Geophysical Constraints on Mechanisms of Ocean Plateau Formation from Shatsky Rise, Northwest Pacific

Cruise Report
MGL1206
R/V Marcus G. Langseth
Guam to Honolulu
24 March – 15 April, 2012

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Summary

Executive Summary

R/V *Marcus G. Langseth* cruise MGL1206 is a follow-up to MGL1004, and the combination of these two cruises formed the major data acquisition phase of the NSF-funded project, "Geophysical Constraints on Mechanisms of Ocean Plateau Formation from Shatsky Rise, Northwest Pacific" (OCE-0926611; OCE-0926945). Deciphering the origins of large oceanic plateaus is a critical element for understanding mantle dynamics and its relation to terrestrial magmatism, and Shatsky Rise was chosen as a high-priority target because it provides a unique tectonic setting to distinguish between various models proposed for the formation of oceanic plateaus. The purpose of this survey was to provide critical missing information on (1) the thickness, velocity structure, and composition of the Shatsky Rise crust, and (2) the history of magmatic emplacement and later tectonic development of the Rise. This was planned to be achieved by acquiring seismic data along two refraction lines over the Tamu Massif, which represents the early, most voluminous phase of the Rise construction, and over 3,000 km of seismic reflection lines covering both the Tamu and Ori Massifs, the latter of which corresponds to the intermediate phase of the plateau evolution.

The cruise MGL1004 was unfortunately hampered by two medical diversions, and the northern part of the planned MCS reflection lines (~1,200 km total) was left undone. The task of MGL1206 was to conduct a MCS reflection survey over these leftover lines and complete the original survey plan.

The *Langseth* fired over 27,000 shots from its 36-gun tuned airgun source, and seismic energy reflected from subsurface structures was recorded by the *Langseth*'s 6-km-long multichannel streamer. Despite challenging sea conditions during most of the survey, with 4-6 meters waves, over 40 knots of wind, and strong opposing currents, the cruise mission was accomplished in full. The newly collected MCS data transect the northern flank of Tamu Massif, the entire Ori Massif, and the Helios Basin that connects these two massifs. Together with the seismic data collected by MGL1004, this data set will provide an important tectonic framework for synthesizing existing geological, geophysical, and geochemical data and for resolving the formation mechanism of this large igneous province.

Scientific Objectives

(Note: this is regarding MGL1004 and MGL1206 combined.)

The Shatsky Rise active-source seismic project is designed to make accurate measurements of crustal thickness and velocity structure over the most prominent volcanic feature of the Rise, the Tamu massif, by wide-angle refraction and reflection recorded by OBS, and to map out basement topography and fine-scale upper crustal structure over a significant fraction of the rise, covering both the Tamu and Ori Massifs, by MCS profiling.

Oceanic plateaus belong to the so-called large igneous provinces (LIPs), the largest of which represent terrestrial magmatism of vast spatial extents formed within a relatively short time period. The origins of such extraordinary geological phenomena are still poorly understood, but the scale of magmatism requires that the source mantle must have been in a thermally, chemically, or dynamically anomalous state. Models put forward for the formation of oceanic plateaus include the impingement of a mantle plume head rising from the core-mantle boundary, tapping of a broad upper-mantle thermal anomaly by spreading centers, and the upwelling of fertile mantle driven by plate-tectonic stresses. Resolving the mechanism of plateau formation is thus directly connected to the first-order issues in mantle dynamics. Contrasting to the abundance of hypotheses, however, field observations that can distinguish between these models are conspicuously missing. Oceanic plateaus have scarcely been surveyed with modern geophysical methods. Shatsky Rise was chosen as a prime target because, compared to other plateaus in the Pacific, its tectonic environment is well understood thanks to its formation during a period of frequent magnetic polarity reversals. Furthermore, despite its large size (equivalent in area to Japan), Shatsky Rise consists of discrete volcanic edifices that are not too large for a single geophysical survey. Because they are the first MCS survey for Shatsky Rise and cover a large portion of that oceanic plateau, the seismic surveys of MGL1004 and MGL1206 thus form a major stepping stone to the new generation of exploring oceanic large igneous provinces.

The Shatsky Rise survey consists of two crossing perpendicular OBS refraction lines over the Tamu Massif and over 3,000-km-long MCS reflection transects that run along and across the major axis of Shatsky Rise. The resulting data will provide answers to several questions regarding the origin of the Rise, including:

1. What is the structure and volume of Shatsky Rise crust? How deep is the Moho discontinuity beneath the Rise? How does topography and crustal thickness correlate?
2. Was Shatsky Rise formed over a thermal or chemical anomaly? Does crustal velocity correlate with crustal thickness positively (thermal origin) or negatively (chemical origin)?
3. How was Shatsky Rise construction modulated by spreading ridges? What is the relation between the ridge-ridge-ridge triple junction and plateau formation?
4. Did a plume head create Shatsky Rise? Did the Rise form rapidly as expected from the melting of a mantle plume head? Or did it form in a prolonged time as predicted by tapping of anomalous mantle by plate tectonics?

Operational Objectives

Cruise MGL1206 was comprised a series of MCS reflection transects over Tamu and Ori Massifs totaling ~1370 km (originally 1216 km) in length. Shots were fired using the *Langseth*'s 108-liter (6600 cubic inch) airgun array.

The primary operational goals were to:

- Fire the 36-gun array into the MCS streamer at an interval of 50 m on all of reflection transects.
- Collect multibeam bathymetry, magnetic, and gravity data along all seismic transects, and collect bathymetry and gravity data during transits as well.
- Produce pseudo-real-time near-trace plots of all MCS data to monitor data quality.
- Produce preliminary stacks of all MCS data.
- Produce CDP-sorted data for all MCS data.
- Copy all raw and processed navigation, seismic, and underway geophysics data to PIs' hard drives.

Preliminary Cruise Assessment

The MCS reflection transects collected during MGL1206 cover from the northern flank of the Tamu Massif to the center of the Ori Massif and crossing IODP drill Sites U1348, U1349, and U1350. All planned transects were completed, and we have accomplished the original survey plan for MGL1004 in full. Unlike the previous cruise, weather was challenging during most of the survey, but the reflection survey was nonetheless successful because of the highly professional *Langseth* crew and LEDO science tech group. Despite high waves, the quality of MCS data was compromised only modestly thanks to the preventive adjustment of streamer depth by the science techs. The steady firing of the airgun array was achieved without major problems; we lost only four hours to repair one of gun strings, which happened to fail in the middle of the last transect. Low biological productivity in the survey area also helped us to finish the plan even with zero contingency time allocated beforehand; we had to power down the array only once and just for an hour, when PSO spotted a fur seal during shooting. Because of rough weather, however, the towed magnetometer had to be brought on board twice during the reflection survey.

Preliminary scientific results from MGL1206 include:

- To determine whether the north flank of Tamu Massif is extensively faulted. Preliminary interpretations are that the south flank is an unmodified volcanic flank whereas the north flank has been extensively faulted
- To determine the structure of Helios basin (between Tamu and Ori massifs), whether it is an abandoned rift, and the implications for the relationship between Tamu and Ori massifs.
- To image the structure of Ori Massif and compare it with that of Tamu Massif. Drilling results suggest that volcanism was less effusive at Ori Massif and preliminary interpretation of MGL1004 data over Tamu Massif imply it is a large, single volcano. Was Ori Massif formed in the same way?
- To image Moho in other areas of the Shatsky Rise. Moho was visible at the edges of Tamu Massif in MGL1004 data where the crust is near normal in thickness. Other studies have interpreted the lithosphere between massifs as being nearly normal in nature, so the imaging of Moho with MGL1206 data will confirm this interpretation and help clarify the nature of crust within the Shatsky Rise.

Project Principal Investigators

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Personnel

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Tatiana Moreno	PSO	RPS
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David Ng	Science Tech	LDEO
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Carlos D. Gutierrez	Source Tech	LDEO
Mike Tatro	Source Tech	LDEO
West Groves	Source Tech	LDEO

R/V Marcus G. Langseth Crew

James E. O'Loughlin	Captain
Lee Dortzbach	Chief Mate
Breckenridge C. Crum	2nd Mate
West S. Wilson	3rd Mate
Ricardo M. Redito	Boatswain
Inocencio B. Rimando	A/B
Marcus B. Nadler	A/B
Joshua A. Schaffner	O/S
Joselyn N. White	O/S
Albert D. Karlyn	Chief Engineer
Matthew S. Tucke	1st Engineer
Michael A. Romero	2nd Engineer
Ross Himebauch	3rd Engineer
Jack C. Billings	Oiler
Rodolfo A. Florendo	Oiler
Guillermo F. Uribe	Oiler
Hervin McLean Fuller	Steward
Leoncio R. Martires	Cook
John H. Schwartz	Electrician

Narrative

March 23, 2012 (Fri)
Korenaga met the rest of the science party at Guam Marriott Resort & Spa at 11:30AM. After a pre-cruise lunch, we all headed to the U.S. naval base, using Miki taxi, which was recommended by the agent as the only taxi that can get into the base. As it turned out, the taxi cannot get into the base and we were dropped off at the main gate. The security guard at the gate didn't have a clearance list with our names on it, but we were somehow allowed to get through. Pulling heavy suitcases, we managed to get to a nearby Macdonald's in the base, where Korenaga was able to make a Skype call to the captain of the *Langseth*, who kindly arranged transportation from there to the pier. The science party had a brief meeting in the main lab. Robert Steinhaus informed us that there would be a safety meeting tomorrow morning at 9 a.m., and that watchstanding would start right after the meeting. After dinner, the science party walked to the Navy Exchange. Fortunately, they have a clearance list with our names, so we were able to do last-minute grocery shopping.

March 24, 2012 (Sat)
The IHA was issued overnight (i.e., during Friday on the mainland U.S.) and the *Langseth* sailed off at ~8 a.m. local time. A safety meeting was held at 9 a.m. in the movie room, followed by a tour around the vessel. Watchstanding started immediately after, at ~10:30 a.m. In this cruise, the watch schedule was as follows: 0-8 a.m. (Patrick, Yanming, Joey), 8 a.m - 4 p.m. (Tanya, Teddy, Heidi), and 4 p.m. - 0 a.m. (Cecilia, Adria, and Sam). A fire & boat drill was held at 1 p.m. The *Langseth* cruised to the NNE at a speed of 10-11 knots toward Shatsky Rise. Sea conditions were moderate, with 1-2 m waves and ~10 knots winds. The magnetometer was not towed in transit because doing so during MGL1004 (at a speed of 10 knots) resulted in minor damage.

March 25, 2012 (Sun)
Steinhaus told Korenaga that although all of four gun strings were operational, there was no spare for a remote control module (RCM) for String 1 (as available spares all turned out to be out of order), so if the RCM were to fail, the whole string would be inoperable. Having only one-week of MCS shooting, we had to trust it not to fail. Steinhaus also said that the streamer had a problem with its telemetry, so streamer deployment would take more time than usual as he would have to fix it. The ship is currently sailing over the Mariana Trench. Sea conditions are better than yesterday (no white caps) and the cruising speed was over 11 knots.

March 26, 2012 (Mon)
Transit to the survey area continued with nice weather. The *Langseth* steamed at a speed of ~12 knots. Despite a lot of clouds over the horizon, there was a small gap just around the sun was setting, and we were able to see a very nice green flash.

March 27, 2012 (Tue)
At 6:30 a.m. local, we had a conference call with Meagan Cummings at Lamont (attended by Steinhaus, Meyer, Captain O'Loughlin, Ingram, and Korenaga), regarding the IHA. No major issues were found. Sea conditions deteriorated slightly (3-4 m waves) and the cruising speed was reduced to ~10 knots.

March 28, 2012 (Wed)
Sea conditions were slightly rough and the cruising speed was ~10 knots. Around 2:30 p.m. local, the starboard-side engine had a fuel injector leak and the *Langseth* had to slow down (to ~5 knots) for an hour to fix it.

March 29, 2012 (Thu)
The clock was advanced one hour during midnight, and the local time was set to GMT+11. Sea conditions improved and the cruising speed has recovered to ~11 knots. The deployment of seismic gear was planned to initiate at 8:30 p.m. local, but while preparing for it, Steinhaus found a major acoustic problem (no communication along the streamer). This was around 7:30 p.m. local. In order to locate a troubled section, we started to deploy the streamer and check connection at every five to ten sections. Around 10:40 p.m., after deploying half way through, a bad section was found, which was fixed at ~1:20 a.m.

March 30, 2012 (Fri)
The streamer deployment was completed at ~5:00 a.m, followed by the deployment of gun strings. Ramping up the guns started at ~7:10 a.m. and MCS data collection started at ~7:40 a.m, which was ~75 km away from waypoint 1 (original start of shooting). Sea conditions were rough with 4-6 m waves and ~30 knots of wind, which prevented steaming faster than ~4 knots. *Langseth* arrived at waypoint 1 at 5:30 p.m. and started the shooting of line 1. Because of rough seas, the streamer was depressed to 10 m (instead of 9 m) below the sea surface. The azimuth of line 1 made the relative wind direction favorable, and the *Langseth* was able to make 5 knots. Soon after the line was started, the magnetometer was found to be malfunctioning because of a bad cable, which was replaced with a new one. The magnetometer was back in water at 9:30 pm. Around 10 p.m., more than half of the streamer nearly surfaced owing to stirring by high swells and it took half an hour or so to for it to settle to the proper depth. To avoid similar incidents in future, the streamer depth was increased to 12 m.

March 31, 2012 (Sat)
Sea conditions improved, and shooting on line 1 continued smoothly. The weather forecast indicated that seas would soon get rougher again (and rougher than before). Though sea conditions remained good, currents were strong and against the ship, which forced us to steam at below 4 knots for the sake of cable tension. Around 2:30 p.m., half of gun string #4 ceased to fire, and it took about an hour to fix it by taking it onboard. The spare guns on other strings were turned on, and we also slowed down to minimize the compromised data section. Currents increased (as high as ~3 knots) and resulted in the cruising speed dropping into the range of 2-3 knots. Had the ship been heading in the opposite direction, it would have been necessary to steam faster than 5 knots to keep streamer tension and the shot spacing would be increased to 75 m instead of 50 m.

April 1, 2012 (Sun)
The strong currents abated and the cruising speed recovered to ~4 knots. Line 1 ended at 2:50 a.m., and shooting over line 2 immediately followed. The *Langseth* was now heading toward Ori Massif. Around 6 a.m., the strong currents resumed and the ship was reduced to crawling along at ~3 knots. Around 8:40 a.m., the magnetometer was brought on board because of deteriorating sea conditions (~40 knots of winds). Around 1 p.m., the streamer depth was adjusted to 14 m to reduce swell noise, and around 5 p.m., it was further deepened to 15 m. The cruising speed was below 3 knots. Around 6:35 p.m. local, PSO spotted a fur seal, and all but one airguns were powered down. Shortly after, PSO lost a sight of it, so following IHA requirements, we waited for 15 minutes and then ramped up the guns.

April 2, 2012 (Mon)
The streamer depth was adjusted to 14 m at ~1 a.m. local. Sea conditions started to improve at ~5 a.m. local and the ship speed was increaed to ~4 knots. The magnetometer was re-deployed at ~6:25 a.m. The steamer depth reduced to 12 m at 7 a.m. Around 3 p.m., shooting line 2 was

completed, and the *Langseth* started an inside turn to line 3. Robert decided to keep going without gun maintenance as the weather was good. Line 3 shooting started at ~3:30 p.m. with a speed of ~5.5 knots. The *Langseth* was then heading eastward and with favorable currents. This turn between lines was a hairpin curve and it took ~45 minutes to get the streamer straight after the start of the line.

April 3, 2012 (Tue)
Due to currents, the ship speed was reduced to ~4.5 knots around 3 a.m. local. The weather continued to be favorable and line 3 shooting went smoothly, although gun #1 of string 4 started to fail frequently. At 9:55 p.m. local, line 3 shooting was completed, and gun strings 1&2 were given maintenance (the idea is that spares on these strings are sufficient to cover the likely eventual failure of string 4's gun #1).

April 4, 2012 (Wed)
The gun maintenance and a turn to the next line were completed in 2.5 hours, and shooting over line 4 started at 00:20 a.m. Currents were not a problem and the average ship speed was around 4.5 knots. Around 8 p.m., the weather started to worsen with >40 knots of winds and we were no longer unable to keep the magnetometer safely in the water (there was danger of entangling with the gun strings), so it was brought on board. The streamer depth was adjusted to 15 m.

April 5, 2012 (Thu)
The weather started to improve, and the magnetometer was put back in the water at 6:35 a.m. Gun #2 of string 4 ceased to fire, reducing the total volume to 6140 cubic inch, at ~7 a.m. At 10:45 a.m., shooting over line 4 was completed. To have continuity with existing MCS lines, the ship made an outside turn, during which gun strings #3 and #4 were given maintenance. As the weather prediction was for moderate weather to continue for another day, the streamer depth was set to 9 m, which would provide good continuity with the lines shot in the previous cruise. Around 1:30 p.m., shooting over line D2 (our last line) started. Because there was 12 hours left after shooting all of the originally planed lines, Korenaga decided to keep shooting with the same azimuth after passing way point 1. This would extend line D2 by ~100 km, covering possibly the transition to the normal oceanic crust, so that we could better delineate the spatial extent of Shatsky Rise. The ship speed was ~5 knots. Sea conditions were good with no white caps. Around 10:40 p.m., however, a few guns on string #2 failed, resulting in a substantial drop in the total volume. String #2 was brought on board for repair, and Korenaga decided to turn around to avoid a major gap in line D2 (line D2 was formally terminated there, and a new line was started as line D2A after the turn). During the turn, string #1 was also repaired.

April 6, 2012 (Fri)
Shooting over line D2A started around 2:45 a.m. Three hours later, the streamer depth was adjusted to 11 m to reduce swell noise. Sea conditions were moderate, and shooting went on smoothly.

April 7, 2012 (Sat)
Shooting was terminated at 3 a.m., and we were able to extend the original line D2 by ~75 km. Gun and streamer retrieval immediately followed, which was completed at 6:30 a.m. The *Langseth* then began transit to Honolulu with the speed of ~12 knots.

April 8, 2012 (Sun)
Transit continued with the speed of ~12 knots. At midnight, the clock was advanced, and Sunday would be repeated as we crossed the International Date Line.

April 8, 2012 (Sun; repeated)
The weather improved. There were still lots of clouds, but it was definitely sunnier than the past several days. With our decreasing latitude toward Honolulu, the outside temperature rose gradually. Transit continued smoothly, but around 4 p.m., the vessel slowed down to 5 knots because an issue was detected with the starboard-side engine. The problem was resolved by 4:20 p.m.

April 9, 2012 (Mon)
Transit continued at a speed of 11-12 knots. We crossed the 180 meridian around 2:30 p.m. local.

April 10, 2012 (Tue)
Transit continued with a speed of ~11 knots. The captain confirmed today that the estimated time of arrival at the Honolulu Sea Buoy would be 7:30 a.m. local on the 15th of April. The clock was advanced by one hour at midnight, placing the ship only one hour behind Hawaii time.

April 11, 2012 (Wed)
We took cruise photos at 1 a.m. Transit continued at the speed of ~10 knots; we slowed down to avoid arriving earlier than the ETA. The weather was quite pleasant.

April 12, 2012 (Thu)
Another good day with nice weather. Cruise report writing continued. The clock was advanced by on hour at midnight and we were finally in the Hawaii time.

April 13, 2012 (Fri)
We had a man overboard drill at 12:30 p.m. It was a 'real' one, with throwing a dummy on water and deploying a rescue boat to recover it.

April 14, 2012 (Sat)
The last full day on the *Langseth.* Transit continued peacefully.

April 15, 2012 (Sat)
The Langseth was safely docked at the UH pier around 8 a.m. At 8:30 a.m., we had the last meeting for the science party.

Initial Survey Plan for MGL1004

The original survey plan (July 2010) may be divided into two parts: (1) OBS refraction lines and (2) MCS reflection profiling (Fig. 1). The former included deploying, shooting to the OBS with the airgun array, and recovery of the OBS. The latter included MCS reflection profiling along the OBS seismic lines for imaging purposes as well as lines elsewhere. The rest of the MCS lines were designed to reveal layering and structure of Tamu and Ori massifs and to run over five ODP and IODP drill sites (1213, U1347-U1350). *For the scientific rationale and relevant background information, please refer to the cruise report for MGL1004***.**

The MCS profiles were situated to give transects across and along the axis of Tamu Massif, to cross Ori Massif, and to cross the basin between the two (Helios Basin of Sager et al. [JGR, 104, 7557-7576, 1999]). In addition, the lines were situated to cross as many of the IODP drillsites from Expedition 324 as possible (Fig. 1). The OBS refraction lines divide the MCS profiles into two sets, those to the north and those to the south. The initial plan was to shoot all of the MCS lines contiguously in order to save operations time from deploying and recovering seismic gear.

In the initial plan, the work elements were laid out in the following order.

1. Deploy 28 OBS along lines A-B and C-D, starting at point A and ending at point B.
2. Shoot along the OBS lines for refraction at a 70-second interval, with the airguns at 12 m depth. This long shot interval was chosen to allow shot noise to disperse between seismic traces for clearer records. Shooting was to begin at B and then progress to points E, DD, D, E, C, CC, E, and then to A. The lines E to DD, DD to D, E to CC, and CC to C were configured to keep from repeating lines E-D and E-C and to give extra data illuminating the lateral structure of Tamu Massif.
3. At point A, the plan was to deploy the streamer and reconfigure the airguns to a shallower depth (9 m), and begin shooting MCS reflection profiles. Shots were to be placed on distance, with 20 m between shots. According to plan, the first profile would be A to B, followed by B to 1, 1 to 3, 3 to 4, 4 to C, C to 6, 6 to 7, and 7 to B. At this point, MCS profiling would be finished and the gear recovered.
4. Recover OBS, beginning at point B. The recovery path would be from B to E, transit to point D, D to C, transit back to point E, and recover E to A.
5. After finishing the recovery of OBS, the ship was to be at point A and any remaining contingency time would be used in a survey of the nearby area using the multibeam echosounder and other underway geophysical instruments.

The initial plan called for 11 days of OBS operations, 16 days of MCS profiling, and 20 days of transit to and from Honolulu. Approximately 5 days of contingency time was built into the plan to allow for mechanical failures, gaps to be filled, or weather delays.

Due to two medical diversions to Japan, however, we were unable to follow the above plan even with a week of extension from NSF, and the northern part of MCS reflection lines were left to be revisited in future.

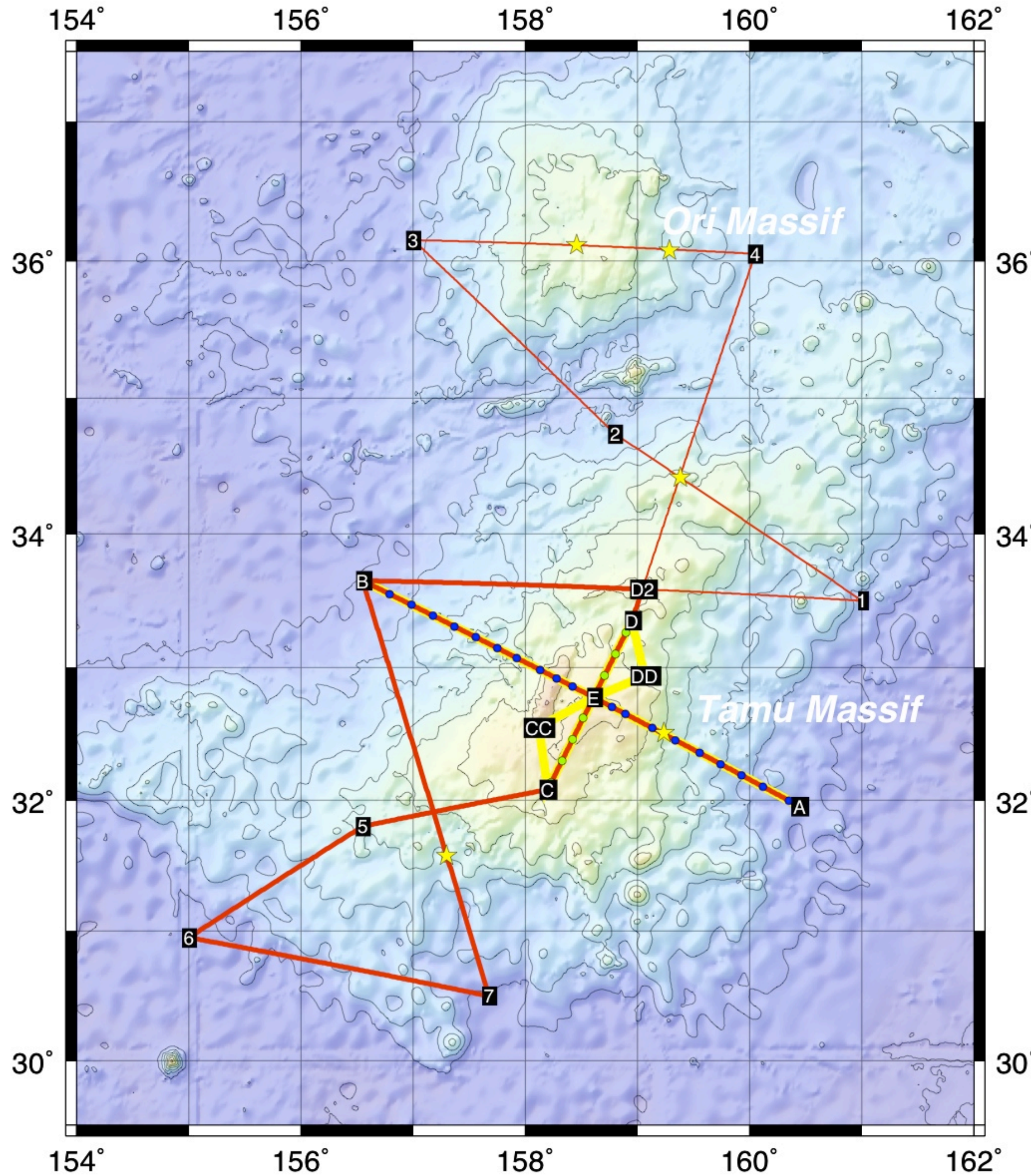


Figure 1. Map showing the initial survey plan, with OBS refraction lines (yellow), MCS reflection lines (red), OBS locations (blue and green circles), and IODP Sites (stars). Thin red lines indicate those not covered during MGL1004.

Operation Details

Navigation

MGL1206 cruise navigation data were provided by three different DGPS (differential Global Positioning System) satellite receivers: CNav 3050, Seapath 200, and Cnav 2000. All three DGPS systems are integrated into the Spectra navigation system with CNav 3050 as primary (weighted heaviest in the final position solution). Spectra resolves a position to the NRP (navigation reference point). The NRP for MGL1004 is the center of frame 0 at the water line, 4.2 m forward of the stern. Serial (NMEA) data from all four DGPS systems are logged to the LDEO logger system. The position referenced in serial data is the position of the respective DGPS antenna location. Most of these antennas are on the MMO tower and are therefore not coincident with the NRP.

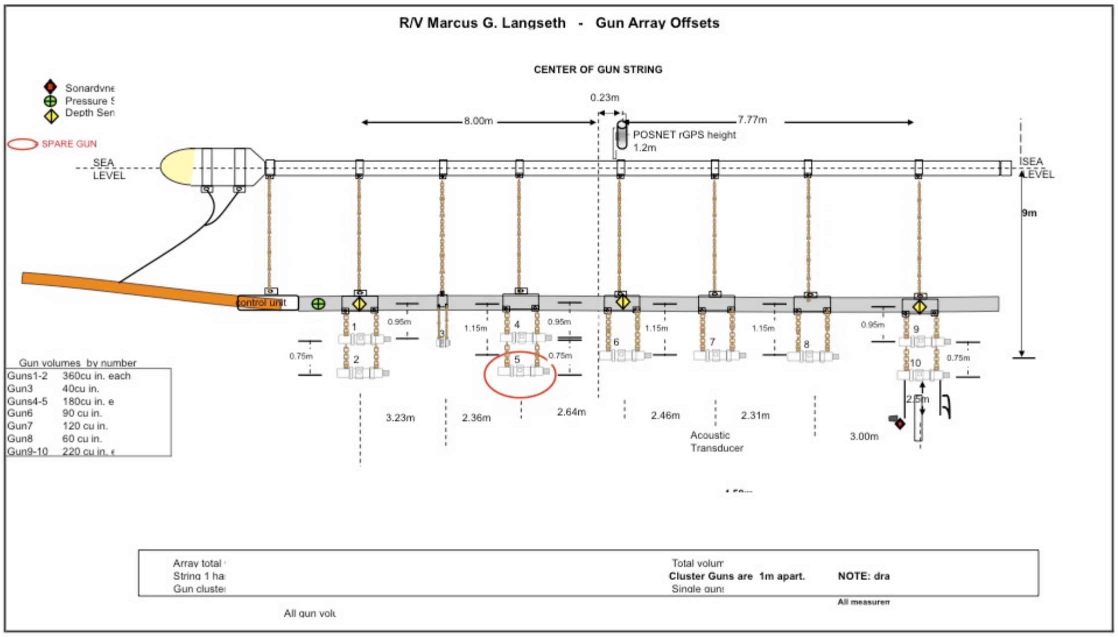
The source and streamer are positioned with a combination of RGPS (Posnet system), acoustic links (SIPS), and depth controller (bird) compasses. The Spectra navigation system resolves a position based on the range and bearing of the Posnet GPS unit on each of the source sub-arrays, as well as the tail bouy at the end of the streamer. The positioning of the source is augmented by acoustic ranging between the sub-arrays and the head of the streamer, with the streamer shape modeled on the 21 compass headings provided by the Digicourse birds attached to the streamer. Streamer depth comes from pressure sensors in the birds.

Multichannel Seismic Shooting Operations

Acquisition Geometry Information: (see Fig. 2 for graphic presentation)
Gun Volume: 6,600 cu. in.
Number of Guns: 36 (4 spares)
Source Depth: 9.0 m
Shot Interval: 50.0 m (~20 sec, shot on distance)
Receiver Depth: 9.0 m (deepened up to 15.0 m depending on wave height; see text)
Receiver Group Interval: 12.5 m
Number of Channels: 468
Sample Rate: 2 ms
Record Length: 16 s
Low-Cut: 2 Hz
High-Cut: 206 Hz
Tape Format: SEG-D
Distance from Antenna to Center of Source: 232.0 m
Distance from Center of Source to First Channel: 152.7 m
Distance from Center of Source to Last Channel: 5990.2 m
Distance from First Channel to Last Channel: 5837.5 m (= (468-1)*12.5m)
Nominal Fold: 58 (=(468 * 12.5) / (2 * 50) = 58.5)
Nominal CDP Bin: 6.25 m

We acquired 1,366 km of multichannel seismic reflection data along five major transects, including two extra segments (from waypoints 1A to 1 and 1 to 1B). The 6,600 cu. in., 36 airgun array was shot on distance with a 50 m (~20 s) shot spacing. With 12.5 m between hydrophone groups and a 50 m shot spacing, the common midpoint (CMP) fold is 58 with a spacing of 6.25 m. We ran into few technical interruptions during the MCS acquisition operations. Preventive airgun maintenance was done twice during line changes, and we lost only four hours by a major gun failure on line D2, for which we had to make an extra turn for gun repair and line reshoot. Only once we powered down shooting operations due to a marine mammal sighting (one fur seal), but because the total down time was less than an hour (and the weather was quite rough), we decided not to reshoot.

Because of severe weather conditions, however, the streamer depth had to be adjusted carefully to avoid swell noise. The default depth was 9 m, but it was increased to 12 m at SP1926 (during line 1), then to 14 m at SP2082, 16 m at SP2978, and back to 12 m at SP4379 (during line 2), to 15 m at SP4952 (line 4). The depth was finally back to 9 m again at the beginning of line D2, and it stayed there for the rest of the survey. Greater receiver depth results in the loss of high-frequency components (and the gain of low-frequency components) due to increased ambient pressure. It was fortunate to recover the depth of 9 m on line D2, which connects to one of MGL1004 transects collected with the streamer depth of 9 m.



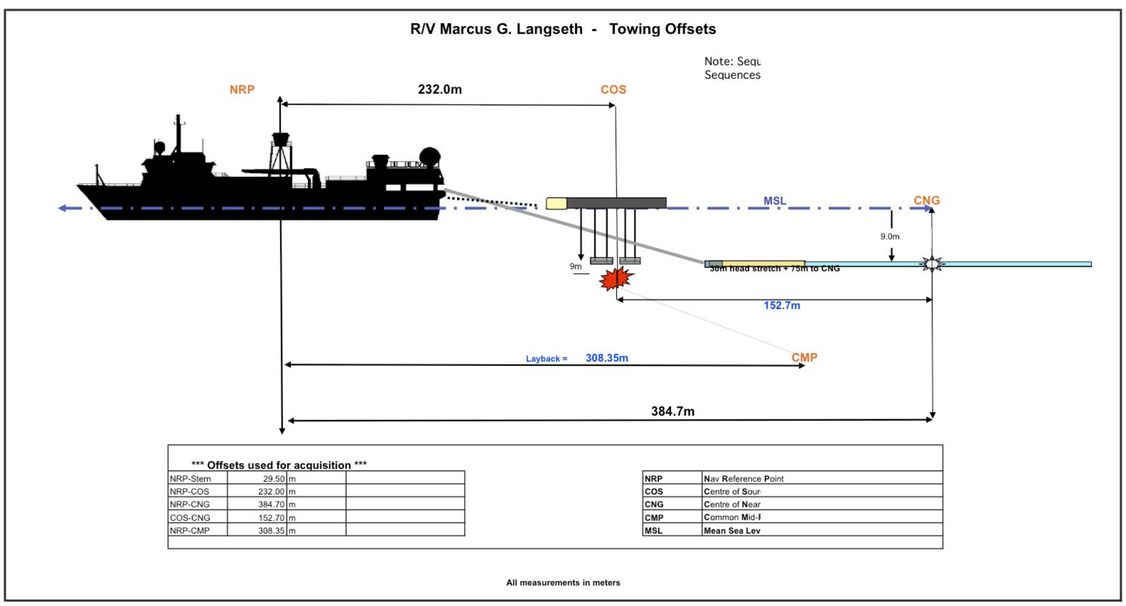


Figure 2. Diagram of source and receiver geometry for MCS operations, MGL1206.

Underway Geophysics

Multibeam Bathymetry

Multibeam bathymetry data were collected during the MGL1206 cruise using the R/V *Marcus G. Langseth*'s hull-mounted Simrad-Kongsberg EM122 echo-sounder. The vessel is fitted with a 0.5° x 1.0° degree array, that forms up to 432 beams per sonar ping in a swath arc 140° wide. Throughout the duration of the cruise, the instrument was operated in dual ping mode, generating two pulses per cycle, which doubles the sampling density and allows for more reliable ping-editing during processing.

Towed magnetometer

Total magnetic field data were measured during cruise MGL1206 using a Geometrics G-882 cesium vapor magnetometer. The magnetometer was towed 125 m astern from the starboard side of the aft main deck rail. Measurements were recorded every second along with time. These data were then merged with navigation at one second intervals.

The towing layback was 150 m during MGL1004, and it was already too short to completely avoid interference by the magnetic anomaly of the ship (see the cruise report of MGL1004 for more on this). The cable was cut down to 125 m to remove a damaged part. In post-cruise processing, this fact needs to be taken into account.

Gravimeter

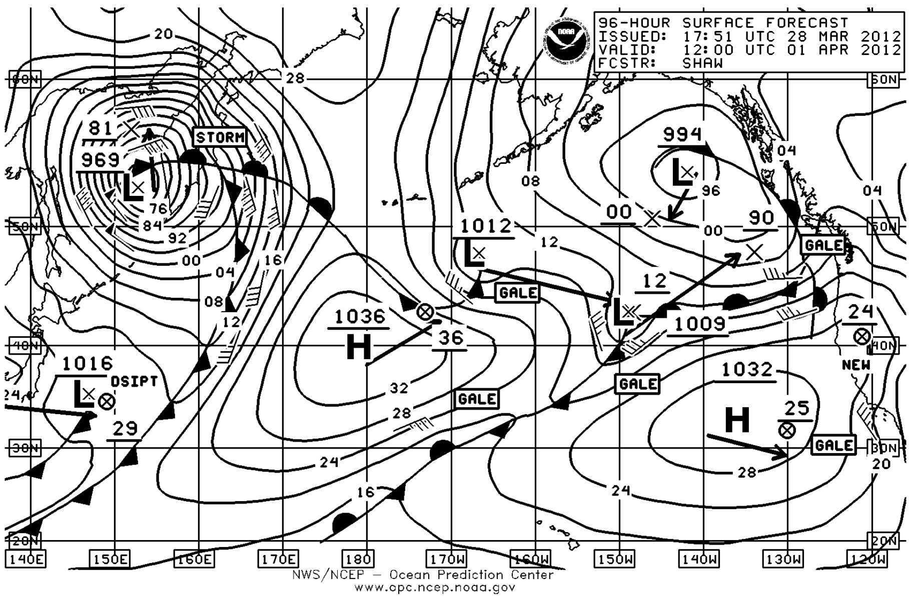
Gravity data were measured by a Bell BGM-3 gravimeter (Bell and Watts, 1986) located in the Langseth main lab. Raw data were recorded at 1-second intervals by the shipboard data logging system. Absolute gravity tie measurements were made before and after the cruise using a portable Worden gravimeter to tie the dock next to the ship with the gravity stations located at the Sierra pier in Guam Navy Base (500 ft mark) and at the UH Pier, Oahu, Hawaii. Gravity data require post-cruise processing including filtering, Eötvos effect, drift correction, and tie to the absolute gravity network.

Weather Information

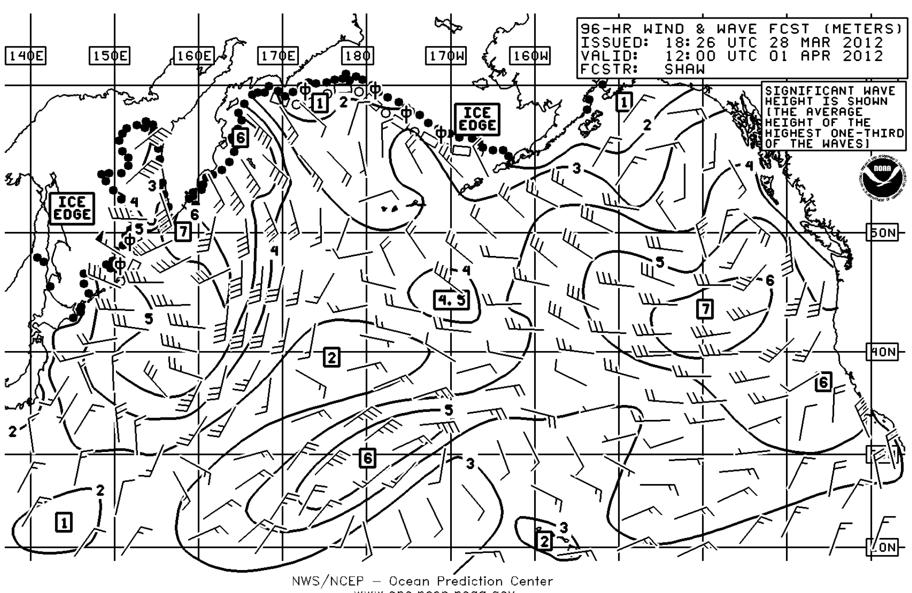
The Chief Science Officer posted daily 48-hour and 96-hour forecasts for atmospheric pressure as well as wind and wave heights, by downloading information from the Ocean Prediction Center of the National Weather Service at NOAA (http://www.opc.ncep.noaa.gov/). He also emailed daily the PIs weekly weather forecast (wind speed and wave height) from buoyweather.com (paid service), to which he personally subscribed, as Columbia University does not pay for weather service.

Sample forecast images are shown below:

* 96-hour surface forecast



* 96-hour wind and wave forecast



Shipboard Computing Environment

Most members of the science party brought their own laptop onboard, and because the Internet connection was available through the Highseas Net on *Langseth*, they were able to post cruise blogs from their laptops. There were two wireless LANs, "Langseth" and "MGL-Admin", through which we can access the cruise web site (containing E-log, data formats, Facebook for crew members, software manuals, etc) as well as the file server "fserve". A public folder on fserve was very useful for file exchange among the science party. "MGL-Admin" allows the chief scientist to connect to the Internet as well after the following routing command "% route -nv add -net 192.168 -interface en1 -host 192.128.0.0 -netmask 255.255.0.0". One HP color laser printer, two HP B/W laser printers, and one HP plotter were also available through the LANs, and they were used to print out various plots of MCS and bathymetry data. The computing environment in the main lab was well maintained and organized.

For shipboard data processing, TAMU's Linux PC (Dell-Optiplex 745 with CentOS) "carina" was supposed to be used for MCS data processing, but its hard drive, which contains a ProMAX license, unfortunately failed at the beginning of the cruise. Fortunately, the main lab has a better computing resource, "proc1", which is a Redhat Linux cluster with 16 CPUs, 24GB memory, and 4TB internal hard drive, and it also has a ProMAX license. MCS data processing was thus done on "proc1". TAMU's iMac was used for multibeam data processing; though its protective glass for LCD display was damaged during its air travel to Guam, it still worked fine.

Shipboard Data Processing

Multichannel Seismic Profiles

On R/V *Marcus Langseth* cruise MGL1206, we created near-trace seismic sections and full-fold, time-migrated stacks using ProMAX. We used GMT to create annotated plots in black and white and color. This section describes the main processing steps for creating near-trace sections, setting up the geometry, processing the data through time migration, and creating plots with GMT. Refer to the outline for details on the specific ProMAX flows and processing parameters.

<u>1: Create Near Trace Seismic Sections, Load SEGD Data</u>

ProMAX was used to select the near channel (468) from each shot gather, apply a bandpass filter, and output each seismic section in SEGY format. ProMAX application SEGD Input was used to load the near channel for each shot. Because of a limitation (possibly a bug) in ProMAX, only one tape of shots could be loaded at a time, so multiple SEGD Input / Disk Data Output steps were created to load all of the tapes for each line in a single flow. A separate Disk Data Input/Output sequence combined the traces from each tape into a single file using the Append option in Disk Data Output. The data were then output to disk in IBM format using SEGY Output. GMT was applied to plot SEGY files in black and white and color (plot_segy_bw_mgl1206.gmt and plot_segy_color_mgl1206.gmt with seis.cpt).

<u>2: ProMAX Processing Procedure</u>

<u>2.1 Geometry Setup, Trace Edit</u>

The most critical procedure to complete during onboard processing is navigation and geometry setup. This allowed us to take advantage of having all of the navigation data and related acquisition information, which is important for taking account of recording failures, ship turns, and other issues during initial geometry setup. Trace editing was also completed, during which noisy traces are removed or filtered for noise bursts. We found that the number of bad channels averaged ~7% of the total number of channels for each line.

2.2 Bandpass Filter, Spike & Noise Edit, Deconvolution, NMO, Stack, Time Migration

Onboard processing steps on MGL1206 included bandpass filtering, spike and noise edit, trace kill, deconvolution, NMO, stack, and time migration. A 200 CDP interval picking of velocity analysis was applied during onboard processing. A predictive deconvolution filter was designed to compress the wavelet before NMO correction. Finally, time migration was applied. We tested migration velocities based on the stacking velocities, but found that Memory Stolt FK migration at a constant velocity of the water (1,500 m/s) worked best to avoid over-migrating errors.

2.3 Optional Post-Cruise Processing

Optional post-cruise data processing steps may include time-variant and multi-window bandpass filtering and deconvolution, more detailed velocity analysis particularly for specific horizons of interest, inside mute and Radon and F-K filtering for multiple removal, and depth migration using an accurate velocity model.

3: Plotting SEGY Seismic Data with GMT

We used GMT to create annotated PostScript plots from the SEGY data. The seismic profiles can be plotted as both variable area black and white images (plot_segy_bw_mgl1206.gmt) and color gridded seismic images (plot_segy_color_mgl1206.gmt with seis.cpt). A custom plot size is needed to plot the seismic sections on large paper.

Multibeam Bathymetry

Bathymetry data were processed using MB-System swath sonar bathymetry software, version 5.13b. This version of the software has a known issue when processing data from current generation Simrad sonars, the EM-122 being such an instrument, which makes it currently impossible to recalculate beam ray paths after applying new sound velocity profiles. Accordingly, due diligence was paid to the operating sound velocity profile used during acquisition, and it was updated with a new eXpendable Bathymetric Thermograph probe (XBT) cast daily.

Bathymetry data were ping edited using MB-System. Erroneous soundings were recognized as outliers by departure from a smooth depth profile and deleted from the dataset prior to gridding of the data. Swath widths during the cruise reliably ranged from 3 to 4.8 times water depth and so gridding resolution was calculated (by dividing swath width by total number of beams per ping) at 50 meters. This value ensures at least one beam in each gridding bin for all depths of the survey, both on site at Shatsky Rise as well as in abyssal depths on the transits to and from the survey site. The current standard for scientific bathymetric surveys is 100 meter resolution, and previous surveys on Shatsky Rise, conducted in 1994, were done at 150 meter resolution, so this is a significant increase in resolution for this survey.

Throughout the duration of the MGL1206 cruise, processed bathymetry data were gridded at the end of each Julian Day (UTC) and merged with 1 arc-minute resolution estimated bathymetry from satellite altimetry (Smith and Sandwell, 1997) to generate daily plots of the bathymetry surveyed.

At the completion of the cruise, the total pool of bathymetry data collected will be gridded into three major regions: The Pacific Basin covered by the transit between Guam and Shatsky Rise, The Pacific Basin covered by the transit between Hawaii and Shatsky Rise, and Shatsky Rise proper. These three grids will be made available to the cruise participants and will be uploaded to the Marine Geophysical Database maintained by Lamont-Dougherty Earth Observatory, where they will be available to the cruise participants via the internet immediately, and to the general public after the expiration of the two-year post-cruise moratorium.

Sound Velocity Profiles (SVPs) were generated during the course of MGL 1206 by the use of Sippican XBTs at an interval of one every 24 hours. At transit speeds, T-7 model XBTs were used, collecting water column temperature profiles to a depth of 760 m. At slower survey speeds, T-5 model XBTs were used to collect profiles up to 5000 m, and one occasion, a C-5 eXpendable Conductivity Temperature Depth (XCTD) probe was used to collect its full suite of water column information to a depth of 1300 m. The temperature profiles collected by these probes, when used with the current seawater salinity (measured by the ship's thermosalinograph system), were used to calculate SVPs that were then loaded into the Seafloor Information System (SIS) acquisition software that is used with the Simrad EM-122 multibeam system. The SIS software compares these SVPs with surface water sound velocity probe values measured from the thermosalinograph system in the multibeam array housing to ensure that the calculated SVP values are within the expected range. If the SVP matches the measured probe values, then SIS applies that profile to the beam depth calculations for each beam in each sonar pulse. At any time that the SVP values were more than three meters per second different than the probe reading, a warning light was turned on in the software, and plans were made to take a new XBT cast to update the SVP in SIS.

Survey Outcome and Assessment

The map below (Fig. 3) summarizes the MCS reflection lines for MGL1206, along with those collected during MGL1004. The shooting started from waypoint 1A, and then in the order of 1-2-3-4-D2-1B. Segments 1A-1 and 1-1B are transects made during extra contingency time. Turns at waypoints were all inside turns, except for waypoint D2, where we made outside turn to achieve continuity with MGL1004 transects. Preventive gun maintenance was done twice during turns at waypoints 4 and D2. Emergency gun repair was made in the middle of a transect from D2 to 1, for which we made an extra turn to avoid data gap.

The most challenging part was a transect from waypoint 2 to 3 (Line 2), where we were forced to move with a speed of ~2 knots due to strong opposing currents. Sea conditions were also quite severe. Before arriving at waypoint 3, however, the weather recovered to a moderate level, and the chief science officer decided to keep shooting without preventive gun maintenance; the idea was to finish the northernmost transect as quickly as possible and escape to lower latitudes. The rest of the transects went smoothly, which more than compensates for the time loss on Line 2, and we were able to extend Line D2 by ~75 km, despite the extra turn made for gun repair.

Sea conditions for the Shatsky-Honolulu transit were consistently good, allowing the *Langseth* to steam at ~12 knots, and we arrived in the port two days early.

In Table 1, we compare the actual timeline with the original schedule. The total cruise duration in the original schedule is 24 days in total (with 8 days for science and 16 days for transits). Cruise waypoints are given in Table 2.

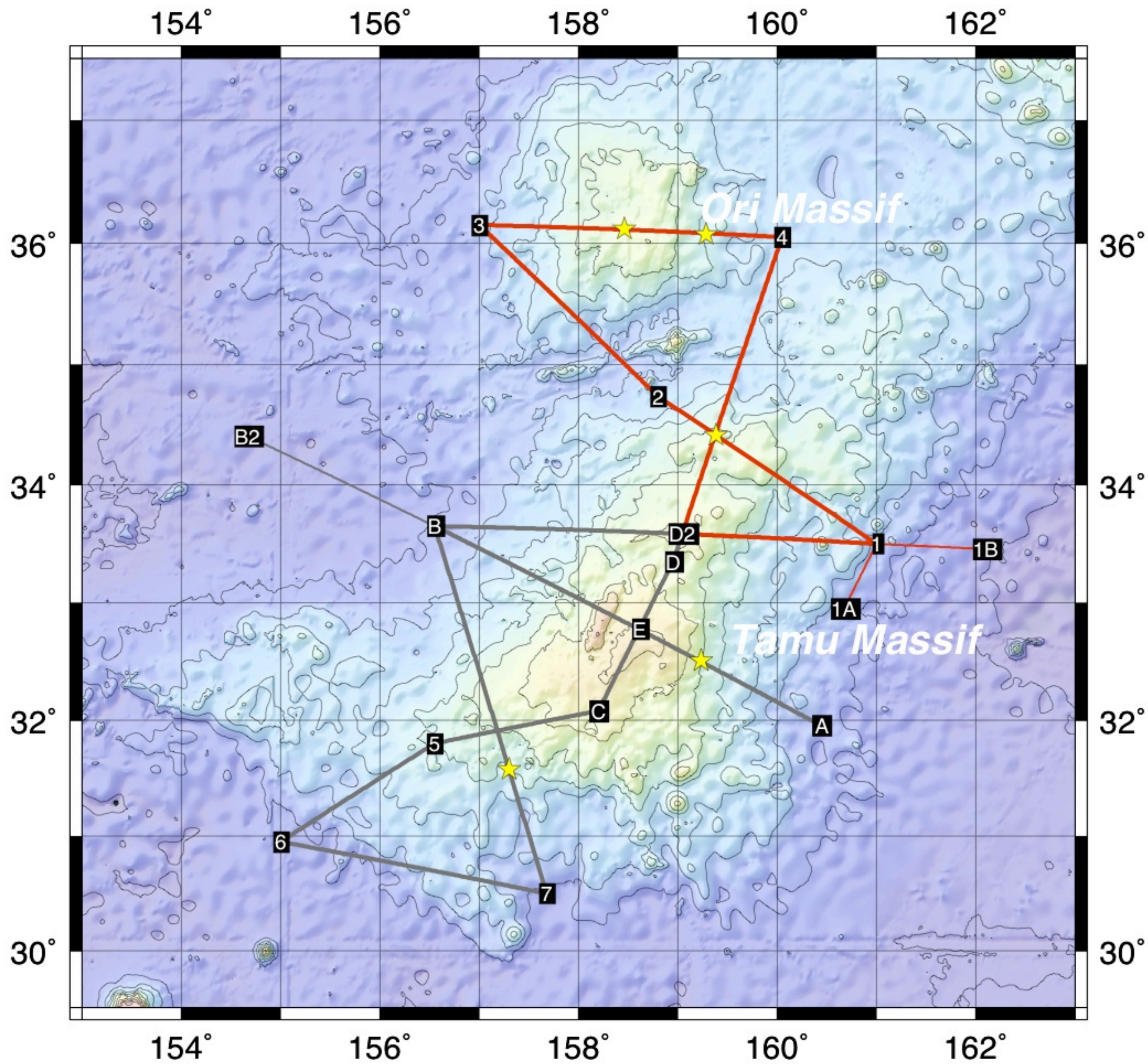


Figure 3. MCS transects collected on cruise MGL1004 and MGL1206. Heavy lines show originally planned transects, and gray and red lines correspond to MGL1004 and MGL1206, respectively. Stars denote the locations of drilling sites.

Table 1. Operation time summary.

Plan					Actual				
	duration	elapsed				elapsed		diff.	
Task	(hour)	(hour)	(day)		duration	(hour)	(day)	(hour)	note
Guam-1	144.0	143.95	6.0		131.5	132	5.5	12.5	
deploy streamer	24.0	167.95	7.0		8.5	140	5.8	15.5	
deploy guns	7.0	174.95	7.3		2.8	143	5.9	4.3	
(MCS shooting 1A-1)					9.8	153	6.4	-9.8	(*1)
MCS shooting 1-2	29.4	204.31	8.5		33.3	186	7.7	-4.0	
MCS shooting 2-3	27.2	231.5	9.6		36.7	223	9.3	-9.5	
gun maintenance	4.0	235.5	9.8		0.0	223	9.3	4.0	(*2)
MCS shooting 3-4	32.9	268.41	11.2		30.4	253	10.5	2.5	
gun maintenance	4.0	272.41	11.4		2.4	255	10.6	1.6	
MCS shooting 4-D2	34.7	307.09	12.8		34.4	290	12.1	0.3	
gun maintenance	4.0	311.09	13.0		2.8	293	12.2	1.2	
MCS shooting D2-1	21.8	332.88	13.9		24.9	317	13.2	-3.1	(*3)
(MCS shooting 1-1B)					12.6	330	13.8	-12.6	(*4)
retrive guns	2.0	334.88	14.0		1.2	331	13.8	0.8	
retrive streamer	8.0	342.88	14.3		2.3	334	13.9	5.7	
1-Honolulu	229.5	572.4	23.9		219.0	553	23.0	10.5	

Transit speed:	10	knots
Shooting speed:	4.5	knots

Shooting net difference(*5):	-13.8	hours
MCS gear-related operations net difference:	33.1	hours

(*1) This is an extra segment not originally planned, gained by the early completion of gear deployment.

(*2) Chief Sci. Officer recommended to keep shooting.

(*3) includes a turn due to gun string failure.

(*4) This is another extra segment, gained by the early completion of the original shooting plan.

(*5) This does not include extra segments.

Table 2. List of cruise waypoints.

	Shooting waypoints				
	latitude	longitude		latitude	longitude
1	33.500000	161.000000	**D2**	33.585700	159.043000
2	34.735000	158.800000	**1A**	32.952000	160.674300
3	36.150000	157.000000	**1B**	33.456500	162.100000
4	36.050000	160.050000			

Preliminary Data Review

Multichannel Seismic Profiles

Line 1. Line 1 crosses the northernmost extent of Tamu Massif, a low, rounded "nose" (Fig. 4). The seismic image shows a broad, rounded swell near the center of the line, with 2 or more volcanic centers interpreted from diverging lava flows. Sediments are variable in thickness, ranging from 0-0.7 seconds two-way traveltime. The thickness variations appear mainly to occur from variable fill of basement lows, but some evidence of erosional truncation is also seen. Intrabasement reflectors can be recognized to a depth of 1-2 seconds two-way traveltime. The basement surface is rough, unlike that of the Tamu Massif south flank. In general, intrabasement reflectors indicate lava flows dipping away from the center of Tamu Massif, but the pattern is more complicated than elsewhere on this volcanic mountain. Down-to-basement faulting, seen elsewhere on Tamu Massif, is not evident. The basement hill upon which IODP Site U1348 was drilled appears to be a constructional feature (i.e., a center of volcanism) rather than a fault block.

Line 2. Line 2 crosses Helios Basin, in between Tamu and Ori massifs (Fig. 5). Sediments are thickest (0.2-0.5 seconds two-way traveltime) on Ori Massif and Tamu Massif and lesser in thickness in the basin. The basement surface dips down to the center of the basin and intrabasement reflectors, which do the same, imply that lava flows from Tamu and Ori massifs flowed to the basin center. At the center of the basin, they meet at a small volcanic mound, which is mostly buried by sediments. This mound appears to be on the trend of a linear seamount (Cooperation Seamount) and ridge on either side of the seismic line. Together they suggest a long, linear volcanic eruption center at the middle of Helios Basin and following the basin axis. Where the seismic line crosses the southwest flank of Ori Massif, several volcanic centers are observed. This implies that Ori is a composite volcano, rather than a single volcano as is suspected of Tamu Massif.

Line 3. Line 3 crosses the summit of Ori Massif from west to east and it also crosses two IODP drill sites (Fig. 6), U1349 at the summit of Ori Massif, and U1350 on the lower east flank. Sediments range from 0.1-0-.7 seconds two-way traveltime, with the thickest accumulations at the top of Ori Massif. The basement surface is well imaged and intrabasement reflectors show flows dipping away from the center of Ori Massif. Nevertheless, the structural picture is more complex than for Tamu Massif with major secondary volcanic centers observed for Ori Massif. A secondary cone on the east flank may be an long term volcanic center. Likewise, dome-like patterns in intrabasement reflector slopes on the west flank imply other major volcanic centers. Basement at the summit of Ori Massif shows no indication of wave planation owing to subaerial exposure. However a summit ridge with a relatively flat top is at the center of the volcanic edifice and this is also the location of Site U1349. Some small, down-to-basin normal faults are observed on this line.

Line 4. Line 4 follows the axis of Tamu Massif beginning in the basin to the east of Ori Massif and climbing the north flank of Tamu Massif to connect with prior MCS lines near the summit (Fig. 7). Sediment thickness increases from ~0.1-0.2 seconds two-way traveltime in the basin to ~0.8 seconds two-way traveltime near the summit of Tamu Massif. Basement is well imaged. The north end of the line crosses a small volcanic mound that has a similar appearance to the volcanic lineament in the center of Helios Basin; although, it is not contiguous with that feature. Bathymetry implies that this is also a linear volcanic ridge that follows the axis of Helios Basin. Intrabasement reflectors imply lava flows dipping down-to-the-north from Tamu Massif to a small cone at the edge of Helios Basin. This transect also crosses IODP Site U1348 and shows that it sits on a constructional volcanic mound. From this crossing, this mound appears to be a surface feature atop the low slope of Tamu Massif. Several small normal faults are observed on the line, but they do not follow a consistent sense of motion.

Line D2. Line D2 continues a transverse transect of Tamu Massif that was begun on cruise MGL1004. The new line overlaps the old line at the high point of the transect atop Tamu Massif. The character of this line is very much like the mirror image of the first part of D2. Intrabasement reflectors are observed to depths of 1.5-2.0 seconds two-way traveltime. These reflectors dip toward the basin from the high point and imply long lava flows trending downslope from the axis of Tamu Massif. At the high point, a summit graben, which likely shows a rift zone location, is observed. As for the west half of line D2, the east half is also consistent with the idea that there were no long term volcanic centers other than the volcanic axis. Several small secondary cones are seen, but they appear to have small volume and steeper (~5°) slopes than the lava flows than the main shield building lava flows. No normal fault offsets were observed on this flank of the massif. In addition, Moho was not observed at the basin end, unlike the western part of the profile.

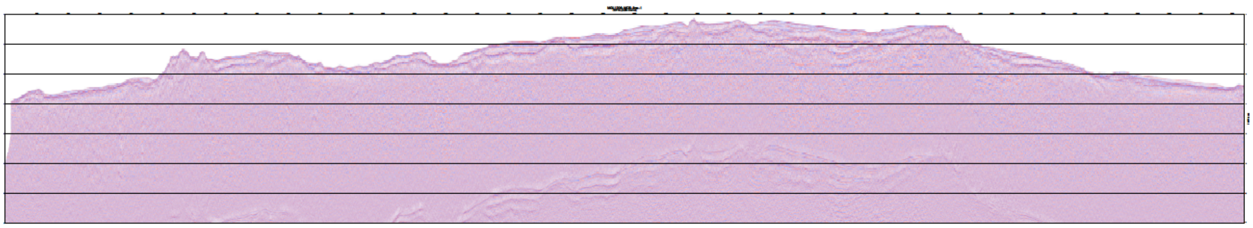


Figure 4. Line 1.

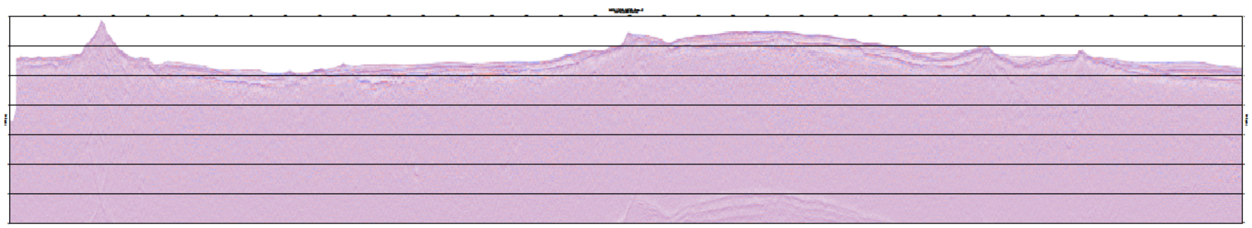


Figure 5. Line 2.

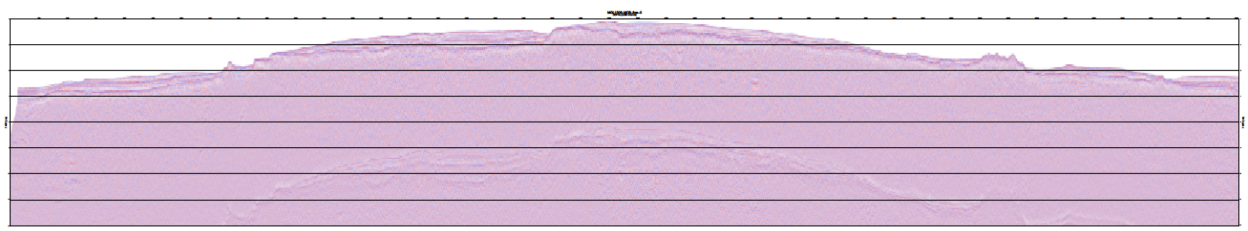


Figure 6. Line 3.

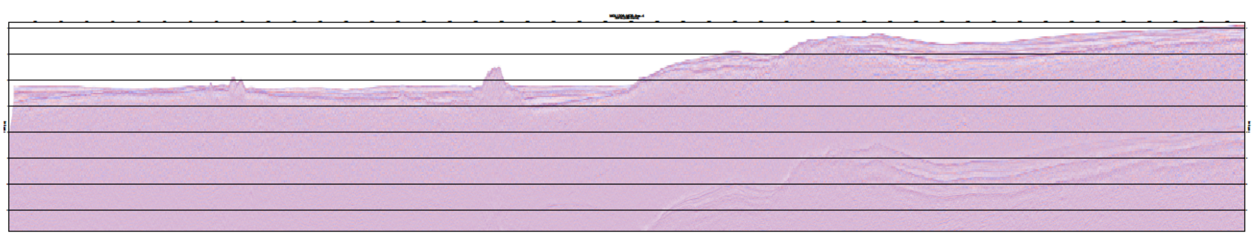


Figure 7. Line 4.

Multibeam Bathymetry

The EM122 multibeam echosounder provided detailed bathymetry on a wide swath throughout the cruise, giving insights to geologic processes and structure. For the purposes of discussion, the cruise is divided into three areas: Shatsky Rise, the transit from Guam, and the transit to Hawaii.

Shatsky Rise.

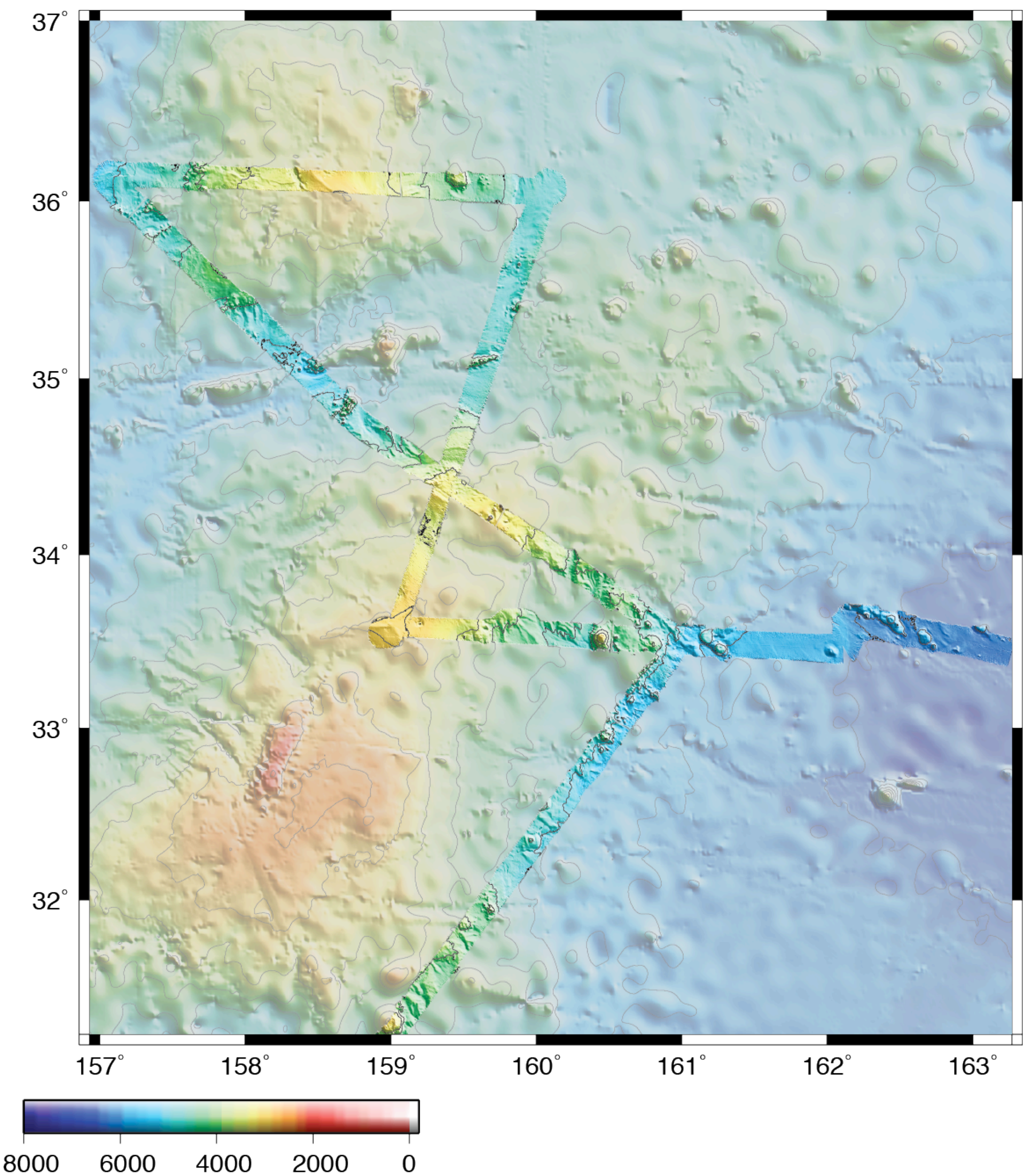


Figure 8 Bathymetry map of Tamu Massif and Ori Massif from merged MGL1206 multibeam (bright colors) and satellite altimetry (faded colors) (Smith and Sandwell, 1997) data. Contours at shown at 500-m intervals.

Guam Transit.

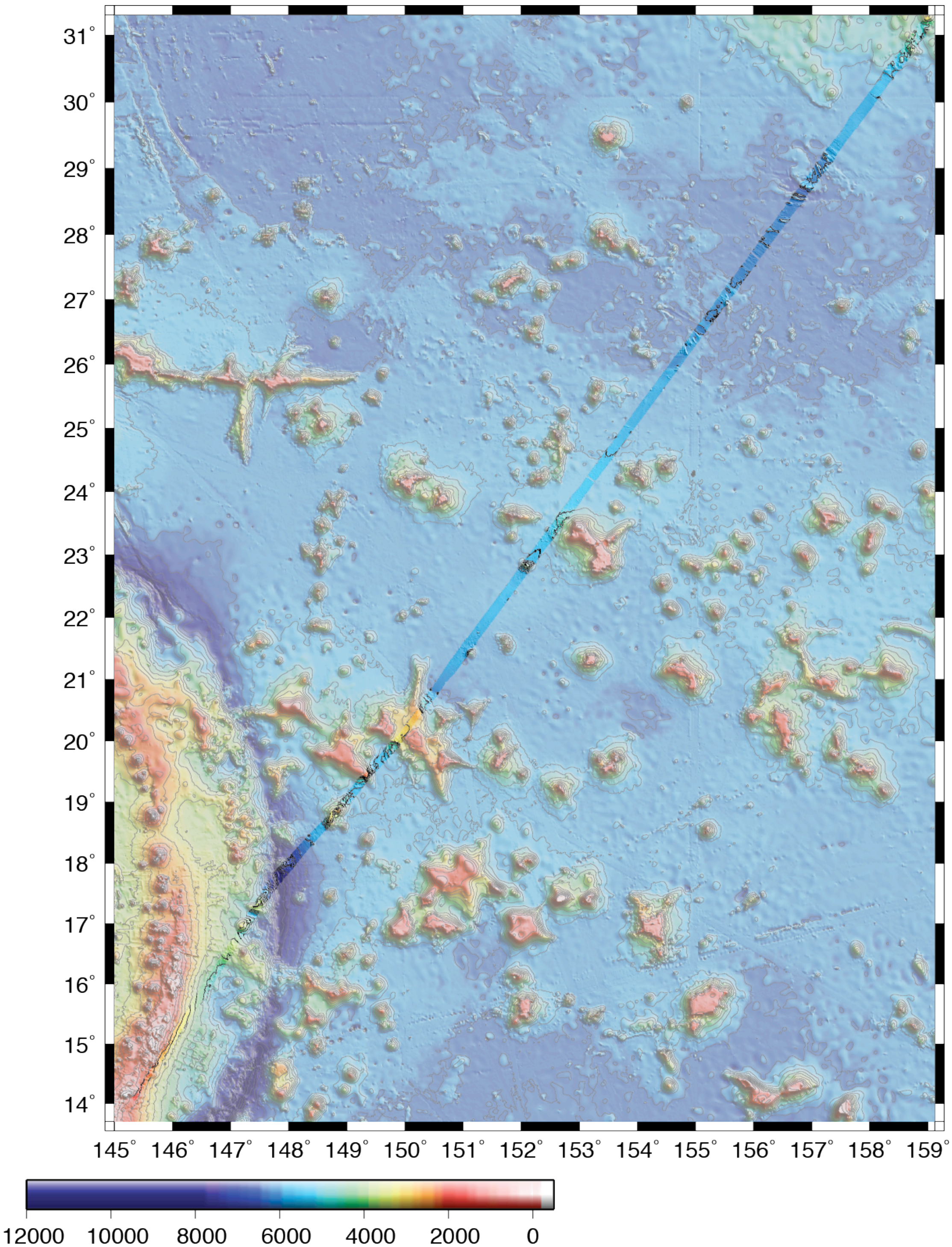


Figure 9. Bathymetry map of the area southwest of Shatsky Rise covered by the transit from Guam. Bathymetry data are from MGL1206 multibeam data (bright colors) and satellite altimetry (faded colors) (Smith and Sandwell, 1997). Contours are shown at 500-m intervals.

Hawaii Transit.

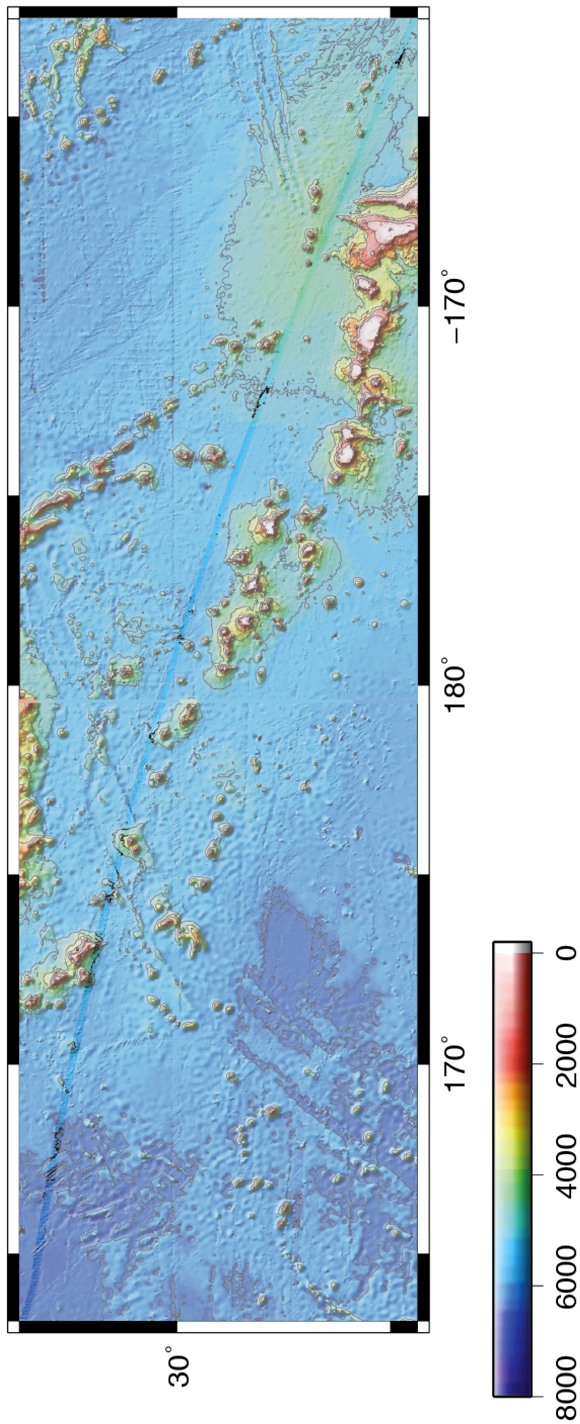


Figure 10. Bathymetry map of the area covered by the transit from Shatsky Rise to Hawaii. Bathymetry data are from MGL1206 multibeam data (bright colors) and satellite altimetry (faded colors) (Smith and Sandwell, 1997). Contours are shown at 1000-m intervals.

Underway Geophysical Data

After merging with navigation data, proton magnetic data were reduced to the total-intensity anomaly, by subtracting the main-field component as predicted by the International Geomagnetic Reference Field (with the 11th generation coefficients). The total-intensity anomaly is shown in Fig. 11.

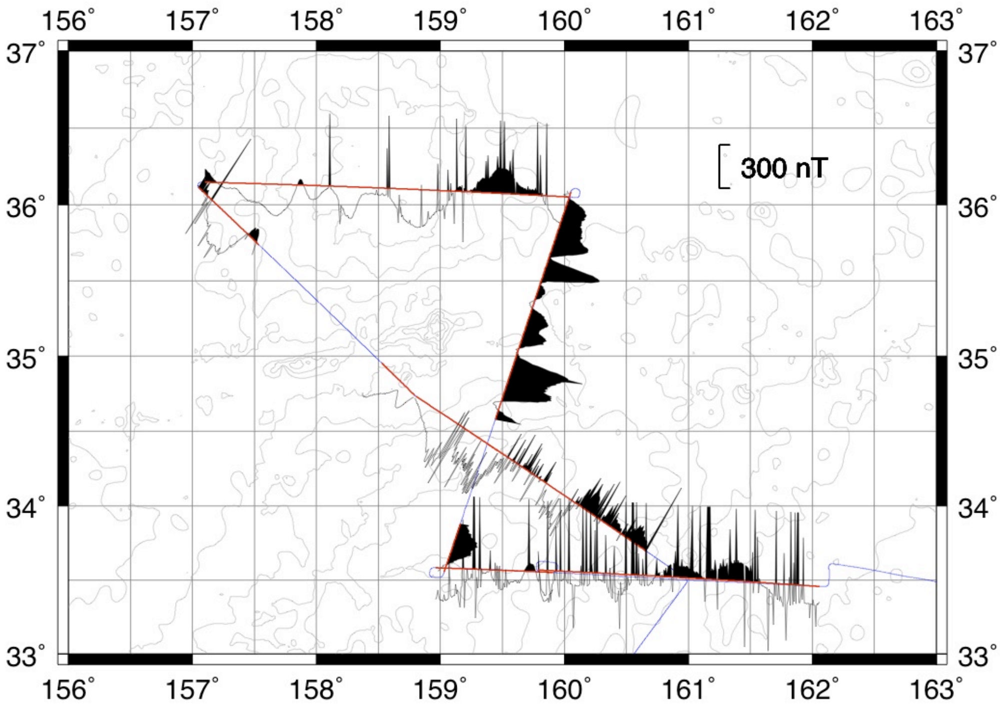


Figure 11. Wiggle plot of magnetic anomalies along MGL1206 ship tracks (blue lines). Red lines indicate where magnetic data were collected. Unfilterd data are plotted with 5-minute interval to reduce the appearance of high-frequency noise.

Except for data along line 4, magnetic data are extremely noisy reflecting the severe sea conditions we have experienced, though they may still be sufficient for the qualitative interpretation of magnetic isochrons. An effort will be necessary to clean the data set of spurious values. As previously noted in the cruise report for MGL1004, *Langseth*'s magnetic data also suffer from the ship's own magnetic field, because the magnetometer is towed from the ship with an offset of only 125 m. Post-cruise processing of magnetic data thus requires great care.

In general, the magnetic anomaly data are consistent with known magnetic anomalies. Clear, seafloor-spreading-like anomalies are seen on line 4 across Helios Basin. Anomalies in this basin were traced by Nakanishi et al. Similar variations are observed along line 3 over the Ori Massif summit and suggest that this massif may contain large magnetic anomalies. Data over most of Tamu Massif are poor owing to weather-generated noise, so more work will be needed to interpret those data.

Processed gravity data were not available during the cruise. Pre-cruise and post-cruise gravity ties were made on 18 March 2012 in Guam and 15 April 2012 in Honolulu, Hawaii, respectively. LDEO R2R (Rolling Deck 2 Repository; contact: Bob Arko, arko@ldeo.columbia.edu) was in charge of post-cruise processing, including drift correction, the Etövös correction, and the calculation of free-air gravity anomaly. *Langseth*'s gravity processing is adapted from R/V *Ewing* processing. R/V Ewing data was previously tied to the Potsdam system. The *Langseth* processing flow is updated to use the post-Potsdam system.

Appendices

Data List

Navigation:

- MGL1206/raw/serial/MGL-cnav* (2.5GB; CNAV GPS receiver data) [Y, T]
- MGL1206/raw/serial/MGL-seapth* (765MB; Seapath 200 navigation data) [Y, T]

MCS data:

- MGL1206_segd/MGL1206/* (434GB; raw MCS data in SEGD format) [Y, T]
- MGL1206/processed_segy/* (5.9GB: processed SEGY files) [Y,T]
- MGL1206/processed/shotlogs/* (3.4MB; shot information) [Y, T]

Multibeam:

- MGL1206/raw/multibeam/* (17GB; raw EM122 data) [Y,T]
- MGL1206/docs/operations/MGL1206_Expendable_Drops.xls [Y,T]
- MGL1206/raw/XBT/* (5MB; raw XBT data) [Y,T]
- MGL1206/processed/svp/* (18MB; sound velocity profiles) [Y,T]
- MGL1206/raw/serial/MGL-bath02* (21MB; EM122 centerbeam data) [Y, T]

Underway geophysics:

- MGL1206/raw/serial/MGL-mag01* (26MB; Geometrics 882 magnetomter data) [Y, T]
- MGL1206/raw/serial/MGL-vc01* (8MB; Bell Aerospace BGM-3 gravimeter) [Y, T]
- MGL1206/raw/knudsen/* (10GB; Knudsen 3.5 kHz data) [Y, T]

Logs:

- MGL1206/docs/elog/* (3MB; E-log) [Y, T]
- MGL1206/docs/operations/NavLogs/* (1MB; seismic nagivation logs) [Y, T]
- MGL1206/docs/operations/ObsLogs/* (1MB; seismic acquisition logs) [Y, T]
- MGL1206/docs/operations/MGL1206_30_min_Log.xls (300KB; 30 min log) [Y,T]

Other useful files:

- MGL1206/public/formats/* (3MB; data formats for serial data) [Y, T]
- MGL1206/docs/gravity_tie/* (1MB; gravity tie information) [Y, T]
- MGL1206/docs/offsets/* (2MB; offset information for MCS survey) [Y, T]
- MGL1206/docs/operations/Daily_Reports/* (7MB; chief science officer's reports) [Y, T]

*Y=Yale, T=TAMU

MCS Logs

LINE	LENGTH (KM)	LOG FGSP	LOG LGSP	PROC FGSP	PROC LGSP	FIRST TAPE	LAST TAPE	FIRST CDP*	LAST CDP	START DAY	END DAY
MCS_1	246.1	1029	5898	1029	5892	4	11	521	39892	90	91
MCS_2	223.7	1005	5421	1005	5421	12	18	521	36316	91	93
MCS_3	269.2	1168	6498	1168	6494	19	27	521	43596	93	94
MCS_4	297.9	943	6841	916	6816	28	36	521	48188	94	95
MCS_D2	295.7	846	6689	834	6689	37	46	521	47828	96	97
Total	1332.6										

*Note: The CDP at the first shot point is set to CDP 1000.

MCS Processing Parameters Outline

Data Storage Locations:

Ship Server:

- Main Directory: smb://fserve/mgl1206
- Navigation Files (p190): smb://fserve/mgl1206/raw/spectra
- SEGD Files: smb://fserve/mgl1206-segd

Processing Computer:

- ProMAX data: /media/disk/promax
- ProMAX scratch: /media/disk/scratch

Creating Near Trace Plots with ProMAX and GMT

1. Copy SEGD tapes from ship server to local working directory
    a. Can run this every few hours as each tape is completed or at the end of the line.
2. Load near trace from each shot (chan#468)
    a. Note: ProMAX can only handle one tape's worth of shots at a time. So you need to set up multiple SEGD Input/Disk Data Output pairs for each tape. Then create a flow to combine all of the tapes into one set of gathers.
    b. SEG-D Input
        i. Browse for tape folder and select shots
        ii. Primary selection choice: Input ALL
        iii. Secondary selection choice: Channel
        iv. Channel selection mode: Include
            1. Specify CHANNEL input list: 468/
    c. Disk Data Output
        i. File name: nt_tape1
3. Combine tapes into one line (sample for combining two tapes into one line)
    a. Disk Data Input: nt_tape1
        i. Trace read option: Get All
    b. Disk Data Output: nt_line_D2
        i. New, or Existing, File: New

c. Disk Data Input: nt_tape2
    i. Trace read option: Get All
d. Disk Data Output: nt_line_D2
    i. New, or Existing, File: Append

4. Output SEGY Near Trace File
    a. Disk Data Input: nt_line_D2
        i. Trace read option: Get All
    b. Bandpass Filter
        i. 4-8-60-80
    c. SEGY Output
        i. Type of SEGY: Standard
        ii. Type of storage to use: Disk Image
        iii. Desired trace format: IBM Real
5. GMT File to Create a Wiggle b&w Seismic Plot: plot_segy_bw_mgl1206.gmt
6. GMT File to Create a Color Gridded Seismic Plot: plot_segy_color_mgl1206.gmt
    a. Color file: seis.cpt

<u>Trace Editing Procedure:</u>

Load first gather from each tape and last gather from last tape and view in Trace Display. Write down bad channel numbers. Create common channel gathers to see if the bad channels should be deleted completely from the line. Small random bursts can be removed with Spike & Noise Burst Removal.

SEGD input - select first and last shot gathers
Bandpass filter – 4-8-60-80
Trace Display – review gathers and header information

<u>ProMAX Processing Parameters:</u>

1. Geometry Setup:
    1) Purpose: Set up geometry in ProMAX
        a) 2D Marine Geometry Spreadsheet
            1. Setup:
                a. Select: Matching pattern number in the SIN and PAT spreadsheets
                b. Station Intervals:
                    i. Nominal Receiver Station Interval: 12.5
                    ii. Nominal Source Station Interval: 50.0
                    iii. Nominal Sail Line Azimuth: 0.0
                    iv. Nominal Source Depth: 9.0
                    v. Nominal Receiver Depth: 9.0
                c. Units: Meters
                d. Co-ordinate origin:
                    i. X0: 0.0
                    ii. Y0: 0.0
            2. Sources: Shot Pattern Spreadsheet:
                a. Upload the source, station, x, y, and water depth from the p190 file.
                b. Fill in by hand source depth (9.0), FFID, and streamer azimuth (180).
                c. *Note: Shot and FFID numbers might not match up along the line such as when a portion of a line needs to be reshot. Hand editing may be required to match the correct Shot and FFID number pairs.

        d. Click Save
        e. Click Exit
    3. Patterns: Receiver Pattern Spreadsheet: Fill in by hand the following values
        a. Min Chan: 468 (Closest to vessel)
        b. Max Chan: 1 (Farthest from vessel)
        c. Chan Inc: -1 (Count from min to max chan)
        d. Group Int: 12.5
        e. X Offset: 152.7 (source to first channel)
        f. Y Offset: 0.0
        g. Click Exit
    4. Bin: 2D Marine Binning
        a. Assign Midpoints
            i. Select Matching pattern number in the SIN and PAT spreadsheets
            ii. Click OK
        b. Binning
            i. Select: Midpoints, user defined OFB parameter
                1. Source station tie to CDP number: Use first shot number
                2. CDP number tie to source station: 1000
                3. Distance between CDPs: 6.25
                4. Offset bin center increment: 12.5
                5. Minimum offset bin center: 152.7
                6. Maximum offset bin center: 5990.2
                7. Check: CDP numbers increase in shooting direction
                8. Click OK
            ii. Select: Receivers
                1. Receiver bin width: 12.5
                2. Check: Receiver numbers increase in shooting direction
                3. Click OK
        c. Finalize Database
            i. Click OK

2. Load SEGD Data and enter Geometry into Trace Headers
    1) Purpose Load SEGD data into ProMAX and combine with Geometry info in one step.
    2) Inline Geom Header Load
        a) Primary header to match database: SOU_SLOC or FFID
3. Shot Display
    1) Purpose: Quality Control Shots. Look for bad channels, spikes, etc.
    2) Disk Data Input
        a) Primary Key: Source Index Number
        b) Secondary Key: Recording Channel Number
4. Trace and noise burst edit
    1) Purpose: Remove bad channels, spikes and noise bursts
    2) Trace Kill
        a) Enter numbers of bad channels determined from shot display
    3) Spike & Noise Burst Edit
        a) Purpose: Test Spike & Noise Burst Edit parameters on known noise bursts
        b) Review with Trace Display

        c) Apply to gathers in subsequent flows

5. Deconvolution Test
    1) Run on near trace CDP plot or brute stacked section (usually just a small section ~1000 CDPs)
    2) Review autocorrelation in trace display
    3) Test deconvolution operator length (~100 ms) and prediction distance (~20 ms)
    4) Note: See Yilmaz for an in-depth discussion of picking deconvolution parameters.
6. Near Trace Plot
    1) Pick basement horizon and other important horizons for use in velocity analysis
    2) Choose secondary header to be CHAN
7. Velocity Analysis
    1) Disk Data Input
        a) Primary Sort Header: CDP
        b) Secondary Sort Header: Absolute Offset Value
        c) Sort Order: 1-99999(200):*/
    2) Bandpass Filter
    3) Spike & Noise Burst Edit
    4) Trace Kill/Reverse
    5) Spiking/Predictive Deconvolution
    6) Velocity Analysis
8. Stack
    1) Bandpass Filter
    2) Spike & Noise Burst Edit
    3) Trace Kill/Reverse
    4) Spiking/Predictive Deconvolution
    5) NMO
    6) CDP Stack
9. Time Migration
    1) Memory Stolt F-K Migration
10. Optional Multiple Removal
    1) F-K filter in CDP domain
        - requires additional velocity analysis
    2) Radon filter in CDP domain
        - takes longer to run
    3) Inside mute
        - inside traces only
    4) Time-variant frequency filter
        - low-pass filter below seafloor multiple applied in addition to above steps

Scripts for MCS Processing

GMT script for plotting b&w seismic sections: plot_segy_bw_mgl1206.gmt

```
gmtset PAPER_MEDIA=Custom_2800x3580
map=Line_1_processed
psbasemap -JX118/-80 -R1/8866/6.8/8.4 -BNEWs500f100:"CDP No.(6.25m
interval)":/.2g.2f.1:"TWTT(sec)"::."MGL1206-MCS-line-1": -X4 -Y7 -K > $map.ps
pssegy $map.segy -JX118/-80 -R1/8866/6.8/8.4 -V  -D.15 -B-.5 -F0 -N -O -
M67000 >> $map.ps
```

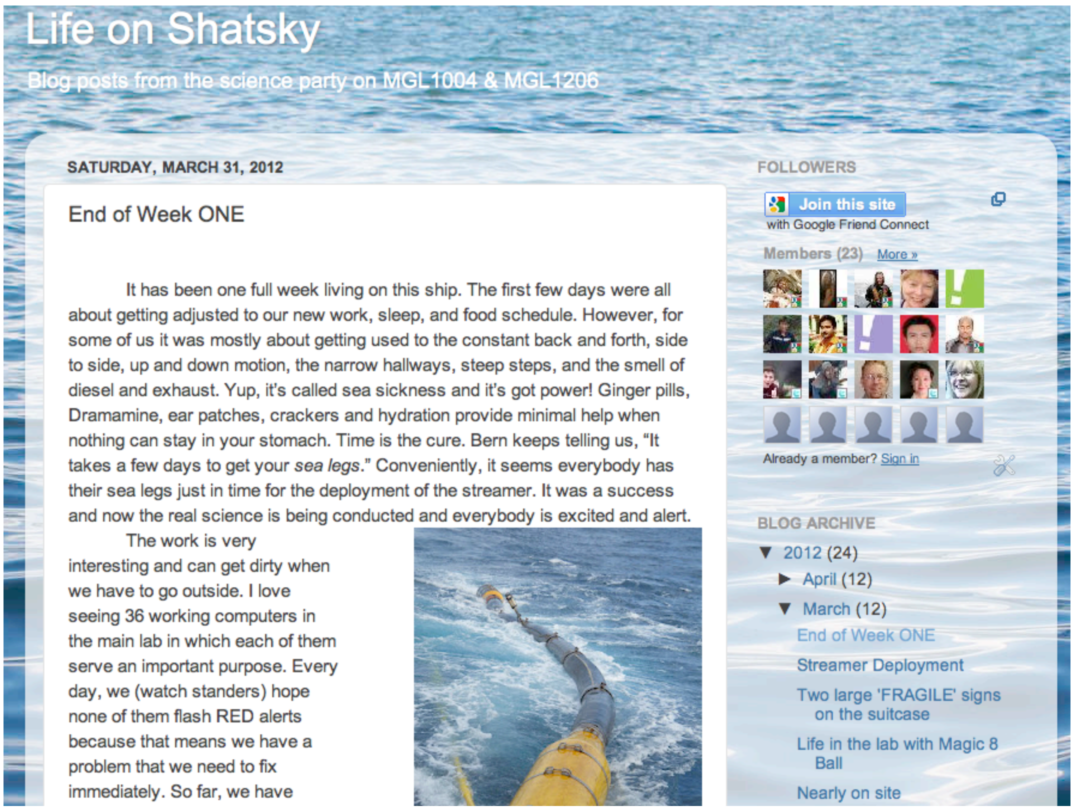
GMT script for plotting color seismic sections: plot_segy_color_mgl1206.gmt

```
gmtset PAPER_MEDIA=Custom_2800x14400

map=Line_2_processed

psbasemap -JX476/-80 -R1/35796/5/12 -BNEWs1000f500:"CDP No.(6.25m
interval)":/1g1f.5:"TWTT(sec)"::."MGL1206-MCS-line-2": -X4 -Y7 -K > $map.ps

segy2grd $map.segy -G$map.grd -I1/0.001s -R1/35796/5/12 -V -M67000

grdimage $map.grd -Cseis.cpt -JX476/-80 -R1/35796/5/12 -O -K -V  >> $map.ps

psbasemap -JX476/-80 -R1/35796/5/12 -BNEWs1000f500:"CDP No.(6.25m
interval)":/1g1f.5:"TWTT(sec)"::."MGL1206-MCS-line-2": -O -V >> $map.ps
```

*GMT color map file: seis.cpt was created by "makecpt -Cpolar -T-20/20/1 -Z".

Notes on Outreach Efforts

Prior to MGL1206, Korenaga revived a cruise blog "Life on Shatsky" (http://lifeonshatsky.blogspot.com/), which was originally created for MGL1004. At the beginning of the cruise, watchstanders were asked to sign up for the blog (requires a Google account) and post an article on a daily basis as a group. We have posted 12 articles in March and 16 articles in April. Students and postdocs all wrote very well; one post even had an original limerick dedicated to the *Langseth*.



The visitor's statistics were tracked by blogger.com's own stats module as well as Google Analytics. The number of daily visits fluctuated around 50 to 70, and the countries from which we collected more than 10 visits during the cruise are USA (900 visits), Japan (80), France (35), UK (30), India (20), Canada (18), Australia (15), and Spain (12). The total number of page views exceeded 2,000. These numbers may be compared to those from MGL1004 (which lasted 59 days): 30-50 daily visits and 3,200 total page views. In between these two cruises (i.e., mid-September 2010 to mid-April 2012), the blog attracted ~8,000 visits from 134 countries (70 countries with more than 10 visits), with more than 12,000 page views. Google Analytics summary for the entire duration of this blog is shown in the next page.

8,675 people visited this site

11,333 **Visits**

8,675 **Unique Visitors**

17,728 **Pageviews**

1.56 **Pages/Visit**

00:01:25 **Avg. Visit Duration**

70.64% **Bounce Rate**

76.47% **% New Visits**