Ewing 03-09

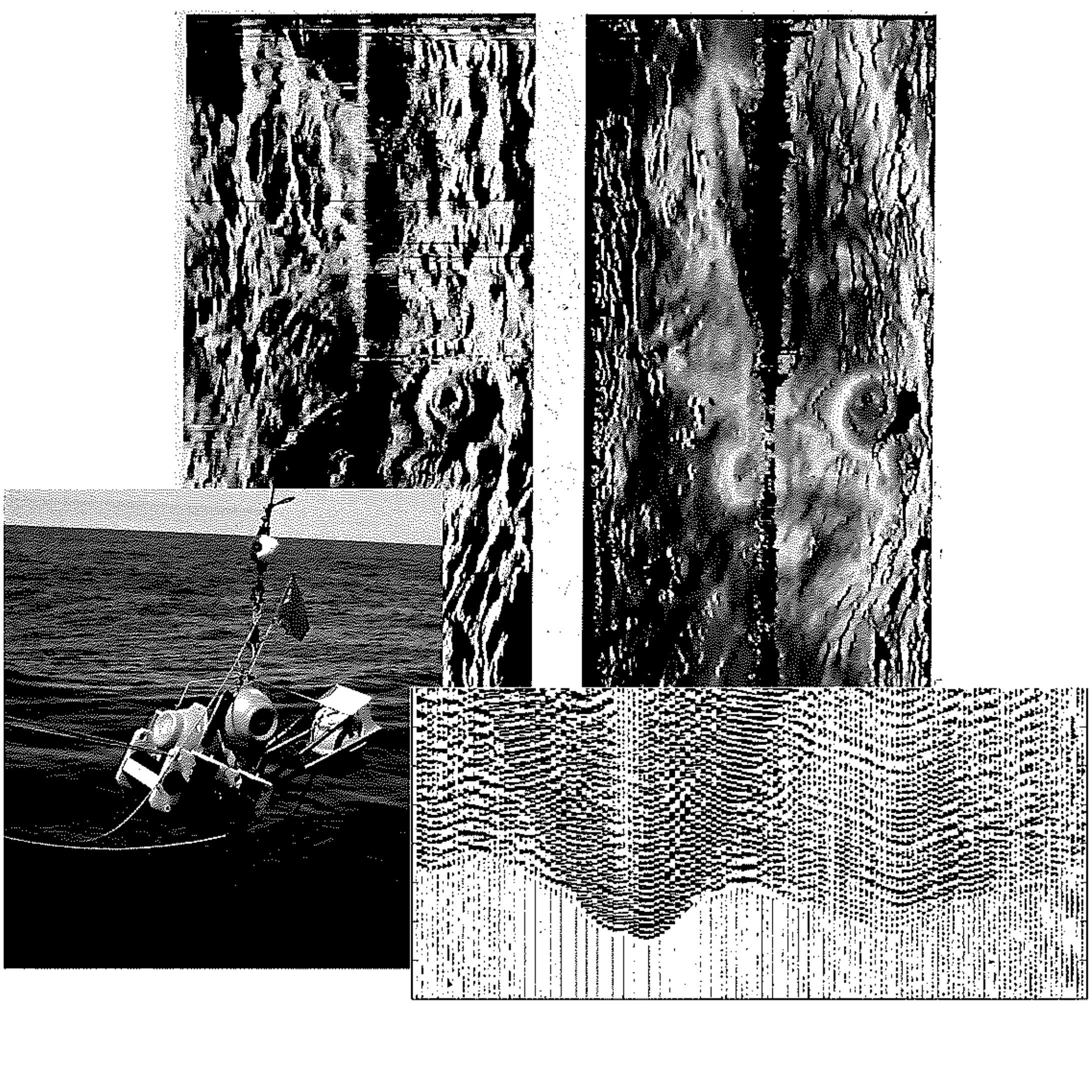
Seismicity and Fluid Flow of the TAG Hydrothermal Mound -2: Seismic Refraction Study of the TAG Segment

Cruise Report

STAG Leg 2

R/V Maurice Ewing EW03-09

October 24 - November 9, 2003



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Chief Scientist: J. Pablo Canales
Co-Chief Scientist: Robert Reves-Sohn

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1. Summary

From October 24th to November 9th, 2003, *R/V Maurice Ewing* cruise EW03-09 conducted a geophysical investigation of the TAG segment on the Mid-Atlantic Ridge, between latitudes 25° 50'N and 26° 25'N. This cruise is the second leg (STAG-II) of a three-leg geophysical experiment devoted to understand the relationships between earthquake activity near a hydrothermal system, exit fluid temperatures, tidal pressures, crustal structure, and tectonic setting.

The first leg STAG-I was conducted aboard the *R/V Atlantis* (Voyage 7-36) in June-July 2003, with the primary objective of deploying a long-term monitoring network of temperature probes on the TAG mound and 13 Ocean Bottom Seismometers (OBS) for earthquake monitoring. The third and last leg (STAG-III) will be conducted in 2004 to recover the temperature probes and the OBS network.

During this second leg (STAG-II) we conducted a marine wide-angle seismic experiment to determine the seismic crustal structure of the TAG segment. Seventeen OBSs were deployed along three profiles in two separate deployments. The instruments recorded the seismic signals produced by the *Ewing*'s 20-airgun array. After recovery of the instruments data were archived to CD, converted to the standard SEGY format in receiver-gather files, and printed for quality-control purposes and preliminary assessment of the crustal structure.

During this cruise we also tested a prototype of seafloor compliance sensor being developed at Lamont-Doherty Earth Observatory. Multibeam bathymetry and gravity data were continuously acquired during the cruise.

2. Cruise Objectives

One of the primary objectives of the STAG experiment is to determine the location and nature of the heat source that is driving hydrothermal convection at the TAG site. With respect to location, there are two competing models for the heat source for the TAG active mound. One model places the heat source in the neovolcanic zone, such that fluid flow pathways are provided by the axis-parallel normal faults (which may become listric at depth) associated with the eastern valley wall. The alternative model calls on discrete volcanic centers to act as the heat source for localized hydrothermal activity, and places the heat source much closer to, and essentially directly beneath the TAG active mound. With respect to the character of the heat source, there are again two competing models for the TAG system. Heat to drive hydrothermal circulation can be derived from either the extraction of latent heat of crystallization from magma chambers, or the extraction of specific heat from hot rocks across downward-migrating cracking fronts. The heat source in the former case is a discrete magma reservoir, whereas in the latter case it is a more broadly distributed zone of hot lower crust.

In principle, both of these fundamental questions can be addressed by determining the seismic crustal structure of the TAG segment, and that is the specific objective of the active source seismic refraction survey conducted during STAG Leg 2. We seek to determine the along- and across-axis seismic structure of the TAG segment and to delineate the size, magnitude, and position of any crustal low-velocity zones that would indicate the presence of discrete magma reservoirs or hot plutonic features that are providing heat to drive hydrothermal circulation at the TAG mound. Secondary objectives include investigating the shallow seismic structure directly beneath the TAG mound as a means of potentially imaging subsurface mineral deposition, and using segment-scale variations in seismic velocity to illuminate the local crustal accretion processes (e.g., crustal thinning at segment tips, core complex formation, etc.). As a practical matter, the velocity models derived from the refraction experiment will also be used to locate earthquakes detected during the passive seismic deployment.

To achieve the above-mentioned scientific objectives and determine the seismic crustal structure of the TAG segment, we have conducted a 6-day wide-angle seismic experiment. The wide-angle data were recorded by 10 LDEO Ocean Bottom Seismometers (OBS). The seismic source was the Ewing's 8760 c.i. 20-gun array fired every 350 m (shot spacing for Lines 6 and 7 was 150 m). The specific operational goals of the cruise are:

- Two deployments of OBS (10 + 8 instruments); produce SEGY archive files of all OBS data; and plot record sections.
- Two deployments of a compliance-meter prototype for testing purposes.
- Acquire underway Hydrosweep multibeam bathymetry and gravity data.

3. Cruise Narrative

JD 297, Friday, October 24, 2003 – The *R/V Maurice Ewing* arrived to San Juan, Puerto Rico, at 08:30L. The science party arrived to the ship at 09:30L. Immediately after, the container with the LDEO OBS was put on the *Ewing's* B-deck. During the day the container was unloaded, and the OBS instrumentation set up in the dry lab. The frames were assembled on the D-deck. The OBS sensors were tested for possible damage during transportation, and the 12 of them were found to be OK. The Ewing left San Juan at 20:00L; underway at 11.5 kts for TAG area, good weather.

JD 298, Saturday, October 25, 2003 – Continuing transit to TAG. ETA: 16:00-20:00L on Wednesday, Oct. 29th. We held a science meeting summarizing the scientific objectives and the science plan and deployments. Meike Holst, the chief Marine Mammal Observer (MMO), explained the marine mammal mitigation procedures approved for cruise EW09-03, which are detailed in the Incidental Harassment Authorization (IHA) (see Appendix).

In summary, the IHA specifies that the safety radius at 180 dB, for cruise EW03-09, has been established at 1350 m. In the event of approaching a marine mammal while operating the airgun array, we will power down the array to only 1 gun firing. Before the start of airgun operations, a 30-minute observation will be conducted. If the area is safe, shooting will start with one gun, ramping-up to the full volume. Airgun shooting cannot start during dark hours since the night-vision equipment of the MMO's only works for distances <200 m, smaller than the safety radius.

Johnny DiBernardo (Chief Gunner), Meike Holst (Chief MMO), and J. Pablo Canales (Chief scientist) met to go over the airgun array configuration. Pablo asked to have the same configuration that was used during cruise EW00-04 (Galápagos Spreading Center), with a total volume of 8755 c.i. Johnny had a slightly different configuration already set up, with a total volume of ~8450 c.i., but said it was no problem to change it. Meike mentioned that she was expecting the configuration used to do the calibration of the array for marine mammals in the Gulf of Mexico (total volume of 8575 c.i.). Since the IHA only restricts the number of airguns of the array (no more than 20), but not the total volume of the array, we all agreed to set up the EW00-04 configuration.

JD 299, Sunday, October 26, 2003 - Continuing transit to TAG at 10.5 kts; good weather. Patrick Jonke (OBS Chief engineer) and Pablo go over the format of the data that the OBS group will produce. We identify the headers that need to be changed so John Collins' *psegygather* program can be used to construct the receiver-gather files. During the 4 days of transits the senior scientists will give a lecture on different topics related to the experiment. Pablo gave a lecture on seismic structure of the Mid-Atlantic Ridge.

JD 300, Monday, October 27, 2003 - Continuing transit to TAG at 11 kts; good weather. We expect to arrive on Wednesday, Oct. 29th, at 16:40. Spahr Webb gives a lecture on "Ocean Bottom Instrumentation".

JD 301, Tuesday, October 28, 2003 – We start the day with good weather, transiting at 11 kts. Rob Reves-Sohn gives a lecture on seismicity of hydrothermal systems. We hold a science meeting to go over the procedures and duties for the watch-standers. During the afternoon the wind starts to pick up. By 17:00L wind speed is 25 kts, with 4-5 feet waves. We reduce speed to 7.5 kts. If continue transiting at this speed, our arrival to the site will be delayed by ~12 hours.

JD 302, Wednesday, October 29, 2003 – During the night winds were 25-30 kts. By midday the weather improves slightly, and we increase the transit speed to 9.5 kts. Wayne Crawford gives a lecture on seafloor compliance. ETA: midnight.

JD 303, Thursday, October 30, 2003 – Watches start at 00:00L. At 04:26Z we deployed the first instrument (OBS-1, Celeste). It started to sink very slowly (<20 m/min), so for the next instruments they will add more weight. We stayed on station for about an hour, and then moved to the next site before it reached the bottom. OBS-2 (Grover) was deployed at 06:42Z. We monitored the sinking of both OBS-1 and 2 from this site. When OBS-1 reached the bottom its transducer was disabled, and then we moved to the next station. This procedure allowed us to speed up the deployment, since the sites were close enough that we could acoustically communicate with two instruments from one site; we did this for the rest of the instruments. OBS-3 (Elroy) was deployed 08:29Z. OBS-4 (Fabio) was deployed at 10:47Z.

The next instrument that was deployed was the prototype of compliance-meter, site C1, at 13:30Z. OBS-9 (Francis) was deployed at 15:47Z. OBS-10 (Joseph) was deployed at 17:39Z. We then headed back to the compliance site (C1). The compliance-meter would send a series of acoustics signal verifying that it has leveled itself and balanced the masses. The communication with the instrument confirms that it has balanced successfully; it was disabled. OBS-5 (Bubbles) deployed at 22:40Z. We had problems with the acoustic unit communicating to this instrument. We switched to a second unit without success. The third attempt was using the EdgeTech transducer over the side, which worked fine after 30 min. of attempting communication. OBS-6 (Tito) deployed at 02:12Z (JD 304).

JD 304, Friday, October 31, 2003 – We continued the deployments during the night without incident. OBS-7 (Natasha) was deployed at 04:01Z, and OBS-8 (Boris) at 05:39Z. At 08:45Z we started the deployment of the airgun array, and the MMO's started their half-hour observation period prior to airgun operations. By 09:30Z the MMO's declared the area safe for shooting, and we started the ramp-up of the guns. We were finally shooting at full volume at 10:10Z. The science officer and computer techs could not program *Spectra* for a shooting rate of 150 s. After several attempts to force Spectra to trigger the guns by time, we decided to shoot by distance, every 350 meters. This allowed us to introduce randomization in the shot time to minimize noise generated by previous-shot, water-column reverberations.

The first line (Line 2) was finished at 14:00Z. One of the drawbacks of using Spectra to trigger the airguns is that it can only shoot in a pre-defined line. In order to keep the guns shooting during the turns and change of lines to avoid the need of ramp-up, the triggering system has to be switched to "cycle". This will trigger the guns by time (we chose 90 s), but the shot information (lat, lon, time) is not logged.

After switching to "cycle", the PC controlling the guns hung. It took half hour to restart, so we had to do a ramp-up. At 14:57Z we were shooting at full volume, and we started Line 4 (transit between the across-axis Line 2 and the axis-parallel Line 1). We did not increase the shot# at the beginning of Line 4; therefore there will be repeated shot numbers in Line 2 and 4. For processing the data we will have to renumber the shots of Line 2, for example, by adding 300 to the shot number. Line 1 was started at 18:46Z, and Spectra displayed error messages. Apparently it was receiving navigation fixes way off where we were supposed to be, so the shot information was not being logged. We lost the first ~15 shots of Line 1 until Ethan solved the problem. Line 1 was finished at 01:57Z (JD 305), and we started to bring back the guns.

JD 305, Saturday, November 1, 2003 – We started the recovery of the instruments at 04:00Z. OBS-8 (Boris) was released at 04:00Z, and was on board the 06:48Z. OBS-7 (Natasha) released at 07:30Z, on board at 09:30Z. OBS-6 (Tito) released at 10:40Z, on board at 12:26Z. OBS-5 (Bubbles) released at 12:50Z, on board at 14:48Z. Compliance-meter C-1 released at 15:30Z, on board at 17:19Z.

At this moment we decided to try to gain some time by alternating the rest of the recoveries with deployments for the next OBS deployment, since the sites are not far apart. We started the deployment of OBS-14 (Boris) at 18:52Z. We then continued with the recovering of OBS-4 (Fabio), which was on board at 22:33Z. From that site we confirmed that OBS-14 was on the bottom and disable it at 22:58Z. We then deployed OBS-13 (Natasha) at 23:34Z, and OBS-12 (Tito) at 01:23Z (JD 306). After that we proceeded to recover OBS-3 (Elroy), which was released at 02:25. While it was rising, we disabled OBS-13.

JD 306, Sunday, November 2, 2003 – OBS-3 on board at 04:06Z. Next operation was to recover OBS-2 (Grover). It was released at 04:30Z, and was on board at 07:36Z. Apparently OBS-2 only dropped one of the anchors, the second one fell off during the recovery. We then proceed to recover OBS-1 (Celeste). Celeste acknowledged both releases, but it did not leave the bottom. After several hours of waiting the instrument was still on the bottom, so we decide to continue with the deployments.

OBS-11 (Bubbles) was deployed at 10:28Z. While monitoring the descent of Bubbles, we received communication from OBS-1 Celeste that it was rising to the surface. We went back to Site 1 and wait for Celeste to arrive to the surface. The ascending rate was slow, probably because it still had one of the anchors. We used the EdgeTech unit to send a release command again hoping it would drop off the second anchor and rise more rapidly. Accidentally, we sent a release command to the instrument we just had deployed (OBS-11, Bubbles), but it did not acknowledge the release. OBS-1 was on board at 12:54Z.

We then head back to site OBS-11. Unfortunately we found that OBS-11 had dropped the anchors and was rising back to the surface. At this moment we decided to recover the instrument and not deploy it again at this site, due to the time constraints. OBS-11 Bubbles was on board after the failed deployment at 14:35Z. The instrument Bubbles was used for the next deployment at site 15.

OBS-15 (Bubbles) was deployed at 16:29Z. We did not wait to reach the bottom, we will come back later to disable it after deploying 2 more OBS. Our time constraint is to have one gun in the water firing before darkness, which is 17:30L. We cannot wait to start shooting the next morning; if we did we would not have time to complete the shooting lines and recover all the instruments in time for our departure to Bermuda. Therefore we will have time to deploy only 2 more OBS. This deployment will have 2 OBS less than we had planned (both at both ends of Line 3): one missed site because of the accidental release of OBS-11, and another one due to the constraints imposed by the IHA rules.

OBS-16 (Fabio) was deployed at 17:43Z, and OBS-17 (Grover) at 18:57Z. We then headed back to Site 15 to disable OBS-15. We put one gun on the water and started shooting at 20:06Z after the MMO's declared the area safe. With one gun shooting we passed over Sites 16 and 17, and we were able to confirm that both instruments were in the bottom and disable them on the way. The deployment of the full airgun array started at 21:12Z, and the ramp-up at 21:40Z. Shooting at full volume on Line 3 (shot spacing 350 m) started at 00:24Z (JD 307).

JD 307, Monday, November 3, 2003 – Line 3 was finished at 07:38Z. Line 5 started at 09:15Z, and finished at 13:06Z. For the next Line 6 we changed the shot spacing to 150 m. Line 6 (composed of 3 segments) started at 13:26Z. After the turn to start the 3rd segment of Line 6 Spectra stopped shooting. We defined the last segment as a new line (Line 7) and continued shooting. We lost 14 shots at the beginning of Line 7, which finished at 16:38Z.

Guns were all back on board at 17:37Z, and the OBS recovery started. OBS-12 (Tito) on board at 20:42Z. OBS-13 (Natasha) on board at 23:16Z. OBS-14 (Boris) on board at 00:59Z (JD 308).

JD 308, Tuesday, November 4, 2003 – OBS-9 (Francis) was recovered at 03:08Z. Apparently the sensor ball did not deployed properly, it was still hanging from the arm when the recovery started. Later inspection of the data showed that despite not having the sensor coupled with the seafloor, OBS-9 recorded reasonably good data. OBS-10 (Joseph), on board at 04:27Z; OBS-15 (Bubbles) at 06:38Z; OBS-16 (Fabio) at 08:27Z, and the last instrument OBS-17 (Grover) on board at 10:01Z. The recovery went much faster and smooth than expected. We averaged less than 2 hours per instrument, while we had expected at least 3 hours (after how things went in the first deployment). This left us with 16 hours of science before the "end of science" time requested by Captain (midnight). We decided to run a *Hydrosweep* survey to fill gaps on the multibeam bathymetry coverage on the flanks of the TAG segment. We run 4 flow-parallel lines extending ~30 km off axis. At 11:00L we finished the survey, and got underway 1 hour prior to Captain's request.

4. Preliminary Cruise Assessment

The *R/V Maurice Ewing* is an excellent vessel to carry out marine seismic research. Its crew and science technicians are very well prepared to face the challenges of marine seismic experiments. We are thankful to all of them for their dedication and support, and helping accommodate the needs of the scientific party. We are especially grateful to Captain Landow and the three mates Stan Zeigler, Shank Bhardwaj, and Mellanie Lovercheck for their excellent skills handling the ship and patience with our many changes of plans during the cruise.

4.1. OBS Deployments

The operations of deployment and recovery of the instruments went very well. Only one deployment out of seventeen failed (OBS site 11). OBS-11 was accidentally released as it sunk, and had to be recovered. The site was abandoned without deploying an instrument because of time constraints (see Narrative for more details).

The LDEO OBS Team was responsible for the operations and handling of the instruments, assisted by the ship's technical personnel Ted Koczynski and Jack Greenberg to operate the starboard winch, and a watch-stander on the tag lines. We were expecting descending and rising velocities in the order of 45-50 m/minute. However during the first deployment we found that the instruments were sinking and rising at rates of 25-30 m/min. This had a significant impact on the duration of the deployment/recovery operations, forcing us to use all the contingency time we had budgeted in order to achieve 100% of the operational goals. It is recommended that the LDEO OBSIP Group increase the weight of the anchors for faster descend, and improve the buoyancy of the instruments for faster rising. A more detailed report on the OBS performance by the Senior Engineer is given in the Appendices.

4.2. Airgun Operations

The *Ewing's* airgun crew Johnny D, Carlos, Ropate, and Justin did an outstanding job. The deployment and recovery of the guns went very smooth and fast. The performance of the guns was flawless during the cruise. Without doubt, this is in large parte due to their commitment to maintenance cruise after cruise. For cruise EW03-09 the airgun crew set up a configuration of 20 guns with a total volume of 8,760 c.i. (see diagram in Appendices).

Our initial idea was to shoot the guns in time, every 150 s. This firing rate should be enough to allow the noise level to decay to normal background noise levels before each shot, which is important for obtaining good signal-to-noise ratios at large shot-receiver offsets. We also intended to add a 50 ms randomizer to minimize coherent noise generated by water-column reverberations of previous shots. However, neither Ted nor Ethan were able to set the

Spectra software (which controls the gun triggering) with these parameters. We then decided to shoot by distance, every 350 m (~150 s at a nominal speed of 4.5 knots). For the last lines 6 and 7 the shooting interval was 150 meters (these lines are intended to resolve shallow structure).

Spectra only triggers the guns along pre-defined lines. We did not want to stop shooting during the turns and change of lines to avoid having to ramp-up the guns as required by the IHA. Therefore during the turns and change of lines we had to switch to an internal cycling triggering which keeps the guns shooting, but does not log the shots time and/or position. This was not a major setback for us because all of our profiles were straight lines for two-dimensional imaging of the crust. However it is very likely that in coming cruises, scientists will want to obtain three-dimensional images of the crust. That will require a complicated distribution of shots over a surface, and not necessarily along pre-defined straight profiles. Therefore it is highly recommended that *Spectra* is adapted to handle such situation, preferably with shooting by time, or that the triggering by "internal cycle" is updated so the shot time and position is logged.

4.3. Mitigation of Incidental Marine Mammal's Harassment

During cruise EW03-09 we strictly followed the procedures established by the National Marine Fisheries Service's Office of Protected Resources under the Incidental Harassment Authorization (IHA) to mitigate any impact on marine mammals and other protected species that our seismic research may encounter. The IHA is reprinted in the Appendices of this report. Mitigation measures included the following: (1) power- or shut-down of the airguns when a marine mammal was sighted within the safety radius (established at 1350 m for 180 dB) of the 20-gun array, (2) no ramp-up of the airguns at night unless at least one gun had been firing before nightfall, and (3) marine mammal observations during ramp-up and 30 min prior to the start of seismic operations. If the area is safe, shooting will start with one gun, ramping-up to the full volume. Airgun shooting cannot start during dark hours since the night-vision equipment of the marine mammal observers (MMO) only works for distances <200 m, smaller than the safety radius.

Three MMO's (Meike Holst, Sarah Stoltz, and Howie Goldstein) conducted observations from the flying bridge since the beginning of the cruise, from dawn (900 GMT) until dusk (2030 GMT); observations were typically not conducted at night. Observations were made whenever the vessel was moving, whether the airguns were firing or not. A total of 22.5 hrs were surveyed in the study area during periods without airgun activity, and 20.4 hrs were surveyed when the airgun array was operating. Of the 20.4 hrs surveyed during airgun activity, 1 hr of observation occurred at night during ramp-up of the airgun array. No marine mammals were seen during periods with or without seismic in the study area. Therefore, no power- or shut-downs of the airgun array due to marine mammals were necessary. Prior to the start of airgun operations the MMO's observed the zone for 30 minutes, and after their approval we started the gun ramp-up. The ramp-up's took 25 minutes, so we planned our approach to the start of the lines taking this factor into consideration. During shooting, the MMO's were informed promptly of any temporary shut down of any gun.

The cooperation and interaction between the science party and the MMO's was excellent. However we found that the on one occasion the rules established in the IHA had a negative impact on the scientific objectives of this cruise. During the second deployment we operated under the constraint of having to start shooting at least one gun before nightfall. This constraint forced us to abandon one of the planned OBS sites without deploying an instrument. This will impact the resolution and the coverage of our seismic crustal models along Line 3. To avoid such conflicts in the future we recommend that either, (1) the MMO's are equipped with appropriate night-vision devices that reach the safety radius established for each cruise, or (2) the rules be made more flexible such that shooting can start at night in the event that no marine mammals have been observed in the study area for a long period (days?) of time. In cruise EW03-09, the available night-vision equipment had a maximum range of 200 m, insufficient for the safety radius of 1350 m. In addition, not a single marine mammal or other protected specie was detected during the entire duration of the scientific operation. As a result it seems illogical to compromise the scientific objectives when the ostensible risk to marine mammals was non-existent.

4.4. Wide-Angle Seismic Data Quality

Thanks to the efforts of Patrick Jonke, Bernard McKirieren, and Eric Phillips, the performance of the LDEO OBS instruments was excellent. We successfully recovered all of the instruments, after a total of 17 deployments. With the exception of OBS-13 (Natasha), all the sensors worked fine, returning good quality data in at least one channel per instrument (only 2 instruments returned 1 or 2 bad channels). OBS-13 Natasha's disk drive failed to spin up when the data logger attempted to write to it, most likely due to the cold since the batteries and the disk worked fine at room temperature.

The instruments were opened and the data downloaded ~12 hours after recovery, to avoid rapid temperature changes and water condensation. Patrick Jonke performed a quick assessment of the data quality on screen while transcribing the data to PASSCAL-SEGY format. The data was then transferred to the *Ewing*'s UNIX computer *grampus*, where Pablo Canales performed a second assessment of the data quality using the *pql* utility of the PASSCAL software. For each instrument, the complete record of the 3 channels was loaded in *pql* and visually inspected.

After constructing the common-receiver SEGY gather we found that first P-wave arrivals are observed at shot-receiver offsets of up to ~40 km. At larger offsets the seismic energy is highly attenuated. High-amplitude energy is observed in most of the record sections at ~22-28 km offsets. We interpret this energy as PmP, or energy turning within a high velocity zone at the base of the crust. The PmP arrivals do not follow a travel-time curve typical of reflected rays, suggesting that in this area the Moho is a transition zone of a discrete thickness, rather that a sharp seismic boundary. In a few cases the PmP arrivals are observed at smaller offsets (15 km), indicating the presence of very thin magmatic crust at the segment ends. In some of the record sections we observed that energy coming from shots above or immediately to the south of the TAG hydrothermal mound is highly attenuated, suggesting high temperatures and possibly the presence of magmatic fluid in the mid- to lower crust beneath the mound.

4.5. Seafloor Compliance Sensor Prototype

We deployed a prototype seafloor compliance sensor for two days at site C1. A compliance meter is an autonomous instrument capable of measuring seafloor pressure signals down to 10 Pa^2/Hz and acceleration signals down to 10^{-17} $(m/s^2)^2/Hz$ between 0.002-0.1 Hz. The tested sensor uses a differential pressure gauge to measure pressure and a Guralp CMG-3 broadband seismometer to measure acceleration. The seismometer sits in a separate glass sphere that is dropped from (but tethered to) the instrument frame at the seafloor. Before the seismometer can start to record, it must be leveled, its beams unclamped and its masses centered. The goals of this test were to evaluate

the ability of the instrument to perform these sequences.

the ability of the instrument to communicate acoustically from the seafloor in case there is a problem with one of these steps

the ease of setting up and deploying, and redeploying the instrument

the ease of communicating with the instrument while it is at the seafloor, to determine if it is making a good measurement

the data quality in the Atlantic Ocean, which may have relatively small source wave energy.

We had hoped to make two deployments, correcting any problems observed on the first deployment during the second, but there was only time for one deployment. Figure 4.5.1 shows the recorded pressure and acceleration time series. The vertical signal was on-scale throughout the experiment (Figure 4.5.1, bottom trace), but the horizontals are off-scale and there is no DPG signal. The DPG was a new, untested unit and we suspect that it was incorrectly wired. We have never had a tested DPG fail, so this problem should be easy to identify and correct.

Power spectral densities from the vertical component (Figure 4.5.2, solid lines) show high noise below 0.03 Hz. Even the quietest data intervals were much noisier than both the instrument noise floor (Figure 4.5.2, dashed line) and the predicted compliance signal level of $\sim 10^{-16}$ $(m/s^2)^2/Hz$ at frequencies below 0.03 Hz. The spectral level is also high at frequencies above 0.1 Hz, but this is probably real seafloor motion because the shape of the peak at 0.1 Hz corresponds well to a seafloor microseism peak.

The low-frequency noise looks like tilt noise on a buoyantly unstable sensor package pushed by tidally driven currents. The noise levels have a 24-hour periodicity, indicating a tidal source. The much higher noise levels on the horizontals indicate that the noise is tilt-induced. We have observed similar records from previous compliance deployments on rocky seafloors, where a too-light instrument couples poorly with an uneven surface. If the sensor has a strong righting moment and lands on a locally sloped surface, the "downhill" end of the sensor may even float up in the water, making the instrument very sensitive to pushing by currents. Increasing the sensor's weight in water and reducing its righting moment should reduce noise levels to below the compliance signal level.

We also see "steps" on the horizontal signals (Figure 4.5.3). These steps may be caused by software-driven mass re-centering or sensor re-leveling. The source of these steps must be identified to allow an important correction to the vertical signal (Crawford and Webb, BSSA 2000). A channel containing status about the instrument levels, mass positions, re-leveling events, etc. would be very useful for determining the source of these and any future problems.

In summary, the instrument should be able to measure compliance, but the TAG measurement is too noisy. The seismometer sphere was probably not stably coupled to the seafloor. A similar problem on a previous compliance sensor was corrected by making the sensor package heavier and reducing its righting moment. Adding weight to the sensor anchor and adding short "legs" should increase its stability. The stability of the current configuration and the effect of the proposed changes should be evaluated in a test pool.

Other suggestions for improving the sensor are: The software should look at (and readjust, if necessary) the levels and mass positions more often. The instrument should send its status information acoustically on request, not just at a pre-specified time. Between deployments, one should be able to download data and set the times for a future deployment without opening the sensor, so that the instrument can be redeployed within 1-2 hours of recovery. The DPG should be tested prior to deployment by pressing on the membrane, then looking at the recorded signal.

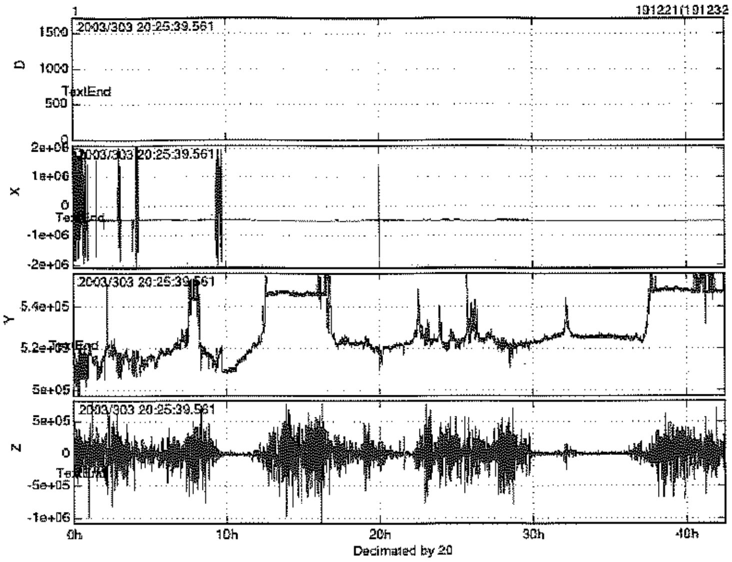

Figure 4.5.1: Pressure and velocity time series from the compliance sensor. Top row = Differential pressure gauge, second and third rows = horizontals, bottom row = vertical channel.

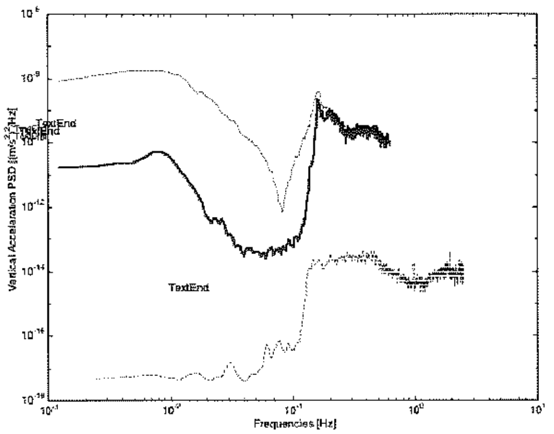

Figure 4.5.2: STAG deployment vertical seismometer spectral levels (solid lines: thin=quietest, thick=average). Dashed line shows seismic signal measured by the same instrument in a seismic vault at LDEO, providing an upper bound on the inherent instrument noise level.

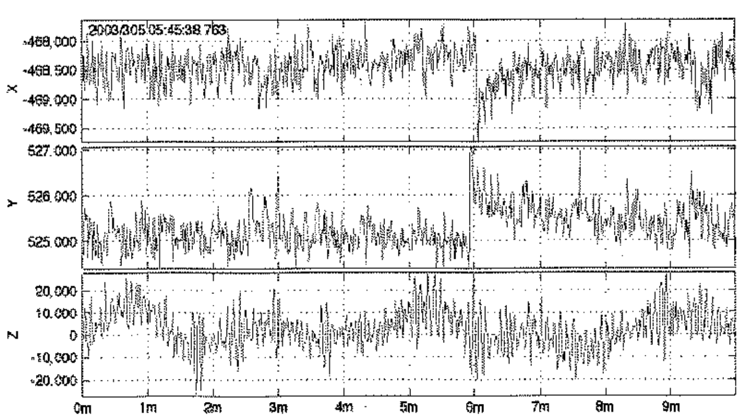

Figure 4.5.3: A 10-minute section of seismometer signals from one of the quietest data sections.

APPENDICES

A.1. Scientific Complement and Ship's Crew for EW03-09

Scientific Party

Name	Position	Address	E-mail
J.Pablo Canales	Chief scientist	Dept. Geology & Geophysics Woods Hole Oceanographic Institution 360 Woods Hole Rd Woods Hole MA 02543 USA	jpcanales@whoi.edu
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Patrick Jonke	OBS Chief engineer	OBS Lab Lamont-Doherty Earth Observatory 61 RT 9W Palisades, NY 10964 USA	pjonke@ldeo.columbia.edu
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Alex Chappell	Graduate Research Assistant	17 Redcar Avenue, Bobblestock, Hereford, Herefordshire, HR4 9TJ. England UK	alex_chappell@hotmail.com
Andrew Delorey	Graduate Research Assistant	723 Hausten St. #104 Honolulu, HI 96826 USA	delorey@hawaii.edu
Katarina Jovanovic	Graduate Research Assistant	Department of Geosciences University of Houston 4800 Calhoun Rd. SR1 Rm. 312 Houston, TX, 77204 USA	katarina.jovanovic@mail.uh.edu
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Genevieve Parent	Under-graduate Research Assistant	779 Marie D'abancourt Beauport, Qc, Canada G1C 7L8	geparent@ggl.ulaval.ca

Ship's Science Technician List

Name	Position
Theodore A. Koczynski	Science officer
Ethan Gold	System manager
John D. DiBernardo	Chief gunner
Carlos D. Gutierrez	Sr. gunner
Ropate Maiwiriwiri	Gunner
Justin M. Walsh	Gunner
Jacob H. Greenberg	Technician
Shin Ae Tassia	Technician

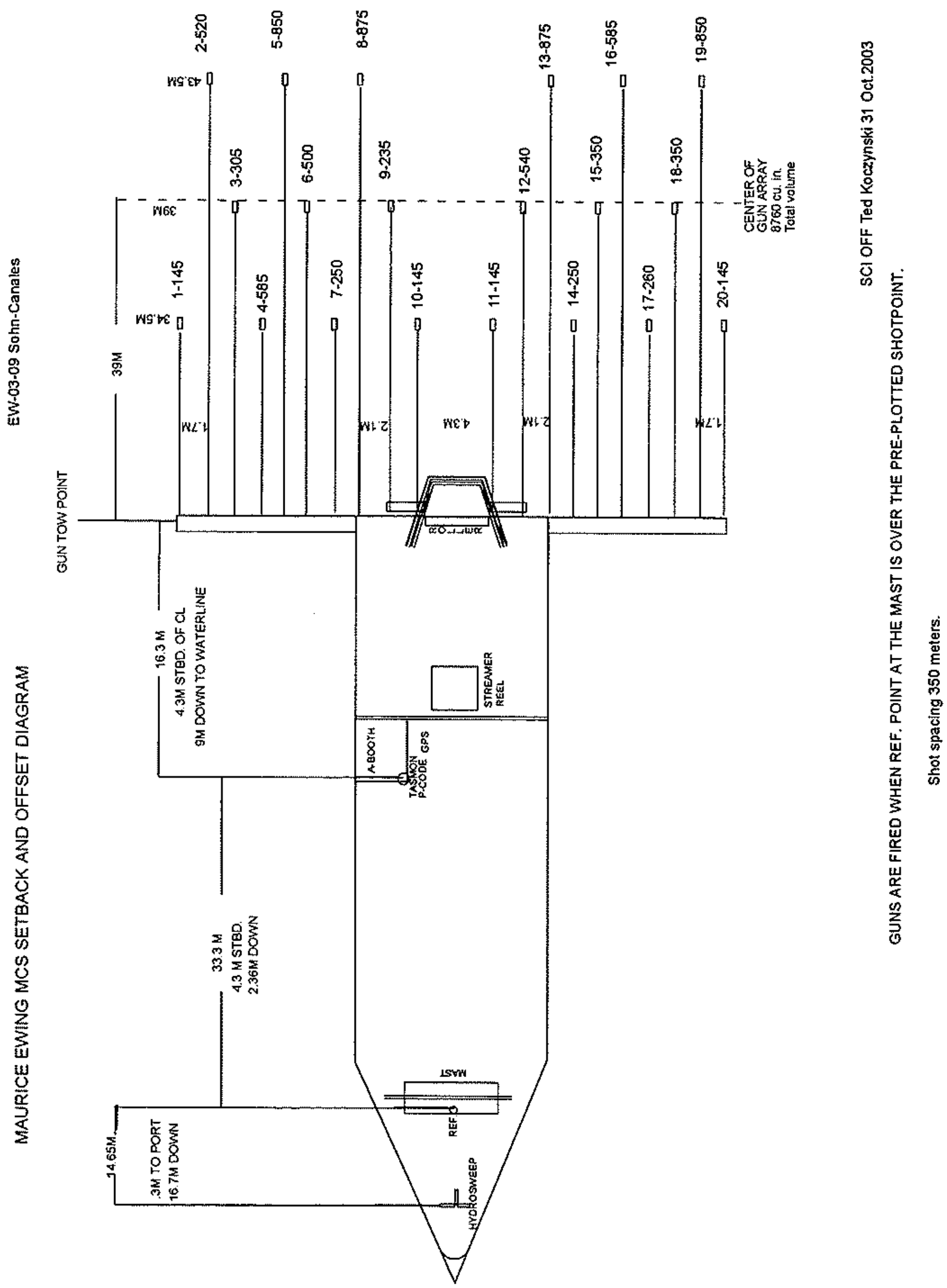
Marine Mammal Observers

Name	Position
Meike Holst	Chief MMO
Sarah Stoltz	MMO
Howie Goldstein	MMO

Crew List

Name	Position
Mark C. Landow	Master
Stanley P. Zeigler	Chief Mate
Shankar Bhardwaj	2nd Mate
Mellanie L. Lovercheck	3rd Mate
David L. Philbrick	Bosun
DennisJ. von Mehren	A/B
Robert J. Fry	A/B
Wakefield B. Walker	A/B
Roger D. Strimback	O/S
Nolan M. Osorio	O/S
Stephen M. Pica	Chief Engr.
Miguel A. Flores	First Engr.
Matthew S. Ingerson	3rd Engr.
Michael R. Unger	3rd Engr.
Robert M. Knight	Oiler
Leslie G. Strickland	Oiler
Steven M. Baxter	Oiler
Shawn M. Lindenmuth	Steward
Michael A. Wees	Cook
Luke Moqo	Utility

A.2. OBS Shooting Airgun Array



A.3. OBSIP Senior Engineer Report

Overall, the LDEO OBS deployment was very successful, especially given that all of the instruments were brand new and had never been deployed on the sea floor. Sensor performance was very good. Out of 18 OBS deployments, 16 of 18 vertical channels and 28 of 36 horizontal channels recorded good to outstanding quality data or better. Performance of the new LDEO 24 bit dataloggers was also very good. Only one OBS failed to record any data, most likely due to a cold temperature related disk failure, and the average clock drift rate encountered was ~3 milliseconds per day. Transponder performance was good. The older Deaton model transponders exhibited a greater range than the new Edgetech BART model, which topped out at approximately 6,500 meters slant range. A few temporal communication problems were encountered, but none that jeopardized an instrument recovery.

Logistically, the instrument launches and recoveries went smoothly, thanks to the highly professional ship handling and the fine weather. One OBS was slightly damaged by a scrape against the ship's hull. A major contributor to this problem was the lack of adequate recovery gear (10 foot poles, snap hooks, etc.) in the possession of both the OBSIF group and the R/V Ewing. Both groups should obtain such equipment (or a second set) as soon as possible. One OBS released prematurely due to the inadvertent transmission of its release code. The latter mistake could have been prevented by sticking to a policy of having only one "active" OBS at a time, but this policy was overidden in order to allow the completion of a second air gun line in the ship time available. One extra day of allocated ship time for the experiment would have allowed for 100% instrument safety.

Instrument data quality was very good or better from all but one OBS deployment. Overall, we found that an average of 12 hours was required after each OBS released from the sea floor to recover, offload and process its data, and reset for launch. Eight of the twelve hours was time alloted for the instrument to warm up after recovery before its pressure case could be opened. Data post-processing consisted of removing each datalogger disk, connecting it to a FireWire interface box and copying the files, and then using a PC-based LabView code to convert the raw binary files to the PASSCAL SEGY (PSEGY) data format. The data was provided to the researchers in this format on CDROM.

A.4. OBS Component Configuration and Operational Comments

//
Configuration
/
SITE: **OBS01**
Name: **Celeste**
Sensor #: 2856
Datalogger #: 042
Sample rate: 125 Hz
Program Start Time: 2003/10/28 1255 Z
Program Stop Time: 2003/11/03 1438 Z

Clock error: 15 milliseconds
Total elapsed time: 1f4474af (hex) milliseconds
/
Operational Comments
/
W/ EW0309 battery pack (7 D cells)
Descent rate: 20 meters/min
Final depth: 4238 m
Transponders: Int Edgetech 30119, Ext Deaton 2_12_10.5_03_02_14
Lost contact w/ both xpdrs for 20 min during descent.
/
Data Processing
/
X (horiz), Z (vert) channels very good, Y (horiz) channel noisy
No clock correction applied.
//
Configuration
/
SITE: **OBS02**
Name: **Grover**
Sensor #: 3322
Datalogger #: 044
Sample rate: 125 Hz
Program Start Time: 2003/10/28 1325 Z
Program Stop Time: 2003/11/02 1704 Z
Clock error: 6 ms
Total elapsed time: 1a884c26 (hex) ms
/
Operational Comments
/
W/ EW0309 battery pack (7 D cells)
Added 5 lb weight.
Descent rate: 25 meters/min
Final depth: 4231 m
Transponders: Int Edgetech 29627, Ext Deaton 2_12_11.0_12_01_15
/
Data Processing
/
X (horiz), Z (vert) channels very good, Y (horiz) channel noisy
No clock correction applied.
//
Configuration
/
SITE: **OBS03**
Name: **Elroy**
Sensor #: 2869

Datalogger #: 002
Sample rate: 125 Hz
Program Start Time: 2003/10/28 1355 Z
Program Stop Time: 2003/11/02 1818 Z
Clock error: 16 ms
Total elapsed time: 1ab094b0 (hex) ms
/
<u>Operational Comments</u>
/
W/ EW0309 battery pack (7 D cells)
Added 10 lb weight.
Descent rate: 30 meters/min
Final depth: 4334 m
Transponders: Int Edgetech 29609, Ext Deaton 2_12_11.0_05_00_15
/
<u>Data Processing</u>
/
X, Y, Z channels very good
No clock correction applied.
//
<u>Configuration</u>
/
SITE: **OBS04**
Name: **Fabio**
Sensor #: 3121
Datalogger #: 043
Sample rate: 125 Hz
Program Start Time: 2003/10/28 1410 Z
Program Stop Time: 2003/11/02 1317 Z
Clock error: 3 ms
Total elapsed time: 198f4623 (hex) ms
/
<u>Operational Comments</u>
/
W/ EW0309 battery pack (7 D cells)
Added 10 lb weight.
Descent rate: 30 meters/min
Final depth: 4145 m
Transponders: Int Edgetech 30123, Ext Deaton 2_12_10.5_05_01_11
/
<u>Data Processing</u>
/
Y, Z channels very good, X noisy
No clock correction applied.
//
<u>Configuration</u>

/
SITE: **OBS05**
Name: **Bubbles**
Sensor #: 3119
Datalogger #: 046
Sample rate: 125 Hz
Program Start Time: 2003/10/29 1600 Z
Program Stop Time: 2003/11/02 0033 Z
Clock error: 5 ms
Total elapsed time: --
/
Operational Comments
/
W/ EW0309 battery pack (7 D cells)
Added 4 kg weight.
Descent rate: 28 meters/min
Final depth: 3937 m
Transponders: Int Edgetech 30115, Ext Edgetech 27968
/
Data Processing
/
Y, Z channels very good, X noisy
No clock correction applied.
//
Configuration
/
SITE: **OBS06**
Name: **Tito**
Sensor #: 3315
Datalogger #: 049
Sample rate: 125 Hz
Program Start Time: 2003/10/29 1620 Z
Program Stop Time: 2003/11/02 0013 Z
Clock error: 1 ms
Total elapsed time: --
/
Operational Comments
/
W/ EW0309 battery pack (7 D cells)
Added 4 kg weight.
Descent rate: 28 meters/min
Final depth: -- m
Transponders: Int Edgetech 30125, Ext Deaton 2_12_10.5_10_00_13
/
Data Processing
/

Y, Z channels very good, X noisy
No clock correction applied.
//
Configuration
/
SITE: **OBS07**
Name: **Natasha**
Sensor #: 3314
Datalogger #: 048
Sample rate: 125 Hz
Program Start Time: 2003/10/30 0850 Z
Program Stop Time: 2003/11/01 1816 Z
Clock error: 6 ms
Total elapsed time: --
/
Operational Comments
/
W/ EW0309 battery pack (7 D cells)
Added 4 kg weight.
Descent rate: 28 meters/min
Final depth: 4228 m
Transponders: Int Edgetech 30118, Ext Deaton 2_12_10.5_12_08_13
/
Data Processing
/
Y, Z channels very good, X noisy but ok.
No clock correction applied.
//
Configuration
/
SITE: **OBS08**
Name: **Boris**
Sensor #: 3318
Datalogger #: 00
Sample rate: 125 Hz
Program Start Time: 2003/10/30 0910 Z
Program Stop Time: 2003/11/01 1610 Z
Clock error: 3 ms
Total elapsed time: --
/
Operational Comments
/
W/ EW0309 battery pack (7 D cells)
Added 4 kg weight.
Descent rate: 28 meters/min
Ascent rate: 48 meters/min

Final depth: 4068 m
Transponders: Int Edgetech 29606, Ext Edgetech 28604
/
Data Processing
/
X, Y, Z channels very good
No clock correction applied.
//
Configuration
/
SITE: **OBS09**
Name: **Francis**
Sensor #: 1529
Datalogger #: 033
Sample rate: 125 Hz
Program Start Time: 2003/10/30 1240 Z
Program Stop Time: 2003/11/04 1620 Z
Clock error: 4 ms
Total elapsed time: 1a893684
/
Operational Comments
/
W/ EW0309 battery pack (7 D cells)
Added 4 kg weight.
Final depth: 3771 m
Transponders: Int Edgetech 30122, Ext Deaton 2_12_11.5_06_01_11
Sensor release system failed; ball still attached to arm at recovery.
Release battery completely drained but wire only partially burned.
Gimbal appeared to have leveled upside down.
No problems apparent with either sensor or release system in lab.
Will investigate further once back at LDEO.
/
Data Processing
/
Z channel data very good.
Y chan very noisy, no useful data.
X chan good until 03/11/02 at 09:00 Z when it went flatline.
No clock correction applied.
//
Configuration
/
SITE: **OBS10**
Name: **Joseph**
Sensor #: 3131
Datalogger #: 047
Sample rate: 125 Hz

Program Start Time: 2003/10/30 1245 Z
Program Stop Time: 2003/11/04 1526 Z
Clock error: -8 ms ("-" = lagging GMT)
Total elapsed time: 1a533258
/
Operational Comments
/
W/ EW0309 battery pack (7 D cells)
Added 4 kg weight.
Final depth: 3771 m
Transponders: Int Edgetech 30116, Ext Deaton 2_12_10.0_03_02_07

/
Data Processing
/
X, Z channel data very good.
Y flatline, no data recorded.
No clock correction applied.
//
Configuration
/
SITE: **OBS11**
Name: **Bubbles**
Sensor #: 3119
Datalogger #: 046
Sample rate: 125 Hz
Program Start Time: 2003/11/02 0050 Z
Program Stop Time: --
Clock error: --
Total elapsed time: --
/
Operational Comments
/
W/ EW0309 battery pack (7 D cells)
Added 8 kg weight.
OBS11 released prematurely by unintentional release command sent from transponder interrogator box.
Launch of OBS11 was combined with recovery of OBS01 (Celeste)
and the release command sent to OBS11 was thought to be the one for OBS01.
Allowing multiple simultaneous OBS operations greatly increases the risk of these kinds of errors
and is not recommended.
Bubbles recovered and redeployed as OBS15.
/
Data Processing
/

Y, Z channels very good, X noisy
No clock correction applied.
//
Configuration
/
SITE: **OBS12**
Name: **Tito**
Sensor #: 3315
Datalogger #: 049
Sample rate: 125 Hz
Program Start Time: 2003/11/02 0030 Z
Program Stop Time: 2003/11/04 1921 Z
Clock error: 0 ms
Total elapsed time: e582e20
/
Operational Comments
/
W/ EW0309 battery pack (7 D cells)
Added 8 kg weight.
Final depth: 4232 m
Transponders: Int Edgetech 30125, Ext Edgetech 27968

/
Data Processing
/
X, Y, Z channel data very good.
No clock correction required (0 ms drift).
//
Configuration
/
SITE: **OBS13**
Name: **Natasha**
Sensor #: 3314
Datalogger #: 048
Sample rate: 125 Hz
Program Start Time: 2003/11/01 2005 Z
Program Stop Time: --
Clock error: --
Total elapsed time: --
/
Operational Comments
/
W/ EW0309 battery pack (7 D cells)
Added 8 kg weight.
Final depth: 4107 m
Transponders: Int Edgetech 30118, Ext Edgetech 28604

/

Data Processing

/

Datalogger program failed at first disk write.
Disk drive, Toshiba 43QJ2235T, failed to spin up.
Disk, battery pack OK in postmortem test,
therefore, most likely a cold temp related disk problem.

//

Configuration

/

SITE: **OBS14**
Name: **Boris**
Sensor #: 3318
Datalogger #: 00
Sample rate: 125 Hz
Program Start Time: 2003/11/01 1805 Z
Program Stop Time: 2003/11/04 1718 Z
Clock error: 4 ms
Total elapsed time: f480c64

/

Operational Comments

/

W/ EW0309 battery pack (7 D cells)
Added 8 kg weight.
Final depth: 4099 m
Transponders: Int Edgetech 29606, Ext Deaton 2_12_10.5_10_00_13

/

Data Processing

/

Y, Z channels very good, X noisy but ok.
No clock correction applied.

//

Configuration

/

SITE: **OBS15**
Name: **Bubbles**
Sensor #: 3119
Datalogger #: 046
Sample rate: 125 Hz
Program Start Time: 2003/11/02 0050 Z
Program Stop Time: 2003/11/04 2345 Z
Clock error: 6 ms
Total elapsed time: f3791a6

/

Operational Comments

/

W/ EW0309 battery pack (7 D cells)
Added 8 kg weight.
Final depth: 3912 m
Transponders: Int Edgetech 30115, Ext Deaton 2_12_10.5_12_08_13
Due to miscalculation after reployment from site OBS11, Bubbles sensor sphere released while still descending to the bottom. Nonetheless, sensor appears to have landed in a level position.
/
Data Processing
/
X, Y, Z channels very good, despite premature sphere release.
No clock correction applied.
//
Configuration
/
SITE: **OBS16**
Name: **Fabio**
Sensor #: 3121
Datalogger #: 043
Sample rate: 125 Hz
Program Start Time: 2003/11/02 1420 Z
Program Stop Time: 2003/11/04 1754 Z
Clock error: 2 ms
Total elapsed time: b10a442 (hex) ms
/
Operational Comments
/
W/ EW0309 battery pack (7 D cells)
Added 8 kg weight.
Final depth: 3693 m
Transponders: Int Edgetech 30123, Ext Deaton 2_12_11.0_12_01_15
/
Data Processing
/
X, Y, Z channels very good.
No clock correction applied.
//
Configuration
/
SITE: **OBS17**
Name: **Grover**
Sensor #: 3322
Datalogger #: 044
Sample rate: 125 Hz
Program Start Time: 2003/11/02 1815 Z
Program Stop Time: 2003/11/04 2256 Z

Clock error: 3 ms
Total elapsed time: b4dfb63 (hex) ms
/
Operational Comments
/
W/ EW0309 battery pack (7 D cells)
Added 8 kg weight.
Final depth: 3870 m
Ascent rate: 38 m/min
Transponders: Int Edgetech 29627, Ext Deaton 2_12_11.0_05_00_15
/
Data Processing
/
Z (vert) channel very good; X & Y (horiz) channels very noisy.
Gimbal may not have leveled properly.
No clock correction applied.
//

A.5. STAG-II Deployment 1

STAG-II Deployment 1 Summary

OBS Site	Name	Instr. Drop Location	Depth (m)	Deployment / Recovery Time (Year:Julian day:UTC Time)	Nearest Shot #	Approach Date /Time
1	Celeste	25° 57.159'N 44° 54.848'W	4238	2003:303:04:26 / 2003:306:12:54	115	2003:304:19:43
2	Grover	25° 59.492'N 44° 53.725'W	4231	2003:303:06:42 / 2003:306:07:36	128	2003:304:20:17
3	Elroy	26° 01.683'N 44°52.634'W	4334	2003:303:08:29 / 2003:306:04:06	141	2003:304:20:50
4	Fabio	26° 03.989'N 44° 51.489'W	4145	2003:303:10:47 / 2003:305:22:33	154	2003:304:21:22
C1	Compliance -meter	26° 08.569'N 44° 50.430'W	3694	2003:303:13:35 / 2003:305:17:40	38 (L2)	2003:304:12:03
9	Francis	26 09.806'N 44° 53.677'W	3771	2003:303:15:47 / 2003:308:03:08	22 (L2)	2003:304:11:19
10	Joseph	26° 10.648'N 44° 55.851'W	2929	2003:303:17:39 / 2003:308:04:27	(L2)	2003:304:10:53
5	Bubbles	26° 12.289'N 44° 47.585'W	3937	2003:303:22:40 / 2003:305:14:48	202	2003:304:23:23
6	Tito	26° 14.594'N 44° 46.452'W	4056	2003:304:02:12 / 2003:305:12:26	215	2003:304:23:54
7	Natasha	26° 16.897'N 44° 45.350'W	4228	2003:304:04:01/ 2003:305:09:30	226	2003:305:00:27
8	Boris	26° 19.182'N 44° 44.279'W	4068	2003:304:05:39 / 2003:305:06:48	241	2003:305:01:00

Fixes are from Tasmon P-Code GPS receiver.

Sampling rate on all instruments is 125 samples/second.

OBS-9 and 10 (Francis and Joseph) recorded both, deployment 1 and 2. Shot spacing in Lines 1, 2, and 4 is 350 m.

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STAG-II Deployment 1: Summary of Data Quality

	OBS-1 Celeste			OBS-2 Grover			OBS-3 Elroy			OBS-4 Fabio			OBS-5 Bubbles			OBS-6 Tito			OBS-7 Natasha			OBS-8 Boris			OBS-9 Francis			OBS-10 Joseph		
channel	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
Line # *shots*	[redacted]																													
2 *314-384*	✔ ≋	✔ ≋	✔ ≋	✔	✔	✔	✔	✔	✔	✔ ≋	✔	✔	✔	≋	✔	✔	✔	✔	☠	☠	☠	☠	☠	☠	✔ ≋	✔ ≋	✔ ≋	✔	☠	✔
4 *7-91*	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	≋	✔	✔ ≋	✔	✔	✔	✔	✔	☠	≋	✔ ≋	✔ ≋	≋	✔	✔	☠	✔
1 *92-263*	✔	✔	✔	✔	✔	✔	✔ ≋	✔ ≋	✔ ≋	✔	✔	✔	✔	≋	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔ ≋	✔ ≋	✔ ≋	✔	☠	✔

✔ Good. ≋ Noisy. ☠ No data, bad or dead channel.

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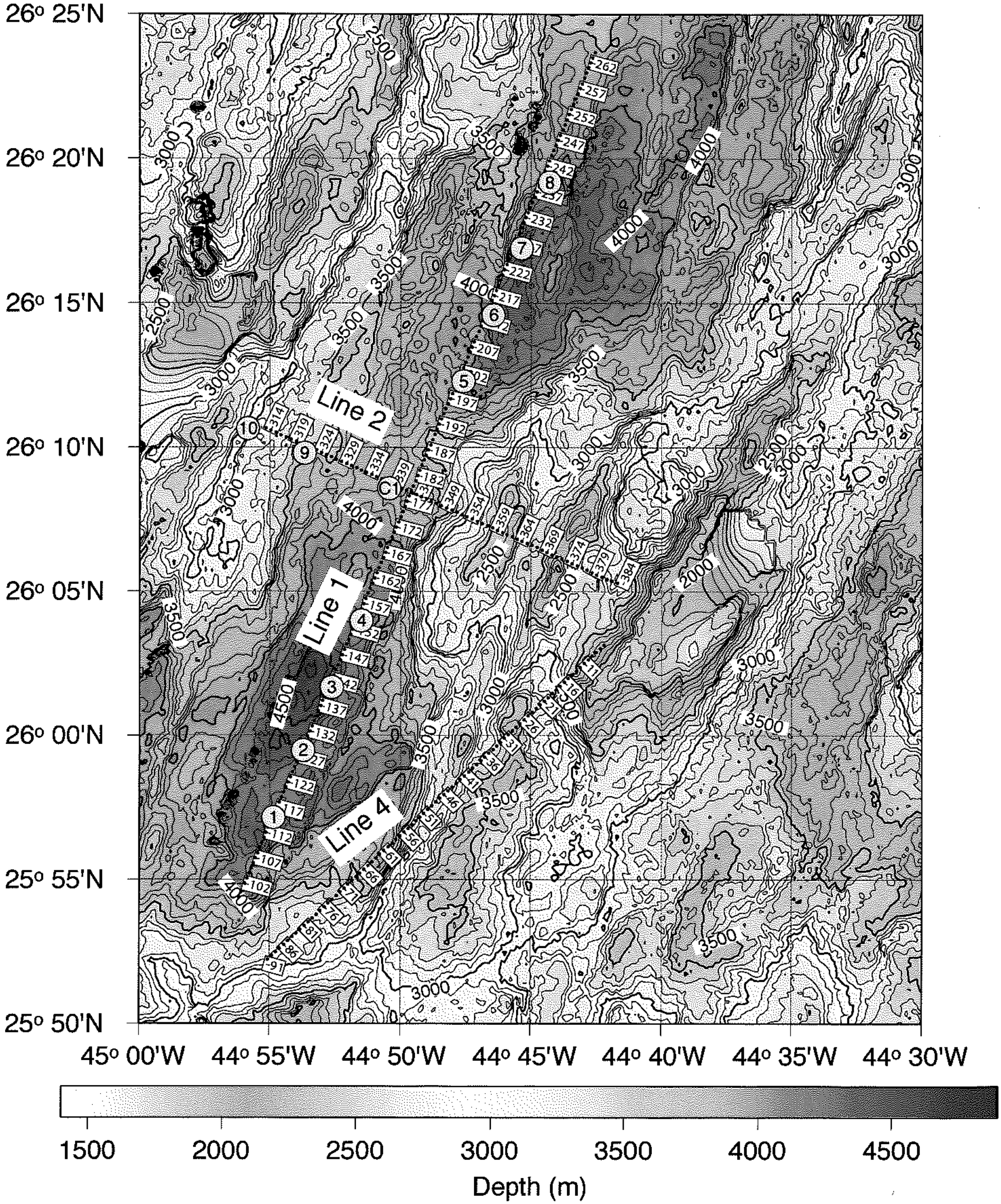
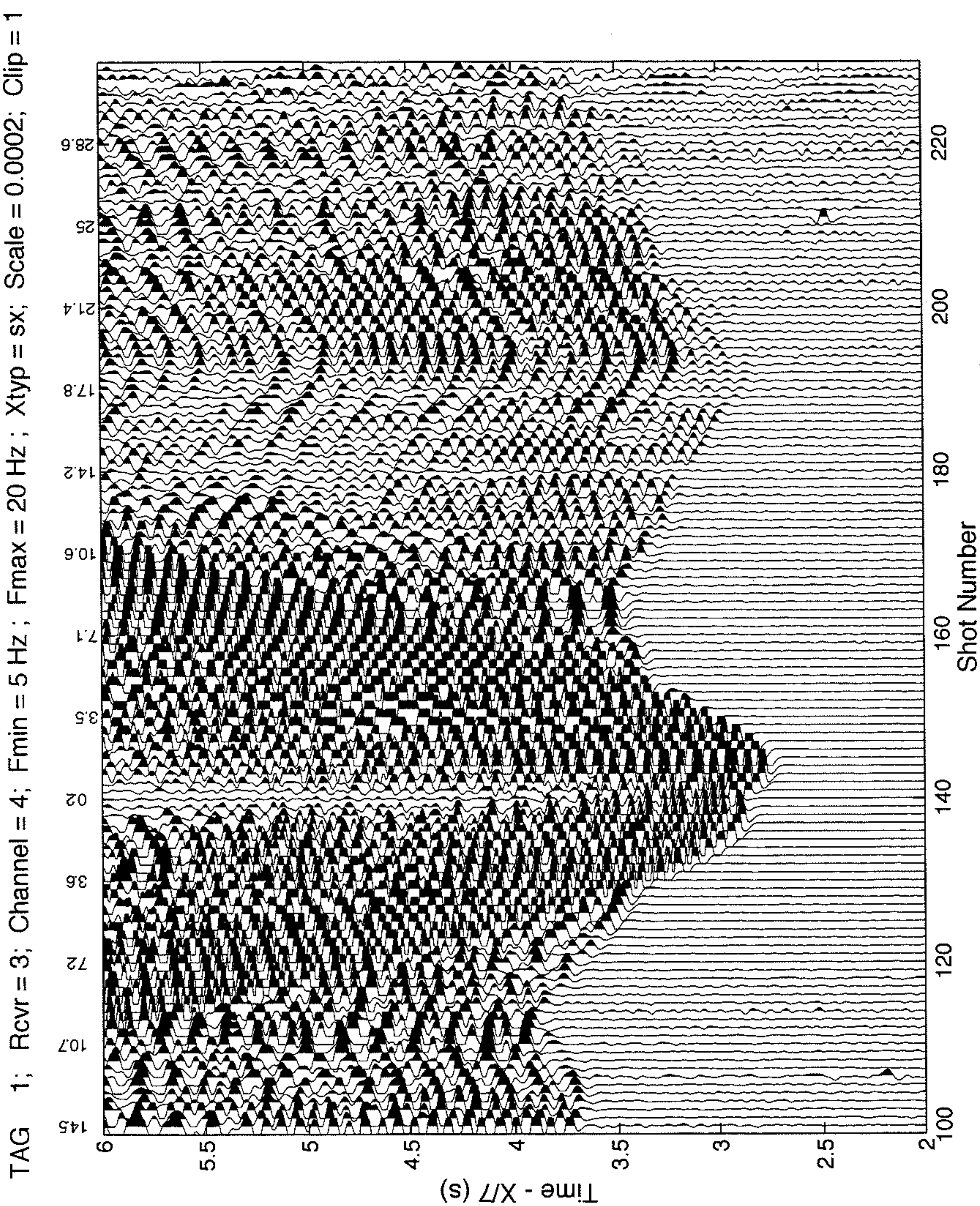
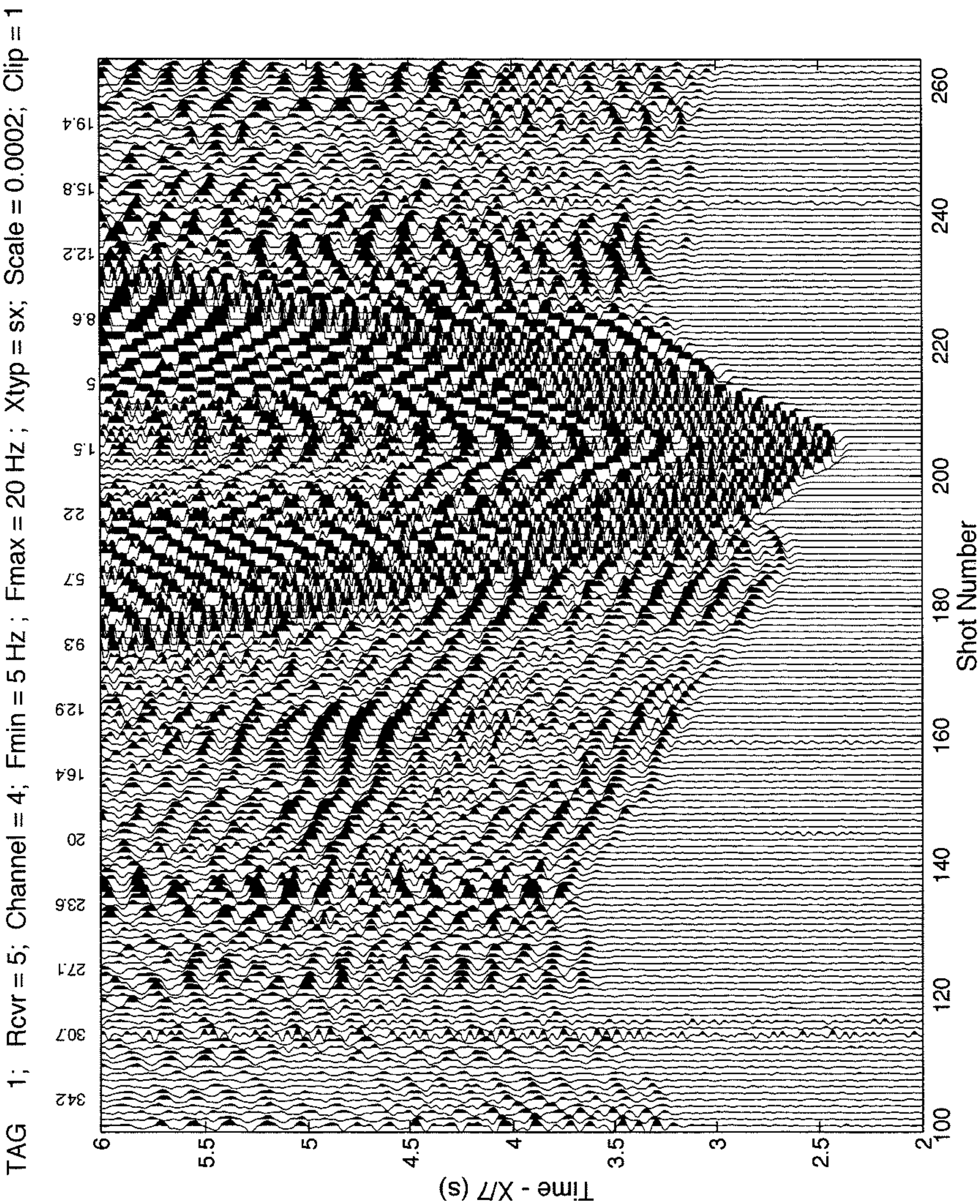
STAG-II DEPLOYMENT 1. OBS Sites and Shot numbers.



Wide-Angle Seismic Record Section, OBS 3 (Elroy), Line 1



Wide-Angle Seismic Record Section, OBS 5 (Bubbles), Line 1



A.6. STAG-II Deployment 2

STAG-II Deployment 2 Summary

OBS Site	Name	Instr. Drop Location	Depth (m)	Deployment / Recovery Time (Year:Julian day:UTC Time)	Nearest Shot #	Approach Date /Time
9	Francis	*See Table Deployment TAG-1.*				
10	Joseph	*See Table Deployment TAG-1.*				
11	*Abandoned site. See narrative.*					
12	Tito	26° 02.008'N 44° 54.715'W	4232	2003:306:01:01 / 2003:307:20:42	629	2003:307:05:47
13	Natasha	26° 04.303'N 44° 53.651'W	4108	2003:305:23:34 / 2003:307:23:16	613	2003:307:05:07
14	Boris	26° 06.521'N 44° 52.615'W	4199	2003:305:18:52 / 2003:308:00:59	601	2003:307:03:38
15	Bubbles	26° 11.269'N 44° 50.320'W	3712	2003:306:16:29 / 2003:308:06:38	574	2003:307:03:29
16	Fabio	26° 13.505'N 44° 49.280'W	3693	2003:306:17:43 / 2003:308:08:27	561	2003:307:02:55
17	Grover	26° 15.827'N 44° 48.131'W	3870	2003:306:18:57 / 2003:308:10:01	548	2003:307:02:22

Fixes are from Tasmon P-Code GPS receiver.

Sampling rate on all instruments is 125 samples/second.

Shot spacing in Lines 3, and 5 is 350 m; and in Lines 6 and 7 is 150 m.

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STAG-II Deployment 2: Summary of Data Quality

	OBS-9 Francis			OBS-10 Joseph			OBS-12 Tito			OBS-13 Natasha			OBS-14 Boris			OBS-15 Bubbles			OBS-16 Fabio			OBS-17 Grover		
channel	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
Line # *shots*																								
3 *501-673*	☠	✔ ≋	✔	✔	☠	✔	✔	✔	✔	☠	☠	☠	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔ ≋	✔
5 *701-798*	☠	✔ ≋	✔	✔	☠	✔	✔	✔	✔	☠	☠	☠	✔	✔	✔	✔ ≋	✔	✔ ≋	✔	✔	✔	✔	✔ ≋	✔
6 *801-919*	☠	✔	✔	≋	☠	✔	✔	✔	✔	☠	☠	☠	✔	✔	✔	≋	≋	≋	✔	≋	≋	✔	≋	✔
7 *1013-1055*	☠	✔	✔	≋	☠	✔	✔	✔	✔	☠	☠	☠	✔	✔	✔	≋	≋	≋	✔	≋	≋	≋	≋	≋

✔ Good. ≋ Noisy. ☠ No data, bad or dead channel.

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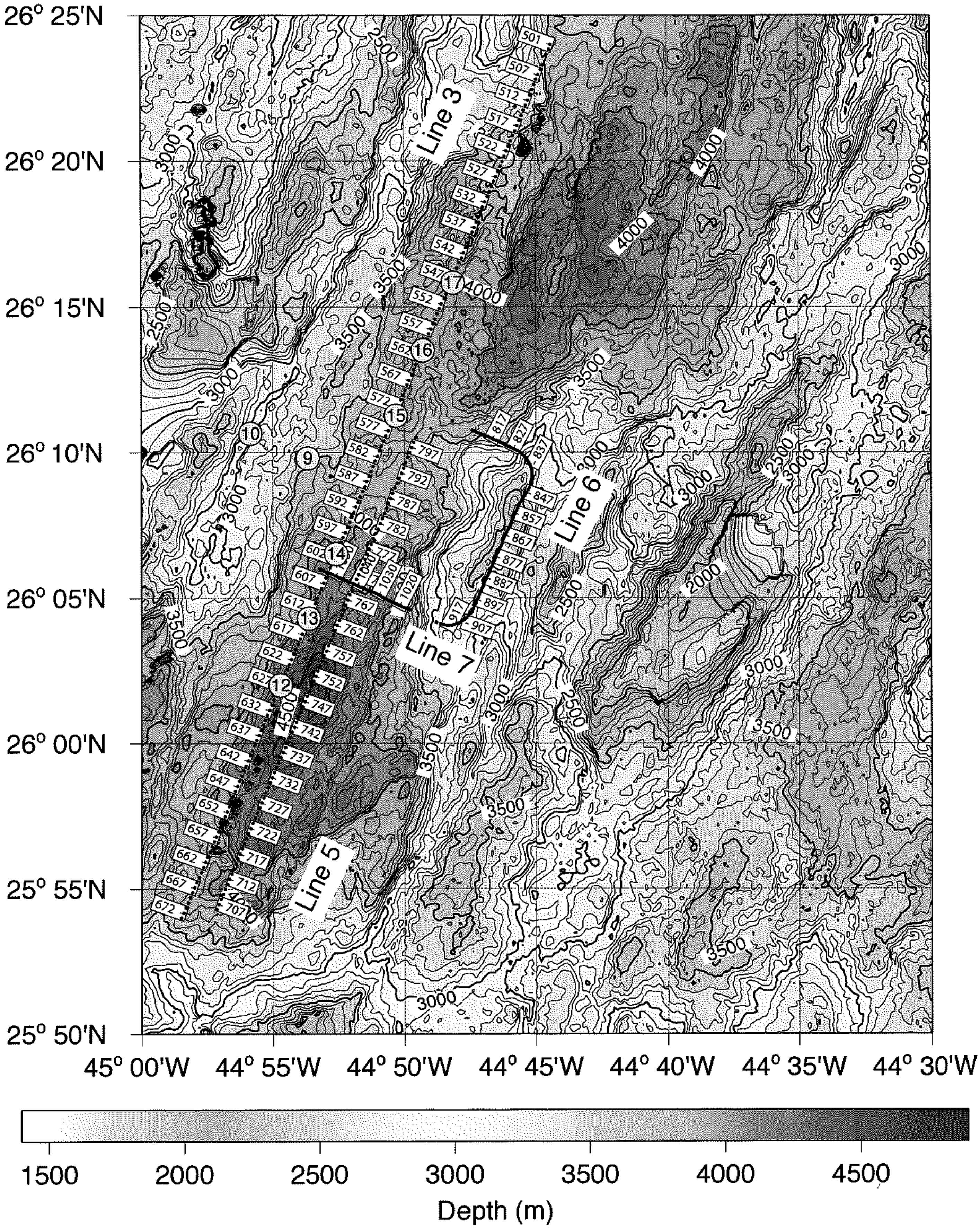
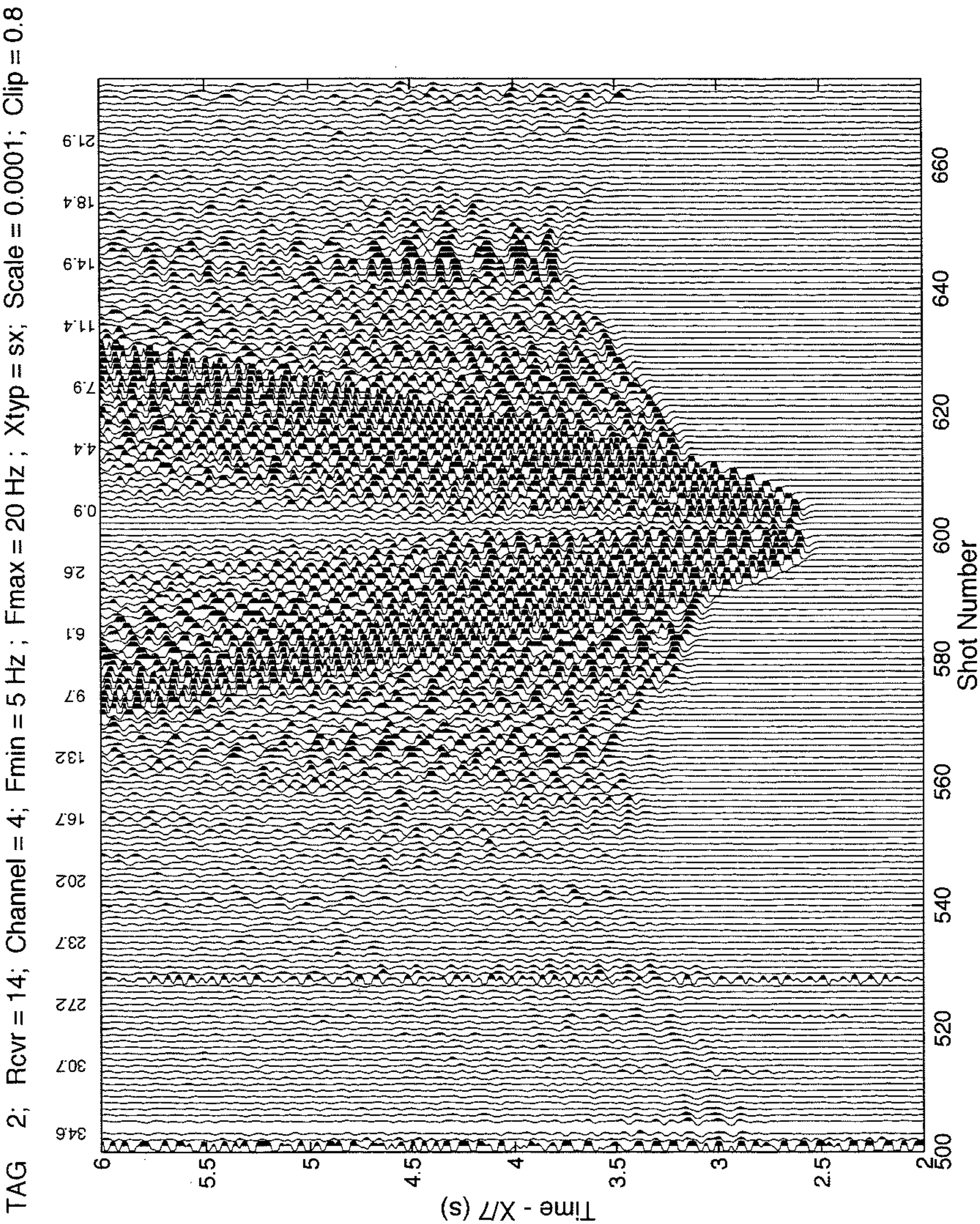
STAG-II DEPLOYMENT 2. OBS Sites and Shot numbers.



Wide-Angle Seismic Record Section, OBS 14 (Boris), Line 3



A.7. Shipboard OBS Data Processing

1.- The PASSCAL SEGY files created by Patrick were archived in *grampus* in the directory */export/home2/scratch/0309/data/raw/*

1.- After shooting was finished, we constructed shot files for each deployment from the ship's shot and navigation files *ts.nddd.*

2.- We then created parameter files for each of the instruments named as:

param.deploy#.NAME (e.g., *param.deploy1.BUBBLES*).

An example of the contents of these files follows:

```
1               # Deployment number
5               # OBS Site number
BUBBLES         # OBS name
EW0309          # OBS Serial number
26  12.289      # Latitude (degrees, minutes)
-44  47.585     # Longitude (degrees, minutes)
3937            # Water depth (positive meters)
```

3.- Pablo wrote a UNIX script called *process.job* to process the 3 channels of one instrument by calling the PASSCAL program *psegygather* (*segygather* modified by John Collins). It uses Collin's *perl* scripts to create the shot and start time files in the appropriate format. The script is run by simply typing: *process.job parameter_file*

The script is reprinted below.

4.- The SEGY receiver gather files were automatically created and archived in:

/export/home2/scratch/0309/data/segy

We used the MATLAB utility *upicker* created by William Wilcock to plot the record sections and print hard copies.

```
PROCESS.JOB
-----------------------------------------------------------------------------------------------
#! /bin/ksh

pfile=$1

rawdir=/export/home2/scratch/0309/data/raw
segydir=/export/home2/scratch/0309/data/segy

offset_gps_gun=88.6   # This is the offset in meters between the GPS antenna and the airgun array
trace_length=20               # This is the length of the traces (seconds) in the final SEGY file.

if [ $# -eq 0 ]; then
  echo Usage: process.job parameter_file
  exit
fi

if [ -r $pfile ]; then
  awk '(NR==1) {print $1}' $pfile | read deploy
  awk '(NR==2) {printf("%02.0f",$1)}' $pfile | read obs
  awk '(NR==3) {print $1}' $pfile | read name
  awk '(NR==4) {print $1}' $pfile | read serial
  awk '(NR==5) {if ($1<0) x=$1-$2/60; else x=$1+$2/60; printf("%12.6f\n",x)}' $pfile | read lat
  awk '(NR==6) {if ($1<0) x=$1-$2/60; else x=$1+$2/60; printf("%12.6f\n",x)}' $pfile | read lon
  awk '(NR==7) {print -sqrt($1*$1)}' $pfile | read depth

  wkdir=deploy$deploy/$name.OBS$obs
  if [ ! -r $wkdir ]; then
    mkdir $wkdir
  fi
```

```
  tsfile=shotfiles/deployment_$deploy.tsfile
  shfile=$wkdir/deployment_$deploy.shots
  stfile=$wkdir/deployment_$deploy.start_times
  rcfile=$wkdir/obs$obs.$name.rec

  cp $pfile $wkdir

  # Creates shot file
  echo Creating shot file..."\n"
# This is the newer shot file perl scriot that handles years>2000.
# However the psegygather files I got do not handle years>2000,
# so I will use the old perl script
#  ./scripts/shot_file_ewing.pl $tsfile $shfile <<END> /dev/null
  ./scripts/shot_file.pl.old $tsfile $shfile <<END> /dev/null
$offset_gps_gun
END

  # Creates start times file
  echo Creating start times file ..."\n"
  ./scripts/start_times_file.pl $tsfile $stfile

  # Loops over the four channels
  for channel in 2 3 4; do   # There is no channel 1 (hydrophone) in the OBS's

    lsfile=$wkdir/obs$obs.$name.ch$channel.list
    segyfile=$segydir/tag$deploy.obs$obs.ch$channel.segy

    # Creates receiver file
    echo Creating receiver file for channel $channel..."\n"
    echo "number   DAS/C    lat      lon      elevation" > $rcfile
    echo $serial $channel $lat $lon $depth |
        awk '{printf(" 1     %s/%1.0f%12.6f%12.6f%7.0f\n",$1,$2,$3,$4,$5)}' >> $rcfile

    # Creates list of PASSCAL SEGY files
    if [ $channel -eq 1 ]; then
      chann=D
    elif [ $channel -eq 2 ]; then
      chann=X
    elif [ $channel -eq 3 ]; then
      chann=Y
    else
      chann=Z
    fi
    ls $rawdir/$name.OBS$obs/PSEGY/$name"_"$serial*$chann > $lsfile

    # Runs psegygather
    echo Running psegygather for channel $channel..."\n"
    psegygather -p -g $rcfile -i $lsfile -s $shfile -l $stfile -n $trace_length -o $segyfile

    # Psegygather keeps the correct sampling rate in the reel header, but not in the trace headers.
    # I run sioseis to set up the sampling rate in each of the trace headers.
    echo Running sioseis  for channel $channel..."\n"
    sioseis <<END
procs diskin header diskoa end
diskin
 ipath $segyfile  fno  0 lno 99999 end
end
header
  fno 0 lno 99999 ftr 1 ltr 9999 header si 0.08 end
end
diskoa
  opath segy.tmp end
end
end
END
  mv segy.tmp $segyfile
  done    # End of channel loop
  else
  echo File $pfile not found.
fi
```

A.8. Multibeam Bathymetry and Gravity Data

During cruise EW03-09 we acquired underway multibeam bathymetry using the *Ewing's* Hydrosweep system, and gravity data using the Bell Aerospace BGM-3 Gravity Meter. The Hydrosweep was running for most part of the cruise, except during deployment or recovery of OBS to improve acoustic communications between the ship and the instrument. Processing and cleaning of the bathymetry data will be conducted onshore. The gravity meter has not worked properly during the cruise. The gravity signal is contaminated by noise of discrete wavelength whose origin is uncertain. It could be either a problem in the gyros or an electronic problem. According to Ted, nothing can be done until the gravity meter is disassembled onshore on a stable setting and tested. Ethan is working on trying to find an appropriate filter to produce the best possible free-air anomaly gravity data out of the original readings.