobes, knobby lobes, irregular flat lobes					
10:20	Lobates	flat irregular lobes with cracked surface, knobby lobes					
10:21	Lobates	flat irregular lobes , knobby lobes					
10:22	Lobates	flat irregular lobes , knobby lobes					
10:23	Lobates	elongated flat lobes, knobby lobes					
10:24	Lobates	irregular flat lobes, knobby lobes					
10:25	Lobates	irregular flat lobes, knobby lobes, small flat broad lobes					

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #9 Photo Descriptions**					
2001_11_29							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
10:26	Lobates	irregular flat lobes, knobby lobes, small flat broad lobes					
10:27	Lobates	irregular flat lobes, knobby lobes					
10:28	Lobates	irregular flat lobes, knobby lobes					
10:29	Lobates	irregular flat lobes, knobby lobes, elongated flat lobes					
10:30	Lobates	irregular flat lobes, knobby lobes, elongated flat lobes, 0.5x0.5m CF				*	
10:31	Lobates	irregular flat lobes, knobby lobes, elongated flat lobes					
10:32	Lobates	irregular flat lobes, knobby lobes, elongated flat lobes, flat broad lobe with 1x2m CF				*	
10:33	Lobates	irregular flat lobes, knobby lobes, elongated flat lobes					
10:34	Lobates	irregular flat lobes, knobby lobes, elongated flat lobes					
10:35	Lobates	irregular flat lobes, knobby lobes, elongated flat lobes					
10:36	Lobates	irregular flat lobes, knobby lobes, elongated flat lobes, 2.5x4m CF				*	
10:37	Collapse Feature	CF, CF bottom is rubbles, c.f.s. hackly with L sed			L	*	
10:38	Hackly	Hackly, partly c.f.s., CF edge. Lobes and partly c.f.s.				*	
10:39	Lobates	irregular flat lobes, knobby lobes, elongated flat lobes, 0.5x0.5m CF				*	
10:40	Lobates	ball lobes, knobby lobes, irregular small flat lobes, bolbous lobes					
10:41	Lobates	bolbous lobes, knobby lobes, irregular flat small lobes, L sed			L		
10:42	Lobates	flat irregular lobes, knobby lobes, elongated lobes					
10:43	Lobates	flat irregular lobes, knobby lobes, elongated lobes, sed in cracks					
10:44	Lobates	flat irregular lobes, knobby lobes, elongated lobes, sed in cracks					
10:45	Lobates	flat irregular lobes, knobby lobes, elongated lobes, sed in cracks					
10:46	Lobates	flat irregular lobes, knobby lobes, elongated lobes, sed in cracks					
10:47	Lobates	flat irregular lobes, knobby lobes, elongated lobes, sed in cracks, circular wheel	10:47:26				
10:48	Lobates	flat irregular lobes, knobby lobes, elongated lobes, sed in cracks					
10:49	Lobates	flat irregular lobes, knobby lobes, elongated lobes, sed in cracks, more knobby than before					
10:50	Lobates	flat irregular lobes, knobby lobes, elongated lobes, sed in cracks		crab			
10:51	Lobates	knobby lobes, small flat lobes		crab			
10:52	Lobates	flat smooth lobes, nobby lobes, sed in cracks					
10:53	Lobates	glassy flat irregular lobes					
10:54	Lobates	glassy flat irregular lobes, knobby lobes		SS			
10:55	Lobates	flat broad lobes, small CF, c.f.s. texture				*	
10:56	Lobates	small lobes,Trans to hackly					L>H
10:57	Hackly	hackly partly c.f.s. then back to lobate (flow MGN), 2x2m CF				*	H>L
10:58	Lobates	irregular flat lobes, knobby lobes, L sed in cracks			L		
10:59	Lobates	irregular flat lobes, knobby lobes, L sed in cracks, ball lobe			L		
11:00	Lobates	flat broad lobes, knobby lobes,					
11:01	Lobates	elongated irregular lobes, to glassy elongated lobe with H sed in cracks and space bet.			H		
11:02	Lobates	glassy elongated lobe with H sed in cracks and space bet. 80-100% flow coverage			H		
11:03	Lobates	glassy smooth irregular lobes, knobby lobes					
11:04	Lobates	glassy smooth flat lobes with 2x5m CF, CF bottom:c.f.s.				*	
		OFF Bottom 11:14				*	

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #10 Photo Descriptions**					
2001_11_29							
Time	**Major Morphology**		**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
15:30		At Bottom,			L		
15:31	Lobates	lobates, intermingled, edges meet, L sed in cracks, 100% coverage					
15:32	Lobates	Lobates, broad, minor curtain folds, rifted crusts, 100% coverage					
15:33	Lobates	Lobates, broad, w/small interstitial lobes between big ones, L sed cover on top			L		
15:34	Lobates	Lobates, broad, w/small interstitial lobes between big ones, L sed cover on top			L		
15:35	Lobates	Lobates, broad with trace of coiled ropy foled feature, w/small interstitial lobes bet. big ones					
15:36	Lobates	knobby lobes with small elongated lobes					
15:37	Lobates	knobby lobes with small elongated lobes					
15:38	Lobates	knobby lobes with small elongated lobes, cracked flat broad lobes					
15:39	Lobates	knobby ball lobes					
15:40	Lobates	knobby ball lobes and cracked flat broad lobes					
15:41	Lobates	knobby ball lobes and cracked flat broad lobes					
15:42	Lobates	knobbly slightly elongated lobes					
15:43	Lobates	knobby lobes					
15:44	Lobates	knobby lobes and cracked tube lobates					
15:45	Lobates	cracked tube lobates with knobby lobes					
15:46	Lobates	ball lobes, knobby lobes					
15:47	Lobates	flat broad lobes with knobby lobes					
15:48	Lobates	flat broad lobes with knobby lobes					
15:49	Lobates	very flat broad lobes , L sed cover on top			L		
15:50	Lobates	very flat broad lobes and partly elongated flat lobes, L sed cover on top			L		
15:51	Lobates	flat broad lobes and partly elongated flat lobes, knobby lobes, L sed cover on top			L		
15:52	Lobates	knobby lobes and cracked tube lobates					
15:53	Lobates	knobby lobes and cracked tube lobates					
15:54	Lobates	flat broad lobes and c.f.s., shallow 1x2m collapse (bottom c.f.s.) in lobate	15:54:25			*	
15:55	Hackly	Trans to hackly	15:55:10				L>H
15:56	Hackly	Hackly with a few pieces of c.f.s.					
15:57	Hackly	hackly with a few pieces of c.f.s., c.f.s. on the smooth M sed surface briefly			M		
15:58	Hackly	Hackly with a few pieces of c.f.s.					
15:59	Hackly	Hackly with a few pieces of c.f.s.					
16:00	Hackly	Hackly with a few pieces of c.f.s.					
16:01	Hackly	Hackly with a few pieces of c.f.s.					
16:02	Hackly	Hackly with a few pieces of c.f.s.					
16:03	Hackly	Hackly with a few pieces of c.f.s.					
16:04	Hackly	Hackly with a few pieces of c.f.s., c.f.s. on the smooth L sed surface briefly			L		
16:05	Hackly	Hackly with a few pieces of c.f.s., c.f.s. on the smooth L sed surface briefly			L		
16:06	Hackly	Hackly with a few pieces of c.f.s.					
16:07	Hackly	Hackly with a few pieces of c.f.s.					
16:08	Hackly	Hackly with a few pieces of c.f.s.					
16:09	Hackly	Hackly with a few pieces of c.f.s.					
16:10	Hackly	Hackly with a few pieces of c.f.s.					
16:11	Hackly	Hackly with a few pieces of c.f.s.					
16:12	Hackly	Hackly with a few pieces of c.f.s., CF, bottom of CF is c.f.s. with L-M sed			L,M	*	
16:13	Curtain	c.f.s.					H>C
16:14	Curtain	c.f.s. and back to the surface layer from the bottom of CF that is flat broad lobes				*	C>L
16:15	Lobates	small flat lobes with knobby and narrow lobes, L sed			L		

Legend

For TRANSitions
H = Hackly
S = Smooth
C = Curtain
L = Lobate
J = Jumbly
N = Lineated
> = transitions to
e.g. N>L
lineated transitions to lobate

For SEDiiment cover
L = low
M = medium
H = high

For COLlapse Feature
* = collapse feature present
** = good view
*** = interesting one

For BIOlogy
ALF = alien life form
BS = brittle stars
SC = sea crabby
SF = star fish
SA = sea anenome

Other Abbreviation
c.f.s.=curtain folded sheet
CF=collapse feature

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #10 Photo Descriptions**					
2001_11_29							
Time	**Major Morphology**		**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
16:16	Lobates	small flat lobes with knobby and narrow lobes, L sed			L		
16:17	Lobates	small flat lobes with c.f. features on the surface and narrow lobes, L sed			L	*	
16:18	Lobates	small flat lobes with c.f. features on the surface, knobby lobes, L sed			L	*	
16:19	Lobates	small flat lobes, ball lobes, knobby lobes					
16:20	Lobates	flat lobes with c.f. features on the surface(one collapsed one), flat elongated lobes,				*	
16:21	Lobates	knobby lobes, elongated thin bolbous lobes					
16:22	Lobates	knobby lobes, elongated thin bolbous lobes					
16:23	Lobates	small flat lobes, ball lobes, knobby lobes					
16:24	Lineated	CF edge, crust of smooth lineated sheet downdropped few cm, L sed	16:24:25, 55		L	*	
16:25	Lineated	Glassy lobates, trans to lineated-smooth M,H sed cov sheet flow			M,H		L>S
16:26	Lineated	smooth-lineated M,H, sed cover sheet flow trans back to lobates, Flow Margin (26:40)	16:26:40		M,H		SN>L
16:27	Lobates	Glassy lobates very little void space, edges conjoin, M sed cover in cracks			M		
16:28	Lobates	Glassy lobates, trans to lineated-smooth M,H sed cov sheet flow, collapsed Flow Margin			M,H	*	
16:29	Lineated	Lineated-smooth M,H sed cov sheet flow >lobes>smooth sed sheet collapsed Flow Margin			M,H	*	N>L>S
16:30	Lineated	Lineated-straight folds sheet flow, M sed, Flow Margin with Ropey flow,	16:30:40		M		N>R
		broad wavelength folds in curtain sheet flow,	16:30:55				
16:31	Curtain	curtain > smooth bumpy M sed flow > lobates, lobates over lineated s.f.?	16:31:40		M		C>S>L
16:32	Lobates	Lobates, broad, conjoining edges, L sed in cracks			L		
16:33	Lobates	C.F. in broad lobe, ropey rind, <1m deep				*	
16:34	Lobates	small C.F. in lobates, intermingled, broad lobes				*	
16:35	Lobates	Lobates, broad, conjoining edges, L sed in cracks			L		
16:36	Lobates	Lobates, broad, conjoining edges, L sed in cracks			L		
16:37	Lobates	Lobates, broad, conjoining edges, L sed in cracks			L		
16:38	Curtain	area of curtain folds amidst lobes, L sed cover, trans to curtain part hackly flow			L		L>CH
16:39	Curtain	Flow Margin between curtain fold and smooth ropey sheet flow, M sed cover	16:39:40, 55		M		
16:40	Curtain	smooth ropey flow, low sed cover, broad curtains,		crab			
16:41	Curtain	smooth ropey flow, low sed cover, broad curtains,					
16:42	Curtain	smooth ropey flow, low sed cover, broad curtains, SWIRL structures, > Hackly	16:42:25				
16:43	Hackly	Hackly Lava					
16:44	Curtain	Trans to broad curtain flow to tight curtain folds, (Missing 44:10)					H>C
16:45	Curtain	Curtain flow, tight and broad curtains, part hackly, ropey whirl texture to flow					
16:46	Hackly	Hackly curtain flow					
16:47	Hackly	Hacly curtain > lineated flow, part smooth, M sed cover > lobes			M		HC>N
16:48	Lobates	Lobates, broad, conjoining edges, L sed in cracks, small C.F.			L		
16:49	Curtain	curtain-ropey flow, M sed in grooves, tans to lobates, curtain and hackly					
16:50	Curtain	broad curtain fold flow, M sed in grooves, trans to smooth flow and lobes					
16:51	Lobates	Lobes, M sed in cracks (missing 51:25), >smooth s.f.					N>L>NS
16:52	Lineated	Lineated sheet flow, lobate island between 2nd lineated-smooth flow					
16:53	Lobates	Lobates, broad, conjoining edges, L sed in cracks					
16:54	Lobates	Lobates, broad, conjoining edges, L sed in cracks, small C.F.				*	
16:55	Lobates	skylight in lobe, eye-glasses window in lobe flow, H sed bottom below,	16:55:25		H		
16:56	Lobates	Broad flat conjoining lobes					
16:57	Lobates	Broad flat conjoining lobes, C.F. 5x6m,					
16:58	Lobates	Lobes, C.F., trans to hackly curtain flow				*	L>H
16:59	Hackly	Hackly curtain flow					

Photo Prefix - Date		Atlantis 7-4 Camera Tow #10 Photo Descriptions					
2001_11_29							
Time	**Major Morphology**		**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
17:00	Hackly	Hackly curtain flow					
17:01	Hackly	Hackly curtain flow					
17:02	Hackly	Hackly curtain flow					
17:03	Curtain	Curtain Hackly flow					
17:04	Curtain	Curtain flow > lineated-fold flow, M, H sed cover in grooves,					
17:05	Sheet	sheet flow > collapsed edge of flow margin w/lobates, C.F. rubbly bottom,				*	S>L
17:06	Hackly	Hackly bottom, several small, low relief collapse features, in lobes/curtains,				*	
17:07	Lobates	C.F. in lobates, smooth-part lineated bottom w M sed, Lobates have very L sed				*	
17:08	Lobates	Collapse features in lobates		SA		*	
17:09	Lobates	Collapse features in lobates, curtain folded bottom, M sed cover,				*	
17:10	Lobates	Broad lobates, M sed cover on tops, small collapses		SA		*	
17:11	Lobates	C.F. in lobates, very L sed			L	*	
17:12	Lobates	Lobates, small hackly collapse, (Missing 12:25) broad lobes				*	
17:13	Lobates	broad lobes, skylight collapse 5x3 m, M sed cover on broad lobes,			L,M	*	
17:14	Lobates	Broad lobes w L,M sed cover			L,M		
17:15	Lobates	Broad lobes w L,M sed cover			L,M		
17:16	Lobates	Broad lobes w L,M sed cover, small collapse features			L,M	*	
17:17	Lobates	Broad lobes w L,M sed cover, small collapse features				*	
17:18	Lobates	C.F. takes up entire frame,smooth ropey bottom, Lobe crust,				*	
17:19	Hackly	hackly lava among lobes, small C.F. in flat lobes				*	
17:20	Lobates	Lobes w/ collapse features				*	
17:21	Lobates	snaky C.F. in lobate crust, rubbly bottom, glassy lobate crust island,				*	
17:22	Lobates	Alvin Weights!!, on lobate crust, L sed, Bright White material in cracks (bio?)	17:22:25				
17:23	Collapse	Alligator Collapse Pit, crenulated sedimented lobes in deep C.F., lobate roof	17:23:10			***	
	Collapse	multiple C.F. Lobe crust, with sedimented crenulated lobe bottom w/ small C.F in lobe	17:23:40			*	
17:24	Lobates	Broad lobates, L sed cover on tops, small collapses			L	*	
17:25	Lobates	Glassy lobates, broad, Deep C.F . WALL IN VIEW!, ~2-3 m deep,	17:25:55				
17:26	Lobates	C.F., sedimented crenulated curtain bottom, broken crust edges on wall, glassy lobeates	17:26:10				
17:27	Lobates	Glassy lobates, small collapses				*	
17:28	ASCT	ASCT!!, Collapse in lobates, lower shelf roof in tact, glassy lobe, deep bottom ~3m	17:28:10, 25				
17:29	ASCT	scaley texture on bulbous folded fow at bottom, curtain folds, small C.F.	17:29:40,			*	
17:30	Hackly	Rubbly hackly lava,					
17:31	Curtain	curtain-folded, ropey flwo, M sed on top, scaly texture,			M		
17:32	ASCT	Wall of ASCT, glassy lobate crust,	17:32:25				
17:33	Lobates	scaley texture in lobate rim of ASCT, pillars visible, H sed cover over, scaley sheet flow	17:33:10				
17:34	Sheet	scaley texture sheet flow, H sed cover, glassy sheen in flash > curtain folded,	17:34:25, 40		H		S>C
17:35	Curtain	Curtain folded flow, glassy, Very low sed cover, coil structures,					
17:36	Hackly	Hackly lava, collapse in lobates, multi-level, skylight, bridge C.F.	17:36:40			***	
17:37	Glassy	Glassy lobates, sed in cracks,					
17:38	Lobates	Lobates, L sed cover			L		
17:39	Lobates	Broad lobates w/conjoined edges,					
17:40	Lobates	Broad lobates w/conjoined edges, small C.F.				*	
17:41	Lobates	Broad lobates w/conjoined edges, small C.F.				*	
17:42	Collapse	wide collapse feature in glassy lobates, rubbly bottom					
17:43	Lobates	Collapsed lobates				*	

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #10 Photo Descriptions**					
2001_11_29							
Time	**Major Morphology**		**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
17:44	Lobates	Lobates, M sed cover, broad and flat, OFF BOTTOM			M		
17:45		OFF BOTTOM					

Photo Prefix - Date		Atlantis 7-4 Camera Tow #11 Photo Descriptions					
2001_11_30							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
6:58		On Bottom,					
6:59	Pillows - Lobates	1-2 m long bulbous and budded pillows with irregular lobates on H sed bottom (50% flow coverage)					
7:00	Pillows - Lobates	irregular small lobates on H sed bottom, pillows, down-drop to left					
7:01	Pillows - Lobates	ball and knobby tubular lobes on H sed bottom					
7:02	Pillows - Lobates	ball and knobby tubular lobes field with some short pillorws on H sed bottom, down-drop to left					
7:03	Pillows - Lobates	ball and knobby tubular lobes field with some short pillorws on H sed bottom, down-drop to left					
7:04	Pillows - Lobates	drizzly lobes, flat lobes, and partly bulbous lobes on H sed bottom, down-drop to left					
7:05	Pillows - Lobates	drizzly lobes, tubular budded lobes, and partly bulbous lobes on H sed bottom					
7:06	Pillows - Lobates	tubular budded lobes, and partly bulbous lobes on H sed bottom (60-75% coverage)					
7:07	Pillows - Lobates	tubular budded lobes, and partly bulbous lobes and short tube pillow on H sed bottom	7:07:53				
7:08	Pillows - Lobates	overlapping tubular budded lobes, and partly knobby lobes and short tube pillow on H sed bottom					
7:09	Pillows - Lobates	tubular budded lobes, and partly knobby lobes and short tube pillow on H sed bottom					
7:10	Pillows - Lobates	wormy budded lobes, and partly knobby lobes and short tube pillow on H sed bottom					
7:11	Pillows - Lobates	wormy budded lobes, and partly knobby lobes and short tube pillow on H sed bottom					
7:12	Pillows - Lobates	wormy budded lobes, and partly knobby lobes and short tube pillow on H sed bottom					
7:13	Pillows - Lobates	wormy budded lobes, and more knobby lobes and short tube pillow on H sed bottom					
7:14	Pillows - Lobates	budded lobes, and more knobby lobes and short tube pillow on H sed bottom					
7:15	Pillows - Lobates	budded lobes, and more knobby lobes and pinch and swell pillow, short tube pillow on H sed bottom					
7:16	Pillows - Lobates	budded lobes, and more knobby lobes and trap door pillow, short tube pillow on H sed bottom	7:16:08				
7:17	Pillows - Lobates	budded bubous and knobby lobes, a few pillows on H sed bottom down drop to left					
7:18	Pillows - Lobates	budded bubous and knobby lobes, a few tube pillows on H sed bottom down drop to left					
7:19	Pillows - Lobates	budded bubous lobes, a few elongated tube pillows on H sed bottom					
7:20	Pillows - Lobates	knobby elongated lobes on H sed bottom					
7:21	Pillows - Lobates	knobby elongated lobes, a mirror-image pillow on H sed bottom, down -drop to left					
7:22	Pillows - Lobates	overlapping staircase tubular pillows directed to the NW photo corner, elongated knobby lobe	7:22:08				
	Pillows - Lobates	knobby lobes on H sed					
7:23	Pillows - Lobates	bulbous short pillows and knobby lobes on h sed					
7:24	Pillows - Lobates	ball and bulbous pillow and budded elongated lobes on H sed					
7:25	Pillows - Lobates	ball and bulbous pillow and budded elongated lobes on H sed		SA			
7:26	Pillows - Lobates	ball and bulbous pillow and budded elongated lobes, <10m wide and 2m deep	7:26:38,53				
	Pillows - Lobates	constructional scarp (from the dropping pillow flow), flow front					
7:27	Pillows - Lobates	scarp bottom is ball pillow and knobby lobes and come up 1m					
7:28	Pillows - Lobates	bulbous short pillows and elongated knobby lobes on H sed					
7:29	Pillows - Lobates	elongated budded lobes and irregular small lobes on H sed					
7:30	Pillows - Lobates	elongated budded lobes and irregular small lobes on H sed					
7:31	Pillows - Lobates	elongated budded lobes and irregular small lobes on H sed					
7:32	Pillows - Lobates	elongated budded lobes and irregular small lobes, bulbous pillows on H sed					
7:33	Pillows - Lobates	elongated budded lobes and irregular small lobes, bulbous pillows on H sed					
7:34	Pillows - Lobates	elongated budded lobes and irregular small lobes, cracked bulbous pillows on H sed	7:34:38				
7:35	Pillows - Lobates	bulbous lobe, knobby lobes, toothpaste pillow, H sed bottom					
7:36	Pillows - Lobates	bulbous pillows and lobe, knobby, striated surfaces, H sed bottom, drizzly balls					
7:37	Pillows - Lobates	drizzly lobes, H sed, giant pillow	7:37:53				
7:38	Pillows - Lobates	butterflied tube pillow, drizzly budded lobes, short stubby tube pillows					
7:39	Pillows - Lobates	narrow lobes lead to pillow field, rifted and toothpaste, slightly elogate, 1 m wide					
7:40	Pillows - Lobates	tube lobes and inlfated lobe w/ several holes in crust that show hollow, tube pllows	7:40:08			*	
7:41	Pillows - Lobates	drizzly knobby lobes, few pillows, lobes are spaced apart,					

Legend

For TRANSitions
H = Hackly
S = Smooth
C = Curtain
L = Lobate
J = Jumbly
N = Lineated
R = Ropey
> = transitions to
e.g. N>L
lineated transitions to lobate

For SEDiiment cover
L = low
M = medium
H = high

For COLlapse Feature
* = collapse feature present
** = good view
*** = interesting one

For BIOlogy
ALF = alien life form
BS = brittle stars
SC = sea crabby
SF = star fish
SA = sea anenome

Photo Prefix - Date		Atlantis 7-4 Camera Tow #11 Photo Descriptions					
2001_11_30							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
7:42	Pillows - Lobates	rifted and cracked lobes, wormy tube lobes, knobby and budded					
7:43	Pillows - Lobates	elongate knobby budded lobe and some pillows, overlapping, down drop to left	7:43:53				
7:44	Pillows - Lobates	HUGE SA, overlapping knobby lobes, down drop to NW photo corner ~1.5 m, pillows	7:44:08	SA			
7:45	Pillows - Lobates	lobes, irregular toe edges, elongate, tiny ball-like lobes, H sed on bottom and cracks					
7:46	Pillows - Lobates	budded bulbous pillows, nice rifted pillow,					
7:47	Pillows - Lobates	knobby lobes, spaced but overlapping in areas.					
7:48	Pillows - Lobates	knobby lobes, tube pillows with bulbous ends striated,					
7:49	Pillows - Lobates	H sed bottom, knobby lobes and stubby tube pillows					
7:50	Pillows - Lobates	elongate budded lobes		SA			
7:51	Pillows - Lobates	H sed bottom, overlapping sheet lobe flows with stubby tube pillows and lobes on surface					
7:52	Pillows - Lobates	elongate budded lobe pile, H sed,	7:52:53				
7:53	Pillows - Lobates	tube pillows, elongate, knobby lobes, piled up H sed bottom, down drop to left photo	7:53:53				
7:54	Pillows - Lobates	narrow lobes, overlapping and piled up, tube pillows, spaced features, H sed bottom					
7:55	Pillows - Lobates	toothpaste pillow, m wide, overlapping constructional flow? Flow to left photo edge?	7:55:08, 23				
7:56	Pillows - Lobates	knobby lobate flow w/small buds, short tube pillow, old flow down to photo left					
7:57	Pillows - Lobates	knobby, lobes, elongate stubby pillow, toothpaste pillow,					
7:58	Pillows - Lobates	elongate tube lobes and pillows, knobby, down drop to NW					
7:59	Pillows - Lobates	hollow pillows, piled and staircased tubes of lava to flowing to NW edge	7:59:08				
8:00	Pillows - Lobates	knobby lobes, flow to NW, piled and staircased tubes, flow to NW photo edge					
8:01	Pillows - Lobates	bulbous pillow, knobby lobes, H sed bottom					
8:02	Fissure	bulbous lobes, FISSURE/CRACK <1m wide, very deep, elongate wormy pillow tubes	8:02:23, 37			***	
	Pillows - Lobates	flow away from fissure axis?				**	
8:03	Pillows - Lobates	knobby lobes and stubby pillows, minor crack in crust, structures overlap and pile up					
8:04	Pillows - Lobates	budded lobe tubes, H sed bottom, partl bulbous					
8:05	Pillows - Lobates	highly knobby lobes, crack? Bulbous lobes, H sed bottom, stubby pillows,					
8:06	Pillows - Lobates	elongate knobby lobes, sort of sheet like in areas, flow to left,		SC			
8:07	Pillows - Lobates	piled up pinch and swell and elongate knobby pillows and lobes, H sed bottom					
8:08	Pillows - Lobates	twinned bulbous pillow, still going down flow slope					
8:09	Pillows - Lobates	knobby lobes, elongate tube lobes/pillows, flow to NW photo crnr,					
8:10	Pillows - Lobates	knobby lobes, elongate tube lobes/pillows, flow to NW photo crnr,					
8:11	Pillows - Lobates	bulbous lobes and pillows on H sed bottom, knobs and buds					
8:12	Pillows - Lobates	bulbous lobes and pillows on H sed bottom, knobs and buds, H sed bottom					
8:13	Pillows - Lobates	features more spaced, flat H sed area		SU			
8:14	Pillows - Lobates	low relief narrow tube lobes and pillows on flat H sed surface					
8:15	Pillows - Lobates	bulbous pillows and knobby lobes, pillows inflated higher than lobes					
8:16	Pillows - Lobates	drizzly lobes, narrow, <j50% coverage, stubby pillow tubes		SC			
8:17	Pillows - Lobates	spaced pillows and cracked bulbous lobes, H sed flat spaces, Star fish in ring structure		BS ring			
8:18	Pillows - Lobates	broad flat turtle shell lobes, H sed bottom, minor pillows					
8:19	Pillows - Lobates	broad flat turtle shell lobes, H sed bottom, minor pillows					
8:20	Pillows - Lobates	elongate pinch and swell pillow, hole in knobby lobe,		SC			
8:21	Pillows - Lobates	knobby lobes, H sed bottom,					
8:22	Pillows - Lobates	knobby lobes, H sed bottom, stubby pillows					
8:23	Pillows - Lobates	knobby lobes, ball lobes, elongated budded pillows transt to striated	8:23:53				
8:24	Pillows - Lobates	bulbous lobes, spaced features, knobby lobes, H sed bottom					
8:25	Pillows - Lobates	spaced knobby lobes, H sed bottom, toothpaste pillow					

Photo Prefix - Date		Atlantis 7-4 Camera Tow #11 Photo Descriptions					
2001_11_30							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
8:26	Pillows - Lobates	H sed bottom w/ knobby flat lobe, bulbous pillows,					
8:27	Pillows - Lobates	tube lobes and pillows staircased, flow direction to NW photo corner,					
8:28	Pillows - Lobates	spaced knobby lobes, H sed bottom,		SA			
8:29	Pillows - Lobates	irregular knobby lobes, drainpipe tube pillow, H sed bottom					
8:30	Pillows - Lobates	nice pillow, elongate knobby lobes					
8:31	Pillows - Lobates	elongated knobby lobes, ball lobes on H sed bottom					
8:32	Pillows - Lobates	elongated knobby lobes, ball lobes, a bulbous pillow on H sed bottom					
8:33	Pillows - Lobates	knobby lobes, elongated bulbous lobes, ball lobes, bulbous pillow on H sed bottom					
8:34	Pillows - Lobates	knobby lobes, elongated bulbous lobes, ball lobes, bulbous pillow on H sed bottom					
8:35	Pillows - Lobates	knobby lobes, ball lobes fill H sed bottom					
8:36	Pillows - Lobates	knobby lobes, ball lobes fill H sed bottom					
8:37	Pillows - Lobates	overlaying flat knobby and irregular lobes with M sed					
8:38	Pillows - Lobates	flat broad lobes with knobby lobes					
8:39	Pillows - Lobates	irregular knobby flat lobes, elongated lobes, 1x2m shallow collapse in broad flat lobes				*	
8:40	Pillows - Lobates	flat broad lobes with knobby lobes					
8:41	Pillows - Lobates	knobby lobes and flat broad lobes					
8:42	Pillows - Lobates	knobby lobes					
8:43	Pillows - Lobates	irregular flat lobes with knobby lobes covered with M sed					
8:44	Pillows - Lobates	knobby lobes, elongated tube lobes, ball lobes					
8:45	Pillows - Lobates	intermingled tubular lobes and pillows, trap door pillow, high coverage 90 %					
8:46	Pillows - Lobates	intermingled tubular lobes and pillows, high coverage 90 %					
8:47	Pillows - Lobates	intermingled lobes, pinch and swell pillow, high coverage, sed in cracks, knobby interspaced lobes			L		
8:48	Pillows - Lobates	intermingled inflated turtle shell lobes, knobs and buds, coverage 75%					
8:49	Pillows - Lobates	intermingled, part drizzly lobes, trap door pillow (49:38),	8:49:38				
8:50	Pillows - Lobates	pipline of knobby tubularlobes side by side, high coverage level, L sed in cracks					
8:51	Pillows - Lobates	bulbous ball pillows conjoined in rows, intermingled w/ knobby drizzly lobes					
8:52	Pillows - Lobates	tube and pillow field, sed in cracks, High Coverage%,					
8:53	Pillows - Lobates	tube and pillow field, knobby interstitial lobes sed in cracks, High Coverage 100 %,					
8:54	Pillows - Lobates	tube and pillow field, knobby interstitial lobes sed in cracks, High Coverage 100 %,					
8:55	Pillows - Lobates	knobby lobes, few pillows,ball lobes interstitial between tubes lobes					
8:56	Pillows - Lobates	ball like knobby lobes, small cylindar pillows from lobes					
8:57	Pillows - Lobates	ball like knobby lobes, small cylindar pillows from lobes					
8:58	Pillows - Lobates	ball like knobby lobes, small cylindar pillows from lobes, piled, some elongated tubes, 100%					
8:59	Hackly	TRANS form lobes and pillows to hackly curtain fold	8:59:38				LP>CH
9:00	Hackly	Hackly curtain flow, w/ some pillows, edge of smooth curtain flow visible					
9:01	Hackly	Hackly curtain flow					
9:02	Hackly	Hackly curtain flow, collapse feature? Or pile, ropey bottom on photo right					
9:03	Hackly	Hackly curtain flow, collapse feature to photo left				*	
9:04	Hackly	Hackly curtain flow, collapse feature edge				*	
9:05	Hackly	Hackly					
9:06	Hackly	Hackly and minor area of c.f.s, part smoothed					
9:07	Hackly	Hackly lava, part trans to smooth sed c.f.s					
9:08	Collapse Feature	Collapse feature in c.f.s 2x2m, channel collapse 1.5 m wide, ropey lava around CF				*	
9:09	Hackly	Hackly > to folded sheet >Hackly > folded smooth curtain flow, H sed cover					H>F
9:10	Hackly	H sed lobates, Hackly pieces, H sed bottom					

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #11 Photo Descriptions**					
2001_11_30							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
9:11	Lobates	Broad Lobates, budded, low relief, covered by sed, Hackly lava pieces on sed.					
9:12	Lobates	Hackly sed covered bottom with elongate lobates, Bread crust cracks,					
	Fissure	Huge deep Fissure/Crack, ~2 m wide, very deep ~3 m? lobate edge w. H sed cover				*	
9:13		End of Photos					
9:14							
9:15		Off Bottom					

Photo Prefix - Date		Atlantis 7-4 Camera Tow #12 Photo Descriptions					
2001_11_30							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
16:45		On bottom: COLOR PHOTOS, 3 "drill cores" attached					
16:46	Lobates	Broad Lobes, M sed cover			M		
16:47	Lobates	pinch and swell lobes, smooth flat tops, intermingling					
16:48	Lobates	Lobates, broad and flat, M sed,			M		
16:49	Lobates	drizzly knobby lobes					
16:50	Lobates	small collapse in lobe edge, flat and knobby lobes					
16:51	Lobates	CORES HIT BOTTOM, L sed flat lobes	16:51:26		L		
16:52	Lobates	tubular lobes, partly knobby					
16:53	Lobates	broad lobes, curtain folds, irregular toe edges					
16:54	Lobates	broad, elongate, flat lobes,					
16:55	Lobates	2 CORES HIT BOTTOM, M sed bulbous lobes	16:55:41		M		
16:56	Lobates	flat top lobes, partly bulbous, elongate narrow toes from edges,					
16:57	Lobates	elongate tubular lobes, pillowey in part		ALF			
16:58	Lobates	tubular lobes, partly knobby, CORES HIT on flat lobates					
16:59	Lobates	Collapse feature 3 m long, in broad sheet Lobes, rubbly bottom	16:59:56			*	
17:00	Lobates	broad flat lobes, pratly tubular		ALF			
17:01	Lobates	Lobates, broad and flat, M sed, collapse feature 3m long			M	*	
17:02	Collapse Feature	Collapse feature, lobate roof, rubbly bottom, 3m wide,very long				*	
17:03	Collapse Feature	Edge of collapse, flat conjoining lobes, collapse continues!!		ALF		*	
17:04	Collapse Feature	Bridge collapse, skylight on left, large collapse on right, lobate crust,curtain folds-bottom	17:04:41	SA		*	
17:05	Curtain - Sheet	looking at collapse bottom, smooth curtain sheet flow, crack in sheet, .4 m fissure	ENTIRE MIN.			*	L>C>S>N
17:06	Lineated	cross cutting lineation direction, smooth channels also, Kink folded tube in Lava	17:06:11, 41				
17:07	Lineated	Smooth lineated sheet flow = collapse bottom, edge of CF thin crust, partly hollow	17:07:41			*	S>L
17:08	Lobates	Bulbous, tubular, budded inflated lobes, intermingled flat lobes		fish			
17:09	Lobates	Overlapping lobes, partly tubular					
17:10	Lobates	Overlapping lobes, partly tubular					
17:11	Lobates	Hackly overhang in overlapping lobes, egg shell lobe (11:11),					
17:12	Lobates	Lobates, broad, joined edges, flat tops,					
17:13	Lobates	CORES HIT BOTTOM, small collapse feature 1x1.5 m, lobate crust				*	
17:14	Collapse Feature	Shallow collapse in lobes, broken roof pieces in CF, can see hollow nature of lobes in rubble				*	
17:15	Collapse Feature	Rubbly bottom of collapse in lobate crust				*	
17:16	Lobates	Edge of collapse, lobate roof crust, .2-.3 m deep,	17:16:11			*	
17:17	Lobates	Lobes and large collapse, <.3 m deep, rubbly bottom,				*	
17:18	Ropey	Rubbly bottom, Ropey textures on bottom					
17:19	Collapse Feature	Lobate island in collapse, smooth curtain sheet >high curtian folded flow				*	
17:20	Collapse Feature	collapse bottom = smooth curtain sheet >high curtian folded flow	17:20:11			*	
17:21	Curtain - Sheet	Curtain folded flow, low sed cover > smooth curtain flow at rubbly CF edge			M		
17:22	Fissure	Deep Fissure, 1.5 m wide, rubbly wall down, lobate roof crust,	17:22:26				
17:23	Lobates	Lobate crust, shallow collapse, rubbly bottom, smooth pieces,			L	*	
17:24	Collapse Feature	sky light collpase in lobates 3x1 m,				*	
17:25	Collapse Feature	Collapse .5 m deep,		SA		*	
17:26	Lobates	Lobates, broad and flat, M sed cover			M		
17:27	Lobates	Lobates, broad and flat, M sed cover			M		
17:28	Lobates	Lobates		ALF			
17:29	Collapse Feature	Collapse Feature, lobate roof, rubbly bottom, very long, rubble, Smooth curtain flow				*	
17:30	Smooth - Curtain	Smooth curtain flow at collapse bottom, rubble				*	

Legend

For TRANSitions
H = Hackly
S = Smooth
C = Curtain
L = Lobate
J = Jumbly
N = Lineated
R = Ropey
> = transitions to
e.g. N>L
lineated transitions to lobate

For SEDiiment cover
L = low
M = medium
H = high

For COLlapse Feature
* = collapse feature present
** = good view
*** = interesting one

For BIOlogy
ALF = alien life form
BS = brittle stars
SC = sea crabby
SF = star fish
SA = sea anenome

Photo Prefix - Date		Atlantis 7-4 Camera Tow #12 Photo Descriptions					
2001_11_30							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
17:31	Smooth - Curtain	Smooth curtain flow at collapse bottom, rubble				*	
17:32	Hackly	Hackly pile in CF bottom, CF edge of lobates and Curtain flow bottom				*	
17:33	Lobates	Lobate crust, skylight collapse				*	
17:34	Collapse Feature	sky light collpase in lobates 3x1 m, can see hollow nature of lobes, SA SC	17:34:26			*	
17:35	Collapse Feature	Lobate crust, Colllapse Featue, roof pieces on bottom				*	
17:36	Collapse Feature	Collapse Feature in lobate crust,				*	
17:37	Lobates	Lobate crust, irregular edges, broad flat tops,				*	
17:38	Lobates	broad flat lobes, partly tubular					
17:39	Lobates	Lobates					
17:40	Lobates	Flat lobates					
17:41	Lobates	Lobates, broad, joined edges, flat tops,					
17:42	Lobates	Lobates, small collapses <.2 m wide,					
17:43	Lobates	Lobates and collapse feature, shallow, ropey bottom					
17:44	Lobates	Lobates and collapse feature, shallow, ropey bottom					
17:45	Lobates	Tubular lobates					
17:46	Lobates	Collapse in very brod flat lobe, roof pieces fit like puzzle				*	
17:47	Lobates	Shallow collapse in lobe, roof pieces at bottom, intermingled flat lobate crust				*	
17:48	Collapse Feature	Skylight collapses				*	
17:49	Collapse Feature	Bridge collapse in lobate crust 2 and 3 m diameters,	17:49:11			*	
17:50	Lobates	Lobates and collapse feature, rubbly bottom				*	
17:51	Lobates	Edge of collapse into lobate crust				*	
17:52	Collapse Feature	Collapse, inside, rubbly, curtain-folded flow, ropey textures,				*	
17:53	Collapse Feature	Collapse, inside, rubbly, curtain-folded flow, ropey textures,	17:53:41			*	
17:54	Curtain - Sheet	Highly folded curtain folded sheet flow at CF bottom, edge is rubbly, bulbous lobate crust				*	
17:55	Collapse Feature	Peninsulas of lobate crust, extensive collapse features through crust area				*	
17:56	Collapse Feature	Bottoms are ropey-curtain-folded flows, rubbly toward CF edges				*	
17:57	Collapse Feature	CF bottom appears to get deeper up tow direction				*	
17:58	Collapse Feature	ALF plants on a pillar top	17:58:56				
17:59	Lobates	Lobates and collapse				*	
18:00	Lobates	Extensive section of lobate crust					
18:01	Lobates	Lobates and collapse				*	
18:02	Collapse Feature	Collapse Feature edge, small collapse in lobate crust w/SA		SA		*	
18:03	Collapse Feature	rubbly collapse bottom				*	
18:04	Collapse Feature	rubbly and curtain folded collapse bottom				*	
18:05	Hackly	Hackly CF bottom		SA			
18:06	Hackly	Hackly CF bottom					
18:07	Hackly	Hackly curtain folded CF bottom					
18:08	Hackly	Hackly curtain folded CF bottom					
18:09	Curtain - Sheet	Curtain folded flow					
18:10	Curtain - Sheet	Different folded textures in Sheet flow, hackly curtain and ropey	18:10:26				
18:11	Smooth - Curtain	FLOW MARGIN: smooth linear curtain folds adjacent to ropey folded part of sheet flow	18:11:11				S>R
18:12	Smooth - Curtain	FLOW MARGIN: smooth linear curtain folds adjacent to ropey folded part of sheet flow					
18:13	Smooth - Curtain	smooth linear curtain folds adjacent to ropey folded part of sheet flow > hackly					
18:14	Smooth - Curtain	smooth linear curtain folds adjacent to ropey folded part of sheet flow					
18:15	Smooth - Curtain	smooth linear curtain folds adjacent to ropey folded part of sheet flow [OFF BOTTOM]					

Photo Prefix - Date		Atlantis 7-4 Camera Tow #13 Photo Descriptions					
2001_12_01							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
8:59		On Bottom					
9:00	Lineated	smooth and lineated sheet flow margin, L sed cover,			L		
9:01	Curtain	trans to folded curtain flow, part hackly					N>C
9:02	Curtain	curtain folded flow, part hackly, > smooth curain flow	9:02:22				
9:03	Curtain	fold transitions from curtain to smooth, flow margin of smooth and cutrain flow					C>S
9:04	Smooth	swirl structure in smooth sheet flow,					
9:05	Smooth	M sed smooth sheet flow,		BS	M		
9:06	Smooth	L sed smooth sheet flow, cracks in flow			L		
9:07	Smooth	1 m wide lineated-folded channels in smooth sheet flow					
9:08	Smooth	2 m wide lineated-folded channels in smooth sheet flow					
9:09	Smooth	smooth and lineated sheet flow margin, L sed cover trans to hackly and lobates	9:09:52				SC>HL
9:10	Hackly	Hackly and lobte lava, pieces of smooth curtain flows, curtain folds					
9:11	Hackly	Hackly and lobte lava, curtain folds					
9:12	Hackly	Hackly lava with broken up curtain folds, ropy features					
9:13	Jumbled	1 m high mound of folded-curtain pieces in hackly jumble lava, > to smooth cruatin flow					H>NC
9:14	Smooth	alternating 2 m wide channels of smooth sheets and lineated sheet flow, cracked crust			L		
9:15	Ropey	ropey , m sed flow			M		
9:16	Ropey	ropey , m sed flow			M		
9:17	Lineated	small collapse in crust of smooth and lineated sheet flow				*	
9:18	Lineated	smooth and lineated-ropey sheet flow, dominatnt smooth flow with few cm cracked crust					
9:19	Smooth	cracked crust of smooth sheet flow					
9:20	Smooth	cracked crust of smooth sheet flow					
9:21	Smooth	cracked crust of smooth sheet flow					
9:22	Lineated	low collapse of lineated-folded crust, alternating smooth and lineated channels				*	S>L
9:23	Lineated	alternating smooth and lineated sheet flows,					
9:24	Lineated	collapse features in lineated sheet flow 1.5x2 m CF	9:23:52			*	
9:25	Lineated	collapses and cracks in smooth-lineated sheet flows				*	
9:26	Ropey	smooth, M sed, sheet flow begin trans to ropey sheet flow,			M		
9:27	Smooth	smooth, L sed, sheet flow	9:27:37	FISH!	L		
9:28	Smooth	Edge of Collpase Feature, smooth, sheet flow at baset, 1 m deep, Lobate crust	Missing, 37,52		L	*	S>L
9:29	Curtain	Back to Collapse bottom, Curtain folded sheet flow, part hackly				*	
9:30	Smooth	Smooth sheet flow at collapse bottom, CF edge rubbyl, lobate crust, L sed cover			L	*	
9:31	Lobate	Extensive features of collapse from 9:31-9:33, lobate crust, bridge and skylights				*	
9:32	Collapse Feature	Collapse bottoms are rubbly, non-continuous islands of lobate crust				*	
9:33	Lobate	Collapse features in lobate crust,				*	
9:34	Lobate	Dinosaur footprint collapse feature!, matrix of lobate crust in extended CF field, sq. col.	9:34:22, 52			***	
9:35	Lobate	sheet flow bottom of collapse covered in rubble, lobate crust				*	
9:36	Curtain	collapse wall visible, rubble on sheet flow surface, ropey-curtain flow bottom,	9:36:22		M	*	
9:37	Hackly	Pillar wall in collapse, rubbly hackly bottom				*	
9:38	Lobate	CF edge , lobate roof, smooth sheet flow bottom cracked like a puzzle, M sed			M	*	
9:39	Smooth	flat, smooth, cracked bottom					
9:40	Smooth	flat, smooth, cracked bottom					
9:41	Collapse Feature	rubbly bottom of Collapse feature, Edge shows smooth M sed sheet btm, lobate roof			M	*	
9:42	Smooth	smooth, M sed, sheet flow, at bottom of collapse feature			M	*	
9:43	Smooth	smooth sheet flow trans to ropey and folded sheet flow, M sed cover,			M		S>R
9:44	Smooth	trans to smooth sheet flow, M sed cover, cracked in places			M		R>S

Legend

For TRANSitions
H = Hackly
S = Smooth
C = Curtain
L = Lobate
J = Jumbly
N = Lineated
R = Ropey, Folded
> = transitions to
e.g. N>L
lineated transitions to lobate

For SEDiiment cover
L = low
M = medium
H = high

For COLlapse Feature
* = collapse feature present
** = good view
*** = interesting one

For BIOlogy
ALF = alien life form
BS = brittle stars
SC = sea crabby
SF = star fish
SA = sea anenome

Other Abbreviation
C.F.=Collapse Features
c.f.s.=curtain folded sheet

Photo Prefix - Date		Atlantis 7-4 Camera Tow #13 Photo Descriptions					
2001_12_01							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
9:45	Lineated	lineated - folded sheet flow, M sed cover			M		
9:46	Jumbled	jumbled pile in lineatd flow, hackly patches in smooth-curtain folded flow					
9:47	Collapse Feature	smooth-curtain flow, Lobate roof crust of collapse, ~1m deep, curtain folded bottom				*	
9:48	Curtain	Curtain folded , M sed cover bottom of collapse			M	*	
9:49	Curtain	rubble and curtain sheet flow at CF bottom				*	
9:50	Lobate	lobate crust, Very L sed cover, edge of CF, smooth sheet bottom of CF			Very L	*	
9:51	Smooth	Smooth sheet flow, curatin folds and coils				*	
9:52	Lobate	Lobate crust edge of collapse, rubble, Very L sed cover on lobes		SA	Very L	*	
9:53	Lobate	Collapse Feature Edge, Lobate crust, rubble bottom				*	
9:54	Collapse Feature	Rubble bottom of CF, part sheet flow peaks, through,				*	
9:55	Collapse Feature	Wall of CF visible, rubbly bottom, lobate crust island,	9:55:07			*	
9:56	Collapse Feature	CF bottom, rubbly and smooth cracked sheet flow, M sed cover			M	*	
9:57	Collapse Feature	Lobte crust island, rubble, and smooth M sed sheet flow at bottom			M		
9:58	Collapse Feature	Lobte crust island, rubble, and smooth M sed sheet flow at bottom			M		
9:59	Lineated	Sheet flow is more lineated, part jumbled, M sed cover			M		S>N
10:00	Lineated	Lineted sheet flow>curtain folded flow, prt hackly, part smooth					N>C
10:01	Hackly	Hackly lava with broken up curtain folds, ropy features					
10:02	Lobate	Lobate roof crust fo flow, SA, rubbly bottom		SA			
10:03	Collapse Feature	wall of CF visible, rubbly bottom,	10:03:07			*	
10:04	Collapse Feature	lobate crust island, curtain folded CF bottom,				*	
10:05	Curtain	Curtain folded , M sed cover bottom of collapse, parth smooth-curtain flow			M	*	
10:06	Hackly	Hackly lava					
10:07	Hackly	Hackly lava					
10:08	Hackly	Hackly lava, part curtain folds, lobate crust of collpase, L sed,			L	*	
10:09	Collapse Feature	wall of CF, rubbly bottom,		SA		*	
10:10	Collapse Feature	Pillar, rubble in CF bottom trans to smooth sheet flow, M sed cover			M	*	
10:11	Smooth	Smooth sheet flow, linetion traces, cracks in crust,					S>CH
10:12	Curtain	trans from smooth to curtain folded and hackly lava					
10:13	Hackly	Hackly lava, island of jumbled lava?, MULTI LEVEL COLLAPSE, rubbly Btm, Lobate roof	10:13:07			***	
10:14	Collapse Feature	Wall of collapse feature!!channelilzed rubble,	10:14:37	FISH!		**	
10:15	Curtain	rubbly bottom, partly curtain folded					
10:16	Hackly	Hackly partly curtian folded					
10:17	Hackly	Hackly partly curtian folded, wall of collapse edge slightly visible				**	
10:18	Hackly	Rubbly hackly, partly curtian folded collapse bottom, wall of Flow visible!	10:18:07			*	
10:19	Hackly	Rubbly hackly, partly curtian folded collapse bottom, wall of Flow visible! Pillar 2 m high	10:19:52			*	
10:20	Pillars	PILLARS! Rubbly bottom	10:20:07, 37			***	
10:21	Collapse Feature	high altitude, bad photos, smooth bottom part rubbly					
10:22	Collapse Feature	remnant lobate crust, rubble, Pillar, smooth sheet flow, part ropey M sed cover			M		
10:23	Collapse Feature	Colapse Feature wall, remantant Pillar walls, rubbly, small pillars				*	
10:24	Pillars	1m high small Pillars, rubbly bottom				*	
10:25	Curtain	Trans from rubbly and smooth curtain folded sheet to c.f.s on the entirely bottom with M sed			M		S>C
10:26	Curtain	mainly c.f.s. with some hackly with L sed			L		
10:27	Curtain	mainly c.f.s. with some hackly with L sed			L	*	
10:28	Smooth	Trans to smooth sheet flow, M sed cover, cracked in places and to the CF edge			M		C>S
10:29	Collapse Feature	reminant lobates crrust with rubby, multi CF with rabbles at the bottom, pillar				*	

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #13 Photo Descriptions**					
2001_12_01							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
10:30	Pillars	pillar, rubbly bottom					
10:31	Smooth	Trans to smooth sheet with a crack running to three photos\					L>S
10:32	Smooth	smooth flat bottom with some cracks to CF edges, hackly				*	
10:33	Collapse Feature	hackly bottom partly lobate crust, partly smooth c.f.s					
10:34	Collapse Feature	rubbly C.F. edge and to c.f.s. to smooth bottom with M sed				*	
10:35	Smooth	smooth with partly c.f.s.					
10:36	Curtain	patch of c.f.s.to more concentrated c.f.s. with hackly					
10:37	Curtain	c.f.s. and hackly to more hackly					
10:38	Hackly	hackly and partly c.f.s. to c.f.s. dominated area					
10:39	Hackly	hackly with pieces of smooth sheet flow					
10:40	Hackly	hackly					
10:41	Hackly	hackly and small C.F. to smooth c.f.s.				*	
10:42	Smooth	flow margin of smooth to c.f.s. and hackly to more hackly					
10:43	Curtain	c.f.s. and hackly					
10:44	Curtain	c.f.s. and hackly					
10:45	Hackly	hackly					
10:46	Hackly	hackly and small C.F.				*	
10:47	Hackly	hackly					
10:48	Hackly	hackly with small C.F.				*	
10:49	Hackly	hackly and c.f.s.					
10:50	Hackly	hackly to the edge of C.F. <0.5 m deep , bottom of C.F. is smooth c.f. with M sed			M	*	
10:51	Smooth	smooth c.f. with some cracks to hackly/rubble				*	
10:52	Curtain	rubbles and c.f.s.					
10:53	Curtain	c.f.s. and partly hackly L sed					
10:54	Smooth	Trans from c.f.s. to smooth with trace of c.f.s. M sed			M		
10:55	Smooth	smooth c.f.s. to hackly with some small cracks					
10:56	Hackly	hackly edges with smooth c.f.s. to hackly dominated area					
10:57	Hackly	hackly with some smooth c.f.s. to more hackly					
10:58	Hackly	hackly covered with L sed			L		
10:59	Hackly	hackly					
11:00	Hackly	hackly and c.f.s.					
11:01	Hackly	hackly					
11:02	Hackly	hackly		SA, fish			
11:03	Hackly	hackly and c.f.s.					
11:04	Hackly	hackly and flow MGN to smooth c.f.s. with L sed			L		
11:05	Collapse Feature	bridge C.F. with lobate crust , bottom is rubbly pieces				*	
11:06	Collapse Feature	horse-shoe C.F. with lobate crust at the top with rubbly bottom (6:22 and 37 missing)	11:06:07			*	
11:07	Hackly	rubbly bottom to hackly					
11:08	Collapse Feature	reminant lobates (pillar wall) crust with rubbly bottom		ALF			
11:09	Collapse Feature	rubbly [Off Bottom]					

Photo Prefix - Date		**Atlantis 7-4 Camera Tow #14 Photo Descriptions**						
2001_12_01								
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**	
15:48	Lobate	On Bottom. knobby lobate flow pieces with M-H sed on H sed flat bottom (flow pieces coverage-40%)			M,H			**Legend**
15:49	Pillow-Lobates	ball-pillow, lobates flow pieces on H sed flat bottom			H			For TRANSitions
15:50	Pillow-Lobates	ball-pillow with buds, lobates flow pieces on H sed flat bottom (coverage-5-15%)			H			H = Hackly
15:51	Pillows	ball-pillow with buds, 1.5m long bulbous P, lobates flow pieces on H sed bottom (coverage-5-15%)			H			S = Smooth
15:52	Pillows	ball-pillow with buds, 1.5m long bulbous P, lobates flow pieces on H sed bottom (coverage-10-35%)		SC	H			C = Curtain
15:53	Pillows	ball-pillow with buds, lobates flow pieces on H sed bottom (coverage-10-25%)			H			L = Lobate
15:54	Pillows	ball-pillow, 2-3m long bulbous pillow with buds on H sed bottom, 0.2m wide crack			H			J = Jumbly
15:55	Pillows	crack continues with ball-pillow, 2-3m long bolbrous pillow with buds along it on H sed			H			N = Lineated
15:56	Lobate	irregular lobate, knobby lobates on H sed bottom with 1m long slit			H			> = transitions to
15:57	Lobate	irregular lobate, knobby lobates on H sed bottom with 1m long slit			H			e.g. N>L
15:58	Lobate	elongated knobby lobates, bolbrous P with buds on flat H sed bottom (C-50-75%)			H			lineated transitions to lobate
15:59	Lobate	flat irregular lobate, knobby lobate, irregular lobate pices (C-75-100%)			H			
16:00	Lobate	irregular flat broad lobates and elongated lobates with knobby and buds, M-sed			M			For SEDiiment cover
16:01	Lobate	irregular flat broad lobates and elongated lobates with knobby and buds, M-sed			M			L = low
16:02	Lobate	irregular flat broad lobates and elongated lobates with knobby and buds, M-sed			M			M = medium
16:03	Lobate	irregular and elongated lobates with knobby and buds, M-sed			M			H = high
16:04	Curtain	shallow (<0.1m) collapse on flat and knobby lobates, bottom of C-curtain folded ropy sheet with hackly				*	L>H	
16:05	Hackly	continuing bottom of the collapse: hackly				*		For COLlapse Feature
16:06	Hackly	continuing bottom of the collapse: hackly with piceces of folded ropy sheet				*		* = collapse feature present
16:07	Hackly	Hackly with L -sed			L			** = good view
16:08	Hackly	Hackly with L -sed			L			*** = interesting one
16:09	Hackly	Hackly with some folded ropy sheets pieces with L-sed			L			
16:10	Hackly	Hackly with some folded ropy sheets pieces with L-sed			L			
16:11	Hackly	Hackly with some folded ropy sheets pieces with L-sed			L			For BIOlogy
16:12	Hackly	Hackly with some folded ropy sheets pieces with L-sed			L			ALF = alien life form
16:13	Hackly	Trans: Hackly with some f.r.s.p to folded ropy sheet flows with M-sed on H-sed flat bottom			M,H			BS = brittle stars
16:14	Ropey	folded ropy sheet flows with M-sed on H-sed flat bottom with <0.1m wide slit along one of the flows			M,H	*		SC = sea crabby
16:15	Lobate	Trans to broken lobate flows (bottom of C)and to the edge of the collapse with P on lobates				*		SF = star fish
16:16	Lobate	Edge of the Collapse top: irregular lobates piceces on H-sed flat bottom			H	*		SA = sea anenome
16:17	Lobate	irregular flat lobates on H sed flat bottom			H			
16:18	Sedimented	H-sed flat bottom with <0.1m side slit running			H			
16:19	Sedimented	H sed flat bottom with slight trace of flow pieces			H			
16:20	Lobate	knobby lobates and flat lobates pieces along 0.3m wide crack on H sed bottom			H			
16:21	Lobate	Two -0.5m wide cracks running paralell to each other with 2.5m wide strip of knobby lobats in middle			H			
16:22	Lobate	Left crack still continues while the right one dissapears and now flat irregular lobates			H			
16:23	Lobate	flat irregular lobate with knobby with M sed			M			
16:24	Lobate	flat irregular lobate with knobby with M sed			M			
16:25	Lobate	flat broad lobate with knobby with M sed			M			
16:26	Lobate	flat irregular lobate with knobby with M sed			M			
16:27	Lobate	flat irregular lobate with knobby with M sed			M			
16:28	Lobate	flat irregular lobate with knobby and pieces of bread crust lobates with M sed			M			
16:29	Lobate	flat irregular lobate with knobby and pieces of bread crust lobates with M sed			M			
16:30	Curtain	Trans to curtain folded ropy sheet and to flat H sed bottom with occasional apprearance of f.r.s.			H		H>C	
16:31	Curtain	flat H sed bottom to curtain folded ropy sheet	16:31:24		H			
16:32	Curtain	c.f.r.s to flat h sed bottom to irregular lobates with M sed			M,H		C>L	
16:33	Lobate	flat lobates with knobby and bread-crust lobates with M sed			M			

Photo Prefix - Date		Atlantis 7-4 Camera Tow #14 Photo Descriptions					
2001_12_01							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
16:34	Lobate	flat lobates and broken pieces of flat lobates					
16:35	Lobate	flat lobates and broken pieces of flat lobates					
16:36	Lobate	flat broad and some irregular lobates and elongated lobates					
16:37	Lobate	flat lobates and broken pieces of flat lobates					
16:38	Lobate	flat lobates and broken pieces of flat lobates					
16:39	Lobate	flat lobates and broken pieces of flat lobates					
16:40	Lobate	flat lobates and broken pieces of flat lobates					
16:41	Lobate	flat lobates and broken pieces of flat lobates with knobby lobates between					
16:42	Lobate	flat lobates and broken pieces of flat lobates with knobby lobates between					
16:43	Lobate	flat lobates and broken pieces of flat lobates with knobby lobates between					
16:44	Lobate	flat lobates and broken pieces of flat lobates with knobby lobates between					
16:45	Lobate	flat lobates and broken pieces of flat lobates with knobby lobates between					
16:46	Lobate	flat lobates and broken pieces of flat lobates with knobby lobates between					
16:47	Lobate	irregular lobates with knobby lobates					
16:48	Lobate	irregular lobates with knobby lobates					
16:49	Lobate	irregular lobates with knobby lobates					
16:50	Lobate	irregular lobates with knobby lobates with 1-2m long tube pillows					
16:51	Pillows	piles of ball, and tube pillows, some w/buds, and knobby flows w/ L sed			L		L>PL
16:52	Pillow-Lobates	elongated irregular lobates and tube pillows on H sed bottom			H		
16:53	Pillow-Lobates	elongated irregular lobates and tube pillows on H sed bottom			H		
16:54	Pillow-Lobates	more irregular lobates w/ buds than pillows on H sed bottom			H		
16:55	Pillow-Lobates	more irregular lobates w/ buds than pillows on H sed bottom to knobby lobates dominated area			H		
16:56	Pillow-Lobates	knobby and elongated lobates with one or two 1m long tube pillows on H sed bottom			H		
16:57	Pillow-Lobates	irregular and knobby lobates on H sed bottom			H		
16:58	Pillow-Lobates	bread-crust lobes, irregular short lobes w/buds and 1-2m long tube pillows on H sed bottom	16:58:09	fish	H		
16:59	Pillow-Lobates	bread-crust lobes, irregular short lobes w/buds and 1-2m long tube pillows on H sed bottom			H		
17:00	Pillow-Lobates	bread-crust lobes, irregular short lobes w/buds and 1-4m long tube pillows on H sed bottom			H		
17:01	Pillow-Lobates	bread-crust lobes, irregular short lobes w/buds and 1-4m long tube pillows on H sed bottom			H		
17:02	Pillow-Lobates	bread-crust lobes, irregular short lobes w/buds and 1-4m long tube pillows on H sed bottom			H		
17:03	Pillows	bublbous, elongated tubular pillows, budded	17:03:24				
17:04	Pillows	bulbous pilllow "pow wow", bread crust cracks, H sed bottom			H		
17:05	Pillows	nice triple juncture rift in pillow (05:39), budded bulbous pillows, H sed bttom,			H		
17:06	Pillows	elongate, pinch and swell tubular pillows, H sed bottom,			H		
17:07	Lobate	Irregular lobes with toes and pillows on H sed bottom			H		
17:08	Pillows	pillows, small collapse feature, lobes			H	*	
17:09	Pillow-Lobates	Nice elongate toothpaset pillow, spaced lobes, edge of collapse				*	
17:10	Pillow-Lobates	bulbous lobes, irregular edge narrow lobes, patch of tubular budded pillows	17:10:54				
17:11	Lobate	flat sheet like lobes, with few elongate pillows, H sed bottom		fish, SC	H		
17:12	Pillow-Lobates	low relief lobates, irregular edges, pillows					
17:13	Lobate	low relief irreglar lobates, H sed bottom			H		
17:14	Pillows	bublbous, elongated tubular pillows, budded					
17:15	Pillows	intermingled tubular pillow field, Hollow pillow w/ sed inside	17:15:09, 54				
17:16	Pillows	bulbous, elongated tubular pillows, budded, inlfated bulbous lobes,		SA			
17:17	Pillows	bulbous pillows, "forked tongue" pillow (17:54),					
17:18	Lobate	bulbous lobaes, edge of collapse feature, hackly lava					

Photo Prefix - Date		Atlantis 7-4 Camera Tow #14 Photo Descriptions					
2001_12_01							
Time	**Major Morphology**	**Comments**	**Best Photos**	**BIO**	**SED**	**COL**	**TRANS**
17:19	Pillows	elongate snake pillows, overlapping, ball pillows, knobby, .2 m crack through crust					
17:20	Pillows	.2 m crack continues, field of 1 m long tube pillows, budded,					
17:21	Pillows	elongate tube pillows, knobby broad lobes, chain of ball pillows					
17:22	Pillows	pinch and swell tube pillows					
17:23	Pillows	ball and tube pillows, budded, knobby lobes, partly overlapping,					
17:24	Pillows	mirro image pillow, elongate pillows, budded, high coverage of pillows (50%)					
17:25	Pillows	low coveage of ball pillows on H sed bottom			H		
17:26	Pillows	spaced knobby ball pillows, H sed bottom			H		
17:27	Pillow-Lobates	Low med coverage of narrow drizzly bulbous elongate pillows and lobes, H sed bot		SC	H		
17:28	Pillow-Lobates	Low med coverage of narrow drizzly bulbous elongate pillows and lobes, H sed bot			H		
17:29	Pillow-Lobates	Low med coverage of narrow drizzly bulbous elongate pillows and lobes, H sed bot			H		
17:30		OFF BOTTOM			H		

Appendix 3:
DSL-120A Sonar Operations Report

November-December 2001 (AT7-4) PI's: Schouten, Tivey, Fornari

SURVEY SUMMARY

On Atlantis Voyage 7, Leg 4, the DSL-120A system was used to collect sonar, magnetics and attitude data on eight tows consisting of fourteen line segments (Figure 1). Speed over the ground for all surveys ranged from 1.0 to 1.7 kts. During both of the first two tows, the system was deployed for approximately 72 hours collecting data for three parallel lines. The last six tows collected data for individual survey lines, each less than 24 hours in duration. The very last deployment of the system had the shortest duration, collecting four hours of usable on-bottom data.

HARDWARE PERFORMANCE

Summary

This report comments on the quality of four aspects of the DSL-120A hardware performance: sonar data, attitude data, vehicle stability and navigation. Other sensors, including the magnetometer, were analyzed by non-HMRG personnel onboard ***Atlantis*** to determine their performance during the CAMH survey; these instruments are not discussed in this document.

Sidescan Data

In general, sidescan sonar data were considered to be very good quality as is evidenced by images such as Figure 2, one of the final page-sized plots delivered to the principal investigators. Sidescan processing was largely completed at sea with just a few problems to be reworked in early 2002. A detailed discussion of specific problems with the acoustic data is presented in the sections following this summary.

Bathymetry data

Bathymetry data were not produced during the survey, partly because the science party was more interested in receiving a finished sidescan product prior to camera tows and ABE surveys, but also because the phase-difference data were problematic. Early in the survey it was evident that the phase-difference data were coherent on both the port and stbd sides and therefore it was agreed that it would be possible to convert them to bathymetry maps. However, approximately 20% of the phase-difference data has incoherent values and the HMRG software is unable to differentiate these bad pings during the processing step that converts raw phase data to x/z pairs. Their presence precluded shipboard generation of usable bathymetry because they introduced enough anomalous values that our filtering approach would not have been able to systematically remove them. A software fix for discarding incoherent phase difference pings was implemented over the holidays but will not be tested until HMRG data processing personnel return from their mainland travels.

A second problem prevented generating bathymetry data at sea. The polarity of the phase differences curves for the DSL-120A sonar is opposite that of HMRG's present sonar system, the HAWAII MR1. Combined with the tendency of the stbd side phase-difference data to flip from positive to negative slope in adjacent pings (a problem HMRG refers to as "ping-

flipping"), software modifications had to be accomplished before bathymetry data could be produced. HMRG has existing software to counteract both "reversed" phase-difference trends and ping-flipping, but these functionalities had never been implemented in combination. The reverse polarity/ping-flipping problem was solved on land during the field program but because it required substantive code modifications, it was not tested until HMRG personnel returned from the CAMH field program, just prior to the American Geophysical Union meeting. The new software was tested and worked well enough to produce a swath of coherent bathymetry data for presentation at the December DESSC meeting to illustrate the DSL-120A system performance.

Vehicle Attitude

Attitude data from the Octans sensor was observed to be of very good quality except for occasional spiked values in heading and pitch (no systematic analysis of roll was undertaken). Most of the data spikes could be removed using a simple median filter. The exception was heading values that rotated through a full 360°+ cycle whenever power was cycled to the Octans. In these instances the anomalous values were replaced using a simple linear interpolation between the last good heading and consistent values that occurred after the 360° swing.

PARO Depth Sensor

Values provided by the PARO depth sensor were bad throughout the cruise. Tom Crook informed us that during the early tows (01, 02, and 03) the PARO was too shallow by approximately 60 meters. After tow03 Bob Waters and Mark Rognstad worked on the system settings and discovered several problems including (possibly) that the sensor was set for fresh water and using inconsistent units. However, after their efforts Tom Crook still believed the sensor was producing incorrect depths, this time offset too deep. **We need to get a specific number from Tom regarding the depth offset for the last five tows.** Until we get accurate depth values from the PARO depth sensor, it won't be possible to use acoustic range to produce accurate fish-ship range.

Vehicle Stability

HMRG personnel are used to working with a shallow-towed system that is pulled through the water at speeds ranging from 6-10 knots, so our expectations regarding vehicle stability differ from those of DSOG personnel. With shallow-towed systems, pitch and roll values typically range from -2 to +2 degrees during operations. Roll values for the DSL-120A system were consistent with HMRG's previous experience and considered to be quite good during the CAMH survey; however, the pitch values could range from +20 to -20 over a matter of seconds and this performance was problematic. When pitch values exceeded ±20 degrees, coherent noise was usually observed in the sonar data. After discussion with DSOG personnel onboard the ship, it was determined that the towing dynamics of the DSL-120A system are an improvement over this system's predecessor. Still, the tendency of the towfish nose to oscillate up-and-down rapidly when the system was being lowered or raised at a wire speed of a few meters per minute seemed extreme. Mark Rognstad suggested that a small drogue would stabilize towfish pitch and even brought a mock-up drogue to the ***Atlantis*** to deploy with the

DSL-120A. Unfortunately, the position of the magnetometer prevented him from being able to deploy and test his drogue.

Navigation

For a first-pass, navigation data provided by DSOG personnel using estimated wire out and "layback" calculation were incorporated into DSL-120A data and used to generate charts. These navigation data are included as part of the raw DSL-120A data stream, but were accessed, subsampled and smoothed from the "HNS" files stored on the DSL "topside" computer.

During tow04 it became apparent that the locations of distinctive lava flows depicted in overlapping sidescan lines acquired during tow02 and tow04 were offset by several hundred meters. HMRG personnel and the principal investigators discussed the idea of using the acoustic range data to navigate the towfish in regions outside of the transponder nets and spent several days extracting the various types of information necessary to perform an acoustic layback calculation from different types of DSOG navigation files. However, toward the end of the cruise time began to get short, and we decided to use the old-fashioned method of navigating swaths by hand using individual lines, scissors and tape. As backward as this approach was, it demonstrated to all parties that the DSL-120A sonar was not following directly in the ***Atlantis's*** track but was slaloming behind the ship. Although acoustic range information could have improved navigation in making the range from the ship to the fish more precise, if it had been implemented assuming the DSL-120A was following in the ship's track, it also would have produced an erroneous result. At present, we believe there are two candidate solutions for improving the DSL-120A navigation. The first would be to integrate a Doppler sonar on the system to improve positional accuracy. There was a Doppler on the DSL-120A during the CAMH survey, but it did not work properly. It also significantly interfered with the quality of the 120kHz sonar data and therefore it was not used during the program. A less effective solution, until the Doppler can be made to work, would be to use software that allows adjacent sidescan or bathymetry swaths to be "rubber-sheeted" to align distinctive features. Candidate software systems include ERMapper and MBsystem. At the present time HMRG personnel are not involved with implementing either of these solutions, but we hope to be kept informed of progress by DSOG personnel.

Problems In Acoustic Data

Winch-induced noise

Performance of the system improved from the beginning until the end of the DSL-120A surveying program. A few problems persisted throughout the survey, while other problems only occurred during one or two tows. Persistent problems included the introduction of significant noise during large changes in pitch when the winch was being used; there was a recognizable correlation between peaks in towfish pitch and the presence of noisy pings in the data in the real-time display. For all tows it was necessary to reboot the system at the beginning of each line when the DSL-120A reached the seafloor. It is possible, but not proven, that this condition is related to the pitch/noise problem. Cycling power to the towfish eventually made the noisy pings disappear although it frequently took several power cycles to get the S:N at the level

deemed acceptable for surveying purposes. For reasons not well understood, bringing the system back on-line at half-power as opposed to very low power improved the S:N more quickly.

Sensor interference

Another persistent problem was the interference between various other sensors and the 120kHz sonar. It was decided that to reduce the amount of interference the 120A would be operated only with systems critical for the CAMH science program. Necessary instruments included the Octans attitude sensor and the magnetometer. The CTD was not used during the CAMH surveys because the noise introduced in the acoustic data was deemed unacceptable.

Magnetometer Ground Fault

During all surveys a ground-fault was detected for the magnetometer. On some tows this ground fault was high enough that we considered turning off the sensor. On other tows, the ground fault light was on, but Bob Waters did not consider the value of the ground fault to be "serious." Oddly, the quality of the sidescan data seemed best when there was a low, but persistent, ground-fault value. When the ground fault disappeared entirely, the 120kHz data showed a noticeable cyclic noise problem. Bob Waters thought this problem might be related to the magnetometer repeatedly checking for a ground fault.

Bad external connectors on tow01

Several sporadic problems occurred during the field program; most of these were fixed upon completion of the tow in which they were discovered. During tow01 the port side transducers collected data that were usable for generating sidescan, but had significantly higher S:N than analogous data on the stbd side. It was possible to scale the signal (and noise) on port side to match the stbd side levels in post-processing, but the resultant port data didn't resolve sidescan features and intensity changes as well as the stbd side. On one occasion the port side stopped collecting data completely and it was necessary to cycle power to the system; however, this did not improve the quality of the port side data. After recovering of the system at the end of tow01, Mark Rognstad and Bob Waters tracked the port side problem to a bad external connector between the port transducers and the electronics bottle. According to the engineers, the source of the port-side problem was several pins that had been shrink-wrapped together in the connectors. Both port and stbd connectors were replaced. The result was that this problem did not reoccur during the field program - for the remainder of the survey the quality of the port sidescan data and the coherence of the port phase-difference data were comparable to that of the stbd side.

Bad stbd DSP chip on tow02

During tow02 we had an intermittent problem with the stbd side. The real-time display would show that the stbd side had quit acquiring data although the port side was operating normally. The only way to solve the problem was to stop the real-time acquisition program, cycle power to the sonar and then restart data acquisition. The problem occurred at random intervals and depending on the alertness of the watchstanders, could yield a few or a several minute data gap on the stbd side (and a smaller gap on the port side when data acquisition was stopped). After repeated failures during the second line of tow02, we decided to run the system

at half power to see if we were overdriving the stbd electronics. After we decreased the power to the system, the stbd failures ceased. We ran the system at lower power for the remainder of the tow, still acquiring a full 1km swath of data with no apparent reduction in the S:N for the sidescan data. Upon completion of the survey Mark Rognstad swapped out one of the stbd DSP's and the problem did not recur for the remainder of the cruise.

No navigation in HNS files on tow03

At the end of the 10-hour tow03, it was discovered that the navigation data both in the raw DSL files and in the HNS files had latitudes in the Arctic circle, clearly incorrect. We never determined what had not been turned on properly during the pre-dive check list, but it was possible to use navigation from another set of files (the PAS) files to generate the true locations for the tow03 track. The reason that the watchstanders hadn't noticed the error was because they were reading the latitude and longitude from DSL's navigation computer and not the real-time display program for the 120 kHz sonar. After we realized what had happed we changed watchstanding procedures and the problem never reoccurred.

Crash of backup acquisition computer

The spare acquisition computer, having been transferred from the engineering support effort to the data processing effort at the end of tow02, crashed between tow04 and tow05 and wasted about one-half a day of processing time. The problem with the computer was the boot disk - the system reported that it was unable to locate the kernel. Dave Sims was able to bring the computer back to life and made several suggestions about reconfiguring the computer in the future, but he could not specifically identify the problem that caused the computer to crash. However, the computer remained functional for the rest of the trip although we did occasionally need to reboot it when some program hung things up.

ACQUISITION SOFTWARE

Tape Logging Program

The tape logging program operated without any problems except once when it overfilled both tapes in the drives. It is possible that this error occurred because the tape blocksize had not been set properly. We are developing some program modifications to insure that this problem does not recur on future surveys. Fifty-seven sets of duplicate raw tapes (#'s 046-103) were written during the CAMH program. Most contained ~4 hours of raw data; however, toward the end of the survey when supplies were running short we increased the amount of raw data per tape to 6 hours. Our land-based archivist has suggested that for future DSL-120A surveys we break the data files every 15 minutes instead of 30 minutes to maximize the amount of space we use on archival CD-ROMs.

Real-time Acquisition Program

The real-time acquisition program operated without incident throughout the survey. Especially during tow02 the program was stopped and restarted on several occasions and it always performed as expected.

Real-time Display Program

The real-time display program also operated without incident. The only problem with this "program" was that we were unable to modify the grayscale on the Raytheon printer to improve the quality of the real-time scrolling sidescan hard copy. On two occasions we manipulated the toggle keys on the back of the Raytheon printer to see if we could darken the display, but we were only able to make minor improvements. The flexibility of the real-time display was otherwise quite useful since we could easily manipulate the different data windows to assess data quality and vehicle performance.

DATA PROCESSING AND PRODUCTS

Bottom Detection

By far the most time-consuming data processing task was the bottom detection step. HMRG's two data processors (Akel Sterling and Tomoko Kurokawa) each spent 12 hour watches working just on generating and correcting bottom detects and were unable to process the data as quickly as it was acquired. The way that we were operating the DSL-120A sonar (collecting one ping every 800 ms) produced ~2250 pings per each 30 minute data file. Toward the middle of the cruise when it became apparent that we would not be able to dive in Alvin and that we would instead collect more DSL-120A data, we drafted other watchstanders to assist with the bottom-detecting step and give Akel and Tomoko some breaks. Because of the learning curve, this actually slowed our operations down, but it improved the consistency of the bottom detecting because it increased the communications and interpretations between all of the watchstanders.

We presently have some ideas to speed up this step in the data processing pipeline, but this will require some programming effort. After discussion with Andy Bowen at AGU, we have agreed that a new data processing approach is a better solution than sending extra personnel to sea solely for the purpose of generating and correcting bottom detects. However this software effort will depend on DSOG's level of funding for CY2002.

Noise Removal, Data Gridding and Charting

Although the bottom detecting step was unable to keep up with the rate of data acquisition, once bottom detection was completed, standard HMRG processing was accomplished quickly and with little modification to the approach already used by the group. Standard processing included the removal of speckle noise, track-parallel stripes and correcting for angle-varying gain. When high pitch angles introduces coherent noise at the outer edges of pings it was occasionally necessary to remove these problems individually, but 90% of the noise removal was accomplished in batch processing. Several days were spent matching sidescan data intensities that differed as a result of changing power levels during the early tows. Once the system was operating at a fixed power level, this time-consuming task disappeared.

One software problem was discovered and corrected during the cruise. The angle varying gain corrections were not being applied accurately in regions with strong specular return. This modification has been incorporated into the main HMRG software back on land and should not recur during future DSL-120A field operations.

Spurious navigation points at first precluded our attempts to create gridded sidescan data. However, once we identified the problem, corrected bad latitude and longitude values, and passed a median filter over the heading data, 90-95% of the data were gridded in batch mode. The exceptions were locations where we had cycled power to the Octans. These areas were identified and the headings corrected manually. At a cell size of 4 meters it took about 1 hour to grid one day's worth of data. The principal investigators requested that the final products be delivered at 2m data cell size, which increased the time necessary to grid the sidescan data by more than a factor of 4.

The HMRG charting approach made several leaps forward to accommodate the wishes of the principal investigators on the CAMH program. HMRG had previously only produced landscape-oriented charts, but our approach has now been modified to also include portrait-oriented charts. We also added options that allow rock core locations, track lines, time annotations, the interpreted Axial Summit Collapse Trough and other features of interest to the scientists to be included or left off a chart with a simple command line argument. We also made some progress incorporating the data into geographical information systems such as ARC so that it could be readily integrated with other datasets.

Data Products

On board Atlantis HMRG personnel produced:

- 2 sets of Exabyte tapes containing all raw 120kHz data files
- 1 set of CD's containing all raw 120kHz data files
- 2 sets of Exabyte tapes containing all processed 120kHz data files
- 3 sets of paper A0 charts for the survey area at a scale of 1:10,000. Some charts included supporting science information, others included just sidescan data
- Digital sets of A0 charts at 1:10,000, 1:15,000 and 1:40,000
- Digital sets of page-sized charts at 1:10,000 and 1:15,000
- 2 sets of Exabyte tapes containing all navigation, scripts, documentation and metadata for the survey

One set of raw Exabyte tapes, all paper and digital charts were delivered to the prinicipal investigators. The remaining materials are either still on the Atlantis awaiting shipment to the University of Hawaii, or have already been incorporated into the HMRG physical data archive.

SUPPLIES

Only minimal expendable data supplies were provided for this cruise. Rolls of plotter paper and ink cartridges were supplied largely by the science party and onboard SSSG group and Alvin Group. In an effort to prevent this from recurring on future cruises, following is a list of supplies and estimates for the amount of each type that HMRG would like to have provided for each DSL-120 program.

Exabyte Tapes

For raw data, two Exabyte tapes are used every four hours for logging. That means 12 Exabyte tapes should be provided for each day of DSL-120A operation just to log the raw data. HMRG needs an additional 40 Exabyte tapes to perform nightly backups of processed data and

to archive processed data and supporting information at the end of a two-week long survey. For a month-long survey, 80 additional Exabyte tapes should be provided.

At least one box of ten Exabyte drive cleaning tapes should also be provided. On the CAMH survey the SSSG technicians provided us with Exabyte cleaning tapes, so we "reimbursed" them with one dozen unused Exabyte data tapes at the end of the field program.

CD-ROMs

HMRG strives to produce two copies of raw data archived on CD for all HAWAII MR1 cruises. Because of the much higher data volume of the DSL-120A, it may not be possible to create two sets during DSOG field operations, but we were successful in creating one complete set during the CAMH survey. Since CD-ROMs are less susceptible to damage due to the new enhanced security systems at most U.S. airports, it seems reasonable to make this a standard policy. One CD is used for every HOUR of raw DSL-120A data collected. For this cruise, 100 CDs were provided to HMRG personnel by Pat Hickey to accomplish this goal.

Printers and Paper

Paper and ink for the HP755 plotters ran out during the CAMH program, so the SSSG techs and Dan Fornari supplied additional materials. It should be said that many of the principal investigators who've used the HAWAII MR1 don't request full A0 charts, so it would be useful to either have HMRG or DSOG personnel contact the lead scientists prior to the next survey to determine what will be required for hard copy output. It is worth noting that the page-sized color printer furnished by HMRG for this field program produced a lot of test output for discussion with the scientists about products. We recommend that DSOG personnel purchase a similar color printer (or even two) for future DSL120A programs.

Office Supplies

HMRG prefers to deliver 3-ring binders filled with charts showing annotated navigation, sidescan and bathymetry as final products for a survey. These charts are available in digital form and thus the notebooks aren't actually required, but we find them to be a very handy reference for discussing any necessary processing, data problems etc. To preserve the quality of the paper charts, all pages are kept in plastic sheet protectors. Typically one notebook is delivered to the principal investigator and the other remains in the HMRG data archives. On the CAMH field program there were no office supplies to accomplish this goal, so Dan Fornari supplied some notebooks. For future program we would request that a half-dozen three-ringer binders be supplied along with several hundred plastic sheet protectors. It would also be useful to have "DSOG" stationery supplies so that it was not necessary to borrow these items from the ship.

COMMUNICATIONS

The CAMH program was certainly successful, producing a unique, high-quality sidescan dataset that will be supplemented with bathymetry data in the early part of 2002. As a "test" of the DSL-120A's performance, HMRG considers the trip to have been very successful. It was also a good learning experience because larger than normal teams of HMRG personnel were able to interact with DSOG employees through all aspects of DSL120A operations including

hardware testing, system operation and data processing. Obviously the two teams worked together effectively enough to produce some very wonderful data. Just as obvious is the area where DSOG and HMRG interactions could be most improved: communications. It was clear from the outset of the program that HMRG personnel and DSOG personnel had very different expectations of the other group's role on the field program . These are issues that will need to be discussed and resolved as the collaborative relationship between the two groups develops during the coming year and in subsequent at-sea operations.

Post-cruise, we have already discussed and begun to implement some of the changes that will hopefully improve the communications between the two groups so that interactions for future field programs continue to improve. A clearer understanding prior to each field program of who will be doing what, and especially who has the ultimate authority to make command decisions, seems a logical extension of the more frequent conferences and face-to-face meetings that DSOG and HMRG are already planning to have.

RECOMMENDATIONS

HMRG makes the following specific recommendations for tasks to be accomplished prior to the next DSL-120A survey. Tasks are listed roughly in the order they should occur.

- HMRG to correct minor problems with sidescan charts delivered to principal investigators
- HMRG to perform bathymetry processing and data quality analysis
- DSOG to perform roll, pitch, heading analysis for Octans
- HMRG to identify and fix cause of incoherent and "flipped" pings
- DSOG to fix PARO depth sensor and magnetometer ground fault
- DSOG to implement improved navigation system, either through integration of Doppler sonar (perhaps with M. Rognstad participation) or software solution
- HMRG to improve contrast on real-time Raytheon hard copy
- HMRG to implement faster algorithm for bottom detection
- DSOG/HMRG to test drogue for improving vehicle pitch

ENGINEERING LOG (PROVIDED BY M. ROGNSTAD)

JD 312/1507 - First tow. Noise from power supplies – adjust vehicle voltage to minimize. Interference from magnetometer, maggie shut down. Once on bottom, port side signal level appears low – find one row on port side has no signal. Chief scientists decide to continue line, since sidescan data is priority.

JD 313/2309 - Port side DSP drops out (no data in uplink telemetry) while winching. Cycle power to sonar electronics and reload, fixes dropout.

JD 315/2030 – First tow complete. Test electronics on bench, both row/sides within 1% signal strength. Fabricate adapter from internal rack end connector to dummy loads, so rack wiring harness can also be tested – also no problem. Pull hydrophones from vehicle, connect through pressure case bulkhead connectors, port side problem returns. (Injecting acoustic signal into hydrophones using Sunwest Technologies Acoustic Test Probe works very well – also useful for detecting transmit operation of sonar.) Discover problem – signal pins heatshrinked together

when internal rack end connector installed in San Diego; heatshrink tubing pulled pins together, shorting out signal. Reworked with heatshrink tubing around each pin and wire.

JD 316/1539 – Second tow. Ground fault trips repeatedly when sonar powered up for deck check; Electronics pulled out, ground fault goes away on bench. Back in vehicle, some GFI tripping at first, after warming up goes away. Condensation? Alvin folks rig dry nitrogen line for purging bottle. In water, vehicle power GUI indicates maggie ground fault, corresponds with noise in sonar record – vehicle recovered. Can't reproduce ground fault on deck with salt water washdown or dipping maggie in bucket.

JD 317/0953 – Third tow. Still have maggie ground fault, but getting good maggie data. Sonar noise associated with maggie, adjust vehicle voltage to minimize.

JD 317/1318 – Starboard DSP data stream drops out, does not respond to downlink commands. Cycle sonar power, reload; fails again within a few minutes. After restarting a few times, leave sonar transmit power at –6dB setting, failures stop.

JD318 – Starboard DSP still locking up periodically. Continuing to cycle power and restart.

JD 320/0906 – End of third tow. Discover attitude data being logged in sonar files was coming from Crossbow, not Octans during last tow. To diagnose starboard DSP dropout problem, run vehicle on deck at full power into dummy load for 2 hours - no lockup; terminate when internal temperature (on power GUI) reaches 37 C. Swap out DSP board on starboard with spare – new board sometimes shows speckle noise, although cycling power can make noise go away. Bob discovers that light meter has flooded, causing maggie ground fault, since it is powered by same Vicor as maggie.

JD 321/0330 – Fourth tow. Noise while lowering when pitch hits ~0 degrees on typical excursions from –40 to 0 degrees – looks like a burst of noise for one or two pings. Suspect cable pinching at vehicle, but no telemetry errors reported by Prizm monitor.

JD 321/1508 - end of line, recovering vehicle. Near end of tow when winching in, intermittent herringbone noise in sonar data, some noise bursts on pitch excursions; herringbone goes away when CTD and Crossbow turned off, but background noise increases significantly. Noise is reduced when winch stopped, goes away when paying out again.

Data processors discover that for the last tow, no navigation data was logged in sonar files. Watch standers are logging nav data from navigation computer, not from sonar computer, so they didn't notice numbers not changing. It is not known why nav data stream wasn't being sent. Data processors noticed apparent cross talk at one point, but only during very low signal part of swath. Also, ping flipping, unflipping code not working – does not have correct offset for this system – programmer back home is correcting.

Offset noticed in depth readings from Paroscientific and SeaBeam during earlier tows. Bob, Pete, and Gary checked Paro with pressure source; Bob discovered it was set to compute depth with coefficients for fresh instead of salt water. We also find that the power GUI subtracts atmospheric offset, since zeroing gauge internally on deck displays –9.4 m on GUI. While finishing up these tests, thought we found major drifting in Paro offset - turned out the folks on deck had deployed without telling us in the lab. Quite a surprise!

JD 322/1900 – Fifth tow. All the way down, very little noise in sonar data, but after stopping winch near bottom, spike/sparkle noise starts up on starboard side. Try winch/no winch, turn on and off CTD, Crossbow, Octans, Mag; no difference. Changing transmit power seems to transiently reduce noise, but not eliminate it; cycling power would give lots of noise until transmit power turned up, then slowly returning noise after. Changed vehicle voltage, finally noise stopped at 240 V. (At this voltage and at full transmit power, cap chargers are on all the time.)

JD 3230/225 - Starboard side noise comes back. Changing transmit power and waveform, vehicle voltage, no improvement; cycle sonar power, noise gone.

JD 324/0043 - End of fifth tow.

JD 324/1145 - Begin sixth tow.

JD 325/1405 - Noise stripes seen in sonar data; cycle sonar power, stripes gone, still some speckles.

JD 325/0412 - End sixth tow.

JD 325/1510 – Start seventh tow. Some Doppler tests during first part of lowering; interference with sonar seen.

JD 325/2312 – Octans stops working; Octans power cycled, comes up okay.

JD 326/1544 – End of line, recovering.

JD 328/0922 – Start eighth tow.

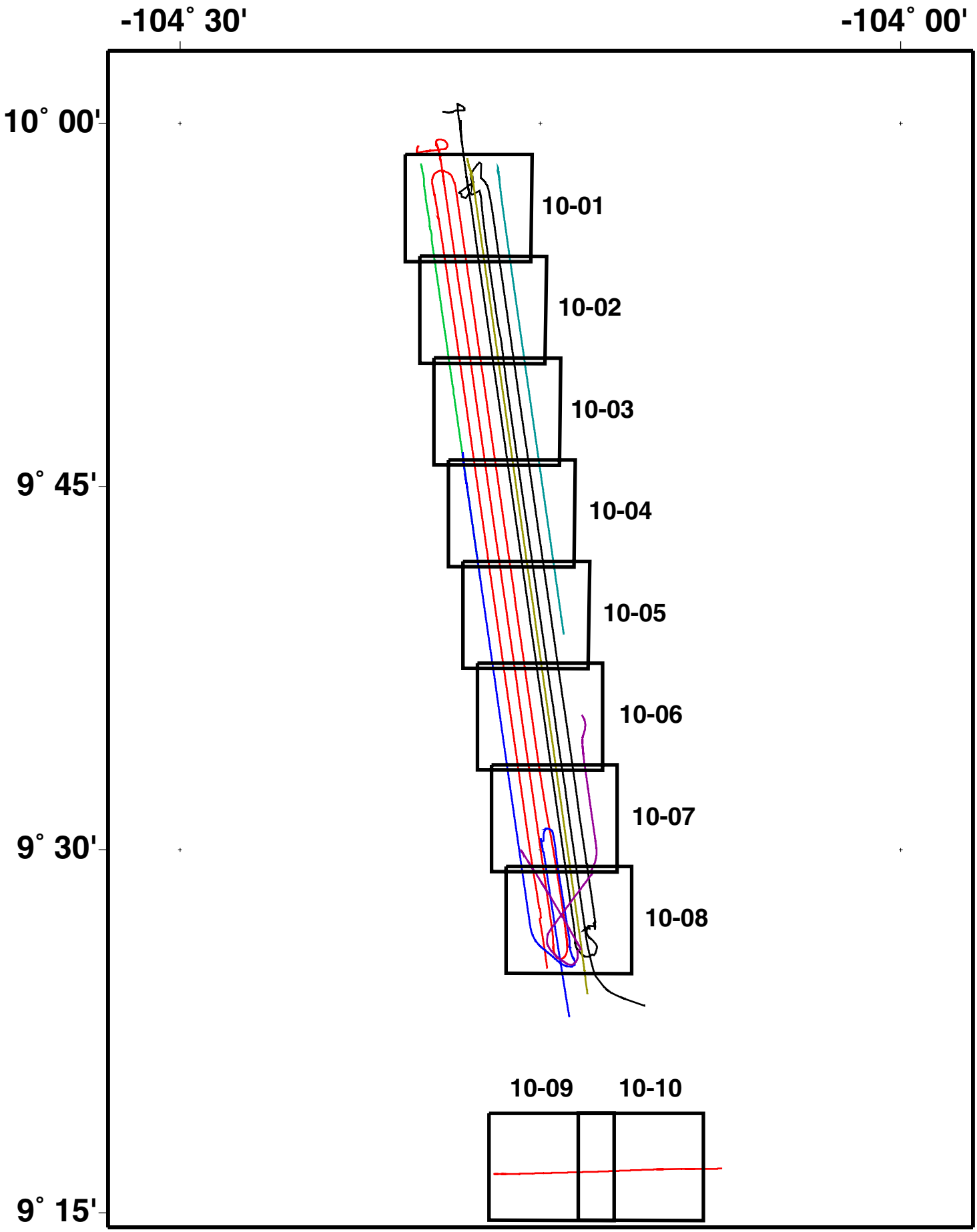
JD 328/1151 - Speckle noise starts up, doesn't go away with power cycle/reload. Margo demonstrates her technique – power cycle with transmit power on, speckle noise stops.

JD 329/0003 – End of eighth tow.

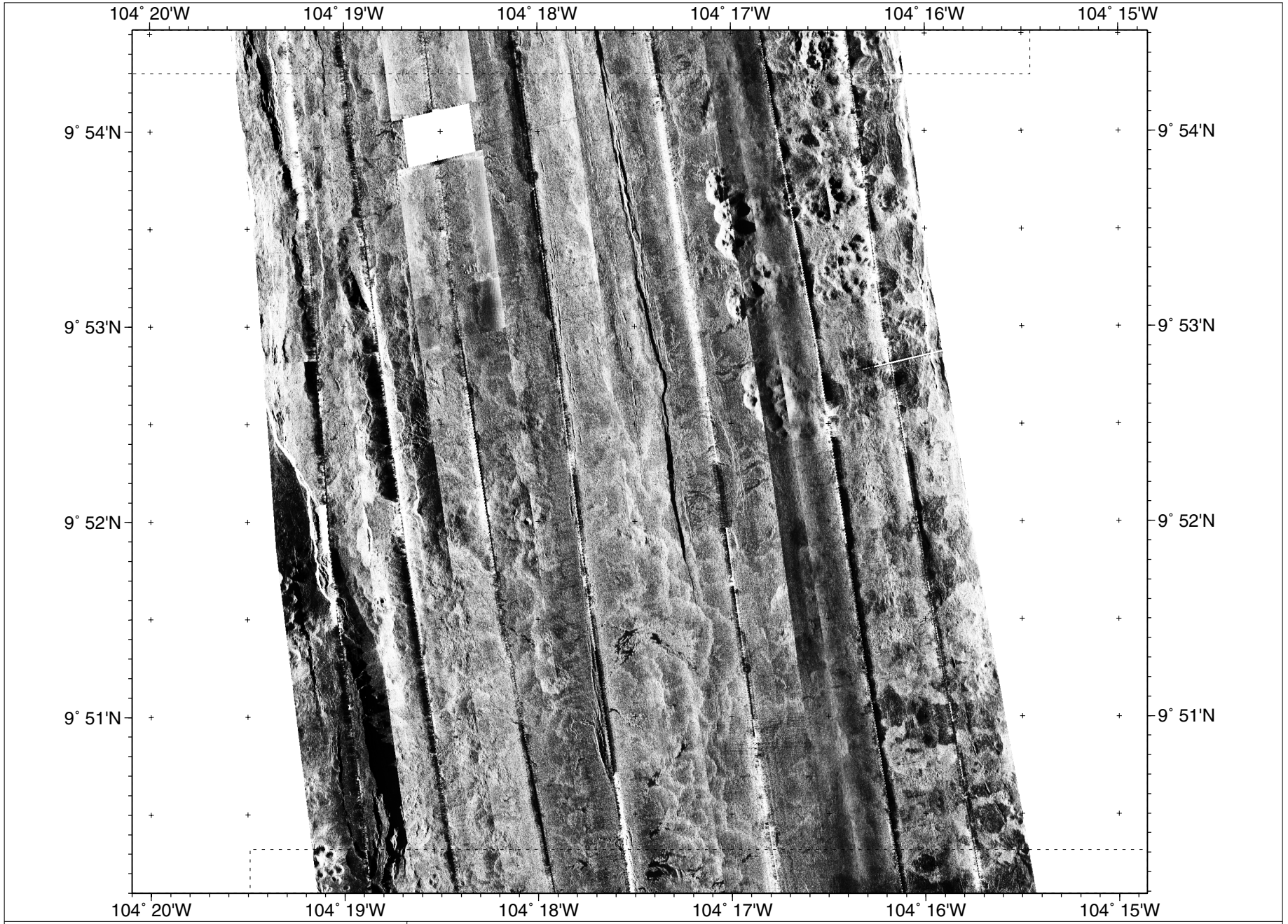
JD 329/1633 – Start of ninth tow.

JD 329/1841 – Sonar not seeing bottom. Discover low speed control telemetry not working, command to transmit never received by fish. Cycle vehicle power, telemetry works, sonar starts transmitting.

JD 330/0122 – End of ninth tow.



Appendix 3 - Fig1 DSL-120A chart boxes for AT7-4 cruise



SURVEY AT-74
DSL-120a ACOUSTIC IMAGERY

Dr. Hans Schouten, Chief Scientist
November - December 2001 - R/V *Atlantis*

Chart at7-4-10-02

Shipboard Preliminary
Acoustic backscatter imagery
Grid size: 4.2 m Ellipsoid: WGS-84

Universal Transverse Mercator Projection
Scale: 1:47500 UTM Zone 13
nautical miles
0 0 kilometers 1 1
Backscatter Magnitude
low high

10.0
9.5
-104.5 -104.0

HAWAI'I MAPPING RESEARCH GROUP

Appendix 3 - Fig2 Example of DSL-120A sidescan sonar imagery from AT7-4 cruise.